SHIVAJI UNIVERSITY, KOLHAPUR - 416004,
MAHARASHTRA
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शिवाजी विद्यापीठ, कोल्हापूर - ४१६००४, महाराष्ट्र
दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दुरध्वनी विभाग ०२३१–२६०९०९४

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जा.क्र.:शिवाजी वि./अ.मं./653 दिनांक :01/09/2023

प्रति,

1	मा.प्राचार्य/संचालक, सर्व संलग्नित महाविद्यालये, शिवाजी विद्यापीठ, कोल्हापूर.	2	मा.अधिविभाग प्रमुख, शिवाजी विद्यापीठ, कोल्हापूर

विषय : एम.एस्सी. फिजीक्स भाग–2 अभ्यासक्रमाच्या (DSC-304) व (DSC-404) बाबत.

महोदय/महोदया,

उपरोक्त विषयास अनुसरून आदेशान्वये कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण, 2020 नुसार शैक्षणिक वर्ष 2023–2024 पासून लागू करण्यात आलेल्या एम.एस्सी. फिजीक्स भाग– 2 सत्र–3 व सत्र–4 च्या अभ्यासक्रमासाठी खालील प्रमाणे अभ्यासक्रम लागू करण्यात आले आहेत.

M.Sc. Part II Sem III & IV	
Sem III DSC-304	**Sem IV DSC-404**
Thin Film Deposition Technology	Modern Analytical Techniques

सदरची बाब सर्व शिक्षक, विद्यार्थी व संबंधीतांच्या निदर्शनास आणावी.

कळावे,

आपला विश्वासू

(डॉ. एस. एम. कुबल)
उपकुलसचिव

प्रत,

1	मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा	5	बी.एस्सी. परीक्षा विभाग
2	मा. संचालक परीक्षा व मुल्यमापन मंडळ	6	परीक्षक नियुक्ती ए व बी विभाग
3	मा.अध्यक्ष, सर्व अभ्यास/अस्थायी मंडळ विज्ञान	7	आय. टी. सेल विभाग
4	दुरशिक्षण व ऑनलाईन शिक्षण विभाग		

Sub: Exam pattern for the courses started in USIC

Course 1: THIN FILM DEPOSITION TECHNOLOGY.

Course Co-ordinator- Dr. J. B. Yadav.

Course 2: MODERN ANALYTICAL TECHNIQUES.

Course Co-ordinator- Dr. J. B. Yadav.

The exam pattern for the above course will be on the basis of 80:20, wherein 20 marks will be allotted for the continuous internal evolution and 80 marks for written examination. The standard of passing will be minimum 40% separately for each head. The examination will be conducted by the USIC department and marks will be communicated to examination section.

The format for the question paper is as;

Q1. Multiple choice question (MCQ)/ True–falls/ fill in the blanks	(20 marks)
Q2. Short answer types question any four.	(20 marks)
Q3 to Q6. Long answer type questions and to be attempted any two	(20 marks each)

Kind approval please.

Course 1. Thin Film deposition Technology (Credit: 4)

1. **Physical vapor deposition (PVD):** (15)
   Introduction, vacuum pumps and systems, Physics and chemistry behind evaporation, film thickness, uniformity and purity, evaporation hardware and techniques; thermal, e-beam etc. sputtering; RF, DC, DC magnetron sputtering, hybrid and modified PVD processes, advantages of PVD, disadvantages of PVD.

2. **Chemical vapor deposition (CVD):** (15)
   Introduction, reaction types, thermodynamics of CVD, gas transport and growth kinetics, CVD process and basic systems; Low-Pressure CVD (LPCVD), Plasma-Enhanced C VD (PECVD), Atmosphere-Pressure CVD (APCVD), Metal-Organic CVD (MOCVD), advantages of CVD, disadvantages of CVD.

3. **Spray deposition techniques:** (15)
   Introduction, basic instrumentation, different type of spray techniques; spray pyrolysis technique, electrospray deposition technique, electro-spin deposition technique, spray printing, advantages and disadvantages of spry deposition techniques.

4. **Other techniques:** (15)
   Electroplating, Spin coating, Sol gel, Langmuir Blodgett (LB) Techniques, Epitaxial Film Growth, SILAR technique, Doctor blade technique etc. their introduction, basic instrumentation, varying parameters, their advantages and disadvantages.

References:

1. "The Material Science of thin films" by Milton Ohring.
2. "Coatings on Glass" (volume 6) by H. K. Pulker.
3. "Langmuir Blodgett films" (volume 3) by C. W. Pitt, G. G. Roberts.
4. "Handbook of thin film Technology" by Frey, Hartmut, Khan and Hamid R.
5. "Thin film Technology and Application" by K. L. Chopra & L. K. Malhotra.
6. "Deposition Technology for films and coatings" by Rointan F. Bunshah.
7. "High vacuum techniques" J. Yarwood (Chapman & Hall) 1967.
8. "Vacuum technology" A. Roth (North-Holland Publishing Company, Amsterdam) 1982

Course 2. Modern analytical techniques: (Credit: 4)

1. **Spectroscopic techniques: principle, instrumentation and analytical application:** (15)
   Introduction to spectroscopic techniques, different type of spectroscopic techniques; UV-VIS spectroscopy, IR spectroscopy, Raman spectroscopy, NMR spectroscopy, Mass spectroscopy (MS), Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma-Optical emission spectroscopy (ICP-OES)/AAS/MS etc. fundamental, principle, basic instrumentation, operation and their application.

2. **Chromatographic technique: principle, instrumentation and analytical application:** (15)
   Introduction to chromatography, fundamental, principle, basic instrumentation, different type of chromatographic techniques; gas chromatography (GC), Liquid chromatography (LC), High Performance Liquid Chromatography (HPLC), Thin layer chromatography, electrophoresis etc.

3. **Structural and Microscopic Techniques:** (15)
   Structural technique:
   Introduction, interaction of light with matter, x-ray tube, different type of x-ray analytical techniques; X-Ray diffraction (XRD), X-Ray photoelectron spectroscopy (XPS), X-Ray fluorocence spectroscopy (XRF) etc. principle, basic instrumentation, data analysis and applications.
   Microscopic technique:
   Introduction to microscopic techniques, different techniques; ordinary microscope, Scanning Electron Microscopy (SEM), Atomic force microscopy (AFM), Transmission Electron Microscopy (TEM) etc. their principle, instrumentation, data analysis and applications.

4. **Thermo gravimetric techniques:** (15)
   Introduction to thermo-gravimetric analysis (TGA), differential scanning colorimetry (DSC) and differential thermal analysis (DTA) etc. principle, basic instrumentation and its application.

References:

1. "Principle of Instrumental Analysis" by Douglas A. Skoog.
2. "Instrumental Methods of Analysis" (6th edition) by Hobert. H. Willard, Lynne L. Merritt. Jr. John A. Dean and Frank A. Settle. Jr.
3. "Handbook of X-ray photoelectron Spectroscopy" by John. F. Moulder, William F Stickle, Peter E. Sobol and Kenneth D. Bomben.
4. "Atomic absorption spectroscopy" by B.Welz (Verlag Chemie, New York) 1976.

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दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९३/९४

SU/BOS/Science/497 **Date: 10/07/2023**

To,

The Principal, All Concerned Affiliated Colleges/Institutions Shivaji University, Kolhapur	The Head/Co-ordinator/Director All Concerned Department (Science) Shivaji University, Kolhapur.

Subject: Regarding syllabi of M.Sc. Part-II (Sem. III & IV) as per NEP-2020 degree programme under the Faculty of Science and Technology.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, nature of question paper and equivalence of M.Sc. Part-II (Sem. III & IV) as per NEP-2020 degree programme under the Faculty of Science and Technology.

M.Sc.Part-II (Sem. III & IV) as per NEP-2020			
1.	Microbiology (HM)	8.	Food Science & Nutrition
2.	Pharmaceutical Microbiology (HM)	9.	Food Science & Technology
3.	Microbiology	10.	Biochemistry
4.	Computer Science	11.	Biotechnology
5.	Computer Science (Online Mode)	12.	Medical Information Management
6.	Data Science	13.	Environmental Science
7.	Information Technology (Entire)	14.	Physics

This syllabus, nature of question and equivalence shall be implemented from the academic year 2023-2024 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website **www.unishivaji.ac.in**)

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2023 & March/April 2024. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Dy Registrar
Dr. S. M. Kubal

Copy to:

1	The Dean, Faculty of Science & Technology	8	P.G. Admission/Seminar Section
2	Director, Board of Examinations and Evaluation	9	Computer Centre/ Eligibility Section
3	The Chairman, Respective Board of Studies	10	Affiliation Section (U.G.) (P.G.)
4	B.Sc. Exam/ Appointment Section	11	Centre for Distance Education

SHIVAJI UNIVERSITY, KOLHAPUR.

Accredited By NAAC with 'A++' Grade

Syllabus For

M.Sc. Physics

(Semester Pattern)

Sem. III to IV

(As Per NEP-2020)

To be implemented From

July, 2023 onwards

Department of Physics,
Shivaji University,
Kolhapur
M. Sc. –Part-II (Physics) Course Structure

NOTE:

The elective courses are offered during the second year. The following in a nutshell gives the scope and extent of each course offered. Each core theory course has two levels of teaching: Lectures and internal exam. There are common laboratories as well as special laboratories associated with electives. A Project Course, equivalent to two full theory courses enables the student to work on specific problems of her/his interest under a faculty member's guidance.

M.Sc. (Physics) (Part-II)
SEMESTER-III CORE PAPER
(COMPULSORY)
M.Sc. (Physics)-Part-II Semester-III (Total 4-creadits)

Course Code	Paper Title	Credits
CC-301	Nuclear and Particle Physics	4-credits
CCS-302	Specialization Subject-I	4-credits
CCS-303	Specialization Subject-II	4-credits
DSE-304	Data Analysis and Statistical Software (2-credits) +Tutorials/LAB work (2-credits)	4-credits
	Numerical Computing Using MATLAB (2-credits) +Tutorials/LAB work (2-credits)	4-credits
	Computational Programming using Mathematica(2-credits) +Tutorials/LAB work (2-credits)	4-credits
CCPR-305	Project on Specialization Subject: Project -I	4-credits
	Practical on Specialization Subject: LAB-I	4-credits
NON-CGPA		
AEC-306	Communicative English	2-credits
EC-307	EC (SWAYAM / MOOC)	2-credits

M.Sc. (Physics) (Part-II) SEMESTER-IVCORE PAPER
(COMPULSORY)
M.Sc. (Physics)-Part-II Semester-IV (Total 4-creadits)

Course Code	Paper Title	Credits
CC-401	EXPERIMENTAL TECHNIQUES	4-credits
CCS-402	Specialization Subject-III	4-credits
CCS-403	Specialization Subject-IV	4-credits
DSE-404	Numerical Methods and Programming	4-credits
	MATLAB Programming and applications (2-credits) +Tutorials/LAB work (2 credits)	4-credits
	Energy Conversion and Storage Devices	4-credits
CCPR-405	Project on Specialization Subject: Project -II	4-credits
	Practical on Specialization Subject: LAB-II	4-credits
	NON-CGPA	
SEC-406	Fundamentals of Information Technology	2-credits
GE-407	Observational Astronomy	2-credits

ELECTIVE PAPERS (Any one Group)

M.Sc. (Physics)-Part-II (Semester-III)		
Specialization Subject – I: **ENERGY SCIENCE** (Total 16-creadits)		
M.Sc. (Physics)-Part-II (Semester-III)		
Course Code		Credits
CCS-302	The New Energy Technologies	4-credits
CCS-303	Solar Thermal Devices	4-credits
CCPR-305	ENERGY SCIENCE PROJECT WORK	4-credits
	ENERGY SCIENCE LAB–I	4-credits
M.Sc. (Physics)-Part-II (Semester-IV)		
Course Code		Credits
CCS-402	Renewable Energy Resources	4-credits
CCS-403	Energy Conversion Devices	4-credits
CCPR-405	ENERGY SCIENCE PROJECT WORK–II	4-credits
	ENERGY SCIENCE LAB–II	4-credits
Specialization Subject –II: **MATERIALS SCIENCE** (Total 16-creadits)		
M.Sc. (Physics)-Part-II (Semester-III)		
Course Code		Credits
CCS-302	Imperfections in crystals	4-credits
CCS-303	Properties of Materials	4-credits
CCPR-305	MATERIALS SCIENCE PROJECT WORK–I	4-credits
	MATERIALS SCIENCE LAB–I	4-credits
M.Sc. (Physics)-Part-II (Semester-IV)		
Course Code		Credits
CCS-402	Special Materials	4-credits
CCS-403	Nanostructured Materials	4-credits
CCPR-405	MATERIALS SCIENCE PROJECT WORK–II	4-credits
	MATERIALS SCIENCE LAB–II	4-credits
Specialization Subject – III: **MODERN OPTICS** (Total 16-creadits)		
M.Sc. (Physics)-Part-II (Semester-III)		
Course Code		Credits
CCS-302	Laser Physics	4-credits
CCS-303	Nonlinear Optics and Fiber Optics	4-credits
CCPR-305	MODERN OPTICS PROJECT WORK–I	4-credits
	MODERN OPTICS LAB–I	4-credits
M.Sc. (Physics)-Part-II (Semester-IV)		
Course Code		Credits
CCS-402	Molecular spectroscopy	4-credits
CCS-403	Holography and Its applications	4-credits
CCPR-405	MODERN OPTICS PROJECT WORK–II	4-credits
	MODERN OPTICS LAB–II	4-credits
Specialization Subject – IV: **SPACE PHYSICS** (Total 16-creadits)		

M.Sc. (Physics)-Part-II (Semester-III)		
Course Code		Credits
CCS-302	Stellar Evolution: Birth, Evolution and Death of the Stars	4-credits
CCS-303	Astrophysics of the Sun	4-credits
CCPR-305	SPACE PHYSICS PROJECT WORK–I	4-credits
	SPACE PHYSICS LAB–I	4-credits
M.Sc. (Physics)-Part-II (Semester-IV)		
Course Code		Credits
CCS-402	Magnetospheric Plasma Dynamics	4-credits
CCS-403	Ionospheric and Space Weather	4-credits
CCPR-405	SPACE PHYSICS PROJECT WORK–II	4-credits
	SPACE PHYSICS LAB–II	4-credits
Specialization Subject –V: **SOLID STATE PHYSICS** (Total 16-creadits)		
M.Sc. (Physics)-Part-II (Semester-III)		
Course Code		Credits
CCS-302	Thin solid films: Deposition and properties	4-credits
CCS-303	Semiconductor Physics	4-credits
CCPR-305	SOLID STATE PHYSICS PROJECT WORK–I	4-credits
	SOLID STATE PHYSICS LAB–I	4-credits
M.Sc. (Physics)-Part-II (Semester-IV)		
Course Code		Credits
CCS-402	Physical Properties of Solids	4-credits
CCS-403	Semiconductor Devices	4-credits
CCPR-405	SOLID STATE PHYSICS PROJECT WORK–II	4-credits
	SOLID STATE PHYSICS LAB–II	4-credits
Specialization Subject –VI: **THEORETICAL PHYSICS** (Total 16-creadits)		
M.Sc. (Physics)-Part-II (Semester-III)		
Course Code		Credits
CCS-302	Fundamentals of Plasma Physics	4-credits
CCS-303	Introduction to General Relativity	4-credits
CCPR-305	THEORETICAL PHYSICS PROJECT WORK–I	4-credits
	THEORETICAL PHYSICS LAB–I	4-credits
M.Sc. (Physics)-Part-II (Semester-IV)		
Course Code		Credits
CCS-402	Interaction of electromagnetic waves with electron beams and plasmas	4-credits
CCS-403	Introduction to Quantum Field Theory	4-credits
CCPR-405	THEORETICAL PHYSICS PROJECT WORK–II	4-credits
	THEORETICAL PHYSICS LAB–II	4-credits

M.Sc. (Physics) (Semester-III)
Course Code: CC-301
Total Credits: 4 – credits
Paper title: Nuclear and Particle Physics

Unit-I Nucleon-Nucleon Interaction: (15)

Nature of the nuclear forces, form of nucleon-nucleon potential, Deuteron problem: The theory of ground state of deuteron, excited states of deuteron, n-p scattering at low energies (cross-section, phase shift analysis, scattering length, n-p scattering for square well potential, effective range theory); p-p scattering at low energies (cross-section, experiment and results) ; exchange forces, tensor forces; high energy N-N scattering (qualitative discussion only of n-p and p-p scatterings), charge-independence and charge-symmetry of nuclear forces.

Unit-II Nuclear Models: (15)

Evidences for shell structure, single-particle shell model, its validity and limitations, collective model: collective vibration and collective rotation, single particle motion in a deformed potential

Unit-III Nuclear Reactions: (15)

Elementary ideas of alpha, beta and gamma decays and their classifications, characteristics, selection rules and basic theoretical understanding. Nuclear reactions, reaction mechanism, Compound nucleus reaction (origin of the compound nucleus hypothesis, discrete resonances, continuum states), optical model of particle-induced nuclear reaction and direct reactions (experimental characteristics, direct inelastic scattering, and transfer reactions). Fission and fusion, Fission, and heavy ion reactions.

Unit-IV Particle Physics: (15)

Classification of fundamental forces. Classification of Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellman-Nishijima formula. Quark model, CPT invariance. Application of symmetry arguments to particle reactions, Parity non-conservation in weak interaction, Relativistic kinematics.

Reference Books:

1. Nuclear and Particle Physics- W.E. Burcham and M.Jobes, (Addison Wesley, Longman, England, 1995).
2. Introduction to Particle Physics- M.P. Khanna (Prentice Hall, India, 1999).
3. Concept of Nuclear Physics, B.L. Cohen, (Tata McGraw-Hill, 2005)
4. Nuclear Physics Principles and Applications, John Lilley, (John Wiley and Sons (Asia) 2001)
5. Nuclear physics – D. C. Tayal. (Himalaya Publishing House,1997)
6. Nuclear Physics- Iriving Kaplan (Narosa, Madras, 1989).
7. Introduction to High Energy Physics- Donald H.Perkins (Addison Wesley, Massachusetts, 1982).

M.Sc. (Physics) (Semester-III)
Course Code: DSE-304
Total Credits: 4 – credits
Paper title: Data Analysis and Statistical Software (2-credits)

Unit-I: Data Analysis

Origin data analysis tools: Analysis Templates™ for automated analysis, Custom Reports, Consolidated Analysis Reports, Recalculation of analysis results, Analysis Themes, Report Tables, Data selection and masking tools, Standardized analysis tools dialogs, Batch Analysis

Unit-II: Curve Fitting

Linear Regression, Polynomial Regression, Sigmoidal Fitting/Dose Response Curves, Nonlinear Fitter, Fitting Function Builder Fitting with Integral, Fitting Function Organizer, Fit Comparison: Compare models and compare datasets, Implicit function fitting with Orthogonal Distance Regression, Multiple Regression

Tutorials/LAB work (30) (2-credits)

Problems solving and tutorials using origin softwareText and

Reference books:

1. Statistical Data Analysis by Glen Cowan, Oxford Science Publications

2. Origin 8 User Guide, Origin Lab Corporation, by Origin Lab Corporation, First Edition (2007)

3. Introduction to Statistics and Data Analysis by Roxy Peck, Chris Olsen , Jay L.Devore, 3rd addition, 2009

M.Sc. (Physics) (Semester-III)
Course Code: DSE-304
Total Credits: 4 – credits
Paper title: Numerical Computing Using MATLAB (2-credits)

Unit-I Introduction and MATLAB Basics (15)

Platforms and Versions, Installation, Starting MATLAB, Typing in the Command Window, Online Help, MATLAB Window, Ending a Session, Input and Output, Arithmetic, Recovering from problems: Errors in Input, Aborting Calculations, Algebraic or Symbolic Computation: Substituting in Symbolic Expressions, Symbolic Expressions, Variable Precision, and Exact Arithmetic, Vector and Matrices: Vector, Matrices, Suppressing Output, Functions: Built-in Functions, User-Defined Functions, Managing Variables, Variables and Assignments, Solving Equations, Graphics, Graphing with ezplot, Modifying Graphs, Graphing with plot, Plotting Multiple Curves

Unit-II Interacting with MATLAB (15)

The MATLAB Interface: The Desktop, The Workspace, The Current Directory and

Search Path, The Command History Window, M-files: Script M-files, Function M- files,, Loops, Presenting your results: Publishing an M-File, Diary Files, Interactive M-files, Wrapping Long Input and Output Lines, Printing and Saving Graphics, M- Books, Fine-tuning your M-files, Suppressing output, Data Classes: String Manipulation, Symbolic and Floating-Point Numbers, Functions and Expressions: Substitution, More about M-Files: Variables in Script M-files, Variables in Functions M-files, Structure of Functions M-files, Complex Arithmetic, More on Matrices: Solving Linear Systems, Calculating Eigenvalues and Eigenvectors, Doing calculus with MATLAB: Differentiation, Integration, Limits, Sums and Products, Taylor Series, Default Variables

Tutorials/LAB work (2-credits)

Algebra, Arithmetic, Calculus and Linear Algebra Problem solving using MATLAB (30)Text &

Reference books:

1. A guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, Cambridge University Press, 2nd edition, 2006
2. Introduction to Numerical Analysis Using MATLAB, By Rizwan Butt
3. Users Guide' student edition of MATLAB latest version
4. Getting Started with MATLAB 5.0: - Rudra Pratap
5. Mastering MATLAB 5.0: - d. Hanselman & B. Littlefield

M.Sc. (Physics) (Semester-III)
Course Code: DSE-304
Total Credits: 4 – credits
Paper title: Computational Programming using Mathematica

Unit-I: Introduction to Mathematica

Running Mathematica, numerical calculations, calculus in Mathematica, numerical mathematics, graphics-simple plot, parametric plots, contour and density plots, three- dimensional plots, complex numbers, animation, input and output control

Unit-II: Vectors and Matrices in Mathematica

Electric field, Ionic crystals, one, two, three-dimensional crystals, tubing curves, matrices, normal modes- system of two-masse, system of three-masse, system of five-masse normal modes of system of n-masse

Tutorials/LAB work (30) (2-credits)

Problems solving and tutorials using MathematicaText and

Reference Books:

1. Mathematical Methods Using Mathematica: For Students of Physics and Related Fields by Sadri Hassani, (Springer-Verlag) 2003

2. The Mthematica Graphics guidebook by comeron smith and Nancy Blachman, Addison-Wesley Publication, 1995

3. Schaum's Outline of Mathematica, 2ed, (Schaum's Outline Series) by Eugene Don,

M.Sc. (Physics) (Semester-III)
Course Code: CCS-302
Total Credits: 4 – credits
Paper title: The New Energy Technologies

Unit I: Environmental Impacts of Renewable Energy Sources (15)

Energy flow diagram to the earth, Carbon cycle, Ecological Niche, Green- house effect. Energy Consumption in India, Environmental degradation due to conventional energy production and utilization: Asian Brown Cloud Effect, Environmental impacts of Biomass energy, solar energy systems, wind energy and ocean thermal energy. Power co-generation.

Unit II: Hydrogen as clean source of Energy (15)

Sources of hydrogen, Thermodynamics of water splitting, Hydrogen production methods, Photoelectrolysis of water, Direct decomposition of water, Thermochemical production of hydrogen; Hydrogen storage methods: Conventional, Liquid Hydrogen storage, Metal Hydrides, and Cryo-adsorbing storage.

Unit III: Superconductors and Fuel Cell Technology (15)

Cuprates and MgB2 superconductors and their properties, superconducting wires, Role of superconductor in Electric generator, Magnetic energy storage devices and power transmission. Working principle of fuel cell, Components of fuel cell, EMF of fuel cell and polarization in fuel cells, Types of fuel cells, Advantages and disadvantages of fuel cell, Power generation with fuel cells.

Unit IV: Batteries and Supercapacitors (15)

Energy storage systems, Faradaic and non-Faradaic processes, Types of capacitors and batteries, Comparison of capacitor and battery, Chargedischarge cycles, experimental evaluation using Cyclic voltammetry, and other techniques, Energy and entropy stored by capacitor, Electrochemical behaviour of RuO_2, IrO_2, and mixed oxides, Energy density and power density, Applications for electric vehicle drive systems.

Reference Books

1) Biological paths to self-reliance- Russell E. Anderson.
2) Encyclopedia of Environmental Energy Resources- G.R. Chhatwal Vol. 1 & 2.
3) Renewable Energy Sources and their Environmental Impacts- S.A. Abbasi & N. Abbasi.
4) Electrochemical supercapacitors by B. E. Conway, Kluwer Academic Press.
5) Hydrogen as an Energy Carrier- T. Carl-Jochen Winter, Joachim Nitsch (eds.)
6) Advances in Renewable Energy Technologies- S.H. Pawar, and L. A. Ekal (eds.)
7) Handbook of Batteries and Fuel Cells- David Linden.

M.Sc. (Physics) (Semester-III)
Course Code: CCS-303
Total Credits: 4 – credits
Paper title: Solar Thermal Devices

Unit 1: Principles of heat transfer (15)

Conduction: plane wall, multiplayer wall, cylinders and spheres, thermal conductivity of solid, liquid and gas, convection: free and forced convections, heat transfer through plane wall, radiation: characteristics of radiation, secular and diffuse reflections, gray surfaces, radiation function table, radiation exchange between two parallel gray surfaces, radiation characteristics and properties of materials, heat exchangers, double pipe heat exchangers, expression for effectiveness, methods to obtain rate of heat transfer in heat exchangers: LMTD and ENTU, flow and convection heat transfer in forced beds, problems.

Unit 2: Flat Plate Collectors (15)

Selective surfaces its characteristics and examples, energy balance equation for flat plate collector, thermal analysis of a flat plate collector, efficiency of flat plate collector, solar cookers, solar thermal systems for various applications, solar dryers and industrial products, problems.

Unit 3: Concentrating solar energy collectors (15)

Reasons for using concentrating collectors, thermodynamic limits to concentration, optical limits to concentration, various types of concentrators, compound parabolic concentrators (CPC) and its thermal analysis, tracking of the sun, continuously tracking solar concentrators.

Unit 4: Solar Pond (15)

Basic principle of operation of solar pond, theoretical analysis of solar pond, extraction ofheat from solar pond, types of solar pond, applications of solar ponds, problems.

Reference Books:

1. Principles of solar engineering by Frank Kreith and Janf Kreider.
2. Solar energy conversion, A. E. Dixon & J. D. Leslie
3. Solar Energy Engineering, A. A. M. Sayigh
4. Solar energy by Sukhatme
5. Solar energy utilization by G.D.Rai
6. Selective surfaces by O.P. Agnihotri

Topics for tutorials:

1. Methods to obtain selective surfaces
2. Examples on determination of rate flow of heat
3. Maintenance of flat plate collector-based devices
4. Derivation of efficiency of CPC
5. Maintenance of solar ponds

M.Sc. (Physics) (Semester-III)
Course Code: CCS-302
Total Credits: 4 – credits
Paper title: Imperfection in Crystals

Unit I: Point defects
(15)

Crystalline materials, Types of Defects in crystalline materials (Point Defects, Stacking Faults, Grain Boundaries, Twin Boundaries, Volume Defects) Point defects in metallic and non-metallic crystals, lattice distortion, migration energy, point defects in thermal equilibrium, point defects in ionic crystals, equilibrium concentration of Frenkel and Schottky defects, ionic conductivity, point defects in non-thermal equilibrium.

Unit II: Dislocations
(15)

Concept and types of dislocation, Dislocations and non-uniform slip, Edge dislocation, Screw dislocation, Curved dislocation line on plane slip surface, Effect of atomic structure on the form of a dislocation (Central force approximation, Bubble model, Directional bonds, Cottrell atmosphere, imperfect or partial dislocations, stacking faults) Thomson tetrahedron, partial dislocations in other crystal structures, multiplication of dislocations, Jogs and their formation, motion of a vacancy jog, measurement of stacking fault energy.

Unit III: Diffusion and Solidification
(15)

Diffusion: Fick's laws of diffusion, solutions to the diffusion equation, calculation of jump frequency, mechanisms of diffusion, self-diffusion, diffusion - along grain boundaries.
Solidification: Homogeneous nucleation, heterogeneous nucleation, atomic kinetics, solute manipulation (normal freezing, zone melting & zone refining).

Unit IV: Principles and applications of phase diagrams
(15)

Freezing of a pure metal, Plane-front and dendritic solidification at a cooled surface, Gas porosity and segregation, Directional solidification, Production of metallic single crystals for research, The concept of a phase, The Phase Rule, Stability of phases, Two-phase equilibria, Three-phase equilibria and reactions, Intermediate phases, Limitations of phase diagrams.

Reference Books:

1) Physical metallurgy - R.W. Cahn, II Edition, North Holland, Amsterdam (1970)
2) Introduction to dislocations - D. Hull, ELBS (1971)
3) Imperfections in crystals - Van Burren, North Holland (1960)

4) Theory of crystal dislocations - F.R.N. Nabarro, Clarendon Press (1968)
5) Dislocations in crystals - W.T. Read, McGraw Hill (1953)
6) Modern physical metallurgy - R.E. Smallman, Butterworths (1970)
7) Techniques of metal research - R.F. Bunshaw, Interscience (1968)
8) Modern techniques in metallography - D.G. Brandon, Butterworths (1966)
9) Introduction to properties of engineering materials- K.J. Pascoe, Blackie and Sons, London (1968).
10) William F Smith, Javad Hashemi, Ravi Prakash, Mater. Sci. and Eng., Tata-McGraw Hill, 4th Edition
11) R. E. Smallman and A. H.W. Ngan, Physical Metallurgy and Advanced Materials (Seventh Edition), Published by Elsevier Ltd, 2007.

M.Sc. (Physics) (Semester-III)
Course Code: CCS-303
Total Credits: 4 – credits
Paper title: Properties of Materials

Unit I: Physical and mechanical properties of the materials (15)
Stress Versus Strain (metals, ceramics and glasses, polymers), Elastic Deformation, Plastic Deformation, Hardness, Creep and Stress Relaxation, Viscoelastic Deformation.

Unit II: Thermal Properties (15)
Thermal expansion, Thermal conductivity, Thermal shock, Specific heat capacity, The specific heat curve and transformations, Free energy of transformation.

Unit III: Electric and magnetic properties (15)
Electric properties: Electric conductivity, Semiconductors, Hall Effect, Superconductivity, Oxide superconductors. Magnetic properties: Magnetic susceptibility, Diamagnetism and paramagnetism, Ferromagnetism, Magnetic alloys, Anti-ferromagnetism and ferrimagnetism, Dielectric materials, Polarization, Capacitors and insulators, Piezoelectric materials, Pyroelectric and ferroelectric materials.

Unit IV: Optical Properties (15)
Optically active materials, Reflection, absorption and transmission effects, optical fibers, ceramic windows, electro-optic ceramics.

References:
1) Physical metallurgy. – R. W. Cahn, II Edition, North Holland, Amsterdam (1970)
2) Physical metallurgy. – R. W. Cahn and P. Haasen, III Edition, North Holland, Amsterdam, (1983)
3) Physical metallurgy principles – R.E. Read-Hill, Affiliated East West Press Ltd.,New Delhi, (1970) 4)
4) Modern physical metallurgy – R.E. Smallman, Butterworths, London (1970)
5) Physical properties of glass - D. G. Holloway Wykeham publications, London (1973)
6) An introduction to metallurgy – A.H. Cottrell, Edward Arnold, London (1967)
7) M.A. Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science

International (2005)
8) K. H. J. Buschow& F. R. de Boer: Physics of Magnetism and Magnetic Materials.
9) S.O. Pillai; Solid State Physics, 6th Ed., New Age International (p) Ltd publishers, (2005)
10) Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons

M.Sc. (Physics) (Semester-III)
Course Code: CCS-302
Total Credits: 4 – credits
Paper title: Laser Physics

Unit I: Laser fundamentals (15)

Laser Fundamentals: Laser idea, Attainment of population inversion, Properties of laser beams, Optical pumping, Laser pumping, Electrical pumping, pumping rate and pump efficiency, **Resonators:** Plane – parallel resonator, concentric resonator, confocal resonator, resonators using a combination of plane and spherical mirrors, confocal resonator, Line shape function, Laser modes.

Unit II: Laser Behavior (15)

Continuous wave laser behavior: Rate equations in 3 level and 4 level laser systems, CW behavior, Optimum output coupling, limit to monochromaticity and frequency pulling.

Transient laser behavior: Step– pump pulse, single mode oscillation, multimode oscillation, Q – Switching, methods of Q – switching, Mode locking, methods of Mode locking, modes of resonator system.

Unit – III: Solid state, Dye and Semiconductor Lasers (15)

Solid state lasers: The Ruby laser, Nd: YAG laser, Nd: Glass lasers, Fiber lasers.

Dye Lasers: Characteristics of Dye lasers, Rate equations for Dye lasers.

Semiconductor Lasers: Principle of semiconductor laser, Homojunction and Heterostructure lasers, Laser Diode Characteristics.

Unit – IV: Gas, chemical, electron Lasers and Applications of lasers: (15)

Gas Lasers: Process of excitation and de-excitation in gas lasers, Neutral-Atom gas laser, Ion lasers, Metal Vapor lasers, Molecular gas lasers: CO_2laser system, Vibronic lasers, Excimer laser, Chemical Lasers, Free electron lasers, X-ray lasers

Applications of lasers: Applications of laser in science, Industrial Applications, Light Wave Communications, Optical data processing and Holography.

Reference Books:

1. Principles of Lasers- Orazio Svelto, Springer, Fourth edition.
2. Lasers: Fundamentals and Applications- K. Thyagarajan, Ajay Ghatak, Springer, Second edition
3. J. Wilson and J.F.B. Hawkes. Laser Principles and Applications, Prentice Hall International, NY, (1987).
4. Laser Fundamentals- W.T. Silvafast, Cambridge University Press, second edition.
5. Laser Physics-L.V. Tarasov, Mir publishers, Moscow.
6. Siegman, An Introduction to Laser and Masers, McGraww Hill Book Co., (1971).
7. Introduction to Laser Physics-B.A. Lengyl,
8. Optical Holography- R.J. Collier.

M.Sc. (Physics) (Semester-III)
Course Code: CCS-303
Total Credits: 4 – credits
Paper title: Nonlinear Optics and Fiber Optics

Unit – I: Nonlinear Medium: (15)

Maxwell's equations in nonlinear media, Nonlinear polarization and susceptibilities, measurement of non-linear optical susceptibilities, classical model of nonlinearity: anharmonic oscillator and free electron gas. Electro-optical and magneto-optical effects, Optical rectification, Induced magnetization.

Unit – II: Nonlinear Phenomena and Applications (15)

Second Harmonic Generations – Polarization waves, phase matching conditions, coherence length, coupled wave equations, Parametric amplification and oscillation, frequency tuning of parametric oscillator, Optical phase conjugation, Self – Self focusing of laser beam – physical description, elementary analysis, Parabolic wave equation and solution for slowly conversing/ diverging beam. Tunable coherence radiation source, Stimulated Raman scattering as spectroscopy tool.

Unit – III: Optical fibers (15)

Basic characteristics of optical fibers, Physical description, numerical aperture, attenuation in optical fibers, pulse dispersion, Loss mechanism, step index and graded index fibers, material and fabrication, light propagation (ray theory), Transmission losses, Nonlinear Optical effects in fiber, Measurement methods in optical fiber

Unit – IV: Optical Fiber Waveguide and Applications: (15)

E.M. theory of propagation, Modes of fiber, Mode's cut-off, Single and multimode fibers, Modal analysis of step index and graded index fibers, Signal distortion – inter modal, material and wave guide dispersion, waveguide dispersion, Sources and Detectors for optical fiber communication, Optical fibers in Telecommunications and Sensor systems.

Reference Books:

1. Y.R. Shen, The Principles of Nonlinear Optics, Wiley Inter Science, (1984).
2.A.K. Ghatak& K. Thyagarajan, Introduction to Fiber Optics, Cambridge University Press (1999).
3. A.K. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University, Press, (1991).
4. A.N. Matveev, Optics, Mir Publisher, (1988).
5. M.S. Sodha, A.K. Ghatak& V.K. Tripathi, Self-Focusing of Laser beams, Tata McGraw Hill, (1974).
6. J. Wilson and J.F.B. Hawkes, Optoelectronics, Prentice Hall, (1989).

M.Sc. (Physics) (Semester-III)
Course Code: CCS-302
Total Credits: 4 – credits
Paper title: Stellar Evolution: Birth, Evolution and Death of the Stars

Unit-I: Formation of the Stars (15)
Interstellar Medium-nebulae, extinction and reddening, interstellar absorption lines, radio observations of the interstellar medium, Birth of Stars-contraction and heating, protostar, star formation confirmed, T-Tauri stars, Herbig-Haro objects, bipolar flow, Sources of Stellar Energy- solar energy generation, proton-proton chain, solar neutrino mystery, hydrogen fusion in star, CNO-cycle, energy transport, hydrostatic equilibrium, the pressure-temperature thermostat.

Unit-II: Stellar Evolution (15)
H-R diagram, Main Sequence Stars-stellar models, end of main sequence, the mass luminosity relation, life of main sequence star, post main sequence star evolution expansion into giant, helium fusion, fusion of elements heavier than helium, Variable Stars-Cepheid variables, pulsating stars, Star Cluster-observing star cluster, stellar evolution confirmed, open cluster and globular cluster.

Unit-III: Death of the Stars (15)
Lower Main Sequence stars-Red Dwarfs, Sun-like stars, Mass loss from stars, planetary nebulae, white dwarfs, black dwarf Chandrasekhar Limit, Upper Main evolution of upper main sequence stars-hydrogen, helium carbon core formation, carbon detonation, the iron core, supernova, observations of supernova, type-I and Type-II supernova, supernova remnant, synchrotron radiation, Evolution of Binary Stars-Mass transfer, recycled stellar evolution, accretion disks.

Unit-IV: Neutron Stars and Black Holes (15)
Neutron stars, properties of neutron stars, Pulsars, Pulsar model, the evolution of Pulsars, binary Pulsars, quasi-periodic objects, bursters, black holes-escape velocity, Schwarzschild Black holes, Schwarzschild radius, Kerr black holes, leaping in, time dilation, gravitational red shift, search for black holes.

Reference Books:

1. Foundations of Astronomy by Michael a. Seeds
2. An Introduction to Birth, Evolution and Death of the Stars by James Lequeux
3. An Introduction to the Theory of Stellar Structure and Evolution by Dina Prialnik
4. Astronomy The Evolving Universe by Michael Zeilik
5. A Brief History of Time, by Stephen Hawking
6. Our Cosmic Origins - From the Big Bang to the Emergence of Life and Intelligence by Armand H. Delsemme

M.Sc. (Physics) (Semester-III)
Course Code: CCS-303
Total Credits: 4 – credits
Paper title: Astrophysics of the Sun

Unit-I: The Sun **(15)**
Characteristics of the Sun, internal structure, solar observations, solar atmosphere, oscillations, Convection, rotation, magnetism, chromo sphere, corona, solar wind, quiet, Sun, Active Sun, Helioseismology.

Unit-II: The Sun and its Emissions **(15)**
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-III: The Sun and its Magneto hydrodynamics **(15)**
Introduction, the sun, role of solar magnetic field, MHD equilibria, waves and instabilities, solar activities, prominences, coronal heating, solar flares, coronal mass ejections.

Unit-IV: The Solar wind and its interactions with magnetized planets **(15)**
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.

Reference Books:
1. Foundations of Astronomy by Michael a. Seeds
2. The Sun – An Introduction by Michael Stix, Second Edition, A & A Library, Springer
3. High Energy Astrophysics, MALCOLM S. LONGAIR, Third Edition, Cambridge university press, 2011, ISBN 978-0-521-75618-1
4. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
5. Magnetohydrodynamics of the Sun, By Eric Priest, Cambridge University Press, June 2014

6. Advanced Magnetohydrodynamics: With Applications to Laboratory and Astrophysical Plasmas by J. P. Goedbloed, Rony Keppens, Stefaan Poedts.
7. Elements of space physics by R. P. Singhal, PHI learning Private limited, Delhi
8. Fundamentals of Solar Astronomy by Arvind Bhatnagar and William Livingston, World Scientific (2005)

M.Sc. (Physics) (Semester-III)
Course Code: CCS-302
Total Credits: 4 – credits
Paper title: Thin solid films: Deposition and properties

Unit 1: Physical methods of thin film deposition (15)

Vacuum deposition apparatus: Vacuum systems, substrate deposition technology, substrate materials, Thermal Evaporation methods: Resistive heating, Flash evaporation, Arc evaporation, laser evaporation, electron bombardment heating, Sputtering: sputtering variants, glow discharge sputtering, Magnetic field assisted (Triode) sputtering, RF Sputtering, Ion beam sputtering, sputtering of multi- component materials.

Unit 2: Chemical methods (15)

Chemical vapor deposition: Common CVD reactions, Methods of film preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD, Chemical bath deposition, Electro deposition, Spray pyrolysis, successive ionic layer adsorption reaction method (SILAR) method, Sol-gel method, Hydrothermal method.

Unit 3: Nucleation growth processes and thickness measurement (15)

Condensation process, Langmuir-Frenkel theory of condensation, Theory of nucleation and growth process, Thickness measurements: Electrical methods, Microbalance monitors, mechanical method, radiation absorption and radiation emission methods, optical interference methods: photometric method, spectrometric method, interference fringes, X-ray interference fringes.

Unit 4: Properties and characterization of thin films (15)

Mechanical properties of thin films: Introduction to elasticity, plasticity, and mechanical behavior, Electrical and magnetic properties of thin films, Optical properties of thin films, Structural characterization: X-ray diffraction, Scanning electron microscopy, Transmission electron spectroscopy, chemical characterization: X-ray Energy Dispersive Analysis (EDX), X-ray photoelectron spectroscopy (XPS).

Reference Books

1. Thin Film Phenomena by K L Chopra McGraw -Hill Book Company, NY 1969
2. The Materials Science of Thin Films by Milton Ohring, Academic Press, (1992)
3. Properties of Thin Films by Joy George, Marcel, and Decker, (1992)
4. Physics of Thin Films by Ludmila Eckertová, Springer (1986)
5. Thin Film Technology by O S Heavens, Methuen young books (1970)
6. Solid State Physics by N.W. Ashcroft, N. D. Mermin, Harcourt College Publishers (1976)
7. Chemical Solution Deposition of Semiconductor Films by G. Hodes, Marcel Dekker Inc. (2002)

M.Sc. (Physics) (Semester-III)
Course Code: CCS-303
Total Credits: 4 – credits
Paper title: Semiconductor Physics

Unit I: Energy Bands and Charge Carriers in Semiconductors: (15)

Direct and Indirect semiconductors, variation of energy bands with alloy composition, Charge carriers in semiconductors: electrons and holes, effective mass, intrinsic and extrinsic materials, electrons and holes in quantum wells, The Fermi level, carrier concentration at equilibrium, temperature dependence, space charge neutrality, conductivity and mobility, Drift and resistance, effects of temperature and doping on mobility, the Hall effect.

Unit II: Excess Carriers in Semiconductors: (15)

Optical absorption, Luminescence: photoluminescence and electroluminescence, Direct recombination of electrons and holes, Indirect recombination and trapping, steady state carrier generation and Quasi Fermi levels, Diffusion processes, Diffusion and Drift of carriers, built-in fields, The continuity equation, steady state carrier injection, diffusion length,

Unit III: Junctions-I (15)

Fabrication of p-n junctions; Thermal oxidation, diffusion, CVD, Photolithography, etching, metallization, The contact potential, Space charge at a junction, qualitative description of current flow at a junction, reverse-bias breakdown, Capacitance of p-n junctions, Zener and Avalanche breakdown, rectifiers.

Unit IV: Junctions-II (15)

The tunnel diode, the Varactor diode, recombination, and generation in the transition region, ohmic losses, graded junctions, Schottky barriers, rectifying contacts, ohmic contacts, hetero-junctions, AlGaAs-GaAs hetero-junction.

References:

1. Solid state electronic devices by B. G. Streetman.
2. Physics of semiconductor devices by S. M. Sze.
3. Solid State and Semiconductor Physics by McKelvey.
4. Principles of Electronic Materials and Devices by S.O. Kasap

M.Sc. (Physics) (Semester-III)
Course Code: CCS-302
Total Credits: 4 – credits
Paper title: Fundamentals of Plasma Physics

Unit I: Introduction **(15)**

Occurrence of Plasmas in Nature, Definition of Plasma, Concept of Temperature, Debye Shielding, The Plasma Parameter, Criteria for Plasmas, Applications of Plasma Physics. Single-Particle Motions: Introduction, Uniform E and B Fields, Non-uniform B Field, Non-uniform E Field, Time Varying E Field, Time-Varying B Field, Summary of Guiding Center Drifts, Adiabatic Invariants.

Unit II: Plasmas as Fluids **(15)**

Introduction, Relation of Plasma Physics to Ordinary Electromagnetics, The Fluid Equation of Motion, Fluid Drifts Parallel and Perpendicular to B, The Plasma Approximation.

Waves in Plasmas: Waves in Plasmas Representation of Waves, Group Velocity, Plasma Oscillations, Electron Plasma Waves, Sound Waves, Ion Waves, Validity of the Plasma Approximation, Comparison of Ion and Electron Waves, Electrostatic Electron Oscillations Perpendicular to B, Electrostatic Ion Waves Perpendicular to B, The Lower Hybrid Frequency, Electromagnetic Waves with $B_0=0$, Electromagnetic Waves Perpendicular to B_0, Cut-offs and Resonances, Electromagnetic Waves Parallel to B_0.

Unit III: Diffusion and Resistivity **(15)**

Diffusion and Mobility in Weakly Ionized Gases, Decay of a Plasma by Diffusion, Steady State Solutions, Recombination, Diffusion Across a Magnetic Field, Collisions in Fully Ionized Plasmas, The Single-Fluid MHD Equations, Diffusion of Fully Ionized Plasmas, Solutions of the Diffusion Equation, Bohm Diffusion and Neoclassical Diffusion.

Unit IV: Kinetic Theory **(15)**

The Meaning of f(v), Equations of Kinetic Theory, Derivation of the Fluid Equations, Plasma Oscillations and Landau Damping, The Meaning of Landau Damping, A Physical Derivation of Landau Damping, Ion Landau Damping, Kinetic Effects in a Magnetic Field.
Nonlinear Effects Introduction, Sheaths, Ion Acoustic Shock Waves, The Ponderomotive Force, Parametric Instabilities, Plasma Echoes, Nonlinear Landau Damping, Equations of Nonlinear Plasma Physics, Reconnection, Turbulence, Sheath Boundaries.

References

1. Introduction to Plasma Physics and Controlled Fusion by Francis F. Chen (3rd Springer International Edition, 2016).
2. Fundamentals of Plasma Physics by Paul M. Bellan, Cambridge University Press (1st Paperback Edition,2008).
3.Fundamentals of Plasma Physics, by J. A. Bittencourt, (3rd Edition) Springer-Verlag. (2004)
4. Plasma Physics: An Introduction by Richard Fitzpatrick, CRC Press, (2014)
5. Elements of Plasma Physics by S N Goswami (2016)

M.Sc. (Physics) (Semester-III)
Course Code: CCS-303
Total Credits: 4 – credits
Paper title: Introduction to General Relativity

Unit-I: Special Relativity (15)
Fundamental principles of STR, Inertial observer, Space-time diagrams, Construction of the coordinates used by another observer, Invariance of interval, Invariance of hyperbolae, The Lorentz transformation, The velocity composition law, paradoxes, and physical intuition.

Unit-II: Vectors and tensors in special relativity (15)
Definition of a vector, Vector algebra, The four-velocity, The four momentum, Scalar product, Applications. The metric tensor, Definition of tensors the (0, 1) tensors: one-forms, The (0,2) tensors, Metric as a mapping of vectors into one-forms, (M, N) tensors, Index raising and lowering, tensor differentiation.

Unit-III: Curvature and manifolds (15)
Relation between gravitation and curvature, Tensor algebra and calculus in polar coordinates, Christoffel symbol and the metric, Non-coordinate bases. Differentiable manifolds and tensors, Riemannian manifolds, Covariant differentiation, Parallel transport, geodesics and curvature, The curvature tensor, Bianchi identities: Ricci and Einstein tensors.

Unit-IV: Physics in curved space-time, Einstein field equations and stellar solutions (15) The transition from differential geometry to gravity, Physics in slightly curved space-times, Curved intuition, Conserved quantities. Purpose and justification of the field equations, Einstein's equations, Einstein's equations for weak-gravitational fields, Newtonian gravitational fields. Coordinates for spherically symmetric space-times, Static spherically symmetric space-times, Static perfect fluid Einstein equations, The exterior geometry, The interior structure of the star, Exact interior solutions, Realistic stars, and gravitational collapse.

Reference Books:

1) A First Course in General Relativity, Bernard Schutz, Cambridge Press
2) Spacetime And Geometry, Sean Carroll, Pearson Education
3) General relativity and Cosmology, Jayant V. Narlikar, Macmillan Press
4) Gravity, James Hartle, Pearson Education

ENERGY SCIENCE LAB-I (4-credits)

List of Experiments

1. Oxygen bomb Calorimeter
2. Wood Pyrolysis-I
3. Wood Pyrolysis-II
4. Powdery Biomass Gasifier
5. Microsoft Excel
6. Current Density
7. Solar Cell Characteristics
8. Sunshine Recorder
9. Pyranometer
10. Wind Data analysis
11. Air mass Ratio
12. Underground Resistivity measurement
13. Heat pipe
14. Biogas Plant
15. Vacuum Deposition System
16. Spray Pyrolysis System

MATERIALS SCIENCE LAB-I (4-credits)

List of Experiments

1. Cooling curves
2. Stress-Strain curves
3. Average grain diameter by SEM
4. Laue diffraction
5. Crystal structure
6. Preparation of ferrite
7. Spectrometry of colored solutions
8. Crystal structure of thin film

9. Crystal growth from solution
10. Ionic conductivity
Tutorials
1 Tutorials will consist of 3-4 experiments based upon syllabi of theory paper of Materials Science.

SOLID STATE PHYSICS LAB –I (4-credits)
List of Experiments
Group I:
[1] Thin film deposition by SILAR method
[2] Thin film deposition by electrodeposition method
[3] Thin film deposition by hydrothermal method
[4] Thin film deposition by reflux method
[5] Thin film deposition by dip-coating method
[6] Thin film deposition by CBD method
[7] Microwave assisted synthesis of thin film
[8] Thin film deposition by spray pyrolysis method
Group II:
[9] Rietveld method of structure refinement
[10] Calculation of XRD peak positions and intensities
[11] Thickness measurement of thin film by transmittance spectroscopy
[12] Electrical resistivity of thin film by 2 probe method
[13] Thermoelectric power of thin film
[14] Contact angle measurement of thin film
[15] Determination of band gap energy of thin film
[16] Measurement of dielectric constant

MODERN OPTICS LAB-I (4-credits)
List of Experiments
1 Michelson's Interferometer
2 Talbot's Bands.
3 Calibration of Spectrograph.
4 Laser beam parameter.
5 Iron arc spectra
6 Copper arc spectra
7 Setting of C.D. spectrograph.
8 Mixture analysis.
9 Zeeman effect
10 Recording of Hologram
11 Mathematica-I
12 Recording of FT-NMR Spectra
13 UV-Visible spectra of organic material
Tutorials
1. Concerning above list of experiments, it is possible to arrange some expt. With the availability of new experimental kits.

SPACE SCIENCE LAB-I (4-credits)
List of Experiments
1) Introduction to Python

2) Introduction to MATLAB
3) Proton precession magnetometer
4) Amplitude Modulation
5) Variable Attenuator
6) NavIC-IRNSS: Data Mining and analysis using MATLAB
7) Total electron content by NavIC-IRNSS
8) Solar Data Analysis-I (Electromagnetic)
9) Solar Data Analysis-II (Energetic Particle)
10) Frequency characteristic of Ku-band
11) Beam width of parabolic dish antenna
12) Mounting of Telescope
13) Solar Data Analysis-III (Sunspots)
14) Designing of Yagi Antenna
15) Study of Leafy Vegetation
16) Beam width of Yagi Antenna & field strength
17) X-band characteristics of patch antenna
18) Solar Data Analysis-IV (Coronal Holes and Solar wind)

THEORETICAL PHYSICS LAB-I (4-credits)
List of Experiments

Introduction to Mathematica for Scientists and Engineers (Notebook form in Mathematica Tutorials) (IMSE)
1. IMSE Ch1: Introduction
2. IMSE Ch2: Functions
3. IMSE Ch3: Symbolic Manipulations
4. IMSE Ch4: Plots
5. IMSE Ch5: Lists, Arrays

Tutorials
Tutorials from Schaum's Outlines: Mathematica (Eugene Don)
1. Getting Acquainted
2. Basic Concepts
3. Lists
4. Two-dimensional Graphics
5. Three-dimensional Graphics
3. Assignments

M.Sc. (Physics) (Semester-IV)

Course Code: CC-401
Total Credits: 4-credits
Paper title: EXPERIMENTAL TECHNIQUES

Unit I Vacuum Techniques (B 1 & 2) (15)

Production of low pressures: rotary, diffusion, and sputter ion pumps; measurement of low pressure: McLeod, Pirani, thermocouple & Penning gauges; leak detection: simple methodsof LD, palladium barrier and halogen leak detectors.

Unit II Low Temperature and Microscopy Techniques (B 3 – 8) (15)

Production of low temperatures: Adiabatic cooling, the Joule-Kelvin expansion, adiabatic demagnetization, 3He cryostat, the dilution refrigerator, principle of Pomerunchuk cooling, principle of nuclear demagnetization; measurement of low temperatures. Optical microscopy, scanning electron microscopy, electron microprobe analysis, low energy electron diffraction.

Unit III Atomic Absorption Spectrometry (B 9 – 11) (15)

Fundamentals: principle, basic equipment, operation, monochromator action, modulation; apparatus: double beam instrument, radiation sources, aspiration and atomization; interferences, control of AAS parameters, reciprocal sensitivity and detection limit techniques of measurement : routine procedure, matrix matching method, and method of additions.

Unit IV X-Ray Fluorescence Spectrometry and Mossbauer Spectroscopy (B 11–16) (15)

Introduction to wavelength-dispersive X-ray fluorescence spectrometry (WDXRF) and energy-

dispersive X-ray fluorescence spectrometry (EDXRF), dispersive systems, detectors, instruments, matrix effects, XRF with synchrotron radiation. Elementary theory of recoil free emission and resonant absorption of gamma rays, Mossbauer experiment, hyperfine interactions: chemical isomer shift, magnetic dipole hf splitting, and electric quadrupole hf splitting; line broadening.

Reference Books:

1. High vacuum techniques- J.Yarwood (Chapman & Hall) 1967
2. Vacuum technology- A.Roth (North-Holland Publishing Company, Amsterdam) 1982
3. Experimental techniques in low temperature physics – G.K.White (Oxford) 1968
4. Low temperature physics – L.C. Jackson
5. Experimental principles & methods below 1K – O.V. Lounasmaa (Academic press, New York) 1974
6. Modern metallography - R.E.Smallman & K.H.G.Ashbee(Peramon press, Oxford)
7. Microscopy of materials - D.K.Bowen & C.R.Hall (the MacMillan press Ltd. (London) 1975; Chap.1-3.
8. Electron optical applications in materials science- L.E. Murr, (McGraw Hill, New York) 1970.
9. Atomic absorption spectroscopy - B.Welz (Verlag Chemie, New York) 1976.
10. Atomic absorption spectroscopy- R.J. Reynolds,K.Aldous & K.C. Thompson (Charles Griffin and company Ltd. London) 1970.
11. Modern methods for trace element determination- C.Vandecasteele & C.B.Block (John Wiley & Sons, New York) 1993.
12. Principles of instrumental analysis- D.A. Skoog & J.J.Leary (Saunders College publishing) 1992.
13. Mössbauer spectroscopy- N.N.Greenwood & T.C. Gi bb (Chapman & Hall, London) 1971.
14. Spectroscopy, vol.1 – Straughan & Walker (Chapm an& Hall, London) 1976; Chap.5.
15. Mössbauer effect: principles and applications- G.K.Wertheim (Academicpress, New York) 1964.
16. An introduction to Mössbauer spectroscopy - Leo pold May, Edr. (Plenumpress, New York) 1971.

M.Sc. (Physics) (Semester-IV)

Course Code: DSE-404
Total Credits: 4-credits
Paper title: Numerical Methods and Programming

Unit-I Numerical Methods **(15)**

Methods of determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions. Solutions of simultaneous linear equations, Gaussian elimination, pivoting, iterative method, Matrix inversion, Eigenvalues and eigenvectors of matrices, Power and

Unit-II Numerical approximation methods **(15)**

Jacobi method Finite differences, interpolation with equally spaced and unevenly spaced points, Curve fitting, Polynomial least squares and Cubic Spline fitting numerical approximation methods, Newton-Cotes Formulae, error estimates, Gauss methods. Random variates,

Unit-III Numerical differentiation and integration

Monte Carlo evaluates of integrals, Methods of importance sampling, Random walk and metropolis method, Numerical solution of ordinary differential equation, Euler and Runge Kutta methods, Predictor and corrector methods. Elementary ideas of solutions of partial differential equations.

Unit-IV Fortran

Digital computer principles, Compliers, Interpreters, operating systems., Fortran programming, Flow Charts, Integer and Floating Point Arithmetic, Expressions, Built-in Functions, executable and non-executable statements, assignment, Control and input-output elements, Subroutines and functions, operation with files.

Text and References Books

1. Introductory methods of Numerical Analysis, by Sastry S.S, Publisher: PHI; 5 edition(13 November 2012)
2. Rajaraman: Numerical Analysis
3. Rajaraman: Fortran Programming
4. Vetterming, Teukolsky, Press and Flannery: Numerical Recipes

The problems given in the text and reference books will form Tutorial course

M.Sc. (Physics) (Semester-IV)

Course Code: DSE-404
Total Credits: 4-credits
Paper title: MATLAB Programming and applications

Unit-I: MATLAB Graphics (15)

Two-Dimensional Plots: Parametric Plots, Contour Plots and Implicit Plots, Field plots, Three-Dimensional Plots: Curves in Three-Dimensional Space, Surfaces in Three- Dimensional Space, Figure Windows: Multiple Figure Windows, The Figure Toolbar, Combining Plots in One Window, Customizing Graphics: Annotation, Change of Plot Style, Full-Fledged Customization, Images, Animations, and Sound: Images, Animations, Sound

Unit-II MATLAB Programming (15)

Branching: Branching with if, Logical Expressions, Branching with switch, More about Loops: Open-Ended loops, Braking from a Loop, Other Programming Commands: Sub- functions, Cell and Structure Arrays, Commands for Parsing Input and Output, Evaluation and Function Handles, User Input and Screen Output, Debugging, Interacting with the Operating System: Calling External Programs, File Input and Output

Tutorials/LAB work (30) (2-credits)

Programming and graphics problem solving using MATLABText &

Reference books:

1. A guide to Matlab, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, Cambridge University Press, 2nd edition, 2006

2. Introduction to Numerical Analysis Using MATLAB, By Rizwan Butt

3. Users Guide' student edition of MATLAB latest version

4. Getting Started with MATLAB 5.0: - Rudra Pratap

5. Mastering MATLAB 5.0: - d. Hanselman & B. Littlefield

M.Sc. (Physics) (Semester-IV)

Course Code: DSE-404
Total Credits: 4-credits
Paper title: Energy Conversion and Storage Devices

UNIT I: Solar Photovoltaics (15)

P-N junction under illumination, Light generated current, I-V equation, Characteristics, Upper limits of cell parameters, losses in solar cells, equivalent circuit, effects of various parameters on efficiency, Solar cell design, Design for high Isc, Antireflective coating (ARC), Design for high Voc and fill factor, Analytical techniques; solar simulator, Quantum efficiency, Minority carrier life time and diffusion length measurement. Thin film solar cells: Advantages, materials, a-Si, CdTe, CIGS

UNIT II: Dye and Quantum Dot Sensitized Solar Cell (15)

Dye sensitized solar cells: - Operation, Materials and their properties, Advantages and Disadvantages
Quantum dot sensitized solar cells: - What is quantum dot? Tuning the electronic properties of Quantum dot, Operation, Materials and their properties, Advantages and Disadvantages

UNIT III: Perovskite and Organic Solar cell (15)

Perovskite sensitized solar cells: - Crystal Structure and Related Properties, Opto-electronic Properties, Device Structures, operation and Performances
Organic Photovoltaic Materials: - Organic Photovoltaic Materials properties, Principles ofOperation and Device Concepts, Stability and Performance

UNIT IV: Supercapacitors and Batteries: (15)

Supercapacitor: Comparison between capacitor, supercapacitor and battery; Capacitor principle, Types of capacitors; Electrochemical capacitor: Introduction, Ragone plot, Charge- discharge of supercapacitor and battery; Electric double layer capacitor: electrode-electrolyte interfaces (models),

construction, advantages and disadvantages; pseudocapacitor: electrochemical pseudocapacitor of electrode-electrolyte interface; electrochemistry of pseudocapacitor: underpotential, Redox, Intercalation; Electrode material, Ruthenium oxide. Introduction to Li-Ion battery, Introduction to fuel cell.

References:

1. Solar photovoltaics, Fundamentals, Technologies and Applications by Chetan Singh Solanki, PHI Learning Private Limited, Delhi-110092.
2. Dye Sensitized Solar Cells by K. Kalyansundaram, EPFL Press, A Swiss academic publisher distributed by CRC press.
3. Quantum dot solar cells. Semiconductor nanocrystals as light harvesters, PV Kamat, The Journal of Physical Chemistry C 112 (48), 18737-18753
4. Photovoltaic Solar Energy: From Fundamentals to Applications by Editors(s): AngèleReinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, John Wiley & Sons, Ltd
5. Clean Electricity from Photovoltaics: Second Edition by Mary D Archer, MartinGreen Imperial College Press
6. Advanced Concepts in Photovoltaics by Arthur J Nozik, Gavin Conibeer and Matthew C Beard, RSC Energy and Environment Series
7. Practical Handbook of Photovoltaics: Fundamentals and Applications by AugustinMcEvoy, Tom Markvart and Luis Castaner. Academic Press
8. Electrochemicalsupercapacitors forenergy storageand deliveryfundamentals and applications by Aipingyu, victor Chabot and jiujunzhang.
9. Electrochemical Supercapacitors, Scientific fundamentals and Technological Applications by B. E. Conway, Kluwer Academic/ Plenum Publishers, New York, Boston, Dordrencht, London, Moscow
10. Battery reference book 3rd edition by T. R. Crompton
11. Battery Technology Handbook by H. A. Kiehne , Marcel Dekker, Inc. , New York, Basel.
12. Fuel cell handbook &th edition by E G and G technical services.Inc.

M.Sc. (Physics) (Semester-IV)

Course Code: CCS-402
Total Credits: 4-credits
Paper title: Renewable Energy Resources

Unit I: Energy and Thermodynamics (15)

Forms of Energy, Conservation of Energy, Entropy, Heat capacity, Thermodynamic cycles: Brayton, Carnot Diesel, Otto and Rankin cycle; Fossil fuels, time scale of fossil fuels and solar energy as an option.

Unit II: Solar Energy for Clean Environment (15)

Sun as the source of energy and its energy transport to the earth, Extraterrestrial and terrestrial solar radiations, solar spectral irradiance, solar radiation geometry, Measurement techniques of solar radiations, Estimation of average solar radiation.

Unit III: Wind Energy (15)

Origin and classification of winds, Aerodynamics of windmill: Maximum power, and Forces on the Blades and thrust on turbines; Wind data collection and field estimation of wind energy, Site selection, Basic components of wind mill, Types of wind mill, Wind energyfarm, Hybrid wind energy systems: wind + PV; The present Indian Scenario.

Unit IV: Biomass Energy and Biogas Technology (15)

Nature of Biomass as a fuel, Biomass energy conversion processes, Direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace; Dry chemical conversion processes: pyrolysis, gasification, types of gasification, Importance of biogas technology, anaerobic

decomposition of biodegradable materials, Factors affecting Bio digestion, Types of biogas plants, Applications of biogas.

Reference Books:

1. Biomass, Energy and Environment- N.H. Ravindranath and D.O Hall, Oxford University Press.

2. Solar Energy and Rural development- S.H. Pawar, C.D. Lokhande and R.N. Patil.
3. Biomass Energy- S.H. Pawar, L.J. Bhosale, A.B. Sabale and S.K. Goel.
4. Solid State Energy Conversion-S.H. Pawar, C.H. Bhosale, and R.N. Patil
5. Solar Energy Conversion-A.E. Dixon and J.D. Leslie.
6. Advances in Energy systems and technology- Peter Auer.

M.Sc. (Physics) (Semester-IV)

Course Code: CCS-403
Total Credits: 4-credits
Paper title: Energy Conversion Devices

Unit 1: Photovoltaic converters (15)

Interaction of solar radiations with semiconductors, photovoltaic effect, types of solar cell, equivalent circuit diagram of a solar cell, determination of series resistance (Rs) and shunt resistance (Rsh), ideal properties of semiconductor for use its solar cell, carrier generation and recombination, dark and illuminated characteristics of solar cell, solar cell output parameters: RL, Voc, Isc, Pm, FF, efficiency, performance dependence of a solar cell on band gap energy, diffusion length and carrier life time, Types of heterojunction, construction of energy band diagram of heterojunctions, origin of capacitance in a heterojunction, expression for junction capacitance, Mott – Schottky relation, problems.

Unit 2: Materials and Solar cell Technology (15)

Single, poly – and amorphous silicon, GaAs, CdS, Cu_2S, $CuInSe_2$, CdTe etc. technologies for fabrication of single and polycrystalline silicon solar cells, amorphous silicon solar cells and tandem cells, solar cell modules, photovoltaic systems, space quality solar cells, problems.

Unit 3: Photochemical Converters (15)

Semiconductor – electrolyte interface, photoelectro chemical solar cells, conversionefficiency in relation to material properties, photoelectrolysis cell, driving force of photoelectrolysis, alkaline fuel cell, semiconductor- septum storage cell, problems.

Unit 4: Thermoelectric Converters (15)

Thermoelectric effects, solid state description of thermodynamic relations, analysis of

thermoelectric temperature distribution and thermal energy transfer performance for thermoelectric cooling, problems. Thermoelectric effect, Kelvin's generators, basicassumptions, for generator

Reference Books:

1. Solar energy conversion: The solar cell, by Richard C. Neville.
2. Photoelectrochemical solar cells – Suresh Chandr a
3. Solar energy conversion – A. E. Dixon and J. D. Leslie.
4. Solar cells – Martin A.Green
5. Heterojunction and metal – semiconductor junctio ns – A.G. Milnes and D. L. Feucht.
6. Solid state electronic devices - B.G. Streetman.
7. Principles of solar engineering – Frank Kreith a nd Janf Kreider.
8. Direct energy conversion (4th edition) – Stanley W Angrist.
9. Handbook of battries and fuel cells – Lindsey. David

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-402
Total Credits: 4 – credits
Paper title: Special Materials

Unit I Composite materials (15)

Introduction, Reinforcing materials for fibrous composites, Manufacture of fiber composites, Elastic properties of a composite, Strength of a fiber composite, Specific stiffness and specific strength, Toughness of fibre composites, Fracture toughness of polyblends.

Unit II Glasses (15)

Glasses: Types of glasses, role of oxides in glasses, glass transition temperature, optical properties of glasses, electrical properties of glasses, electronically conducting glasses, special glasses, metallic glasses.

Unit III Functional Materials (15)

Nanophase materials: Introduction, synthesis and techniques, Nucleation and growth mechanism, properties of Nanophase Materials, Applications.

Advanced Ceramics: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications.

Polymer Materials: Introduction, Polymerization Mechanism, Degree of Polymerization, Classification of Polymers, Structures of polymer and preparation methods, important properties and applications of polymers. (Nylon, Polyesters, Silicones, Composites, Composite material including nanomaterial)

Unit IV Ferroelectrics, Piezoelectrics and Pyroelectrics (15)

Ferroelectrics: Ferroelectric phenomena, Types of ferroelectrics, Theory of ferroelectric displacive transitions, Ferroelectric and antiferroelectric transition, Formation and dynamics of ferroelectric domains, Experimental evidence of domain structure, ferroelectric materials, and their applications.

Piezoelectric: Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials, and their applications.
Pyroelectrics: Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, pyroelectric materials, and their applications.

Reference Books:

1)Modern composite materials - L. J. Broutman and R H Krock Addition-Wesley Pub. Co., Massachusetts (1967)
2) Glass science - R H Doremus, John Wiley and sons, N. Y. (1973)
3) Physical properties of glass - D. G. Holloway Wykeham publications, London (1973)
4) Introduction to ceramics - W. D. Kingery, John Wiley and sons, N. Y. (1960)
5) Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons
6) M.A.Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
7) Materials Science: V. Rajendran, A. Marikani, Tata MC Graw Hill
8) Materials Science & Engineering: Raghavan, Tata MC Graw Hill
9) Materials Science: Arumugam
10) Materials Science &Metallurgy: O. P. Khanna
11) Materials Science and Engineering: Callister S.

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-403
Total Credits: 4 – credits
Paper title: Nanostructured Materials

Unit I: Nano-Material Synthesis and Characterization (15)
Material Synthesis: Physical Methods: Introduction, methods based on evaporation, sputter deposition, chemical vapour deposition, electro deposition, ion beam technique, Chemical Methods: Introduction, colloids and colloidal solutions, growth of nanoparticles, sol-gel method.

Unit II: Characterizations and Applications of Nanostructured Materials (15)
Material Characterization: Analysis by XRD, XPS, SEM/FESEM, FT-IR, UV-Vis, Raman Spectroscopy, AFM, TEM, TG-DTA, Wettability and contact angle measurement. Electronics, energy, automobiles, sports and toys, textile, cosmetic, domestic appliances, space, and defense, medical, nanotechnology and environment.

Unit III: Nano-Biomaterials (15)
Biomaterial requirements, Dental materials, bore materials, Reconstructive surgery materials, Drug delivery system, Carbon Nanomaterials as Nanocarriers for Drug Delivery: Concepts and Challenges, Delivery of Anticancer Drugs

Unit IV: Environmental and Social issues of Nano-Materials Science (15)
Recycling issue of materials science, World banned materials, Salty of hazards materials, Nanomaterials and health, Nanomaterials and the environment, Sustainable nonmanufacturing and green nanotechnology, Societal and ethical considerations.

Reference Books

1) Physical metallurgy principles - R. E. Reed-Hill, Affiliated East-west press Pvt. Ltd., New Delhi (1973)
2) Physical Metallurgy andAdvanced Materials, Seventh edition,R. E. Smallman and A. H.W. Ngan. Published by Elsevier Ltd. (2007)
3) Structure and principle of engineering materials - R. M. Brick, A. W. Pense and R. B. Gordon, McGraw-Hill Kogakusha, Ltd., Tokyo (1977)
4) Introduction to materials science for engineers - J.F. Shackelford McMillan, N. Y. (1985)
5) Modern composite materials - L. J. Broutman and R H Krock Addition-Wesley Pub. Co., Massachusetts (1967)
6) Materials science, testing, and properties for technicians - W. O. Fellers Prentice Hall, N. J. (1990)
7) Elements of materials science -L. H. van Vlack Addition-Wesley, Massachusetts (1959)
8) Introduction to ceramics - W. D. Kingery, John Wiley and sons, N. Y. (1960)
9) Carbon Nanomaterials for Biomedical Applications, Mei Zhang, Rajesh R. Naik, Liming Dai. Springer International Publishing Switzerland 2016
10) Nanotechnology Environmental Health and Safety, Second Edition, Matthew S. Hull and Diana M. Bowman. Published by Elsevier Inc. (2014)

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-402
Total Credits: 4 – credits
Paper title: Molecular spectroscopy

Unit I: Basics of molecular spectroscopy (15)

Molecular Structure and Molecular Spectra: Covalent, ionic and Vander Waal bonding, Valence bond and Molecular orbital approach for molecular bonding, Crystal Field Theory, electronic structure of homo nuclear diatomic molecules, pairing and valency, hetero nuclear diatomic molecules,, Electronic spectra of diatomic molecules – Born-Oppenheimer approximation, Electronic structure of polyatomic molecules: hybridization-hybrid orbital's, bonding in hydrocarbons.

Unit II: Absorption and Luminescence spectroscopy (15)

UV/Visible Molecular Absorption Spectroscopy: Optical absorption: Free carrier absorption-optical transition between bands-direct, and indirect-excitons, Beer's law, and its limitations.
Instrumentation: sources; single and double beam spectrometers; Solvent-effects; Bathochromic and Hypochromic shifts; Assignment of σ and π transitions.
Molecular Luminescence Spectroscopy: Luminescence in crystal - excitation and emission – decay mechanism, Fluorescence and Phosphorescence (with energy level diagram); Transition types; quantum efficiency (yield). Instruments: Fluoro meters and Spectro fluoro meters; lifetime measurements, Radiative and Natural lifetime, Decay curves, Applications.

Unit III: Vibrational Spectroscopy (15)

The vibrations of polyatomic molecules: Infrared Absorption process, Modes of stretching and bending, bond properties and absorption trends, vibrational coarse structure – progressions. Intensity of vibrational transitions – the Franck-Condon principle, Molecular vibrations and Group frequencies,
Infrared Spectrometry: IR sources; transducers, Instruments: Dispersive and FT-based spectrometers; sample handling. Interpretation of spectra-structure correlations.

Raman Spectroscopy: Origin of Raman scattering (qualitative); activity and intensity of Raman bands; depolarization ratio. Pure rotational Raman spectra, Vibrational Raman spectra, Polarization of light and the Raman effect. Instrumentation; sources; dispersive and FT-based Raman spectrometers; sample handling. Applications. Comparison of vibrational Raman and infrared spectra.

Unit IV: Nuclear spectroscopy **(15)**

Nuclear Magnetic Resonance (NMR) Spectroscopy: Nuclear Magnetic Resonance: Principles, Classical treatment of NMR (Bloch equations), Interaction between nuclear spin and magnetic moment; resonance condition; population of energy levels. Relaxation processes: spin-lattice and spin-spin relaxations (qualitative). The chemical shift and its correlation with molecular structure. Typical NMR spectrometers (cw/FT); sample handling, applications of NMR.

Photoelectron spectroscopy Types - UPS and XPS. Experimental method for UPS and XPS. Ionization processes and Koopmans' theorem. Interpretation of UP and XP spectra with Applications. Auger electron and X-ray fluorescence spectroscopy: experimental methods and processes.

Reference Books

1) Fundamentals of Molecular Spectroscopy, 4thEdition. – C.N. Banwell, Tata Mac Graw Hill (2008).
2) Molecular structure and spectroscopy-2nd Edition -G. Aruldhas, Prentice Hall of India, (2002)
3) Introduction to Spectroscopy, 5th Edition- Pavia, Lampman, Kriz, and Vyvyan, Cengage Learning, USA,
4) Modern Spectroscopy (4th Ed): J.M. Hollas, John Wiley & Sons Ltd, UK (2004)
5) Principles of Instrumental Analysis (5th ed): D. A. Skogg, F. J. Holler & T. A. Nieman, Harcourt Asia Pte. Ltd. (1998)
5) Introduction to Molecular Spectroscopy – G.M. Barrow, MacGraw Hill (1962).
6) Molecular Spectra and molecular structure I, II, III, G. Herzberg, D. Van Nostrand Company Inc., 1963
7) Physics of Atoms and Molecules - B. H. Bransden and C. J. Joachain, Pearson; 2008.
8) A. H. Kitai; Solid State Luminescence; Chapman and Hall, London; 1993.
9) Luminescence of Solids edited by D. R. Vij, Plenum Press, New York, 1998.

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-403
Total Credits: 4 – credits
Paper title: Holography and Its applications

Unit – I: Introduction to Basic Concepts: (15)
Optical holography, Light waves, hologram formation, wave front reconstruction, Plane and Volume hologram formation geometries, Basic holography equations. Beginning of Optical Holography, in - line (Gabor) hologram, the off-axis hologram, Image hologram, Fraunhofer Hologram, Thin hologram and Volume hologram, Properties of holograms. Critical assessment of Holograms.

Unit – II: Optical system and Hologram recording materials (15)
Optical system: Mechanical Stability in Hologram Formation, Fringe visibility, Optical components, Coherence requirements. Temporal coherence of laser light, Laser safety.
Hologram Recording Materials: Optical changes in Photosensitive materials, Exposure & sensitivity, Recording resolution, Noise and Recording Linearity and Ideal recording material, Silver halide photographic emulsion, Photoconductor-Thermoplastic films, Dichromate gelatin films, Thermoplastic films, Photochromic materials.

Unit – III: Holography and Interferometry (15)
Color Holography, Computer generated holograms in optical testing, Time gated holography, Hologram copying, Acoustical Holography.
Holographic Interferometry: Time average holographic Interferometry, Real time & Double exposure holographic interferometry, electronic holographic interferometry, Difference holographic interferometry.

Unit – IV: Applications of Holography: (15)
Imaging applications: Holographic microscopy; Particle size analysis; multiple imaging,

Holographic optical elements: Diffraction gratings; filters; scanners,
Information storage and processing: Associative storage; pattern recognition; coding and multiplexing; Image processing; information storage.
Holography and communication: Holographic Diffuser Screen, Holographic Display, Holographic TV, Holographic Movie, Holography in solar energy and Architecture

Text and Reference Books:
1. R. J. Collier, C.B. Burukhardt, L. Lan, Optical Holography, Academic Press (1971).
2. P. Hariharan, Optical Holography, Cambridge University Press, (1984)
3. G.K. Ackermann, J. Eichler, Holography- a practical approach, Wiley-VCH, (2007).
3. H.M. Smith, Principles of Holography, Wiley Interscience Inc., (1969).
4. L. M. Soroko, Holography & Coherent optics, Plenum Press, (1980).

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-402
Total Credits: 4 – credits
Paper title: Magnetospheric Plasma Dynamics

Unit-I: The Earth's Magnetic Field and Magnetosphere (15)
The Earth's Magnetic Field and Magnetosphere, The magnetopause, the geomagnetic tail, magnetic reconnection-concept, magnetic reconnection and Magnetospheric dynamics, fluid description of reconnection, particle description of reconnection.

Unit-II: Reconnection at Magnetopause (15)
Magnetopause boundary layers, signatures of magnetopause reconnections, patchy, unsteady reconnection, reconnection, and the plasma-sheet boundary layer.

Unit-III: Magnetospheric configuration (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.

Unit-IV: Geomagnetic storms (15)
Geomagnetic storms, geomagnetic indices, effects of geomagnetic storms on the Earth's upper atmosphere and ionosphere-electric field and neutral wind disturbances.

Reference Books:
1. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
2. The Earth's Ionosphere-Plasma Physics and Electrodynamics, Second Edition, Michael C. Kelley,

Academic Press, Elsevier
3. An introduction to the ionosphere and magnetosphere. J. A. Ratcliffe, Cambridge University Press, 1972,
4. Ionospheres: Physics, Plasma Physics, and Chemistry by Robert Schunk Andrew Nagy
5. Elements of space physics by R. P. Singhal
6. Advanced Magnetohydrodynamics: With Applications to Laboratory and Astrophysical Plasmas by J. P. Goedbloed, Rony Keppens, Stefaan Poedts
7. Source book on space science by S. Glasstone
8. The Upper Atmosphere Data Analysis and Interpretation, W. Dieminger G.K.Hartmann R. Leitinger (Eds.), Springer- 1996, ISBN-13 :978-3-642-78719-5

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-403
Total Credits: 4 – credits
Paper title: Ionospheric Physics and Space Weather

Unit-I: Physical and Chemical process in Atmosphere (15)
Pressures, radiative heating-solar and planetary radiation, radiation trapping-greenhouse effect diurnal and seasonal variations, temperature profiles-troposphere, stratosphere, mesosphere, thermosphere, vertical transport, ion chemistry in the atmosphere, ionization mechanisms, f-region processes, E-region processes, D-region processes.

Unit-II: Ionosphere (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.

Unit-IIII: Implications of Space weather effects (15)
Electrical charges in the atmosphere, aurora, geomagnetic fluctuations, radio propagation, Effect on satellite electronics, satellite charging, satellite drag, heating of the neutral atmosphere, Effect on radio wave propagation, effect on communications and navigational outages

Unit-IV: Global Navigation Satellite System (GNSS) (15)
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. Introduction to Space Physics by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)
2. Space Physics: An Introduction, by C. T. Russell, J. G. Luhmann, et al. Cambridge University Press; Har/Psc edition (August 18, 2016)
3. Chemistry of Atmospheres: An Introduction to the Chemistry of the Atmospheres of Earth, the Planets, and their Satellites 3rd Edition, Oxford University Press; 3 edition (March 30, 2000)
4. Elements of space physics by R. P. Singhal
5. The Upper Atmosphere Data Analysis and Interpretation, W. Dieminger G.K. Hartmann R. Leitinger (Eds.), Springer- 1996, ISBN-13 :978-3-642-78719-5
6. An Introduction to GNSS GPS, GLONASS, BeiDou, Galileo and other Global Navigation Satellite Systems, second edition, Published by NovAtel Inc. ISBN: 978-0-9813754-0-3

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-402
Total Credits: 4 – credits
Paper title: Physical properties of Solids

Unit 1: Electronic Structure of Crystals (15)

Basic assumptions of Model, Collision or relaxation times, DC electrical conductivity, Failures of the free electron model, The tight-binding method, Linear combinations of atomic orbitals, Application to bands from s-Levels, General features of Tight-binding levels, Wannier functions, Other methods for calculating band structure, Independent electron approximation, general features of valence band wave functions, Cellular method, Muffin Tin potentials, Augmented plane wave (APW) method, Green's function (KKR) method, Orthogonalized Plane Wave (OPW) method Pseudo potentials.

Unit 2: Transport Properties of Metals (15)

Drift velocity and relaxation time, The Boltzmann transport relation, The Sommerfeld theory of metals of electrical conductivity, The mean free path in metals, Thermal scattering, The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators, Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.

Unit 3: Phonons, Plasmons, Polaritons, and Polarons (15)

Vibrations of monatomic lattices: first Brillion zone, group velocity, Long wavelength limit, Lattice with two atoms per primitive cell. Quantization of lattice vibrations, Phonon momentum Dielectric function of the electron gas, Plasma optics, Dispersion relation for Electromagnetic waves, Transverse optical

modes in a plasma, Longitudinal Plasma oscillations, Plasmons, Polaritons, LST relations, Electron-electron interaction, Electron phonon interaction: Polarons.

Unit 4: Defects in crystals **(15)**

Thermodynamics of point defects, Schottky and Frenkel defects, annealing, electrical conductivity of ionic crystals, color centers, Polarons and exciton, dislocations, strength of crystals, crystal growth, stacking faults and grain boundaries.

Reference Books:

1. Solid State Physics by N W Ashcroft and N D Mermin, HRW, International editions (1996) (Units 1, 2 and 3)
2. Introduction to Solid State Physics by C Kittle (4th edition) John Willey Publication (1979) (Units 3)
3. Solid State Physics by A J Dekker ((1986) Macmillan India Ltd

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-403
Total Credits: 4 – credits
Paper title: Semiconductor Devices

Unit I: Transistors and Microwave Devices: **(15)**

Bipolar junction transistor (BJT), Frequency response and switching, of BJT, Base Narrowing, Ebers-Moll Model, Gummel–Poon Model, Kirk Effect, Field effect transistor (FET), JFET, MOSFET, MESFET, Tunnel diode, Transferred electron devices and Gunn diode, Avalanche transit time diode and, IMPATT diode.

Unit II: Photonic Devices: **(15)**

Optical absorption, Radiative and non-radiative transitions, Light emitting diodes, Organic LED, Infrared LED, Photo detector, Photoconductor, Photodiode, Solar cells, Semiconductor Lasers.

Unit III: Memory Devices: **(15)**

Number system and its conversion to binary number, Semiconducting memories, Memory organization, Read and Write operation, expanding memory size, Classification and characteristics of memories, Static and dynamic RAM, Charge couple memory (CCD) devices, Magnetic, optical, ferroelectric, Spintronic and other memory-based devices.

Unit IV: Other electronic Devices: (15)

Magneto-optic and acousto-optic effects, Material's properties related to get these effects, Piezoelectric, Electrostrictive and Magnetostrictive effects, Sensors, and actuator devices.

Reference Books:

1) Semiconductor devices: Physics and Technology 2nd Edition, S. M. Sze
2) Modern Digital Electronics, R. P. Jain
3) Introduction to Semiconductor devices by M. S. Tyagi
4) Optical electronics by Ajoy Ghatak and K. Thyagrajan, Cambridge University Press.

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-402
Total Credits: 4 – credits
Paper title: Interaction of Electromagnetic Waves with Electron Beams and Plasmas

Unit 1: Basic equations and properties of linear Waves (15)
Introduction, Maxwell Equations, Dispersion Relation, Energy Density and Energy flow, The Kinetic equation, Fluid equations, Plasma response to an electromagnetic wave, Diffraction divergence, Dispersion broadening.

Unit 2: Resonance absorption, plasma wave excitation, coherent emission of radiation (15)
Current Density, Coupled Mode Equations, Mode conversion, Excitation of a Langmuir wave, Electron Acceleration in a Langmuir wave.

Unit 3: Self-focussing and filamentation, parametric instabilities in a homogeneous plasma (15)
Phase coherence and Bunching, Cerenkov FEL, Free Electron Laser (Till Growth rate), Self-focusing, Filamentation Instability a Harmonic oscillator, Parametric oscillator with two degrees of freedom, Parametric coupling in a Plasma.

Unit 4: A nonlinear Schrodinger equation and parametric instabilities in an inhomogeneous plasma (15)

Basic equation, Stationary solution, Instability of an Envelope Soliton, Criterion for Collapse, WKB Solution, Raman Side scattering, Brillouin Side scattering,

Reference book:

1. Interaction of Electromagnetic waves with electron beams and Plasmas, World Scientific, 1994
By C S Liu and V S Tripathi,

M.Sc. (Physics) (Semester-IV)
Course Code: CCS-403
Total Credits: 4 – credits
Paper title: Introduction to Quantum Field Theory

Unit-I: Single particle relativistic wave equation (15)

Relativistic Notation, Klein-Gordan equation, Dirac equation, Prediction of antiparticles, Dirac matrices and Dirac spinors, Non-relativistic limit and electron magnetic moment, Relevance of Poincare group: spin operators and zero mass limit, Maxwell and Proca equations.

Unit-II: Canonical quantization of spin zero, spin half and spin one fields (15)

Lagrangian formulation, The real scalar field, Complex scalar field and electromagnetic field, Canonical quantization of real and complex Klein-Gordan field, Canonical quantization of Dirac field, Quantization of electromagnetic field, The massive vector field.

Unit-III: Path integral quantization of spin zero and spin half fields (15)

Path integral formulation of quantum mechanics, Perturbation theory and S-matrix, Coulomb scattering, Generating functional for scalar fields, Functional integration, Free Green's function, The S-matrix and reduction formula, Scattering cross section.

Unit-IV: Path integral quantization of gauge fields (15)

Propagators and gauge conditions in QED, Non-Abelian gauge fields, Self-energy and vertex function, Ward-Takahashi identities in QED, Gauge Theory of Standard Model, Spontaneous Symmetry breaking and Higgs Mechanism.

Reference Books:

1. Quantum Field Theory, Lewis Ryder, Cambridge Press.
2. Student Friendly Quantum Field Theory, Robert Klauber, Sandtrove Press; 2nd Edition.
3. An Introduction to Quantum Field Theory, Michael Peskin and Daniel Schroeder, Westview Press.
4. Diagrammatica, Martinus Veltman, Cambridge Press.
5. The Quantum Theory of Fields Vol. I and II, Steven Weinberg, Cambridge Press.
6. Quarks and Leptones: An Introductory Course in Modern Particle Physics, Francis Halzen and Alan D. Martin (Wiley)

ENERGY SCIENCE LAB-II

List of Experiments

1. Solar Line Concentrator (I)
2. Solar Line Concentrator (II)
3. Solar Pont Concentrator
4. Solar Still
5. Solar Dryer
6. Solar Cooker
7. Flat Plate Collector
8. PV – IV Characteristics
9. PV-Water Pumping System
10. PV-Spray System
11. Flue Gas Analyser
12. Wind Energy Conversion
13. Particle Size Measurement
14. Close Cycle Cryogenic System
15. Hot Water Bumb
16. 3kW Aerogenerator

MATERIALS SCIENCE LAB-II

List of Experiments

1. Brinell hardness
2. Effect of dip coating cycles on wettability of the thin film
3. Hysteresis loop tracer
4. Band gap of semiconducting thin films

5. Abrasion tests of thin films/coating
6. Intensity calculations by using XRD- pattern
7. Optical properties of thin films by UV-VIS spectrophotometer
8. Microstructure of steels
9. Crystal growth by gel technique
10. Contact angle measurement

Tutorials

1 Tutorials will consist of 3-4 experiments based upon syllabi of theory paper of Materials Science.

SOLID STATE PHYSICS LAB–II

List of Experiments

Group I:

[1] Particle size analysis by dynamic light scattering
[2] Photoelectrochemical Solar Cell
[3] Characteristics of phototransistor and LDR
[4] Spectral response of solar cell
[5] Gas sensing properties of thin film
[6] I-V characteristics of solar panel
[7] Analysis of EIS spectrum
[8] I-V characteristics and solar cell parameters

Group II:

[9] Analysis of FT-IR and FT-IR spectra
[10] Cyclic Voltammetry and electrochromism
[11] Supercapacitive behaviour of MnO_2 sample
[12] Specific area by BET method
[13] Analysis of PL spectrum and calculation of life time of defects
[14] Analysis of TG-DTA pattern
[15] Analysis of XAFs pattern

MODERN OPTICS LAB—II

List of Experiments

1 Vibrational analysis of CN
2 Vibrational analysis of AlO
3 Vibrational analysis of C2
4 Mixture analysis
5 Solar Spectrum
6 Temperature of flame
7 Measurement of Brewster angle and R.I. of materials like glass
8 Determination of wavelength of light by grating
9 Production and analysis of polarized light with the help of He-Ne laser
10 Fabry-Parot etalon – Exact fraction method
11 Recording of IR spectra
12 CD-spectrometer by using Hydrogen and Helium lamp.

Depending on availability of new experimental kits, few new experiments will be added to this list

SPACE SCIENCE LAB–II

List of Experiments

1. Sky observations-I (Moon & Planets)
2. Sky observations-II (Binary stars & Nebula)
3. Geomagnetic Indices-Kp and Ap
4. Interplanetary Magnetic Field (IMF)
5. Sun's Magnetogram
6. Solar Dynamic Observatory (Sun Now)
7. Solar Proton Events
8. Geomagnetic Events
9. Magnetometer
10. GOES Electron Flux
11. GOES Magnetometer
12. GOES Proton Flux
13. GOES Solar X-ray Imager
14. GOES X-ray Flux
15. LASCO Coronagraph
16. Planetary K-index
17. Real Time Solar Wind
18. Van Allen Probes Radiation Belt

THEORETICAL PHYSICS LAB–II (4-credits)
ADVANCED MATHEMATICA
TUTORIALS:
2. Introduction to Mathematica for Scientists and Engineers (Notebook form in Mathematica Tutorials)
IMSE Ch7: Complex
IMSE Ch8: Fourier
IMSE Ch9: Programming
IMSE Ch10: Statistics
IMSE Ch5: Input-Output
IMSE Ch6: Solve – Numerical Solutions
List of Experiments
From Schaum's Outlines: Mathematica (Eugene Don)
Chapter 7: Algebra and Trigonometry
Chapter 7: Differential Calculus
Chapter 9: Integral Calculus
Chapter 10: Multivariate Calculus
Chapter 11: Ordinary Differential Equations
Chapter 12: Linear Algebra
3. Assignments

NON-CGPA COURSE OFFERED BY DEPARTMENT OF PHYSICS

M.Sc. (Physics) (Semester-IV)
Course Code: GE-407
Total Credits: 2-credits
Paper title: Observational Astronomy

Unit-I: The Earth and Sky

The Stars: constellations, names of stars, brightness of stars, celestial sphere: A model of the sky, reference marks on the sky, angles on the sky, precession, motion of the Sun: the ecliptic, the season, the motion of the planets: the moving planets, lunar phases tides and eclipses: the phases of the Moon: The Moon's orbit, phase cycle, lunar eclipses: the Earth's shadow, types of lunar eclipses, solar eclipses: the Moons shadow, types of solar eclipse

Unit-II: Light and Telescopes

Radiation: EMR, the electromagnetic spectrum, astronomical telescope: refracting telescope, reflecting telescope, new generation, power of the telescope, special instruments: the photometer, the spectrograph, radio telescope: operation of telescope, the radio interferometer, advantage of radio telescope, space astronomy: infrared astronomy, ultraviolet astronomy, X-ray astronomy, gamma ray telescope

Reference Books:

1. Foundations of Astronomy by Michael a. Seeds, Publisher-Brooks/Cole; International edition (15 March 2006)
2. Astronomy: A Beginner's Guide to the Universe, by McMillan Eric, Chaisson, Steve, Publisher: Pearson Education; Seventh edition (30 June 2017)
3. Our Universe, Jo Dunkley, Publisher: Pelican (31 January 2019)