ETHIRAJ COLLEGE FOR WOMEN (AUTONOMOUS)

CHENNAI - 600 008

DEPARTMENT OF PHYSICS (SS)

M.PHIL SYLLABUS

CHOICE BASED CREDIT SYSTEM
OUTCOME BASED EDUCATION

(OFFERED FROM THE ACADEMIC YEAR 2018 – 2019)

CONTENTS

RULES AND REGULATIONS FOR THE PROGRAMME

Master of Philosophy in Physics

(Revised syllabus effective from the academic year 2018 – 2019)

The duration of the course for full time is one academic year and every academic year is divided into two semester sessions. The duration of the course for part time is two years. Teaching is organized into a modular pattern of credit courses. Credit is normally related to the number of hours a teacher teaches a particular subject. It is also related to the number of hours a student spends learning a subject and carrying out a project.

Regulations

1. **Eligibility for Admission:**

Candidates for admission to the Degree of Master of Philosophy in Physics course should have passed two year M.Sc. degree course in Physics after three year degree course in Physics and Higher Secondary of twelve years duration or Pre-University under eleven year S.S.L.C + one year or 10+2 pattern. The minimum eligibility mark shall be as prescribed in the guidelines for admission to the M.Phil. degree in Physics by the University of Madras.

2. **Eligibility for the Award of Degree:**

A candidate shall be eligible for the award of the Degree only if she has undergone the prescribed course of study for a period of not less than one academic year (for full time and two academic years for part time), passed all the examinations as prescribed and earned a total of 36 credits.

3. **Course of Study:**

The main subject of study for M.Phil. Degree in Physics shall consist of the following

Core papers : 2

Elective paper : 1

Dissertation : 1

4. **Passing Minimum:**

A Candidate shall be declared to have passed in each paper / project of the Core subject of study wherever prescribed, if she secured NOT LESS THAN 50% of the marks prescribed for the end semester examination and there is no passing minimum for Continuous Assessment (CA).

5. **Classification of Successful Candidates:**

Successful candidates passing the examination and securing the marks

i) 60% and above and

ii) 50% and above but below 60% in the aggregate shall be declared to have passed the examination in the FIRST CLASS and SECOND CLASS respectively.

Candidates who pass all the examinations prescribed for the course in the FIRST APPEARANCE ITSELF ALONE are eligible for ranking.

6. **Question Paper Pattern:**

Unless and otherwise specified in the syllabus for each paper, the pattern of question paper shall be as follows.

Core and Elective Course:

Component	**Nature of the Question**	**Maximum Marks**
One	Descriptions / Application / Analysis / Synthesis	5/8 x 20 =100

The paper can have 5 questions to be answered out of 8 questions covering the 5 units.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

On obtaining a research degree the scholar will be able to:

PEO1. Demonstrate advanced domain knowledge competencies and display high order discerning and synthesizing capabilities to address local, regional and national concerns through innovative well researched solutions.

PEO2. Continue to serve the community of professionals and experts as both independent and team player with a strong grounding in ethics, inclusivity, gender parity and environmental sustainability.

PROGRAMME OUTCOME (PO)

PO1- To acquire advanced conceptual knowledge and comprehensive understanding of the fundamental principles in respective discipline.

PO2- To apply knowledge and critically evaluate the concepts and scientific developments to take up any challenge.

PO3- To visualize and work on laboratory multidisciplinary tasks related to current research in the fields of Mathematical, Physical and Life sciences

PO4- To acquire research based knowledge and design methods to conduct investigations of complex problems in research/ Industrial field and achieve employability / self employment.

PO5- To communicate effectively ideas verbally in English, leading to Entrepreneurship ventures such as consultancy and training.

PO6- Employ innovative and environment friendly methods, novel ideas to solve complex and challenging societal and environmental issues.

PROGRAMMME SPECIFIC OUTCOMES (PSOs)

Upon completion of M.Phil degree programme, the graduates will be able to:

PSO1. Apply the in-depth conceptual understanding of the subject through literature survey and characterization techniques. To choose advanced level research in the country and aboard.

PSO2. Demonstrate innovation in the application of knowledge, in solving problems, planning and implementation of research and critical evaluation.

PSO3. Apply the practical understanding of interpreting research and enquiry as knowledge, enabling them to function effectively in multidisciplinary academic environments.

PSO4. Evolve as excellent professionals in universities and scientific establishments like BARC/ISRO/DRDO/CSIR/TIFR laboratories and contribute towards scientific growth.

PSO5. Analyze the impact of new emerging areas of physics in the global, economic, environmental and societal consideration.

PSO6. Develop inventive methodologies to tackle the issues identified and contribute to the development of scientific knowledge and intellectual property.

PROGRAMME PROFILE – M.PHIL PHYSICS

SEM	COURSE CODE	TITLE OF THE PAPER	CREDITS	TOTAL HOURS	CA	SE	TOTAL
I	14M18/RMY	Research Methodology	5	60	40	60	100
	14M18/MLS	Materials Science	5	60	40	60	100
	14M18/EIP1, EIP2, EIP3	Elective – Internal Paper	5	60	40	60	100
II	14M18/DTN	Dissertation	21		40	60	100

TOTAL CREDITS: 36

EVALUATION PATTERN FOR CONTINUOUS ASSESSMENT

2 theory core papers, 1/3 major elective paper & 1 Dissertation

INTERNAL VALUATION BY COURSE TEACHERS

CORE / ELECTIVE – THEORY PAPERS

COMPONENT	**TIME**	**MAX. MARKS**	**CA MARKS**
1. TEST I	2 Hrs.	50 MARKS (TO BE CONVERTED)	10
2. TEST II	2 Hrs.	50 MARKS (TO BE CONVERTED)	10
3. ASSIGNMENT/ SEMINAR /FIELD VISIT			20
TOTAL			40

DISSERTATION:

COMPONENT	**MARKS**
1. SELECTRION OF PROBLEM & REVIEW OF LITERATURE	10
2. PERIODICAL REPORTS & EVALUATION	10
3. SEMINAR	10
4. INTERNAL VIVA-VOCE	10
TOTAL	40

CA QUESTION PAPER PATTERN – M.PHIL

Knowledge Level	**Section**	**Word Limit**	**Total Marks**
K4, K5	A – 5/8 X 10 marks	750	50

RUBRICS FOR CONTINUOUS ASSESMENT

Assignment	Content/originality/Presentation/Schematic Representation and Diagram/Bibliography
Seminar	Organization/Subject Knowledge/Visual Aids/Confidence level/presentation-Communication and Language
Field Visit	Participation/Preparation/Attitude/Leadership
Participation	Answering Questions/Clearing Doubts/Participating in Group Discussions/Regular Attendance
Case Study	Finding the Problem/Analysis/Solution/Justification
Problem Solving	Understanding Concepts/Formula and Variable Identification/Logical Sequence/Answer
Group Discussion	Preparation/Situation Analysis/Relationship Management/Information Exchange/Delivery Skills
Flipped / Blended Learning	Preparation/Information Exchange/Group interaction/Clearing doubts

- FIRST TWO RUBRICS SHOULD BE INCLUDED
- OTHERS ARE OPTIONAL BASED ON TEACHING-LEARNING METHODOLOGY ADOPTED FOR THE PROGRAMME OF STUDY

END SEMESTER EVALUATION PATTERN – M.PHIL

THEORY PAPERS

SEMESTER I

DOUBLE VALUATION BY COURSE TEACHER AND EXTERNAL EXAMINER

MAXIMUM MARKS : 100 TO BE CONVERTED TO 60

PASSING MARKS : 50

PROJECT PAPER

SEMESTER : IV

DOUBLE VALUATION BY RESEARCH SUPERVISOR AND EXTERNAL EXAMINER

DISSERTATION : 60

VIVA : 40

MAXIMUM MARKS : 100 TO BE CONVERTED TO 60

PASSING MARKS : 50

SEMESTER I COURSE PROFILE – M.PHIL

SEM	COURSE CODE	TITLE OF THE PAPER	CREDITS	TOTAL HOURS	CA	SE	TOTAL
I	14M18/RMY	Research Methodology	5	60	40	60	100
	14M18/MLS	Materials Science	5	60	40	60	100
	14M18/EIP1, EIP2, EIP3	Elective – Internal Paper	5	60	40	60	100

RESEARCH METHODOLOGY

TOTAL HOURS: 60 **COURSE CODE: 14M18/RMY**
CREDITS: 5

COURSE OBJECTIVES:

1. To understand the required research techniques for the preparation of research paper.
2. To introduce the important topics necessary for thesis writing.
3. To impart the knowledge of statistical problems needed in research.
4. To improvise the understanding of Numerical problems for advance research studies.
5. To understand the importance of the application of C-Programming and Web resources in research.

COURSE OUTLINE:

Unit I: Techniques for Research

Nature and importance of research – aims, objectives, principles and problems – Identification of the problem – literature survey – reference – awareness of current status of the art, abstraction of research paper. **12 Hrs**

Unit II: Thesis Writing

Preparation of technical papers and thesis writing – presentation of data – symbols – the observations – tables and figures – equations – the style – sentence length – word length – page and chapter format – use of quotation and foot notes – referencing – appendices – reversing, editing and evaluating the final material – proof reading. **12 Hrs**

Unit III: Statistical Methods

Discrete and continuous random variables – Mean, variance, standard deviation, moments, Poisson, Binomial and normal distributions and their properties-skewness.

Elementary aspects of hypothesis testing: Simple hypothesis type I and type II errors; one tailed and two tailed tests, X^2 goodness–of-fits test – distribution.

12 Hrs

Unit IV: Numerical Methods

Principle of least squares – straight line and parabola - Numerical differentiation and integration – Trapezoidal rule – Simpson's rule – Gaussian quadrature formula – Numerical solution of ordinary differential equations solutions by Taylor's series – Euler's method – Runge kutta method with Runge's co-efficient - Numerical solution of partial differential equations using finite difference method. **12 Hrs**

Unit V: Computer Programming and Internet

Review of C language – Application of C language – Matrix addition, Numerical Integration by Trapezoidal rule and Simpson's rule, least squares line calculation, calculation of mean and standard deviation of one dimensional random variables. Internet and its applications – e-resources to research – WWW – Web browsing.

12 Hrs

RECOMMENDED TEXTBOOKS:

1. Rajammal PA Devadas , A hand book of Methodology of Research , 4th Edition, Vidhyalaya press, Coimbatore , 1976.
2. C.Hawkins and M.Sorgi, Research – How to plan, speak and write about it, 1st Edition, Narosa Publications 1987.

REFERENCE BOOKS:

1. Satyaprakash, Mathematical Physics, 4th Edition, Sultan and Chand, 2002.
2. Terry E.Shoup, Applied Numerical methods for the Micro computer, 2nd Edition, Prentice Hall Inc., Englewood Cliffs, New Jeney, 1984.
3. Evous, D.J, Software for Numerical Methods, 2nd Edition, Academic Press Inc., New York, 1974.
4. E.V.Krishnamurthy, Numerical Analysis and algorithm, 4th Edition, Wiley Eastern, 1982.
5. Jain,M.K., Numerical Analysis for Scientists and Engineers, 2nd Edition, SBW Publishers, Delhi, 1971.
6. E.Balaguruswami, Programming in ANSI C, 3rd Edition, Tata McGraw-Hill Pub. Com Ltd., New Delhi 1988.

JOURNALS:

1. English for Specific Purposes
2. Numerische Mathematik
3. Journal of Scientific and Industrial Research

E- LEARNING RESOURCES:

1. http://www.slideworld.org/pdf-ebook.aspx/research%20methodology
2. http://www.sst.ph.ic.ac.uk/angus/Lecturs/compphys/comphys.html
3. http://www.iiserpune.ac.in/ayan/sahoo_textbook.pdf
4. http://www.math.ust.hk/machas/numerical-methods
5. http://www.digitalunite.com/technology..internet/...browsing/what

CO No.	CO Statement	Knowledge Level
CO 1	Identify area of research problem and methodology in its implementation.	K4
CO 2	Formulate the layout and format of thesis. Evaluate and proof read the content of the thesis	K5, K6
CO 3	Apply statistical methods for analysis and interpretation of data.	K3,K4
CO 4	Evaluate and solve research problems by applying numerical methods to the data and information collected.	K4
CO 5	Demonstrate proficiency in the use of Web resources and programming using C language.	K4

MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO 1	3	2	3	3	2	2
CO 2	3	2	2	2	1	1
CO 3	1	3	3	2	1	2
CO 4	1	3	2	2	1	2
CO 5	2	3	3	2	1	2
Average	**2**	**2.6**	**2.8**	**2.2**	**1.2**	**1.8**

KEY: STRONGLY CORELATED -3 MODERATELY CORELATED -2 WEAKLY CORELATED – 1 NO CORELATED-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk –OHP –LCD)
Flipped Learning/Blended Classroom – E Content, Videos
Problem Solving – Group Discussion –Quiz/Seminar

QUESTION PAPER PATTERN – M. Phil

Knowledge level	Section	Word Limit	Total Marks
K5, K6	A-5/8 x 20marks	1500	100

MATERIALS SCIENCE

TOTAL HOURS: 60 **COURSE CODE: 14M18/MLS**
CREDITS: 5

COURSE OBJECTIVES:

1.To impart the basics of nanomaterials and their applications.
2.To make the students understand the significance of Shape Memory Alloys and biomaterials and their day to day applications.
3.To familiarize the application and importance of NLO materials required for research.
4.To impart knowledge on the electrical, optical, and semiconducting properties of solid state materials.
5.To introduce the characterization techniques required to study the properties of materials.

COURSE OUTLINE:

Unit I: Nano Materials

Nanomaterials – Fundamentals Physics and chemistry of Nano-synthesis, physical and chemical methods – properties, chemical, mechanical - low temperature, high temperature –applications. **12 Hrs**

Unit II: Shape Memory Alloys and Bio Materials

Shape Memory alloys (SMA) – Characteristic properties, principle of Shape Memory effect, hystersis, two way SMA, super-elasticity, thermo-mechanical behavior - Processing –resistivity measurements, transformation of Shape Memory alloy with temperature, tensile strength– applications

Biomaterials – Classifications of biomaterials – Polymers, Mechanism and degree of polymerizations – Ceramics, Fabrication and Processing -Types –structure and optical properties and applications of Ceramics – Structure properties of polymers. **12 Hrs**

Unit III: Nonlinear Optical materials

Nonlinear materials – Principle – Classification, passive and active –Properties, polarization, frequency doubling or tripling, optical mixing, optical phase conjugation, optical rectification, phase matching-Nonlinear Materials, ADP, KDP, Lithium Niobate –applications. **12 Hrs**

Unit IV: Electrical, Optical and Semi-conducting Properties

Electrical conduction- band structure in solids - conduction in terms of band and atomic bonding models – applications - Insulators – Dielectrics - optical properties of metals and nonmetals - interaction of light with solid – applications of optical materials –Types of semiconductors, Extrinsic, Intrinsic - applications – Micro electrical mechanical systems(MEMS), Quantum dots, Spintronics. **12 Hrs**

UNIT V: Characterization Techniques

Non destructive testing (NDT) techniques - X ray Diffraction (XRD) and FTIR as identity tools-Surface electron microscopy for analysis of surface morphologies - Ultrasonics – study of molecular interaction of materials – Atomic force microscopy – Determination of NLO efficiency of materials – Hardness studies - Polymer characterization – Thermo Gravimetric analysis – TDA and DSC. **12 Hrs**

RECOMMENDED TEXTBOOKS:

1. V. Rajendran and A. Marikani, Material Science, Tata McGraw Hill, New Delhi, 2nd Edition,2005.
2. Leonid V. Azaloff, Introduction to Solids, 1st Edition, Tata McGraw Hill Publishing Company 2000.

REFERENCE BOOKS:

1. C. Kittel Wiley, Introduction to Solid State Physics, 2nd Edition, Eastern University Edition. 1987.
2. L.Kakani and Amit Kakani, Material Science, 2nd Edition, New Age International Publisher, New Delhi, 2004.
3. C.Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Encyclopedia of Materials
4. Characterization, 2nd Edition, Butterworth-Heinemann Publishers 1992.
   C. N. Banwell, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata Mc Graw Publ 1978.
5. T. Jeyakumar, Baldevraj, V.Rajendran and P.Palanichamy, Science and Technology of Ultrasonics, 1st Edition, Narosa Publishing House, New Delhi, 2004.

JOURNALS:

1. Royal Society of Chemistry
2. IOP-Journal of Condensed Matter
3. Bulletin of Materials Science

E- LERANING RESOURCES:

1. http://www.physics.brocku.ca/courses/4p70/
2. http://web.mit.edu./afs/athena/course/6/6/732/www/texts.html
3. http://wwwthphys.physics.ox.ac.uk/people/SteveSimon/condmat2012/LectureNotes2012.pdf
4. http://folk.uio.no/yurig/fys448/f448pdf.pdf
5. http://www.acadpubl.eu/hub/2018-119-12/articles/2/484.pdf

CO No.	CO Statement	Knowledge Level
CO 1	Discuss the basic science behind the properties of nanomaterials and their applications.	K4
CO 2	Analyze and explain the concepts and properties of SMA and biomaterials.	K5,K6
CO 3	Explain the importance of non-linear optical materials and their principles.	K4,K5
CO 4	Outline the semiconducting nature of various solid materials.	K6
CO 5	Select and analyze the properties of materials using various characterization techniques.	K5

MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO 1	3	3	2	2	3	3
CO 2	3	2	2	2	3	2
CO 3	3	2	2	2	2	2
CO 4	3	2	2	2	3	2
CO 5	1	1	3	2	1	2
Average	**2.6**	**2**	**2.2**	**2**	**2.4**	**2.2**

KEY: STRONGLY CORELATED -3 MODERATELY CORELATED -2 WEAKLY CORELATED – 1 NO CORELATED-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk –OHP –LCD
Flipped Learning/Blended Classroom – E Content, Videos
Problem Solving – Group Discussion –Quiz/Seminar

QUESTION PAPER PATTERN – M. Phil

Knowledge level	Section	Word Limit	Total Marks
K5, K6	A-5/8 x 20marks	1500	100

CRYSTAL GROWTH AND CHARACTERIZATION

TOTAL HOURS: 60 **COURSE CODE: 14M18/EIP1**
CREDITS: 5

COURSE OBJECTIVES:

1. Introduce the basic concepts of crystal structure and their applications.
2. To review the crystal growth parameters and techniques.
3. To give an in-depth explanation of the different methods of crystal growth.
4. To impart the significance of defects in crystals essential in the study of their properties.
5. To understand the characterization methods required to study physical properties of crystal.

COURSE OUTLINE:

Unit I: Introduction to Crystals

Introduction to crystal symmetry and physical properties, point and space group, crystal binding - formation of solids – types of bonding – cohesive energy Vander Waal forces – Madelung energy. **12 Hrs**

Unit II: Background of Growth technique

Growth techniques - criteria for equilibria in crystal growth - phase diagrams - solid solubility - classification of growth processes - kinetics of growth - nucleation, diffusion and surface migration - solution growth technique – low temperature, high temperature and gel growth. **12 Hrs**

Unit III:Method of Crystal Growth

Bulk crystal growth methods - Kryopolous, Bridgman – Stockbarger - Growth of III-V and II-VI compounds - high pressure techniques - flame fusion and hydrothermal growth - chemical vapour deposition - hot wall epitaxy, molecular beam epitaxy, liquid and vapour phase epitaxy - MOCVD. **12 Hrs**

Unit IV:Defects of Crystals

Surface impurity contamination - dopant solubility - defects - motion of dislocation, dislocation density and its determination - etch pit density - thermo dynamics of point defects - influence of defects on physical properties - conductivity, diffusion - application of defect in solid state. **12 Hrs**

Unit V: Characterization Techniques

X-ray diffraction – basic principles – characterization by XRD – FTIR – methodologies and accessories – spectral analysis - Scanning electron microscopy – primary modes of operation – sample requirements – applications – Transmission electron microscopy –TEM operation – specimen preparation – Vicker's hardness tests – analysis of hardness parameters. **12 Hrs**

RECOMMENDED TEXTBOOKS:

1. Boardman A. D., O'Conner D. E. and Young D. A., Symmetry and its Applications in Science, London McGraw Hill, 1973.
2. Introduction to Crystallography Philips ELBS Publication.

REFERENCE BOOKS:

1. B. D. Cullity Addison, Elements of X-ray diffraction, Wesley Publishers, 1977.
2. Santhana Raghavan and Dr. P. Ramasamy, Crystal growth processes and methods, KRU publications.
3. Leonid V. Azaloff, Introduction to Solids, Tata McGraw Hill Publishing Company.
4. C. Kittel Wiley, Introduction to Solid State Physics, Eastern University Edition.
5. C.Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Encyclopedia of Materials Characterization, Butterworth-Heinemann Publishers, 1992.
6. Nakamoto K. Translated by Huang D.R. and Wang R.Q., Infrared and Raman spectra of inorganic and coordination compounds, 3rd Edition, Wiley, Beijing, Chemical Industry Press, (in Chinese), (1986).

JOURNALS:

1. Journal of Crystal Growth
2. Crystal Research and Technology
3. Indian Journal of Engineering and Materials Science

E-LEARNING RESOURCES:

1. http://www.sciencedirect.com/science/book/9780444633033
2. http://cosmobillebooks.metroblog.com/download_ebook_crystal_growth_processes based_on_capillarity_czochralski,_floating_zone,_shaping_and_crucible_techniqes
3. http://www.hans-scheel.ch/downloads.html
4. http://www.acadpubl.eu/hub/2018-119-12/articles/2/484.pdf
5. http://www.mse.berkely.edu/groups/morris/mse205/defects.pdf

CO No.	CO Statement	Knowledge Level
CO 1	Identify the structure and space group of crystals.	K4
CO 2	Outline the need and principles of various crystal growth techniques.	K3
CO 3	Demonstrate the method of crystal growth from the three different states of matter.	K3,K4
CO 4	Analyze the crystal defects and its impact on the properties of crystal.	K6
CO 5	Predict the properties of crystals via characterization techniques	K4,K5

MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO 1	1	1	3	2	2	1
CO 2	3	2	3	2	3	2
CO 3	1	3	2	2	2	3
CO 4	3	3	3	2	3	3
CO 5	2	1	2	2	1	1
Average	**2**	**2**	**2.6**	**2**	**2.2**	**2**

KEY: STRONGLY CORELATED -3 MODERATELY CORELATED -2 WEAKLY CORELATED – 1 NO CORELATED-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk –OHP –LCD
Flipped Learning/Blended Classroom – E Content, Videos
Problem Solving – Group Discussion – Quiz/Seminar

QUESTION PAPER PATTERN – M. Phil

Knowledge level	Section	Word Limit	Total Marks
K5, K6	A-5/8 x 20marks	1500	100

X-RAY CRYSTALLOGRAPHY

TOTAL HOURS: 60 **COURSE CODE: 14M18/EIP2**
CREDITS: 5

COURSE OBJECTIVES:

1. To introduce the fundamental concepts behind structure determination using X-ray crystallography.
2. To enhance the knowledge on the methods of structure analysis of crystals.
3. To give a in-depth understanding of the science behind the direct methods employed for solving the phase problems.
4. To teach the concept behind the experimental techniques and refinement of crystal structure.
5. To help the student in grasping the concept of conformational analysis.

COURSE OUTLINE:

Unit I: Introduction

Description of lattices – lattice planes - Concepts of point groups - Space groups – symmetries – translations-rotations – inversion – screw glide – symmetry relationships –equivalent positions.

Fourier transforms – Real & Fourier space – Mathematical description of diffraction pattern using Fourier transforms **12 Hrs**

Unit II: Methods of Structure Analysis

Atomic Scattering factor-structure factor – electron density function –Friedels' law-systematic absences - Phase problem in crystallography –Methods of its solution(qualitative) – Patterson – Heavy atom – Anomalous scattering – Isomorphous replacement – Intensity measurement & data corrections **12 Hrs**

Unit III: Direct Methods

Unitary and normalized structure factors- Harker – Kasper inequalities – Sayer's relations – general phase and probability relations – structure invariants and semi invariants – symbolic addition methods **12 Hrs**

Unit IV: Experimental techniques & Refinement

X-ray sources – crystal setting – Powder method - Single crystal X-ray diffractometry Necessity for refinement- Trial structure – Cyclic Fourier refinement-Residual Index – Least square refinement **12 Hrs**

Unit V: Interpretation of Results

Bond lengths – Bond angles – Torsion angles – stereochemistry – concepts of conformation - Vander Waals radii of atoms – Vander Waal's interactions – hydrogen bonds – molecular stability – crystal packing. **12 Hrs**

RECOMMENDED TEXT BOOKS:

1. Dennis Sherwood, Crystal, X-ray and Proteins , Longman group Ltd, London.
2. D. Velmurugan, Elementary Crystallography, MJP Publishers, Chennai.
3. L.V. Azaroff, Elements of X-ray Crystallography, McGraw-Hill Inc., US.

REFERENCE BOOKS:

1. Stout and Jensen, X-ray Structure Determination, 2nd Edition, John Wiley Publications.
2. Ladd and Palmer, Structure Determination by X-ray Crystallography, 2nd Edition-Plenum Press, London.
3. F.C.Philips, An Introduction to Crystallography, Longmans I Publications.
4. M.M.Woolfson, An Introduction to Crystallography, Cambridge university press II Edn.
5. W.Clegg, A.J.Blake, R.O.Gould, P.Main, Crystal Structure Analysis –Principles and Practice, Oxford university press.

JOURNALS:

1. Acta Crystallographica Section C & E
2. Journal of Applied Crystallography
3. Indian Journal of Engineering and Materials Sciences

E-LEARNING RESOURCES:

1. http://www.mic.ucla.edu/X-ray/tutorials.html
2. http://ocw.mit.edu/courses/chemistry/5-069-crystal-structure-analysis-spring 2010/lecture-notes/
3. www.youtube.com/watch?v=oj4QJ-1lxgU
4. https://www.jstor.org/stable/1697181
5. https://www.doitpoms.ac.uk/

CO No.	CO Statement	Knowledge Level
CO 1	Discuss the basic science in determining the symmetries and related mathematics of crystal structure.	K4
CO 2	Demonstrate the different methods of structural analysis.	K5
CO 3	Outline the direct methods for resolving the phase problem.	K6
CO 4	Explain the methods of refinement of crystal data	K6
CO 5	Analyze the results to identify the structure and its conformation.	K6

MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO 1	2	3	3	3	1	1
CO 2	2	2	2	2	1	3
CO 3	2	1	2	3	1	2
CO 4	3	3	3	3	3	3
CO 5	3	3	3	3	2	3
Average	**2.4**	**2.4**	**2.6**	**2.8**	**1.6**	**2.4**

KEY: STRONGLY CORELATED -3 MODERATELY CORELATED -2 WEAKLY CORELATED – 1 NO CORELATED-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk –OHP –LCD
Flipped Learning/Blended Classroom – E Content, Videos
Problem Solving – Group Discussion –Quiz/Seminar

QUESTION PAPER PATTERN – M. Phil

Knowledge level	Section	Word Limit	Total Marks
K5, K6	A-5/8 x 20marks	1500	100

APPLICATIONS OF MOLECULAR SPECTROSCOPY

TOTAL HOURS: 60 **COURSE CODE:14M18/EIP3**
CREDITS:5

COURSE OBJECTIVES:

1. To understand the overall perspective of microwave and UV-Visible spectroscopy.
2. To introduce the theory and applications of FTIR spectroscopy.
3. To enhance the knowledge of Raman spectroscopy and its applications.
4. To explain the principles of NMR spectroscopy and its applications.
5. To impart the knowledge of diverse NMR techniques.

COURSE OUTLINE:

Unit I: Microwave Spectroscopy and UV visible Spectroscopy

The nature of electronic excitations – Origin of UV band structure – principles of absorption spectroscopy – instrumentation – solvents – effect of conjuction – aromatic compounds – model compound status – instrumentation of radiation with rotating molecules – isotope effect in rotational spectra – Stark effect – Quadrapole hyperfine interaction – Microwave spectrometer. **12 Hrs**

Unit II: FTIR Spectroscopy

IR Absorption process – uses of FTIR spectrum-modes of stretching and bending-IR spectrometer-Dispersive IR Spectrometers-Fourier transform spectrometer-preparation of samples of FTIR spectroscopy-Examination of FTIR Spectroscopy-Analysis of spectra-Hydrocarbons-Alkanes, Alkenos-aromatic rings-Alcohols and phenols-nitro, sulphur and phosphorous compounds- applications. **12 Hrs**

Unit III: Raman Spectroscopy

Nature of Raman Effect – Instrumentation techniques-sources- sampling methods-CARS- Raman effect in molecular structure- Laser Raman spectroscopy in molecular structural confirmation of water and carbondioxide molecule- study of molecular vibrations – applications. **12 Hrs**

Unit IV: Nuclear Magnetic Resonance Spectroscopy

Nuclear magnetic moments – Nuclear magnetic spectrometer – Ethyl group – survey of typical NMR absorptions by the type of compound-alcohols, Amines, ketones- coupling constant symbols- mechanism of coupling-aromatic compounds-substitutional benzene rings. **12 Hrs**

Unit V: Advanced NMR Techniques

Pulse sequences-pulse widths, spins and magnetization vectors-Determining the number of attached hydrogen-COSY Technique-HETCOR Techniques-Magnetic Resonance Imaging –Double resonance – f NMR. **12 Hrs**

RECOMMENDED TEXTBOOKS:

1. Pavia Lampman Kriz, Introduction to Spectroscopy, Third Edition, Thomson Books Cole, 2006.
2. C.N.Banwell and E.M.Mccash, Fundamentals of Molecular Spectroscopy, 5th Edition TMH, NewDelhi, 2013.

REFERENCE BOOKS:

1. Walker and Straughan, Spectroscopy, Vols, I and II, 4th Edition, Chapman and Hall,1976.
2. D.N.Sathyanarayana, Vibrational Spectroscopy and Applications, 2nd Edition, New Age International Publication, 2004.
4. V.B.Patania, Spectroscopy, 1st Edition, Campus books International, 2002.
5. J.L. Mc.Hale, Molecular Spectroscopy, 1st Edition, Prentice Hall, 1999.
6. W.L. Struve, Fundamentals of Spectroscopy,1st Edition, Wiley, 1989.

JOURNALS:

1. Journal of Molecular Spectroscopy
2. Spectrochimica Acta Part A: Molecular Spectroscopy
3. Bulletin of Material Science

E-LEARNING RESOURCES:

1. http://www.freebookcentre.net/chemistry-books-download/Introduction-to-Spectroscopic-methods-%28PDF-70P%29.html
2. http://www.digitalbookindex.org/_search/search010chemspectroscopya.asp
3. http://www.freebookcentre.net/chemistry-books-download/Principles-of-Spectroscopy.html
4. http://www.sciencedirect.com/topics/chemistry/nmr-spectrum
5. http://www.rsc.org/learn-chemistry/collections/spectroscopy/introduction

CO No.	CO Statement	Knowledge Level
CO 1	Apply the techniques of microwave and UV-Visible spectroscopy in explaining the structure and properties of molecules.	K5
CO 2	Explain and analyze the Fourier transform Infrared spectrum of compounds.	K4, K5
CO 3	Apply the Raman spectroscopic techniques in molecular studies.	K4
CO 4	Analyze a compound both qualitatively and quantitatively by resonance technique.	K5
CO 5	Outline different NMR techniques to determine placement of the proton and fluorine.	K6

MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO 1	2	2	2	2	2	2
CO 2	2	3	2	3	3	2
CO 3	2	2	3	3	2	2
CO 4	2	2	3	3	3	2
CO 5	3	3	3	3	3	3
Average	**2.6**	**2**	**2.6**	**2.8**	**2.6**	**2.2**

KEY: STRONGLY CORELATED -3 MODERATELY CORELATED -2 WEAKLY CORELATED – 1 NO CORELATED-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk –OHP –LCD
Flipped Learning/Blended Classroom – E Content, Videos
Problem Solving – Group Discussion – Quiz/Seminar

QUESTION PAPER PATTERN – M. Phil

Knowledge level	Section	Word Limit	Total Marks
K5, K6	A-5/8 x 20marks	1500	100

RESEARCH TRENDS IN NANOSCIENCE AND NANOTECHNOLOGY

TOTAL HOURS: 60 **COURSE CODE: 14M18/EIP4**
CREDITS: 5

COURSE OBJECTIVES:

1. To introduce the fundamental concepts of physical and chemical properties of nanomaterials.
2. To expose the necessary quantum theory to study the nature of nanomaterials.
3. To enhance the knowledge on the synthesis of nanomaterials of all dimensions.
4. To introduce the characterization techniques required to study the properties of nanomaterials.
5. To impart the knowledge of the current and future applications of nanotechnology in various fields

COURSE OUTLINE:

Unit I: Fundamentals of Physics and chemistry - Nano

Introduction: Physical and chemical properties of nano. Necessity of characterization. Macroscopic properties: Optical. Electrical, dielectric, magnetic, mechanical (b) Microscopic properties – chemical structure, composition, surface characterization. **12 Hrs**

Unit II: Quantum background of Nanomaterials

Quantum mechanics and Quantum Confinement: Introduction to Quantum mechanics and Quantum confinement and application with reference to Quantum wells, Quantum wires, Quantum dots, Nano clusters and Nano crystals. **12 Hrs**

Unit III: Synthesis of Nanomaterials

Introduction to Synthesis of Nanomaterials: Types and strategies for synthesis of nanomaterials depending on end applications. Zero-Dimensional Nanostructures: Nanoparticles: Introduction, different strategies for synthesis of 0D nanomaterials and their technological applications. One-Dimensional Nanostructures: Nanorods and Nanowires: Introduction, different strategies for synthesis of 1D nanomaterials and their technological applications. Two-Dimensional Nanostructures: Thin Film: Introduction, different strategies for synthesis of 2D **12 Hrs**

Unit IV: Characterization Techniques

Probing bulk and nano-structure – XRD, TEM, HRTEM, Neutron scattering. Surface structure and topography – SEM, STM, LEED, AFM. Microstructure – UV-VIS, Raman, FTIR. **12 Hrs**

Unit V: Application of Nanotechnology

Applications of Nanotechnology in various fields: Renewable energy, solar energy, fuel cells etc. Materials manufacturing and automobile industry, Biomedical science, medicine, diagnostics, etc. Computers, electronics and communication Analytical, Pharma and Environmental sciences Biosciences- (Nano Biosciences - Biotechnology), Sport sector, printing, optics, Agriculture, food, textile, cosmetics, Defense, Aerospace and Marine Nanotechnology. **12 Hrs**

RECOMMENDED TEXTBOOKS:

1. Charles P.Poole, Jr. and Frank J.Owens, Introduction to Nanotechnology, Wiley, 2003.
2. G.M.Chow and K.E.Gonslaves Nanotechnology - Molecularly Designed Material American chemical society.

REFERENCE BOOKS:

1. J.D.Plummer, M.D.Deal and P.B. Griffin, Silicon VLSI Technologies, Prentice Hall, 2000.
2. K.P.Jain, Physics of semiconductor Nanostructures: 3rd Edition Narosa Publishers,New Delhi 1997.
3. Vladimir V. Mitin, V.A. Kochelap, M.A.Stroscio, Introduction to Nanoelectronics, 2nd Edition, Cambridge University press, 2011.
4. Sujaul Chowdhury, Nanosructure Physics an Microelectronics, 2nd Edition, Narosa Publishing house, New Delhi.
5. H. Nejo, Nanostructures – Fabrication and Analysis, 1st Edition, Springer International, Berlin.

JOURNALS:

1. ACS Nano
2. Nano Materials Science
3. Bulletin of Materials Science

E-LEARNING RSOURCS:

1. https://www.oreilly.com/library/view/engineering-physics/9788131775073/xhtml/ch13- sub13.1.xhtml
2. https://www.news-medical.net/life-sciences/Properties-of-Nanoparticles.aspx
3. https://www.ttu.ee/public/m/Mehaanikateaduskond/Instituudid/Materjalitehnika_instituut/MTX9100/Lecture11_Synthesis.pdf
4. https://www.nanoscience.com/techniques/scanning-electron-microscopy/
5. https://www.understandingnano.com/nanomaterials.html

CO No.	CO Statement	Knowledge Level
CO 1	Communicate the science behind the properties of nanomaterials.	K3
CO 2	Utilize the quantum theory and apply it to the 0D, 1D and 2D nanomaterials	K5
CO 3	Demonstrate various synthesis techniques for the preparation of nanomaterials.	K4
CO 4	Discuss various characterization techniques and compile its results.	K5
CO 5	Predict and design nanomaterials for potential application in various fields.	K6

MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO 1	3	2	3	2	2	2
CO 2	3	3	3	3	3	3
CO 3	2	2	2	2	2	3
CO 4	2	2	2	3	2	2
CO 5	3	3	3	3	3	3
Average	**2.6**	**2.4**	**2.6**	**2.6**	**2.4**	**2.6**

KEY: STRONGLY CORELATED -3 MODERATELY CORELATED -2 WEAKLY CORELATED – 1 NO CORELATED-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk –OHP –LCD
Flipped Learning/Blended Classroom – E Content, Videos
Problem Solving – Group Discussion – Quiz/Seminar

QUESTION PAPER PATTERN – M. Phil

Knowledge level	Section	Word Limit	Total Marks
K5, K6	A-5/8 x 20marks	1500	100

SEMESTER II COURSE PROFILE – M.PHIL

SEM	COURSE CODE	TITLE OF THE PAPER	CREDITS	TOTAL HOURS	CA	SE	TOTAL
II	14M18/DTN	Dissertation	21		40	60	100

DISSERTATION

COURSE CODE: 14M18/DTN **CREDITS: 21**

COURSE OBJECTIVES:

1. To give a wide understanding through literature survey in the area of research interest.
2. To give a practical understanding of research problem, planning and implementing various methodologies to solve them.
3. Familiarize the student to the various synthesis methods, characterization techniques and software programs.
4. Guiding the student to collect and graphically represent data using necessary software. Analyze the results and tackle the issues identified. Evaluate and proof read the content of prepared thesis.
5. Enriching the project work towards research presentations and journal publications thereby, contributing towards the scientific growth of the country.