

SHIVAJI UNIVERSITY, KOLHAPUR.



**Accredited By NAAC with 'A' Grade
Revised Syllabus For**

M. Phil./ Ph. D. Course Work

Physics

**Syllabus to be implemented from
June, 2020 onwards.**

ANY *ONE* **"ELECTIVE PAPER"** CAN BE OFFERED AS PER THE SPECIALIZATION OF RESEARCH AREA.

PAPER CODE	PAPER TITLE	MARKS
CP-I	Research Methodology and Computer Applications in Physical Sciences	100
CP-II	Frontiers in Physics	100
EP-I	Sol Gel Processing in Solid State	100
EP -II	Laser-Plasma Interaction	100
EP-III	Space Physics	100
EP-IV	Deposition of films and their applications	100
EP-V	Holography and its Applications	100
EP-VI	Photocatalysis	100
EP-VII	Solar cell: Fundamentals and Applied aspects	100
EP-VIII	Vacuum Techniques and Thin Films	100

***CP- Compulsory paper, EP- Elective paper**

COMPULSORY PAPER-I

Research Methodology and Computer Applications in Physical Sciences

Unit-I Computer Basics and Applications

(15)

- a) Introduction to: Computer and its generations, hardware, software-system software and application software, computer networks and internet,
- b) Data and Program representation-digital data representation representing numerical data (binary), coding system for text based data(ASCII and EBCDIC) , Computer hardware: coding system for other types of data (graphics, audio and video data), inside the system unit - motherboard, power supply and drive bays, CPU, Memory Cooling components, expansion slots, expansion cards and express cards, ports and connectors
- c) Operating systems-WINDOW, LINUX, application software- Origin, MATLAB, MATHEMATICA, word processing concept, spreadsheet concept, database concept, presentation graphic concepts, graphics and multimedia concepts

Unit-II Quantitative Techniques

(15)

Classification of quantitative methods, General steps required for quantitative analysis, reliability of the data, classification of errors, accuracy, precision, statistical treatment of random errors, the standard deviation of complete results, error proportion in arithmetic calculations, Uncertainty and its use in representing significant digits of results, confidence limits, Estimation of detection limit.

Unit-III Research Methodology

(15)

- a) Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus research and scientific methodology, importance of knowing how research is done, research progress, criteria of good research,
- b) Research design: meaning of research design, features of good design, important concepts of relating research design, different basic designs
- c) Method of data collection, types of data analysis; statistics in research, measure of central tendency, measure of dispersion; measure of asymmetry, measure of relationship, simple regression analysis, multiple correlation and regression, partial correlation

Unit-IV Literature Searching and Report Writing:

(15)

- a) Literature Searching: On-line searching, Database, SciFinder, Scopus, ScienceDirect, CA on CD, Searching research articles, Citation Index, Impact Factor, H-index etc,
- b) Writing scientific report: Structure and components of research report, revision and refining' writing project proposal, Paper writing for International Journals, submitting to editors. Conference presentation, preparation of effective slides, pictures, graphs and citation styles.
- c) Thesis writing: the preliminary pages and the introduction, the literature review, methodology, the data analysis chapters, the conclusions

Text Books:

1. Fundamentals of computers, Morley & Parkar, Cengage Learning Pvt. Ltd. New Delhi,
2. Research Methodology – Methods and Techniques, C. R. Kothari, Wiley Easter Ltd, New Delhi 1985.
3. Writing your thesis, Paul Oliver, Vistaar Publication, New Delhi
4. Fundamentals of analytical Chemistry by D. A. Skoog, D. M. West and F. J. Hooler.
5. Quality in the Analytical Chemistry Laboratory by R. D. Treble and D. G. Holcombe.

Reference Books:

1. Molecular dynamics simulations elementary methods by J. M. Haile.
2. The art of molecular dynamics simulations by D. C. Rapaport.
3. Introduction to computational chemistry by F. Jensen.
4. Molecular modeling principles and applications by A. R. Leach.
5. Computer Education by Prof. Lalini Varanasi, Prof. V. Sudhakar and Dr. T. Mrunalini, Neelkamal Publications PVT. LTD.
6. Basic Computing Principles by B. West, BPB Publications, New Delhi 1992
7. Essentials of computational chemistry by C. J. Cramer.
8. Practical Research Methods, Catherine Dawson, UBS Publishers Distribution, New Delhi 2002
9. Research Methodology – A Step by step Guide for Beginners 2nd edn. Kumar Ranjit, Pearson Education, Singapore, 2005
10. Introduction to Research and Research Methodology M. S. Sridhar
11. The Information Specialist's Guide to Searching & Researching on the Internate & the World Wide Web by Ernest Ackermann, Karen Hartman, Fitzroy Dearborn Publishers, London.
12. Learning to Use the World Wide Web, Ernest Ackermann, BPB Publications.

COMPULSORY PAPER-II

FRONTIERS IN PHYSICS

Unit 1: Structural characterizations: Construction, Principle and working of XRD, SEM, TEM, AFM, XPS, TGA-DTA characterization techniques- Data analysis using above characterization techniques

Unit 2: Compositional Analysis: Atomic Absorption Spectrometry: EDAX, Augur electron spectroscopy- Working, actual determination, limitations, procedure, and experimental analysis

Unit 3: Optical Properties: UV–Vis–IR, Raman spectroscopy and photoluminescence: principle and working, reflection, absorption, transmission analysis, band gap determination, Identification of molecular groups for radicals in solids, zero phonon mode of vibration, electron- phonon and phonon-phonon interactions, scattering geometry in Raman spectroscopy.

Unit 4: Thin Film Applications: Solid state solar cells, Fuel cells, Photoelectrochemical solar cell, Super-capacitors, Sensors, Holography, Aerogels, Microwaves, smart windows, water purification, photodetectors by different methods, the Sun, space weather, the Earth's atmosphere.

Reference books

1. Elements of X- ray diffraction By B. D. Cullity, (1956), Addison-Wesley Publishing company Inc., USA
2. X ray theory and experiments by Compton and Alison
3. Instrumental methods of analysis (Vth edition) by Willard, Merritt, Dean Settle
4. Photoelectrochemical solar cells by Suresh Chandra
5. Solar cells by Martin a Green
6. Thin film preparation by Joy George
7. Characterization techniques by Chatwal Anand
8. Modern Raman Spectroscopy: Practical Approach by Deon and Smith
9. Microscopy of materials - D.K. Bowen & C.R. Hall (the MacMillan press Ltd. (London) 1975
10. Fundamentals of Astronomy by Michael a. Seeds
11. Introduction to Space Physics, by M. G. Kivelson, C. T. Russell

ELECTIVE PAPER- I

SOL GEL PROCESSING IN SOLID STATE

MATERIALS Unit 1: Physicochemical Aspects of Dispersed System 15

Properties of dispersed of systems, classification of disperse system of dispersity, state of aggregation, types of disperse systems, molecular- kinetic properties of disperse systems, concepts of Brownian motion, osmosis, sedimentation of sustentation, measure of dispersion.

UNIT 2: VFEATURE OF COLLOIDAL SOLUTION 15

Colloidal state, scattering and absorption of light by colloidal systems and colloidal systems,, importance of colloidal systems and colloidal processes in nature and Engineering , stability and coagulation of colloidal systems , Synthesis and swelling processing in coagulate structural system

UNIT 3: CHEMICAL ASPECT OF SOL GEL PROCESS 15

Various parameters involved in sol gel process, composition, Gel formation, precursors, Drying , aging and processing ,Role of organics, incorporation of organics, preparation, Properties and uses of Aerogel, precursors for sol gel drying: Metal alkoxides and their synthesis, physical and chemical properties of metal alkoxides, Degree of oligomerization, volatility, viscosity, Reaction with alcohols, molecular association between alkoxides, stabilization against hydrolysis, non alkoxides precursors, carboxyl ate and Acetyltonates.

UNIT4: HYDROLYSIS AND CONDESAION OF SILICATES AND STRUCTURAL ASPECTS 15

Hydrolysis and condensation: effect of catalyst, steric and inductive effects, effect of water contest, solvent effects, mechanisms, transterfication, Reesterification, effects of reverse reaction, sol gel kinematics , structural evolution, types of aerogels: silica, organic, metal oxide & others, , xerogel, x-aerogel, zerogel, Physical and chemical properties of aerogels, applications

References:

- 1 . A course in colloid Chemistry : By D.A. Fridrikhsberg, MIR publishers Moscow,1986
- 2 Advance in polymer chemistry: ByV.V.Korshank, MIR publishers Moscow,1986
- 3 Introduction to Sol-Gel Processing,By Alain C. Pierre, Second edition, Springer

Nature 2020

- 4 Handbook of sol-gel science and technology. 1. Sol-gel processing edited by Sumio Sakka, Hiromitsu Kozuka, Springer Science & Business Media. 2005
- 5 Sol-Gel Processing for Conventional and Alternative Energy (Advances in Sol-Gel Derived Materials and Technologies) by Mario Aparicio, Andrei Jitianu, et al. 2012
- 6 Handbook of Sol-Gel Science and Technology: Processing, Characterization and Applications
- 7 by Lisa Klein, Mario Aparicio, et al.2018

ELECTIVE PAPER-II
Laser-Plasma Interaction

UNIT I

Introduction The Parabolic Equation and General Equations for Self-focusing
Steady state Self-focusing in Parabolic Media: Geometrical Optics and Wave Optics
Consideration

UNIT II

Steady state Self-focusing in Media with Saturating Nonlinearity
Steady state Self-focusing in Inhomogeneous and Absorbing Media

UNIT III

Thermal Focusing /Defocusing of Laser Beams
Steady State Self-focusing of Electromagnetic waves in Semiconductors

UNIT IV

Self-focusing of Electromagnetic waves in Anisotropic Dielectrics
Self-focusing of Electromagnetic waves in Plasmas

References:

1. Self-focusing of Laser Beams in Dielectrics, Plasmas and Semiconductors
M. S. Sodha, A.K. Ghatak and V.K. Tripathi **Tata Mc-GRAW-HILL Publishing Co. New
Delhi**
2. Progress in Optics Vol-XIII

Elective paper-III Space Physics

Unit-I: The Sun and its Emissions (15)

Characteristics of the Sun, internal structure, solar observations, solar atmosphere, oscillations, Convection, rotation, magnetism, chromosphere, corona, solar wind, quiet, Sun, Active Sun, Helioseismology, Solar electromagnetic radiations-radio, far IR, IR-Visible, UV, extreme UV, X-ray (soft and hard), solar cycle and solar variability, magnetic field energy-solar flares and coronal mass ejections

Unit-II: The Sun and its Magnetohydrodynamics (15)

Introduction, the sun, role of solar magnetic field, MHD equilibria, waves and instabilities, solar activities, prominences, coronal heating, solar flares, coronal mass ejections, the Solar wind and its interactions with magnetized planets solar energetic particles-solar wind, Properties of solar wind, origin of solar wind, magnetic structure of the corona and solar wind, major time dependent disturbances of solar wind, planetary magnetic fields, Size of magnetic cavity, shape of magnetic cavity, self-consistent models, flow around the magnetosphere

Unit-III: Magnetospheric configuration and geomagnetic storms (15)

Magnetic field configuration of the earth's magnetosphere, plasma in the earth's middle and inner magnetosphere-plasma in the Earth's near magnetotail, geostationary orbit region, trapped radiation belt and the ring-current particles, plasma sphere, electric fields and Magnetospheric convection, ionosphere-magnetosphere coupling, Ionospheric currents, loss of Magnetospheric particles in earth's atmosphere, Geomagnetic storms, geomagnetic indices, effects of geomagnetic storms on the Earth's upper atmosphere and ionosphere-electric field and neutral wind disturbances

Unit-IV Ionosphere and Global Navigation Satellite System (GNSS) (15)

Structure of the Neutral Atmosphere and the Main Ionosphere, Formation of the ionosphere, photo-ionization and the Chapman production function, ionization by energetic particles, ion loss mechanisms, determination of ionospheric density from production and loss rates, the Earth's ionosphere, high-speed outflow, conductivity and current systems, GNSS Systems, GPS (United States), GLONASS (Russia), Galileo (European Union), BeiDou (China), IRNSS (India), QZSS (Japan), GNSS Architecture, Space Segment, Control Segment, User Segment, GNSS Signals, GNSS Positioning, GNSS User Equipment, GNSS Antennas, GNSS Receivers, GNSS Augmentation

Reference Books:

1. Foundations of Astronomy by Michael a. Seeds, ,Publisher-Brooks/Cole; International edition (15 March 2006)
2. The Sun – An Introduction by Michael Stix, Second Edition, A & A Library, Springer
3. Chemistry of Atmospheres: An Introduction to the Chemistry of the Atmospheres of Earth, the Planets, and Their Satellites, Richard Peer Wayne, Oxford University Press, 3rd Edition, 2000
4. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
5. Space Physics: An Introduction ,by C. T. Russell, J. G. Luhmann, et al. Cambridge University Press; Har/Psc edition (August 18, 2016)
6. Elements of space physics by R. P. Singhal
7. The Upper Atmosphere Data Analysis and Interpretation, W. Dieminger G.K. Hartmann R. Leitinger (Eds.), Springer- 1996, ISBN-13 :978-3-642-78719-5
8. An Introduction to GNSS GPS, GLONASS, BeiDou, Galileo and other Global Navigation Satellite Systems, scnd edition, Published by NovAtel Inc. ISBN: 978-0-9813754-0-3

ELECTIVE PAPER-IV
Deposition of films and their applications

Unit I. Deposition of films using Physical methods **(15)**

Thermal evaporation:- Vacuum systems, Evaporation methods- Resistive heating , Laser evaporation, electron beam bombardment heating.

- i) **Cathodic Sputtering:-** Sputtering process , Glow discharge, Sputtering Variants, low pressure sputtering, Reactive sputtering, Magnetron sputtering, RF Sputtering

Unit II. Deposition of films using Chemical methods **(15)**

- i) **Chemical vapour deposition:** Deposition mechanism, Laser CVD, Photothermal CVD, Plasma enhanced CVD, MOCVD.

- ii) **Solution deposition:** - Ionic and solubility products, deposition parameters and process, Chemical deposition, SILAR, Spray pyrolysis and Spin coating.

- iii) **Electrodeposition:** - Faradays laws, mechanisms and deposition parameter, binary and ternary alloy deposition.

- iv) **Epitaxial growth of films:-**Influence of substrate and deposition condition, Theories of epitaxy.

Unit III (Solar energy devices) **(15)**

- i) **Solid state junction solar cells:-** principle of solar cells, Fabrication of CdS/ Cu₂S and CdS / CuInSe₂ solar cells, performance testing, stability and efficiency consideration. Organic solar cells

- ii) **Photoelectrochemical Solar Cells:-**Basic principle, fabrication of CdSe/Polysulphide/Pt cell, band diagram, Stability of PEC cells.

- iii) **Dye sensitized solar cells (DSSC):-** Working principle, Fabrication of DSSCs based on TiO₂ and ZnO, stability and performance of dyes.

- iv) **Solar selective Surface:-**Method of obtaining selective surface, Application of selective surface in photo thermal conversion.

Unit IV (Other devices) **(15)**

- i) **Microelectronics:-** MOS transistors, different steps in C MOS technology, thick film hybrid micro circuits.

- ii) **Super capacitor:** - Materials for super capacitors, Types of super capacitors, thin film based super capacitors on carbon, polymers, metal oxides.

- iii) **Thin film gas sensor:-** Basic parameters and mechanism of gas sensing, electrical resistivity and heterojunction based sensors.

Reference books

- 1) Thin film phenomena- K. L. Chopra, Mc Graw Hill, N.Y (1969)
- 2) Preparation of thin films- Joy George, Marcel & Dekker (1992)

- 3) Physics of thin film –L. Eckertova. Plenum press, N.Y (1986)
- 4) The theory and practice of microelectronics-S. K. Gandhi, John. Wiley & sons, N.Y (1968)
- 5) Gas sensors, V Demarne and R Sanjincs, Dordrecht, (1992)
- (6) Electrochemical Supercapacitors, B E Conway. Kluwar- plenum, NY 1999.

ELECTIVE PAPER-V

Holography and its Applications

1. History of Holography

Introductory concepts in holography, Hologram formation, Wave front reconstruction, Plane and Volume Hologram, Basic Holographic equations, In-line and Off-axis hologram

2. Analysis of plane hologram

Off axis holography with non-diffuse subject light, Off-axis holography with diffuse signal, Hologram forming geometric, Effects of resolution and size of the recording medium, maximum efficiency of plane hologram.

3. Holographic Interferometry

Real time Interferometry, Double Exposure holographic Interferometry (DEHI), Fringe localization and interpretation, Interferometry of vibrating surface, contour generation, applications and improvements average holographic interferometry, real time holography

4. Recording Materials and Techniques for Holography

Classification of Holograms, Diffraction efficiency, Silver Halide photographic materials, holographic linear recording, phase hologram, other recording materials, Digital recording and reconstruction of holograms, Scientific and engineering application of Holography with special reference to non-destructive techniques. Time-

References:

1. Optical Holography- Robert J. Coolier.
2. An Introduction to coherent optics and Holography- Strokes Robert Jones
3. Holography and Speckle Interferometry-Catherine Wykes
4. Speckle Interferometry- P. K. Rastogi

ELECTIVE PAPER-VI

Photocatalysis

Unit No. I Basic concepts of photochemical transformations (15)

Concept of light, Adsorption and Emission of light, Beer-Lambert law, selection rules for optical transitions, Electronic energy transfer and electron transfer, Redox reactions, Photoelectrochemical (PEC) solar cell, Efficiency of photochemical process- Homogeneous systems: Quantum yields, Chemical change, emission process, heterogeneous systems: photonic efficiencies.

Unit No. II Environmental photochemistry in heterogeneous media (15)

Solid-state and surface photochemistry, Metals, Semiconductors and Insulators, Interaction between surface and adsorbate, Heterogeneous reactions of environmental significance, Recombination kinetics, Charge transfer kinetics, Hole transfer through the intermediate formation of hydroxyl radicals, Haloaromatic and aliphatic compounds

Unit No. III Photochemistry of PAHS & PCBS in water (15)

Photochemistry at the interface, photochemistry in surfactant solutions, Titanium dioxide, Reactions of photogenerated hydroxyl radicals in air and water, Direct photolysis of nitrate and nitrite, transformation reactions in the presence of organic compounds-transformation of organic compounds upon photolysis of nitrite and nitrate

Unit No. IV Introduction to photochemical advanced oxidation processes for water (15) treatment

Direct photolysis, sensitization, photolysis of water in vacuum ultraviolet, UV/H₂O₂, UV/O₃, Photoinduced ozonation, Fenton reaction, Photo-Fenton and related reactions, SORAS technology, UV/periodate, UV/O₃/H₂O₂, Photoelectro-Fenton, Solar photocatalytic treatment of real waste water, Hydrophobicity- wettability on the surface, proposed mechanism for highly hydrophilic conversion, Photoelectrochemical detoxification reactor for degradation of organic molecules such as Oxalic acid.

References

1. O.Hutzinger, The Handbook of Environmental Chemistry, Available online at- SpringerLink.com, Vol. 2/M, 2005
2. Pierre Boule, Detlef W. Bahnemann, Peter K.J. Robertson, Environmental Photochemistry Part-II, Available online at- SpringerLink.com, Vol. 2/M, 2005
3. Environmental Impact Assessment of Recycled wastes on surface and ground waters, Engineering modeling and sustainability, Editor: T.A. Kassim, Vol. 5/F (3 Vols.), 2005
4. Photoelectrochemical Solar cells- Suresh Chandra

ELECTIVE PAPER-VII
Solar cell: Fundamentals and Applied aspects

Unit I: Fundamentals of Solar cells (15)

Basic of Semiconductor Physics- the p-n junction, charge carriers in semiconductors , optical properties of semiconductors, Hetero- junctions, Solar energy fundamentals-nature of solar energy, conversion of solar energy, photochemical conversion of solar energy, photovoltaic conversion, photophysics of semiconductors and semiconductor particles, photocatalysis.

Unit II: Silicon solar cells (15)

Device physics of silicon solar cells- Semiconductor device equations, The p-n junction model of Shockley, Real diode characteristics, Crystalline silicon solar cells- Silicon cell development, Substrate production, cell processing, cell cost, Opportunities for improvement, amorphous silicon solar cells, Amorphous silicon-based materials, Manufacturing costs, Environmental issues, Challenges for the future.

Chapter III: Dye sensitized solar cell (15)

Photoelectrochemical solar cell, semiconductor electrolyte interface, Basic principle and working of Graetzel Cell i.e., dye sensitized solar cells (DSSCs), Derivation of the Lifetime in DSSCs, theory of EIS, IMPS-IMVS for DSSCs, factors affecting on efficiency of DSSCs, present DSSCs research and developments, limitations of DSSCs.

Chapter IV: Polymer based and Quantum Dot Sensitized Solar Cells (15)

Introduction to conducting polymers, basic principle of HOMO & LUMO, bulk heterojunction polymer: solar cell Basic working principles, device architectures, single layer, Bilayer, Bulk heterojunction, diffuse bilayer heterojunction, tandem solar cell, efficiency relationship in organic bulk heterojunction solar cells. Quantisation effects in semiconductor nanostructures, optical spectroscopy of quantum wells, superlattices and quantum dots, Basic principle and working of quantum dot sensitized solar cells, effect of device architecture, theory of electron and light dynamic in QDSSCs, study of EIS, IMPS-IMVS in QDSSCs.

References:

1. Physics of solar cells from principles to new concepts: Peter Würfel
2. Photoelectrochemical Solar Cells: Suresh Chandra
3. Solar energy conversion: A. E. Dixon and J. D. Leslie
4. Solar cells: Martin A. Green
5. Solid State electronic Devices: B.G. Streetman
6. Photoelectrochemical solar cell: Suresh Chandra
7. Dye sensitized solar cell: Michael Graetzel (Review Articles)
8. N. S. Sariciftci and A. J. Heeger in Handbook of Organic Conductive Molecules and Polymers Vol. 1, edited by H. S. Nalwa, John Wiley & Sons, 1997
9. Nanostructured and photoelectrochemical systems for solar photon conversion: Mary D. Archer & Arthur. J. Nozik
10. Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters: P. V. Kamat (Review Articles)
11. Clean electricity for photovoltaics: Mary D. Archer & Robert Hill
12. Solar cell technology and applications: A. R. Jha.

ELECTIVE PAPER-VIII

Vacuum Techniques and Thin Films

Unit. 1 High Vacuum technology & Vacuum Measurements

Vacuum pumps, mechanical pumps, diffusion pumps, cryogenic pumps, getter pumps, cryosorption pumps, molecular pumps, Leak detection, pressure measurements, residual gas analysis.

Unit 2. Thin film deposition technology

Resistive heating, electron beam evaporation, sputtering, electrodeposition, chemical vapor deposition, plasma polymerization.

Unit3. Nature of the thin films & analytical techniques

Condensation, nucleation, growth, structure in the thin films, epitaxial films. Optical interference techniques, magnetic, electrical and mechanical methods, analysis of film composition. Chemical analysis, structural analysis, surface structure.

Unit 4. Mechanical and optical properties & Applications of the thin films

Adhesion, stress, experimental techniques, optical constants of thin films, experimental methods, multilayer optical system, Antireflective, high reflecting, beam splitters, absorptive films, transparent conductive coatings, anticorrosive coatings, laser coatings, integrated optics, optical waveguides.

References:

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| 1. Handbook of thin film technology | L. I. Maisel & R. Glang |
| 2. Thin film phenomenon | K. L. Chopra |
| 3. Vacuum technology | Roth |
| 4. Optical properties of thin solid films | O. S. Heavens |
| 5. Thin film technology & applications | K. L. Chopra |
| 6. Physics of thin films | Ludimila Eckertova |
| 7. Physical Properties of Polymers | James E. Mark Handbook |
| 8. Conductive polymers by
A literature survey | L. M. H. Groenewoud plasma techniques: |