Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics)
(Ref. Reso. 68.02 of 63rd Senate of SVNIT dated 24.01.2025)

Sr. No.	Subject	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)
	Seventh Semester (4th year of MSc)				
1	Statistical Mechanics	PH401	3-1-0	4	70
2	Digital Electronics	PH403	3-0-2	4	85
3	Condensed Matter Physics	PH405	3-1-0	4	70
4	Elective #3	PH4AA	3-X-X	3/4	55/70/85
5	Elective #4	PH4BB	3-X-X	3/4	55/70/85
6	Elective #5 (MOOC)	PH4CC	X-0-0	3/4	55/70
			Total	**23/24**	**390-465**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	PHV07 / PHP07	0-0-10	5	200 (20 x 10)
	Eighth Semester (4th year of MSc)				
1	Computational Physics	PH402	3-0-2	4	85
2	Particle Physics	PH404	3-1-0	4	70
3	Elective #6	PH4DD	3-X-X	4	70/85
4	Elective #7	PH4EE	3-X-X	3/4	55/70/85
5	Elective #8	PH4FF	3-X-X	3/4	55/70/85
6	Elective #9 (MOOC)	PH4GG	X-0-0	3/4	55/70
			Total	**21-24**	**390-480**

Sr. No.	Elective(s)	Code	Scheme L-T-P
	Elective #3 (7th semester)		
9	Astrophysics and space science	PH451	3-1-0
10	Microprocessor and Microcontrollers	PH453	3-0-2
11	Characterization Techniques	PH455	3-0-2
	Elective #4 (7th semester)		
12	Density Functional Theory	PH457	3-0-2
13	Elementary Excitation in Solids	PH459	3-1-0
14	Green's Function and Partial Differential Equations	PH461	3-1-0
	Elective #5 (7th semester)		
15	NPTEL, SWAYAM or any other Massive Open Online Course (MOOC)	PH463	3-0-0/4-0-0
	Elective #6 (8th semester)		
16	Simulations and Modelling	PH452	3-0-2
17	Advanced Crystallography	PH454	3-1-0
18	Electromagnetic Communications	PH456	3-1-0

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	Elective #7 (8th semester)		
19	Global Navigation Satellite System	PH458	3-1-0
20	Quantum Field Theory	PH460	3-1-0
21	Thin Films and Vacuum Technology	PH462	3-1-0
	Elective #8 (8th semester)		
22	Nuclear Science and Technology	PH464	3-0-2
23	Non-Destructive Testing	PH466	3-1-0
24	Microwave Plasma Technology	PH468	3-0-2
	Elective #9 (8th semester)		
25	NPTEL, SWAYAM or any other Massive Open Online Course (MOOC)	PH470	3-0-0/4-0-0

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. IV, Semester-VII STATISTICAL MECHANICS PH401	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Identify the correlation between statistics and thermodynamics.
CO2	Interpret the properties of microcanonical, canonical and grand canonical ensembles.
CO3	Examine the quantum statistics and density matrix for various systems.
CO4	Classify the consequences associated with Bose-Einstein and Fermi-Dirac statistics.
CO5	Analyze the phase equilibrium and transport phenomena.

2.	**Syllabus**	
	THE STATISTICAL BASIS OF THERMODYNAMICS	**(08 Hours)**
	The connection between statistics and thermodynamics; Concept of microstates phase space and its connection to Entropy; Classical Ideal Gas and the Maxwell Boltzmann Distribution, Entropy of mixing and Gibbs Paradox.	
	ELEMENTS OF ENSEMBLE THEORY	**(08 Hours)**
	Liouville's Theorem, Microcanonical Ensemble, Canonical Ensemble and Partition Function calculation for various systems; Energy fluctuations in the Canonical Ensemble; Grand Canonical Ensemble; Number Density and Energy Fluctuations in the Grand Canonical ensemble.	
	FORMULATION OF QUANTUM STATISTICS	**(12 Hours)**
	Quantum Statistics and calculation of the Density matrix for various systems; Indistinguishability of Particles, Symmetric and Anti - Symmetric wave functions and calculation of the Bose-Einstein and Fermi-Dirac Distribution for a quantum Ideal Gas; Thermodynamic behaviour of an Ideal Bose Gas.	
	IDEAL BOSE AND FERMI SYSTEM	**(12 Hours)**
	Black-Body radiation and other applications of Bose-Einstein statistics; Thermodynamic behaviour of an ideal Fermi gas and various applications of Fermi-Dirac statistics such as Pauli paramagnetism and calculation of Chandrasekhar limit in White Dwarf stars; Cluster expansion techniques for interacting systems.	
	PHASE EQUILIBRIUM AND TRANSPORT PHENOMENA	**(05 Hours)**
	Equilibrium conditions, classification of phase transitions, Clausius-Clapeyron and Van der waal's equation, Mean collision time, Scattering cross section, Viscosity etc.	

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	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**

(Total Contact Time: 45 Hours + 15 Hours= 60 Hours)

3.	**Tutorials will be based on**
1	the Ideal Gas and the Maxwell Boltzmann distribution.
2	the microstates and entropy.
3	the different ensemble and partition function.
4	the Liouville’s theorem.
5	the number density and energy fluctuations.
6	the Fermi-Dirac distribution.
7	the Bose-Einstein distribution.
8	the Black-Body radiation and Chandrasekhar limit.
9	the ideal Bose gas.
10	the Clausius-Clapeyron and Van der Waal’s equation.

4.	**Books Recommended**
1.	F. Reif, Fundamentals of statistical and thermal physics, Waveland Press, Long Grove, 2009.
2.	M. Kardar, Statistical physics of particles, Cambridge University Press, Cambridge, 2007.
3.	R. K. Pathria and P.D. Beale, Statistical Mechanics, 3rd edition, Academic Press, Cambridge, 2011.
4.	K. Huang, Statistical Mechanics, 2nd Ed., John Wiley & Sons, New York, 2008.
5.	B. B. Laud, Fundamentals of Statistical Mechanics, New Age Int. Pvt. Ltd., New Delhi, 2012.
Additional Reference Books	
1.	D. Yoshioka, Statistical Physics: An Introduction, Springer, Berlin, 2007.
2.	S. Chandra, A Textbook of Statistical Mechanics, CBS Publishers, New Delhi, 2016.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester - VII DIGITAL ELECTRONICS PH403	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Comprehend and use different number systems and binary codes.
CO2	Interpret the logic operations by using Gates, Boolean algebra and K-maps.
CO3	Analyze various combination circuits, flip-flops and timing circuits.
CO4	Implement A to D and D to A conversions.
CO5	To design and construct application-oriented digital circuits.

2.	Syllabus	
	INTRODUCTION, NUMBER SYSTEM	**(04 Hours)**
	Digital & Analog System, Logic Levels and Pulse Waveforms, Elements of Digital Logic, Functions of Digital Logic, Digital Integrated Circuits, The Decimal Number System, The Binary Number System, Representation of Signed Numbers and Binary Arithmetic in Computers, Different Number Systems.	
	BINARY CODES & LOGIC GATES	**(03 Hours)**
	Different Codes, and Gates, , Inhibit circuits, 7400 series ICs, ANSI/IEEE Standard Logic symbols, Pulsed operation of Logic Gates.	
	BOOLEAN ALGEBRA	**(03 Hours)**
	Logic Operations, Axioms and Laws of Boolean Algebra, Duality, Reducing Boolean Expressions, Boolean Expression and Logic Diagrams, Converting AND/OR/Invert Logic to NAND/NOR logic, Determination of Output lev0el from the diagram.	
	THE KARNAUGH AND QUINE-McCLUSKY METHODS	**(06 Hours)**
	Expansion of a Boolean Expression to SOP & POS form, Computation of total Gate inputs, All variables K-map, Don't care combinations, Hybrid logic, Minimization of Multiple output circuits, Variable mapping, Quine-McClusky Method, Function minimization of multiple output circuits.	
	COMBINATION CIRCUITS	**(06 Hours)**
	The Half- Full-adder -Subtractor, Parallel Binary Address, the look-ahead carry adder, IC parallel adders, Two's complement addition & subtraction using parallel Adders, serial Adders, BCD Adders, Binary multipliers, code converters, Parity generators/checkers, Comparators, IC Comparator, Decoders, BCD to seven segment decoders, Display devices, Encoders, Multiplexers, Demultiplexers and Applications	
	FLIP-FLOPS AND TIMING CIRCUITS	**(04 Hours)**
	The S-R latch, Gated latches, Edge-trigged Flip-Flops, Asynchronous inputs, Flip-flop operating characteristics, Master Slave (Pulse-triggered) flip-flop, Conversion of Flip-flops, Applications of Flip-flops, ANSI/IEEE Symbols, Schmitt Trigger, Multivibrators, crystal controlled clock generators.	
	SHIFT REGISTERS, COUNTERS	**(06 Hours)**
	Buffer register, Controlled Buffer register, Shift Registers & Data Transmission in shift register, Counters, Pulse Train Generators, Pulse Generators using shift registers, Cascading of Synchronous counters.	

	LOGIC FAMILIES AND ANALOG-TO-DIGITAL AND ANALOG–TO-ANALOG CONVERTERS	**(06 Hours)**
	Digital IC Specification Technology, Logic Families, Transistor Transistor Logic (TTL), Open –collector Gates, Digital-to-Analog(D/A) Conversion, The R-2R Ladder Type DAC, The Weighted –resistor Type DAC, The Switched Current-source Type DAC, Analog-to-Digital Conversion, The Counter-type A/D Converter, The Tracking-type A/D Converter, The Flash-type A/D Converter, The Dual-slop Type A/D Converter, The Successive-approximation Type ADC	
	DESIGNING DIGITAL CIRCUITS	**(07 Hours)**
	Various Application and their circuits designs, Reactor design, Traffic signal, Stepper motor, Motion Control Circuits	
	Practical will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals will be based on**
1.	To construct and, nand, or, nor and not gate using transistor.
2.	To construct xor gate using only nand gate, nor gate and aoi.
3.	To construct circuit of half adder and full adder, half subtactor and full subtractor.
4.	To construct circuit which converts 4 bit binary to gray and gray to binary codes.
5.	To construct a circuit to generate parity bit for even and odd parity for 7-bits hamming code
6.	To construct a circuit for multiplexer and demultiplexer.
7.	To construct a circuit for 8-to-3 encoder and 3-to-8 decoder.
8.	To construct a 2-bit comparator & 4-bit comparator.
9.	To construct a circuit of gated sr latch and gated d latch.
10.	To construct a circuit for positive edge detector ripple up/down 2 bit counter.

4.	**Books Recommended**
1.	Floyd T. L, Jain R. P., Digital Fundamentals, Dorling Kindersley Pvt. Ltd., New Delhi, 2008.
2.	Morris Mano M. Digital Logic & Computer Design, Dorling Kindersley Pvt. Ltd., New Delhi, 2008.
3.	A. Anand Kumar, Fundamentals of Digital Circuits, Prentice-hall of India Pvt. Ltd., New Delhi, 2016.
4.	Jain. R. P., Modern Digital Electronics, Tata McGraw Hill, New York, 2009.
5.	Malvino A.P., Leach P. D., Digital Principals & Applications., 8^{th} Ed., Tata McGraw Hill, New York, 2014.

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	Scheme	L	T	P	Credit
Fourth Year of Five Years of Integrated M.Sc. (Physics) **M.Sc. - IV, Semester - VII** **CONDENSED MATTER PHYSICS** **PH405**		**3**	**1**	**0**	**4**

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Recall the significance and value of condensed matter physics, both scientifically and in the wider community.
CO2	Interpret the electron transport and lattice vibration.
CO3	Explain the temperature dependence of electrical and thermal conductivities.
CO4	Apply the knowledge of magnetism and superconductivity towards their applications.
CO5	Examine the problem and make inference out of that.

2.	**Syllabus**	
	CRYSTALLINE SOLIDS	**09 Hours**
	Principles of condensed matter physics, Symmetry in perfect solids, Space groups, diffraction of waves in periodic structures.	
	LATTICE VIBRATION	**09 Hours**
	Vibrations of crystal lattices, phonons and Debye theory of specific heats, Lattice vibration, thermal expansion and Phonon thermal conductivity.	
	THE FREE ELECTRON THEORY	**09 Hours**
	Free electron theory, Band structure of solids, effective mass, electrons and holes, electrical conductivity, Hall effect and cyclotron resonance, carrier lifetime.	
	DIELECTRICS	**05 Hours**
	Dielectric solids, polarizability, susceptibility, Dispersion and absorption of electromagnetic waves, Different types of polarizabilities.	
	MAGNETISM	**05 Hours**
	Dia-, Para-, and Ferromagnetism in solids, exchange interactions, magnetic ordering, spin waves, Band magnetism.	
	SUPERCONDUCTIVITY	**04 Hours**
	Superconductors, Ginzburg- Landau theory and BCS theory, Josephson tunnelling, High-temperature superconductors.	
	NON-CRYSTALLINE SOLIDS	**04 Hours**
	Scaling theory and weak localization, defects in solids, point defects and dislocations.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

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3.	**Tutorials will be based on**
1.	Symmetry in perfect solids.
2.	Diffraction from crystalline materials.
3.	Free electron theory of metals.
4.	Electrical conductivity of metals.
5.	Thermal conductivity of metals.
6.	Thermal conductivity (Phonon part) of metals.
7.	Dielectric materials.
8.	Magnetism and Magnetic materials.
9.	Superconductors.
10.	Defects and Dislocations in Crystals.

4.	**Books Recommended**
1.	Marder M.P., Condensed Matter Physics, 2nd Edition, John Wiley & Sons Inc, New Jersey, 2011.
2.	Basu S., Condensed Matter Physics: A Modern Perspective, IOP Publishing, Bristol, UK, 2022.
3.	Blundell S., Magnetism in Condensed Matter, 1st Edition, Oxford University Press, Oxford, 2001.
4.	Girvin S. M., Yang K., Modern Condensed Matter Physics, 1st Edition, Cambridge University Press, Cambridge, 2019.
5.	Kittel C., Kittel's Introduction to Solid State Physics, Wiley India Edition, India, 2019.

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Fourth Year of Five Years of Integrated M.Sc. (Physics) **M.Sc. - IV, Semester – VII** **ASTROPHYSICS AND SPACE SCIENCE** **PH451**	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**1**	**0**	**4**

1.	**Course Outcomes (COs):** **At the end of the course students will be able to**
CO1	Recall & understand the concepts of Astrophysics, and Space Science.
CO2	Understand how astrophysical processes are studied, understood and utilized for furthering our understanding of the universe.
CO3	Apply the concepts of space science to different problems.
CO4	Evaluate the applications to various problems related to Astrophysics and Space Sciences.
CO5	Analyse the satellite system such as GPS, Galileo, IRNSS.

2.	**Syllabus**	
	INTRODUCTION TO THE COURSE	**(04 Hours)**
	LARGE SCALE OBJECTS	**(10 Hours)**
	Astrophysical objects of interests like Galaxies, stars, their Evolution, Clusters, techniques to study these objects.	
	STELLAR OBJECTS	**(10 Hours)**
	Types of stars, their properties. Evolution of stellar objects. The Sun, the standard model. Quiescent Sun, Disturbed sun.	
	SOLAR TERRESTRIAL RELATIONSHIP	**(10 Hours)**
	The quiet and disturbed solar features and their impact on space weather. Magnetosphere, Ionosphere, atmosphere.	
	RADIO WAVE PROPAGATION THROUGH IONOSPHERE	**(06 Hours)**
	Refraction, effect of the ionosphere on wave propagation. Quiet ionosphere, disturbed ionosphere. The effects on technological systems.	
	ADVANCED TOPICS OF RELEVANCE	**(05 Hours)**
	Global Navigational Satellite System like GPS, Galileo, IRNSS.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

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3.	**Tutorials will be based on**
1.	first unit on Introduction to the Course.
2.	to understand the large-scale objects such as galaxies, stars etc.
3.	techniques to study such large size objects.
4.	various types of stars and their properties.
5.	quiescent sun and disturbed sun.
6.	standard model to understand the stellar objects.
7.	solar terrestrial relationship.
8.	radio wave and its propagation through the ionosphere etc.
9.	the effects on technological systems.
10.	GPS, Galileo, IRNSS.

4.	**Books Recommended**
1.	Ratcliff, J. A., Introduction to ionosphere & Magnetosphere, Cambridge Univ. Press., Cambridge, 1975.
2.	Hargreaves, J. K., The Solar Terrestrial Environment, Cambridge Univ. Press, Cambridge, 2010.
3.	Kievelson, M. J. et al., Introduction to Space Physics Cambridge Univ. Press, Cambridge, 2019.
4.	Lang, K. R. Sun, Earth and Sky, Springer, New York, 2006.
5.	Basu Baidyabath, T. Chattopadhyay and S. N. Biswas, An Introduction to Astrophysics, PHI Learning Pvt. Ltd., New Delhi, 2018.

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Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester - VII MICROPROCESSOR AND MICROCONTROLLERS PH453	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	To remember components of microprocessors & microcontrollers.
CO2	To understand concept of memory mapping.
CO3	To model microprocessors and microcontrollers using assembly level language.
CO4	To make use of microprocessors and microcontrollers to various devices.
CO5	To design and construct microcontroller-based automatic systems.

2.	Syllabus	
	REVIEW OF DIGITAL LOGIC CONCEPTS	**(04 Hours)**
	Number systems, gates & De-Morgan's equivalents, 3-state logic gates, flip-flops, buffers, decoders, encoders, multiplexers, de-multiplexers.	
	INTRODUCTION TO MICROPROCESSOR SYSTEM	**(04 Hours)**
	Introduction, Registers, concept of address and data buses, system control signals, basic bus timing, memory (RAM, ROM), input output devices, Microcomputer systems, over view of 8-16-32 bit microprocessors family.	
	8085A MICROPROCESSOR ARCHITECTURE	**(08 Hours)**
	Introduction to 8085A, pin diagram and pin description, bus timing and instruction timing, de-multiplexing of buses, generation of control signals, concept of interrupts.	
	MEMORY INTERFACING WITH 8085A	**(06 Hours)**
	Different types of memory, memory map, address decoding scheme for different memory, memory timings.	
	INPUT OUTPUT DEVICES INTERFACING WITH 8085A	**(08 Hours)**
	Basic interfacing concepts, peripheral I/O interfacing and memory mapped I/O interfacing, interfacing of 7 segment LED display, keys, relays, interfacing of programmable devices like 8255, 8254.	
	THE 8051 MICROCONTROLLER ARCHITECTURE	**(06 Hours)**
	Introduction, 8051 family microcontrollers, hardware architecture, input/output pins, I/O ports and circuits, on chip ram, general purpose registers, special function registers, timers-counters, concepts of interrupts.	
	ASSEMBLY LANGUAGE PROGRAMMING OF 8051 & APPLICATIONS	**(09 Hours)**
	Concept of IDE (assembler, compiler, linker, de-bugger), addressing modes, data move instructions, arithmetic and logical instructions, jump, loop and call instructions, concepts of subroutines, interrupt service routine, interfacing peripherals and applications	
	Practical will be based on the coverage of the above topics separately	**(30 Hours)**
		(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

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3.	**Practicals will be based on**
1.	Write a program for addition of 10 data bytes stored at given memory location. Save the results in external memory at given locations.
2.	Write an 8085 program to calculate factorial of a number.
3.	Write an 8085 program to convert BCD number to HEX and vice-versa.
4.	Write an 8085 program to count number of data bytes containing ODD, EVEN & ZERO from a set of data bytes stored from memory location C100H to C10AH
5	Write an 8085 program to count number of data bytes containing POSITIVE, NEGATIVE and ZERO from a set of data bytes stored from memory location C100H to C10AH.
6.	Write an 8085 program to generate 14 numbers from Fibonacci sequence and store them at memory location C000H onwards. Fibonacci sequence starts from 0, 1, …
7.	Write an 8085 program to arrange given numbers in Ascending & Descending orders.
8.	Write an 8085 program to count vowels from given string of data.
9.	Write a program to generate square wave of frequency 2 Hz with a duty cycle of 25% and send it as output to the LED.
10.	Write a program to dancing LED with period of shift being 1 sec.

4.	**Books Recommended**
1.	R. S. Gaonker, Microprocessor Architecture, programming and applications with 8085, 5th Ed., Prentice Hall, New Jersey, 2013.
2.	K. J. Ayala, The 8051 Microcontroller, 3rd Ed., Penram International, Boston, 2007.
3.	M. Mazidi et al., The 8051 Microcontroller and Embedded Systems, 2nd Ed., PRENTICE Hall, New Delhi, 2007.
4.	M. Slater, Microprocessor based Design, Pearson Education, New Delhi, 2016.
5.	B. Ram, Fundamentals of microprocessors and microcomputers, Dhanpat Rai Publ., New Delhi, 2018.

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Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester - VII CHARACTERIZATION TECHNIQUES PH455	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Recall preliminary concepts of the material's structure and various characterization techniques such as X-ray diffraction, Scanning electron microscopy, Transmission electron microscopy and other magnetic, electrical and thermal measurement techniques for the structure-property relationship of materials.
CO2	Outline different sophisticated characterization tools and explain basic knowledge about working principles.
CO3	Identify characterization tools necessary for measurement or analysis and solve related problems based on concepts used in various techniques.
CO4	Examine the material's properties and analyze the results using specific techniques related to the material's perspective.
CO5	Compile acquired parameters to recommend materials for optimization purposes.

	Syllabus	
	STRUCTURAL ANALYSIS BY X-RAYS	**08 Hours**
	X-rays and their properties, Safety precautions, generation of X-rays, characteristic X-ray spectrum, Moseley's law, methods to remove K_β radiation, X-ray interaction with matter, X-ray Diffraction, Bragg's Law, basic powder diffraction, factors affecting the intensity of diffraction peaks, diffraction analysis for cubic lattices, phase identification, Indexing patterns, Scherrer formula, grain size, particle size, crystal perfection, and micro/macro strains, X-ray reflectivity.	
	MICROSTRUCTURAL OBSERVATION	**07 Hours**
	Advantages/disadvantages as compared to Optical Microscopy and other imaging techniques, scanning electron microscopy and image formation, modes of operation, microanalysis using WDS and EDS, Applications of SEM, qualitative and quantitative analysis, Composition analysis by EDX, Electron diffraction, Transmission electron microscopy imaging, analysis of SAED patterns, lattice imaging, TEM sample preparation.	
	MOLECULAR SPECTROSCOPY STRUCTURE DETERMINATION	**06 Hours**
	Microwave and Infrared Spectroscopy, Fourier transform IR, Raman spectroscopy.	
	ELECTRON SPECTROSCOPY FOR SURFACE ANALYSIS	**07 Hours**
	X-ray Photoelectron spectroscopy, Auger electron spectroscopy, photoelectron spectra, Auger electron spectra peak shifts, information about chemical state and elemental compositions, X-ray absorption, peak identification, chemical shift, Qualitative and quantitative analysis.	
	SCANNING PROBE MICROSCOPY FOR SURFACE MORPHOLOGY	**08 Hours**
	Atomic Force Microscopy (contact & non-contact mode), broad areas of applications, AFM basics, Scanning Tunneling Microscopy, Magnetic Force Microscopy.	

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	THERMAL CHARACTERIZATION	**04 Hours**
	Nomenclature, Importance of thermal characterization techniques, Thermo-gravimetric analysis, Differential thermal analysis, Differential scanning calorimetry – working principle, differences and applications.	
	ELECTRICAL AND MAGNETIC CHARACTERIZATION	**05 Hours**
	2-probe and 4-probe techniques, Van der Pauw method, Sheet resistance, Hall measurement, Magnetoresistance, Vibrating Sample Magnetometer, SQUID, Dielectric measurement, Impedance analyzer.	
	Practical will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals will be based on**
1.	Structural determination by X-ray diffraction.
2.	Refinement of structural parameters obtained by XRD.
3.	Determination of optical band gap of prepared given samples by UV-Vis spectroscopy.
4.	Analysis of various bonding in given samples by Infrared spectroscopy.
5.	Measurement of magnetic properties of a given magnetic material.
6.	Analysis of thermal properties of a given sample.
7.	Electrical resistivity of a resistive material as a function of temperature using the DC four-probe method.
8.	To study the temperature dependence of the Hall coefficient of semiconducting materials.
9.	Frequency-dependent Dielectric measurements of given samples and their analysis.
10.	Study of magnetoresistance of a semiconductor material.

4.	**Books Recommended**
1.	Cullity B. D., Stock S. R., Elements of X-Ray Diffraction, 3rd Edition, Pearson, USA, 2014.
2.	Kaufmann E. N., Characterization of Materials, (Vol. 1-3) John Wiley & Sons Inc, New Jersey, 2012.
3.	Banwell C. N., McCash E. M., Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw Hill Education, London, 2017.
4.	Williams D. B., Carter C. B., Introduction to Transmission Electron Microscope, 2nd Edition, Springer, USA, 2009.
5.	Zhang S., Li L., Kumar A., Materials Characterization Techniques, CRC Press, New York, 2008.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester - VII DENSITY FUNCTIONAL THEORY PH457	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the course students will be able to
CO1	Understand the Thomas-Fermi energy and minimum energy principle.
CO2	Identify the exchange and correlation energy by using Hartree-Fock method.
CO3	Interpret the Hohenberg-Kohn theorem and Kohn-Sham equations using variational principle.
CO4	Analyze the approximations for exchange correlation energies and their applications.
CO5	Apply time dependent density functional theory to excited states problems.
CO6	Apply DFT and TDDFT for simulation of molecule and materials properties.

2.	Syllabus	
	BACKGROUND	**(04 Hours)**
	Brief review on introductory quantum mechanics, Electron density, Founders of Density Functional Theory (DFT), Applications of DFT.	
	MANY-BODY EFFECTS	**(04 Hours)**
	Many-body effects, Observables, Observable of external potential energy and electron density, Functional, Functional derivatives.	
	HOHENBERG-KOHN THEOREM	**(04 Hours)**
	Hohenberg-Kohn theorem I and proof, Hohenberg-Kohn theorem II and proof, Hohenberg-Kohn functional, V-representability.	
	THOMAS FERMI EQUATION AND BEYOND	**(04 Hours)**
	Thomas Fermi equation, Minimum Energy Principle, Dirac exchange, von Weizsäcker correction, Thomas Fermi Dirac Weizsäcker functional.	
	KOHN-SHAM EQUATIONS AND VARIATIONAL PRINCIPLE	**(07 Hours)**
	Auxiliary systems, Basic Kohn-Sham theory, Variational principle and self-consistent equations, Exchange correlation energy (E_{xc}), Kohn-Sham equation and its solution.	
	HARTREE AND KOHN-SHAM EQUATIONS	**(04 Hours)**
	Hartree-Fock formulations, Kohn-Sham theory – practical approach.	
	EXCHANGE CORRELATION ENERGIES	**(08 Hours)**
	Exchange correlation energies, Strategies for approximations to exchange correlation energies, Local density approximations (LDA), Homogeneous electron gas, Exchange-correlation hole, Generalized gradient approximations (GGA), Meta-GGA functionals, Hybrid functionals, Examples.	

Subject Code:##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4)EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	TIME DEPENDENT DENSITY FUNCTIONAL THEORY	**(04 Hours)**
	Time dependent density functional theory (TDDFT) and its application to excited state problems. Runge-Gross theorem and its proof, Considerations in TDDFT, TDDFT in practice.	
	DFT BASED SIMULATION FOR MOLECULES AND MATERIALS	**(06 Hours)**
	DFT Hamiltonian, Basis set, Molecule and material modeling (Software: Avogadro, VESTA, XCrysden, etc.), DFT simulation (Software: GAMESS, Quantum Espresso, etc.).	
	Practicals will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals will be based on**
1.	Modeling molecules and clusters using visualization softwares.
2.	Preparing inputs for simulation of molecules.
3.	Preparing inputs for simulation of atomic and molecules clusters.
4.	Simulation of molecules using DFT software, and analyzing outputs.
5.	Simulation of atomic and molecular clusters using DFT software, and analyzing outputs.
6.	Modeling materials using visualization software.
7.	Preparing inputs for simulation of materials.
8.	Simulation of materials using DFT software, and analyzing outputs.
9.	Individual/group wise molecules and clusters related project.
10.	Individual/group wise materials related project.

4.	**Books Recommended**
1.	R. G. Parr and W. Yang, Density-Functional Theory of Atoms and Molecules, Oxford University Press, Oxford, 1994.
2.	W. Koch and M. C. Holthausen, A Chemist’s Guide to Density Functional Theory, John Wiley & Sons, New Jersey, 2015.
3.	R. E. Nalewajski, Density Functional Theory (Relativistic & Time Dependent), Springer, Berlin, 2010.
4.	C. Fiolhais, F. Nogueira and M. Marques (Eds.), A Primer in Density Functional Theory, Berlin, 2010.
5.	K. Burke, Lecture notes on ‘The ABC of DFT’, 2007.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth year of Five Years Integrated M.Sc. (Physics) M.Sc.–IV, Semester – VII ELEMENTARY EXCITATIONS IN SOLIDS PH459	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	Understand the concepts and the principles of elementary excitations in solids.
CO2	Identify the relevance of approximation methods in elementary excitations in solids and extend the concept to explain the dynamics of complex systems.
CO3	Analyze the relevance of elementary excitation in real in real life.
CO4	Interpret the relevance of elementary excitations in solids.
CO5	Explain the meaning of second quantization.

2.	Syllabus	
	INTRODUCTORY SURVEY	**(06 Hours)**
	General considerations, Basic Hamiltonian, Elementary excitations, The measurement of the elementary excitation spectrum.	
	PHONONS	**(08 Hours)**
	Lattice dynamics in one dimension, lattice dynamics in three dimension, lattice specific heat, melting criterion, neutron scattering in solids, Phonon-phonon interactions.	
	ELECTRONS AND PLASMONS	**(06 Hours)**
	Sommerfeld non-interacting electron gas, Hartree and Hartree-Fock approximations, correlation and correlation energy, dielectric response of an electron system, Properties of the electron gas in the RPA, Properties of the electron gas at metallic densities.	
	ELECTRONS, PLASMONS, AND PHOTONS IN SOLIDS	**(05 Hours)**
	Introductory considerations, Experimental observation of Plasmons in solids, optical properties of solids, optical studies of solids.	
	ELECTRON-PHONON INTERACTION IN METALS	**(10 Hours)**
	Basic Hamiltonian, New features associated with the electron-phonon interaction, General physical Picture, High temperature conductivity, Low temperature conductivity, Quasi-particle properties.	
	SECOND QUANTIZATION	**(10 Hours)**
	Quantization of free fields, elastic and electromagnetic fields, boson and fermion fields, illustration from problems in scattering.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

3.	**Tutorials will be based on**
1.	The measurement of the elementary excitation spectrum.
2.	Lattice dynamics
3.	Neutron scattering in solids
4.	Correlation and correlation energy
5.	Properties of the electron gas
6.	Electron-phonon interaction
7.	High temperature conductivity
8.	Quasi-particle properties.
9.	Quantization of free fields
10.	Illustration from problems in scattering

4.	**Books Recommended**
1.	L. I. Schiff, Quantum Mechanics, McGraw-Hill, New York, 2017.
2.	D. Pines, Elementary Excitations in Solids, Westview Press, Boulder, 1999.
3.	S. Nakajima, Y. Toyozawa, R. Abe, The Physics of Elementary Excitations, Springer, Berlin, 1980.
4.	S. M. Girvin and K. Yang. Modern Condensed Matter Physics, Westview Press, Boulder, 2019.
5.	David J Griffiths, Introduction to Quantum Mechanics, Pearson, New Delhi, 2018.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester - VII GREEN'S FUNCTION AND PARTIAL DIFFERENTIAL EQUATIONS PH461	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the semester students will be able to,
CO1	Identify the correlation between the Green's function and ordinary differential equations.
CO2	Understand the mathematical modeling for partial differential equations.
CO3	Examine the characteristics of random walker and diffusion equation.
CO4	Analyse and interpret the solution of Laplace, Poisson, wave and linear transport equation.
CO5	Apply the Green's function to find the solution of non-homogenous PDE.

2.	Syllabus:	
	GREEN'S FUNCTIONS AND ORDINARY DIFFERENTIAL EQUATIONS	**(05 Hours)**
	The Dirac-Delta functions and its properties, Different representation of Dirac delta function, Definition of Green's function, Superposition integral, Initial value problem, Boundary value problem.	
	METHODS FOR GREEN'S FUNCTIONS AND MATHEMATICAL MODELLING	**(11 Hours)**
	Eigenvalue expansions method, Laplace transform and Fourier transform method, Path integral method, Perturbation method, Numerical method, Retarded and advanced Green's functions, applications to ODEs. Mathematical Modelling, Well-posed problem, Classification of partial differential equations (PDEs), Linear and non-linear PDEs, 1D string fixed at both ends, Damped harmonic oscillator, LR circuit.	
	DIFFUSION AND LINEAR TRANSPORT	**(12 Hours)**
	Fick's laws of diffusion, Random walk, Diffusion in d+1 dimension, Green's function for the diffusion equation, Reflection and Absorbing boundary condition, Method of images, Diffusion with drift, Survival probability, First passage time, conduction of heat, uniqueness and stability, the Cauchy problem, Applications to Finance, Linear transport equation, Green's function for the transport equation, applications.	
	LAPLACE AND POISSON'S EQUATION	**(07 Hours)**
	Harmonic functions, well-posed problem and uniqueness, solution of the Poisson's equation for some mass distributions, properties of the solutions, Green's function for Laplace equation in d-dimensions, Divergences, Dimensional regularization.	
	WAVE EQUATION	**(10 Hours)**

	Concepts related to waves, Group velocity and dispersion relations, Finite speed of information transfer, Waves on a string, 1-D wave equation, Initial and boundary value problems, separation of variables, d'Alembert equation, Linear and non-linear case, Cauchy problem, Green's Function for the wave equation.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
		(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

3.	**Tutorials will be based on the**
1.	Representation of Dirac delta function and its properties.
2.	Different approaches of obtaining the Green's function.
3.	Application of Green's function in obtaining the solution of ODE.
4.	Identification of well-poised problem and classification of partial differential equation.
5.	Green's function for the Diffusion equation.
6.	Application of diffusion equation to finance.
7.	Stability and application for the linear transport equation.
8.	Harmonic functions, well-posed problem and uniqueness theorem.
9.	Application of Green's function for the Laplace and Poisson'sequation.
10.	Green's function for wave equation in 1, 2, and 3 dimensions.

4.	**Books Recommended**
1.	Rother T., Green's Function in classical physics, Springer, Switzerland, 2017.
2.	Salsa S., Partial differential equations in action: from modelling to theory, Springer, Switzerland, 2016.
3.	Duffy D. G., Green's functions with applications, Chapman and Hall/CRC, Florida, 2015.
4.	Farlow S. J., Partial differential equations for scientists and engineers, Dover publications, New York, 2003.
5.	Roach, G. F., Green's Functions, Cambridge University Press; 2nd edition, Cambridge, 1982.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

	Scheme	L	T	P	Credit
First Year of Five Years of Integrated M.Sc. (Physics) M.Sc. – IV (Physics), Semester – VIII COMPUTATIONAL PHYSICS PH402		**3**	**0**	**2**	**4**

1.	**Course Outcomes (COs): At the end of the course, the students will be able to**
CO1	explain and apply the numerical methods.
CO2	solve the problems involving partial differential equations numerically.
CO3	interpret the concept of Fourier series, Fourier integral and extend it to conclude the Fourier transform and its applications.
CO4	study the strategy of Monte-Carlo methods by making use of random numbers.
CO5	apply the Monte-Carlo methods for solving physical systems.

2.	**Syllabus**	
	REVIEW OF NUMERICAL METHODS	**(10 Hours)**
	Errors & approximation, Algebraic and transcendental equations, Least square curve fitting, Lagrange's Interpolation, Numerical integration, Numerical solution of ordinary differential equations	
	SYSTEM OF LINEAR EQUATIONS	**(05 Hours)**
	Gauss and Gauss-Jordan elimination, Matrix Inversion, LU decomposition, Eigen value and eigenvector problems, Power and Jacobi method, application to physics problems;	
	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	**(05 Hours)**
	Introduction, Wave equation, Laplace's and Poisson's equations, Heat diffusion equation	
	FOURIER ANALYSIS AND FOURIER TRANSFORM	**(10 Hours)**
	Fourier series of a periodic function, Examples. Half-range expansions, Fourier cosine and sine integral, The Fourier transform, FFT, DFT	
	MONTE-CARLO METHODS	**(07 Hours)**
	Introduction, Random numbers, Multiplicative congruential algorithm, Buffon's needle experiment, Markov process and Markov chain, simple and importance sampling, Metropolis algorithm, 2D- Ising model.	
	NUMERICAL TECHNIQUES FOR PHYSICS PROBLEMS	**(08 Hours)**
	Random number generator, π value calculation, Random walk, Heat distribution problem, Monte-Carlo integrations, Particle in a box, Radio-active decay	
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Practicals will be based on**
1	Writing and testing Python program for solution of Algebraic and transcendental equation using Newton Raphson Method.
2	Writing and testing Python program for Lagrange's Interpolation formula.
3	Writing and testing Python program for Numerical Integration using Simpson 1/3rd method.
4	Writing and testing Python program for Solutions of Ordinary Differential Equations using Runge–Kutta Method.
5	Writing and testing Python program for solution of System of linear equations using Matrix Inversion Method.
6	Writing and testing Python program for Random Walk simulation.
7	Writing and testing Python program for Radioactive decay simulation.
8	Writing and testing Python program for Random number generator.
9	Writing and testing Python program for π value calculation using Monte Carlo Method.
10	Writing and testing Python program for Numerical Integration using Monte Carlo Method.

4.	**Books Recommended**
1	Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers. 7th Edition, Tata McGraw Hill, New York, 2021.
2	Kreyszig, E., Advanced Engineering Mathematics 10th edition Wiley, Jefferson City, MO, 2023.
3	Arfken, G. B. and Weber, H. J., Mathematical Methods for Physicists, Academic Press. California, USA, 2005.
4	Giordano, N. J. and Nakanishi, H., Computational Physics, Pearson-Prentice-Hall, New Jersey, 2006.
5	Landau R. H., Páez M. J., Bordeianu C., Computational Physics: Problem Solving with Python, Wiley-VCH, New York, 2015.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. IV, Semester-VIII PARTICLE PHYSICS PH404	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Classify the principle and operation of various accelerators and detectors.
CO2	Explain the bound states of hydrogen atom structure and its association with particle physics.
CO3	Interpret the concepts of relativistic kinematics and Feynman calculations.
CO4	Examine the symmetries associated with conservation laws and properties of quarks.
CO5	Analyze the interactions of fundamental particles and decay using Feynman rules.

2.	**Syllabus**	
	PARTICLE ACCELERATORS AND DETECTORS	**(06 Hours)**
	Electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filled counters, scintillation detectors, semiconductor detectors.	
	REVIEW OF PARTICLE PHYSICS	**(08 Hours)**
	Historical Introduction, Classification of fundamental forces and Natural Units, Classification of particles: Photon, Antiparticles, Strange Particle, Neutrino, Eightfold way, Quark model, November Revolution and J/psi particle,Introduction to standand model, QED and QCD.	
	RELATIVISTIC KINEMATICS	**(04 Hours)**
	Lorentz transformations, Four Vectors, Energy and momentum, Collisions in lab and CM frame.	
	SYMMETRIES AND QUARKS	**(08 Hours)**
	Symmetries, Groups, Conservation laws, Spin and Angular Momentum, Addition of angular momentum, Flavour symmetries, Parity, Charge conjugation, CP Violation, Time reversal and the CPT Theorem. Mesons, Baryons hadrons masses and colour factor.	
	BOUND STATES	**(07 Hours)**
	The Schrodinger equation for the central potential, Hydrogen atom, Fine structure, Lamb shift, Hyperfine structure, Positronium, quarkonium, Light quark mesons, Baryon masses and magnetic moment.	
	SCATERRING AND DECAY	**(12 Hours)**
	Feynman Diagrams for the fundamental interactions, decays and conservation laws, Lifetime and decay rates, Muon decay, Mandelstam variables, Scattering of elementary particles: electron-electron scattering, electron-muon scattering, Bhabha scattering, Compton scattering.	

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	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**

(Total Contact Time: 45 Hours + 15 Hours= 60 Hours)

3.	**Tutorials will be based on**
1	cyclotron, synchrotron, linear accelerators.
2	counters, scintillation detectors, semiconductor detectors.
3	classification of particles and quark model.
4	Lorentz transformations and relativistic kinematics.
5	collisions in lab and CM frame.
6	conservation laws and angular momentum.
7	the fine and hyperfine structure.
8	the Feynman rules and Feynman diagrams.
9	decay rates and life time of the particle decay.
10	cross section and interaction of elementary particles.

4.	**Books Recommended**
1.	Viehhauser G. and Weidberg T., Detectors in Particle Physics: A Modern Introduction, CRC press, Florida, 2024.
2.	Butterworth J., A Map of the Invisible: Journeys into Particle Physics, Windmill Books, 2018.
3.	Mann R., An Introduction to Particle Physics and the Standard Model, CRC press, Boca Raton, 2010.
4.	Griffiths, D.J., Introduction to elementary particles, John Wiley & Sons, New Jersey, 2008.
5.	Perkins D.H., Introduction to High Energy Physics, Cambridge Univ. Press; 4th Ed., Cambridge, 2000.
Additional Reference Books	
1.	Halzen F. and Martin A.D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley & Sons, New Jersey, 2015.
2.	Coughlan G.D., Dodd J.E. and Gripaios B. M., The ideas of Particle Physics: An introduction for Scientists, Cambridge University Press, Cambridge, 2006.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

First Year of Five Years of Integrated M.Sc. (Physics) Int. M.Sc. – IV (Physics), Semester – VII SIMULATIONS AND MODELLING PH452	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the course students will be able to
CO1	study MATLAB/Octave software for basic programming
CO2	explain the concept of mathematical modelling & simulation
CO3	analyze the mathematical model for Physical Science systems
CO4	apply simulation in analysis of Physical Science systems
CO5	develop a computer code for the simulation of a system

2.	Syllabus	
	MATLAB/OCTAVE FOR THEORETICAL PHYSICS	**(12 Hours)**
	Introduction: interfaces, numerical and algebraic calculations, differentiation, integration, sums and products, solving equations, differential equations, power series, and limits, integral transforms, integrals numerical equation solving, numerical differential equations, optimization, Functions and programs, Graphics and sound, Input/output File operations	
	SIMULATION OF CLASSICAL MECHANICS SYSTEM	**(07 Hours)**
	Simulation of one-dimensional motion: Falling object, oscillatory motion (with and without damping), Model of an accelerating car, Simulation in two-dimensions: Projectile motion.	
	SIMULATIONS OF PLANETARY MOTIONS	**(07 Hours)**
	Planetary orbit using Euler Cromer methods, Kepler's law, simulation of earth orbit, three body problem	
	SIMULATION OF ELECTROMAGNETIC SYSTEMS	**(07 Hours)**
	Electric potentials and fields. Laplace & Poisson's equation, waves	
	SIMULATION OF CLASSICAL MOLECULAR DYNAMICS	**(07 Hours)**
	Intermolecular potential, the numerical algorithm, Verlet Algorithm, boundary condition, molecular dynamics program, microscopic quantities	
	SIMULATION OF QUANTUM SYSTEMS	**(05 Hours)**
	Time-independent Schrödinger equation in 1D and 2D, infinite square well, Time-dependent Schrödinger equation	
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Practicals will be based on**
1	Writing and testing MATLAB/Octave program for simulation of free falling object
2	Writing and testing MATLAB/Octave program for Simple Harmonic motion example using a variety of numerical approaches
3	Writing and testing MATLAB/Octave program for damped pendulum using the Euler-Cromer method
4	Writing and testing MATLAB/Octave program for simulation of Projectile motion
5	Writing and testing MATLAB/Octave program for simulations of planetary motions using Kepler's law
6	Writing and testing MATLAB/Octave program for simulations of the three body problem and the effect of Jupiter on Earth
7	Writing and testing MATLAB/Octave program for simulations of Electric potentials and fields
8	Writing and testing MATLAB/Octave program for simulations of Waves on a string
9	Writing and testing MATLAB/Octave program for simulations of Time-independent Schrödinger equation in one Dimension
10	Writing and testing MATLAB/Octave program for simulations of Time-independent Schrödinger equation in two Dimension

4.	**Books Recommended**
1	Giordano N. J., Computational Physics, 2nd edition, Pearson Education Inc, New Jersey, 2006
2	Pang T., An introduction to computational physics, Cambridge Uni. Press, Cambridge, 2012.
3	Gould H. and Tobochnik J., An Introduction to computer simulation methods, vols. 1-2, 3rd Edition, Addison Wesley, Massachusetts, 2006.
4	Steinhauser M. O., Computer Simulation in Physics and Engineering, De Gruyter, Berlin, 2012
5	Koonin S. E. and Meredith D., Computational Physics, Taylor & Francis Limited, London, 2019.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. – IV, Semester – VIII ADVANCED CRYSTALLOGRAPHY PH454	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the course students will be able to
CO1	analyze the nucleation process and choose proper growth rate condition for crystal growth.
CO2	classify the different experimental crystal growth methods.
CO3	examine defects in crystalline materials after growth.
CO4	explain in detail experimental method for crystal structure.
CO5	determine the crystal structure.
CO6	develop the application of crystals in protein crystallizations.

2.	Syllabus	
	NUCLEATION AND GROWTH RATE	**(05 Hours)**
	Nucleation, homogeneous nucleation and heterogeneous nucleation, driving force for crystallization, growth on rough faces, growth on perfect singular faces, growth on imperfect singular faces, transport at growth interface, transport in bulk solids, growth rate of a crystal.	
	CRYSTAL GROWTH METHODS	**(10 Hours)**
	Bridgman and related methods-basic processes, Czochralski and related methods: Kyropoulos growth, Dendrite method, Stepanov method, edge define film fed growth, high pressure methods, hydrothermal growth. Chemical vapour transport technique: introduction, some theoretical aspects- concepts of epitaxy, reaction, transport processes, stability condition, closed systems, open systems for bulk crystals, open systems for thin layers.	
	DEFECTS IN CRYSTALLINE MATERIALS	**(10 Hours)**
	Defects in crystalline materials – an introduction, concept of slip, dislocations and slip, cross slip, velocity of dislocations, climb, and experimental observations of climb. Stress field of a dislocation-edge and screw, strain energy of a dislocation, forces on dislocations, forces between dislocations, unit dislocation, partial dislocations- the Shockley partial, Frank partial or Sessile dislocation, Lomer-Cottrell sessile dislocation, Intersections of dislocations, movement of dislocation containing elementary jogs, composite jogs.	
	EXPERIMENTAL METHOD FOR CRYSTAL STRUCTURE	**(08 Hours)**
	Laue Photographs, Powder Photographs, Diffractometer and Spectrometer Measurements.	
	PROTEIN CRYSTALS	**(06 Hours)**

	Protein sources, Protein Purification, Principles of Protein Crystallization, Protein crystallization Techniques, Phase Calculations using isomorphism and anomalous dispersion methods, multiple wave length methods, Ramchandran plot, Protein folding, Application of Synchrotron radiation.	
	APPLICATIONS	**(06 Hours)**
	Orientation and Quality of Single Crystals, Structure of Polycrystalline Aggregates, Determination of Crystal Structure.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials will be based on**
1.	nucleation.
2.	crystal growth rate.
3.	various crystal growth methods.
4.	crystal defects.
5.	various dislocations in crystal.
6.	different X-ray diffraction methods.
7.	protein crystals.
8.	single crystals.
9.	polycrystalline solids.
10.	determination of crystal structure.

4.	**Books Recommended**
1	P. Santaraghvan and P. Ramasamy, Crystal growth, Kru Publishers, Kumbakonam, 2000.
2	D. Hull and D. J. Bacon, Introduction to dislocation, Butterworth-Heinemann, 2011.
3	B. D. Cullity and S. R. Stock, Elements of X-ray diffraction, Prentice Hall, New Jersey, 2001.
4	A. Pimpinelli and J. Villain, Physics of Crystal Growth, Cambridge Univ. Press, Cambridge, 2010.
5.	D. Sherwood and J. Cooper, Crystals, X-rays and Proteins: Comprehensive Protein Crystallography, Oxford University Press, Oxford, 2015.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester - VIII ELECTROMAGNETIC COMMUNICATIONS PH456	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the course students will be able to
CO1	Understand the characteristics of transmission lines and cables.
CO2	Classify the electromagnetic waves in bounded and unbounded mediums, especially focused on microwave and wave guides.
CO3	Extensive summary of propagation properties of radio waves.
CO4	Discuss the fundamental concepts of antenna and its applications.
CO5	Examine the key factors associated with the satellite communications.

2.	Syllabus	
	TRANSMISSION LINES AND CABLES	(10 Hours)
	Primary Line Constants, Phase Velocity and Line Wavelength, Characteristic Impedance, Propagation Coefficient, Phase and Group Velocities, Standing Waves, Lossless Lines at Radio Frequencies, Voltage Standing-wave Ratio, Slotted-line Measurements at Radio Frequencies, Transmission Lines as Circuit Elements, Smith Chart, Time-domain Reflectometry, Telephone Lines and Cables, Radio-frequency Lines, Microstrip Transmission Lines, Use of Mathcad in Transmission Line Calculations.	
	INTRODUCTION TO MICROWAVE THEORY AND WAVE GUIDES	(10 Hours)
	Electromagnetic wave equation, Microwave, microwave frequency bands, Categories of microwave systems, Applications, Introduction to Wave guides, Rectangular Wave guides, Other Modes.	
	RADIO-WAVE PROPAGATION	(08 Hours)
	Propagation in Free Space, Troposphere Propagation, Ionosphere Propagation, Surface Wave, Low Frequency Propagation and Very Low Frequency Propagation, Extremely Low-frequency Propagation, Summary of Radio-wave Propagation.	
	ANTENNAS	(10 Hours)
	Antenna Equivalent Circuits, Coordinate System, Radiation Fields, Polarization, Isotropic Radiator, Power Gain of an Antenna, Effective Area of an Antenna, Effective Length of an Antenna, Hertzian Dipole, Half-wave Dipole, Vertical Antennas, Folded Elements, Loop and Ferrite-rod Receiving Antennas, Nonresonant Antennas, Driven Arrays, Parasitic Arrays, VHF-UHF Antennas, Microwave Antennas.	

	SATELLITE COMMUNICATIONS	**(07 Hours)**
	Telephone Systems, Wire Telephony, Public Telephone Network, Problems Facsimile And Television, Facsimile Transmission, Television, Television Signal, Problems, Introduction, Kepler's First Law, Kepler's Second Law, Kepler's Third Law, Orbits, Geostationary Orbit, Power Systems, Attitude Control, Satellite Station Keeping, Antenna Look Angles, Limits of Visibility, Frequency Plans and Polarization, Transponders, Uplink Power Budget Calculations, Down link, Power Budget Calculations, Overall Link Budget Calculations, Digital Carrier.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials will be based on**
1.	Primary line constants, propagation coefficient, phase and group velocities etc.
2.	Smith chart.
3.	Electromagnetic waves and microwaves.
4.	Rectangular wave guides and other various aspects involved in wave guides.
5.	Radio wave propagation in free space, troposphere and ionosphere.
6.	Surface wave.
7.	Design of antenna.
8.	Radiation fields from various kind of antenna.
9.	Non-resonant antennas, receiving antennas.
10.	Satellite communications.

4.	**Books Recommended**
1.	D. Roddy, and J. Coolen, Electronic Communications, Prentice-hall of India Pvt Ltd., New Delhi, India, 2008.
2.	R. Blake, Electronic Communication Systems, Delmar Thomson Learning, New York, 2008.
3.	K. George, and D. Bernard, Electronic Communication Systems, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
4.	H. Simon, Communication Systems, John Wiley & Sons, New York, 2007.
5.	H. Taub and D. L. Schilling, Principles of Communication Systems, McGraw Hill Education, New Delhi, 2017.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester – VIII GLOBAL NAVIGATION SATELLITE SYSTEM PH458	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the course students will be able to
CO1	Explain the fundamentals of navigation systems
CO2	Identify the segments of GNSS
CO3	Analyze the characteristics of satellite signals
CO4	Relate the components of receiving systems
CO5	Apply the GNSS in surveying, location-based services and aircraft landing

2.	Syllabus	
	INTRODUCTION AND OVERVIEW	**(04 Hours)**
	FUNDAMENTALS OF NAVIGATION SYSTEM	**(08 Hours)**
	Concept of Ranging using Time of Arrival, Reference coordinate system, fundamentals of satellite orbits, positioning.	
	DIFFERENT SATELLITE NAVIGATIONAL SYSTEMS	**(08 Hours)**
	GPS, Galileo, IRNSS, Beidou etc.	
	GNSS SEGMENTS	**(10 Hours)**
	Control Segment, Space segment, User segment.	
	SATELLITE SIGNAL CHARACTERISTICS	**(07 Hours)**
	Frequency and modulation, tracking loops, filters, formation of pseudorange, signal acquisition, Processing.	
	RECEIVING SYSTEMS	**(04 Hours)**
	Single frequency receivers, Dual frequency receivers, position accuracy, dilution of precision, Ne frequencies added.	
	APPLICATIONS OF GNSS	**(04 Hours)**
	Surveying, location-based services, aircraft landing, others.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

Subject Code:##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4)EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Tutorials will be based on**
1.	basics of navigation system.
2.	various satellite navigation systems.
3.	control segment, space segment and user segment.
4.	frequency and modulation and tracking loops.
5.	filters and signal acquisition.
6.	various receiving systems.
7.	surveying and location-based services.
8.	aircraft landing and other applications.

4.	**Books Recommended**
1.	E. D. Kaplan and C. Hegarty (Editors), Understanding GPS: Principles and applications, Artech House, New York, 2005.
2.	R. Ahmed, Introduction to GPS: The Global Positioning System, Artech House, New York, 2006.
3.	G. Xu and X. Yu, GPS: Theory, Algorithms and Applications Springer, New York, 2016.
4.	B. W. Parkiwson and J. J. Jr. Spilker (Ed.); James J. Spilker (contributor), Global positioning system: Theory and applications (American Inst. of Aeronautics & Astronaulid), Reston, 1996.
5.	J. B-Y. Tsui, Fundamentals of Global Positioning system Receivers, Wiley, New Jersey, 2005.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. IV, Semester-VIII QUANTUM FIELD THEORY PH460	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Define the field, charge conjugation, parity, time reversal, S matrix, etc.
CO2	Show that every continuous symmetry of the physical system corresponds to a conserved charge.
CO3	Derive the Euler-Lagrange equation for fields using the action principle.
CO4	Explain the quantization of scalar, Dirac, and gauge field.
CO5	Apply the Feynman rules to understand the structure of hadrons.

2.	Syllabus	
	ELEMENTS OF CLASSICAL FIELD THEORIES	**(10 Hours)**
	Space and time in relativistic quantum theory, Natural units, A quick review of particle mechanics and Poisson bracket, Action principle, Lagrangian formulation, Hamiltonian formulation, Euler-Lagrange equation for fields, Noether's theorem, Conserved current and conserved charges.	
	QUANTIZATION OF FIELDS	**(12 Hours)**
	Scalar field: Equation of motion, Canonical quantization, Fourier decomposition of scalar field, Normal ordering of Hamiltonian, Fock space, Complex scalar field, Symmetries and conserved charges, Propagator for scalar field. Dirac field: Dirac equation, Plane wave solution of Dirac equation, Properties of gamma matrices, Projection operators, Fourier decomposition and propagator for Dirac field.	
	QUANTUM ELECTRODYNAMICS AND FEYNMAN RULES	**(12 Hours)**
	Interacting field, S matrix, Wick's theorem, Feynman diagram and rules, Virtual particles, Quantization of the electromagnetic field, Problems with quantization, Modification of classical Lagrangian, Fourier decomposition and propagator for electromagnetic field, Physical states, Elementary Ideas on Radiative Corrections and Renormalization.	
	QUANTUM CHROMODYNAMICS AND HARDON STRUCTURE	**(11 Hours)**
	Strong coupling constant, Electron proton elastic scattering, Form factors, Briet Frame, Inelastic electron-proton scattering, Structure functions, Bjorken scaling and parton model, Parton distribution function, Callan-Gross relation, Sea quarks, Gluon emission, Scaling violation: DGLAP equation	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**

(Total Contact Time: 45 Hours + 15 Hours= 60 Hours)

Subject Code:##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4)EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Tutorials will be based on the**
1	Lagrangian and Hamiltonian formulation of fields.
2	Noether's theorem and conserved charges.
3	Local, global, and internal symmetry of fields.
4	Quantization of fields.
5	Dirac gamma matrices.
6	Charge conjugation, parity and time reversal.
7	Wick's theorem and S matrix
8	Feynman rules and Feynman diagram.
9	Radiative correction and renormalization.
10	Form factors and structure function.

4.	**Books Recommended**
1.	Semenoff G. W., Quantum Field Theory: An Introduction, Springer Nature, Singapore, 2023.
2.	Zee A., Quantum Field Theory as Simply as Possible, Princeton University Press, New Jersey 2023.
3.	Klauber R.D., Student Friendly Quantum Field Theory, Sandtrove Press, Iowa, 2022.
4.	Das A., Lectures on Quantum Field Theory, World Scientific Publishing Co Pte Ltd, Singapore, 2008.
5.	Lahiri A., Pal P.B., A first book of quantum field theory, Alpha Science International Ltd., Oxford, 2005.
Additional Reference Books	
1.	Weinberg S., The Quantum Theory of Fields, Cambridge University Press, Cambridge, 2005.
2.	Peskin M.E., Schroeder D. V., An introduction to quantum field theory, CRC press, Florida, 1995.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth year of Five Years Integrated M.Sc. (Physics) M.Sc. – IV, Semester – VIII THIN FILMS AND CACUUM TECHNOLOGY PH 462	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes (COs):** **At the end of the semester, students will be able to**
CO1	Apply important laws of physics which govern how a vacuum system works
CO2	Account for components used in a vacuum system, their construction, function and use.
CO3	Explain the general principles and techniques of thin film deposition.
CO4	Evaluate and use models for nucleating and growth of thin films.
CO5	Discuss typical thin film applications.

2.	**Syllabus:**	
	INTRODUCTION TO VACUUM TECHNOLOGY	**(08 Hours)**
	Introduction to Vacuum, Brief History of Vacuum technology, Units of Vacuum, Vacuum and Kinetic theory of Gasses, Pressure and Molecular Velocity, The Molecular Density, Collision Frequency, Monolayer Formation Times, The Mean Free Path, Gas Flow Regimes: viscous, turbulent and molecular flow, pumping speed, throughput, The Idea of Conductance, characteristics of vacuum, Reynold Number and Knudsen Number, classification of vacuum ranges, applications of vacuum and vacuum system.	
	PRODUCTION OF VACUUM	**(08 Hours)**
	Classification of vacuum pumps, Rotary pumps, Roots pumps, Diffusion pumps. Molecular drag and Turbo molecular pumps, Sorption pumps, Cryogenic pump, Measurement of pumping speed, Constant pressure methods.	
	CLASSIFICATION OF VACUUM GAUGES	**(08 Hours)**
	Mechanical gauges, Bourdon gauge, McLeod gauge, Pirani Gauge, Penney Gauge, thermocouple gauge, Bayard-Alpert gauge, modified Ionization gauges, Magnetron gauge.	
	COMPONENTS OF VACUUM	**(04 Hours)**
	Chambers, Connecting Tubes and Flange Sizes, Valves, Choice of Materials, System Volumes, Leak Rates.	
	GROWTH OF THIN FILMS	**(04 Hours)**
	Collisions with Surfaces, Kinetics of Crystal Growth, Diffusion, Nucleation Barriers in Classical and Atomistic Models, Growth Modes: Island Growth, Clustering, Coalescence and Ripening.	
	THIN FILM DEPOSITION TECHNIQUES	**(08 Hours)**
	Physical vapor deposition, thermal deposition, Electron beam deposition, Sputtering methods: Glow discharge, DC and RF Sputtering, Reactive Sputtering, Magnetron Sputtering, Ion plating,	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	Ion beam deposition Chemical methods: Electroplating, Thermal spray and detonation technology, plasma chemical vapor deposition (PCVD), Metal organic Chemical vapor deposition (MOCVD), Laser ablation. Epitaxial deposition, Molecular beam epitaxy, Spin-coating.	
	THIN FILM CHARACTERIZATION AND APPLICATIONS	**(05 Hours)**
	Characterization of thin films: thickness (Interferometer, Ellipsometry), Phase, composition, stress state, morphology (AFM, SEM, TEM, STM), adhesion, degree of crystallinity, Physical properties: optical, electrical, magnetic, and mechanical Properties, Applications of thin films.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials will be based on**
1.	Kinetic theory of gases
2.	Vacuum parameters
3.	Vacuum ranges, Knudsen number and Reynold number
4.	Working principle of pumps
5.	Measurement of Vacuum in chamber
6.	Vacuum in Connecting pipes
7.	Pumping speed
8.	Throughput
9.	Leak rates
10.	Coalescence and Ripening

4.	**Books Recommended**
1.	Smith D. L., Thin-Film deposition: Principle and practice, McGraw Hill, London, 1995.
2.	Milton O., Materials Science of Thin Films, 2nd Edition, Academic Press, New York, 2001.
3.	Goswami A., Thin film fundamentals, New Age International, New Delhi, 2007.
4.	Chopra K. L., Thin Film Phenomena, McGraw Hill, London, 2000.
5.	Weissler G. L., Vacuum physics and technology, Academic Press, New York, 1979.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) Int. M.Sc. – IV. Semester - VIII NUCLEAR SCIENCE AND TECHNOLOGY PH464	Scheme	L	T	P	Credit
		3	0	2	4

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	examine the principles of nuclear fission, energy release,and fission chain reactions demonstrating an understanding of their applications in reactor physics.
CO2	explain the production, classification, and interactions of neutrons with matter
CO3	make use of diffusion and detection principles, and analyze neutron reactions, scattering, and their effects on materials
CO4	compare various reactor types, their classifications, features, and historical development
CO5	assess the dose limits and radiation safety, and understand the medical, industrial, agricultural, and other practical applications of radiation.

2.	**Syllabus**	
	NUCLEAR RADIATION PROTECTION AND APPLICATIONS	**(8 Hours)**
	Exposure and Absorbed Dose, Determination of Exposure, Dose Limits, Shielding, radiation safety. Medical, Industrial and Agricultural Applications and other uses.	
	NUCLEAR FISSION ENERGY	**(07 Hours)**
	Introduction, Asymmetric fission -Mass yield, Emission of delayed neutrons, Nuclear energy release in fission, Nature of fission fragments, Energy released in the fission of U235, Fission of lighter nuclei, Fission chain reaction.	
	NEUTRON PHYSICS	**(15 Hours)**
	Production and Classification of Neutrons, interaction of neutrons with matter in bulk, diffusion of thermal neutrons, neutron detection. The elastic collision, Average logarithmic energy decrement, Slowing down density, Diffusion of neutrons, The basic diffusion equation, Diffusion of thermal neutrons, Diffusion length, Neutrons reactions, absorption, Radiative capture reactions, inelastic scattering, elastic scattering, The Maxwell- Boltzmann distribution, Departure from Maxwellian distribution, structural changes caused by neutron interactions.	
	NUCLEAR REACTORS AND ENERGY PRODUCTION	**(15 Hours)**
	Reactors Classification, general features, history of reactor development and efficiency. Nuclear materials employed in reactors, Chain reaction, Multiplication factor, Leakage of neutrons, Critical size calculation, Homogenous and heterogeneous reactor, Boiling water reactors (BWR), Pressurized water reactors (PWR), Pressurized heavy water reactors (PHWR), Light water cooled graphite	

	moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Fusion reactors.	
	Practicals will be based on the coverage of the above topics	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals will be based on**
1.	determining the activity of an unknown gamma source using a NaI(Tl) scintillation detector
2.	determining the range and energy of an unknown beta source and to calculate the absorption coefficient using GM counter
3.	verification of Inverse square law variation of radiation
4.	characterization of CeBr3 detector: Calibration, resolution and efficiency measurements
5.	characterization of HPGe detector: Calibration, resolution and efficiency measurements
6.	alpha spectroscopy with mixed and single alpha sources
7.	characterization of shielding materials [Cu, Al, Pb , polyethylene , steel] and their efficacy for gamma sources
8.	Rutherford scattering measurement

4.	**Books Recommended**
1.	K. S. Krane, Introductory Nuclear Physics, Wiley, New Delhi, 2008.
2.	G. F. Knoll, Radiation detection and measurements, Wiley, 3rd Ed., New York, 2000.
3.	L.F. Curtiss, Introduction to Neutron Physics, D. Van Nostrand, Princeton, 1959.
4.	J. R. Lamarsh and A. J. Baratta, Introduction to Nuclear Engineering, 3d Ed., Prentice-Hall, New Jersey, 2001.
5.	S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, Vol. I & II, CBS Publishers, 4th Ed., New Delhi, 2004.
Additional Reference Books	
1.	S.B. Patel, Nuclear Physics, New Age International(P) Ltd., New Delhi, 2012.
2.	D. C. Tayal, Nuclear Physics, Himalaya Publishing, Mumbai, 2013.
3.	W. R. Leo, Techniques for nuclear and particle physics experiments, Springer, Berlin, 1987.
4.	J.R. Lamarsh, Introduction to nuclear reactor theory, American Nuclear Society, Illinois, 2002.
5.	IAEA Safety Standards and Reports, Vienna, Austria, 2025.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester – VIII NON-DESTRUCTIVE TESTING PH466	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**1**	**0**	**4**

1.	**Course Outcomes (COs): At the end of the course students will be able to**
CO1	Classify stress strain relationships and the application of these to mechanical behaviour of a broad range of materials.
CO2	Evaluate mechanical behaviour, measurements of mechanical properties and test methods.
CO3	Calculate and interpret mechanical properties using Griffith equation.
CO4	Explain importance of non-destructive testing in quality assurance.
CO5	Make use of the dye penetrant test and magnetic particle test to detect surface defects.

2.	**Syllabus**	
	INTRODUCTION TO NON-DESTRUCTIVE TESTING	**(03 Hours)**
	MECHANICAL BEHAVIOR OF MATERIALS	**(10 Hours)**
	Engineering Stress, Engineering Strain, True Stress, True Strain, Shear Stress, Shear Strain, Tensile Test (Tension Test), Elastic and Plastic deformation, Ductility, Toughness, Resilience, Hardness, Hardness testing method, Fatigue, Creep. Dislocations & Plastic deformation and Mechanisms of Plastic deformation in metals (Slip System and Twinning), Critical Resolved Shear Stress (Schmid's law), Strengthening Mechanisms in Metals, Recovery, Recrystallization and Grain growth.	
	FRACTURE MECANICS AND MODES OF FAILURES	**(08 Hours)**
	Types of fractures – Ductile and brittle fractures, Types of Fracture in materials Intergranular Fracture and Transgranular (Intragranular) Fracture**,** Features of fracture surface for Ductile and Brittle fractography. Stresses around cracks - linear elastic fracture mechanics, Griffith's criterion for brittle crack propagation, Fracture Toughness, Impact testing, Ductile to Brittle transition temperature.	
	VISUAL TESTING	**(04 Hours)**
	Fundamentals of Visual Testing, Basic principle, The Eye (defect which can be detected by Unaided visual inspection), Optical aids used for visual inspection, Microscope, Borescope, Endscope, Fibroscope, Holography, Application and Limitation of Visual Testing, Standards and Specifications (ASME, ASTM, AWS, BIS etc.).	
	LIQUID PENETRANT TESTING	**(04 Hours)**
	Introduction to Penetrant testing, Penetrants and their application, penetrant removal, Drying, developing, inspection, equipment's and control checks, Limitations	
	MAGNETIC PARTICLE TESTING	**(08 Hours)**
	Theory of magnetism - ferromagnetic, Paramagnetic materials - magnetization by means of direct and alternating current - surface strength characteristics - Depth of penetration factors, Direct pulsating current typical fields, advantages - Circular magnetization techniques, field around a	

	strength conductors, right hand rule field - Prods technique, current calculation – Longitudinal magnetization.	
	ULTRA SONIC TESTING	**(08 Hours)**
	Nature of sound waves, wave propagation - modes of sound wave generation Various methods of ultrasonic wave generation - Principle of pulse echo method, through transmission method, Resonance Method - Advantages, limitations - contact testing, Immersion Testing.	
	Tutorials will be based on the coverage of the above topics	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials will be based on**
1.	mechanical behaviour of materials (e.g., stress, strain, etc).
2.	fracture mechanics.
3.	various modes of failure.
4.	visual testing.
5.	various magnetic materials.
6.	magnetization techniques.
7.	wave propagation.
8.	principle of pulse echo method.

4.	**Books Recommended**
1.	V. Raghavan, Materials Science and Engineering: A First Course, PHI; 5th edition, New Delhi, 2011.
2.	W. F. Smith, J. Hashemi, R. Prakash, Material Science and Engineering (In Si Units), McGraw Hill, 5th edition, New York, 2017.
3.	G. E. Dieter, Mechanical Metallurgy, 3th edition, McGraw Hill Education 2017.
4.	J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, New Jersey, 1986.
5.	P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, Taylor & Francis, Boca Raton, 2002.
Additional Reference Books	
1.	C. Hellier, Handbook of Nondestructive Evaluation, 3rd Ed., McGraw-Hill, New York, 2020.
2.	D. E. Bray, and R. K. Stanley, Nondestructive Evaluation: A Tool for Design Manufacturing and Service, CRC Press, Boca Raton, 1997.
3.	Nondestructive Evaluation of Materials, Volume 17, ASM Int., Ohio, 2018.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Fourth Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - IV, Semester – VIII MICROWAVE PLASMA TECHNOLOGY PH468	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	Explain the operation of microwave plasma sources.
CO2	Construct the diagnostic system to obtain plasma parameters.
CO3	Analyze the microwave propagation modes in confined space.
CO4	Evaluate waveguide and antenna system for microwave propagation.
CO5	Design a microwave plasma experimental set-up.

2.	Syllabus	
	ELEMENTS OF MICROWAVE PROPAGATION	**(08 Hours)**
	Maxwell's equations, Boundary conditions, Propagation of microwaves across a boundary, Skin depth, Waveguide – TE and TM modes of propagation, Coaxial transmission line, TEM mode of propagation, Electric dipole radiation, Magnetic dipole radiation, Near and far fields, Radiation pattern, Half-wave dipole antenna, Antenna parameters.	
	MICROWAVE SOURCE AND COMPONENTS	**(08 Hours)**
	Microwave frequency and spectra, Advantages and applications of microwaves, Microwave sources (Klystron, Magnetron, Gunn diode), Some waveguide components (isolator, directional coupler, tuner), S-parameter.	
	PHYSICS OF MICROWAVE PLASMA	**(12 Hours)**
	Plasma definition – quasineutrality and collective behaviour, Plasma parameters – Electron energy distribution function (EEDF), plasma oscillation frequency and Debye length, Criterion for existence of plasma, Important collision processes in plasma; Diffusion in plasma, Methods of plasma generation, Classification of plasmas, Physics of microwave plasma generation, Energy gain and power transfer.	
	REALIZATION OF MICROWAVE PLASMA AND ITS APPLICATIONS	**(10 Hours)**
	Components of microwave plasma source, Electron cyclotron resonance assisted plasma, Electromagnetic wave propagation in plasma, Surface wave discharges, Emerging applications in energy, environment and communications (CO_2 conversion, Plasma thrusters, Plasma antenna).	
	MICROWAVE PLASMA DIAGNOSTICS	**(07 Hours)**
	Langmuir probe and its I-V characteristics, Optical emission spectroscopy.	
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

Subject Code:##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4)EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

3.	**Practicals will be based on**
1.	Measurement of frequency, guide wavelength and VSWR in a rectangular waveguide.
2.	Measurement of radiation pattern of an antenna.
3.	Gunn diode characteristics
4.	Reflex klystron characteristics.
5.	S-parameter of a Directional coupler.
6.	S-parameter of a H-plane tee.
7.	Optical Emission Spectroscopy of plasma.
8.	I-V characteristics of Langmuir Probe.
9.	Radiation pattern of a plasma antenna.

4.	**Books Recommended**
1.	D. J. Griffiths, Introduction to Electrodynamics, 4th Ed., Prentice-Hall India Pvt. Ltd., New Delhi, 2015.
2.	D. M. Pozar, Microwave Engineering, 4th Edition, John Wiley & Sons, Inc., New York, 2012.
3.	D. Roddy and J. Coolen, Electronic Communications, 4th Edition, Pearson, New Delhi, 2014.
4.	M. Moisan and J. Pelletier, Microwave excited plasma: Volume 4 (Plasma Technology), Elsevier Science, Amsterdam, 1992.
5.	M. A. Liebermann and A. J. Lichtenberg, Principles of Plasma Discharges and Material Processing, 2nd Edition, Wiley & Sons, Inc. New Jersey, 2005.