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

	o The knowledge to interpret the results of important experiments like Stark effect, Zeeman effect, Quantum Hall effect, diamagnetism and paramagnetism etc. o 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. o 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. o 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 o Quantum mechanical approaches to study and understand relativistic systems. o 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, 6th 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, 2nd 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
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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,4th 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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