SCHEME OF EXAMINATION

AND SYLLABI

w.e.f Academic Year 2024 onwards

DOCTOR IN PHILOSOPHY

Scheme and Syllabus for

a. **Physics**
b. **Chemistry**
c. **Mathematics**

Offered by

University School of Basic & Applied Sciences
at
GGSIP University Campus, Dwarka

Approved in the 59th meeting of the academic Council of GGSIP University held on 25/09/2024 vide agenda item AC 59.24

Vision of the Program

The major purpose of the PhD programme is to achieve advance knowledge in the chosen field of research so that students can take on future research challenges for the benefit of society.

Mission of the Program

The main goal of the Doctor of Philosophy (Ph.D.) programme in Physics, Chemistry, and Mathematics is to prepare students for original research and to foster autonomous and inventive thinking, which are necessary for a successful research career in science.

Programme outcomes (POs)

1. Creative and Critical Reasoning

- The students will use creative & critical thinking to generate new and imaginative ways to understand and evaluate their research topic.
- The students will be able to develop new and better ideas and methods.

2. Information and Data Gathering

- Students will be able to validate their results by doing a thorough investigation of documented literature.
- Student will be able to take decisions related to the information available.

3. Communication Skills

- As students Participate in seminars, research group meetings and competitions, all these enhance the communication skills of the students.
- workshops and seminars, peer review groups, presentation and writing resources, and tutorials are also part of this programme.
- Through conference talks, poster presentations, and teaching, you will learn to feel comfortable in front of a larger audience, engage them, and present complex ideas in a straightforward way.

4. Analytical Reasoning

- Student will be able to understand the concepts or the intentions behind what is written.
- As problem solution and its analysis is one of the part of this programme it will enhance the critical thinking skills of the student

Programme Specific Outcomes (PSOs)

1. **Critical Thinking:** Read, analyze, and write logical arguments to prove mathematical concepts.
2. **Knowledge:** students will be able to identify and conduct original research.
3. **Ethical and Responsible Research:** students will conduct research in an ethical and responsible manner
4. **Effective Communication:** students will effectively communicate their field of study.
5. **Research Aptitude:** Students would be able to develop their research aptitude and orientation.
6. **Statistics Tools:** Students would be acquainted with the statistics tools involved in the research methodology like, Mat Lab etc.

Programme Outcomes (PO) to Programme Specific Outcomes (PSO) Mapping (Scale 10)						
PO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
PO1	5	7	5	7	9	9
PO2	6	8	9	6	9	9
PO3	4	5	9	9	9	8
PO4	3	7	8	9	8	8

S. No.	Paper ID	Paper Code	Paper Name	L	P	Credits
1.	904701, 905701. 945701	RPE-701	Research and Publication Ethics	2 NUES	0	2
2.	904101, 905101. 945101	CWP-101, CWC-101, CWM-101	Research Methodology for Science & Technology	4	0	4
3.	904102, 905102. 945102	CWP-102, CWC-102, CWM-102	Introduction to MATLAB and Computational Methods - Theory	2	0	2
4.	904103, 905103. 945103	CWP-103, CWC-103, CWM-103	MATLAB and Computational Method - Practical	0	2	2
5.	904104, 905104	CWP-104, CWC-104	Advanced Characterization Techniques	4	0	4
6.	904105, 905105	CWP-105, CWC-105	Synthesis of Nanomaterials & Introduction to Nanocomposites	4	0	4
7.	904106	CWP-106	Thermoluminescence dosimetry	4	0	2
8.	904107	CWP-107	Ion Beams In Material Science	4	0	4
9.	904108	CWP-108	Solar Radiation and Solar Photovoltaic Science and Engineering	4	0	4
10.	904109	CWP-109	Nanostructured Thermoelectric Materials	4	0	4
11.	905106	CWC-106	Heterocyclic Chemistry & Synthon Approach	4	0	4
12.	905107	CWC-107	Synthesis, Isolation and Purification of Air Sensitive Compounds	4	0	4
13.	905108	CWC-108	Natural Products and Instrumentation	4	0	4
14.	905109	CWC-109	Synthesis and Application of Organophosphorus Compounds	4	0	4
15.	905110	CWC-110	Biological Chemistry	4	0	4
16.	945104	CWM-104	Nonlinear Dynamics	4	0	4
17.	945105	CWM-105	An introduction to fuzzy mathematical programming	4	0	4
18.	945106	CWM-106	Wavelet Analysis	4	0	4
19.	945107	CWM-107	Space Dynamics	4	0	4
20.	945108	CWM-108	Lie groups and Homogeneous spaces	4	0	4
21.	945109	CWM-109	Mathematical Modelling and Ecology	4	0	4
22.	945110	CWM-110	Stochastic Process, Queuing Theory & Reliability	4	0	4
23.	945111	CWM-111	An Introduction to Financial Mathematics	4	0	4
24.	945112	CWM-112	Differentiable Manifolds	4	0	4

<table>
<tr><td>Paper Code:
CWP-101, CWC-101, CWM-101</td><td>Paper: RESEARCH METHODOLOGY FOR SCIENCE & TECHNOLOGY</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
904101, 905101, 945101</td><td></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td colspan="5">Marking Scheme:
• Teachers Continuous Evaluation: 40 marks
• Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="5">Instructions for paper setter:</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="4">To expose the scholars for some details associated with the theoretical and experimental research in the different branches of sciences and the technologies involved.</td></tr>
<tr><td>2:</td><td colspan="4">Learn methods to devise and design a research set-up</td></tr>
<tr><td>3:</td><td colspan="4">Planning their research career</td></tr>
<tr><td>4:</td><td colspan="4">Conclude research in report writing and meaningful interpretation.</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td colspan="5">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="4">Students will learn basic concepts of research and importance.</td></tr>
<tr><td>CO2:</td><td colspan="4">Collect data through experiments or survey as per research requirement.</td></tr>
<tr><td>CO3:</td><td colspan="4">Develop understanding on various kinds of research, objectives of doing research, research process</td></tr>
<tr><td>CO4:</td><td colspan="4">Write research report, research proposal with proper citations.</td></tr>
<tr><td colspan="5">Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)</td></tr>
</table>

CO/PO	PO1	PO2	PO3	PO4
CO1	3	3	3	3
CO2	2	3	2	1
CO3	3	2	3	3
CO4	3	3	2	3

UNIT-I
Basic concepts in Scientific approach to research: Introduction of high education and importance of higher education in society, importance of information and communication technology (ICT) in higher education. Overview of research institutes related to Physics, Chemistry and Mathematics in India. Overview of Indian Scientific and funding agencies. Rules and regulations and funding agencies for Ph.D. students of attending National and international conferences/seminars/workshops/fellowships/awards etc. Overview of Indian Science Academy, Overview of research scenario in India. Definition, motivation & significance of research, types of research, research process and steps in conducting research; planning research-Problem identification and formulation; Research design.
UNIT-II
Literature survey, Report writing and Journals: Review of the publisher research in the relevant field; Reviewing literature; Report Preparation, Structure of Report, Report Writing Skills, Research Papers,; formulation of research projects proposal, ethical issues, bibliography, introduction of Mendeley software, types of reports, Types of journals, overview of Web of Science, Scopus, Open Access journals, impact factors of journal as per, citations etc., h-index, i-index etc.
UNIT-III
Plagiarism & Software tools: Definition, types of plagiarism, unintentional plagiarism, mechanisms for avoiding plagiarism. types of plagiarism, overview of Turnitin and Urkund plagiarism software, introduction of origin and Gaussian software's etc., one visit for research centre.
UNIT-IV
Invention, Innovation, IPR: Understanding of invention & innovation and its role in economic development; patents & copyrights, trademark, legislations & administrative covering IPRs in India, importance & basic knowledge of Intellectual Property Right (IPR); what can and cannot be protected.

Note: *In the backdrop of the above, the assignments may be in the context of the chosen research field of the scholar, and may be designed to facilitate in identity the topic and in the process of Synopsis preparation for their respective proposed research. The work out format for the assignments must be intensively participatory; may be conducted by way of presentations and participative discussions in class*

SUGGESTED REFERENCES

1. Research Methodology Methods and Techniquest - C.R. Kothari, New Age Intl. Pub. (2004)
2. Business Statistics for contemporary decision making- Ken Black, John Wiley and Sons, Inc. 2010.
3. Research Methodology (Concept and Cases)-Deepak Chawla & Neena Sodhi, Vikas Publication House (P) Ltd. (2011)
4. Research Methodology- Dr. Debashis Chokarvaty, Surbhi (P) Ltd. (2010)
5. Research Methodology-Navin Sharma, Deep & Deep (P) Ltd. (2007)
6. Ranjit Kumar (2006), Research Methodology, Delhi Pearson Education
7. "The Role of Invention, Innovation And The Industrial Property System in Economic Development, available at the website: www.wipo.int/cdocs/mdocs/innovation/en/.../wipo_inn_cai_97_1.doc
8. Joseph Gibaldi (1999 15th edition), MLA Handbook for Writers of Research Papes, New Delhi, Affiliated East West Press.
9. *"On being A Scientist: A guide to responsible conduct in research"* National Academies Press (2009)

Approved in the 59th meeting of the academic Council of GGSIP University held on 25/09/2024 vide agenda item AC 59.24

<table>
<tr><td>Paper Code:
CWP-102, CWC-102, CWM-102</td><td colspan="2">Paper: Introduction to MATLAB and Computational methods -Theory</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
904102, 905102. 945102</td><td colspan="2"></td><td>2</td><td>-</td><td>2</td></tr>
<tr><td colspan="6">Marking Scheme:
Teachers Continuous Evaluation: 40 marks
Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="6">Instructions for paper setter:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="5">Introduce the students from diverse backgrounds to the importance of computational techniques and to expand their mathematical skills in areas of numerical methods.</td></tr>
<tr><td>2:</td><td colspan="5">Introduce and train students in computational methods with MATLAB as the programming language</td></tr>
<tr><td>3:</td><td colspan="5">Expose students to introductory topics and the basics of numerical techniques and programming. Problems are selected from a list which is updated from time to time in tune with the needs of industry/research and topical subjects.</td></tr>
<tr><td>4:</td><td colspan="5">Educate students to learn the logic behind solving problems related to real physical examples, simulation, modelling and designing the algorithms and translating them into programmes</td></tr>
<tr><td></td><td colspan="5"></td></tr>
<tr><td colspan="6">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="5">The students are expected to develop the flavour of modelling and simulation.</td></tr>
<tr><td>CO2:</td><td colspan="5">To generate working knowledge of MATLAB.</td></tr>
<tr><td>CO3:</td><td colspan="5">To gain working knowledge of Monte Carlo methods, Time series analysis method for application to real life problems.</td></tr>
<tr><td>CO4:</td><td colspan="5">To solve some famous and advanced physics / chemistry problems using simulation.</td></tr>
</table>

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	3	2	2
CO2	3	2	3	2
CO3	2	3	3	3
CO4	2	3	3	3

UNIT-I
Introduction to the MATLAB programming language: Operations in MATLAB: basic mathematical operations with matrices, arrays, etc. Plotting with MATLAB: line plots, 1-D, 2-D, 3-D, mesh grid, labelling axes, legends, importing and plotting data files in MATLAB; Root fnding and curve fitting.
UNIT-II
Numerical methods for solving ordinary differential equations: The Euler method, Programming in MATLAB to solve 1st order and 2nd order ODEs by Euler method, Solving ODEs using inbuilt MATLAB solvers UNIT-III
Numerical methods for Integration: Rectangular, Trapezoidal, Simpson methods Using direct MATLAB solvers for integration, Introduction to Monte Carlo methods: random numbers, Monte Carlo Integration. Some examples from linear algebra and matrices; Fractals, polynomial fit and exponential fit.
UNIT-IV
Time Series Analysis Methods: Stationary processes, Lag plots, Auto correlation function, Power spectral density.

References
1. Rudra Pratap, Getting started with MATLAB [Oxford University Press] 2. Chapman, Essentials of MATLAB Programming 3. Balagurusamy, Numerical Methods [Tata McGraw Hill] 4. Tao Pang, An introduction to Computational Physics [Cambridge University Press] 5. Andi Klein and Alexander Godunov, Introductory Computational Physics [Cambridge University Press] 6. Ward Cheney and David Kincaid, Numerical Methods and Computing 7. Alfio Quarteroni and Fausto Saleri, Scientific Computing with MATLAB and Octave 8. S. R. Otto and J. P. Denier, An Introduction to Programming and Numerical Methods in MATLAB

<table>
<tr><td>Paper Code:
CWP-103, CWC-103, CWM-103</td><td colspan="2">Paper: MATLAB and Computational Methods - Practical</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
904103, 905103, 945103</td><td colspan="2"></td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="6">Marking Scheme:
Teachers Continuous Evaluation: 40 marks
Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="6">Instructions for paper setter:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="5">Introduce the students from diverse backgrounds to the importance of computational techniques and to expand their mathematical skills in areas of numerical methods.
Introduce the concepts and theory of various simple problems and algorithms that can be subsequently applied to programming in MATLAB to solve then in the Lab.</td></tr>
<tr><td>2:</td><td colspan="5">Introduce and hands on training of students in computational methods with MATLAB as the programming language</td></tr>
<tr><td>3:</td><td colspan="5">Problems are selected from a list which is updated from time to time in tune with the needs of industry/research and topical subjects.</td></tr>
<tr><td>4:</td><td colspan="5">Educate students to learn the logic behind solving problems related to real physical examples, simulation, modelling and designing the algorithms and translating them into programmes</td></tr>
<tr><td></td><td colspan="5"></td></tr>
<tr><td colspan="6">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="5">Students will have a working understanding of the mathematical skills needed for programming.</td></tr>
<tr><td>CO2:</td><td colspan="5">They will generate working knowledge of MATLAB.</td></tr>
<tr><td>CO3:</td><td colspan="5">They will be able to solve some famous and advanced physics problems using simulation which are otherwise difficult to solve analytically.</td></tr>
<tr><td>CO4:</td><td colspan="5">The students are expected to develop the flavour of modelling and simulation.</td></tr>
<tr><td colspan="6">Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)</td></tr>
</table>

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	3	2
CO2	2	3	3	1
CO3	3	2	2	3
CO4	3	1	2	3

UNIT-I
Plotting (a) Eigenvalues & Eigenfunctions for Particle in a Box – 1D & 2D; (b) Hydrogen atom wave functions
UNIT-II
ODE's – exmples- (a) Simple, damped and driven Harmonic Oscillator; (b) Van der Pol Oscillator; (c) Radioactive Decay; (d) LCR Circuit; (e) Schrodinger equation in 1D; (f) Coupled ODEs – The Lorenz Equations; (g) Calculation of Eigen functions (π molecular orbitals using HMO theory); (h) Kinetics of oscillatory reactions.;
UNIT-III
Monte Carlo mthods (a) Simulate coin toss, die roll etc. using MATLAB's inbuilt commands; (b) Estimating the value of "pi" using random numbers on a circle & sphere; (c) Monte Carlo Integration
UNIT-IV
Time Series Analysis Methods: Stationary Processes, Lag Plots, Auto Co-relation Function, Power Spectral Density

This list may be updates/modified to included related application from time to time

Assignments may be designed relevant to the broad area of research of the research scholar.

References

1. Rudra Pratap: Getting started with MATLAB [Oxford University Press]
2. Chapman: Essentials of MATLAB Programming
3. Tao Pang: An introduction to Computational Physics [Cambridge University Press]
4. Andi Klein and Alexander Godunov: Introductory Computational Physics [Cambridge University Press]
5. Ward Cheney and David Kincaid: Numerical Methods and Computing
6. Alfio Quarteroni and Fausto Saleri: Scientific Computing with MATLAB and Octave
7. S.R. Otto and J.P Denier An Introduction to Programming and Numerical Methods in MATLAB.

<table>
<tr><td>Paper Code:
CWP-104, CWC-104</td><td>Paper: Advanced Characterization Techniques</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID: 904104, 905104</td><td></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td colspan="5">Marking Scheme:
• Teachers Continuous Evaluation: 40 marks
• Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="5">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="4">To understand the basic concepts of Instruments and utility of the XRD, SEM and TEM</td></tr>
<tr><td>2:</td><td colspan="4">Students are expected to learn the state of art of science and power of Technology to study their experimental research work.</td></tr>
<tr><td>3:</td><td colspan="4">To k To know the interaction of electromagnetic radiation with matter with respect to NMR, IR and UV spectroscopy to identify the molecules.</td></tr>
<tr><td>4:</td><td colspan="4">To u To understand the General Principle, Instrumentation and Applications of Photoluminescence Spectroscopy, Raman Spectroscopy, Electron Spin Resonance, Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC)</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td colspan="5">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="4">The end of the course the students are able to acquire enough knowledge to analyse their experimental results.</td></tr>
<tr><td>CO2:</td><td colspan="4">This course will help to understand and analyse their experimental results in specific to structural, morphology, chemical analysis and transport mechanism</td></tr>
<tr><td>CO3:</td><td colspan="4">The students will understand instrumentation and application of spectroscopic techniques like: NMR, IR, UV, and will be able to elucidate the structure of molecules</td></tr>
<tr><td>CO4:</td><td colspan="4">The students will understand instrumentation and application of Photoluminescence Spectroscopy, Raman Spectroscopy, Electron Spin Resonance, Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) which they can use that during their research studies.</td></tr>
<tr><td colspan="5">Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)</td></tr>
</table>

CO/PO	PO1	PO2	PO3	PO4
CO1	3	-	-	-
CO2	-	3	-	-
CO3	-	-	3	-
CO4	-	-	-	3

UNIT-I
Structural Characterization: **(a) X-ray Diffraction** Components of X-ray diffraction-X-ray soruce; Specimen; optics; detector ;- X- ray saftey , Indexing of powder x-ray diffraction and sample prepartion methods; (b) **Determination** : Crystallite Size;Phase Determination,Crystal Structure(Cubic only),lattice paratmeter, qualitative analysis of powder mixure, Breif introcduyction of Retveild analysis.
UNIT-II
Electron Diffraction : **(a) Electron Microscopy Methods**- Electron beam specimen interations, Scanning electron microscopy(SEM), Chemical Analysis, Transimission electron microscopy(TEM),energy disperseive X-ray spectroscopy analysis, Specimen Prepartion for SEM analysis and Specimen Prepartion for TEM analysis; High Resulation Transimission Electron Microscpy. **(b) Transport Characterization:** Electrical Conductivity, Seebeck Coefficient, Thermal Conductivity, Techniques for measurements of Hall effect (Over View only), AC and DC conductivity.
UNIT-III
Spectroscopic Techniques: Nuclear Magnetic Resonance (NMR) Spectroscopy, Infra Red (IR)Spectroscopy-Fourier Transform Infrared Spectroscopy (FTIR) and Attenuated Total Reflection Spectroscopy (ATR), Ultra Violet-Visible (UV-Vis) Spectroscopy.
UNIT-IV
General Principle, Instrumentation and Applications ofPhotoluminescence Spectroscopy, Raman Spectroscopy, Electron Spin Resonance, Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC)

References

1. Element of X-ray diffraction, BD Cullity and SR Stock, 2001, Pearson.
2. Electron Microscopy: Principles and Fundamentals, Edited by : S. Amelinckx, Dirk vanDyck, Gustaaf van Tendeloo, J. Van Landuyt, 2008, John Wiley & Sons.
3. An Introduction to Surface Analysis, John F. Watts,John Wolstenholme, 2003, Wiley.
4. ASM Hand Book Volume 10- Material Characterization, Edited by : Thomas J. Bruno, Ryan Deacon, Jeffrey A. Jansen, Neal Magdefrau, Erik Mueller, George F. Vander Voort, Dehua Yang, 2019, ASM International.
5. Organic Spectroscopy, William Kemp, 1991, Palgrave, London.
6. Thermal Analysis, Wendlandt, Wesley William, 1986, Wiley-Interscience. New York.

Paper Code: CWP-105, CWC-105	**Paper: Synthesis of Nanomaterials & Introduction to Nanocomposites**	**L**	**T/P**	**C**
Paper ID: 904105, 905105		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To enable students to learn about Chemical precipitation and co-precipitation
2:	To enable students to know the basics of Sol-gel & Microemulsions synthesis
3:	To enable students to be competent in biological methods of nanoparticle preparation
4:	To enable students to understand the various categories of Nanocomposites

Course Outcomes (CO):

CO1:	The students will get proper knowledge of various soft routes of nanoparticle synthesis which helps in utilizing the synthesis technique most suitable to produce nanoparticles with desired properties
CO2:	The students will learn the chemical methods of nanoparticle synthesis which help them to apply these techniques while carrying out a reaction in a laboratory/industry
CO3:	The students will learn the biological methods of nanoparticle synthesis which help them to be able to synthesize nanoparticles in a green way
CO4:	The students will able to distinguish the types, Nanocomposites and their significant characteristics

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	2	2
CO2	2	2	3	3
CO3	3	3	2	2
CO4	3	3	3	3

Unit I:
Chemical precipitation and co-precipitation: Theory & Thermodynamics, nucleation, growth, Oswald Ripening and Stabilization. Microwave assisted co-precipitation; Sonochemical assisted co-precipitation. Metal nanocrystals by reduction; Precipitation of Metals by Electrochemical reduction; Precipitation of Metals by Radiation-assisted reduction; Precipitation of Metals by Thermolysis routes.
Unit II:
Sol-gel & Microemulsions synthesis: Sol-gel synthesis: Fundamental steps, Chemistry of Metal Alkoxides, Chemistry of aqueous metal cations, Xerogels & Aerogels, Gel sintering. Microemulsions or reverse micelles: Fundamentals, Surfactants & their selection, Phase equilibria, Reaction Dynamics. Synthesis in supercritical fluids & Solvothermal synthesis.
Unit III:
Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes, Viruses, Plants for nanoparticle synthesis.
Unit IV:
Various categories of Nanocomposites: Coupled nanocomposites, Capped nanocomposites, Core-Shell structured nanocomposites, Super hard Nanocomposites.

References:

1. Chemistry of nanomaterials: Synthesis, properties and applications, CNR Rao, H.C. mult. Achim Müller, A. K. Cheetham, **2004,** Wiley-VCH Verlag GmbH & Co. KGaA,
2. Nano chemistry: A Chemical Approach to Nanomaterials, Geoffrey A Ozin, André Arsenault, Ludovico. Cademartiri, **2008,** Royal Society of Chemistry, Cambridge UK,
3. Nanobiotechnology: Concepts, Applications and Perspectives, Editors: C.M. Niemeyer, C.A. Mirkin, **2004,** Wiley-VCH
4. Introduction to Nanotechnology, R. Singh, S. M. Gupta, **2016,** Oxford University Press
5. Nanocomposite Science and Technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, **2003,** Wiley, New York
6. The search for novel, super hard materials (Review Article), Stan Veprek, **1999,** Journal of Vacuum Science & Technology A **17**, 2401 (1999); https://doi.org/10.1116/1.581977.

Paper Code: CWP-106	**Paper: Thermoluminescence dosimetry**	**L**	**T/P**	**C**
Paper ID: 904106		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To give knowledge about various radiation sources their measurements and radiation safety
2:	To understand concepts of TL dosimeters
3:	To be aware of recent research trends in TLD
4:	To understand preparation methods of TL dosimeters and their applications

Course Outcomes (CO):

CO1:	Gained the knowledge of radiations, doses and safety limits
CO2:	Understood TLD and its dosimeter evaluations techniques.
CO3:	Studied about TL dosimetry and their applications
CO4:	Have sufficient knowledge of recent research trends in TLD.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	**2**	**3**		**3**
CO2	**2**	**3**	**1**	**3**
CO3	**2**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**2**

UNIT-I
Definition of radiation and its types, Ionizing and non ionizing radiation, Quantities and units, Interaction of radiation with matter, Sources of radiation: Natural and Artificial. Radioactive sources: beta, alpha, gamma and X ray sources, Measurement of radiation: different type of dosimeters, Occupational Exposure Limits, Dose limits to Public, General safety of radiation sources, Radiation Measuring instruments, Radiation Hazard evaluation and control, Regulatory requirements: National Regulatory Body, safety standards.
UNIT-II
Luminescence mechanism, Principle of Thermoluminescence, Application of Thermoluminescence: Personnel monitoring, environmental monitoring, radio diagnostics or radiotherapy, food processing, Models of Thermoluminescence: traps and recombination centres, simple model; alternate model; Thermoluminescence glow curve analysis: Evaluate of TL parameters E and s, Peak shape method, curve fitting, computerised glow curve deconvolution. TL properties: glow curve structure, dose response, energy response, annealing procedures, fading, reproducibility.
UNIT-III
Various type of TLD phosphor; tissue equivalent and non tissue equivalent phosphor. Method of preparation, melting method, co precipitation method and crystal growth method: edge defined film fed growth technique: Advantage of EFG technique for preparing phosphor in the form of sheet: Growth procedure.
UNIT-IV
Applicability for TL dosimeter for personnel monitoring and Radiotherapy Treatment; Patient skin dose distribution; treatment planning and quality assurance in radiation therapy, Environmental monitoring, recent research trends in TLD dosimetry

Suggested Readings and References
1. The physics of radiation therapy, Faiz M. Khan, 4th edition (2010), Lippincott, Williams and Wilkins, USA. 2. Fundamental of X-ray and Radium Physics - Joseph Selman, (1970). Charles C. Thomas Publisher. 3. Basic Medical Radiation Physics – Stanton, (1969), New York : Appleton-Century-Crofts. 4. Radiation Detection and Measurement, 3rd Edition, Wiley, New York (2000), G.T. Knoll. 5. Introduction to Radiological Physics and Radiation Dosimetry, Wiley, New York (1986), F.H. Attix. 6. Thermoluminescence of solid, Cambridge Solid State Science Series, (1988), S.W.S. McKeever.

Paper Code: CWP-107	**Paper: Ion Beams In Material Science**	**L**	**T/P**	**C**
Paper ID: 904107		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	Ion beam technology is currently one of the most modern topics in nuclear science and technology.
2:	The main objective of ion beam in materials science course is to train students with new accelerator technology in the field of research, health care, industry and different theoretical design and usage of various accelerators.
3:	Ion beam analysis (IBA) for materials, material modifications and create nanostructures & applications.
4:	The course focus is skills based.

Course Outcomes (CO):

CO1:	The student will be familiar with the basic tools required to work with accelerator, ion source, beam optics, vacuum technology, ion implantation and latest accelerator available around the world.
CO2:	Develop new processes for nanofabrication by ion beam.
CO3:	Future Technology & Applications like: (a) Free Electron Laser (FEL) (b) Superconducting Linacs& Cyclotrons.
CO4:	On completion of this course, the student will be ready for assignments and placement in the growing accelerator technology in many fields like, health care, medicines, reactor technology, nuclear technology and accelerator-based research and industry.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	3	3
CO2	3	3	2	3
CO3	3	3	3	2
CO4	2	3	1	3

Unit I:
Accelerators: Accelerators, Types of accelerators, [Introduction of Electrostatic accelerators–Cockcroft-Walton, Van–de–Graf, linear accelerator] and compression & applications, Pelletron, Cyclotron, Synchrotron, Nuclear energy and uses, status of accelerators in India and Abroad.
Unit II:
Vacuum: Basic principles of vacuum technology and brief overview, Elements of a vacuum system, Vacuum coating system and their importance, Types of vacuum pumps and applications, Rotary pump, Diffusion pump, Pirani gauge, Thermocouple gauge, Ultra high vacuum technology, Leak detection techniques.
UNIT III:
Ion interaction with matter: Ion stopping, energy losses, effective charge of moving ion, high energy and low energy losses, ion range and distribution, straggling, **Nano-structuring by Ion beams:** Synthesis of nanostructured materials under electronic excitation and nuclear energy loss, nanostructures within ion track and at the surface by self-organization, nano-pattering: ripple formation, nano-dot formation.
Unit IV
Ion beam-based techniques for material analysis and applications: Trace element analysis, Various methods, Rutherford backscattering spectrometry (RBS): Principle, instrumentation, working and applications, Elastic Recoil Detection Analysis (ERDA): Principle, instrumentation, working and applications, Nuclear reaction analysis (NRA): Principle, instrumentation, working and applications, Particle induced X–ray emission (PIXE): Principle, instrumentation, working and applications, Accelerator mass spectrometry (AMS): Principle, instrumentation, working and applications, Medical applications of accelerators. [12]

Reference Books:

1. Materials Science with ion beam, Harry Bernas, Springer 2010
2. Accelerator Based Research in Basic and Applied Sciences, 2002, Amit Roy and D. K. Avasthi, Phoenix Publishers.
3. Introduction to High Energy Physics (4th edition) by D. H. Perkins 2000.
4. Swift Heavy Ions for Materials Engineering and Nano structuring, Springer, D. K. Avasthi. and G.K. Mehta,
5. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
6. Introductory Nuclear Physics by K. S. Krane, Wiley-India Publication, 2008.
7. Nuclear Physics by R. Prasad, Pearson, 2014.
8. R.R. Roy and B. P. Nigam: Nuclear Physics, Theory and Experiment (John-Wiley and Sons, INC.)

Paper Code: CWP-108	**Paper: Solar radiation and Solar Photovoltaic Science and Engineering**	**L**	**T/P**	**C**
Paper ID: 904108		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To have an overview about the status, recent trends and future scope of solar energy in general and solar photovoltaic in particular.
2:	Designing of a Photovoltaic system
3:	To be aware of recent research trends and emerging technologies in Photovoltaic.
4:	To understand concepts of solar radiation

Course Outcomes (CO):

CO1:	Explain the existing solar energy potential.
CO2:	Explain the operation and performance of solar Photovoltaic system
CO3:	Perform a solar resource assessment of a potential site and develop understanding on the Photovoltaic plant design.
CO4:	Have sufficient knowledge of recent trends and emerging technologies in solar Photovoltaic.

Course Outcomes (CO) to Program Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**
CO1	**1**	**3**	**3**	**3**
CO2	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**3**
CO4	**1**	**3**	**3**	**3**

Unit I:
Introduction: Current energy scenario and importance of renewable energy in general and solar energy in particular, Solar radiation, usefulness of radiation data for solar engineers, designers and architects. Sun-Earth relations, Thermal radiation, Extra-terrestrial Solar Radiation, Interaction of Solar radiation with atmosphere, various scattering, absorption and reflection processes, Terrestrial Solar Radiation, radiation data from satellite, Solar radiation measuring instruments: Pyranometer, Pyrheliometer, sun shine recorder etc., hourly global, beam and diffuse radiation, estimation of global radiation on horizontal surface, importance of radiation data for modelling of devices and simulations
Unit II :
Status, Trends, Challenges and the future scope of Solar photovoltaics: What is photovoltaics, history, goals of todays PV research, global trends, motivation for photovoltaic application and development, crystalline Silicon technology, progress and challenges, Physics of solar cell: fundamental properties of semiconductors, pn junction diode electrostatics, solar cell fundamentals, spectral response, theoretical limits of photovoltaic conversion, V-I characteristics of solar cell, properties of efficient solar cells PV cell, module, Array, Energy storage, study of associated system electronic components in brief like charge controller, battery, inverter, wiring, stand etc.
Unit III:
PV System Designing: Designing, modelling and simulation of standalone PV Systems, Designing, modelling and simulation of PV, hybrid systems, utility interactive system.
Unit IV:
Emerging PV Technologies and their future: Dye sensitized solar cell, other variants of Dye Sensitized solar cells, Perovskite solar cell, organic solar cell and other emerging technologies in solar photovoltaics.

References

1. Solar Energy: Fundamentals, design, Modelling and Applications, G.N. Tiwari,2002, Narosa Publishing house
2. Understanding renewable energy systems, Volker Quaschning, 2006, Replika Press Pvt. Ltd., India.
3. Alternative Energy, Vol 1-3, Neil Schlager and Jayne weisblatt, 2006
4. Thompson Gale Generating electricity from the sun, Fred C Treble,1991, Pergramon Press
5. Solar Cells: Operating principles, technology and system Applications, Martin A. Green, 1982, Prentice Hall
6. Physics of solar cells, Peter Wurfel, 2016, Wiley VCH Verlag GmbH & Co. KGaA
7. Terrestrial solar photovoltaics, Tapan Bhattacharya, 1998, Narosa Publishing House

Paper Code: CWP-109	Paper: Nanostructured Thermoelectric Materials	L	T/P	C
Paper ID: 904109		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	Nanos Nanostructured Thermoelectric Materials is currently one of the hottest topics in the energy sector, physics & engineering, expected to revolutionize the future demand for renewable energy.
2:	This course demands an experimental science and will introduce students to this exciting new field and cover its main ideas, current developments, and future trends.
3:	To introduce students to the basic concepts in transport properties and to familiarize them with its unique development of good thermoelectric materials and applications which form a base for both working in upcoming companies as well as research groups in top IT companies and academia
4:	To educate students with the basics of electronic, phonon transport, the figure of merit, and thermoelectric device concepts, nanoscience concepts and decouple of thermoelectric properties. To introduce these concepts one can, visualize the various way to improve the thermoelectric properties and mechanism to fabricate the thermoelectric device.

Course Outcomes (CO):

CO1:	The student will be in a position to better understand the impact of this powerful discipline and be ready for the new frontiers opening up in the energy sector.
CO2:	The student will be familiar with the basic knowledge required to develop a new efficient thermoelectric material
CO3:	On completion of this course, the student will be ready for assignments and placement in the growing energy sector.
CO4:	The students will be able to start their start-ups to develop economically viable nano and micro thermoelectric devices for multiple applications.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	2	3	2
CO2	1	3	2	1
CO3	3	3	2	3
CO4	2	3	2	3

UNIT-I
Electronic structure of material: Statistical equilibrium of free electrons: density of states for bulk and low dimensional system, distributions: Maxwell Boltzmann, Fermi Dirac, carries concentration, impurity semiconductors, quantum wells, quantum wires and quantum dots.
UNIT-II
Static properties: Specific heat of materials, thermionic emission **Transport properties of materials:** Boltzmann transport equation, particle diffusion, electrical and electronic thermal conductivity, Isothermal Hall effect Phonons, Lattice thermal conductivity Transport properties of quantum wells, quantum wires and nanocomposites.
UNIT-III
Thermo Electric Materials: See beck coefficient, Peltier effect, Figure of merit, Selection of the material for TEM, Comparability parameter, Efficiency, Different types of TEM and recent development in low dimensional TEM, doping, alloying and size effects and its applications.
UNIT-IV
Thermoelectric module and device: Introduction, Single mode and multi-mode devices, Segment thermoelectric model, Modelling and optimization of Segmented Thermoelectric Uncouples, Optimum Conversion Efficiency

References

1. Statistical physics: Patheria (Butterworth- Heinemann, Oxford, 1972)
2. Statistical physics: K.Huang(Wiley Eastern, New Delhi, 1975)
3. B.K.Aggarwal & Melvin Eisner : Statistical physics (Wiley Eastern, New Delhi)
4. CRC handbook of Thermoelectrics,Ed. CR Rowe, 1955

<table>
<tr><td>Paper Code:
CWC-106</td><td colspan="4">Paper: Heterocyclic Chemistry & Synthon Approach</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
905106</td><td colspan="4"></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td colspan="8">Marking Scheme:
• Teachers Continuous Evaluation: 40 marks
• Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="7">It is aimed to skill students in designing the synthesis of important organic molecules</td></tr>
<tr><td>2:</td><td colspan="7">Learning of synthesis and utility of various heterocyclic compounds</td></tr>
<tr><td>3:</td><td colspan="7">Learning of application of organic reagents in a reaction</td></tr>
<tr><td>4:</td><td colspan="7">To acquire knowledge on catalytic reactions</td></tr>
<tr><td></td><td colspan="7"></td></tr>
<tr><td colspan="8">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="7">Students shall able to design the synthesis of new organic molecules</td></tr>
<tr><td>CO2:</td><td colspan="7">Gained knowledge on the synthesis of various heterocycles and to use further for designing new derivatives</td></tr>
<tr><td>CO3:</td><td colspan="7">Utility of organic reagents in a reaction and can apply them in their research project</td></tr>
<tr><td>CO4:</td><td colspan="7">Learnt how to use catalyst in a reaction</td></tr>
<tr><td colspan="8">Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)</td></tr>
<tr><td>CO/PO</td><td>PO1</td><td>PO2</td><td>PO3</td><td colspan="4">PO4</td></tr>
<tr><td>CO1</td><td>3</td><td>2</td><td>2</td><td colspan="4">3</td></tr>
<tr><td>CO2</td><td>3</td><td>2</td><td>2</td><td colspan="4">3</td></tr>
<tr><td>CO3</td><td>3</td><td>2</td><td>2</td><td colspan="4">3</td></tr>
<tr><td>CO4</td><td>3</td><td>3</td><td>2</td><td colspan="4">2</td></tr>
</table>

UNIT-I
Chemistry of Heterocyclic Compounds: Introduction to Heterocycles: Nomenclature (Hantzsch Widman System), spectral characteristics, reactivity and aromaticity of monocyclic, fused and bridged heterocycles. Five and six-membered heterocycles with two or more hetero atoms: Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyrazole, Imidazole, Oxazole, Thiazole, Pyrimidine, Pyrazine, Oxazine, Thiazine, Triazoles, Oxadiazoles, Thiadiazoles, Triazines. Synthesis and reactivity of Benzofuran, Benzothiophene, Benzopyrroles, Indole, Quinoline and Isoquinoline.
UNIT-II
Synthon Approach: Definition of terms-disconnection, synthon, functional group interconversion(FGI), Basic rules in Disconnection, Designing Organic Synthesis: rearrangement in synthesis, use of ketene in synthesis, aromatic heterocycles five member rings and synthesis of five and six member rings. Use of synthon approach in the synthesis of following compounds: Terfenadine, Ibuprofen, Propanolol, Fentanyl, Ciprofloxacin, Diclofenac.
UNIT-III
Organometallic and Non-organometallic Reagents: Preparation, properties and applications of the following in organic synthesis with mechanistic details: Lithium aluminium hydride, Lithium Diisopropylamide, Trimethylsilyl iodide, Diazomethane, Polyphosphoric acid, Dicyclohexylcarbodiimide, Lead Tetra-acetate, Osmium tetraoxide. Organocopper Reagents, Organochromium Reagents, Organosilicon Reagents and Organo-nonmetallic Reagents.
UNIT-IV
Industrial Oxidizing and Reducing Agents: Reactions and mechanism of industrial Oxidizing agents: $KMnO_4$, $K_2Cr_2O_7$ and H_2O_2. Reducing agents: Na_2SO_3 and $Na_2S_2O_3$. **Industrial Metals: Catalytic** Reactions (hydrogenation, Zeigler Natta process, Wacker process and Fischer Tropsch process) of Raney nickel, Pd, Cr, V, Pt and Ti.

References:
1. Organometallics in J.M. Swan and D. organic synthesis C. Black, 1974, Champman and Hall 2. Designing of S. Warren organic synthesis, 1991, Wiley 3. Advanced Organic Jerry March chemistry, 6th edition, 2006, Wiley Eastern 4th edition 4. Some Modern W. Carruthers Methods of Organic Synthesis, 4th edition, 2005, Cambridge University Press 5. Advanced Organic Chemistry, Part B, F. A Carey and R.J. Sundeberg, 5th edition (2007) Springer

Paper Code: CWC-107	Paper: Synthesis, Isolation and Purification of Air Sensitive Compounds	L	T/P	C
Paper ID: 905107		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	A research student will learn about various drying reagents, different methods of distillation / purification required for various types of organic solvents under normal conditions and under vacuum using nomograph
2:	Students will acquire the knowledge of types of glass wares/ apparatus to be used like Schlenk Apparatus- round bottom Schlenk flask, Schlenk tubes, Young tubes, Glove Box and the important points about their handling in the laboratory environment.
3:	Students will learn about the synthesis and purification of air sensitive compounds.
4:	Students will learn how to isolate the air sensitive compounds from their mixture with the help of low temperature column chromatography.

Course Outcomes (CO):

CO1:	Students will hone their skills independently to distil various types of solvents with different drying agents and particularly about high boiling solvents at variable temperature under vacuum with the help of nomograph.
CO2:	Students will get familiar with sophisticated glass wares like Schlenk Apparatus- round bottom Schlenk flask, Schlenk tubes, Young tubes, Glove Box and their handling during the synthesis.
CO3:	Students will be able to carry out independently the synthesis of air sensitive compounds and their purification by recrystallization at room temperature / low temperature under inert atmosphere, washing/ removal of impurities from unstable compounds at low temperature.
CO4:	Students will be able to isolate air sensitive compounds from their mixture by applying their knowledge of column chromatography particularly by low temperature column chromatography

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	**3**	**-**	**-**	**-**
CO2	**-**	**3**	**-**	**-**
CO3	**-**	**-**	**3**	**-**
CO4	**-**	**-**	**-**	**3**

Unit I
Purification: Distillation of organic solvents and distillation under vacuum and use of nomograph (manometer / vacuum pump and Schlenk Apparatus) to establish b. p. of a solvent/ compound at various pressures, common drying agents, design of apparatus for distillation under inert atmosphere of dry nitrogen or argon gas.
Unit II
Schlenk Techniques: Synthesis of air sensitive compounds and manipulation of air sensitive reactions. Designs of Schlenk Apparatus- round bottom Schlenk flask, Schlenk tubes, Young tubes.
Unit III
Purification of air sensitive compounds: Recrystallization at room temperature / low temperature under inert atmosphere, washing/ removal of impurities from unstable compounds at low temperature.
Unit IV
Chromatography Techniques: column chromatography and low temperature column chromatography, design of column for low temperature chromatography, types of silica gel and their characteristics and types of alumina.

Suggested Readings and References
1. A laboratory handbook of chromatography Synthesis, E.Heftmann, **1975,** New York 2. Organic Experiments, K. L. Williamson, 2007, New York 3. Organometallic Reagents in Synthesis, R. Jenkins, **1992,** Oxford

Paper Code: CWC-108	Paper: Natural Products and Instrumentation	L	T/P	C
Paper ID: 905108		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To learn basic knowledge of isolation and purification of natural molecules
2:	To study compounds produced by plants that have biological activity
3:	To learn identification of natural molecules with the help of spectroscopic techniques
4:	To enable students to compare natural molecule with synthetic molecule

Course Outcomes (CO):

CO1:	It offers an excellent strategy towards identifying novel natural products
CO2:	The students will be able to discover bioactive molecules with special emphasis on developing 'Investigative New Drugs' (INDs)
CO3:	The students will be able to understand spectroscopic techniques [NMR, IR, UV, Mass etc] thoroughly
CO4:	The students will be able to modify natural product as per the need of the project.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	-	-	-
CO2	-	3	-	-
CO3	-	-	3	-
CO4	-	-	-	3

Unit-I
Literature survey and identification of natural products
Unit-II
Characterization of Natural Products: Natural Product Chemistry and its importance in our life, Activity guided fractionation, isolation and characterization of leads from natural products spectroscopy.
Unit-III
Chromatography: Gas Chromatography and High Performance Liquid Chromatography- instrumentation, detectors and applications, TLC, Column chromatography, Gel filtration, Ion Exchange chromatography and Affinity chromatography and Electro- chromatography.
Unit-IV
Instrumentation: Nuclear Magnetic Resonance [NMR (^{1}H, ^{13}C)], Infra red (IR) spectroscopy, Ulta Violet (UV) spectroscopy, Mass. Spectrometry, Electrophoresis.

Text/Reference Book:

1. Organic Spectroscopy by William Kemp (1991)
2. **Spectrometric Identification of Organic Compounds** by Robert M. Silverstein, Francis X. Webster, and David Kiemle
3. Quantitative Chemical Analysis by Daniel C. Harris
4. Isolation, identification and characterization of allelochemical/natural products by Diego A. Sampietro, Cesar A. N. Catalan, Mark A. Vattuone (2009)
5. Introduction to organic Spectroscopy by Laurence M. Harwood (1996)

Paper Code: CWC-109	Paper: **Synthesis and Application of Organophosphorus Compounds**	L	T/P	C
Paper ID: 905109		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	Students will learn about various organometallic reagents, their properties and applications/ importance in synthesis.
2:	Students will learn chemistry of Phosphorus monovalent compounds (phosphinidenes) and their stabilization by complexation with organometallic reagents.
3:	Students will learn the chemistry of variety of phosphorus compounds like Phosphines/ Phosphanes, Phosphaalkenes, Phosphaalkynes, Phosphapines Phosphazenes, Phosphites, Arbuzov reactions.
4:	Students will get familiar with chemistry of phosphine chalcogenides (X= O, S, Se, Te), phosphorus ylides, Wittig reactions, phosphonates and their application.

Course Outcomes (CO):

CO1:	Students will be able to synthesise various organometallic reagents for synthesis and stabilisation of different organophosphorus compounds.
CO2:	Students will be able to synthesise of phosphorus monovalent compounds (phosphinidenes) *in-situ* and by trapping them with suitable reagents via cycloaddition or insertion reactions with C-X (Carbon-Halogens) bonds.
CO3:	Students will be able to synthesise a variety of phosphorus compounds like Phosphines/ Phosphanes, Phosphaalkenes, Phosphaalkynes, Phosphapines Phosphazenes, Phosphites.
CO4:	Students will be able to oxidise a variety of phosphorus compounds to their chalcogenides (P(V) compounds) with the help of suitable oxidising agents like DMSO, pyridine-N-oxide, H_2O_2 , urea- H_2O_2, S, Se, Te etc.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	**3**	-	-	-
CO2	-	**3**	-	-
CO3	-	-	**3**	-
CO4	-	-	-	**3**

Unit I
<u>Organometallic Reagents in Synthesis:</u> Metallated saturated hydrocarbons, metallated alkenes, metallated alkynes, metaalated aromatic compounds, metallated heterocyclic compounds and heteroatom stablised organometallic reagents.
Unit II
<u>Chemistry of Phosphorus (I) Compounds:</u> Phosphinidenes, synthesis and stabilization of phosphinidenes, singlet and triplet phosphinidenes, insertion reactions of phosphinidenes, reagents to generate phosphinidenes.
Unit III
<u>Chemistry of Phosphorus (III) Compounds:</u> Synthesis and stabilization Phosphines/ Phosphanes, Phosphaalkenes, Phosphaalkynes, Phosphapines Phosphazenes, Phosphites, Arbuzov reactions.
Unit IV
<u>Chemistry of Phosphorus (V) Compounds:</u> Phosphine chalcogenides- synthesis and their application, Phosphorus ylides, Wittig reactions. Arbuzov reactions, phosphonates.

Suggested Readings and References
1. Organometallic Reagents in Synthesis, Paul R. Jenkins, **1992,** Oxford 2. Phosphorus Ylides, Oleg I. Kolodiazhnyi, 1999, Wiley-VCH, Weinheim 3. Multiple Bonds and Low Coordination in Phosphorus Chemistry, F. Mathey, Edited by M. Regitz and O. J. Scherer, 1990, Georg Thiene Verlag, New York 4. Phosphorus: the Carbon Copy, K. B. Dillon, F. Mathey, and J. F. Nixon, 1998, Wiley, Chichester

Paper Code: CWC-110	Paper: Biological Chemistry	L	T/P	C
Paper ID: 905110		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	Demonstrate knowledge and understanding of the principles that govern the structures, functions and metabolism of macromolecules and their participation in molecular recognition
2:	Demonstrate knowledge and understanding of the principles and basic instrumentation to separate and identify the macromolecules
3:	To understand the basic knowledge of enzymatic catalysis and its regulatory mechanism
4:	To acquire understanding of designing target oriented drug synthesis and their biological activity evaluation

Course Outcomes (CO):

CO1:	The students will understand the chemistry of carbohydrates, lipids, proteins and amino acids.
CO2:	The students will understand the principle and instrumentation of basic instruments used in separation of biomolecules
CO3:	The students will understand the mechanism of enzyme action & identify the classes of enzymes and regulation of metabolism.
CO4:	The students will understand the synthesis of bioactive molecules and their biological activity evaluation.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	-	-	-
CO2	-	3	-	-
CO3	-	-	3	-
CO4	-	-	-	3

Unit-I
Introduction to Biomolecules: Amino Acids, Proteins, carbohydrates, Lipids and their metabolism. Protein modification: Enzymatic and non enzymatic.
Unit-II
Chromatography: Gas Chromatography and High Performance Liquid Chromatography- instrumentation, detectors and applications, Gel filtration, Ion Exchange chromatography, Affinity chromatography and Electrophoresis.
Unit-III
Enzymes: An Overview of Kinetics and Regulation, Biocatalysis Metabolic Pathways and their Regulatory Mechanisms.
Unit-IV
Synthesis of target oriented drugs and their biological activity evaluation: Synthesis of different target oriented molecules and their biological activities like antioxidant, antifungal, anticarcinogen, antimicrobial etc. evaluation.

Text/Reference Book:
1. Lehninger Principles of Biochemistry, Albert L. Lehninger , David L. Nelson, Michael M., 2004 Cox. 4th Edition. 2004. W H Freeman & Co. 2. Quantitative Chemical Analysis, Daniel C. Harris, 2006, 7th edition, 2006, W.H Freeman and Company. 3. Biochemistry, Lubert Stryer, 1995, 4th Edition. 1995, W H Freeman & Co.

Paper Code: CWM-104	Paper: Nonlinear Dynamics	L	T/P	C
Paper ID: 945104		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To understand the nonlinear dynamic systems, from periodic to chaotic systems
2:	To understand the basic concepts of fractal geometry and fractals.
3:	To introduce phase space and dynamical system .
4:	To introduce mathematical modeling of dynamical system.

Course Outcomes (CO):

CO1:	The students are able to acquire enough knowledge of discrete and continuous dynamical system.
CO2:	This course will enhance the geometrical, computational and analytical thinking.
CO3:	The students will be able to understand the basic classes of nonlinear systems and will be able to analyse them using analytic and diagrammatic methods.
CO4:	The student will have an understanding of how and why a dynamical system becomes chaotic.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	1	2	1	2
CO2	3	3	3	3
CO3	3	3	3	3
CO4	2	2	3	2

Unit-I
Central manifold and Normal form, attractors, 1D map, Logistic map, Poincare' maps, circle map. Bifurcations- Saddle-node, Transcritical, Hopf-bifurcation, Global bifurcations, Poincare's surface of sections, Melnikov's method for homoclinic orbits. Strange attractors & fractals dimentions. Henon map and Rossler system, Box-counting, Hausdorff dimensions. Lyapunov exponent, Horseshoe map chaotic transitions, intermittency, crisis, quasiperiodicity, controlling & synchronization of chaos.
Unit-II
Fractals in nature, Mathematical fractals (the Koch curve and other), Mathematical chaos (the Lorenz attractor). The Cantor set, the Sierpinski triangle and carpet, Self-similar fractals, fractal dimension, modeling of biological growth, Box dimension. Random fractals: Fractal forgeries, Iteration initial value, orbit, fixed point (attracting, repelling, neither), k-cycle (attracting, repelling, neither), fixed points, Period doubling.
Unit-III
The Feigenbaum constant, similarity of the Feigenbaum diagram for different functions. Continuous dynamical systems and strange attractors, Discrete dynamical systems. Phase space. The motion of a pendulum.
Unit-IV
Mathematical modeling, Atractors of typical 2-dimensional systems. Nodes, saddles, focuses, limit cycles, Strange attractors, The Mandelbrot set, the Julia set, geometrical features of Julia and Mandelbrot sets. The selection of programming languages and solving tools for applications will be done accordingly.

References
1.Dynamical Systems, Jurgen Jost, 2005, Springer 2.Dynamical Systems Stability, Controllability & Chaotic Behaviour, Werner Krabs, 2010, Springer 3.Fractals & Chaos, B.B. Mandelbrot, 2004, Springer 4. Stability of Dynamical Systems Continuous, discontinuous & Discrete Systems, Anthony N. Michel, 2008, Birkhauser Boston

<table>
<tr><td>Paper Code:
CWM-105</td><td colspan="5">Paper: An Introduction to Fuzzy Mathematical Programming</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
945105</td><td colspan="5"></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td colspan="9">Marking Scheme:
• Teachers Continuous Evaluation: 40 marks
• Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="9">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="8">To understand the basic concepts of fuzzy set theory</td></tr>
<tr><td>2:</td><td colspan="8">To understand the basic concepts of Linear Programming Problem and Duality.</td></tr>
<tr><td>3:</td><td colspan="8">To know the application of Linear Programming Problem in Game Theory</td></tr>
<tr><td>4:</td><td colspan="8">To understand the application of fuzzy set theory in decision making.</td></tr>
<tr><td></td><td colspan="8"></td></tr>
<tr><td colspan="9">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="8">The end of the course the students are able to acquire enough knowledge to analyse the set theory and fuzzy set theory</td></tr>
<tr><td>CO2:</td><td colspan="8">This course will help to understand mathematical programming and matrix game theory in a systematic and focused way.</td></tr>
<tr><td>CO3:</td><td colspan="8">The students will study the application of fuzzy sets to decision making. The students will understand fuzzy linear programming and fuzzy matrix game</td></tr>
<tr><td>CO4:</td><td colspan="8">The students will study the application of fuzzy sets to decision making.</td></tr>
<tr><td colspan="9">Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)</td></tr>
</table>

CO/PO	PO1	PO2	PO3	PO4
CO1	2	3	3	3
CO2	3	2	2	2
CO3	2	2	2	3
CO4	2	2	3	2

UNIT I:
Duality in linear programming, two person zero-sum matrix games, linear programming and matrix game equivalence, two person non-zero sum (bi-matrix) games, quadratic programming and bi-matrix game, constrained matrix games.
UNIT II:
Introduction of fuzzy sets, Basic definitions and terminologies, Fuzzy set theoretic operations, alpha-cuts and their properties, Convex fuzzy sets, Zadeh extension principle, Fuzzy relations, Similarity relation and partitioning, Triangular norms (t-norms) and triangular conorms (t-conorms). Lingustic variable and linguistic Hedges. Fuzzy if-then rule.
UNIT-III
Introduction of fuzzy numbers, Interval arithmetic, Fuzzy numbers and their representation, Arithmetic of fuzzy numbers, Special types of fuzzy numbers and their arithmetic, Ranking of fuzzy numbers.
UNIT-IV
Decision Making in fuzzy environment, Fuzzy linear programming, Quadratic programming in fuzzy environment, A two phase approach for solving fuzzy linear programming, Linear goal programming under fuzzy environment, Matrix game with fuzzy goals, Matrix game with fuzzy pay-offs, Fuzzy Bi-matrix game.

References:
Fuzzy Mathematical Programming and Fuzzy Matrix, Bector, C.R. and Chandra, S.2005, V Games, Springer Fuzzy Sets and Logic: Theory and Applications, Klir, G.J. and Yaun, B.,2004Prentice Hall , India Fuzzy Sets Theory and its Appliocations, Zimmermann, H.-J.,2001, 4th edition, Springer Game Theory, G.Owen, 1995, Academic Press, , San Diego

Paper Code: CWM-106	Paper: Wavelet Analysis	L	T/P	C
Paper ID: 945106		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	This course will provide an introduction to the theory of wavelets.
2:	This course will develop skills to extract information, analyze and interpret the data
3:	To establish the theory necessary to understand and use wavelets and related transformations.
4:	Explain the properties and application of wavelet transform.

Course Outcomes (CO):

CO1:	Students will be able to classify various wavelet transforms and will get the systematic importance of it.
CO2:	The students will be able to describe Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT).
CO3:	The students will be able to develop and realize computationally efficient wavelet based algorithms.
CO4:	The student will have a knowledge of brief features and strength of transform.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	2	3	2	3
CO2	3	2	3	1
CO3	1	1	3	3
CO4	2	3	3	2

Unit-I
Fourier and Inverse Fourier Transforms, Continuous-Time Convolution and the Delta Function, Fourier Transform of Square Integrable Functions. Fourier Series. Basic Convergence Theory and Poisson's Summation Formula.
Unit-II
The Gabor Transform. Basic Properties of Gabor Transforms. The Integral Wavelet Transforms, Dyadic Wavelets and Inversions.
Unit-III
Basic Properties of Wavelet Transforms. The Discrete Wavelet Transforms. Orthonormal Wavelets, Wavelet frames & Multiband, Curvelets. Definition of Multiresolution Analysis and Examples.
Unit-IV
Properties Scaling Functions and Orthonormal Wavelet Bases. Construction of Orthonormal Wavelets. Daubechies' Wavelets and Algorithms. The selection of programming languages and solving tools for applications will be done accordingly.

References:
1.The Fourier Transform & Its Applications, Ronald Bracewell, 2000, Mc Graw Hill 2.An Introduction to Wavelet, Charles Chui, 1992, Academic Press 3.Wavelets made easy, Yves Nievergelt, 1999, Springer-Verlag 4.Essential Wavelets for Statistical Applications & Data Analysis, Todd Ogden, 1996, Birkhaus Boston

Paper Code: CWM-107	**Paper: Space Dynamics**	**L**	**T/P**	**C**
Paper ID: 945107		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To develop the mathematical skill of using various mathematical methods
2:	To give introduction about different co-ordinate systems.
3:	To give introduction about relativity theory.
4:	To introduce the change of co-ordinate system.

Course Outcomes (CO):

CO1:	Students will learn Kepler's law.
CO2:	Students will learn about angular momentum.
CO3:	Students will be familiar to compute surfaces of zero relative velocity.
CO4:	Students will learn to compute parabolic and hyperbolic orbits.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	**3**	**2**	**1**	**2**
CO2	**3**	**2**	**1**	**2**
CO3	**3**	**2**	**1**	**2**
CO4	**3**	**2**	**1**	**2**

Unit I:
Formulation of the Two Body Problem. Integrals of area, angular momentum and energy. Equation of the relative orbit and its solution. Kepler's equation and its solution.
Unit II
Heliocentric and Geocentric Co-ordinates, Parabolic and Hyperbolic orbits, Melnikov's Integral, Orbit computation by Laplace and Gauss methods. Lagrange's solution for the motion of three bodies.
Unit III:
Restricted three body problem. Surfaces of zero relative velocity. Double points. Stability of straight line and equilateral triangle solutions. The ten integrals of motion of the n-body problem.
Unit IV:
Transfer of origin to one of the particles. The perturbing function. Virial theorem. Numerical integration by Cowell's and Encke's methods.

The selection of programming languages and solving tools for applications will be done accordingly.

Suggested Readings and References

1. Theory of Orbits by V. Szebhely, Academic Press, 1967
2. Theory of Orbits by Boccaletti, Dina etc., Springer, 2004
3. Theory of Orbit Determination by Andrea Milani, Cambridge University Press, 2009.
4. Theory of satellite orbits in an atmosphere by Desmond King-Hele, Butterworths edition, in English, 1987

<table>
<tr><td>Paper Code:
CWM-108</td><td>Paper: Lie Groups and Homogeneous spaces</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
945108</td><td></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td colspan="5">Marking Scheme:
• Teachers Continuous Evaluation: 40 marks
• Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="5">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="4">To give an introductory course on the theory of Lie groups</td></tr>
<tr><td>2:</td><td colspan="4">To give basic concepts about Representation theory</td></tr>
<tr><td>3:</td><td colspan="4">To give an introductory course on the theory of homogeneous spaces.</td></tr>
<tr><td>4:</td><td colspan="4">To introduce basic concepts about symmetric spaces</td></tr>
<tr><td></td><td colspan="4"></td></tr>
<tr><td colspan="5">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="4">Students will learn basic concepts of Lie groups</td></tr>
<tr><td>CO2:</td><td colspan="4">Students will understand elementary concepts about Representation theory</td></tr>
<tr><td>CO3:</td><td colspan="4">Students will be familiar with Homogenous spaces and with computation of bi-invariant metrics</td></tr>
<tr><td>CO4:</td><td colspan="4">Students will learn basic concepts about symmetric spaces and with computation of G-invariant metrics</td></tr>
</table>

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	**3**	**2**	**1**	**2**
CO2	**3**	**2**	**1**	**2**
CO3	**3**	**2**	**1**	**2**
CO4	**3**	**2**	**1**	**2**

Unit-I
Lie groups, Example of Lie groups, Smooth manifolds: A review, tangent space of a Lie group- Lie algebras, One parameter subgroups, the Campbell-Baker-Hausdorff series, Lie theorems.
Unit-II
Representation theory: elementary concepts, Adjoint representation, Killing form, tori, Classification of compact and connected Lie groups, Complex semisimple Lie algebras.
Unit-III
Left invariant and bi-invariant metrics, Geometrical aspect of a compact Lie group, Homogeneous spaces, Coset manifolds, Reductive homogeneous spaces, Isotropy representation.
Unit-IV
G-invariant metrics, Riemannian connection, Curvature, Symmetric spaces, structure of symmetric space, Geometry of symmetric space, duality, Hypersurfaces in metric Lie groups.

Text books/Reference books:

1. Lie Groups: An Introduction through Linear Groups, Wulf Rossmann, Oxford Graduate Texts in Mathematics, Oxford University Press Inc., New York.
2. Naive Lie Theory, John Stillwell, Springer, 2008.
3. Matrix Groups: An Introduction to Lie Group Theory, Andrew Baker, Springer, 2003.
4. Lie Groups, Lie Algebras, and Representations: An Elementary Introduction, Brian C. Hall, Springer, 2004.
5. Lie Groups: An Approach through Invariants and Representations, Claudio Procesi, Springer, 2006.
6. Lie Groups beyond an Introduction, Anthony W. Knapp, Birkhauser, 2002.
7. Differential Geometry, Lie Groups, and Symmetric Spaces, Sigurdur Helgason, American Mathematical Society, 2001.

Paper Code: CWM-109	Paper: Mathematical Modelling and Ecology	L	T/P	C
Paper ID: 945109		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To develop the Mathematical skill of using various mathematical methods.
2:	Enable students understand how mathematical models are formulated, solved, and interpreted.
3:	Make students appreciate the power and limitations of mathematics in solving practical real-life problems
4:	**Introduce students to the world of mathematical modelling – the art, the mechanics, the possibilities, and the limitations**

Course Outcomes (CO):

CO1:	Students will develop scientific understanding
CO2:	Students will be able to do sensitivity analysis for the changes in a system.
CO3:	Students will able to take decisions including tactical and strategic decisions.
CO4:	Assess the validity and accuracy of their approach relative to what the problem requires

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	**2**	**3**	**3**	**2**
CO2	**1**	**2**	**1**	**3**
CO3	**2**	**2**	**2**	**3**
CO4	**3**	**1**	**3**	**2**

Unit-I
Deterministic and stochastic models, tools, techniques, modeling approaches. Models of single and interacting populations, prey-predator, competition, chemical state, AIDS/HIV/ SARS. Epidemic and genetic models. Model for dialysis, Model for brain tumour.
Unit-II
Single species models, Exponential, logistic, Gompertz growth, Harvest model, Discrete-time and Delay model, Interacting population model, Dynamics of exploited populations, Spatially structured models.
Unit-III
Models for traffic flow, computer data communications, Stock Market, spatio-temporal pattern. Modeling of Physical and Engineering systems -Heating and cooling systems, Henon-Heiles systems, Hydro power plant, fuel injection systems and ankle joint.
Unit-IV
Age-structured models, Leslie matrix, Randomly fluctuating Environment, prey-predator and multi-species models in stochastic environment. The selection of programming languages and solving tools for applications will be done accordingly.

Recommended Books:

1. Mathematical Modelling by J.N. Kapur, New Age International, 1998
2. Mathematical Biology by J.D. Murray, Springer, 2003
3. Elements of Mathematical Ecology by Mark Kot, Cambridge University Press, 2001
4. Mathematical Models & Methods for Real World Systems by Frauti, Siddiqui, Taylor Francis Group (CRC), 2005

Paper Code: CWM-110	Paper: Stochastic Processes, Queuing Theory & Reliability	L	T/P	C
Paper ID: 945110		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:

1:	To develop the mathematical skill of using various mathematical methods
2:	To give introduction about Random walk.
3:	To give introduction about Poisson process.
4:	To introduce the basic idea of Queuing theory

Course Outcomes (CO):

CO1:	Students will learn generalized queuing models.
CO2:	Students will learn about Markov process.
CO3:	Students will be familiar to discrete time queuesy.
CO4:	Students will learn Reliability theory.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	2	**2**	3	**2**
CO2	1	3	2	**2**
CO3	**3**	3	3	**2**
CO4	**3**	**2**	3	**2**

<u>Unit I:</u>
Markov chains with finite and countable state space, classification of states, limiting behavior of n-step transition probabilities, stationary distribution, branching processes, Random walk, Gambler's ruin. Markov processes in continuous time, Poisson processes, birth and death processes, Wiener process.
<u>Unit II</u>
General Concept, Generalized Queuing model, M/M/1, M/M/1/N and M/M/s Queue, Bulk Queue, Network of Monrovian Queueing System, Non Markovian Queueing Models, M/G/1, GI/M/1 Queue.
<u>Unit III</u>:
General concept of discrete time queues, Applications of Queuing theory. Introduction to Reliability Theory, System Reliability, Repairable and Non Repairable Systems.
<u>Unit IV</u>:
Markov Modeling in Reliability, Life testing using the exponential and Weibull models, Shock Models and Wear Process, Concept of Redundancy.

The selection of programming languages and solving tools for applications will be done accordingly.

Suggested Readings and References

1. Stochastic Processes by Sheldon M. Ross, Wiley India Pvt. Ltd., 1995
2. Essentials of Stochastic Processes by Rick Durrett, Springer, 1999
3. Mathematical Methods in Queuing Theory by Kalashnikov, Kluwer Academic Publisher, 2010
4. Reliability Theory and Practice by Igor Bazovsky, Dover Publication, 2004

Paper Code: CWM-111	Paper: An Introduction to Financial Mathematics	L	T/P	C
Paper ID: 945111		**4**	**-**	**4**

Marking Scheme:

- Teachers Continuous Evaluation: 40 marks
- Term end Theory Examinations: 60 marks

Course Objectives:	
1:	Introduce the concepts of financial mathematics.
2:	Introduce students to the use of mathematical models for financial products
3:	Develop student abilities to create, derive, and apply mathematical models
4:	The course will introduce the concept of risk and return

Course Outcomes (CO):	
CO1:	The knowledge of risk and return will be integrated in optimal decision making
CO2:	**Develop computational skills in students**
CO3:	**Develop in students the ability to apply mathematics to real-world problems**
CO4:	**Promote analytical and critical thinking.**

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	3	2	3
CO2	2	3	2	2
CO3	3	3	3	3
CO4	3	3	3	2

Unit-I
Basic Terminology: Financial markets, Interest computation, value, growth and discount factors, derivative products.
Unit-II
Derivative Pricing: Basics of option theory, single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CRR) model, volatility, Black-Scholes formula for option pricing as a limit of CRR model, Greeks and hedging.
Unit-III
Portfolio Optimization: Mean-Variance portfolio theory: Markowitz model, Capital Asset Pricing Model (CAPM), Factor models.
Unit-IV
Interest Rates and Interest Rate Derivatives, Binomial Tree Models.

Suggested Books and References

1. D. G. Luenberger, Investment Science, Oxford University Press, 1999 (new edn. 2013).
2. M. Capińsky and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer, 2004 (new edn, 2011).
3. J C Hull, Options, Futures and other Derivatives, Prentice Hall, 8th edn, (2011).
4. S. Chandra, S. Dharmaraja, A. Mehra and R. Khemchandani, Financial Mathematics: An Introdu Publishing House, 2013.

<table>
<tr><td>Paper Code:
CWM-112</td><td colspan="3">Paper: Differentiable Manifolds</td><td>L</td><td>T/P</td><td>C</td></tr>
<tr><td>Paper ID:
945112</td><td colspan="3"></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td colspan="7">Marking Scheme:
• Teachers Continuous Evaluation: 40 marks
• Term end Theory Examinations: 60 marks</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1:</td><td colspan="6">To give basic concepts of differentiable manifolds</td></tr>
<tr><td>2:</td><td colspan="6">To give introduction about calculus on differentiable manifolds</td></tr>
<tr><td>3:</td><td colspan="6">To give introduction about connections, Riemannian metrics and curvatures on differentiable manifolds</td></tr>
<tr><td>4:</td><td colspan="6">To introduce variations of arc length and exponential maps, Jacobi vector field</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td colspan="7">Course Outcomes (CO):</td></tr>
<tr><td>CO1:</td><td colspan="6">Students will learn basic concepts of manifolds</td></tr>
<tr><td>CO2:</td><td colspan="6">Students will understand to apply calculus on manifolds</td></tr>
<tr><td>CO3:</td><td colspan="6">Students will be familiar to compute Riemannian connections and curvatures</td></tr>
<tr><td>CO4:</td><td colspan="6">Students will learn to compute first and second variation of arc length, exponential maps and its applications on smooth manifolds</td></tr>
<tr><td colspan="7">Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: low, 2: Medium, 3: High)</td></tr>
</table>

CO/PO	PO1	PO2	PO3	PO4
CO1	**3**	**2**	**1**	**2**
CO2	**3**	**2**	**1**	**2**
CO3	**3**	**2**	**1**	**2**
CO4	**3**	**2**	**1**	**2**

Unit I:
Introduction : Topological and differentiable manifold with examples, product manifolds, vector field and tangent space, Lie brackets, differential map and Jacobians, immersions and imbeddings, differential forms and cotangent space, pull back map, geodesic and parallel transportation, covariant derivative and coefficients of affine connections.
Unit II
Calculus on Manifolds : Exterior derivative, Lie derivative, gradient, curl, divergence, Laplacian, Hessian on manifolds, interior product, orientations and volume element, integration in R^n and its generalisation to manifolds, Stoke's theorem
Unit III:
Riemannian Connections and Curvatures: Levi-Civita connections, torsions and symmetry, Riemannian metrics and Riemannian connections, Riemannian curvature, sectional curvature, Ricci curvature, scalar curvature, connection forms, structural equations, curvature forms.
Unit IV:
Variations of Arc Length: First and second variation of arc length, Bonnet Theorem, exponential map, Jacobi vector fields and conjugate points, Submanifolds with examples, tangent space and normal space.

Suggested Readings and References
1. Riemannian Geometry, M. P. Do Carmo, **1992**, Birkhauser Boston 2. The Geometry of Physics, Theodore Frankel, **2011**, Cambridge University press 3. Introduction to Smooth manifolds, J.M.Lee, **2013**, Springer-Verlag New York

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