Sardar Patel University
Programme- MSc
(Under Choice Based Credit System)
M.Sc. (Physics) Semester –III
Syllabus with effect from June-2022-23

Course Type	**Course code**	Name of the Course	T/P	Credit	Exam duration in hrs	Components of Marks		
						Internal	External	Total
						Total/passing	Total/passing	100/passing
Core Courses	PS03CPHY51	Advanced quantum mechanics	T	04	3hrs	30/10	70/28	100/40
	PS03CPHY52	Physics of Nano materials	T	04	3hrs	30/10	70/28	100/40
Elective courses	PS03EPHY51	Crystallography and Materials science (CMP)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY52	Magnetic and Optical Properties of condensed matter (CMP)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY53	Microwave communication: Electronics and Technology (EC)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY54	Microprocessors: Programming, Interfacing and Applications (EC)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY55	Computer Programming in Fortran 90 and Numerical methods (CP)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY56	Computational Physics –I (CP)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY57	Solar energy & Geothermal energy (EST)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY58	Wind energy and Ocean energy (EST)	T	04	3hrs	30/10	70/28	100/40
	PS03EPHY59	CMP Practicals -I	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY60	CMP Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY61	EC Practicals -I	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY62	EC Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY63	CP Practicals -I	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY64	CP Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY65	EST Practicals –I	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY66	EST Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS03EPHY67	CMP Comprehensive Viva	T	01	Acc. req	-	50/20	50/20
	PS03EPHY68	EC Comprehensive Viva	T	01	Acc. req	-	50/20	50/20
	PS03EPHY69	CP Comprehensive Viva	T	01	Acc. req	-	50/20	50/20
	PS03EPHY70	EST Comprehensive Viva	T	01	Acc. req	-	50/20	50/20

CMP: Condensed Matter Physics **EC : Electronics and Communication**
CP : Computational Physics **EST: Earth Science and Technology**

Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03CPHY51**	Title of the Course	**Advanced Quantum Mechanics**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	The basic objective of this advanced course on quantum mechanics is to train the students how to study non- exactly solvable quantum systems. To provide the basic foundational training to deal time independent and time dependent quantum phenomenon. To provide sufficient training on theoretical methods to compute various scattering cross sections (both elastic and inelastic) and interpretations of the scattering data. To make the students aware about the various approximation methods its limitations and applications to study different quantum mechanical problems. To provide exposure and basic training to deal relativistic quantum systems, their mathematical details and interpretations of the solutions.

Course Content		
Unit	Description	Weightage* (%)
1.	*Time Independent Perturbation theory:* Perturbation theory for discrete levels, Equation in various orders of perturbation theory, The non-degenerate case for first and second order corrections, The degenerate case-removal of degeneracy. Stark effect. *The variation method:* Upper bound on ground state energy. Application to excited states, The ground state of a two-electron atom. The Hydrogen molecule-exchange interaction. *The WKB approximation:* The one-dimensional Schrödinger equation, the asymptotic solution, Solution near turning point, matching at turning points and connection formulae, The Bohr-Sommerfeld quantum condition. WKB solution of the radial wave equation.	25%
2.	Scattering theory–Kinematics of the scattering process, Differential and total cross sections. Wave mechanical picture of scattering, Scattering amplitude and its formal expression by Green's function. The Born approximation and its validity through examples, Partial wave analysis, Asymptotic behavior of partial waves, phase shifts and scattering amplitudes. Optical theorem.	25%

	Phase shifts- relation with the potential. Potential of finite range. The Eikonal approximation. Applications to selected problems.	
3.	*Evolution with time:* The Schrödinger equation and general solution, Propagators, Sudden approximation. *Perturbative theory for time evolution problems:* Perturbative solution for transition amplitude, Constant perturbation and Fermi's golden rule, Scattering of a particle by a potential-elastic scattering, Harmonic perturbations, Interaction of an atom with electromagnetic radiation, The dipole approximation, Einstein coefficients-spontaneous emission. *Alternative pictures of time evolution:* The Schrödinger picture, Heisenberg picture, interaction picture.	25%
4.	Relativistic wave equations, generalization of the Schrödinger equation, the Klein-Gordon equation and its plane wave solutions. Dirac's relativistic Hamiltonian and the Dirac equation, position probability density and expectation values, Dirac matrices, plane wave solution of the Dirac equation, the spin of the Dirac particles, significance of the negative energy states, Relativistic electron in a central potential, electron in magnetic field and spin magnetic moment.	25%

Teaching-Learning Methodology	Off line / Online mode of direct teaching learning, class discussions, Tutorials, class assignments.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to acquire

- Training to compute various properties of quantum systems/particle under different external fields.
- The knowledge of approximation methods to solve quantum mechanical system under the influence of different applied fields.

- The knowledge to interpret the results of important experiments like Stark effect, Zeeman effect, Quantum Hall effect, diamagnetism and paramagnetism etc.
- Understanding of the quantum mechanical phenomenon and will be able to apply the advanced quantum mechanical tools for the interpretation and analysis of various physical phenomenon.
- Confidentiality in handling to take up any study that employs the quantum mechanical techniques to compute time independent and time dependent quantum mechanical events and phenomenon quantitatively.
- The knowledge to understand important electron photon interactions like light absorption and emission in materials, to understand lattice vibration and the related scattering of electrons
- Quantum mechanical approaches to study and understand relativistic systems.
- The correct interpretations of negative energy solutions as antiparticles.

The understanding of the abstract concept of spin naturally.

Suggested References:

Sr. No.	References
1	A text book of Quantum Mechanics, by Mathews &Venkatesan, TMH Publication (2010).
2	Quantum Mechanics by V. K. Thankappan, Wiley Eastern Ltd. New Delhi 1983, second Ed. New Age Int. Publishers1993, 4th Ed. New Academic Science, 2014
3	Quantum Mechanics by Ghatak & Loknathan; McMillan India Publication
4	Quantum Mechanics by G. Aruldhas, Prentice-Hall India, Pvt., Ltd. 2016

On-line resources to be used if available as reference material

On-line Resources

MIT Open Course Ware https://ocw.mit.edu
www.mooclab.club
www.edx.org www.
my-
mooc.com www.pdf
drive.com

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03CPHY52**	Title of the Course	**Physics of Nanomaterials**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	
	➢ This course will provide conceptual knowledge of nanoscience and nanotechnology, including preparation of nanomaterials, their characterization and applications. ➢ As per the present scenario, this subject holds enough commercial promise to be regarded as the next technological revolution. It will help the students to understand how to manipulate matter at molecular/atomic scale, customizing it according to our specific needs.

Course Content		
Unit	Description	Weightage* (%)
1.	*Properties of individual nanoparticles* : introduction, metal nanoclusters: magic numbers, theoretical modelling of nanoparticles, geometric structure, electronic structure, reactivity, magnetic clusters, bulk to nanotransition. Semiconducting nanoparticles: optical properties, photofragmentation, coulombic explosion, Rare gases and molecular clusters: inert gas clusters, superfluid clusters, molecular clusters. Carbon clusters and carbon nanotubes : fabrication, structure, electrical, vibrational and mechanical properties.	25%
2.	*Lithography and synthesis of nanomaterials*: Preparation of quantum nanostructures by lithography: photo, X-ray, fast ion beam (FIB), neutral beam, and electron-beam, dip pen lithography. *Size and dimensionality effects*: size effects, conduction electrons and dimensionality, Fermi gas and density of states, potential wells, partial confinement, properties dependent on density of states. *Method of synthesis*: RF plasma, chemical method, thermolysis, pulsed laser method, Arc discharge method, laser ablation, aerosol synthesis, inert gas condensation, high energy ball milling, chemical vapour deposition, Reverse micellar/microemulsion method, sol-gel method.	25%
3.	*Characterization techniques of Nanostructures*: Transmission electron microscopy (TEM), High Resolution TEM (HRTEM), Particle Size Analyzer(DLS) , Spectroscopy of semiconductors: Excitons, Infrared surface spectroscopy, Raman Spectroscopy, Brillouin spectroscopy	25%

	and Luminescence, Scanning tunneling microscopy (STM), Atomic-force microscopy (AFM), Scanning near field optical microscopy (SNOM).	
4.	*Applications of nanostructures*: Single electron tunnelling, IR detectors, quantum dot lasers, biotechnology and medical field, targeted drug delivery, space and defence. *Applications of carbon nanotubes*: field emission and shielding, computers, fuel cells, chemical sensors, catalysis, mechanical reinforcement. *General applications*: high energy density batteries, next generation computer technology, Electronics, phosphors for high definition TV, low cost flat panel displays, water purification, communication sector, food, fabric industry, environment, automobiles, tougher and harder cutting tools. Microelectromechanical systems (MEMS), Nanoelectromechanical systems (NEMS), Nanodevices and Nanomachines.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching, Tutorials, class assignments as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	They will learn about the nanoparticles ,nanoclusters and their properties.
2.	They will have an idea about how lithography technique can be used in the fabrication of different electronic devices and synthesis of nanomaterials by different ways at the laboratory scale.
3.	Possessing the knowledge of characterising the materials with modern equipments i.e. AFM,STM,SNOM, TEM, DLS, RAMAN, PL etc. will help the students to explore them for the future technological developments.

4.	This was also provide them an idea about how nanomaterials can be used for different applications in the field of electronics, environment, defence, medical area, automobiles, food and fabric industry etc.

Suggested References:	
Sr. No.	References
1.	Introduction to Nanotechnology, Charles P. Poole, and Frank J. Owens, Wiley India Pvt. Ltd, 2009.
2.	Nanotechnology: Principles and practices: S. K. Kulkarni, Capital publishing company, 2009.
3.	Nano: The Essentials –Understanding Nanoscience and Nanotechnology, T. Pradeep, Tata McGraw- Hill Publishing Company Ltd., 2007.
4.	Principles of Nanoscience and Nanotechnology, M.A. Shah, Tokeer Ahmad, Narosa Publishing House, 2010.
5.	Nanomaterials: An introduction to synthesis, properties and applications, Dieter Vollath, Wiley-VCH Verlag GmbH, 2008.
6.	Principles of Instrumental Analysis, 6^{th} edition, D.A. Skoog, E.J. Holler, S.R. Crouch, Thomson Brooks/Cole, 2007.

On-line resources to be used if available as reference material
On-line Resources

- A NPTEL course on Nanotechnology - Nanostructures https://nptel.ac.in/courses/118/104/118104008/
- A video lecture on the Characterization techniques of Nanostructures https://www.youtube.com/watch?v=iiT_KJJ1Uhs
- A video lecture on the Method of synthesis nanoparticles https://www.youtube.com/watch?v=x-zC6VqPz3M
- A NPTEL course on Nanotechnology, Science and Applications https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-mm21/
- A video on Nanoparticle characterisation https://www.youtube.com/watch?v=iiT_KJJ1Uhs
- A video on Nanoparticle characterisation :

https://www.youtube.com/watch?v=1Ro1nV7vn5E

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY51**	Title of the Course	**Crystallography and Materials science (CMP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ Introduction to essential concepts of different X-ray crystallography techniques to record and solve the structure of crystals. ➢ To provide a detailed account of the scattering of X-rays by a crystal and the various factors that affects the intensities of diffracted X-rays. ➢ Learn important concepts and principles related to the optical properties of semiconductors and magnetic properties of superconducting materials. ➢ Familiarization with the functional materials, its properties and the associated physical phenomena from the experimental as well as solid state theory viewpoints.

Course Content		
Unit	Description	Weightage* (%)
1.	*Crystal structure determination*: Determination of lattice parameter- Indexing cubic and Non-cubic structure–Analytical & Graphical Method, Diffraction under non-ideal condition and crystallite size, Accurate determination of lattice parameter for polycrystalline materials, Single crystal X-ray diffractometry, Weissenberg method, Precession method, X-ray optics, wavelength dispersion, Chemical analysis by X-ray spectrometer, Stereographic projections and its uses.	25%
2.	*X-ray scattering and Ferroelectric materials* : Scattering of X- rays by crystal, Structure factor Equation for an electron, an atom and a unit cell, Structure factor calculation for different structures, Factors affecting the intensity of diffraction lines, Ferroelectric crystals: Rochelle Salts & $BaTiO_3$, Classification of Ferroelectric, electric displacive transition: Polarization catastrophe, 'Frozen-in' Transverse Optical Phonons, Thermodynamic theory of ferroelectric transition, ferroelectric domain, Piezoelectricity, piezoelectric coefficient, simple application with respect to piezoelectric slab.	25%

3.	*Important optical and magnetic phenomena*: Polaritons, LST relation, Electron-electron interaction, electron-phonon interaction: polarons, optical reflectance, Kramers-Kroning relations, electronic interband transitions, Excitons, Frenkel excitons and Wannier-Mott exciton, Raman Effect in crystals. Integral and Fractional Quantum Hall Effect, Josephson tunnelling, supercurrent quantum interference, High temperature superconductors: Rare earth, Bi and Tl-based cuprates and their properties, GMR-CMR materials.	25%
4.	*Materials in different forms with their applications*: Amorphous semiconductors–Band structure, electronic conduction, optical properties, switching and Xerography. Amorphous Ferro-magnets, Liquid crystals, classification of liquid crystals, properties and applications of liquid crystals, Quasi crystals, Carbon: diamond, graphite, fullerenes and carbon nanotubes, Polymers, classification of polymers, structures of long chain polymer, Nanofluids for improved heat transfer, Ferrofluids: general consideration, properties of ferrofluids, applications of ferrofluids.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will	
1.	Acquire the knowledge of the principle, design and working of different X-ray crystallography techniques. Students will be able to interpret, analyse the XRD pattern recorded in these techniques and extract structural parameters related to the crystal.
2.	Understand the physics behind the scattering of X-ray by crystals and the observed intensity distribution in the XRD pattern.
3.	Get familiarized with the ferroelectric materials, its properties and the theory of phase

	transition in these materials.
4.	Be acquainted with the important concepts, physical principles and phenomena related to optical and magnetic properties of semiconductors and superconductors.
5.	Know about different interesting material types like liquid crystals, ferrofluids, etc. and their applications.

Suggested References:

Sr. No.	References
1.	Introduction to Solid State Physics by Charles Kittel, John Wiley & Sons, 7th edition,1996.
2.	Solid State Physics:An introduction to Solid State Electronic Devices, Ajay Kumar Saxena, Macmillan Publishers India Ltd., 2010.
3.	Elementary Solid State Physics, M.A. Omar, Addison-Wesley Publication Company, 1975.
4.	Principle of Solid State Physics, F. Levy, Academic Press, 1968.
5.	Nanomaterials: An introduction to synthesis, properties and applications, Dieter Vollath, Wiley-VCH Verlag GmbH, 2008.
6.	Elements of Solid State Physics, J.P. Srivastava, Prentice Hall of India, 2001.
7.	Materials science and Engineering an introduction by William D. Callister. Jr, John-Wiley and Sons, 2006.
8.	An Introduction to X-ray Crystallography, M. M. Woolfson, 2nd Edition, Cambridge University Press, 1997.
9.	Essentials of Crystallography, D. McKie and C. McKie, Blackwell Scientific Publications, 1986.
10.	Elements of X-Ray diffraction, B. D. Cullity, 2^{nd} Edition., Addison -Wesley Publication company, 1978.
11.	Essentials of Crystallography, M. A. Wahab, Narosa Publishing House, New Delhi, 2009.
12.	The Interpretation of X-ray Diffraction Photographs, N.F.M. Henry, H Lipson, W.A. Wooster, Macmillan & Co. Ltd., 1961.
13.	Elements of Solid State Physics, J.P. Srivastava, Prentice Hall of India, 2001.

On-line resources to be used if available as reference material
On-line Resources
• **Historical Account of various single crystal X-ray diffraction techniques and its description:** https://www.xtal.iqfr.csic.es/Cristalografia/parte_06-en.html • **A course on Fundamentals of X-ray diffraction and Transmission electron microscopy** https://nptel.ac.in/courses/113/106/113106069/ • **A course on Fundamentals and applications of dielectric ceramics** https://nptel.ac.in/courses/113/104/113104090/ • **A video lecture: Introduction: Amorphous Semiconductors** https://freevideolectures.com/course/4332/nptel-semiconductor-devices-circuits/51 • **Liquid Crystalline materials used in LCD display** https://en.wikipedia.org/wiki/Liquid-crystal_display • **High temperature Superconductors** https://nptel.ac.in/content/storage2/courses/113104005/lecture_pdf/module7.pdf • **A video lecture on Quantum Hall Effect** https://freevideolectures.com/course/4512/nptel-advanced-condensed-matter-physics/23

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY52**	Title of the Course	**Magnetic and Optical Properties of Condensed Matter (CMP)**
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	The course introduces the students to the; 1. Principles of luminescence, its mechanism and applications. 2. Theory of Mossbauer Effect, its understanding and consequence of different parameters. 3. Different types of magnetisms in condensed matter, its parameters and thorough understanding. 4. The different dielectric materials, theory and various parameters. 5. Nuclear magnetic resonance theory and its parameters for different magnetism.

Course Content

Unit	Description	Weightage* (%)
1.	Luminescence :Introduction, Excitation and Emission, The Franck-Condon principle, Radiation-less transitions, Temperature dependence of luminescence, Decay mechanisms-Temperature independent exponential decay, Temperature dependent exponential decay, Power-law decay, Thermo luminescence and glow curves, Thallium activated alkali halides, Emission spectra, Concentration dependence of the luminescence efficiency, Models of luminescence in sulphide phosphors, Another proposed model, Comparison with experiment, Electroluminescence: The Gudden-Pohl effect, The Destriau effect, Carrier injection luminescence, Applications.	25%
2.	Mossbauer effect **:** Introduction, Resonant absorption, Recoil energy, Natural broadening, Doppler broadening, Cross-section of resonance processes, Approach in attempt to observe resonance fluorescence, Mechanism of Mossbauer effect, The experiment of Mossbauer effect, Mossbauer effect as a variable experimental tool, Debye-Waller factor and its temperature dependence, General importance of Mossbauer effect, Mossbauer effect and lattice dynamics, Quadruple coupling, Mossbauer effect and magnetism, Isomer shift. Applications: Electronic Structure, Molecular Structure, Crystal Symmetry and Magnetic Structure, Surface Studies, Biological Applications.	25%

3.	Optical properties: Propagation of light in conducting media, Anamalous skin effect, Drude model, absorption processes, exciton absorption, free carrier absorption, absorption processes involving impurities, photoconductivity, response time and gain factor, p-n junction photovoltaic cells, characteristics and applications, photovoltaic detectors. Dielectrics: Polarizability and its dependence on frequency, dielectric constant and dielectric loss, effect of alternating fields, complex dielectric constants of non-polar solids, dipolar relaxation, energy absorption and losses, some important insulating materials.	25%
4.	Magnetism :Ferromagnetic order, Curie point, temperature dependence of saturation magnetization, magnons, thermal excitation of magnon, neutron magnetic scattering, ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, anti-ferromagnetic order, susceptibility below Neel temperature, anti-ferromagnetic magnons, Magneto-Achostic effect. Resonances: Magnetic resonance, paramagnetic resonance, resonance with relaxation, nuclear magnetic resonance, line width, hyperfine splitting, Knight Shift, nuclear quadruple resonance, ferromagnetic resonance, anti-ferromagnetic resonance, spin wave resonance, electron paramagnetic resonance, cyclotron resonance and size effect, the de Haas-Van Alphen effect.	25%

Teaching-Learning Methodology	- Use traditional black board and chalk. - Over head projector, power point presentation, smart board is used for better understanding of scientific ideas. - Reference books, lecture notes, supporting materials are provided. The students can use departmental library and University library as and when needed.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination / Projects (As per CBCS R.6.8.3)	15%
2.	Internal MCQ based Quizzes, Seminar Presentation / Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	The optical properties of the matter in general and luminescent properties of the phosphors in particular.
2.	The different magnetism in matter and its theory.
3.	Two important techniques, Mossbauer Effect and Nuclear Magnetic Resonance.
4.	Applications of the Mossbauer effect and the luminescent materials.

Suggested References:	
Sr. No.	References
1.	Solid State Physics by A.J.Dekker, Macmillan India Ltd., New Delhi (2002).
2.	Fundamentals of Solid State Physics by B.S.Saxena, R.C.Gupta, P.N.Saxena, Pragati Prakashan, Meerut (2008).
3.	Molecular Structure and Spectroscopy by G. Aruldhas, PHI Learning Private Limited, New Delhi, Second Edition (2009).
4.	Principles of the theory of Solids by J.M.Ziman, Cambridge University Press, UK (2011).
5.	Introduction to Semiconductor theory by A. I. Anselm, MIR Publisher, Moscow (1981).
6.	Solid State Electronic Devices by B. G. Streetman, Prentice-Hall Inc, NJ (1994).
7.	Principles of Solid State Physics by R. A. Levy, Academic Press (1972).
8.	Solid State Physics by S. O. Pillai, New Age International Publisher (2016).
9.	Solid State Physics by N. W. Aschroft and N.D. Mermein, Harcourt Asia Pte Ltd. (2001).
10.	Solid State Physical Electronic by Aldert Van der Ziel, Prentice-Hall, (1957).

On-line resources to be used if available as reference material
On-line Resources
https://youtu.be/yhms0h5nfzY (Photoluminescence, electroluminescence) https://youtu.be/FJB7LJt6hGk (Introduction, types of luminescence, advantages, disadvantage, applications) https://youtu.be/Ukq2yvmKwoc (Radiationless transition, https://youtu.be/as6ExuBSgXY (Luminescence and types of luminescence) https://youtu.be/s7zsL9yFOsg (Mossbauer spectroscopy, recoil energy, isomer shift) https://youtu.be/H5UDMjwoRxI (recoil effect, recoil energy) https://youtu.be/v0oO4DE2mxI (natural broadening or natural line width) https://youtu.be/DvkOJ0jx-Uk (line broadening or Doppler broadening) https://youtu.be/9zimhww51WI (Mossbauer spectroscopy, recoil energy, chemical shift, isomer shift) https://youtu.be/2WGlKtW3yDU (Application of Mossbauer spectroscopy: isomer shift, quadrupole interaction, magnetic interaction splitting https://youtu.be/vIScSZEqj10 (Experimental arrangement for Mossbauer spectroscopy) https://www.youtube.com/watch?v=mN0zyefCKfY (propagation of light in conducting media) https://www.youtube.com/watch?v=p5SxML5T1kI (photoconductivity) https://www.youtube.com/watch?v=ewPhEKAs7_8 (dielectric and polarization) https://nptel.ac.in/courses/115/105/115105099/ (ferromagnetism, ferromagnetism, anti-ferromagnetism) https://www.youtube.com/watch?v=it6uaY8lB3A (Nuclear magnetic resonance) https://www.youtube.com/watch?v=Qgrp36u-aNs (nuclear quadruple resonance) https://www.youtube.com/watch?v=lUii0svCOPM (magnetic resonance)

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY53**	Title of the Course	**Microwave Communication: Electronics and Technology (EC)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ Students will learn in this paper about the fundamental aspects of modern techniques required and being practiced today for meaningful and effective electronic communication. ➢ Different ways of wave propagation, antenna, transmission lines and waveguides along with microwave devices are included here that provide complete idea on electronics and technology of microwave communication.

Course Content		
Unit	Description	Weightage* (%)
1.	**Transmission Lines and Wave Guides**: Classification of signals on the basis of frequency, Use of different frequency range for different applications, Low and medium frequency transmission, Fundamentals of Transmission lines- parallel wire, co-axial cable, equivalent circuits, Characteristics impedance, Primary line constants, Phase velocity, Voltage Standing Wave Ratio (VSWR) Design aspects of waveguides- rectangular and circular waveguides, Waveguide dimensions. Waveguide joints- cylindrical and rectangular, Magic- tee, Applications of magic- tee.	25%
2.	**Vacuum Tube and Solid State Microwave Devices**: Generation and detection of signals in microwave range, Vacuum tube based Microwave devices: Klystrons- Reflex Klystrons. Performance characteristics and applications Cavity magnetron, Travelling Wave Tube (TWT), Solid State Microwave Devices: Microwave Transistors- Constructional features of BJT and MESFET, Varactor diode, PIN diode, Schottky diode, Negative Resistance Microwave Devices- Tunnel diode, Gunn diode and Impatt diodes.	25%
3.	**RF Wave Propagation and Communication:** Wave-Propagation in	25%

	free space, Propagation characteristics, Classification of sky wave propagation, Ground waves, Space waves, Idea about tropospheric propagation and its range, Ionospheric layers, Ionospheric propagation and its range, Parameters affecting sky wave propagation, Radio horizon, Critical frequency, critical angle, Maximum usable frequency, Virtual height, Fading, multiple hope transmission, satellite communication.	
4.	**Transmission and reception of RF waves**: Antennas- Classification of antennas, Radiation fields and antenna patterns, Vertical antennas, Folded antennas, construction and working of Loop antennas, Ferrite rode antennas, Structure and operation of Yagi Uda antenna. VHF, UHF and Microwave antenna- structure and working of Horn antenna, Parabolic antenna, Structure of Dish Antenna, radiation mechanism in dish antenna, operation of dish antenna.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: On completion of this course, students will be able to understand how effectively electronic communication is made using necessary components involved in the whole process from source to receiver for information transfer through a channel.

Suggested References:	
Sr. No.	References
1.	Electronic Communication : D. Roody and J. Coolen, Prentice Hall.

2.	Electronic Communication Systems: G. Kennedy, Mc-Graw Hill.
3.	Electronic Communication Systems: F. R. Dungan, Delmar Publishers Inc.
4.	Microwave Principles: H. J. Reich, J. G. Skalnik, P. F. Ordung and H. L. Krauss, East-West Press
5.	Modern Microwave Technology: V. F. Velley, Prentice Hall.

On-line resources to be used if available as reference material
On-line Resources
• Introduction to microwave engineering https://nptel.ac.in/courses/108/103/108103141/ • Microwave generating tubes. http://www.digimat.in/nptel/courses/video/117105130/L17.html • Transmission lines, waveguides and antennas. https://nptel.ac.in/courses/117/101/117101056/ • Radio wave propagation. https://www.youtube.com/watch?v=lBJdZzb2cl0

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY54**	Title of the Course	**Microprocessor Programming, Interfacing and Applications (EC)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ Microprocessors and microcontrollers have become an integral part of most of the electronic systems used in consumer, instrumentation, research and development and space electronics. ➢ Students will learn about the basic ideas of microprocessor programming, interfacing and application along with introduction to microcontroller.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction to 8085**: Introduction to microprocessors; Evolution of Microprocessors, Organization and Architecture of Intel-8085, PIN diagram, Significance of data bus and address bus, OpCode and Operands, Instruction word size. Fetch and Execute Operations. Timing diagrams Instruction set of Intel 8085: Data transfer group, Arithmetic group, Logical group, Branch control group, Stack I/O and Machine control group. Subroutine. Assembly language programming of 8085. Address space partitioning, Schemes of allocation of addresses, Memory and I/O interfacing.	25%
2.	**Data Transfer Techniques and Peripheral Devices**: Data transfer schemes; Synchronous, Asynchronous and Interrupt driven schemes. Interrupts of Intel-8085, Interrupt circuits and programming, Interfacing Devices and I/O Devices: I/O ports of INTEL-8255, Architecture and operating modes of INTEL-8255, Programmable DMA controller Intel-8257, Programmable interrupt controller Intel-8259. Programmable counter/interval timer INTEL-8252.	25%
3.	**Data Acquisition using 8085 Microprocessor based data acquisition system:** A/D converter, Clock for A/D converter, sample and hold circuit IC LF-398, Analog multiplexer, ADC 0800-	25%

	Interfacing and programming, Interfacing and Programming of ADC-0800, Analog Multiplexer AM-3705 and Sample and Hold circuit LF-398, ADC 0801 Series. D/A converter, Operating Principle, DAC0800- Interfacing, Realization of A/D converter using D/A converter.	
4.	**Microprocessor Applications**: Delay subroutine, Display of decimal numbers, Display of Alphanumeric characters, Multiple Digital Display, Measurement of electrical and physical quantities: Frequency, Frequency Measurement using SID line, Phase angle and Power Factor Measurement, Voltage, Current, Resistance measurement, Temperature measurement and control. Introduction to microcontroller Intel-8051.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- Students will be able to understand and interface microprocessor 8085 with peripheral devices and program them using an assembly language program.
- They will also learn about the basics of microcontroller-8051.

Suggested References:	
Sr. No.	References
1.	Fundamentals of Microprocessors and Microcomputers: B. Ram (Dhanpat Rai and Sons, Delhi).
2.	Microprocessor Architecture, Programming and Applications with the 8085/8080A:

	R. S. Gaonkar, Wiley Eastern Ltd.
3.	Microprocessors: Theory and Applications, M. Rafiquzzaman, Printice Hall International Inc.
4.	Introduction to Microprocessors: A. P. Mathur, Tata Mac Graw Hill Publishing Co. Ltd. New Delhi.
5.	The 8051 Microcontroller, Architecture, Programming and Application, Kenneth J Ayala, Penram International.

~~On line resources to be used if available as reference material~~

~~On line Resources~~

- Architecture and Organization of 8085: https://www.youtube.com/watch?v=p4RcMLFIr5o
- Architecture and Organization of 8085 continued lecture:

  https://www.youtube.com/watch?v=MqH6KFnSY78
- Microprocessors and Interfacing:https://nptel.ac.in/courses/108/103/108103157/
- Data Transfer techniques:

  https://www.youtube.com/watch?v=_6IzWp9jQcc&list=PL0E131A78ABFBFDD0&index=14
- I/O Ports:
- https://www.youtube.com/watch?v=QoNRqn8XD78&list=PL0E131A78ABFBFDD0&in dex=15
- Programmable Interrupt and DMA controllers:https://www.youtube.com/watch?v=CxtwG8B7ihA&list=PL0E131A78ABFBFDD0&index=17
- Programmable Timer/Counter:https://www.youtube.com/watch?v=nxAQ1PFEd5U&list=PL0E131A78ABFBFDD0&index=19
- Designing Microprocessor based systems:https://www.youtube.com/watch?v=hOqpTM1raOo&list=PL0E131A78ABFBFDD0&index=20

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY55**	Title of the Course	**Computer Programming in Fortran 90 and Numerical Methods (CP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To provide hands on training of using Linux operating system, its features, and utilities for scientific computing. 2. To impart knowledge and training of Fortran 90 computer programming language 3. To train the students to design algorithms and write programs in Fortran 90 for scientific computing 4. Exposure to various numerical methods and its implementation through Fortran 90 for solving science problems.

Course Content		
Unit	Description	Weightage* (%)
1.	*Linux operating system*: Introduction, architecture, features and advantages, utilities and applications for scientific computing. *Errors and Uncertainties in Computations*: Machine Numbers and Rounding Errors, Numerical Errors of Elementary Floating-point Operations, Error Propagation, Stability and Conditioning	25%
2.	*Basic elements of Fortran:* The Fortran Character Set, The structure of a Fortran Statement, The Structure of a Fortran Program, Constants and Variables, Assignment Statements and Arithmetic Calculations, Intrinsic Functions, Initialization of Variables *Basic Input/Output Concepts:* List-directed input and output, Format and Formatted READ/WRITE statements, Format Descriptors, Introduction to Files and File processing *Introduction to Arrays:* Declaring Arrays, Using Array Elements in Fortran Statements, Two-dimensional or Rank-2 arrays, Allocatable Arrays	25%
3.	*Program Design and Branching Structures:* Introduction to Top-down Design Techniques, Use of pseudocode and Flowcharts, *Control Constructs:* Logical constants, Variables and Operators,	25%

	Branches (`IF, IF_ELSE, SELECT CASE` etc.), Loops (`While`, `DO WHILE` etc.), Character Assignment and Character Manipulation *Introduction to Procedures:* Subroutines, Sharing Data using Modules, Module Procedures, Fortran Functions.	
4.	*Interpolation and Approximation of function*: Polynomial Interpolation (Lagrange and Hermite), Cubic Spline interpolation, Least-square fitting (Chi squared fit, straight-line fit, General linear fit), Examples of related physics problems	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content. Hand on training of computer programming in Computer Lab.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will	
1.	Acquire knowledge and skill of programming in Fortran 90
2.	Be able to write and execute programs in Fortran 90 to solve basic computational physics problems using different numerical methods.

Suggested References:	
Sr. No.	References
1.	Introduction to Linux: A Hands on Guide, Machtelt Garrels
2.	Introduction to Programming with Fortran, I. Chivers and J. Sleightholme,4^{th} Edition, Springer (2018).

3.	Fortran 90/95 for Scientists and Engineers, S. J. Chapman, McGraw Hill Education (India) Pvt. Ltd., 2nd Edition (2013).
4.	Computer Programming in Fortran 90 and 95, V. Rajaraman, PHI Learning Pvt. Ltd., 2019.
5.	Introductory Methods of Numerical Analysis, S. S. Sastry, Fifth edition, PHI Learning Pvt. Ltd., New Delhi (2012).
5.	Computer Oriented Numerical Methods, V. Rajaraman, Third Edition, Prentice-Hall of India Private Ltd (2008).
6.	Numerical Recipes: The Art of Scientific Computing, W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery, Third Edition, Cambridge University Press (2007).

On-line resources to be used if available as reference material

On-line Resources

- Unix Tutorial for Beginners http://www.ee.surrey.ac.uk/Teaching/Unix/
- A course on Computational Physics http://physics.bu.edu/py502/
- Fortran tutorials https://web.stanford.edu/class/me200c/
- Fortran 90/95 reference http://www.icl.utk.edu/~mgates3/docs/fortran.html
- Numerical subroutines from the Reference book 6 http://numerical.recipes/routines/instf90.html
- Numerical Methods Tutorials https://global.oup.com/uk/orc/biosciences/maths/reed/01student/numerical_tutorials/
- Numerical methods (Online SWAYAM course) By Prof. A. K. Nayak & Prof. Sanjeev Kumar, IIT Roorkee https://onlinecourses.nptel.ac.in/noc19_ma21/preview

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY56**	Title of the Course	**Computational Physics-I (CP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Provide knowledge of various numerical methods and techniques used in computational physics 2. Impart training of implementation of algorithms and computer programs based on the numerical methods to solve computation physics problems

Course Content

Unit	Description	Weightage* (%)
1.	*Random numbers, Random-walk and Random-Decay*: Deterministic Randomness, Random Sequences, Random-Number Generation Algorithm. Assessing Randomness and Uniformity, Random Walk Model of Diffusion and its Simulation, Spontaneous Decay Problem (Discrete and Continuous Decay)	25%
2.	*Numerical Differentiation and Integration*: Forward, backward and central difference methods, Richardson extrapolation, Trapezoidal rule, Simpson rule, Gaussian quadrature. Extremes of a function Examples of related physics problems *Root-Finding*: Bisection method, Newton-Raphson method, Secant method	25%
3.	*Numerical Methods for Matrices*: Matrices in physics, Basic Matrix operations, Solution for the system of linear equations (Gaussian elimination, LU method), Eigen value problems: Eigen values of Hermitian matrix, General matrix, Eigenvectors of matrix, The Faddeev--Leverrier method	25%
4.	*Ordinary Differential Equations*: The initial-value problems, The Euler and Picard Method, Predictor-Corrector Method, The Runge-Kutta method, Application to system of equations, Examples related to physics problems, Order and chaos in two-dimensional motion	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content. Hands-on training sessions and tutorials of computer programming and problem solving.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will	
1.	Acquire the knowledge of various numerical methods and techniques used in scientific computing for the solution of problems in computational physics.
2.	Be equipped with the skill of implementing the algorithms and computer programs to solve preliminary and advanced computational physics problems.

Suggested References:	
Sr. No.	References
1.	Computational Physics: Problem Solving with Computers, R. H. Landau, M. J. Páez, and C. C. Bordeianu, Second Edition, Wiley-VCH Verlag GmbH (2007).
2.	Numerical Analysis with Algorithms and Programming, S. S. Ray, CRC Press, Taylor & Francis Group (2016).
3.	An Introduction to Computational Physics, T. Pang, Second Edition, Cambridge University Press (2006).
4.	An Introduction to Numerical Methods and Analysis, J. F. Epperson, Second Edition, John Wiley & Sons Inc. (2013).
5.	Computational Problems for Physics: With Guided Solutions Using Python, R. H. Landau, M. J. Páez, CRC Press, Taylor & Francis Group (2018).
6.	Numerical Recipes: The Art of Scientific Computing, W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery, Third Edition, Cambridge University Press

	(2007).

On-line resources to be used if available as reference material

On-line Resources
• Numerical methods (Online SWAYAM course) By Prof. A. K. Nayak & Prof. Sanjeev Kumar, IIT Roorkee https://onlinecourses.nptel.ac.in/noc19_ma21/preview • Numerical subroutines from the Reference book 6 http://numerical.recipes/routines/instf90.html • Numerical Methods Tutorials https://global.oup.com/uk/orc/biosciences/maths/reed/01student/numerical_tutorials/

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY57**	Title of the Course	**Solar Energy and Geothermal Energy (EST)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ Important aspects of solar energy and its application methods e.g. by photovoltaic and geothermal route are included in this unit to make students aware about the non-conventional energy harvesting methods.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction: Solar Energy and its Applications:** Essential subsystem in a solar energy plant. Solar energy routes and their prospects, Units of solar power and solar energy, Merits and limitations of solar energy conversion and utilization, Energy from Sun. Solar constant, Power density for various wavelengths of sunlight, Clarity index, solar insolation, Tilt angle of the fixed flat plate collector, solar calculations, Local apparent time.	25%
2.	**Solar thermal collectors:** Parabolic collectors, Paraboloidal dish collectors, Fresnel lens point focus collector and heliostate with central receiver, Heat transfer fluid, Thermal energy storage. Solar distributed collector thermal power plants, Solar boiler/steam generator with large reflector and a central receiver, Solar pond, Solar thermo-electric converter, Introduction to Photovoltaic systems, Merits and limitations of solar PV system, Prospects of solar PV system. Principle of a photovoltaic cell, V-I characteristics of a solar cell, Interconnections of solar cells.	25%
3.	**Solar PV Systems:** Efficiency of a solar cell and spectral response, Configuration of a solar PV panel, Small solar PV system for residence - typical ratings of small PV systems, Large solar PV systems – PV cell technology, Selective surfaces – basic requirements and basic principles – Types of selective surfaces. Applications of selective coatings to the flat plate collector. Principles of photoelectrochemical solar cell.	25%
4.	**Introduction to the Geothermal Energy Applications:** Geothermal	25%

	energy resources, Origin of geothermal resources, Non-uniform geothermal gradients, hydrogeothermal resources, Geopressure geothermal resources, Hot dry geothermal resources, Geothermal fluids for electrical power plants.	

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- On completion of this course, students will be able to understand about the working principles of non-conventional energy harvesting methods and factors affecting their performance.

Suggested References:

Sr. No.	References
1.	Energy Technology (Non conventional, Renewable and conventional) : S. Rao and Dr. P. B. Perulkar
2.	Solar Energy conversion, An introductory course: A. E. Dikon and J. D. Loslie
3.	Photoelectrochemical Solar Cells: Suresh Chandra
4.	Principles of Energy Conversion: Archie W. Cupl Jr.

On-line resources to be used if available as reference material
On-line Resources
• Energy and dependence on external sources and Sun, Physical description and reactions: https://nptel.ac.in/courses/112/105/112105051/ • Solar Collector Basics: • https://nptel.ac.in/courses/112/105/112105051/ • PV Cell characteristics and Equivalent Circuit: https://nptel.ac.in/courses/117/108/117108141/ • Short Circuit, Open Circuit and Peak Power Parameters: https://nptel.ac.in/courses/117/108/117108141/ • Geothermal Energy: https://www.youtube.com/watch?v=x2Lxt-KS_v4

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Master of Science in Physics
M. Sc. (Physics) Semester III

Course Code	**PS03EPHY58**	Title of the Course	**Wind Energy and Ocean Energy (EST)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ Students will learn about the important aspects of wind and ocean energy in this paper. They will also learn about the requirements, design aspects, application and limitations of different wind turbine generators and ocean energy conversion technologies.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction to wind energy**: Application of wind energy and historical back ground, Merits and limitations of wind energy conversions, Nature of wind and origin of wind, Wind energy quantum and variables in wind energy conversion systems, Wind power density, Power in a wind stream, Wind turbine efficiency, Power of a wind turbine for given incoming wind velocity. Forces on the blades of a propeller, Wind velocities and height from ground and site selection, Examples of wind farm site, Mean wind velocity, and wind velocity duration curve, Energy pattern factor and wind power duration characteristics	25%
2.	**Introduction to wind turbine generator and terms and definitions**, Types and characteristics of wind turbine generators, Horizontal axis propeller type wind turbine generator, Three blade HAWT. Dimensioning of HAWT, Vertical axis wind turbines, Vertical axis-Darreus rotor wind turbine, Vertical axis wind turbine with H-rotor, Wind turbine rotor speeds, Practical P.V. characteristics, Power coefficients versus tip speed ratio for various types of wind turbines, Operation and control of wind turbine generator unit, Wind to electrical energy conversion system, Power versus velocity characteristics of WTG unit	25%
3.	**Advantages and limitations of ocean energy conversion technologies**, Introduction to the ocean wave energy conversion, Ocean waves and parameters of a progressive wave, Equation of a	25%

	progressive and energy and power ocean waves, Summary of equations, Motion of water particles in the wave and wave data collection. Wave machine, Dolphin-buoy type ocean wave energy converter, Three-raft energy converter – Nodding Duck oscillating cam wave machine – ring-cam roller follower design, Oscillating hydraulic piston-accumulator wave machine oscillating hydraulic piston wave energy pumped storage plant – Dam-Atoll wave machine.	
4.	**Forces on the wave machines and associated structures**-Recent advances in ocean wave energy technology, some recent wave machine concepts, Merits of ocean wave energy – limitations and demerits of wave energy and wave energy plants. Introduction to the tidal energy conversion- tidal currents- tidal energy conversion, Tidal power – average theoretical power per tide-ocean tidal energy schemes-terms and definitions, Single basin tidal schemes – double basin schemes and multi-basin schemes.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- On completion of this course, students will be able to understand about the working principles and limitations of methods of harvesting wind and ocean energy.

Suggested References:	
Sr. No.	References
1.	Energy Technology (Non conventional, Renewable and conventional): S. Rao and Dr. P. B. Perulkar.
2.	Solar Energy conversion, An introductory course:A. E. Dikon and J. D. Loslie.
3.	Photoelectrochemical Solar Cells: Suresh Chandra .
4.	Principles of Energy Conversion: Archie W. Cupl. Jr.

On-line resources to be used if available as reference material
On-line Resources
• Wind Energy-I: https://www.youtube.com/watch?v=GExTwRNkQBg&t=72s • Wind Energy-II: https://www.youtube.com/watch?v=gMxPkVQYXz8 • Wind Generation: https://nptel.ac.in/content/storage2/courses/108108078/pdf/chap6/teach_slides06.pdf • Wave Energy: https://nptel.ac.in/content/storage2/courses/108108078/pdf/chap8/teach_slides08.pdf • Tidal Energy: https://nptel.ac.in/courses/108/105/108105058/

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Sardar Patel University
Programme- MSc
(Under Choice Based Credit System)
M.Sc. (Physics) Semester –IV
Syllabus with effect from June-2022-23

Course Type	**Course code**	Name of the Course	T/P	Credit	Exam duration in hrs	Components of Marks		
						Internal	External	Total
						Total/passing	Total/passing	100/passing
Core Courses	PS04CPHY51	Nuclear & Particle Physics	T	04	3hrs	30/10	70/28	100/40
	PS04CPHY52	Thin films & Advanced Characterization Techniques	T	04	3hrs	30/10	70/28	100/40
Elective courses	PS04EPHY51	Biophysics (CMP)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY52	Crystal Growth & Imperfections in solids (CMP)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY53	Signal Processing and Satellite communications (EC)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY54	Advanced Solid state electronic devices (EC)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY55	Computer Programming in Python and Numerical methods (CP)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY56	Computational Physics –II (CP)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY57	Biomass, Oother systems and energy storage (EST)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY58	Nuclear energy and energy strategies (EST)	T	04	3hrs	30/10	70/28	100/40
	PS04EPHY59	CMP Practicals -I	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY60	CMP Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY61	EC Practicals -I	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY62	EC Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY63	CP Practicals -I	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY64	CP Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY65	EST Practicals –I	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY66	EST Practicals -II	P	04	3hrs	30/10	70/28	100/40
	PS04EPHY67	CMP Comprehensive Viva	T	01	Acc. req	-	50/20	50/20
	PS04EPHY68	EC Comprehensive Viva	T	01	Acc. req	-	50/20	50/20
	PS04EPHY69	CP Comprehensive Viva	T	01	Acc. req	-	50/20	50/20
	PS04EPHY70	EST Comprehensive Viva	T	01	Acc. req	-	50/20	50/20

CMP: Condensed Matter Physics **EC : Electronics and Communication**
CP : Computational Physics **EST: Earth Science and Technology**

Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04CPHY51**	Title of the Course	**Nuclear and Particle Physics**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The basic objective of this course on nuclear and particle physics is to educate the students on various aspects of the static and dynamic properties of nucleus from light nuclei to heavy nuclei. To appraise the applications of quantum mechanics in understanding nuclear processes. Aims to provide the properties of nuclear force and their consequences in deriving applications for the benefit of our society in terms of energy production, medical, industrial and agricultural applications. Aims to provide the modern knowledge regarding the most fundamental constituents of matter and their interactions, the conservation laws abide by them and its consequences that lead to the present understanding of our universe. Aims to provide training on the basic aspects of the standard model of particle physics.

Course Content		
Unit	Description	Weightage* (%)
1	The deuteron Problem: The ground state of deuteron, the Schrödinger wave equation and its solution shape of ground state wave function, Normalization of deuteron wave, radius of deuteron Mixing of orbitals in deuteron, Magnetic moment of Deuteron, Quadrupole moment of deuteron. Nuclear Forces: charge independence, charge symmetry, Non central (Tensor) force, Exchange forces. Nuclear Models: Single particle shell model, Explanation of nuclear data, Nordheim's rules for odd Z - odd N nuclei, Islands of isomerism, Successes and failures of shell model. Collective nuclear model, Rotational motion of the nucleus, Vibration of spherical nuclei, classification of vibration of spherical nuclei. Quadrupole moment of deformed nuclei.	**25%**

2	Alpha Decay: Basic alpha decay processes alpha decay systematic, Geiger-Nuttall Law for Alpha Decay, Theory of alpha emission, Angular momentum and parity in alpha decay. Beta decay: Experimental information about Beta particles, Energy released in beta decay (Q-value). Continuous beta spectrum and neutrino hypothesis, Fermi theory of beta decay, Fermi-Kurie plot. Angular momentum and parity selection rules, Experimental detection of neutrino. Gamma decay - Electromagnetic transitions, Radiation field multipolarity, selection rules, gamma ray transition probability.	**25%**
3	Interaction of heavy charged particles with matter: energy loss by electrons, Absorption curve and range, Interaction and slowing down of neutrons in matter. Nuclear reaction theory: Nuclear Reaction mechanism, pre-equilibrium mechanism, Compound nucleus, Direct interaction process in nuclear reactions, Coupled channel theory of inelastic scattering. Nuclear Fusion, Sources of energy in stars, nucleo - synthesis processes, Controlled fusion, Lawson Criterion. Applications of Nuclear Physics: Trace element analysis, Alpha decay applications, Diagnostic and therapeutic nuclear medicine, Hadron therapy.	**25%**
4	Elementary particle and forces of Interactions: Classification of fundamental forces, Elementary particles and their quantum numbers, Conservation laws, CPT theorem. Gellmann- Nishijima formula, Quark model, Baryons and mesons- their quark structure. Parity non-conservation in weak decays, Wu's experiment. Summary of Standard model of Particle physics: Introduction to field theory, Gauge theory, Electro-Weak theory, Spontaneous symmetry breaking, Higgs boson, Grand Unification attempts and Early Universe.	**25%**

Teaching-Learning Methodology	Off line / Online mode of direct teaching learning, class discussions, Tutorials, class assignments.	
Evaluation Pattern		
Sr.No.	Details of the Evaluation	Weightage
1	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
	Acquire o In detail the static and dynamic properties of nucleus and will be able to compute the energy released during fission, fusion and other nuclear reactions. o The understanding of non-central nature of the nuclear force and its properties. o The knowledge related to various physical processes that occur when charge particles or gamma radiation passes through matter. o A clear understanding of the nuclear techniques for the energy production, medical and industrial applications. o A comprehensive understanding of the various forces of nature and the relevant conservation laws and symmetries abide by the fundamental particles and their consequences towards a better understanding of early universe. o The knowledge of the most fundamental constituents of matter and their interactions. o The basic concepts of the grand unification theory. o Elementary training on gauge theory and the standard model of particle physics.

Suggested References:	
Sr.No.	References
1	Introductory Nuclear Physics by Kenneth S Krane, John Wiley & Sons, Singapore (1988)
2	Fundamentals of Nuclear Physics by J. C. Verma, R. C. Bhandari& D.R.S. Somayajulu, CBS Publishers & Distributers (2005), New Delhi
3	Fundamentals of Nuclear Physics by Jahan Singh, Pragati Prakashan, Meerut 1st ed.2012.
4	Introduction to Particle Physics' by M P Khanna, Prentice Hall of India (1999) New Delhi.
5	An Introduction to Nuclear Physics' by W N Cottingam& Greenwood, Cambridge Univ. Press UK
6	Introduction to High energy Physics' by D H Perkins, Addison Wesley
7	Introduction to Elementary particles' by David Griffiths, John Wiley & Sons Singapore (1987).
8	Introduction To Nuclear And Particle Physics' by R C Verma, V K Mittal S C Gupta, Prentice Hall of India (2009), New Delhi

On-line resources to be used if available as reference material

On-line Resources
• MIT OpenCourseWare • CERN@school – CERN@school brings technology from CERN into the classroom to aid with the teaching of particle and nuclear physics. • TimPix – Through TimPix school students across the UK are monitoring the radiation levels on the International Space Station (ISS) using data downloaded from Timepix detectors on board the ISS. • Binding Blocks – Binding Blocks is a nuclear physics outreach project that aims to get members of the public and schools to build an eight metre long 3D nuclear chart of all isotopes made completely out of LEGO®. Curriculum-linked workshops cover a range of topics from radiation to energy. • Teaching Radioactivity - A number of teaching resources developed by the Institute of Physics to support the teaching of radioactivity and to give students a more authentic and engaging experience of ionising radiations and sub-atomic particles. • NUPEX - The NUclear Physics EXperience: a free database of knowledge created and maintained by expert nuclear physicists from all over Europe. • The ABC's of Nuclear Science - A brief introduction to nuclear physics covering a wide range of topics from basic nuclear structure to industrial applications of nuclear science. • Applications from UK Nuclear Physics Research - Showcasing the applications of nuclear physics research by UK Universities.

Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04CPHY52**	Title of the Course	**Thin films & Advanced Characterization Techniques**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	This course will provide complete depth to the students how thin films of different materials can be deposited by various experimental techniques along with recent characterisation methods. Apart from this they will also learn how optoelectronic devices like LED's, LASERS can be fabricated at the laboratory scale.

Course Content

Unit	Description	Weightage* (%)
1.	*Classification of vacuum pumps/Gauges* : Molecular drag pump, Sputter ion pump, Classification of gauges : Thermal conductivity gauges, Ionization gauges : Triode and Penning gauge. *Theory of thin film nucleation* - Impingement, adsorption and thermal accommodation, The capillarity model, Atomistic model, Four stages of thin film growth, cluster coalescence and depletion, *Thickness measurement :*Optical methods of measuring thin film thickness : FET, FECO, VAMFO, step gauges, ellipsometry, Mechanical methods for measuring thin film thickness : Stylus profilometry, weight measurement, Quartz crystal oscillators.	25%
2.	*Evaporation and Sputtering* : Physics and chemistry of evaporation, evaporation rate, vapour pressure of elements, evaporation of compounds and alloys, Thermal deposition in vacuum, kinetic theory of gases and emission condition, distribution of deposit, thermal evaporation, electron beam method, sputtering-ion surface interactions ,sputter yield, sputtering of alloys, glow discharge DC sputtering, low pressure sputtering, reactive sputtering. *Hybrid and modified PVD processes* : Ion plating, reactive evaporation processes, Ion beam assisted deposition processes, Ionized cluster beam deposition, Pulsed laser deposition(PLD), Atomic layer deposition(ALD).	25%
3.	*OtherThin film deposition techniques*: Radio frequency and magnetron Sputtering, CVD reaction types, PECVD, LECVD, MOCVD, HTCVD, Introduction to Epitaxy, lattice misfit, epitaxy of compound semiconductors, Applications of epitaxy : Optical communications, Light emitting semiconductor devices (e.g. GaN), Molecular beam epitaxy (MBE), Liquid Phase epitaxy (LPE), Vapour phase epitaxy	25%

	(VPE), Langmuir Blodgett films, Spray method : Spray Hydrolysis, Spray pyrolysis.	
4.	*Characterization techniques* : X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS) and Angular dependent X-ray photoelectron spectroscopy , RBS (Rutherford back scattering), SIMS (Secondary ion mass spectrometry). SAXS and SANS (small angle X-ray and neutron scattering spectroscopy), Ultraviolet and Bremsstrahlung isochromat spectroscopy, , Electron energy loss spectroscopy (EELS).	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching, Tutorials, class assignments as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	They will learn how to create/measure high vacuum. Theoretical background of growth of thin films will make them aware of how actually films grows and how the thickness of films can be measured by different ways.
2.	They will have clear basic knowledge of evaporation, sputtering and chemical vapour deposition techniques along with the recent developments made in this field of thin film deposition.
3.	Epitaxial thin film growth techniques like LPE, MBE, Langmuir Blodgett films have been included in this course so as to expose the students to the present day thin film devices made out of it.
4.	They will be benefited by studying different modern techniques which are used for characterisation of thin films, i.e SEM, SIMS, RBS,XPS, AES, SAXS, SANS, RHEED, EELS etc.

Suggested References:

Sr. No.	References
1.	Handbook of Thin Film Technology, L.I. Maissel and R. Glang, McGraw-Hill,1983.
2.	The Materials Science of Thin Films, Milton Ohring, Academic press, 2002.
3.	Thin Film Phenomena, K. L. Chopra, McGraw-Hill Inc., 1969.
4.	Thin Film Solar Cells, K. L. Chopra and S. R. Das, Springer Publication,1983.
5.	Material and Devices Characterization, Dieter K. Schroder, John Wiley and Sons, NY, 1990.
6.	Surface Science: An Introduction, K. Oura, V.G. Lifshits, A. A. Saranin, A. V. Zotov and M. Katayama, Springer-Verlag, 2003.
7.	Thin film fundamentals, A. Goswami, New Age International Ltd., 1996.
8.	Materials characterization and chemical analysis, John P. Sibilia, VCH publishers, 1988.
9.	Preparation of thin films, Joy George, Marcel Dekker Inc.,1992.
10.	Vacuum Science and Technology, V.V. Rao, T.B. Ghosh and K.L. Chopra, Allied Publishers Ltd, India, 1998.

On-line resources to be used if available as reference material

On-line Resources

- Vacuum Technology https://www.youtube.com/watch?v=Vuqk-Ag7xV4
- Thin film Mateirals and Deposition https://www.youtube.com/watch?v=p0XxWT2QdEk

DC/RF/Sputtering https://www.youtube.com/watch?v=CAVF-OqgR3I

- Magnetron Sputtering https://www.youtube.com/watch?v=rOoL-P9h3lQ
- Characterization technique https://nptel.ac.in/courses/113/105/113105100/ https://nptel.ac.in/courses/115/103/115103030/ https://nptel.ac.in/courses/113/104/113104004/
- Thin film deposition: https://nptel.ac.in/courses/113/105/113105086/

- Lithography : https://www.youtube.com/watch?v=HMT7DxmkBAw

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY51**	Title of the Course	**Biophysics (CMP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	To impart the knowledge and understanding of: ➢ essential physical principles, concepts and theories related to the structural and dynamical aspects of biomolecules and cells. ➢ the physics of some important phenomena in biomolecules and cells. ➢ Amino acids-the building blocks of the proteins, bonding and the resultant different types of structures, crystallization techniques for the proteins. ➢ Experimental separation and spectroscopic techniques necessary for study of biomolecules and cells.

Course Content

Unit	Description	Weightage* (%)
1.	*Molecular forces in biological structures* Dispersion forces, Hydrophobic forces, Hydration forces, Hydrogen bonds, Steric repulsions, Bond flexing and harmonic potentials, Stabilizing forces in proteins, Protein force fields, Stabilizing forces in nucleic acids *Structural and dynamical aspects of Biomacromolecules:* Flexibility of macromolecules, Elasticity, Dynamics of polymer chains, Topology of polymer chains– Super Coiling	25%
2.	*Biophysical phenomena:* Aggregating self-assembly, Surfactants, Viruses, Self-Assembly of proteins, *Biological membranes physics:* Lipid bilayers and membrane proteins, Undulations, Bending resistance, Elasticity, Intermembrane Forces *Experimental techniques for separation and study of biomolecules and cells:* Chromatography, Electrophoresis, Optical tweezers, Patch-clamping.	25%
3.	*Proteins & Nucleic acids :* Protein – Amino acids and the primary structure and secondary structure of proteins, tertiary structure, quaternary structure. Organization of nucleic acid - Primary, secondary, tertiary structure of DNA, Structure of RNA, Sequencing of nucleic acids, antigens and antibodies. Crystallization of protein – few general methods of crystallization – vapor diffusion and micro techniques. Biological applications of delocalization in molecules, radiation damage in biological molecules, ESR studies of Myoglobin and haemoglobin molecules, electronic properties of proteins, enzyme studies, carcinogenic activity, NMR applications: biochemistry, biophysics and in medicine.	25%
4.	*Spectroscopic techniques used for studying biological molecules* : Light scattering, small angle X-ray scattering, Mass Spectrometry : MALDI-TOF, Ultraviolet/visible spectroscopy, circular dichroism(CD) and optical rotatory dispersion(ORD), fluoroscence spectroscopy, Infrared spectroscopy, Raman spectroscopy.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching, Tutorials, class assignments as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will	
1.	Be able to comprehend the role of different types of physical forces in governing the structure, stability and dynamics of biomolecules
2.	Acquire knowledge and understanding of the important structural and dynamical properties of the biomolecules and its role in key biophysical processes.
3.	Be acquainted with the amino acids, their importance in the constitution and structures of proteins, DNA and RNA etc.
4	Learn about the experimental techniques used for crystallization, separation, structure determination, spectroscopic and optical characterization of biomaterials.

Suggested References:

Sr. No.	References
1	Biophysics, Vasantha Pattabhi and N. Gautham, Kluwer Academic Publishers, 2002.
2	Bio-Physics, Principles and techniques: M. A Subramanian, MJP Publishers, 2005.
3	Elementary Solid State Physics: Principles and Applications M. A. Omar, Addison-Wesley Publishing Co., 1975.
4	Molecular and Cellular Biophysics, Meyer B. Jackson, Cambridge University Press, 2006.
5	Applied Biophysics: A Molecular Approach for Physical Scientists. Tom A. Waigh, John Wiley & Sons, Ltd, 2007.
6	Biophysics - An Introduction, Rodney M. J. Cotterill, John Wiley & Sons, Ltd, 2002

On-line resources to be used if available as reference material

On-line Resources
• Physics of Biological Systems https://nptel.ac.in/courses/115/101/115101121/ • A course on introduction to Biophysics https://canvas.ucsc.edu/courses/1077 https://canvas.ucsc.edu/courses/1077/pages/useful-links • A course on spectroscopic techniques https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY52**	Title of the Course	**Crystal Growth & Imperfections in solids (CMP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ To provide theoretical and experimental background to crystal growth processes, phase equilibrium diagrams, crystal defects, diffusion phenomena, radiation damage,which will help students to understand many of the physical properties of solids. ➢ To understand the basics of failure of materials with the objective of rationalizing, predicting, modifying and describing the mechanical behavior of materials.

Course Content		
Unit	Description	Weightage* (%)
1.	*Nucleation and crystal growth processes* : Nucleation, Classical theory of nucleation : Gibb's – Thomson equation for vapour, melt and solution, Energy formation of nucleus, heterogeneous nucleation, Crystal growth techniques – Bridgman- basic process, Crystal pulling method , Vernueil flame fusion process, float zone process, solution growth: slow cooling process at low and high temperature, growth from gel, flux growth, direct vapour transport technique and chemical vapour transport technique, High pressure high temperature growth of diamond.	25%
2.	*Phase equilibrium diagrams* : Stability of phases and equilibria, liquid – solid transition, solid solutions, phase rule and phase equilibrium, cooling curves, solid solution equilibrium diagram, Lever rule, non-equilibrium cooling, Eutectic systems : components mutually soluble in liquid state and insoluble in the solid state, eutectic system with partial solubility in solid state, the Peritectic equilibrium diagram, layer type equilibrium diagrams. *Radiation damage in materials* : Radiation damage in solids and interactions with solids, differential cross section, total scattering cross-section, interaction mean free path of penetration depth, choice of differential cross section, displacement cross section, damage by non-ionizing radiation, damage by ionizing and other radiations.	25%

3.	*Dislocation observation* : surface method , decoration method, electron microscopy, X-ray diffraction topography, field ion microscopy, cross-slip, velocity of dislocations, ,forces on dislocation, forces between dislocations,Intersection of dislocations,movement of dislocations containing elementary jogs, composite jogs. *Diffusion mechanisms*: steady state diffusion and non-steady state diffusion, factors that influence diffusion : diffusing species and temperature, some applications of diffusion : measurement of diffusion coefficient, Carburizing and Decarburizing process in steel, random walk treatment of diffusion, Kirkendall effect, ionic conductivity.	25%
4.	*Failure of materials* : Fracture , ductile and brittle, stress concentration, fracture toughness, design using fracture mechanics, impact fracture testing, crack initiation and propagation, factors that affect fatigue life, Fatigue, cyclic stresses, the S-N curve, Creep- generalized creep behaviour, stress and temperature effects, data extrapolation method, Failure of an automobile rear axle, Hardness, Rockwell hardness tests, Brinell Hardness tests, Knoop and Vicker's microhardness tests.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching, Tutorials, class assignments as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Students will understand the basic concepts of crystal growth and methods by which crystalline materials can be synthesized.
2.	By knowing different states of material occurring at particular temperature across the phase boundary, students can apply these concepts to solve problems in the field of Materials Science / Material Engineering. They will also learn about how radiation damage whether ionizing or non-ionizing radiation can effect the properties of materials.

3.	It will help students to have a depth of the imperfections and diffusion mechanism in materials for any device fabrication.
4	It concentrates on the physics of deformation, failure of materials by fracture, fatigue and creep and hardness measurement.

Suggested References:

Sr. No.	References
1.	Crystal growth: Processes and Methods, P. S. Raghavan and P. Ramasamy, KRU Publications, Kumbakonam, 2000.
2.	Materials Science and Engineering: An introduction, William D. Callister. Jr, John-Wiley and Sons, 2006.
3.	Crystal Growth Processes, J. C. Brice, Halsted Press, New York, 1986.
4.	The Physics of Engineering Solids, T. S. Hutchison and D.C. Baird, John Wiley and Sons Inc., 1968.
5.	The nature and properties of Engineering Materials, 3rd Edition, Zbigniews. D. Jasterzzebski, John Wiley & Sons, 1987
6.	Introduction to Dislocation, D. Hull, Pergamon Press Ltd., 1969.
7.	Solid State Physics: Structure and Properties of Materials, M. A. Wahab, 2nd Edition, Narosa Publishing House, New Delhi, 2007.
8.	Elements of Solid State Physics, J. P. Srivastava, Prentice Hall of India, 2001.
9.	Introduction to Solid State Physics, 7th Edition, Charles Kittel, John Wiley & Sons, 1996.
10.	Principle of Solid State Physics, F. Levy, Academic press, 1968.
11.	Elementary Solid State Physics, M.A. Omar , Addison -Wesley Publication Company, 1975.
12.	Introduction to crystal growth principles and practice, H. L. Bhat, CRC Press, Taylor & Francis Group, New York, 2015.

On-line resources to be used if available as reference material

On-line Resources

- Nucleation https://youtu.be/Odw6fGFC6dY
  https://youtu.be/Od5yT-l7aK4

- Bridgman https://youtu.be/P5GMX9Cr22g
- Czochralski https://youtu.be/RdVTBIyf6kg
- Verneuil https://youtu.be/Qp0u0Vp2jQU
- Floating zone https://youtu.be/K4X9WsfgEPQ
- Gel growth https://youtu.be/v7J8aJMJ1so
- Hydrothermal growth https://youtu.be/tLurHk8kYVg
- Phase rule https://youtu.be/erOKm7wbkJE,
- Lever rule https://youtu.be/Ub3VsJW6UM0
- Non-equilibrium cooling https://youtu.be/ZSoEJRyVPOk
- Eutectic system https://youtu.be/KfGq1-InJqY https://youtu.be/0i_W1X8cdMU https://youtu.be/w9iTLjiJWIk https://youtu.be/GVK3gRAx-ZY
- Peritectic https://youtu.be/P6WgQE3ZqFM https://youtu.be/R5K7nXMVF1Y
- Layer type https://youtu.be/UFJj-ad2Bv4

- Defects in crystalline solids https://nptel.ac.in/courses/113/106/113106075/
- Fatigue failure https://freevideolectures.com/course/3470/advanced-marine-structures/8
- Diffusion https://nptel.ac.in/content/storage2/courses/112108150/pdf/Lecture_Notes/MLN_05.pdf
- Creep https://nptel.ac.in/courses/113/106/113106088/
- Fracture https://nptel.ac.in/courses/112/106/112106065/
- Failure https://nptel.ac.in/content/storage2/courses/112108150/pdf/PPTs/MTS_08_m.pdf

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY53**	Title of the Course	**Signal Processing and Satellite Communication (EC)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ Looking at the present scenario of communication systems, this paper is designed to cater the needs of imparting modern knowledge of communication systems. ➢ The students will be made aware of modulation techniques which are basics of electronic communication systems.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction to Communication Systems and Analog Modulation**: Nature of communication systems, Signals in time and frequency-domains, Types of Modulation, Amplitude Modulation theory, Frequency spectrum of AM wave, Representation of AM, Power relation in AM wave, Current calculation, Modulation by several sine waves, Frequency and Phase modulations, Spectra, Power distribution and transmission bandwidths, Single Side Band amplitude modulation.	25%
2.	**Unit: 2 Generation of Analog Modulation:** Generation of AM, Basic requirements and comparison of levels, Grid modulated Class C-Amplifier, Plate modulated class-c amplifier, Evolution and description of Single Side Band , Suppression of carrier, Effect of non-linear resistance on added signals, Balanced modulator, Suppression of unwanted side band, The Filter Method, Phase Shift Method and The Third Method Introduction to frequency modulation and phase modulation: Mathematical representation of FM	25%
3.	**Unit: 3 Digital, Microwave and Optical Communication Techniques**: Types of Pulse Modulation Systems, Pulse Amplitude Modulation and sampling theorem, Pulse Code Modulation, Delta Modulation, Data communication systems - transmission speeds and bandwidths, Synchronisation, Types of synchronization, modems,	25%

	Digital modulation and demodulation: Frequency shift keying, Phase shift keying. Microwave repeaters, Geostationary satellites, Transponder and earth stations, Principles of multiple access systems- Frequency Division Multiplexing, Time Division Multiplexing, Optical fiber communication system.	
4.	**Unit: 4 Principles of Mobile Communication**: Wireless mobile communication, Transceiver, Difference between repeater and transceiver, Cellular telephones-principle of operation, idea about cell structure, Interpretation of International Mobile Equipment Identity(IMEI) number, its importance, structure of IMEI number, significance of Luhn check digit and software version number. Global System for Mobile communication(GSM)- Definition, frequency range, Advantages, limitations, Operation of Code Division Multiple Access (CDMA), advantages, limitations, comparison between GSM and CDMA.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- After systematic study of this paper the students will have ample knowledge of the processes involved in radio frequencies and microwave communication.
- They will also understand important aspects related to mobile communication systems useful for job opportunities in open market.

Suggested References:

Sr. No.	References
1.	Electronic Communication: D. Roody and J. Coolen Prentice Hall. Introduction to Solid State Physics by Charles Kittel, John Wiley & Sons, 7th edition,1996.
2.	Electronic Communication Systems: G. Kennedy, Mc-Graw Hill.
3.	Electronic Communication Systems: F. R. Dungan, Delmar Publishers Inc.
4.	Microwave Principles:, H. J. Reich, J. G. Skalnik, P. F. Ordung and H. L. Krauss, East-West Press Modern Microwave Technology, V. F. Velley, Prentice Hall.
5.	Nanomaterials: An introduction to synthesis, properties and applications, Dieter Vollath, Wiley-VCH Verlag GmbH, 2008.

On-line resources to be used if available as reference material
On-line Resources
• Introduction to Communication Engineering: https://nptel.ac.in/courses/117/102/117102059/ • Analog Modulation of Carriers, Amplitude Modulation, Angle Modulation, Single Side Band Modulation, Superheterodyne Receiver: https://nptel.ac.in/courses/117/102/117102059/ • Pulse Modulation Scheme:PWM, PPM https://nptel.ac.in/courses/117/102/117102059/ • Pulse Code Modulation; https://nptel.ac.in/courses/117/102/117102059/ • Mobile Wireless Communication: https://www.youtube.com/watch?v=4R1qHE0E8lE&t=27s

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY54**	Title of the Course	**Advanced Solid State Electronic Devices (EC)**
Total Credits of the Course	04	Hours per Week	04

Couse Objectives:	➢ This paper is designed to develop understanding of students in the area of various advanced electronic devices used in entire electronic industry. ➢ The included advanced devices in this paper are the work horse of day to day applications in all areas.

Course Content		
Unit	Description	Weightage* (%)
1.	**Heterojunction Bipolar Transistors**: BJT design limitations: Need for band tailoring and its methods, Hetrojunction bipolar transistor - Si based HBTs, GaAs/AIGaAs HBTs, InGaAs/InAlAs and InGaAs/InP HBTs, Techniques of channel isolation in field effect devices, JFET, MESFET : I-V characteristics, approximations used in I-V characteristics derivation, active and saturation regimes. Effects in real devices- Velocity field relations, Channel length modulation,	25%
2.	**Advanced Field Effect Devices**: Heterojunction FETs-Key motivations, Charge control model for MODFET, Current control in MODFET: Active and saturation regions, High frequency, high speed issues - Small signal characteristics, Equivalent circuit, Large signal analog applications and requirements of semiconductor parameters. Charge coupled devices, Advanced MOS devices-HMOS and SIMOX.	25%
3.	**MOSFET:** Metal Oxide Semiconductor capacitor, Accumulation, Depletion and Inversion regions, Capacitance-Voltage characteristics of the MOS structure, equivalent circuit of MOS capacitor, MOSFET, MOSFET structure, brief description of I-V characteristics, Depletion MOSFET and Enhancement MOSFET, Complementary MOSFETs, Important effects in long channel and short channel MOSFETs, High frequency issues.	25%
4.	**Optical Detectors and Emitters:** Optical absorption in semiconductors, photocurrent in a P-N diode, Photoconductive detector, P-I-N photodetector, Avalanche Photodetector, APD design issues,	25%

	Materials for light emitting devices, Internal and external quantum efficiency, LED performance issues, Light-current characteristics, Spectral purity, Temporal response, Advanced LED structures, Hetrojunction LED, Edge emitting LED, Surface emitting LED.	

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- After completion of this paper, the students will be able to understand the basic concepts involved in structure, operation and applications of all advanced devices used in present day semiconductor technology.
- The strengthened understanding of device physics will open ample opportunities for students in the semiconductor industry.

Suggested References:	
Sr. No.	References
1.	Semiconductor Devices - An introduction: Jasprit Singh, McGraw-Hill Inc.
2.	Physics of Semiconductors and their Heterostructures: Jasprit Singh, McGraw-Hill Inc.
3.	Semiconductor Optoelectronic Devices: Pallab Bhattacharya, Prentice Hall of India.

4.	Electronic Devices and Components: J. Seymore, Longman Scientific and Technical Publication.

On-line resources to be used if available as reference material
On-line Resources
• High Speed Devices and Circuits, Heterojunctions; https://nptel.ac.in/courses/117/106/117106089/ • MESFETs: I-V Characteristics, Velocity Field relation https://nptel.ac.in/courses/117/106/117106089/ • MODFET: https://www.youtube.com/watch?v=FHGopzr64XY • MOSFET: https://www.youtube.com/watch?v=MuBiC9yz2fc • Optical Sources and Detectors-I: https://www.youtube.com/watch?v=fnIebfgEgW8 • Optical Sources and Detectors-II: https://www.youtube.com/watch?v=F1fanv9OsDM

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY55**	Title of the Course	**Computer Programming in Python and Numerical Methods (CP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Provide knowledge and training of Python computer programming language 2. Train the students to design algorithms and write programs in Python for scientific computing 3. Impart knowledge of importrant numerical methods and its implementation in Python for solving science problems.

Course Content		
Unit	Description	Weightage* (%)
1.	Introduction to Python and its use in Science, The interactive Python pane, Python modules, Python interpreter, Script files and Programs, Comments, Simple Input & Output, Variables, Mathematical Operators, Lines in Python, Strings, Lists, Arrays and Dictionaries, Input and Output	25%
2.	Conditionals (`if, elif, else` etc.), Loops (`for, while`, etc.), List Comprehensions, Functions, Python functions, User-defined functions, Methods and Attributes SciPy, NumPy and MatPlotLib: Introduction and its preliminary applications	25%
3.	*Differential equations: Boundary-value and Eigenvalue problems* The shooting method, Linear equations and the Sturm--Liouville problem, Solution of one-dimensional Schrodinger equation, The Numerov algorithm, Green's function solution of boundary-value problem, Eigenvalues of the wave equation, The relaxation method, Ground water dynamics	25%

4.	*Data analytics for physics* Discrete Fourier transforms, fast Fourier transforms, noise reduction, spectral analysis for non-stationary signals, principal component analysis, fractal dimension determination,	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content. Hands on training in computer laboratory.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will	
1.	Be able to write and execute programs in Python to solve basic computational physics problems.
2.	Get the skill of using different libraries, packages and modules for data plotting and visualization, subroutines for numerical calculations.
3.	Be able to write and execute programs in Python to solve basic computational physics problems using different numerical methods.

Suggested References:	
Sr. No.	References
1.	Python from the Very Beginning, J. Whitington, Coherent Press, 2020.
2.	Programming and Problem Solving with Python, A. N. Kamthane and A. A. Kamthane, McGraw Hill Education (India) Private Limited (2018).
3.	Guide to NumPy, T. E. Oliphant, Second edition, Creatspace Independent Publisher, (2015).
4.	Introduction to Python for Science, D. Pine, 2019
5.	Computational Physics With Python, E. Ayars, 2013.

6.	Computational Problems for Physics: With Guided Solutions Using Python, R. H. Landau, M. J. Páez, CRC Press, Taylor & Francis Group (2018).
7.	An Introduction to Computational Physics, T. Pang, Second Edition, Cambridge University Press (2006).
8.	Computational Physics Fortran Version, S. E. Koonin and D. E. Meredith, CRC Press, Taylor & Francis Group (2018).

On-line resources to be used if available as reference material

On-line Resources
• A course on Computational Science and Engineering using Python https://nptel.ac.in/courses/115/104/115104095/
• Python Tutorial for Beginners https://python.land/python-tutorial • Python Tutorial https://www.w3schools.com/python/default.asp • A Beginners Guide to Python https://wiki.python.org/moin/BeginnersGuide

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY56**	Title of the Course	**Computational Physics-II (CP)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Provide essential knowledge of advanced computer simulation methods and tools used in computational physics for research. 2. Train the students to implement different computer simulation methods to study preliminary computational physics problems.

Course Content		
Unit	Description	Weightage* (%)
1.	*Monte Carlo Simulation*: Ensemble averages, The Metropolis algorithm (MA), Sampling in MA, updating the energy in MA, The Ising model, Example simulations of the Ising model, Monte Carlo for atomic systems, Simulations of atoms in the canonical (NVT) ensemble, Example calculations for "Lennard-Jonesium", Other ensembles, Time in a Monte Carlo simulation, Assessment of the Monte Carlo method, Uses of the Monte Carlo method in materials research	25%
2.	*Classical Molecular Dynamics (MD) Simulation*: Basics of molecular dynamics for atomic systems, Numerical integration of Newton's equations, Conservation laws, Examining the reliability of a simulation, Connection to thermodynamics, Initial conditions, Steps in an MD simulation, An example calculation, Potential cutoffs, Analysis of molecular dynamics simulations, "Lennard-Jonesium" as a model for materials, Spatial correlation functions, Time correlation functions, Velocity rescaling, Molecular dynamics in other ensembles, Accelerated dynamics, Limitations of molecular dynamics, Molecular dynamics in materials research	25%
3.	*Electronic structure Methods and Density Functional Theory*: Quantum mechanics of multi-electron systems, Early density functional theories, The Hohenberg-Kohn theorem, Kohn-Sham method, The exchange-correlation functional, Wave functions, Pseudopotentials, Use of density functional theory, Ab initio molecular dynamics, Car-Parinello simulation scheme.	25%

4.	*Genetic algorithm and programming* Basic elements of a genetic algorithm, the Thomson problem, continuous genetic algorithm, Other applications: molecules, clusters and solids, genetic programming. Biological Models: Population Dynamics & Plant Growth	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content. Hands on training in computer lab.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will	
1.	Acquire the knowledge of various important computer simulation methods and tools used for research in materials science
2.	Equipped with the knowhows of the essential methodology and algorithm involved in the computer simulation techniques.
3.	Be able to execute preliminary computer simulation programs to study computational materials science problems.

Suggested References:	
Sr. No.	References
1.	Introduction to Computational Materials Science : Fundamentals to Applications, R. Lesar, Cambridge University Press (2013)
2.	An Introduction to Computational Physics, T. Pang, Second Edition, Cambridge University Press (2006).
3.	Computational Problems for Physics : With Guided Solutions Using Python, R. H. Landau, M. J. Páez, CRC Press, Taylor & Francis Group (2018).
4.	Computational Physics Fortran Version, S. E. Koonin and D. E. Meredith, CRC Press, Taylor & Francis Group (2018).

5.	Computational Physics: Problem Solving with Computers, R. H. Landau, M. J. Páez, and C. C. Bordeianu, Second Edition, Wiley-VCH Verlag GmbH (2007).
6.	Computational Physics: Simulation of Classical and Quantum Systems, P. O. J. Scherer, Springer-Verlag Berlin Heidelberg (2010).

On-line resources to be used if available as reference material

On-line Resources

- Computational Physics (Online course on Swayam Portal) By Prof. A. Chatterji and Prof. P. Ghosh, IISER Pune https://onlinecourses.nptel.ac.in/noc21_ph20/preview
- Introduction to Computational Thinking and Data Science (Online MIT Course) By Prof. E. Grimson, Prof. J. Guttag and Dr. Ana Bell https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-0002- introduction-to-computational-thinking-and-data-science-fall-2016/index.htm
- Density Functional Theory http://www.ch.ic.ac.uk/harrison/Teaching/DFT_NATO.pdf

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY57**	Title of the Course	**Bio-Mass, Other Systems and Energy Storage (EST)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ In the present day scenario of depleting convention energy sources, this paper is designed to enhance the knowledge of students in the area of renewable energy and energy storage.

Course Content		
Unit	Description	Weightage* (%)
1.	**Biomass conversion processes and MHD**: direct combustion of biomass (incineration) thermo chemical conversion of biomass – biochemical conversion, Fermentation- ethanol gaseous fuels from biomass – applications of biomass energy conversion processes, introduction to the magnetohydrodynamics energy conversion – basic principle – segmented electrodes – description of typical open cycle MHD plant.	25%
2.	**Design aspects of MHD and Fuel Cells**: alternate MHD systems-technical particulars of conceptual MHD fundamental equations of MHD generation, introduction to the fuel cells and fuel cell power plants – advantages of fuel cell power sources – theory of electro-chemistry applied to fuel cells. Classification and types of fuel cells, fuels for fuel cells electrical circuit and performance characteristics of fuel cells.	25%
3.	**Introduction to the energy storage systems**: Energy storage systems for the electrical utility peak saving, pumped hydro energy storage plant, underground pumped hydro-compressed air energy storage. CASE with gas turbine peaking power plants, Huntor compressed air energy storage system with gas turbine power plant, battery energy storage systems, lead acid battery, Nickel-cadmium battery, advanced batteries superconducting magnet storage, advanced flywheel energy storage AFES.	25%
4.	**Thermal energy storage and Hydro Energy Systems**: Chemical reaction material energy storage, Hydrogen energy storage, Introduction to the hydro energy, Merits and demerits of the hydroenergy,	25%

	Hydroenergy resources in India, Types of hydro-electric plant and energy conversion schemes, Terms and definitions, Generation description, Typical hydro-electric power plant, Hydro-electric turbines, Specific speeds of hydroturbines, Impulse turbine, Reaction turbine, Choice of hydro-turbine, speed control and hydrothermal coordination, Merits of hydro-turbines, Types of turbines for small hydro, classifications, Mini, micro, small hydro-electric projects, Run-of river and storage plants, Environments aspects concerned with hydro power.	

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- By studying this paper the students will get an idea about production processes involved in production and applications of some non-conventional energy systems and energy storage.

Suggested References:	
Sr. No.	References
1.	Energy Technology (Non conventional, Renewable and conventional): S. Rao and Dr. P. B. Perulkar
2.	Solar Energy conversion, An introductory course:A. E. Dikon and J. D. Loslie

3.	Photoelectrochemical Solar Cells: Suresh Chandra Principles of Energy Conversion By Archie W. Cupl. Jr.

On-line resources to be used if available as reference material
On-line Resources
• Biomass Basics: https://www.youtube.com/watch?v=F1fanv9OsDM • MHD Power Generation http://www.digimat.in/nptel/courses/video/112105221/L44.html • Thermal Energy Storage Systems-Part-1: https://www.youtube.com/watch?v=0FSEKHc-COA • Hydroelectric Power: https://www.youtube.com/watch?v=i9yCpuiMze0

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Master of Science in Physics
M. Sc. (Physics) Semester IV

Course Code	**PS04EPHY58**	Title of the Course	**Nuclear Energy and Energy Strategies (EST)**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	➢ To cater the large scale energy need of the society, this paper is designed to enhance the knowledge of students in the area of nuclear energy and energy strategies.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction to the nuclear energy**: Historical background status and prospects nuclear energy application compared with coal, Fuels for nuclear fission reactor, Terms and definitions-nuclear fuel cycle-storage transportations. Nuclear fission and chain reaction, Moderators – energy from nuclear fission reactions, Uranium enrichment process – Nuclear reactor power plant, Fast breeder reactors, Boiling water reactor, pressurized heavy water reactor, and pressurized light water reactor Gas cooled reactor, Liquid metal fast breeder reactor, Nuclear waste management, Introduction to the nuclear fusion, Nuclear fusion reactions, Problems with nuclear fusion, Plasma confinement.	25%
2.	**Use of Plasma and Fossil Fules:** Toroidal magnetic confinement of plasma-magnetic mirror confinement, Laser inertial confinement reactors, Fusion-fission hybrid, Environmental and safety with nuclear fusion, Compact toroids, Introduction to the environmental aspects of energy and pollution control, terms and definitions. Pollution from use of energy, Combustion products of fossil fuels, Particulate matter, Electro-static precipitator (ESP), Fabric filter and bag house, Carbon dioxide, Green house effect and global warming, Emission of carbon monoxide, Pollution by sulphur dioxide and hydrogen sulphide, Emission of nitrogen oxides, Acid rains, Acid snow, Acidic fog and dry acidic deposit, FGD and SCR systems for cleaning flue gases.	25%
3.	**Hydrogen and Methanol based System:** Introduction to the hydrogen and methanol fuels, Applications of hydrogen, Productions of hydrogen, Storage and transportation of hydrogen, Methanol, Energy strategies, Energy management and energy conservation measures (Over view),	25%

	Efficiency of the energy converters, Primary resources of energy, National energy strategy of India, Essential steps in energy planning, Energy planning in India.	
4.	**Energy Strategies:** Growth of energy sector of India/world, issues on global warming and climate change, Planning in electrical power sector and the objectives in energy planning, Growth of India's energy sector, Petroleum sector in India, Planning of coal in India, Energy conservation Opportunities (ECOs) and Energy Conservation measures (ECMs), ECOs in electrical power supply sector, ECOs in transportation, ECOs in residential and commercial sectors, ECOs in industry sector, Energy management activities, Economic benefits, Nonconventional renewable sources of energy, Energy audit.	25%

Teaching-Learning Methodology	Lectures using traditional blackboard teaching as well as the ICT tools for effective delivery of the content.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes:

- ➢ Students will be able to understand processes involved in production, application and strategies of high energy systems based on nuclear processes.

Suggested References:	
Sr. No.	References
1.	Energy Technology (Non conventional, Renewable and conventional): S. Rao and Dr. P. B. Perulkar

2.	Solar Energy conversion, An introductory course: A. E. Dikon and J. D. Loslie
3.	Photoelectrochemical Solar Cells: Suresh Chandra
4.	Principles of Energy Conversion: Archie W. Cupl. Jr.

On-line resources to be used if available as reference material
On-line Resources
• Fundamentals of Nuclear Power Generation: https://nptel.ac.in/courses/112/103/112103243/ • Nuclear Reactors: https://www.youtube.com/watch?v=7U_CVtBCjaM • Introduction and overview of fuel cell: https://nptel.ac.in/courses/103/102/103102015/ • Energy Scenario and Basic Concepts: https://www.youtube.com/watch?v=O8zMD1eCbq0

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