Learning Outcomes based Curriculum Framework (LOCF)

For

Ph.D. Physics Programme

Department of Physics
Chaudhary Devi Lal University
Sirsa-125055, Haryana
2022

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1. About the Department

The Department of Physics, Chaudhary Devi Lal University, Sirsa was established in 2004. Presently, the Department is located in CV Raman Bhawan of the University. The first batch of M. Sc. Physics was commenced in August, 2004. The department has produced about 600 postgraduate and 29 Ph.D. Scholars, and most of them are actively engaged in jobs in various fields. Currently, the department is running M.Sc. (two year) and Ph.D. programmes in Physics. The Department has two well aerated classroom for M.Sc. (Previous) and M.Sc. (Final) with proper sitting arrangement, electricity facility, projector and/or smart boards. The Department has one air-conditioned computer lab having twenty two computers with LAN internet facility. Also, the Department has three well-equipped laboratories for M.Sc. Physics Programme and four research laboratories for Ph.D. Physics Programme.

The holistic development of the students to compete the changing scenario of the world in the 21st century world is of prime importance. The Department of Physics is committed to impart quality education comprising academic knowledge and technical skills to all the students. Our aim is to increase their curiosity of knowledge and progression in learning; and to activate their full potential for academic excellence and for facing challenges of life during and beyond their study. While the pace and the path towards achieving these outcomes will vary from person to person, the goal of department for every physics research scholar/student is to inculcate and possess required academic capabilities/capacities by the time they graduate. The department is making sincere efforts to produce research scholars inculcated with critical thinking and problem solving, creativity and innovation, civic literacy, adaptability and other cognitive capacities necessary for successful life in the 21st century.

2. Learning Outcomes based Curriculum Framework

The Choice Based Credit Scheme (CBCS)evolved into learning outcome-based curriculum framework and provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

2.1 Objectives of the Programme

- Ph.D. Physics pass out scholars will have knowledge of various advanced research areas with philosophical aptitude and in-depth understanding of research on the topic of thesis work along with applications in diverse areas.

- Doctor of Philosophy degree holders will develop research and analytical skills which might include advanced laboratory techniques, numerical/theoretical methods, computer interfacing etc.

- After completing the degree of Ph.D. in Physics, the scholars will become effective researcher, scientist, teacher and/or technologist; and will be able to exhibit/conduct good research, scientific knowledge and temperament in diverse areas/fields/environment.
- The scholars will develop the skill to plan, execute with inspiring ideas and report on experimental and/or theoretical physics research problems with effective scientific approach in future endeavour.

2.2 Programme Outcomes (POs)

After completing the programme, the scholars have:

PO1	Knowledge with Learning Aptitude	Capability of demonstrating comprehensive disciplinary knowledge with research aptitude acquired during course work of study and to apply knowledge /skill in conducting research/ innovation/discovery.
PO2	Research & Problem Solving Aptitude	Capability to raise/ask relevant/appropriate questions/queries for identifying, formulating and analyzing the research problems and applying knowledge/skill for solving them with philosophical aptitude.
PO3	Investigation of Problems	Ability of critical thinking, analytical reasoning and research based knowledge including design of experiments/theoretical models and to provide fresh interpretation/analysis of data with conclusions/new findings.
PO4	Individual & Team Work	Capability to conduct research work effectively as an individual, and as a member or group leader in diverse nature of fields with multidisciplinary approach.
PO5	Communication & Society	Ability to communicate effectively on research /scientific topics with the scientific community and with the society at large relevant to professional scientific practices.
PO6	Ethics in Research	Capability to identify and apply ethical issues related to one's work, avoid unethical behavior such as fabrication of data, committing plagiarism and unbiased truthful actions in all aspects of work in the research.
PO7	Modern Tool Usage	Ability to use and learn techniques, skill and modern tools for scientific practices.
PO8	Project Management	Ability to demonstrate knowledge and understanding of the scientific principles and apply these to manage research projects.

2.3 Programme Specific Outcomes (PSOs)

After completing the programme, the scholars:

PSO1	Aquire an in-depth research oriented knowledge and understanding of the core/specific/skill areas of physics in experimentation/ theoretical explanation of physical phenomena covering wide range and time scales.
PSO2	Be capable of applying the core/basic laws of physics to reveal a multitude of physical properties, processes, and effects involving radiation, nuclei, atoms, ions, molecules, bulk matter and nanomaterials.
PSO3	Develop hands-on skills for carrying out basic/applied research using advanced experiments/theories in different research fields of Physics viz. nanomaterials, ,nonlinear dynamics, laser physics, condensed matter physics, materials science, computational physics, nanotechnology, high energy physics & opto-electronics, along with enhancing understanding of physical and theoretical concepts.
PSO4	Attain abilities of critical thinking, problem mapping & solving using fundamental principles of Physics, systematic analysis & interpretation of results, and unambiguous oral & writing/presentation skills, in order to conduct quality research work in diverse fields.

3. Programme Structure

Ph.D. Physics Programme having: (i) One-semester Pre-Ph.D.Course in Physics with 16 credits weightage consisting of Core Courses (CC), Discipline Specific Elective Courses (DSC), Skill Enhancement Courses (SEC) (ii) Research Work for Ph.D. Thesis on a topic after registration for partial fulfillment of the degree of Ph.D. in Physics.

Department of Physics
Chaudhary Devi Lal University, Sirsa (Hry.)

Learning Outcomes based Curriculum Framework (LOCF)

For

Pre-Ph.D. Course Work in Physics (Choice Based Credit System)
(One semester course)

Under

Ph.D. Programme in Physics - PhD/Phy

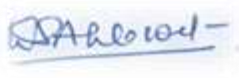
Scheme of Examination and Syllabi Session 2021-22

Semester-I

Paper	Course Code	Title of Course	Teaching Hours per week	Credits	Internal Assessment/ Evaluation	End term Examination	Total	Duration of Exam.(Hrs.) Theory/ Practical
Paper-I	PhD/Phy/1/SEC 1	Research Methodology	4	4	30	70	100	3
Paper-II	PhD/Phy/1/CC1	Advances in Physics	4	4	30	70	100	3
Any one of the following discipline electives (PhD/Phy/7/ DSC1-A , PhD/Phy/7/ DSC1-B, PhD/Phy/7/ DSC1- C)								
Paper-III	PhD/Phy/1/ DSC1-A	Nano Science & Technology	4	4	30	70	100	3
	PhD/Phy/1/ DSC1-B	Laser & Spectroscopy						
	PhD/Phy/1/ DSC1- C	Non-linear Dynamics						
Paper-IV	PhD/RPE-4	Research and Publication Ethics or Its MOOC available on SWAYAM portal*	2	2	20	30	50	3
Total				14			350	

- **SEC:** Skill Enhancement Course, **CC:** Core Course, **DSC:** Discipline Specific Elective Course.

***Note:** "Research Ethics" (2 credits) paper equivalent to "Research Ethics" by Sh. Manoj Kumar K. Central University of Himachal Pradesh, National Co-ordinator CEC- 04 credits (15 weeks) or "Research Ethics and Plagiarism" by Dr. Gaurav Singh, IGNOU, National Co-ordinator, IGNOU 02 credits (8 weeks) available on SWAYAM portal. Research Scholar will be free to complete the online course before submission of Ph.D. thesis. Further, if a student has completed this course in online mode from SWAYAM portal before admission in the Ph.D. Programme the same will also be considered for this purpose.




General instructions:

1. The discipline selective courses will be allotted to the students on the basis of their preference, merit and availability of seats under the concerned research supervisor.
2. The Ph.D. Ordinance (LOCF with Choice Based Credit System) of the university shall be followed by the department.

PhD/Phy/1/SEC1: Research Methodology

Credits: 4 **Max. Marks: 70**
Periods per week: 4 Hrs. **Duration of Exam.: 3 Hrs.**

Objective: This course conveys a broad knowledge about the plan and design of research and provides systematic structure. Help students to develop better insight into topic.

Course outcomes:
CO1: Realize the basics of objectives, types, scope and process of research
CO2: Describe the methods of data collection and characteristics of hypothesis.
CO3: Able to calculate errors in data analysis.
CO4: Have an understanding about writing scientific paper, journal impact factor and preparation of research dissertation.

Note for the Paper Setter: *The question paper will consists of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Unit-I

Introduction: Concept of research; characteristics features of research, Types of research, objectives of research, Review of Literature. Scope of research, validity and reliability of research, Process of research: steps involved in research process, Selecting a research topic, Planning and designing research, Criteria of good research, Rules and principles of scientific methods.

Unit-II

Science and Technology, Scientific attitude, Scientific temper, Scientific Community, Scientific Statement, Data collection, Need for data collection, Methods of data collection, Analysis and interpretation of data**,** Meaning of hypothesis, Importance of hypothesis, Types of hypothesis, Source of hypothesis, Characteristics of hypothesis, Use of hypothesis in research, Different form of hypothesis, Difficulties in the formation of hypothesis, Testing of hypothesis.

Unit-III

Errors & Curve Fitting: Errors- Round off error, Truncation error, Machine error, Random error, Propagation of errors. Loss of Significance: Significant digits, Computer caused loss of significance, Avoiding loss of significance in subtraction, Least square curve fitting: The principle of least square fitting, Linear regression, Polynomial regression, Fitting exponential and trigonometric functions.

Unit-IV

Preparation of Dissertation: Reading a scientific paper, Writing a scientific paper, Communicating to a journal, Journal impact factor, Citation index, h-index, g-index, hg-index, Seminar, Conference and Workshops, Types and layout of research, Precautions in preparing the research dissertation, Bibliography and annexure, Discussion of results, Draw conclusions, Giving suggestions and recommendations to the concerned persons.

Text and Reference Books:

1. Prathapan K. (2014). Research Methodology for Scientific Research. New Delhi: I. K. International Publishing House Pvt. Ltd.
2. Kumar R. (2011). Research Methodology. New Delhi: Sage Publications India Pvt. Ltd.
3. Kothari C.R. (2019). Research Methodology: Methods & Techniques. New Delhi: New Age International Publishers.
4. Patil P.B. and Verma U.P. (2009). Numerical Computational Methods. United Kingdom: Alpha Science International Ltd.
5. Sastry S.S. (2012). Introductory Methods of Numerical Analysis. New Delhi: PHI Learning Pvt. Ltd.
6. Gupta S. (2002). Research Methodology and Statistical Techniques. Canada: Laurier Books, Limited.

Mapping matrix of COs, POs and PSOs of PhD/Phy/1/SEC1: Research Methodology

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	2	2	2	2	2	3	2	2	3
CO2	2	2	3	2	3	2	3	3	3	2	2	2
CO3	2	2	2	2	2	2	3	2	3	2	2	3
CO4	2	2	2	2	2	2	2	3	2	2	2	3
Average	2.25	2.25	2.5	2	2.25	2	2.5	2.5	2.75	2	2	2.75

PhD/Phy/1/CC1: Advances in Physics

Credits: 4 **Max. Marks: 70**
Periods per week: 4 Hrs. **Duration of Exam.: 3 Hrs.**

Objective: This course will develop the understanding about advanced materials in physics. This course equips students to learn thin film deposition processes, smart materials and optical properties.

Course outcomes:
CO1: Acquire knowledge about thin film deposition processes and their thickness measurement.
CO2: Learn basics about various smart materials.
CO3: Understand the basic characteristics of optical materials and optical properties.
CO4: Know main aspects of field Quantization and field equations (Classical and Quantum).

Note for the Paper Setter: *The question paper will consists of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Unit-I

Thin film deposition processes: Resistive heating, R.F. heating, Electron bombardment heating, Laser ablation, RF, DC & Ion beam sputtering, Electrodeposition, Chemical vapor deposition, MOCVD, PECVD, Choice of thin film substrates.
Measurement of thickness of thin films; Basic principle involved in optical, electrical, mechanical and radiation based thickness measurement techniques.

Unit-II

Introduction to smart materials, Principles of piezoelectricity, Perovskite piezoceramic materials, piezoelectric polymers, Multiferroics and magnetoelectrics, Smart actuators, Principles of magnetostriction, Rare earth magnetostrictive materials, Giant magnetostriction and magnetoresistance effect, Shape memory alloys.

Unit-III

Intensity dependent refractive index, Nonlinear optical materials, Phase matching, Saturable absorption ,Photochoromic and electrochromic materials, Optical properties of semiconductors, Second –order optical nonlinearity, Third order optical nonlinearity, Second order susceptibility, Poled ploymers, Photosensitive and photothermal materials, Photo refractive materials and their applications.

Unit IV

Field Quantization (brief idea), Classical and Quantum field equations: Coordinates of the field, Time derivatives, Classical Lagrangian equation, Classical Hamiltonian equations; Quantum equation of the field, Field with more than one component, Complex field, Quantization of the non relativistic Schrodinger equation (Second quantization): Classical Lagrangian and Hamiltonian equations, Quantum field equations.

Text and Reference Books:

1. Thyagarajan K.and Ghatak A. K. (1981). Laser: Theory and Applications. London: Cambridge University Press.
2. Davis C. C. (2014). Laser and Electro-optics. London: Cambridge University Press.
3. Silfvast W. T; (2008). Laser Fundamentals. London: Cambridge University Press.
4. Simmons J. H. and Potter K.S. (1999). Optical Materials. London: Elsevier.
5. Maissel L. I. and Glang R. (1970). Hand book of Thin Film Technology. New York: McGraw Hill Higher Education.
6. Chopra K. L. (1969). Thin Film Phenomena. New York: McGraw-Hill Book Company.
7. Ohring M. (2001). Materials Science of Thin Films. Cambridge: Academic Press.
8. Schiff L. I. (1969). Quantum Mechanics (3rd Edition). Singapore:McGraw Hill/Asia.
9. Sakurai J. J. (1967). Advanced Quantum Mechanics. London:Pearson.
10. Shahinpoor M. (2020). Fundamentals of Smart Materials. London: Royal Society of Chemistry.
11. Mittemeijer E. J. (2010). Fundamentals of Materials Science. New York: Springer.
12. Kittel C. (2012). Introduction to Solid State Physics. New York: Wiley.
13. Dekker A. J. (2008). Solid State Physics. New Delhi: Laxmi Publications.

Mapping matrix of COs, POs and PSOs of PhD/Phy/1/CC1: Advances in Physics

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	2	2	3	2	3	3	2	2
CO2	2	2	2	2	2	2	3	2	3	3	2	2
CO3	2	2	2	2	2	2	3	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2
Average	2	2	2	2	2	2	2.75	2	2.5	2.5	2	2

PhD/Phy/1/ DSC1-B: Laser & Spectroscopy

Credits: 4 **Max. Marks: 100**
Lectures: 60 **Final Term Exam.: 70**
Duration of Exam.: 3 Hrs. **Internal Assessment: 30**

Objective: To provide essential knowledge on advancement in some laser based techniques, nonlinear optics and laser spectroscopy methods.

Course outcomes:
CO1: Understanding diode lasers and unique properties of laser light for applications.
CO2: Students acquired basics of non-linear optics and new frequency generation useful in research.
CO3: Students inspired on some research techniques using lasers to study materials properties.
CO4: Students inspired on some laser spectroscopy methods for characterization of materials for their potentiality.

Note for the Paper Setter: *The question paper will consists of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Unit – I

Coherence property of laser radiation and laser safety, Laser systems: Er-doped silica fiber laser, Ti: Sapphire laser, Developments in semiconductor laser; Double heterostructure and Quantum-well semiconductor lasers, Distributed feedback laser, Diode laser array, Applications of lasers in data storage, Conventional holography. Introduction to speckle phenomenon.

Unit – II

Maxwell's equation in non-linear medium, Steady state nonlinear optical effects, Slowly varying envelope approximation, Classical, Semi-classical and Quantum approaches (Elementary Idea only), Nonlinear polarization & susceptibilities, Three wave mixing phenomenon, Sum & difference frequency generation, Phase matching conditions, Parametric amplification and oscillation, Second harmonic generation and its conversion efficiency.

Unit – III

Stimulated Brillouin scattering,Phase shifting interferometry, Optical phase conjugation,Brief idea of hologram recording materials,Real time holography, Two photon absorption, Z-scan technique, Self-focusing and self-defocusing phenomena and its applications, Induced dipole moment,Time resolved spectroscopy technique.

Unit – IV

Principle, construction and applications of techniques: Laser Raman spectroscopy, Photoacoustic spectroscopy, High sensitivity methods of absorption spectroscopy; intracavity absorption (using single and multimode operation), Fluorescence excitation spectroscopy, Fabry-Perot spectroscopy, Laser induced fluorescence spectroscopy.

Text and Reference Books:

1. Verdeyen, J.T. (1995) Laser Electronics: Pearson
2. Davis C. C. (2014) Lasers and Electro-Optics: Cambridge University Press.
3. Silfwast, W. T. (1998) Lasers Fundamentals: Cambridge University Press.
4. Ahlawat, D.S. (2017) Basic Concepts of Laser Physics: Mittal Publications, New Delhi.
5. Svelto, O. (1982) Principles of Lasers: Plenum Press, New York.
6. Ghatak, A. & Tayagrajan, K. (2011) Optical Electronics: Cambridge.
7. Ghatak, A. & Tayagrajan, K. (2005) Laser Theory & Applications: Macmillan, Delhi
8. Demtroder, W. (1996) Laser Spectroscopy : Springer.
9. Demtroder, W. (2015) Laser Spectroscopy 2 : Springer.
10. Laud, B.B. (2020) Lasers and Non-linear Optics: New Age International.
11. Nagabhushana S. & Sathyanarayana N. (2010) Laser and Optical Instrumentation: I.K. International.

Mapping Matrix of COs, POs & PSOs of PhD/Phy/1/ DSC1-B: Laser & Spectroscopy

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2.0	1.5	2.0	1.5	1.5	1.0	2.0	2.0	2.5	2.5	2.5	2.0
CO2	2.0	1.5	2.0	1.5	1.5	1.0	2.0	2.5	2.5	2.0	1.5	2.5
CO3	2.5	2.5	2.5	1.5	2.0	1.0	2.5	3.0	3.0	2.0	2.5	2.5
CO4	3.0	2.5	2.5	1.5	2.0	1.0	3.0	3.0	3.0	2.5	2.5	2.5
Average	2.4	2.0	2.25	1.5	1.75	1.0	2.38	2.63	2.75	2.25	2.25	2.38

PhD/Phy/1/ DSC1-A: Nanoscience and Technology

Credits: 4 **Max. Marks: 70+30**
Periods per week: 4 Hrs. **Duration of Exam.: 3 Hrs.**

Objective: The objective of this course is to provide scholars with basic knowledge of nanoscale materials and their properties. This course will also discuss the synthesis and characterization techniques of nanomaterials.

Course Outcomes:
CO1: Scholars will be able to understand how reducing the size of a material to the nanoscale, can change electronic energy states and hence the physical properties of nanomaterials.
CO2: The scholar will get enough knowledge about various top-down and bottom-up approaches for the synthesis of nanomaterials.
CO3: Scholars will be aware of the various characterization techniques for nanomaterials.
CO4: In-depth knowledge of the emergence of nanotechnology and its applications in various fields will be well understood by scholars.

Note for the Paper Setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Unit-I (Physical properties of Nanomaterials)

Quantum Confinement: 1D, 2D, and 3D nanostructure, Density of states, Exciton, Surface plasmon, Energy bands; Size effect, specific surface area, Classification of nanomaterials/nanostructures; Semiconductor quantum well, wire and dot; Structural, Optical, Chemical, Mechanical, Magnetic, dielectric properties of nanoparticles; Emergence of nanotechnology and its applications.

Unit-II (Synthesis of Nanostructured materials)

Top-down and Bottom-up approaches, Physical Processes: Ball milling, Ion beam sputtering, Inert gas condensation, Arc discharge, RF- plasma, Plasma arc technique, Pulsed laser deposition, chemical vapor deposition, Chemical Processes: Sol-gel, Co-precipitation, Electro-deposition, Hydrothermal, Solvothermal synthesis methods.

Unit-III (Microscopic Techniques)

Principle, instrumentation, methodology, and applications of the following techniques:
Optical Microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), BET Surface Area and Porosimetry, Scanning Probe Microscopy, Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy, Vibrating Sample Magnetometry (VSM).

Unit-IV (Spectroscopic Techniques)

Principle, instrumentation, methodology, and applications of the following techniques:
X-ray diffraction (XRD), Energy-dispersive X-ray Fluorescence (EDX/EDS), X-ray Photoelectron Spectroscopy (XPS/ESCA). UV-Visible Spectroscopy, Fourier Transform Infrared spectroscopy (FTIR), Luminescence and its types, Raman spectroscopy, Jablonski diagram.

Text/Reference Books:

1. Cao, G. (2011). Nanostructures & Nanomaterials. Singapore: World scientific publishing.
2. Poole, C. P. & Qwens, F. J. (2003). Introduction to Nanotechnology. New Delhi: Wiley-Interscience.
3. Hornyak, G. L., Tibbals, H. F., Dutta, J. & Moore, J. H. (2008) Introduction to Nanoscience & Nanotechnology. Florida: CRC press.
4. Wilson, M. et al. (2002). Nanotechnology. Florida: CRC press.
5. Jain, K. P. (1997). Physics of Semiconductor Nano Structures. New Delhi: Narosa.
6. Davies, J. H. (1997). Physics of Low Dimensional Semiconductors. Cambridge: Cambridge University Press.
7. Fendler, J. H. (Ed.). (1998). Nanoparticles and Nanostructured Films. Germany: Wiley-VCH.
8. Harrison, P. (2016). Quantum Wells, Wires and Dots. New York: Wiley.
9. Edelstein, A. S. & Cammarata, R. C. (1998). Nanomaterials: Synthesis, Properties & Applications. Florida: CRC press.
10. Dresselhaus, M. S., Dressclhaus, G. & Avoris, Ph. (2001). CNT- Carbon Nanotubes: Synthesis, Structure, Properties and Applications. New York: Springer.
11. Harrison Paul (2016) Quantum Wells, Wires & Dots. New York: John Wiley & Sons

Mapping matrix of COs, Pos, and PSOs of PhD/Phy/1/ DSC1-A: Nanoscience and Technology

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO 8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	3	2	3	2.5	1.5	2	3	2	2	2
CO2	2.5	2.5	2	1.5	3	2	1.5	2.5	2	2	1	2
CO3	2	2	2	2	2	3	3	3	3	1	2	1
CO4	2	2.5	2.5	1.5	2	2.5	3	2	2	2	3	2
Average	2.12	2.25	2.37	1.75	2.5	2.5	1.5	2.37	2.5	1.75	2	1.75

PhD/Phy/1/ DSC1-C: Nonlinear Dynamics

Credits: 4 | **Max. Marks: 100**
Lectures: 60 | **Final Term Exam.: 70**
Duration of Exam.: 3 Hrs. | **Internal Assessment: 30**

Course Objectives : : The main objective of this course is to is to to expertise the students about various theoretical models used in nonlinear physics, After going through this course, the students are supposed to understand fundamental of nonlinear dynamics. The course concentrates on simple models of dynamical systems, and their relevance to natural phenomena. The contents of the study introduce the students to the basic concepts of nonlinear systems, dynamical theory, integrability, solitons, and chaos. These concepts will be demonstrated using simple models based on ordinary & partial differential equations and discrete maps. At the end of the course, students will be able to grasp the fundamentals concepts of nonlinear dynamics and capable to implement such phenomenon in society, science and engineering

Course Outcomes: After successful completion of the course on Fundamental of Electronics, a student will be able to:

CO1: Students will gain the basic knowledge and familiarity about dynamical system and theory of both linear and nonlinear systems.
CO2: Students will learn about the integrability of dynamical systems and to familiarize the different types of invariant and constant of motion for both time dependent and time independent dynamical systems describing the trajectory of a system.
CO3: It will be benefited to the student to learn about the solitons, compactons , various types of solitons, nonlinear equation like KdV, mKdV and generalized KdVs equation and its solitonic solutions.
CO4: Students would be enabled to learn about various chaoitic systems and their behavior. It emphasis on the bifurcation, strange attractor, fractals and various types of attractors.

Note for the Paper Setter: *The question paper will consists of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Unit – I

Linear and Nonlinear Systems : Introduction, Dynamical systems, Linear and Nonlinear Systems, Effects of Nonlinearity, Linear oscillators and Predictability - Free Oscillations, Damped oscillations, Damped and Forced Oscillations, Damped and Driven Nonlinear Oscillators- Free Oscillations, Damped oscillations and Forced Oscillations, Subharmonic and Superharmonic resonances, Nonlinear oscillations and bifurcations .

Unit – II

Integrability : Introduction, Integrable and Nonintegrable systems, Different types of Invariants, some formal remarks about the dynamical invariants, Invariants for time independent (TID) systems, Forms of second invariant, Method of Construction of second invariant for TID systems, Nonintegrable and Superintegrable systems, Invariants for time dependent (TD) systems, Methods for construction of TD invariants in one dimension.

Unit – III

Solitons : Linear Waves, Linear Dispersive Wave propagation, Wave packet and dispersion, Nonlinear dispersive systems, Solitons, Compactons, Solitary waves, Types of travelling wave solutions, John Scott Russel's great wave of translation, The Birth of Solitons, Simple idea of KdV and mKdV equations, Solitary wave solutions and Basic Solutions- Pulse soliton, Envelope solitons, Spin solitons, The Sine-Gordan equation-Kink, Antikink and Breathers .

Unit – IV

Chaotic dynamics : Introduction, Bifurcation, Saddle-node bifurcation, The pitchfork bifurcation, Transcritical bifurcation, Hopf bifurcation, Bifurcation diagram, Limit cycle-Attractors, N- Torus, Strange attractor, Chaos, Chaos on a strange attractor, Poincare sections, Lyapunov exponents, Logistic map (Numeric and analysis), Lorenz equations, Simple Properties of Lorenz equations, Lorenz map, Fractals, Kolmogorov-Arnold-Moser (KAM) Theorem

Text and Reference Books:

1. Lakshmanan M. and Rajasekar S. (2003). Nonlinear Dynamics Integrability, Chaos and Patterns. New York : Springer
2. Kaushal, R.S.(1998). Classical and Quantum Mechanics of Noncentral Potentials. New Delhi : Narosa Publishing House
3. Strogatz S. H. (1994) . Nonlinear Dynamics and Chaos. New York : Perseus Books Publishing
4. Alligood K. T., Sauer T. D and Yorke J. A. (1997). Chaos – An Introduction to Dynamical Systems. New York : Springer.
5. Upadhyaya J.C. (2010). Classical Mechanics , Mumbai : Himalaya Publishing House .
6. Verma, R. C. , Ahluwalia P.K. & Sharma K.C. (2014). Computational Physics an Introduction. New Delhi : New Age International Publisher.

Mapping Matrix of COs, POs & PSOs of PhD/Phy/1/ DSC1-C: Nonlinear Dynamics

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	3	2	3	2	3	2	2	3
CO2	2	2	2	2	3	3	2	3	2	3	2	2
CO3	3	3	2	3	3	3	3	2	3	2	3	3
CO4	2	3	3	3	2	2	3	2	3	3	3	3
Average	**2.50**	**2.75**	**2.25**	**2.50**	**2.55**	**2.5**	**2.75**	**2.25**	**2.75**	**2.50**	**2.50**	**2.75**