CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

CBCS, LOCF and NEP-2020 Based

Curriculum and Syllabi
Of
M.Sc. Physics

(w.e.f. October 2021)

DEPARTMENT OF PHYSICS & ASTROPHYSICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	Approved	Approved	Approved
Approval Date :	08-09-2021	20-09-2021	12-10-2021

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VISION AND MISSION

i) Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ii) Vision and Mission of the Department

Vision

To establish a platform for the dissemination and creation of knowledge through teaching and research in Physics and Astrophysics at various levels. To help create a scientific society which encourages logical thinking.

Mission

- To offer a state of art Academic Programs in Physics and interdisciplinary areas.
- To create intellectual property through innovations, quality research publications and patents
- To create state of art research laboratories which will facilitate the research of Central University of Haryana as well as other academic institutions.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED);

holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering ‘Knowledge of India’; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-

Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About the Subject

Physics is the natural science that studies the matter, its motion and behavior through space and time, and the related entities of energy and force. Physics is one of the most fundamental scientific disciplines and its main goal is to understand the behavior of universe and its characteristics.

Physics uses the scientific method to help uncover the basic principles governing light and matter, and to discover the implications of those laws. It assumes that there are rules by which the universe functions, and that those laws can be at least partially understood by humans. It is also commonly believed that those laws could be used to predict everything about the universe's future if complete information was available about the present state of all light and matter.

On inclusion of Astronomy, the Physics became one of the oldest academic disciplines. Physics intersects with many interdisciplinary areas of research. New ideas in Physics often explain the fundamental mechanisms studied by other branches of science and suggest new avenues of research in academic disciplines such mathematics etc. Advancement in Physics often leads to new technologies.

iii)About the Programme (Nature, extent and aims)

M.Sc. Physics is a two year regular programme. There four semesters in this programme. Each semester is of sixteen weeks duration. Teaching and learning process of M.Sc. Physics involves theory and practical classes along with seminar presentation and research project work.

The curriculum will be taught through formal lectures with the aid of power-point presentations, audio and video tools and other teaching aids can be used as and when required. Emphasis will be given to laboratory work and visit to National laboratories to give hands on experience to students. Students will be encourage to do semester long project in their own institutes as well as in reputed institutes of National level. Aims of the Programme are as follows

- Understand the underlying Physics in respective specializations, and, be able to teach and guide successfully
- Introduce advanced ideas and techniques that are applicable in respective fields.
- Provide the students with a broad spectrum of Physics Courses
- Emphasize the role of Physics in other disciplines such as (Chemical Sciences, Mathematical Sciences, Life Sciences and their applied areas)
- Develop the ability of the students to observe, perform, analyse and report an experiment
- Develop the ability of the students to deal with physical models and formulas mathematically
- Equip the students with different practical, intellectual and transferable skills.
- Strengthen the student knowledge of Physics and its applications in real world.
- Provide the student with mathematical and computational tools and models to be used in solving professional problems
- Improve the student's inter disciplinary skills.
- To develop human resources with a solid foundation in theoretical and experimental aspects of respective specializations as a preparation for career in academia and industry.

iv) Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive a M.Sc. Degree in the Physics. The postgraduate of Department of Physics and Astrophysics are expected to opt different paths seeking sphere of knowledge and domain of professional work that can fulfill their dreams. Students will be able to demonstrate their knowledge in advance branches of Physics. This will establish a platform over which students can pursue higher studies. The possible career paths for postgraduate in M.Sc. Physics are

1. Teaching Assignments
2. Scientific Assignments

3. Instruments development
4. Research and Development in Industries
5. Simulation Techniques Development in Science
6. Role in Renewable Energy Resources
7. University/Institute Administrative Assignments
8. Technician in Lasers, Accelerators, Detectors and Electronics
9. Astronomer
10. Medical Device Designer
11. Radiologist

2. PROGRAMME OUTCOMES (POs)

Students enrolled in the Master's Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.

	education	
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following specific outcomes by the end of program studies:

Number	**Programme Specific Outcomes**
PSO-1	Identify, formulate, and solve Physics problems
PSO-2	Design and conduct experiments, as well as to analyse and interpret data
PSO-3	Apply knowledge of Physics in a different stream of science and to communicate effectively.
PSO-4	Ability to use the techniques, skills, and modern physical tools in real world application.
PSO-5	Engage in life-long learning and will have recognition.

4. Postgraduate Attributes

No.	P.G. Attributes
PGA-1	have the ability to demonstrate advanced independent critical enquiry, analysis and reflection
PGA-2	In-depth knowledge of their specialist discipline(s)
PGA-3	be critical and creative thinkers, with an aptitude for continued self-directed learning
PGA-4	be able to examine critically, synthesize and evaluate knowledge across a broad range of disciplines.
PGA-5	Reach a high level of achievement in writing, research or project activities, problem solving and communication.
PGA-6	have a set of flexible and transferable skills for different types of employment
PGA-7	have a strong sence of intellectual integrity and ethics of scholarship.
PGA-8	be able to initiate and implement constructive change in their communities, including professions and workplaces.

5. STRUCTURE OF MASTER'S COURSE

Total Credits of M.Sc. Physics : 96

Types of Courses	Nature	Total Credits	%
Core Courses(CC)	Compulsory	60	**62.5**
Elective Courses (EC)	Discipline Centric Elective Courses	0	**0**
	Discipline Specialized Elective Courses	16	**16.6**
	Generic Elective Courses	8	**8.3**
Skilled-based courses/ Self-study based courses	Skill Enhancement Courses	12	**12.5**

List of Courses (*, **, ***, ****)

6. LEARNING OUTCOME INDEX

6.1A Mapping of Core Courses with PSOs

POs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5
Course No. ⇩					
1	√		√		√
2	√		√		√
3	√		√		√
4	√	√		√	
5	√	√			√
6	√		√		√
7	√		√		√
8	√		√		√

9	√	√	√		
10	√	√		√	
11	√		√	√	
12	√		√	√	
13	√	√			√
14	√		√	√	

6.1B Mapping of Discipline Centric Courses with PSOs

POs ⇨	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
Course No. ⇩					
1	√				√
2	√	√		√	√
3		√		√	√
4		√		√	√
5	√		√		√
6		√	√	√	
7	√	√			√
8		√	√	√	
9	√	√	√		
10	√		√		√
11	√		√		
12	√		√		√
13		√	√	√	
14		√	√	√	

15	√		√		
16	√		√		√
17	√		√		√
18	√		√		√
19	√		√		√
20	√	√			
21	√	√		√	
22	√		√	√	
23	√			√	√
24		√		√	
25		√		√	
26	√			√	√
27	√	√			

7. SEMESTER-WISE COURSES AND CREDIT √DISTRIBUTION

SEMESTER-I (26-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Core Courses								
1	1	SBS PHY 01 101 CC 3104	Mathematical Methods in Physics – I	3	1	0	4	4
2	2	SBS PHY 01 102 CC 3104	Classical Mechanics	3	1	0	4	4
3	3	SBS PHY 01 103 CC 3104	Quantum Mechanics - I	3	1	0	4	4

4	4	SBS PHY 01 104 CC 3104	Semiconductor Devices	3	1	0	4	4
5	5	SBS PHY 01 105 CC 00126	Laboratory I	0	0	12	12	6

Generic Elective Courses (for students of other Departments)

6	1	SBS PHY 01 101 GEC 2124	Numerical Methods and Programming	2	1	2	7	4
7	2	SBS PHY 01 102 GEC 3104	Modern Optics	3	1	0	4	4
8	3	SBS PHY 01 103 GEC 3104	Physics of Digital Photography	3	1	0	4	4
9	4	SBS PHY 01 104 GEC 2002	Renewable Energy Resources	2	0	0	2	2

SEMESTER-II (26-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Core Courses								
1	6	SBS PHY 01 201 CC 3104	Statistical Mechanics	3	1	0	4	4
2	7	SBS PHY 01 202 CC 3104	Classical Electrodynamics	3	1	0	4	4
3	8	SBS PHY 01 203 CC 3104	Mathematical Methods in Physics- II	3	1	0	4	4
4	9	SBS PHY 01 202 CC 3104	Quantum Mechanics – II	3	1	0	4	4
4	10	SBS PHY 01 204 CC 3104	Laboratory II	0	0	12	12	6

Discipline Centric Elective Courses								
5	1	SBS PHY 01 204 DCEC 3104	Introduction to Astronomy and Astrophysics	3	1	0	4	4
6	2	SBS PHY 01 205 DCEC 3104	Solar Energy and Physics of Photovoltaic	3	1	0	4	4
7	3	SBS PHY 01 206 DCEC 3104	Accelerator Physics	3	1	0	4	4
8	4	SBS PHY 01 207 DCEC 3104	Radiation Physics	3	1	0	4	4
Discipline Centric Skill based courses								
9	5	SBS PHY 01 201 DCEC 3024	Computational Physics	3	0	2	5	4
10	6	SBS PHY 01 203 DCEC 3104	Analog Electronics	3	1	0	4	4

Generic Elective Courses (for students of other Departments)

13	5	SBS PHY 01 202 GEC 3104	Environmental Physics	3	1	0	4	4
12	6	SBS PHY 01 201 GEC 2002	Latex for Humans	1	0	2	3	2

SEMESTER-III (28-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Core Courses								
1	11	SBS PHY 01 301 CC 3104	Atomic, Molecular Physics and Lasers	3	1	0	4	4
2	12	SBS PHY 01 302 CC 3104	Nuclear and Particle Physics	3	1	0	4	4
3	13	SBS PHY 01 303 CC 3104	Solid State Physics	3	1	0	4	4
4	14	SBS PHY 01 304 CC 3104	Laboratory III	0	0	12	12	6

Discipline Centric Elective Courses								
5	7	SBS PHY 01 301 DCEC 3104	Physics of Electronic Materials and Devices	3	1	0	4	4
6	8	SBS PHY 01 302 DCEC 3104	Nuclear Reactor Physics	3	1	0	4	4
7	9	SBS PHY 01 303 DCEC 3104	Plasma Physics and Fusion Reactor	3	1	0	4	4
8	10	SBS PHY 01 304 DCEC 3104	Physics of Nanomaterials	3	1	0	4	4
9	11	SBS PHY 01 306 DCEC 3104	General Theory of Relativity	3	1	0	4	4
10	12	SBS PHY 01 309 DCEC 3104	Astrophysics of Stars	3	1	0	4	4
Discipline Centric Skill based courses								
11	13	SBS PHY 01 305 DCEC 3024	Characterization Techniques for Materials	3	0	2	5	4
12	14	SBS PHY 01 307 DCEC 3104	Digital Electronics and Microprocessor	3	1	0	4	4
13	15	SBS PHY 01 308 DCEC 3104	Programming with Python	3	1	0	4	4
14	16	SBS PHY 01 309 CC 0202	Seminar Presentation	0	2	0	2	2
15	17	SBS PHY 01 310 CC 2002	Research and Publication Ethics	2	0	0	2	2

SEMESTER-IV (16-Credits)

Sr. No.	Course No	Course Code	Course Title	L	T	P	Hrs/Week	Total Credits
Major Research Project								
1	1	SBS PHY 01 401 PROJ 000	Dissertation	0	0	0	16	16
Discipline Centric Elective Courses								
2	18	SBS PHY 01 401 DCEC 3104	Advanced Nuclear Physics	3	1	0	4	4
3	19	SBS PHY 01 402 DCEC 3104	Particle Physics	3	1	0	4	4
4	20	SBS PHY 01 404 DCEC 3104	Cosmology	3	1	0	4	4
5	21	SBS PHY 01 406 DCEC 3104	Ferroelectricity and Magnetism	3	1	0	4	4
6	22	SBS PHY 01 408 DCEC 3104	Advanced Carbon Materials	3	1	0	4	4
Discipline Centric Skill based courses								
7	23	SBS PHY 01 403 DCEC 3104	Experimental Techniques in	3	1	0	4	4

			Nuclear and Particle Physics					
8	**24**	**SBS PHY 01 405 DCEC 3104**	**Astronomy Laboratory**	**3**	**1**	**0**	**4**	**4**
9	**25**	**SBS PHY 01 407 DCEC 3104**	**Vacuum Science and Thin Film Technology**	**3**	**1**	**0**	**4**	**4**
10	**26**	**SBS PHY 01 409 DCEC 3104**	**Minor Project**	**3**	**1**	**0**	**4**	**4**
11	**27**	**SBS PHY 01 410 DCEC 3104**	**Introduction to Hydrogen Energy Systems**	**3**	**1**	**0**	**4**	**4**

Note:

- This GEC* courses offered by the Department can only be taken by the students of other Departments. The students of the Physics Department will take GEC from other Departments.

- The Department may offer more than one discipline centric elective courses (DCECs) depending on specialization and strength of faculty members, and the number of students have to opt one of them for semester II. If class strength is less than 10, then that particular subject will not be offered.

- In semester III, students are required to opt two DCEC (courses) out of more than two courses offered by the Department, depending on the specialization and strength of the faculty.

- In semester IV, the students have to opt four DCEC (courses) out of options offered by the Department or Students may opt for full semester major research project.

8. COURSE-LEVEL LEARNING OUTCOMES

Course Structure

Mathematical Methods in Physics I

Scheme Version: 2021-22	**Name of the subject: Mathematical Methods in Physics I**	**L**	**T**	**P**	**C**	**Semester:** I (1st Year)	**Contact Hours per Week:** 4
		3	1	0	4		**Total Hours:**

							60
Subject Code: SBS PHY 01 101 CC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** B.Sc.		
Course Description	This course has been developed to introduce students to some topics of mathematical Physics which are directly relevant in different papers of Physics course. It includes elements of matrices and group theory, introduction to tensor algebra, function of a complex variable and calculus along with an introduction to computational techniques and statistical measures used in physics Course.						
Course Objectives	• Learning about matrices and groups • Understanding basics of Tensors. • Getting to know the significance of Complex algebra • Understanding Numerical methods in Physics						
Course Outcomes	**After successful completion of the course the student will be able to do the following :** **CO101C.1 :** To use matrices for solving linear algebraic equations and to use group theory for understanding of crystallography. **CO101C.2 :** To use tensor transformation and related algebra in physics. **CO101C.3 :** To solve real definite integrals in theoretical Physics. **CO101C.4 :** To find roots of a given polynomial and understand the properties of a statistical distribution of point particles						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Matrices and Group Theory : [Course Outcome(s): CO101C.1]** Linear vector spaces, matrix spaces, linear operators, eigenvectors and eigenvalues, matrix diagonalization, special matrices. Symmetries and groups, multiplication table and representations, permutation group, translation and rotation groups, O(N) and U(N) groups.	15
2	**Tensors Analysis : [Course Outcome(s): CO101C.2]** Coordinate transformations, scalars, contravariant and covariant vectors, mixed and covariant tensor of second	15

	rank, addition, subtraction and contraction of tensors, quotient rule. Christoffel symbols, transformation of Christoffel symbols, Covariant differentiation, Ricci's theorem, divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form.	
3	**Complex Variables :[Course Outcome(s): CO101C.3]** Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy-Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville’s theorem. Power series Taylor’s theorem, Laurent’s theorem. Calculus of residues–poles, essential singularities and branch points, residue theorem, Jordan’s lemma, singularities on contours of integration, evaluation of definite integrals.	15
4	**Computational Techniques and Probability Theory : [Course Outcome(s): CO101C.4]** Root of functions, interpolation, extrapolation, Integration by trapezoid and Simpson’s rule,solution of first order differential equation : using Runge-Kutta method and Finite difference methods. , Preliminary Concepts : mean values, standard deviation, various moments; Random walk problem, Binomial distribution, Poisson distribution, Gaussian distributions, Lorentz distribution, Central Limit Theorem.	15

TEXT BOOKS

1. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications, Mineola, New York, Vol 1&2, 1970.
2. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, S.CHAND (Prentice Hall of India), New Delhi, 2^{nd} Edition, 1987.
3. **George Arfken and Hans J Weber**, Mathematical Methods for Physicists, Elsevier Academic Press. Cambridge, Massachusetts, 7^{th} Edition 2012
4. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, Dover Publication Inc., Mineola, New York 3rd Edition 2014.
5. **E. Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons. Hoboken, New Jersey (United States), 10^{th} Edition, 2015.
6. **K. F. Riley, M.P. Hobson, and S. J. Bence,** Mathematical methods for Physicists and Engineers, S. CHAND (Cambridge University Press), New Delhi, 3^{rd} edition, 2018.
7. **V. BALAKRISHNAN,** Mathematical Physics with Applications, Problems and

Solutions, Ane Books, New Delhi, 1st Edition, 2018

Classical Mechanics

Scheme Version:	**Name of the subject:** Classical Mechanics	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
							Total

<table>
<tr><td>2021-22</td><td></td><td>3</td><td>1</td><td>0</td><td>4</td><td>I
(1st Year)</td><td>Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 102 CC 3104</td><td rowspan="2">Applicable to Programs:M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims at providing knowledge of Classical Mechanics to the students so that they are able to understand the Lagrangian & Hamiltonian mechanics of systems of particles interacting with various forces and also their applications in various branches of Physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of classical mechanics
• To get familiar with various classical mechanical problems related to Lagrangian & Hamiltonian formulations
• To aware the students about applications of classical mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
CO102C.1. Understand the mechanics of system of particles, D’Alembert’s principle, Lagrangian mechanics, & Euler’s equation of motion.
CO102C.2. Learn about Hamiltonian formulation, Hamilton’s Equations of Motion and Principle of least action.
CO102C.3. Learn Canonical Transformations & Hamilton-Jacobi theory.
CO102C.4. Learn about Rigid body dynamics including problems.
CO102C.5. Understand the two body central force problem and its related aspects.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Lagrangian Formulation and Central Force Problem: [Course Outcome(s): CO102C.1]** Newtonian mechanics of one and many particle systems, Virtual work, Constraints: holonomic and non-holonomic, D'Alembert's Principle and Euler-Lagrange Equations of motion, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton's Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Conservation theorems and Symmetry Properties, Noether's theorem.	15
2	**Hamilton's Equations of Motion: [Course Outcome(s): CO102C.2]** Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical equation from Hamilton's variational principle. The principle of least action.	15
3	**Canonical Transformation and Hamilton-Jacobi Theory: [Course Outcome(s): CO102C.3]** Canonical transformation, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation and its application. Action angle variable: adiabatic invariance of action variable,the Kepler problem in action angle variables.	15
4	**Small Oscillations and Rigid Body Motion: [Course Outcome(s): CO102C.4 & CO102C.5]** Stable and unstable equilibria; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibrations of linear triatomic oscillator. Orthogonal transformation, Eigenvalues of the inertia tensor, Euler equations, Eulerian angles, moment of Inertia.	15

	Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent one-dimension problem and classification of orbits. Coriolis force.	
TEXT BOOKS		

1. **A.Sommerfeld,** Mechanics, Academic Press,United States, 1st Edition, 1952.
2. **I. Percival and D. Richards**, Introduction to Dynamics, Cambridge University Press, 1st Edition1982.
3. **Ronald L. Greene,** Classical Mechanics with Maple, Springer,Germany, 2nd Edition, 2000.
4. **Herbert Goldstein, Charles Poole, John Safko,** Classical Mechanics, Pearson Education,UK, 3rd Edition, 2011.
5. **L.D. Landau and E.M. Lifshitz,** Mechanics, Butterworth-Heinemann, UK, 2nd Edition, 2012.
6. **N.C. Rana and P.S. Joag,** Classical Mechanics, Tata McGraw Hill, New Delhi, 1st Edition, 2015.

QUANTUM MECHANICS - I

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Quantum Mechanics – I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I
(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 103 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Graduation Level Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed for fundamental knowledge of quantum mechanics, which has comprehensive and rich applicability in condensed matter physics, atomic and molecular physics, nuclear physics, space science, and chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To understand the fundamentals of quantum mechanics
• To make familiar with various quantum mechanical problems related to vector space, eigenvalue, Schrödinger equation, free particle, harmonic oscillator, potential barrier and well, angular momenta etc.
• To aware the students about applications of quantum mechanics in various science branches</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completetion of this course, students will be able to
CO103C.1. explain the theories and phenomena of vector space, operators, Dirac's notations, matrices, and commutators which are very helpful in solving the various quantum mechanics problems</td></tr>
</table>

	CO103C.2. understand the uncertainty relation between two arbitrary operators **CO103C.3.** distinguish the actual meaning of time independent and time dependent Schrodinger's equations **CO103C.4.** illustrate Ehrenfest theorem, Poisson Brackets, wave packets and wave functions in position and momentum space **CO103C.5.** analyze the energy eigenvalues and wave functions of harmonic oscillator, infinite and finite square wells, free particle, and hydrogen atom **CO103C.6.** determine the transmission and reflection coefficients of potential barrier and well, potential step, and delta function well **CO103C.7.** recognize the importance of angular momentum and its applications in quantum mechanics **CO103C.8.** explain the physics behind the addition of angular momenta

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Mathematical Tools of Quantum Mechanics [Course Outcome(s): CO103C.1 & CO103C.2]** Vector Spaces, Linear Independence, Bases, Dimensionality, Linear Transformations, Similarity Transformations, Eigen Values and Eigen Vectors, Inner Product, Orthogonality and Completeness, Hilbert Space, Hermitian and Unitary Operators, Orthonormality, Completeness and Closure, Dirac's Bra and Ket Notation, Matrix Representation and Change of Basis, Operators and Observables, Commutation Relations, Uncertainty principle for two arbitrary Operators.	15
2	**Quantum Dynamics [Course Outcome(s): CO103C.3, CO103C.4 & CO103C.5]** Time Evolution Operator, Stationary States, Schrodinger	15

	Equation, The Schrodinger versus the Heisenberg Picture, The Infinite Square Well and the Simple Harmonic Oscillator: Energy Eigenvalues and Energy Eigenstates, Connecting Quantum to Classical Mechanics: The Ehrenfest Theorem; Poisson Brackets and Commutators, Wave Packets, Wave Functions in Position and Momentum Space.	
3	**Quantum Mechanics in One and Three Dimensions [Course Outcome(s): CO103C.5 & CO103C.6]** Properties of One Dimensional Motion: Bound States and Scattering States, The Free Particle, The Potential Step, The Potential Barrier and Well, The Finite Square Well, The Delta-Function Well, Three Dimension Problems: Hydrogen Atom.	15
4	**Angular Momenta and Approximate Analysis [Course Outcome(s): CO103C.7 & CO103C.8]** Orbital angular momentum, General Formalism of Angular Momentum, Eigenfunctions and Eigenvalues of Orbital Angular Momentum, Addition of Angular Momenta, Spin Angular Momentum: Stern-Gerlach Experiment; Pauli Matrices and Spinors, Clebsch-Gordan Coefficients.	15

TEXT BOOKS

1. **L. D. Landau and E.M. Lifshitz**, Quantum Mechanics, Butterworth Heinemann, The Netherlands, 3rd Edition, 1981.
2. **P. A. M. Dirac**, The Principles of Quantum Mechanics, Oxford University Press, UK, 4th Edition, 1988.
3. **R. Shankar**, Principles of Quantum Mechanics, Springer, Germany, 2nd Edition, 1994.
4. **N. Zettili**, Quantum Mechanics: Concepts and Applications, Wiley, USA, 2nd Edition, 2009.
5. **J. J. Sakurai**, Modern Quantum Mechanics, Pearson, India, 2nd Edition, 2013.
6. **L. I. Schiff**, Quantum Mechanics, McGraw Hill Education, USA, 4th Edition, 2017.
7. **D. J. Griffiths**, Introduction to Quantum Mechanics, Cambridge University Press, UK, 3rd Edition, 2018.
8. **C. Cohen-Tannoudji, B. Diu, and F. Laloe**, Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Wiley, USA, 2nd Edition, 2019.

Semiconductor Devices

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Semiconductor Devices</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I

(1^{st} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 104 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the course on Semiconductor Devices is to introduce semiconductor physics, physical principle of devices and their basic applications.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• An understanding of basic semiconductor device physics
• An understanding of the application of Field-Effect Transistors.
• An understanding of the application of Bipolar Junction Transistors.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO104C.1. To understand the basic properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier injection/excitation.

CO104C.2. To understand how to find the Fermi energy level and carrier density in n-type and p-type semiconductors.

CO104C.3. To understand basic properties of PN junctions and Metal-Semiconductor junction.

CO104C.4. To understand the working, design and applications of various semiconducting devices like rectifiers, clippers, LED, Solar cells.</td></tr>
</table>

	CO104C.5. To understand the working, design, and applications of BJTs and FETs. **CO104C.6.** To understand the working, design and applications of Operational amplifier

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Semiconductors [Course Outcome(s): CO104C.1 & CO104C.2]** Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors: Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration in equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility: Effect of temperature, Doping and high electric field, Hall Effect.	**15**
2	**Junctions [Course Outcome(s): CO104C.3 & CO104C.4]** p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Diode Applications: Load-Line Analysis, Series Diode Configurations, Parallel and Series-Parallel Configurations (AND/OR Gates), Half-Wave Rectification, Full-Wave Rectification, Clippers, Clampers. Network with a DC and AC Source, LED, Solar cell and photodetectors, Metal-Semiconductor contact: Rectifying contact and Ohmic contact.	**15**
3	**Bipolar Junction Transistors (BJT) [Course Outcome(s): CO104C.5]** Fundamentals of BJT, BJT Operation: Common-Base Configuration, Common-Emitter Configuration, Common-Collector Configuration, Limits of Operation, Minority carrier distribution, BJT DC Biasing: Operating Point, Fixed-Bias Configuration, Emitter-Bias Configuration, Voltage-Divider Bias Configuration, Collector Feedback Configuration, Emitter-Follower Configuration, **Field Effect Transistors:** JEFT: Construction and Characteristics of JFETS, Transfer Characteristics, MOSFET: Depletion-Type MOSFET, Enhancement-Type MOSFET, Transfer Characteristics.	**15**

4	**Operational Amplifiers [Course Outcome(s): CO104C.6]** Differential amplifier (DA)- Basic circuit of differential amplifier Operation of differential amplifier: Common-mode rejection ratio (CMRR), DC analysis of differential, Applications of OP-amp: Inverting amplifier-Input and impedance of inverting amplifier, Noninverting amplifier-Voltage follower, Effect of negative feedback on OP-amp in feedback circuits, Summing amplifiers-Applications of summing amp, OP-amp as integrators and differentiators.	

TEXT BOOKS

1. **J.J. Cathey**, Schaum's Outline of Electronic Devices and Circuits, McGraw Hill, New York, 2nd Edition 2002.
2. **B. Streetman and S. Banerjee**, Solid State Electronics, Prentice Hall India, New Delhi, 6th Edition, 2006.
3. **Millman and Halkias**, Integrated Electronics, McGraw Hill, New York, 2nd Edition 2009.
4. **A.P. Malvino**, Electronic Principles, McGraw, New Delhi, New York 7th, Edition, 2009.
5. **J.H. Moore, C.C. Davis and M.A. Coplan**, Building Scientific Apparatus, Addison Wesley, United States, 4th Edition 2009.
6. **R.L. Boylestad and L. Nashelsky**, Electronics Devices and Circuit Theory, Prentice Hall of India, New Delhi, 11th Edition, 2013.
7. **P. Horowitz and W. Hill**, The Art of Electronics, Cambridge University Press, 3rd Edition, 2015.

LABORATORY I

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Laboratory I</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I (1st Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 105
CC 00126</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the lab 1 is to train students to perform various experiments associated with Electronics, Quantum physics, Waves mechanics and Spectroscopy. Students assigned the general laboratory work will perform at least ten (10) experiments of the above mentioned list of Physics experiments and further 8 experiments from the C programming section.. Experiments of equal standard may be added. Workshop soldering and designing of experiments should be included</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To give hands on experience to students for generating magnetic field and measurement of various parameters.
• To teach how temperature controlled oven works
• To take measurements of current and voltage using various equipment</td></tr>
<tr><td>Course</td><td colspan="7">After completition of this course, the students will be able to</td></tr>
</table>

Outcomes	**CO105C.1.** learn various Physics aspects by performing the experiments related to electronic devices, atomic and molecular physics, light wave, sound waves etc. **CO105C.2.** Learn Error analysis **CO105C.3.** Use excel for plotting graphs **CO105C.4.** to do C programming	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	1. Hall Effect 2. Four Probe Method to find band gap of semiconductor 3. Electron Spin Resonance 4. Frank-Hertz experiment 5. PN Junction characteristics 6. Solar cell characteristics 7. Velocity of ultrasonic wave in liquids 8. Characteristics of MOSFET 9. Diode as voltage regulator 10. Ionization potential of mercury 11. Planck's constant using LED 12. Law of Malus 13. Zener diode characteristics	150
2	Introduction to C Programming: 1. Write a Program to calculate and display the volume of a CUBE having its height, width and depth. 2. Write a C program to perform addition, subtraction, division and multiplication of two numbers 3. Write a program to input two numbers and display the maximum number. 4. Write a program to find the largest and smallest among three entered numbers and also display whether the identified largest/smallest number is even or odd. 5. Write a program to find the roots of quadratic equation. 6. Write a program to check whether the entered year is leap year or not (a year is leap if it is divisible by 4 and divisible by	30

	100 or 400.) 7. Write a program to find the factorial of a number. 8. Write a program to check number is Armstrong or not. 9. Write a program to find GCD (greatest common divisor or HCF) and LCM (least common multiple) of two numbers 10. Write a program to generate Fibonacci series.	

TEXT BOOKS

1. **Worsnop and Flint,** Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951.
2. **A. C. Melissinos, J. Napolitano,** Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2^{nd} Edition, 2003.
3. Lab manuals, prepared by faculty of the Department of Physics, 2018.

Numerical Methods and Programming

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Numerical Methods and Programming</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>1</td><td>1</td><td>2</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 101 GEC 2124</td><td rowspan="2">Applicable to Programs: M.Sc.</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: B.Sc. With Mathematics.</td></tr>
<tr><td>Course Description</td><td colspan="7">This course teaches the students to solve basic problems of mathematics and sciences with the help of an approximation and a computer.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To make the student
• 1) Understand basics of a Programming Language
• 2) Aware of various Numerical methods.
• 3) Able to create hypothetical data sets for Physical Systems.
4) familiar with random sampling of large data sets.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Students will be able to learn :
CO101G.1 : to write a computer program in C.

CO101G.2 : the solutions of linear and non-linear equations along with solutions of simultaneous linear equations.

CO101G.3 : Numerical differentiation and integration.

CO101G.4 : Monte Carlo methods and its application to problems of physical world.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">C/C++: [Course Outcome(s): CO101G.1]
Flow charts, Algorithms, Input and output statements, Control statements, Arrays, Repetitive and logical structures, Subroutines and functions.</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Numerical Methods of Analysis: [Course Outcome(s): CO101G.2, CO101G.3]</td><td>35</td></tr>
</table>

	Roots of a function, Solution of simulteneous linear equation, Interpolation and curve fitting, Numerical differentiation and integration, Solution of ordinary differential equations	
3	Simulations I: **[Course Outcome(s): CO101G.3, CO101G.4]** Generation of random numbers, Statistical tests of randomness,, Monte-Carlo evaluation of integrals and Error Analysis.	35
4	Simulations II : **[Course Outcome(s): CO101G.4]** Inhomogeneous distribution and Importance of data sampling, Metropolis algorithm, Brownian motion as random walk problem and its Monte-Carlo simulation.	20

TEXT BOOKS

1. **S. S. M. Wong,** Computational Methods in Physics and Engineering, World Scientific, Singapore, 2nd Edition, 1997.
2. **C. F. Gerald,** Applied Numerical Analysis, Pearson/Addison Wesley, UK, 7th Edition, 2003.
3. **Teukolsky, Vetterling and Flannery,** Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, 3rd Edition 2007.
4. **Landau and Binder,** A Guide to Monte Carlo Simulations in Statistical Physics, Cambridge University Press, 3rd Edition, 2013.
5. **V. Rajaraman,** Computer Oriented Numerical Methods, Prentice Hall of India, New Delhi, 4th Edition, 2015.
6. **V. Rajaraman,** Computer Programming in FORTRAN 90/95, Prentice Hall of India, New Delhi, 1st Edition, 2015.

Modern Optics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Modern Optics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I

(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 102 GEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: B.Sc. with Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">The course has focus on the Geometrical and wave optics, thin films, Holography, optical fiber, liquid crystals, LED and Photonic band gap crystals.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To understand the fundamentals of optics.
To impart knowledge about different physical phenomena.
To update the students with the latest technologies.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completetion of this course, students would be able to:

CO102G.1. Understand the various physical phenomena & their real life applications.

CO102G.2. Learn about the wave optics and holography.

CO102G.3. Get knowledge about the basics of Lasers.

CO102G.4. Learn about the fiber optics & LED.</td></tr>
<tr><td colspan="8"></td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**An overview of Geometrical and Wave Optics: [Course Outcome(s): CO102G.1]** Laws of Reflection, Refraction, Total Internal Reflection; Ideas of Interference, Diffraction, Polarization, Dispersion.	15
2	**Fresnel Relations: [Course Outcome(s): CO102G.2]** Conductors, Thin Films: Reflection Model, Matrix Formalism, Coating Design, Fourier Optics: Wave Propagation, Fraunhofer Diffraction, Fresnel Diffraction, Spatial Filtering, Holography and Holograms.	15
3	**Coherence, Interference and Visibility, Laser Physics: [Course Outcome(s): CO102G.3]** Overview, Gain Saturation, Light-Atom Interactions, Optical Gain and Pumping Schemes, Output Characteristics, Light Shifts and Optical Forces, Atom-Photon interactions.	15
4	**Fiber Optics: [Course Outcome(s): CO102G.4]** Mode Analysis, Single mode and multimode optical fiber, Loss and Dispersion, Photonics Band-gap Crystals, Liquid crystals, Introduction of LED.	15

TEXT BOOKS

1. 1. **A. E. Siegman,** Lasers, University Science Book, USA,Revised Edition, 1986.
2. **G. R. Fowles,** Introduction to Modern Optics, Dover Publication, USA, 2nd Edition, 1989.
3. **J. T. Verdeyen,** Laser Electronics, Prentice-Hall, India,New Delhi, 3rd Edition, 1995.
4. **E. Hecht,** Optics, Addison Wesley, USA, 4th Edition, 2001.
5. **Pedrotti,**Introduction to Optics, Pearson UK, 3rd Edition, 2006.
6. **B. E. A. Saleh and M. C. Teich,** Fundamentals of Photonics, Wiley,United States, 2nd Edition, 2012.
7. **A. Ghatak,** Optics, Tata McGraw-Hill, New Delhi, 6th Edition, 2017.

Physics of Digital Photography

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Physics of Digital Photography</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
I (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 103 GEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: B.Sc. with Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim of this course is to provide a theoretical overview of the photographic imaging chain. The course is intended to serve as a link between imaging science and photographic practice.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To become proficient at the technical aspect of photographing with a digital camera.
• To develop and practice skills using digital photography tools and the Internet including emailing and posting to a web site
• To develop the habit of looking closely at the visible world around you in order to represent it in terms of aesthetics, beauty and truth. – To look at what you are seeing and to see what you are looking at.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
CO103G.1. To understand the photographic optics & methods</td></tr>
</table>

	CO103G.2. To understand the basic principle of photography **CO103G.3.** To understand the theory of exposure **CO103G.4.** To understand about the image quality

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Fundamental optical formulae [Course Outcome(s): CO103G.1]** Image formation: Refraction, Gaussian optics, Lens refractive power, Magnification, Focal length, Lens focusing movement Field of view: Entrance and exit pupils, Chief and marginal rays, Angular field of view, Field of view area, Focal-length multiplier, Depth of field: Circle of confusion, Depth of field equations, Hyperfocal distance, Focus and recompose limits, distortion, Exposure: Photometry, Flux emitted into a cone, Relative aperture, f-number, Working f-number, f-stop, Natural vignetting, Photometric exposure, Exposure value, f-number for aplanatic lenses	**15**
2	**History of photography [Course Outcome(s): CO103G.2]** Pinhole Camera, Camera Obscura, Normal Human Eye and Process of Seeing-Human eye and camera, Camera principles: Compact cameras and SLR's - Working of SLR camera- Different image sensors-CCD and CMOS. Angle of view- Different types of lenses- normal lens, wide angle lens, fish eye lens, prime lens, telephoto lens. Depth of Field-Shallow depth of field, large depth of field, Depth of focus - circles of confusion	**15**
3	**Exposure strategy [Course Outcome(s): CO103G.3]** Digital output, Sensor response, Colour, Digital output levels, Dynamic range, Tonal range, Tone reproduction, Gamma, Tone curves, Histograms, verage photometry, Reflected-light metering, Average scene luminance, Exposure index, ISO speed, Standard output sensitivity, Exposure modes: Metering modes, Exposure compensation, Aperture priority (A or Av), Shutter priority (S or Tv), Program mode (P), Manual mode (M)	**15**

4	**Image quality [Course Outcome(s): CO103G.4]** Colour temperature, White balance, Color space, Lens MTF, sharpness, Signal-to-noise ratio, Different Image capturing formats: RAW, TIFF, JPEG, Storage Devices- SD card CF card, Principles of Composition: Perspective - Space (Negative and Positive), Directional lines-Golden Section and Rule of the Third, Colour Theory	**15**

TEXT BOOKS

1. **Steven Heller**, A History of Photography: From 1839 to the Present
2. **Tom Ang,** Photography: The Definitive Visual History
3. **Todd Gustavson** and **George Eastman House**, Camera: A History of Photography from Daguerreotype to Digital by Understanding Exposure, Fourth Edition by BRYAN PETERSON.
4. **DK**, Digital Photography Complete Course Hardcover
5. **Fil Hunter, Steven Biver and Paul Fuqua**, Light Science & Magic: An Introduction to Photographic Lighting by Understanding Color in Photography by Bryan Peterson.
6. **Andy Rowland**, Physics of Digital Photography by (IOP Publishing).

INTRODUCTION TO RENEWABLE ENERGY RESOURCES

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:
Introduction to Renewable Energy Resources</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

I (1^{st} Year)</td><td>Contact hours per week: 2</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 30</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 104 GEC 2002</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Pre-requisite of course: 10+2 with Non-Medical</td></tr>
<tr><td>Course Description</td><td colspan="7">To introduce the pattern of fuel consumption, energy demand, various renewable sources of energy and modern applications.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• The course treats the basics of various renewable energy resources and energy generation using different methods; it is suitable for students from interdisciplinary background.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:

CO104G.1 The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues.
CO104G.2 The Course will be introducing the students to all the aspects of PV technology. This will enable them to understand the requirements for PV materials and PV systems for different applications.
CO104G.3 It creates awareness among students about wind and geothermal energy technologies and provide adequate inputs on a variety of issues.
CO104G.4 To teach fundamentals of hydrogen energy as energy systems, production processes, storage, utilization, and safety that is necessary for taking some important elective subjects.
CO104G.5 It increases the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.
CO104G.6 To give an idea about different biomass and nuclear as energy source and their processing and utilization for recovery of energy and other valuable products. A comprehensive knowledge of how wastes are utilized for recovery of value would be immensely useful for the students from all fields.</td></tr>
<tr><td></td><td colspan="7">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1.</td><td colspan="5">Energy Scenario and Solar Energy: [Course Outcome (s): CO104G.1 & CO104G.2]
Global and Indian Energy Scenario and Energy Policy, Commercial and Noncommercial Forms of Energy, Fossil Fuels, Renewable Sources, Impact of Energy Systems on Environment, Need for use of New and Renewable Energy Sources, Solar Thermal and Solar Photovoltaic Energy.</td><td colspan="2">15</td></tr>
</table>

2.	**Wind and Geothermal Energy: [Course Outcome (s): CO104G.3]** Wind Energy Basics- Global circulation, Forces influencing Wind - Pressure gradient force and Coriolis force, Local and Regional Wind systems, Geothermal Tidal and Wave Energy, Geothermal regions, geothermal sources, Geothermal energy conversion technologies.	15
3.	**Hydrogen Energy and Fuel cells: [Course Outcome (s): CO104G.4 & CO104G.5]** Hydrogen Energy-production and storage, Production Processes: Thermo chemical Water Splitting, Gasification, Pyrolysis methods. Electrochemical, Electrolysis, Photo electro chemical. General storage methods, compressed storage, Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Fuel cells- Thermodynamics and performance of Fuel Cells, Its working, construction, classifications and applications.	15
4.	**Biomass and Nuclear Energy**: **[Course Outcome (s): CO104G.6]** Biomass Energy and application, Techniques for biomass assessment, Thermochemical conversion of biomass, Mini/micro hydro power: classification of hydropower schemes, Nuclear Energy: Fission, Fusion, Different type of nuclear reactors, Nuclear waste disposal and environment measures.	15

REFERENCE BOOKS

1. Solar Energy: S. P. Sukhatme, (Tata McGraw Hill).
2. Garg .H.P,Prakash .J, "Solar energy fundamentals and applications", Tata McGraw Hill publishing Co. Ltd, 2006.
3. Xianguo Li, Principles of Fuel Cells, Taylor and Francis, 2005.
4. Fundamentals of Renewable Energy Processes, Aldo Vieira da Rosa, Elsevier Academic Press.
5. J Twidell and T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006.
6. KC Khandelwal, SS Mahdi, Biogas Technology - A Practical Handbook, Tata McGraw Hill, 1986.
7. EH Lysen, Introduction to Wind Energy, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983.
8. JG Collier and GF Hewitt, Introduction to Nuclear Power, Hemisphere Publishing, New York, 1987.

STATISTICAL MECHANICS

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Statistical Mechanics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 201 CC 3104</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Graduation Level Quantum Mechanics and Mathematical Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is developed for understanding of thermodynamics and statistical mechanics, which have broad and rich applicability in quantum mechanics, condensed matter physics, classical mechanics and electrodynamics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To understand the fundamentals of thermodynamics and statistical mechanics
To make familiar with various thermodynamical and statistical mechanics terms such as entropy, free energy, phase space, statistical ensembles, Bose-Einstein statistics, Fermi-Dirac statistics etc.
To able the students for solve the problems related to thermodynamics and statistical physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to
CO201C.1. explain the various thermodynamical quantities and Maxwell’s relations
CO201C.2 apply the thermodynamics in ideal gas, magnetic and dielectric materials</td></tr>
</table>

	CO201C.3. describe various statistical approaches which describe systems of particles **CO201C.4.** evaluate the formulae of random walk and diffusion equation **CO201C.5.** compare microstates, macrostates, and statistical ensembles **CO201C.6.**understand the theories and mathematical approaches of statistical ensembles, equipartition theorem and Maxwell-Boltzmann statistics **CO201C.7.** illustatre the fundamental concepts of Bose-Einstein and Fermi-Dirac Statistics **CO201C.8.** calculate the problems related to Bosons and Fermions	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Review of Thermodynamics [Course Outcome(s): CO201C.1 & CO201C.2]** Extensive and intensive variables, laws of thermodynamics, Entropy for Different Systems, Gibbs Paradox, Boltzmann Relation for Entropy, Legendre Transformations and Thermodynamic Potentials, Chemical Potential, Free Energy and Its Connection with Thermodynamic Quantities, Maxwell Relations, Applications of Thermodynamics to (a) Ideal Gas, (b) Magnetic Material, and (c) Dielectric Material.	15
2	**Statistical Methods and Description of Systems of Particles [Course Outcome(s): CO201C.3, CO201C.4, & CO201C.5]** Binomial distribution, Poisson distribution, Gaussian distributions, Central Limit Theorem, Random Walk and Brownian Motion, Diffusion Equation, Phase Space, Liouville's Theorem, Phase Equilibrium, Microstates and Macrostates, Statistical Ensembles, Irreversibility and the Attainment of Equilibrium	15
3	**Classical Statistical Mechanics [Course Outcome(s): CO201C.6]** Micro-Canonical Ensemble, Canonical Ensemble: Derivation of Partition Function and Thermodynamic Quantities; Mean Values and Fluctuations, Grand Canonical Ensemble: Gibbs Factor; Gibbs Distribution; Derivation of Partition Function and Thermodynamic	15

	Quantities; Fluctuations in the Number of Particles, Applications of Canonical and Grand Canonical Ensembles, Equipartition Theorem and It's Applications, Maxwell-Boltzmann Statistics.	
4	**Quantum Statistical Mechanics [Course Outcome(s): CO201C.7 & CO201C.8]** Bosons: Occupation Number; Bose-Einstein Statistics; Debye Theory of Specific Heat; Grand partition function For Ideal Bose Gas; Black-Body Radiation; Bose-Einstein Condensation, Fermions: Occupation Number; Fermi-Dirac Statistics; Ideal Fermi gas, Pauli Paramagnetism, First and Second Order Phase Transitions, Ising Model, Phase Equilibria: Equilibrium Conditions; Simple Phase Diagrams; Clausius-Clapeyron Equation.	15

TEXT BOOKS

1. **F. Reif**, Fundamental of Statistical and Thermal Physics, McGraw-Hill, USA, 1965.
2. **L. D. Landau and E. M. Lifshitz**, Statistical Physics, UK, 3rd Edition, 1980.
3. **D. V. Schroeder**, An Introduction to Thermal Physics, Addison Wesley Longman, UK, 2000.
4. **J. P. Sethna**, Statistical Mechanics: Entropy, Order Parameters and Complexity, Oxford University Press, UK, 2006.
5. **M. Kardar**, Statistical Physics of Particles, Cambridge University Press, UK, 2007.
6. **H. Gould and J. Tobochnik**, Statistical and Thermal Physics: With Computer Applications, Princeton University Press, USA, 2010.
7. **K. Huang**, Statistical Mechanics, Wiley, India, 2nd Edition, 2011.
8. **R. K. Pathria and P. D. Beale**, Statistical Mechanics, Academic Press, USA, 2011.

Classical Electrodynamics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Classical Electrodynamics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II

(1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 202 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed for fundamental knowledge of basic electrodynamics and it’s applications to various phenomena.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To evaluate fields and forces in Electrodynamics and Magneto dynamics using basic scientific method.

• To provide concepts of relativistic electrodynamics and its applications in branches of Physical Sciences.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO202C.1. To understand the basics of electrostatics

CO202C.2. To use of Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.

CO202C.3. To describe the nature of electromagnetic wave and its propagation through different media and interfaces.</td></tr>
</table>

	CO202C.4. The students will be able to analyze s radiation systems in which the electric dipole, magnetic dipole or electric quadruple dominate. **CO202C.5.** The students will have an understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration. **CO202C.6.** To explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Electrostatics [Course Outcome(s): CO202.1]** Coulomb's law, Guass's law, Poisson's equation, Laplace equation. Simple boundary value problems illustrating various techniques such as method of images, separation of variables, Green's functions, Multipole expansion. Electrostatics of dielectric media, multipole expansion. Boundary value problems in dielectrics; molecular polarisability, electrostatic energy in dielectric media.	**15**
2	**Magnetostatics & Maxwell's Equations [Course Outcome(s): CO202.2]** Review of Magnetostatics: Biot-Savart law, Ampere's theorem, Electromagnetic induction, examples of magnetostatic problems, , Scalar and vector potentials, Gauge symmetry, Coulomb and Lorentz gauges Gauge invariance, Displacement current, Time varying fields, Maxwell's equations in free space and linear isotropic media (non conducting) boundary conditions on the fields at interfaces. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field,	**15**
3	**Electromagnetic Waves [Course Outcome(s): CO202.3]** Electromagnetic waves in free space, dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation	**15**

	modes in wave guides.	
4	**Radiation and Relativistic Electrodynamics [Course Outcome(s): CO202.4CO202.5 CO202.6]** Lorentz Transformation, Lorentz invariance of Maxwell's equation. Dynamics of charged particles in static and uniform electromagnetic fields. Radiation- from moving charges and dipoles and retarded potentials Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, Lienard-Wiechert potentials, Total power radiated by an accelerated charge, Lorentz formula. Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.	**15**

TEXT BOOKS

1. **L.D. Landau** and E.M. Lifshitz, Classical Theory of Electrodynamics, Butterworth-Heinemann. Germany, 4th Edition, 1987.
2. **Melvin Schwartz**, Principles of Electrodynamics, Dover Publications, UK, 1st Edition, 1987.
3. **Walter Greiner**, Classical Electrodynamics, Springer, Germany, 1st Edition, 1998.
4. **J. Schwinger**, L.L. Deraad Jr, K.A. Milton, W-Y. Tsai and J. Norton, Classical Electrodynamics, Westview Press, UK, 1998.
5. **David J. Griffiths**, Introduction to Electrodynamics, Benjamin Cummings, USA, 3rd Edition, 1999.
6. **J.D. Jackson**, Classical Electrodynamics, John Wiley & Sons, United States, 2nd Edition, 2003.
7. **Charles A. Brau**, Modern Problems in Classical Electrodynamics, Oxford University Press, 1st Edition, 2003.
8. **L. D. Landau** and E. M. Lifshitz & L. P. Pitaevskii, Electrodynamics of Continuous Media Oxford, 1st Edition, 2005.
9. **Wolfgang K. H. Panofsky** and Melba Phillips, Classical Electricity and Magnetism, Dover Publications, UK, 2nd Edition, 2012.
10. **Joseph Edminister**, Schaum's outline of electromagnetics, New Delhi, 2nd Edition, 2017.

Mathematical Methods in Physics II

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Mathematical Methods in Physics II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 203 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Mathematical Methods in Physics I</td></tr>
<tr><td>Course Description</td><td colspan="7">This course has been developed to introduce students to some topics of mathematical Physics which are directly relevant in different subjects of M.Sc. Physics. It includes Ordinary differential equation, special functions and different transformation methods to solve differential equation.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To Make the students familiar with
• Partial and Ordinary differential equations in Physics.
• Power series method of their solution and different polynomials
• Fourier Transfor and Laplace Transform as a tool to solve differential equation.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to:
CO203C.1 : to solve second order differential equation.
CO203C.2 : to use the special function in Quantum mechanics and electrodynamics
CO203C.3 : to perform Fourier transform on a given data set.
CO203C.4 : to perform Laplace transform on a given data set.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Second Order Differential Equations : [Course Outcomes : CO203C.1]
Separation of variables-ordinary differential equations, singular points, series solutions leading to Legendre, Bessel, Hermite, Laguerre functions as solutions. Orthogonal properties and recurrence relations of these functions.</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Special functions : [Course Outcomes : CO203C.2]

Spherical harmonics and associated Legendre polynomials. Sturm -Liouville systems and orthogonal polynomials.</td><td>15</td></tr>
</table>

	Wronskian linear independence and/ linear dependence.	
3	**Fourier Transforms : [Course Outcomes : CO203C.3]** Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform, Convolution theorem. Simple Applications: FTIR, Telecommunication systems, Solution of partial differential equation wave equation	15
4	**Laplace Transforms : [Course Outcomes : CO203C.4]** Laplace transforms and their properties, Convolution theorem, Application of Laplace transform in solving linear, differential equations with constant coefficient, with variable coefficient and linear partial differential equation.	15

TEXT BOOKS

1. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, S. CHAND (Prentice Hall of India), New Delhi, 2nd Edition, 1987.
2. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications, UK, Vol 1 &2, 1970.
3. **George Arfken and Hans J Weber**, Mathematical Methods for Physicists, Elsevier Academic Press, Cambridge, 7th Edition, 2012.
4. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, Dover Publication Inc. 2014.
5. **E. Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons, United States, 10th Edition, 2015,
6. **K.F.Riley, M.P. Hobson, and S.J.Bence,** Mathematical methods for Physicists and Engineers, S. CHAND (Cambridge University Press), New Delhi, 3rd Edition, 2018.
7. **V Balakrishnan:** Mathematical Physics with Applications, Problems and Solutions; Ane Books, 1st Edition, 2018.

LABORATORY II

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Laboratory II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
II (1st Year)</td><td>Contact Hours per Week: 12</td></tr>
<tr><td>0</td><td>0</td><td>12</td><td>6</td><td>Total Hours: 180</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 204 CC 00126</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The aim & objective of the course is to impart the practical training on various electronics devices such as; Op-Amp, Vibrators, Amplifiers, Michelson interferometer etc. Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned. More experiments of similar nature may be added.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To train students for various electronics experiments and take measurements
• To train students on various optical instruments like Spectrometer, Michelson Interferometer
• To have hand on experiment for measurement of magnetoresistance and dielectric constant.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students will be able to
CO204C.1. Understand spectral lines, grating spectra, and interference fringes
CO204C.2. Learn the characteristics of Op-Amp, vibrators, clipper, clampers, and DA/</td></tr>
</table>

	AD **CO204C.3.** Use excel for plotting graphs **CO204C.4.** Understand motion of temperature and magnetic field dependence of Hall coefficient.

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	1. Study of Balmer series and Rydberg constant 2. Op-Amp as inverting and non-inverting amplifier 3. Op-Amp as differentiator, Integrator and Adder 4. e/m by Thomson method 5. Single stage RC coupled amplifier 6. Frequency response of common emitter amplifier 7. Bistable/Monostable/Astable vibrators 8. Grating spectra 9. Refractive index of water and oil using prism 10. Magneto resistance 11. Temperature dependence of Hall coefficient 12. Digital to Analog converter, Analog to Digital converter 13. Michelson Interferometer 14. Faraday Effect 15. Clipper and clampers	150
2	1. Root finding of a polynomial equation using numerical methods 2. Solving first and second order differential equation numerical methods 3. Numerical integration 4. Generating finite and infinite series	30

TEXT BOOKS

2. **Worsnop and Flint,** Experimental Physics, Little hampton Book Services Ltd, United Kingdom, 9th Edition, 1951.
3. **A. C. Melissinos, J. Napolitano,** Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2^{nd} Edition, 2003.
3. Lab manuals, prepared by faculty of the Department of Physics, 2018.

Latex for Humans

Scheme Version: 2021-22	Name of the subject: Latex for Humans	L	T	P	C	Semester: II (1st Year)	Contact Hours per Week: 2
		1	0	2	2		Total Hours: 30
Subject Code: SBS PHY 01 201 GEC 1022	Applicable to Programs: All Masters/ Bachelors Program	Evaluation (Total Marks: 50)	CIE	15 Marks	Examination Duration: 2 hours		
			TEE	35 Marks	Prerequisite: 10+2 with Non-Medical		
Course Description	To impart knowledge to student about different tools used in writing scientific/non-scientific literature.						
Course Objectives	**Write beautifully presentable documents using Latex.**						
Course Outcomes	**On completion of the course, student would be able to:** **CO201G.1 :**Write CV, documents, books and reports. **CO201G.2 :** Write mathematical formulae using simple commands. **CO201G.3 :** Produce fonts in different languages like Roman and Greek. **CO201G.4 :** Write Thesis and seminar presentations using latex **CO201G.5 : Tell the advantages of LaTeX over other more traditional softwares.** **CO201G.6 :** install and use MikTeX. **CO201G.7 :** List **LaTeX** compatible operating systems. **CO201G.8 : Explain how to obtain LaTeX**						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	[Course Outcomes : **CO201G.5 , CO201G.6 , CO201G.7, CO201G.8**] Software installation, Markup Languages	5
2	[Course Outcomes : **CO201G.2 , CO201G.3**] LATEX typesetting basics, LATEX math typesetting	10
3	[Course Outcomes : **CO201G.2 , CO201G.4**] Tables and matrices, Graphics, Packages, User definable packages	7

4	[Course Outcomes : **CO201G.1**] Document classes, text bibTEX, beamer, flash cards / CV, Creating your own package, Project.	8
Text Books		
1. **Helmut Kopka & Patrick W. Daly,**Guide to LATEX, Addison-Wesley, New Delhi, 4th Edition 2003. 2. **Stefan Kottwitz** , LaTeX Beginner's Guide, Packt Publishing, UK. 1st Edition, 2011 3. Resources from websites: The not so short introduction to LaTeX - Tobi Oetiker *https://tobi.oetiker.ch/lshort/lshort.pdf*		

Environmental Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Environmental Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 202 GEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: 10+2 with Science</td></tr>
<tr><td>Course Description</td><td colspan="7">This course aims to introduce students to the application of core physical concepts of the Earth system, with special focus on: atmospheric radiation, greenhouse gases, pollution, and climate change. This course will demonstrate how physics is fundamental to understand natural and human influences on climate and atmospheric composition.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To understand the broad scope of problems to which the principles of environmental physics can be applied and to appreciate the commonalities that exist among widely varying systems;

• To develop problem solving abilities and a critical, practical awareness of global environmental change.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO202G.1. To understand the concepts like energy transformations and various forms of energy, climate change and its effect on living beings

CO202G.2. To understand the concepts like thermodynamics and its applications to various energy transformation processes:

CO202G.3. To develop an awareness of climate change and its effects</td></tr>
</table>

	CO202G.4. To develop an awareness of different fossil fuels and their alternatives	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction to Energy [Course Outcome(s): CO202G.1]** Importance of energy in science and society. Types of energy (mechanical, heat, chemical, nuclear, electrical). Law of conservation of energy. Energy transformations. Mechanical energy: force, work, kinetic and potential energy, PE diagrams, conservation of mechanical energy, bound systems. Electricity Basics.	**15**
2	**Heat Energy and Kinetic Theory [Course Outcome(s): CO202G.2]** Heat and Temperature. Internal Energy, Specific Heat. Ideal gas equation. Kinetic theory interpretation of pressure and temperature. Work, heat, and the first law of thermodynamics. Adiabatic lapse rate. Radiant energy. Blackbody radiation. Heat engines and the second law of thermodynamics. The Carnot cycle. Applications of the second law to various energy transformation processes: heat pumps and refrigerators; different engine cycles. Entropy and disorder.	**15**
3	**Energy and Climate Change [Course Outcome(s): CO202G.3]** Energy balance of the Earth. Greenhouse effect. Climate feedbacks (water, clouds, ice albedo). Global Climate Models. Evidence for climate change. Paleo-climate. Climate change impacts. Climate change mitigation. Target CO_2 levels.	**15**
4	**Energy Source [Course Outcome(s): CO202G.4]** Chemical energy. Energy in biology, photosynthesis, respiration. Energy use in the human body, energy content of food. Fossil fuels and their origin (coal, oil, natural gas). Problems with fossil fuels, greenhouse pollution, peak oil. Alternatives to fossil fuels. Alternative energy resource: Wind energy, energy from water on land, ocean energy. Biomass and other sources.	

TEXT BOOKS

1. **Sol Wieder**, An Introduction of Solar Energy for scientists and Engineers, John Wiley, United States, 1st Edition, 1982.
2. **J.T. Widell** and **J. Weir**, Renewable Energy Resources, Elbs, 1st Edition, 1988.
3. **R.N. Keshavamurthy** and **M. Shankar Rao**, The Physics of Monsoons, Allied Publishers, New Delhi, 1st Edition, 1992.

4. **Landau** & **Lifshitz**, Fluid Mechanics, Pergamon Press, UK, 2nd Edition, 2000.
5. **Egbert Boeker** & **Rienk Van Groundelle**, Environmental Physics, John Wiley, United States, 2nd Edition, 2000.
6. **J.T. Hougtyion**, The Physics of Atmosphere, Cambridge University Press, 3rd Edition, 2002.
7. **C. W. Rose**, An Introduction to the Environmental Physics of Soil, Water and Watersheds, Cambridge University Press, 1st Edition, 2004.
8. **R. A. Hinrichs** and **M. Kleinbach**, Energy, Its Use and the Environment, Brooks Cole, Stanford University Press, 4th Edition, 2005.
9. **P. Hughes**, **N. J. Mason**, Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor & Francis, France, 1st Edition, 2005.
10. **J. Monteith** and **M. Unsworth**, Principles of Environmental Physics: Plants, Animals and the Atmosphere, Elsevier, 4th Edition, Europe, 2013.
11. **K.L. Kumar**, Engineering Fluid Mechanics, S. Chand, New Delhi, 4th Edition, 2016.

Computational Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Computational Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 201 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">The objective of the course is to train the students for various computational techniques to solve integration, differentiation and molecular dynamics simulation techniques.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To train students for computer programming
• To make students familiar with simulation techniques
• To train students for executing many body problems related computer programs</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:
• computations techniques to solve various differential equations
• the computational integration
• the molecular simulations and optimization techniques.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
</table>

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Stochastic Processes:** Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion.	**15**
2	**Numerical Integration and Stochastic Differential Equations:** Dynamical equations, Finite Difference Method, Langevin dynamics, TDGL equation, Cahn-Hilliard equation, Burgers' equation, KPZ model, Traffic Flow Dynamics.	**15**
3	**Molecular Dynamics (MD) and Monte Carlo (MC) Simulations:** Elementary ideas of molecular dynamics simulation, Physical potentials, Verlet algorithm. Time average and Ensemble average, Monte Carlo methods, Metropolis algorithm. Application of Monte-carlo simulations: (a) Ising model in magnetism (b) Glauber and Kawasaki dynamics.	**15**
4	**Combinatorial Optimization Problems:** Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique. **Computational experiments using computer programming** 1. Finite and infinite series 2. Root finding: (bisection, Secant and Newton-Raphson methods), 3. Solving first and second order ordinary differential equations including simultaneous, equations (Euler and Runge-Kutta methods) 4. Numerical integration (trapezoidal, Simpson, Gauss quadrature, methods) 5. Matrices (arrays of variable sizes, addition, multiplication, eigenvalues, eigenvectors, inversion, solutions of simultaneous equations) 6. To determine Wien's constant using bisection method and	**15**

	false position method. 7. To solve Kepler's equation by Newton-Raphson method. 8. To solve van der Waals gas equation for volume of a real gas by the method of successive approximation. 9. To interpolate a real data set from an experiment using the Lagrange's method, and Newton's method of forward differences and cubic splines. 10. To fit the Einstein's photoelectric equation to a realistic data set and hence calculate Planck's constant. To estimate the value of π by rectangular method, Simpson rule and Gauss quadrature by numerically evaluating suitable integral. 11. To find the area of a unit circle by Monte Carlo integration. 12. To simulate Buffen's needle experiment. 13. To simulate the random walk. 14. To study the motion of an artificial satellite by solving Newton's equation for its orbit using Euler method. 15. To study the growth and decay of current in RL circuit containing (a) DC source and (b) AC using Runge Kutta method, and to draw graphs between current and time in each case. 16. To study the motion of two coupled harmonic oscillators.	

TEXT BOOKS

1. **V. Rajaraman,** Computer Oriented Numerical Methods, Prentice Hall of India, 3rd Edition, 1993.
2. **V. Rajaraman,** Computer Programming in FORTRAN 90/95, Prentice Hall of India, 1st Edition,1997.
3. **D. Frenkel & B. Smit,** Understanding Molecular Simulation, Academic Press,2nd Edition,2001.
4. **M. Plischke & B. Bergersen,** Equilibrium Statistical Physics, World Scientific, 3rd Edition, 2006.

1. **W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,** Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.
2. **M. P. Allen,** Computer Simulation of Liquids, Oxford University Press,2nd Edition , 2017.
3. **Kurt Binder and Heerman,** Monte Carlo Simulation in Statistical Physics,Springer,6th Edition,2019.

QUANTUM MECHANICS - II

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Quantum Mechanics – II</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 202 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Quantum Mechanics-I</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is designed to understand some advanced topics such as symmetries, identical particles, approximation methods and relativity in quantum mechanics, which has broad and rich applicability in condensed matter physics, atomic and molecular physics, nuclear physics, space science, and chemistry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To make familiar with various advanced topics of quantum mechanics such as symmetries and conservation laws, fermions and bosons, time independent and time dependent perturbation theories, variational and WKB methods, scattering theory, delta function and relativistic theory

• To aware the students about applications of advanced phenomena of quantum</td></tr>
</table>

	mechanics in physical, mathematical and chemical sciences	
Course Outcomes	After completetion of this course, students will be able to **CO202D.1.** understand the concepts of symmetries, conservation laws, bosons and fermions in quantum mechanics **CO202D.2.** apply symmetries and conservation laws in various quantum mechanical problems **CO202D.3.** illustatre the time independent and time dependent perturbation theories, the variational and WKB methods **CO202D.4.** describe the fine structure and Zeeman effect phenomena **CO202D.5.** explain the basics of scattering theory **CO202D.6.** apply the delta function's properties in various quantum mechanical problems **CO202D.7.** understand the basics of relativistic quantum mechanics **CO202D.8.** recognize the importance and applications of relativistic quantum mechanics	
COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Symmetries, Conservation Laws & Identical Particles [Course Outcome(s): CO202D.1 & CO202D.2]** Transformation in space, The Translation Operator, Translation Symmetry, Conservation Laws, Parity: Parity in One & Three Dimensions; Parity Selection Rules, Rotational Symmetry, Degeneracy, Rotational Selection Rules, Many Particle Systems, Systems of Identical Particles, The Helium Atom, The Pauli Exclusion Principle.	15
2	**Approximation Methods [Course Outcome(s): CO202D.3 &**	15

	CO202D.4] Time Independent Perturbation Theory: Nondegenerate Perturbation Theory; Degenerate Perturbation Theory; Fine Structure; The Zeeman Effect, The Variational Method, The WKB method, Time Dependent Perturbation Theory, Adiabatic & Sudden Approximations.	
3	**Scattering Theory & The Delta Function [Course Outcome(s): CO202D.5 & CO202D.6]** Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering, The Delta Function: One Dimensional Delta Function and Three Dimensional Delta Function.	15
4	**Relativistic Quantum Mechanics [Course Outcome(s): CO202D.7 & CO202D.8]** Klein-Gordon equation, Dirac equation, Probability and Current Density, Plane Wave Solutions, Symmetries of the Dirac equation, Dirac's Equation for a Central Potential, Covariance of Dirac's Equation, Relativistic Hydrogen Atom Problem, The Hole Theory and Positrons.	15

TEXT BOOKS

1. **L. D. Landau and E.M. Lifshitz**, Quantum Mechanics, Butterworth Heinemann, The Netherlands, 3rd Edition, 1981.
2. **P. A. M. Dirac**, The Principles of Quantum Mechanics, Oxford University Press, UK, 4th Edition, 1988.
3. **R. Shankar**, Principles of Quantum Mechanics, Springer, Germany, 2nd Edition, 1994.
4. **N. Zettili**, Quantum Mechanics: Concepts and Applications, Wiley, USA, 2nd Edition, 2009.
5. **J. J. Sakurai**, Modern Quantum Mechanics, Pearson, India, 2nd Edition, 2013.
6. **L. I. Schiff**, Quantum Mechanics, McGraw Hill Education, USA, 4th Edition, 2017.
7. **D. J. Griffiths**, Introduction to Quantum Mechanics, Cambridge University Press, UK, 3rd Edition, 2018.
8. **C. Cohen-Tannoudji, B. Diu, and F. Laloe**, Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Wiley, USA, 2nd Edition, 2019.

Analog Electronics

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Analog Electronics	3	1	0	4	II (1st Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 203 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		
Course Description	This course covers the design, construction, and operation of analog electronic circuits. The main contents are: the basic principles of operation, terminal characteristics, and equivalent circuit models for diodes, transistors, and op-amps. Frequency response of cascaded amplifiers and gain-bandwidth considerations. Concepts of feedback, stability						

	and frequency compensation.
Course Objective	• To introduce students to entire circuit designs • To provide in-depth theoretical base of Digital Electronics
Course Outcomes	On completion of the course, student would be able: **CO203D.1.** To understand the techniques to shape of signals. **CO203D.2** To understand the principle of multivibrators **CO203D.3** To understand basic properties of analog systems **CO203D.4** To understand the fundamental designing concepts of different types of Logic Gates, Minimization techniques etc.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Linear Wave Shaping [Course Outcome(s): CO203D.1]** High Pass RC circuits: Its response to step, Pulse, Square wave, Ramp, exponential waveforms, Low pass RC Circuit: Its response to step, pulse, Square wave, Ramp, Exponential wave forms, Its application as an integrator. Attenuators, Time base Signal in a CRO. Operation of Clamping Circuits, Clamping Circuit theorem, Practical Clamping Circuit theorem, Operation of Transistor as a switch. **Clipping and Switching Circuits:** Diode Clippers, Combinational and Biased clippers Transistor Clippers, Comparators, Applications of Voltage Comparators.	**15**
2	**Multivibrators [Course Outcome(s): CO203D.2]** A bistable multivibrator-basic concepts of its operation. Symmetrical and Unsymmetrical triggering, Application (brief). Monostable Multivibrator, Basic concepts of its operation, quantitative discussion of Quasi stable state, Application, Astable multivibrator - basic concepts of operation. Quantitative discussion of the period of oscillation, Application.	**15**
3	**Analog Systems [Course Outcome(s): CO203D.3]**	**15**

	Operational Amplifier, Differential Amplifier, Transfer Characteristics, Frequency Characteristics, IC Operational Amplifier, Compensation in Operational Amplifiers, Application of OP-AMP as adder, Multiplier, Differentiator, Integrator, Log and Antilog Amplifier, Application of Operational Amplifier to analogue computation.	
4	**Logic Systems [Course Outcome(s): CO203D.4]** Basic Concepts of dc positive and negative logic systems, Dynamic logic systems, OR gate and AND gate, NOT gate, NAND gate, EX-OR gate, NOR gate & their applications, Response to input pulse operation. TTL (transistor transistor logic) and DTL (diode transistor logic) logics Binary Adders, Half adders and full adders, Multiplexing and demultiplexing.	**15**

TEXT BOOKS

12. **P. Horowitz and W. Hill,** The Art of Electronics, Cambridge University Press, 2nd Edition, 1989.
13. **J.J. Cathey,** Schaum's Outline of Electronic Devices and Circuits, McGraw Hill Education, New York, 2nd Edition, 2002.
14. **R.L. Boylestad and L. Nashelsky**, Electronics Devices and Circuit Theory, Prentice Hall of India, New Delhi, 8th Edition 2003.
15. **A.P. Malvino**, Electronic Principles, Tata McGraw, New Delhi, 7th Edition, 2009.
16. **J.H. Moore, C.C. Davis and M.A. Coplan**, Building Scientific Apparatus, Cambridge University Press, 4th Edition 2009.
17. **W. Kleitz**, Digital Electronics, A Practical Approach, Pearson, UK, 9th Edition 2011.
18. **R. J. Tocci**, Digital Systems-Principles and Applications, Prentice Hall of India, New Delhi, 10th Edition 2013.
19. **Millman and Halkias**, Integrated Electronics, McGraw Hill, New York, 2nd Edition, 2017.

Introduction to Astronomy and Astrophysics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Introduction to Astronomy and Astrophysics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 204 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: General Mathematics</td></tr>
<tr><td>Course Description</td><td colspan="7">To make the students aware about different theoretical and observational technique adopted in understanding astrophysics and astronomy</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The objective of this course is to make the students
Understand coordinate systems in Astronomy
Understand the Sun
Understand Binary stars.
Understand stellar distances</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to :
CO204D.1 : differentiate between various coordinate systems
CO204D.2 : know about the characteristics of Sun
CO204D.3 : Know about Binary stars and their motions
CO204D.4 : Know about stellar distances and other properties</td></tr>
</table>

<table>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td>Observational Data: [Course Outcomes : CO204D.1]
Astronomical Coordinates- Celestial Sphere, Horizon, Equatorial, Ecliptic and galactic system of coordinates, Conversion from one coordinate system to another. Aspects of sky from different places on the earth. Twilight, Seasons, Sidereal. Apparent and Mean solar time and their relations. Calendar. Julian date and heliocentric correction. Determination of Mass, luminosity, radius, temperature and distance of a star, H-R Diagram, Empirical mass-luminosity relation.</td><td>15</td></tr>
</table>

2	**Stellar Distances and Magnitudes : [Course Outcomes : CO204D.4]** Distances of stars from the trigonometric, secular and moving cluster parallaxes. Stellar motions. Magnitude scale and magnitude systems. Atmospheric extinction. Absolute magnitudes and distance modulus. Colour index. Black-body approximation to the continuous radiation and temperatures of stars. Variable stars as distance indicators.	15
3	**Binaries and Variable Stars : [Course Outcomes : CO204D.2]** Visual, spectroscopic and eclipsing binaries. Importance of binary stars as source of basic astrophysical data. Classification and properties of various types of intrinsic and eruptive variable stars. Astrophysical importance of the study of variable stars. Novae and Supernovae.	15
4	**Sun** : [Course Outcomes : **CO204D.3**] Physical Characteristic of Sun – Basic data, solar rotation, solar magnetic fields, Photosphere- granulation, sun-spots, Babcock model of sunspot formation, solar atmosphere-chromospheres and corona, Solar activity – flares, prominences, Solar wind, activity cycle, Helioseismology	15

TEXT BOOKS

1. **W.M.Smart**: Text book of Spherical Astronomy, Cambridge University Press; 6th edition, 1977
2. **M. Zeilik,** Astronomy, The evolving Universe, Cambridge University Press , 1st Edition, 2002.
3. **P.V. Foukal,** Solar Astrophysics , Wiley-VCH, United States, 1st Edition, 2004.

4. **I. Morrison,** Introduction to Astronomy and Cosmology, Wiley, United States, 1st Edition, 2008

SOLAR ENERGY AND PHYSICS OF PHOTOVOLTAICS

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:

Solar Energy and Physics of Photovoltaics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1^{st} Year)</td><td>Contact hours per week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 01 205
DCEC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Pre-requisite of course: There is no prerequisite or co-requisite for this course. But students are expected to know basic semiconductor physics.</td></tr>
<tr><td>Course Description</td><td colspan="7">The course is intended for students who have interest in alternate energy sources as a contributor to sustainability. It provides a comprehensive treatise on the science and technology of solar energy, its collection and the design principles that need to be understood for its effective use in a variety of installations and uses.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• The Course will be introducing the students to all the aspects of PV technology.
• To develop basic understanding related to fabrication ad characterization of different types of solar cells.
• To know state of art in the field of solar cells materials and solar cells.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:

CO204.1 The available solar energy and the current solar energy conversion and utilization processes, solar spectrum.

CO204.2 The factors that influence the use of solar radiation as an energy source.

CO204.3 The various active and passive technologies that are available for collecting solar energy; have the ability to apply design principles to selection of an appropriate solar energy installation to meet requirements.</td></tr>
</table>

	CO204.4 How solar cells convert light into electricity, how solar cells are manufactured, how solar cells are evaluated. **CO204.5** What technologies are currently on the market, and how to evaluate the risk and potential of existing and emerging solar cell technologies. **CO204.6** To examine the potential & drawbacks of currently manufactured technologies, as well as pre-commercial technologies. How to enhance solar cell performance and reduce cost, and the major hurdles-technological and economic, towards widespread adoption.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**Solar Radiation: [Course Outcome (s): CO204.1 & CO204.2]** origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, sun tracking systems, photo thermal conversion, solar energy collectors, collector efficiency and its dependence on various parameters.	15
2.	**Solar energy: [Course Outcome (s): CO204.3]** storage of solar energy, solar pond, solar water heater, solar distillation, solar cooker, solar green houses, solar dryers, absorption air conditioning. solar fuels: electrolysis of water, photoelectrochemical splitting of water.	15
3.	**Fundamentals of solar cells: [Course Outcome (s): CO204.4 & CO204.5]** Photo voltaic effect, semiconductor properties, energy levels, basic equations, p-n junction its characteristics, fabrication steps, thermal equilibrium condition, depletion capacitance, junction breakdown, heterojunction. Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells.	15

4.	**Device physics**: **[Course Outcome (s): CO204.6]** Solar cell device structures, construction, output power, efficiency, fill factor and optimization for maximum power, surface structures for maximum light absorption, current voltage characteristics in dark and light, operating temperature vs conversion efficiency, charge carrier generation, recombination and other losses. Cadmium telluride solar cells, copper indium gallium selenide solar cells, organic solar cells, perovskite solar cells, Advanced concepts in photovoltaic research.	15

REFERENCE BOOKS

9. S P Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 1996.

10. Solid State Electronic Devices, Ben. G. Streetman, S. K. Banerjee, PHI Leaning Pvt. Ltd, 2000.

11. D. Yogi Goswami, Frank Kreith, Jan F. Kreider, Principles of Solar Engineering, Taylor and Francis, 2000.

12. Jasprit Singh, Semiconductor Devices, Basic Principles, Wiley, 2001

13. Stephen J.Fonash, Solar Cell Device Physics, 2nd edition, Academic Press, 2003.

14. H P Garg, J Prakash, Solar energy fundamentals and applications, Tata McGraw Hill publishing Co. Ltd, 2006.

Accelerator Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Accelerator Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 206 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Nuclear Physics, Electrodynamics, Quantum mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to expose the students to theoretical design and usage of various particle accelerators.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To understand the beam optics.
Get knowledge about different types of accelerators
To understand the main features of superconducting cyclotron, linear accelerators and high energy accelerators.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completetion of this course, students would be able to:

CO206D.1. Understand the beam optics & beam transport system.

CO206D.2. About various theoretical techniques to accelerate particles and technical details of electrostatic accelerators.

CO206D.3. Get knowledge about latest accelerator technology based on Rf cavities.

CO206D.4. About Synchrotron Radiations & production of radioactive ion beams.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Charged Particle Dynamics: [Course Outcome(s): CO206D.1]** Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, microbeams, Particle and ion sources, secondary beams, Measurement of beam parameters.	15
2	**Electrostatic and Heavy Ion Accelerators: [Course Outcome(s): CO206D.2]** Van de Graaff voltage generator, Cockcroft-Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions, Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams.	15
3	**Radiofrequency Accelerators: [Course Outcome(s): CO206D.3]** Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs, Superconducting Heavy Ion Linear Accelerators. Circular accelerators- Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.	15
4	**Synchrotron Radiation Sources: [Course Outcome(s): CO206D.4]** Electromagnetic radiation from relativistic electron beams, Electron synchrotron, Characteristics of synchrotron radiation. Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators.	15

TEXT BOOKS
1. **M.S. Livingston and J.P. Blewel**, Particle Accelerators, McGraw-Hill Book Press, 1962. 2. **Ed. J. Cerny**, Nuclear Spectroscopy and Reactions Part-A, Academic Press, 1974. 3. **H.J. Wiedman**, Particle Accelerator Physics, Vol I and II, Springer Verlag, 1998. 4. **S. Y. Lee**, Accelerator Physics, World Scientific, Singapore, 2004

Radiation Physics

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject:
Radiation Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
II (1st Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 207 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Nuclear Physics, Electrodynamics, Quantum mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">To impart knowledge in depth about nuclear radiation, its detection, nuclear spectrometry and related aspects</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• To aware the students about the various type of nuclear radiations and their interaction with matter
• To learn various techniques for detection of radiations
• To study the nuclear spectrometry</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, students would be able to:
CO207D.1. Understand nuclear radiation and its detection procedure, nuclear spectrometry.
CO207D.2. Know applications of nuclear spectrometry</td></tr>
</table>

	CO207D.3. Know how to solve problems related to safety aspect of nuclear radiation CO207D.4 Understand the nuclear spectroscopy and basics of nuclear medicine.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Interaction of Nuclear Radiations: [Course Outcome(s): CO207D.1]** Origin and energy spectra, Brief discussion of interactions of gamma rays, Electron and heavy charged particles with matter, Different types of neutron sources, Interaction of neutron with matter, Neutron detectors.	15
2	**Nuclear Radiation Detector: [Course Outcome(s): CO207D.2]** Gas filled detectors; Ionization chamber, Proportional counter and GM counter, Scintillation detector, semiconductor detector for X-rays, gamma rays and charged particle detection, Radiation exposure, Biological effects of radiation, radiation monitoring	15
3	**Nuclear Spectrometry and Applications[Course Outcome(s):CO207D.3]** Analysis of nuclear spectrometric data, measurement of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, measurement of g-factor and hyperfine fields.	15
4	**Mossbauer Effect: [Course Outcome(s): CO207D.4]** Positron annihilation, particle and photon induced x-ray emission, Elemental concentration analysis by charged particles and neutron activation analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.	15

TEXT BOOKS
1. Knoll G. F., Radiation Detection and Measurement, John Wiley & Sons, 1989. 2. Singuru R. M., Introduction to experimental nuclear physics, Wiley Eastern Publications, 1987. 3. Muraleedhara V. Nuclear radiation Detection, measurement and Analysis, Narosa Publishing House, 2009.

Atomic, Molecular Physics and Lasers

<table>
<tr><td rowspan="2">Scheme Version:
2021-22</td><td rowspan="2">Name of the subject: Atomic, Molecular Physics and Lasers</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:
III
(2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 301 CC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Mathematical Methods in Physics I, Quantum Mechanics I, Statistical Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of the course is to aware students about various atomic and molecular spectra and to understand the working of LASERs.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The students will be exposed to
. Rotation and Vibration spectroscopy
. Raman Effect and Raman spectroscopy of molecules.
. Working of Lasers</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to :
CO301C.1 : Understand different models of an Atom
CO301C.2 : derive the energy distribution corresponding to different levels of an atom
CO301C.3 : Understand rotation spectroscopy and Understand Raman Effect and Raman spectroscopy of molecules.
CO301C.4 : understand the working of He-Ne Laser and Ruby Laser.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="5">Content of Each Unit</td><td colspan="2">Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="5">Atomic Spectra I: [Course Outcomes : CO301C.1]
Review of Atomic Models: Rutherford’s Model, Bohr’s model, Sommerfeld’s model, Stern-Gerlach experiment for electron spin. Revision of quantum numbers, exclusion principle, electronic configuration. Relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect.</td><td colspan="2">15</td></tr>
</table>

2	**Atomic Spectra II: [Course Outcomes : CO301C.2]** Spin-orbit interaction and fine structure, LS and JJ coupling, Relativistic correction to spectra of hydrogen atom, Lamb shift, effect of magnetic field on the hydrogen atom spectra, Zeeman and Paschen-Back effect. Hyperfine structure and isotope shift, Auger Effect and Frank Condon Principle. Born-Oppenheimer approximation.	15
3	**Molecular spectra: [Course Outcomes : CO301C.3]** Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, Vi vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy (Brief Introduction).	15
4	**Lasers: [Course Outcomes : CO301C.4]** Spontaneous and stimulated emission, Spatial and temporal Coherence, Einstein A and B coefficients, Optical Pumping, Population Inversion, Modes of resonator, Q-switching and Mode Locking, Ultra short pulse generation, He-Ne Laser and Ruby Laser- Principle, Construction and working, Application of lasers in the field of medicine and Industry.	15

Text Books

1. **H. E. White,** Introduction to Atomic Spectra, McGraw Hill, New York, 1st Edition, 1934.
2. **H. G. Kuhn,** Introduction to Atomic Spectra, Green and Co., Harlow, 2nd Edition, 1969.
3. **K. Thyagarajan and A.K. Ghatak,** Lasers - Theory and Applications, Plenum Press, New York, 1st Edition, 1981.
4. **B. H.Bransden and C. J Joachain,** Physics of Atoms and Molecules, Pearson, UK, 2nd Edition, 2003.
5. **R. Eisberg and R. Resnick,** Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, United States, 2nd Edition, 2006.
6. **Arthur Beiser,** Perspectives of Modern Physics, McGraw Hill, New York, 6th Edition, 2006.
7. **C. N. Banwell,** Fundamentals of Molecular Spectroscopy, McGraw Hill, New York, 4th Edition, 2017.

NULEAR PHYSICS

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Nuclear and Particle Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 302
CC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course:
Mathematical Physics and Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course will enable the M.Sc. students to understand the basic concepts of static properties of nuclei, radioactive decays, nuclear forces, nuclear reactions. They will also learn about the elementary particle physics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Students will be exposed to
General properties of nuclei
Interactions among the nucleons
Different models developed to explain the nuclear structure
Elementary classification of particles and their properties</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completetion of this course, the students will be able to
CO302C.1. Understand basic properties of nuclei
CO302C.2. Understand interactions between nucleons, meson theory and spin dependence of nuclear forces
CO302C.3. Get knowledge about Nuclear models, Magic numbers, and Collective nuclear model. Elementary knowledge about classification of particles.
CO302C.4. Classify the particles and will be able to understand their properties.</td></tr>
</table>

COURSE SYLLABUS		
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introductory Concept of Nuclei: [Course outcomes:CO302C.1]** Scattering and electromagnetic methods for determining the nuclear radius, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles, Nuclear Disintegration: Simple theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.	15
2	**Inter Nucleon Forces: [Course outcomes: CO302C.2]** Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon-nucleon scattering at low energy, Charge-independence of nuclear forces, Many–nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.	15
3	**Nuclear Structure and Models: [Course outcomes: CO302C.3]** Fermi gas model, Experimental evidence for shell structure in nuclei, Basic assumption for shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular moment, Parities and magnetic moment of nuclear ground states, Liquid drop model, Semi-empirical mass formula, Nuclear fission, The unified model.	15
4	**Particle Physics: [Course outcomes: CO302C.4]** Properties and origin, Elementary particles, Properties, classification, type of interactions and conservation laws, Properties of mesons, Resonance particles, Strange particles and Strangeness quantum number, Simple ideas of group theory, Symmetry and conservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3) classification of hadrons, Quarks, Gell-Mann-Okubu mass formula.	15

TEXT BOOKS		

1. **Roy & Nigam,** Nuclear Physics, John Wiley & Sons, USA, 1st Edition, 1967.
2. **H. Enge,** Introduction to nuclear Physics, Addison Wesley, USA, 1st Edition 1969.
3. **J.M. Blatt and V.F. Weisskopf,** Theoretical Nuclear Physics, Springer, Germany, 1st Edition, 1969.
4. **M.Leon,** Particle Physics:An introduction, Elsevier, Netherlands, 1st Edition, 1973.
5. **S. N. Ghoshal**, Nuclear Physics, S. Chand, India, 1st Edition, 1994.
6. **F.I. Stancu,** Group Theory in Subnuclear Physics, Clarendon Press, UK, 1st Edition, 1997.
7. **J.D. Walecka,** Theoretical Nuclear and Subnuclear Physics, World Scientific, Singapore, 2nd Edition, 2004.
8. **B. R. Martin and G. Shaw,** Particle Physics, John Wiley & Sons, USA, 3rd Edition, 2008.

SOLID STATE PHYSICS

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Solid State Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 303 CC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Graduation Level Solid State Physics and Quantum Mechanics</td></tr>
<tr><td>Course Description</td><td colspan="7">The solid state physics is the branch of physics dealing with physical properties of solids particularly crystals, including the behavior of electrons in these solids. The course solid state physics is basically designed for fundamental understanding of several breakthrough phenomena such as crystal structure, lattice dynamics, various crystal bonding, free electrons theory, band theory and superconductivity in solids.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To understand the fundamentals of intriguing phenomena such as direct lattice, reciprocal lattice, lattice vibration in solids, specific heat of metals, band formation in solids, effective mass, and superconductivity.
To develop the scientific and positive attitudes in students related to the materials science which is a part of solid state physics
To able the students for solve the problems related to solid state physics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of this course, the students will be able to</td></tr>
</table>

	CO303C.1. identify various crystal structures and their symmetries in solids **CO303C.2.** determine the crystal structure through X-ray diffraction, rotating crystal, and Laue methods **CO303C.3.** explain the theories and phenomena of lattice dynamics, various bonding, and thermal properties (specifically specific heat) in solids **CO303C.4.** calculate the specific heat and density of states of various solids **CO303C.5.** interpret the electrical conductivity and resistivity, mean free path, relaxation time, Fermi energy, electronic specific heat, and band formation in solids **CO303C.6.** recognize the importance of effective mass, nearly free-electron model and tight binding approximation **CO303C.7.** identify the basic differences between conductors and superconductors **CO303C.8.** illustrate the some exciting phenomena such as Meissner effect, Isotope effect, London's equations, BCS theory, and Josephson effect of superconductors **CO303C.9.** understand the basics of high temperature superconductors and commercial applications of superconductors

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Crystal Structure [Course Outcome(s): CO303C.1 & CO303C.2]** Crystal Structures and Lattices with Basis, Miller Indices, Common Crystal Structures, Reciprocal Lattice, Brillouin Zones, X-ray Diffraction by a Crystal and Their Equivalence, Laue Equations, Ewald Construction, Brillouin Interpretation, Intensity of X-ray Reflections: Atomic Scattering Factor; Geometrical Structure Factor, Structure Factors, Structure Factor; Experimental Methods of Structure Analysis: Laue's Method; Rotating Crystal	15

	Method; Powder Method, Diffraction from Non-Crystalline Systems.	
2	**Lattice Dynamics, Crystal Binding and Thermal Properties [Course Outcome(s): CO303C.3 & CO303C.4]** Classical Theory of Lattice Dynamics: Vibrations of Crystals with Monatomic Basis and Two Atomic Basis; Dispersion Relation; Group Velocity; Acoustical and Optical modes, Bonding in Solids, Elastic Constants and Properties, Phonons: Quantization of Lattice Vibration; Phonon Momentum; Inelastic Scattering of Neutrons by Phonons, Thermal Properties: Heat Capacity; Density of States; Normal Modes; Debye and Einstein Models.	15
3	**Free Electrons and Energy Band in Solids [Course Outcome(s): CO303C.5 & CO303C.6]** Free Electron Gas Model and Its Limitations, Electrons Moving in One and Three Dimensional Potential Well, The Density of States, Fermi Energy, Effect of Temperature on Fermi Distribution Function, The Electronic Specific Heat, The Electrical Conductivity of Metals, Relaxation Time and Mean Free Path, The Electrical Resistivity, Band Theory:Bloch Theorem; The Kronig-Penny Model; Symmetry Properties of the Energy Function; Effective Mass of an Electron; The Nearly Free Electron Model and Tight Binding Approximation; Metals; Insulators and Semiconductors.	15
4	**Superconductivity [Course Outcome(s): CO303C.7, CO303C.8 & CO303C.9]** Introduction to Superconductivity, Effect of Magnetic Field, The Meissner Effect, Type I and Type II Superconductors, Entropy, Free Energy, Heat Capacity, Energy gap, Isotope Effect, Thermodynamics of the Superconducting Transition, London Equation and Penetration Depth, Coherence Length, BCS Theory of Superconductivity, Cooper Pair, Flux Quantization, DC and AC Josephson Effects: SQUIDs, High Temperature Superconductivity, Applications of Superconductors.	15

TEXT BOOKS

1. **J. M. Ziman**, Principles of the Theory of Solids, Cambridge University Press, UK, 2nd Edition, 1979.
2. **J. F. Annett**, Superconductivity Super fluids and Condensates, Oxford University Press, UK, 1st Edition, 2004.

3. **J. P. Srivastava**, Elements of Solid State Physics, Prentice-Hall of India, 2nd Edition, 2006.
4. **H. Ibach and H. Luth**, Solid State Physics: An Introduction to Theory and Experiment, Springer, Germany, 4th Edition, 2009.
5. **M. A. Wahab**, Solid State Physics: Structure and Properties of Materials, Narosa Publications, India, 2nd Edition, 2009.
6. **C. Kittel**, Introduction to Solid State Physics, John Wiley and Sons, USA, 8th Edition, 2012.
7. **N. W. Ashcroft and N. D. Mermin**, Solid State Physics, Holt, Rinehart and Winston, USA, Revised Edition, 2016.
8. **S. O. Pillai,** Solid State Physics, New Age International Publishers, 8th Edition, 2018.

LABORATORY III

Scheme Version: 2021-22	**Name of the subject:** Laboratory III	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 12
		0	0	12	6	III (2nd Year)	**Total Hours:** 180
Subject Code: SBS PHY 01 304 CC 00126	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		
Course Description	Aim of Lab III is to train students for advanced practical related to solid state physics, nuclear physics, electronics, numerical techniques and material science. Each student is required to perform at least five experiments from Section A and at least three experiments from any one of the optional subtopics of Section B: (i) Electronics (ii) Thin Film and Nano-Material (iii) Numerical Techniques; depending upon the courses opted under discipline centric elective course						
Course Objectives	• To train students on advanced experiments • To give training on advance instruments • To introduce students to latest numerical techniques						

<table>
<tr><td>Course Outcomes</td><td colspan="2">After completion of this course, the students will be able to

CO304C.1. Apart from some experiments based on nuclear physics, electronics, computation and solid state physics.

CO304C.2. To understand the basic synthesis and characterization techniques for different materials such as thin films and nanoparticles.

CO304C.3. students will also perform the advance experiments like DTA, TGA, UV-VIS, Microwave furnace and thin film coating techniques.

CO204C.4. Students will advance techniques of numerical analysis</td></tr>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td>1. Kerr Effect
2. Curie Temperature
3. B-H curve
4. Dielectric constant
5. Solid State Nuclear Track Detector (SSNTD)
6. G.M. Counters: characteristics, dead time and counting statistics
7. Scintillation detector-energy calibration, resolution and determination of gamma ray energy
8. Quinks tube method to find susceptibility of a material
9. Nuclear Magnetic Resonance
10. Zeeman Effect
11. To study Lattice Dynamics</td><td>100</td></tr>
<tr><td>2</td><td>(i) Electronics

1. PCM/delta modulation and demodulation
2. Fiber optic communication
3. Modulation/Demodulation
4. 4-bit ripple counter
(ii) Thin Film and Nano-Material

1. Data Analysis of XRD, SEM and TEM
2. Chemical Deposition (for CNT growth)
3. ZnO wire by thermal oxidation
4. Band gap estimation by Tauc-plot method
5. Thin film deposition technique
6. DTA/TGA analysis
(iii) Numerical Techniques</td><td>80</td></tr>
</table>

	1. Solution of Linear algebraic equation: Gauss Jordon elimination, Singular Value Decomposition, Sparse linear system. 2. Evaluation of Functions: special functions, evaluation of functions by path integration, incomplete gamma, beta function. 3. Random Numbers: Uniform random numbers generators, statistical distributions and their properties, Rejection Methods, transformation method, simple Monte Carlo integration, Adaptive and recursive Monte Carlo methods, Test of randomness. 4. Signal Processing: FFT, IFFT, Filtering with FFT, convolution and correlation functions, application to real time series data. 5. Eigen systems: Solving eigenvalues and finding eigen functions of Schrodinger equation for analytically unsolvable potentials using variational principle.	

TEXT BOOKS

1. Albert Malvino, Digital Principles and Applications, McGraw Hill, New York, 4th Edition, 1986.

2. **A. C. Melissinos, J. Napolitano,** Experiments in Modern Physics, Academic Press, Cambridge, Massachusetts, 2nd Edition, 2003.

3.**W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,** Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007.

4. J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters, and Complexity, Oxford University Press, 2nd Edition, 2007.

5. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, New Delhi, 1st Edition, 2017.

Physics of Electronic Material and Devices

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Physics of Electronic Material and Devices</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

II (2^{nd} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 301 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: None</td></tr>
<tr><td>Course Description</td><td colspan="7">This course intends to provide knowledge about band structure and electronic properties of semiconducting materials. In addition, this course aims to provide a detailed theory and design of electronic, microwave and photonics devices.</td></tr>
<tr><td>Course Objective</td><td colspan="7">• To acquire the fundamental knowledge and expose to the field of semiconductor theory and devices and their applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able:

CO301D.1. To describe the properties of materials and application of semiconductor</td></tr>
</table>

	electronics **CO301D.2.** To understand the oncepts of recombination and generations of charge carriers **CO301D.3.** To understand basic properties of Metal-Semiconductor junction. **CO301D.4.** To understand the working, design and applications of various semiconducting devices like rectifiers, clippers, LED, Solar cells.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Fundamentals of Semiconductors [Course Outcome(s): CO301D.1]** Carrier concentration of semiconductor, Transport Equations, Fundamentals of Compound Semiconductors: Introduction of Compound Semiconductors, Properties of Compound semiconductors, Synthesis of Compound Semiconductors. Crystal structures of Elemental and III-IV	**15**
2	**Carrier mobility in semiconductors [Course Outcome(s): CO301D.2]** Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Shockley read theory of recombination, Switching in electronic devices.	**15**
3	**Metal-semiconductor, Metal-Insulator-Semiconductor and MOS devices [Course Outcome(s): CO301D.3]** Native oxides of Compound semiconductors for MOS devices and the interface state density related issues. Metal semiconductor contacts, Schottky barrier diode, Metal semiconductor Field Effect Transistors (MESFETs): Pinch off voltage and threshold voltage of MESFETs. D.C. characteristics and analysis of drain current. Velocity overshoot effects and the related advantages of GaAs, InP and GaN based devices for high speed operation. Sub threshold characteristics, short channel effects and the performance of scaled down devices.	**15**
4	**High Frequency Devices [Course Outcome(s): CO301D.4]** Essential Condition of High frequency device and compound semiconductor,Tunnel diode, MIS Tunnel diode, Degenerate and Non-degenerate semiconductor, MIS switch diode, MIM Tunnel diode. IMPATT diode. Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred electron devices.	**15**

	Photonic devices: LED and LASER, Photo detectors, Solar-cells.	

TEXT BOOKS

1. **A.S. Grove**, Physics and Technology of Semiconductor Devices, WILEY, United States, 1st Edition , 1967.
2. **B.L. Sharma,Metal**, Semiconductor Schottky Barrier Junction and their Applications, Springer, USA, 1st Edition, 1984.
3. **E. H.Rhoderick**, Metal/Semicond uctor Contacts, Clarendon Press, UK, 1st Edition , 1988.
4. **Jasprit Singh**, Semiconductor Devices Basic Principles, John Wiley & Sons, United States, 1st Edition, 2000.
5. **S.M. Sze**, Physics of Semiconductor Devices, John Wiley & Sons, United States, 2nd Edition, 2003.

Nuclear Reactor Physics

Scheme Version: 2021-22	**Name of the subject:** Nuclear Reactor Physics	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
		3	1	0	4	III (2nd Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 302 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		
Course Description	This course is intended to impart primary but wide theoretical knowledge about nuclear reactor and related topics.						
Course Objectives	• To understand the theoretical and experimental knowledge about nuclear reactors. • To know about the basic designs of nuclear reactors. • To understand the need of nuclear fuel and waste management.						

Course Outcomes	After completetion of this course, students would be able to: **CO302D.1.** Understand the nuclear fission reactions. **CO302D.2.** Learn about neutron sources and moderators. **CO302D.3.** Get knowledge about working of nuclear reactors. **CO302D.4.** Get knowledge about different types of power reactors **CO302D.5.** Learn how to manage the nuclear fuel and waste.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Nuclear Reactions: [Course Outcome(s): CO302D.1]** Characteristics of atomic nucleus, Binding energy, Nuclear fission, Cross section, Interaction of neutrons with nuclei.	15
2	**Neutron moderation**: **[Course Outcome(s): CO302D.2]** Inelastic scattering, Elastic collisions, Moderating ratio, Slowing down Density, Resonance escape, Moderators, Neutron sources, Prompt neutrons, Fast fission, Fission energy, Thermal utilization, Fission products, Chain reaction, Multiplication factor, Leakage of neutrons, Critical size, Diffusion and slowing down theory, Homogenous and heterogeneous reactors.	15
3	**Nuclear Reactors: [Course Outcome(s): CO302D.3]** Fuel materials, Moderator materials, Cladding materials, Coolant materials and control materials, Control requirement calculations, Means of control, Reactor kinematics: Neutron lifetime, Generation time, Point kinetic equation and solution of the equations for step input reactivity.	15
4	**Types of Power reactors & Fuel and waste management: [Course Outcome(s): CO302D.4 & CO302D.5]** Boiling water reactors, Pressurized water reactors,	15

	Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Fuel management schemes, Fuel composition, Fuel cycle cost and waste management.	

Laboratory Assignments:

Visits to fission reactor sites and related case studies for generation of nuclear energy.

TEXT BOOKS

1. **Lamarshs, J.R.**, Introduction to Nuclear Reactor Theory, Addison-Wesley Publishing Co., 1966.
2. **Glasstons**, Sammuel and Sesonske, Alexander, Nuclear reactor Engineer, CBS Publishers & Distributors, 1986.

PLASMA PHYSICS AND FUSION REACTOR

Scheme Version: 2021-22	**Name of the subject:** Plasma Physics and Fusion Reactor	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
		3	1	0	4	III (2nd Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 303 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Mathematical Physics and Quantum Mechanics		
Course Description	Students will be exposed to theory related to motion of charge particle in inhomogeneous field, production of plasma and usage of plasma.						

<table>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>Course Objectives</td><td colspan="2">To make students familiar with fourth state of matter
To aware students about plasma creation in laboratory
To make students familiar with production of energy in fusion reactor</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">After completion of this course, the students will have understanding of

CO303D.1. what are theoretical method to study the charge particle motion
CO303D.2 Idea behind the magnetic confinement
CO303D.3. how to generate plasma in the laboratory
CO303D.4. how plasma production is helpful to make fusion reactors</td></tr>
<tr><td colspan="3">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td>Introduction: [Course outcomes: CO303D.1]

Plasma state, plasma parameters, applications of plasmas.

Single particle orbit theory: Drift of charge particle under different combinations of electric and magnetic field, crossed electric and magnetic fields, homogenous electric and magnetic fields, spatially and time varying electric and magnetic fields,</td><td>15</td></tr>
<tr><td>2</td><td>The Boltzmann Equation: [Course outcomes: CO303D.2]

Simplified magneto-hydrodynamic equations - Electron plasma oscillations Debye shielding phenomenon and criteria for plasma, motion of charged particles in electromagnetic field, Electric field drift, parallel acceleration, curvature drift, adiabatic invariants; fundamental equations of magneto-hydrodynamics(MHD), magnetic confinement.</td><td>15</td></tr>
<tr><td>3</td><td>Production of Plasma in laboratory: [Course outcomes: CO303D.3]

Physics of glow discharge, electron emission, ionization breakdown of gases, Paschen’s law and different regimes of E/ρ in a discharge.

Plasma diagnostic: Probes, energy analysers, magnetic probes and optical diagnostics, preliminary concepts.</td><td>15</td></tr>
</table>

4	**Fusion Reactor**: **[Course outcomes: CO303D.4]** Potential of fusion energy, controlled thermonuclear reactions, fusion reactions, fusion cross-sections, fusion power generation, energy balance for fusion systems, ignition criterion, gain factor, plasma heating, ohmic heating, neutral beam injection, radio frequency heating, inertial confinement fusion, tokamaks, stability, operating limits and transport.	15
TEXT BOOKS		
1. Nicholson, D. R., Introduction to Plasma theory, Wiley, 1983 2. Chen, F.F., Introduction to Plasma Physics, Springer, 1984 3. Sturrock, P.A., Plasma Astrophysics, Cambridge University Press, 1994 4. Choudhuri, A.R., The Physics of Fluids and Plasmas, Cambridge University Press, 1998		

PHYSICS OF NANOMATERIALS

Scheme Version: 2021-2022	**Name of the Subject:** Physics of Nanomaterials	**L**	**T**	**P**	**C**	**Semester:** **III**(2^{nd}Year)	**Contact hours per week:** 4
		3	**1**	**0**	**4**		**Total Hours: 60**
Subject Code: SBS PHY 01 304 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks):** 100	**CIE**	**30 Marks**	**Examination Duration: 3 hours**		
			TEE	**70 Marks**	**Pre-requisite of course:** Solid State Physics		
Course Description	To introduce knowledge on basics of nanoscience and the fundamental concepts behind size reduction in various physical properties. More specifically, the student will be able to understand the different properties of materials being used in various length scales.						

<table>
<tr><td>Course Objectives</td><td colspan="2">The objective of this course is to provide the knowledge on the Physics of nanostructure materials, materials growth aspects important for size control and size selection and application of nanoscale materials.
The course lays foundation for advanced courses in engineering aspects of materials and their applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="2">On completion of this course, student will learn:

CO304.1 Correlate properties of nanostructures with their size, shape and surface characteristics.

CO304.2 Qualitatively describe how the nanoparticle size can affect the morphology, crystal structure, reactivity, and mechanical properties.

CO304.3 Understand the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.

CO304.4 Describe several synthesis methods for fabrication of inorganic nanoparticles, one-dimensional nanostructures (nanotubes, nanorods, nanowires), thin films, nonporous materials, and nanostructured bulk materials, and also could describe how different lithography methods can be used for making nanostructures.

CO304.5 Understand some specific materials like graphene and carbon nanotubes for various applications.

CO304.6 To comprehend basic knowledge on the characterization of nanomaterials by different methods.</td></tr>
<tr><td></td><td colspan="2">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td>Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1.</td><td>Introduction to Nanostructure Materials: [Course Outcome (s): CO304.1 & CO304.2]

Nanoscience & nanotechnology, size dependence of properties, Chemical- reactivity, Mechanical properties at nanoscale, Moor’s law, Surface energy and Melting point (quasi melting) of nanoparticles, Excitons, Density of states, Variation of density of states with energy and size of crystal. Population of conduction and valance band for 0D, 1D, 2D & 3D material.</td><td>15</td></tr>
</table>

2.	**Quantum Size Effect: [Course Outcome (s): CO304.3]** Quantum confinement and its consequences, quantum wells, quantum wires and quantum dots and artificial atoms. Electronic structure from bulk to quantum dot. Electron states in direct and indirect gap semiconductors nanocrystals. Confinement in disordered and amorphous systems.	15
3.	**Synthesis of Nanomaterials: [Course Outcome (s): CO304.4 & CO304.5]** Key issue in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Thermal and e-beam evaporation, Gas phase synthesis of nanopowders, chemical and colloidal methods, sol gel method, functionalization of nanoparticles. Ball Milling, Specific materials like graphene and carbon nanotubes (CNTs).	15
4.	**Characterization techniques: [Course Outcome (s): CO304.6]** XRD (Scherrer's formula), Electron Microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), Raman Spectroscopy and XPS, Estimation of band gap using UV-Vis-NIR spectroscopy, Thermogravimetric analysis.	15

REFERENCE BOOKS

1. D. Bimberg, M. Grundmann, N.N. Ledenstov, Quantum Dot Hetrostructures, John Wiley & Sons, United States, 1st Edition, 1999.
2. Charles P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, United States, 1st Edition, 2003.
3. Guozhong Cao, Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press, UK, 1st Edition, 2004
4. Liming Dai, Carbon Nanotechnology, Elsevier, Netherland, 1st Edition, 2006.
5. Michael J. O'Connell, Carbon Nanotubes: Properties and Applications, CRC Press, USA, 1st Edition, 2006.
6. T. Pradeep, Nano: The Essentials, McGraw Hill Companies, New York, 1st Edition, 2007.
7. Hornyak G.L., Tibbals H.F., Dutta J.,Moore J.J., Introduction to Nanoscience and Nanotechnology, CRC Press, USA, 1st Edition, 2008.

Characterization Techniques for Materials

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Characterization Techniques for Materials	3	1	0	4	I (1st Year)	Total Hours: 60
Subject Code: SBS PHY 01 305 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks:**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
				70	**Prerequisite of Course:** None		

		100)	**TEE**	Marks	

Course Description	This course covers the fundamental principles and practical applications of different classes of materials and characterization techniques. The course discusses characterization techniques used for chemical and structural analysis of materials, including metals, ceramics, polymers, composites, and semiconductors. The topics include important spectroscopic, microscopic and thermal methods for materials characterization.
Course Objective	• To introduce the materials characterization techniques to the students • Help the students to understand the instrumentation aspects • To provide a detailed understanding of data interpretation • To provide hands on experience of the characterization techniques
Course Outcomes	On completion of the course, student would be able: **CO305D.1.** To determine crystal structure of specimen and estimate its crystallite size and stress **CO305D.2.** To choose an appropriate microscopy techniques to investigate microstructure of materials at high resolution **CO305D.3.** To use appropriate spectroscopic technique to measure vibrational/electronic transitions to estimate parameters like energy band gap, elemental concentration, etc. **CO305D.4.** To apply thermal analysis techniques to determine thermal stability of and thermodynamic transitions of the specimen.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Structure analysis [Course Outcome(s): CO305D.1]** X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Phase identification, indexing and lattice parameter determination, Powder X-ray diffractometer. Applications of XRD in bulk and nano-materials.	**15**
2	**Microscopy techniques [Course Outcome(s): CO305D.2]**	**15**

	Introduction to Microscopes, Optical microscopy, Transmission Electron Microscopy (TEM); Basic Electron scattering, Concepts of resolution, TEM instruments, Various imaging modes, Analysis of micrographs, Electron Energy Loss Spectroscopy, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (AFM and STM)	
3	**Spectrophotometric analysis of materials [Course Outcome(s): CO305D.3]** UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron Spectroscopy (XPS).	**15**
4	**Thermal analysis techniques [Course Outcome(s): CO305D.4]** Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermo-gravimetric analysis (TGA), **Electrical characterization techniques:** Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance	**15**

TEXT BOOKS

6. **Wendlandt, W.W.,** Thermal Analysis, John Wiley & Sons, 1986.
7. **Wachtman, J.B.,** Kalman, Z.H., Characterization of Materials, Butterworth Heinemann, 1993.
8. **Murphy, Douglas B,** Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, 2000.
9. **Cullity, B.D.,** and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, 2001.
10. **B. Raj**, **T. Jayakumar**, **M. Thavasimuthu**, Practical Non-Destructive Testing, 2nd ed., Narosa Publishing House, 2002.
11. **D. A. Skoog**, **F.J. Holler**, **S. R. Crouch**, Instrumental Analysis, Cengage Learning, 2007.
12. **Li Lin**, **Ashok Kumar**, Materials Characterization Techniques Sam Zhang; CRC Press, 2008.
13. **Y. Leng**, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.
14. **J. C. Vickerman**, **I. Gilmore**, Surface Analysis: The Principal Techniques, 2 nd ed., John Wiley & Sons, Inc.2009.

General Theory of Relativity

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: General Theory of Relativity</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III(2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 306 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Classical Electrodynamics, Mathematical Methods in Physics I & II</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of the course is to familiarize students with different aspects of theory of gravitation.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The student will come to understand
. Special Theory of Relativity
. General Theory of Relativity
. Few applications of Geeral Theory of Relativity.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to
CO306D.1 : understand the mathematical rigour that goes behind the theory of relativity and also be able to
CO306D.2 : Understand few applications of general theory of relativity.
CO306D.3 : Understand the Special theory of relativity
CO306D.4 : Understand the origin of gravitational waves</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Historical Background [Course Outcomes : CO306D.3]
Review of Newtonian Mechanics. Special theory of relativity. Prelude to General relativity, historical developments, 4-Vectors and 4-tensors, examples from physics</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Tensors in GTR [Course Outcomes : CO306D.1]
Principle of Equivalence, Equations of motion, Gravitational force, Tensor Analysis in Riemannian space, Effects of Gravitation, Riemann-Christoffel curvature tensor, Ricci Tensor, Curvature Scalar</td><td>15</td></tr>
<tr><td>3</td><td colspan="6">Applications of GTR [Course Outcomes : CO306D.2]
Einstein Field Equations, Experimental tests of General Theory of Relativity, Scwartzchild Solution, Gravitational</td><td>15</td></tr>
</table>

	lensing	
4	**Gravitational Radiation [Course Outcomes : CO306D.4]** Gravitational waves: generation and detection, Energy, momentum and angular momentum in Gravitation	15
Text Books		

1. **S. Weinberg,** Cosmology, Oxford University, 1 st Edition, 2008.
2. **Ray D'Inverno**, Introducing Einstein's General Relativity, Oxford University, 1 st Edition, 1992.
3. **M. Berry,** Principle of Cosmology and Gravitation, Taylor & Francis; 1 st Edition, 1989.
4. **Tai L. Chow**, Introduction to General theory of Relativity and Cosmology, Springer, 1 st Edition, 2008.
5. **P.A.M. Dirac**, General theory of Relativity, Wiley-Blackwell, 1 st Edition, 1975.
6. **L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Publishere, Shroff, 2 nd Edition, 2010**

Digital Electronics and Microprocessor

Scheme Version: 2021-22	**Name of the subject:** Digital Electronics and Microprocessor	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
		3	0	2	4	III (2^{nd} Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 307 DCEC 3024	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Physics of Semiconductor Devices, Analog Electronics		
Course Description	This course is intended to train the M.Sc students for digital systems, their implementation and application of microprocessor.						
Course Objectives	• To understand the fundamentals of digital systems. • To make familiar with various logic families and their implementation in logic circuits. • To understand the design of microprocessors and their applications.						
Course Outcomes	After completion of this course, students will be able to learn about: **CO307D.1.** The basics of digital systems and Boolean algebra. **CO307D.2.** Digital arithmetic operations and combinational & sequential circuits. **CO307D.3.** Various memory devices & their applications. **CO307D.4.** Microprocessor and its various operations.						
COURSE SYLLABUS							
Unit No.	**Content of Each Unit**						**Hours of Each Unit**

1	**Digital Systems: [Course Outcome(s): CO307D.1]** Digital signals, binary number system, conversions, Boolean algebra, logic gates, standard gate assemblies, implementing circuits from boolean expressions, SOP, POS, Simplifying logic circuits: algebraic method, K-mapping, Error detection: Parity method, checksum method.	15
2	**Digital Circuits**: **[Course Outcome(s): CO307D.2]** Combinational Circuits: Half Adder, Full Adder, Decoder, Encoder, Multiplexer, Demultiplexer and their applications. Sequential Circuits: Flip flops; SR, T, D and J-K, Shift Register, Parallel and Serial data transfer, Timming Waveforms. Counters: Synchronous and Asynchronous Up, Down, and Bidirectional Counters, Timing Wave forms. Digital to Analog Converters and their properties, weighted resistor and R-2R Ladder type, Analog to digital Converters: Flash, Successive approximation, Sigma- Delta ADC.	15
3	**Applications: [Course Outcome(s): CO307D.3]** Memory: Read Only Memory (ROM): PROM, EPROM, EEPROM, Applications, Programming a ROM, Random Access Memory(RAM): SRAM, DRAM, Applications, Memory Storage cell, Read and Write operations, Programmable Logic Devices (PLD) Digital Display, Seven segment display.	15
4	**8085 Microprocessor: [Course Outcome(s): CO307D.4]** Basics of Microprocessor-8085, PIN description, Microprocessor initiated operations. Internal data operations. Introduction to 8085 assembly language programming. 8085 instruction, Microprocessor Applications, Recent trends in Microprocessor Technology.	15

Laboratory Assignments:

To construct logic gates OR, AND, NOT, NOR, NAND gates using discrete components and verify their truth tables

To construct logic gates AND, NOT, EX-NOR and EX-OR using NAND gates and verify their truth tables.

To perform 4 bit DAC and ADC operations

To arrange a data set in ascending order using 8080 microprocessor.

Use the IC555 chip as astable, bistable and monostable multivibrator.

To study various operations of Arithmetic logic Unit (ALU).
To perform the addition and subtraction of n 8 bit numbers using 8085 microprocessor
To perform the multiplication and division of two 8 bit number using 8085 microprocessor
To write a program to arrange an array of data in ascending order using 8085 microprocessor
To design and construct multiplexer and demultiplexer and verify their truth tables.
To study the encoders and decoders
To perform BCD to Binary operation using 8085 microprocessor.

TEXT BOOKS

1. **Malvino A.P**. and **Brown A**., Digital Computer Electronics, Prentice-Hall, India, New Delhi, 3rd Edition, 1999.
2. **Gaonkar R. S**., Microprocessor Architecture, Programming and Applications, Prentice-Hall, India,New Delhi, 2nd Edition, 2014.
3. **Tocci R. J**., Digital Systems-Principles and Applications, Prentice Hall of India, New Delhi, 8th Edition, 2015.

Programming with Python

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Programming
with Python</td><td></td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td></td><td>3</td><td>0</td><td>2</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 308 DCEC 3024</td><td rowspan="2">Applicable to Programs:
M.Sc. Physics</td><td></td><td rowspan="2">Evaluation
(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td></td><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basic knowledge of computer</td></tr>
<tr><td>Course Description</td><td></td><td colspan="7">The objective of the course on Computational Methods is to familiarize the students about various computational techniques by using Python.</td></tr>
<tr><td>Course Objectives</td><td></td><td colspan="7">• To train student in scientific language Python
• To make students comfortable with code writing techniques
• To apply numerical methods using Python language</td></tr>
<tr><td>Course Outcomes</td><td></td><td colspan="7">After completion of this course, students will be able to learn about:

CO308D.1. Learn the basics of programming using Python as a scientific programming language.
CO308D.2. Understand the basics of input and output formatting and display techniques along with graphical user interface
CO308D.3. Design algorithms for various numerical methods using Python and
CO308D.4. Solve selected problems using Python algorithms and programming.</td></tr>
<tr><td></td><td colspan="8"></td></tr>
</table>

	COURSE SYLLABUS		
Unit No.		**Content of Each Unit**	**Hours of Each Unit**
1		**Basic of Python: [Course Outcome(s): CO308D.1]** Computational modeling, python programming for a Physicist, structure of a python program, running python program in console and in editor. constant and variables, numbers-integers, long integer, floating point number, complex number, sequences-string, list, tuples, dictionaries, operators – arithmetic operators, relational operators.	15
2		**Logical Statements**: **[Course Outcome(s): CO308D.2]** logical operators, assignment operators, conditional operator. Control statements if, if else, if-elif-else, while, for loop, nested if and nested for loops, break and continue.	15
3		**Functions in Python: [Course Outcome(s): CO308D.3]** user made, library, inbuilt. Functions definition and declaration, passing arguments, return values, default values and optional parameters. Importing modules, File handling operation with files, opening and closing a file. Formatting inputs and outputs, visualizing data, 2D, 3D, scatter graphs, animating graphs, statistical analysis of data- mean, median, mode, variance**.**	15
4		**Selected Problem using Python: [Course Outcome(s): CO308D.4]** Optimization: designing an algorithm for accuracy, designing an algorithm for speed, Errors in computation and Numerical stability , numerical integration, differentiation. Curve fitting, least squares method principle, Fourier Transform, symbolic computation, numerical computation.	15

	TEXT BOOKS
	2. Patil P. B. &Verma U. P., Numerical Computational Methods, Revised Edition (Reprint 2013), Narosa Publication. 3. Fangohr H., Introduction to Python for Computational Science and Engineering (A beginner's guide), (2015), Faculty of Engineering and the Environment, University of Southampton. 4. Rajaraman V., Computer Oriented Numerical methods, 3rd Edition (2015), Prentice Hall India Ltd.

Research and Publication Ethics

Scheme Version:	Name of the subject:		L	T	P	C	Semester:	Contact Hours per Week: 2
2021-22	Research and Publication Ethics		2	0	0	2	III (2nd Year)	**Total Hours:** 30
Subject Code: SBS PHY 01 310 DCEC 2002	**Applicable to Programs:** M.Sc. Physics		**Evaluation (Total Marks: 100)**	CIE	15 Marks	**Examination Duration:** 1.5 Hours		
				TEE	35 Marks	**Prerequisite of Course:** None		
Course Description		The objective of the course is to familiarize the students with ethics of research and how to make publications						
Course Objectives		• To train student for research • To make students aware of IPR policy						
Course Outcomes		On completion of the course, the student should be able to: **CO310D.1**: Understand the basic ethics of research. **CO310D.2**: Maintain the research integrity and intellectual honesty. **CO310D.3:** Understand the scientific misconduct and proper citations. **CO310D.4**: Acquire knowledge of databases and software's.						

	COURSE SYLLABUS		
Unit No.		**Content of Each Unit**	**Hours of Each Unit**
1		**Theory: [Course Outcome(s): CO310D.1, CO310D.2]** RPE 01: Philosophy and Ethics (3 hrs.) 1. Introduction to philosophy: definition, concept, branches, nature and scope, 2. Ethics: definition, moral philosophy, nature of moral judgements and reactions RPE 02: Scientific Conduct (5 hrs.) 1. Ethics with respect to science and research 2. Intellectual honesty and research integrity 3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP) 4. Redundant publications: duplicate and overlapping publications, salami slicing 5. Selective reporting and misrepresentation of data RPE 03: Publication Ethics (7 hrs.) 1. Publication ethics: definition, introduction and importance 2. Best practices/standards setting initiatives and guidance: COPE, WAME, etc. 3. Conflicts of interest 4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types 5. Violation of publication ethics, authorship and contribution-ship 6. Identification of publication misconduct, complaints and appeals 7. Predatory publishers and journals	15
2		Practice: [Course Outcome(s): CO310D.3, CO310D.4] RPE 04: Open Access Publishing (4 hrs.) 1. Open access publications and initiatives 2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving polices	15

3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE 05: Publication Misconduct (4 hrs.)

A. Group Discussion (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

1. Use of plagiarism software like Turnitin, Urkund and other open source software tools

RPE 06: Databases and Research Metrics (7 hrs.)

A. Databases (4 hrs.)

1. Indexing databases Research Metrics
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score
2. Metrics: h index, g index, i10 index, almetrics

TEXT BOOKS

1. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance, 2019, ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

2. Chaddah, P., Ethics in Competitive Research: Do not get scooped; do not get plagiarized 2018, ISBN:978-9387480865.
3. Beall, J. Predatory publishers are corrupting open access, Nature, 489 (7415), 179-179, 2012. https://doi.org/10.1038/489179a

4. Resnik, D. B., What is ethics in research and why is it important, National Institute of Environmental Health Sciences, 1-10. Retrived from https://www.neihs.nih.gov/research/resources/bioethics/whatis/index.cfm

	2011. 5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, On Being a Scientist: A Guide to Responsible Conduct in Research: 3rd edition , National Academics Press 2009. Bird, A., Philosophy of Science, Routledge 2006. 6. MacIntyre, A., A Short History of Ethics, London 1967.

Astrophysics of Stars

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Astrophysics of Stars</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

III(2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 309 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Introduction to Astronomy and Astrophysics</td></tr>
<tr><td>Course Description</td><td colspan="7">Aim of the Course : Stars are the fundamental building blocks of the Universe. By injecting vast amounts of energy and momentum into their surround-ings, they act as drivers for the evolution of their host galaxies..</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Aim of this course is to understand in detail what goes on deep inside an object that, to us, is a mere pinprick of light in the sky.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to
CO307D.1 : quantify the basic parameters of stars.
CO307D.2 : understand how radiation interacts with matter at the surfaces of stars
CO307D.3 : Understand how to produce the spectra that we observe
CO307D.4 : know about the processes that determine the interior structure, composition and evolution of stars.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Stellar Observations : [Course Outcomes : CO307D.1]
Introduction, Distance & magnitude, Blackbody radiation, Colors & line spectra, Binary systems : visual binaries, Eclipsing & spectroscopic binaries, The Hertzsprung-Russel diagram, Spectral classification</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Stellar Atmospheres : [Course Outcomes : CO307D.2]

Stellar atmospheres, Describing radiation, Radiation & matter , Radiative transfer, The Eddington approximation, The grey atmosphere, Realistic model atmospheres, Opacity sources, Spectral features, Profile</td><td>15</td></tr>
</table>

	shapes, Line strengths	
3	Stellar Interiors : [Course Outcomes : **CO307D.4**] **Mechanical structure, The virial theorem, Polytropes, Equation of state, Energy conservation; diffusive transport, Mass-luminosity relation; main sequences, Convective transport, Energy generation, Nuclear fusion networks, Fusion rates, Rotation, Stellar model building**	15
4	Stellar Evolution : [Course Outcomes : **CO307D.3]** **The main sequence, The Sun, Massive stars, Star formation, Pre-main-sequence evolution, Evolution off the main sequence, Helium burning & beyond, Stellar death, Stellar pulsation, White dwarfs, Neutron stars**	15
Text Books		
1. "An Introduction to Modern Stellar Astrophysics" , Bradley W Carroll and Dale A Ostlie (ISBN: 978-08053034830), Cambridge University Press (2017) 2. "Stellar Structure and Evolution", R. Kippenhahn & A. Weiger, (2012) Springer-Verlag Berlin Heidelberg 3. Structure and Evolution of the Stars, by M. Schwarzschild. (ISBN : 9780691652832), 2016, Princton University Press 4. Stellar Atmospheres, by Ivan Hubeny , Springer Verlag **5. Radiative Processes in Astrophysics : G. Rybiki and A. Lightmann, 2004 WILEY-VCH Verlag GmbH & Co.**		

Major Research Project

Scheme Version:	Name of the subject:		L	T	P	C	Semester:	Contact Hours per Week:
2021-22	Major Research Project		0	0		16	IV (2^{nd} Year)	Total Hours:
Subject Code: SBS PHY 01 401 DCEC 00016	Applicable to Programs: M.Sc. Physics		Evaluation (Total Marks: 100)	CIE	00	Examination Duration:3 hours		
				TEE	100 Marks	Prerequisite of Course: None		

Course Description		The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics according to the skill and merit of the students.
Course Objectives		• To make students familiar with approach to do literature survey • To make student capable of independent thinking • Students will learn basic techniques for carrying out research
Course Outcomes		After completion of this project, students will be able to learn about: **CO401.1.** Basic of literature review **CO401.2.** Techniques used for performing research **CO401.3.** Analyze the results and tabulate them in a proper manner **CO401.4.** How to write and dissertation, making presentation and viva etc.

Evaluation: The evaluation will be done by an external examiner. External examiner will award the grades based on quality of research work done recorded in dissertation and presentation made by student.

ADVANCED NULEAR PHYSICS

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:
Advanced Nuclear Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV (2^{nd} Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:
SBS PHY 01 401
DCEC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Mathematical Physics and Nuclear Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">To impart knowledge about nuclear deformations, properties and nuclear models for understanding of related reaction dynamics. Beside this students will be exposed to heavy ion physics and nuclear astrophysics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• Students will understand about the stability of nuclei away from the drip line and deformed nuclei
• Students will know the different theoretical approaches to explain the structure of nuclei
• Student will understand the basics of heavy ion nuclear physics and its correlation to Astrophysics</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After competitions of this course, the students will be able to

CO401D.1. Know the basic properties of deformed shapes of nuclei
CO401D.2. Understand the nuclear models to study the nuclear structure properties
CO401D.3. Understand the various aspects of heavy ion collisions nuclear</td></tr>
</table>

	astrophysics **CO401D.4.** Understand the nuclear astrophysics and related applications.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Nuclear deformations: [Course outcomes: CO401D.1:]** Effect of quadrupole deformations and higher multipole deformations, Nuclear orientation effect, static and dynamic deformations, deformed magic shells and related nuclear aspects, Importance of Exotic nuclear systems, halo shapes and bubble effect.	15
2	**Collective Model of Nucleus: [Course outcomes: CO401D.2:]** Collective motion, parameterization of nuclear surface, Rotation of deformed nuclei, Collective model Hamiltonian, nuclear wave function for even-even nuclei and odd-A nuclei, Rotation-vibrational coupling, Nilsson model, Cranking shell model.	15
3	**Heavy-Ion Physics: [Course outcomes: CO401D.3:]** Total Hamiltonian function, Scattering of deformed nuclei, Fusion fission dynamics, Radioactive ion beams, tightly and loosely bound interactions, Nuclear isomers, Nuclear Molecules, Nuclear Dynamics at Intermediate and high energies, Relativistic heavy ion collisions	15
4	**Nuclear Astrophysics: [Course outcomes: CO401D.4:]** Hot big bang cosmology, Primordial nucleosynthesis, Stellar nucleosynthesis, energy production in stars, pp chain, CNO cycle, production of elements. **Nuclear Applications**: Recent trends in nuclear structure physics and related important applications	15

TEXT BOOKS

1. Pal, M.K., Theory of Nuclear Structure, East-West Press Delhi, 1983.
2. Preston M. A. and Bhaduri R. K., Structure of Nucleus Addison-Wesley, 2000.
3. Lilley J.S., Nuclear physics principles and applications John Wiley & sons Ltd., 2007.
4. Krane K.S. Nuclear Physics, Wiley India Pvt. Ltd., 2008.

PARTICLE PHYSICS

Scheme Version: 2021-22	**Name of the subject:** Particle Physics	**L**	**T**	**P**	**C**	**Semester:** IV (2nd Year)	**Contact Hours per Week:** 4
		3	1	0	4		**Total Hours:** 60
Subject Code: SBS PHY 01 402 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Mathematical Physics and Quantum Mechanics, Nuclear Physics		
Course Description	To impart the knowledge of fundamental particles, fundamental interaction and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.						
Course Objectives	• Students will understand the different type of particles and interactions among them • Students will be able to understand the conservation laws in particle physics • Students will get to know the production cross section for particles • Students will understand the quark model.						
Course Outcomes	After completion of this course, the students will be able to **CO402D.1.** Need of standard model and its limitations and the properties of QCD.						

	CO402D.2. Basic rules of Feynman diagrams and the quark model for hadrons **CO402D.3.** Properties of neutrons and protons in terms of a simple quark model **CO402D.4.** . Weak interaction between quarks and how that this is responsible for β decay. **CO402D.5** Leptons and how the(electron) neutrinos and (electron) antineutrinos are produced during β+ and β- decays respectively	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Introduction: [Course outcomes: CO402D.1:]** Fermions and bosons, Particles and antiparticles, Quarks and leptons, Interactions and fields in particle physics, Classical and quantum pictures, Yukawa picture, Types of interactions - electromagnetic, weak, strong and gravitational, units.	15
2	**Invariance Principles and Conservation Laws: [Course outcomes: CO401D.2:]** Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem.	15
3	**Hadron-Hadron Interactions: [Course outcomes: CO401D.3:]** Cross section and decay rates, Pion spin, Isospin, Two-nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy.	15
4	**Static Quark model of Hadrons: [Course outcomes: CO401D.4, CO402D.5:]** The Eightfold way, Meson nonet, Baryon octet, Baryon Decuplet, hypothesis of quarks, SU (3) symmetry, Quark spin and color, Quark-antiquark combinations. **Weak Interactions:** Classification of weak interactions, Fermi theory, Weinberg-Salam model, Parity non-conservation in β-decay, Helicity of neutrino, Experimental verification of parity violation, K-decay.	15
	TEXT BOOKS	
	1. Perkins, D.H., Introduction to High Energy Physics, Cambridge University Press, 2000, 3rded. 2. Hughes, I.S., Elementary Particles, Cambridge University Press, 1991.	

3. Close, F.E., Introduction to Quarks and Partons, Academic Press, 1979.
4. Segre, E., Nuclei and Particles, Benjamin-Cummings, 1977.
5. Khanna, M.P., Introduction to Particle Physics, Prentice-Hall of India, 2004.

Experimental Techniques in Nuclear and Particle Physics

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject:

Experimental Techniques in Nuclear and Particle Physics</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV (2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 403 DCEC 3104</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation

(Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration:3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite of Course: Basics of Nuclear and Particle Physics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course is intended to familiarize the M.Sc. students to the experimental techniques used in the fields of nuclear physics and particle physics. Various detection techniques will be introduced followed by a description of on-detector and off-detector electronics.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• Get knowledge about various experimental techniques used in the fields of nuclear physics and particle physics.
• To get familiar with various detector systems and related electronics.</td></tr>
</table>

Course Outcomes	After completetion of this course, students would be able to: **CO403D.1.** Get knowledge about different types of radiations & their interaction with matter. **CO403D.2.** Understand the radiation exposure and its effects on biological system. **CO403D.3.** Learn about how to detect radiations. **CO403D.4.** Get knowledge about the various electronic components of radiation detectors and pulse signal processing. **CO403D.5.** Understand Learn about different existing detector facilities all around the world.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Radiation interactions: [Course Outcome(s): CO403D.1 & CO403D.2]** Nuclear processes in radioactive sources: types of radiations & radiation sources; Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. Radiation protection, Biological effects of radiation, radiation monitoring.	15
2	**Detection of radiations: [Course Outcome(s): CO403D.3]** General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Gas-filled detectors: Ionization chamber, Proportional counters, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Scintillation detector, Phoswich detectors, Cherenkov detector. Semiconductor detectors. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General Background and detector shielding.	15
3	**Detector electronics: [Course Outcome(s): CO403D.4]** Electronics for pulse signal processing, CR-$(RC)^n$ and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers, overload recovery and pileup, Linear	15

	amplifiers, single-channel analyser, analog-to-digital converters, multichannel analyzer. Basic considerations in time measurements; Walk and jitter, Time pickoff methods, time-to-amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM and CAMAC instrumentation standards and data acquisition system.	
4	**Experimental Facilities: [Course Outcome(s): CO403D.5]** Detector systems for heavy-ion reactions: Large neutron detector array, gamma and charge particle detector arrays, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments**:** basics of Collider physics, Modern Hybrid experiments- CMS and ALICE.	15
TEXT BOOKS		

1. **W.R. Leo,** Techniques for Nuclear and Particle Physics Experiments, Springer, Berlin Heidelberg, 2nd Edition, 1994.
2. **Konrad Kleinknecht**, Detectors for particle radiation, Cambridge University Press, 1999.
3. **Richard Fernow**, Introduction to Experimental Particle Physics, Cambridge University Press, 2001.
4. Glenn F. Knoll**,** Radiation Detection and Measurement, John Wiley & Sons, 4th Edition, 2010.

Cosmology

Scheme Version: 2021-22	Name of the subject: Cosmology	L	T	P	C	Semester: IV(^{2nd} Year)	Contact Hours per Week: 4
		3	1	0	4		**Total Hours:** 60

Subject Code: SBS **PHY 01 404 DCEC 3104**	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours
			TEE	70 Marks	**Prerequisite: Introduction to Astronomy and Astrophysics**

Course Description	**Cosmology** is a branch of astronomy that involves the origin and evolution of the universe, from the Big Bang to today and on into the future.
Course Objectives	The aim of this course is to introduce the model of the universe on large scales
Course Outcomes	On completion of the course, student would be able to **CO404D.1 :** Understand the concepts of STR and GTR **CO404D.2 :** Apply the concepts of GTR to cosmology **CO404D.3 :** Understand the model of expanding universe **CO404D.4 :** Explain the model of early universe and its thermal history.

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**Principles of Relativity: [Course Outcomes : CO404D.1]** Overview of Special Relativity - spacetime interval and Lorentz metric- four vectors - Introduction to general relativity (GR) - equivalence principle - notions of curvature	15
2	**Gravitation as a manifestation of the curvature of spacetime : [Course Outcomes : CO404D.2]** gravitational redshift and clock corrections - orbits in strong gravity, light bending and gravitational lensing - concept of horizon and ergosphere, hydrostatic equilibrium in GR - gravitational radiation.	15
3	**Cosmological Models: [Course Outcomes : CO404D.3]** Universe at large scales – Homogeneity and isotropy – distance ladder –Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble's law -	15

	Robertson-Walker metric - Observable quantities – luminosity and angular diameter distances - Horizon distance- Dynamics of Friedman- Robertson-Walker models: Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes.	
4	**Physical Cosmology and Early Universe: [Course Outcomes** : **CO404D.4**] Thermal History of the Universe - distribution functions in the early Universe – relativistic and nonrelativistic limits - Decoupling of neutrinos and the relic neutrino background - Nucleosynthesis - Decoupling of matter and radiation – Cosmic microwave background radiation (CMB)- Anisotropies in CMB - Inflation – Origin and growth of Density Perturbations - Formation of galaxies and large scale structures - Accelerating universe and type-Ia supernovae - The Intergalactic medium and reionization.	15

Text Books

1. Cosmological Physics, Cambridge University Press, J . A. Peacock

2. An Introduction to Relativity, J. V. Narlikar, Cambridge University Press, 2010

3. Theoretical Astrophysics, Volume III: Galaxies and Cosmology,
T. Padmanabhan,Cambridge University Press, 2002 (for lectures on Cosmology)

4. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press, 1994 (For more material on General Relativity).

5. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993 (For the lectures on Cosmology).

6. First course in general relativity, B. F. Schutz, Cambridge university press, 1985 (For material on General Relativity).

7. Structure Formation in the Universe. T. Padmanabhan, Cambridge University Press, 1995 (for material on Cosmology and Structure formation).

Astronomy Laboratory

<table>
<tr><td rowspan="2">Scheme Version:

2021-22</td><td rowspan="2">Name of the subject: Astronomy Laboratory</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV(2nd Year)</td><td>Contact Hours per Week: 4</td></tr>
<tr><td>0</td><td>0</td><td>8</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code: SBS PHY 01 405 DCEC 0084</td><td rowspan="2">Applicable to Programs: M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks: 100)</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Prerequisite: Introduction to Astronomy and Astrophysics</td></tr>
<tr><td>Course Description</td><td colspan="7">This course shall be providing the tools and know-how to apply the principles of astronomy first-hand.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The aim of this course to make students aware about different softwares (e.g. stellarium etc.) available to simulate night sky and observe astronomical phenomenon.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, student would be able to

CO307D.1 : become familiar with astronomical coordinate system

CO307D.2 : Study the spectrum of celestial objects

CO307D.3 : observe the distance of planets

CO307D.4 : observe the proper motion of stars</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content of Each Unit</td><td>Hours of Each Unit</td></tr>
<tr><td>1</td><td colspan="6">Getting to know : [Course Outcomes : CO307D.1]
Experiment 1 : To become familiar with night sky

Experiment 2: Becoming Familiar with Constellations

Experiment 3: Retrograde motion of Planets</td><td>15</td></tr>
<tr><td>2</td><td colspan="6">Spectral Analysis : [Course Outcomes : CO307D.2]
Experiment 4: Study of solar spectrum</td><td>15</td></tr>
</table>

	Experiment 5: Spectral classification of stars Experiment 6: Extracting position of a star	
3	Stellar Motions : [**Course Outcomes : CO307D.4**] Experiment 7: Cepheid Variables Experiment 8: To measure the Proper Motion of Barnard's Star Experiment 9: Circumpolar Star	15
4	Stellar Distances : [**Course Outcomes : CO307D.3**] Experiment 10: Colour Magnitude Diagram Experiment 11:Orbital Inclination Experiment 12: Planetary Distances Experiment 13: Distance to the Moon	15

References

1. http://www3.gettysburg.edu/~marschal/clea/Vireo.html
2. https://astro.unl.edu/vlabs/
3. http://va-iitk.vlabs.ac.in/
4. https://www.astro.indiana.edu/catyp/minilabs.html
5. https://depts.washington.edu/naivpl/content/welcome-virtual-planetary-laboratory

FERROELECTRICITY AND MAGNETISM

Scheme Version:	**Name of the subject:**	**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
2021-22	Ferroelectricity and Magnetism	3	1	0	4	IV (2nd Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 406 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** Graduation Level Solid-State Physics		
Course Description	This course is designed to convey the understanding about dielectric, ferroelectric, and magnetic materials, which possess several breakthrough applications in actuators, sensors, energy storage devices, data storage devices etc.						
Course Objectives	• To understand the fundamentals of dielectric, ferroelectric and magnetism phenomenon in solids • To make acquainted with several types of electric and magnetic materials and their exciting properties • To aware the students about industrial applications of ferroelectric and magnetic materials • To develop the positive and scientific attitudes and analytical thinking in the students related to materials science						
Course Outcomes	After competitions of this course, the students will be able to **CO406D.1.** explain the dielectric phenomenon in crystals with their exciting						

	properties **CO406D.2.** interpret the theory of polarization and components of polarizability of polar dielectrics **CO406D.3.** learn the basics of ferroelectric and piezoelectric crystals **CO406D.4.** understand the applications of ferroelectric and piezoelectric materials in various electronic devices **CO406D.5.** describe the diamagnetism and paramagnetism phenomenon in solids, specifically the magnetic susceptibility behavior with temperature **CO406D.6.** evaluate the paramagnetic susceptibility of iron group ions, rare earth ions,and conduction electrons **CO406D.7.** compare the general mechanism of ferro, ferri, and anti-ferro magnetic materials **CO406D.8.** recognize some new ferromagnetic materials which possess intriguing applications in data storage devices	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1	**Theory of Dielectrics [Course Outcome(s): CO406D.1 & CO406D.2]** Introduction, The Microscopic Concept of Polarization, Langevin's Theory of Polarization in Polar Dielectrics, Internal-Field or Local Field, Clausius-Mossotti Relation, Components of Polarizability: Electronic Polarizability; Ionic Polarizability; Orientational Polarizability; Total Polarizability, Measurement of Dielectric Constant, Dielectric Losses, Optical Phenomena.	15
2	**Ferroelectric Crystals [Course Outcome(s): CO406D.3 & CO406D.4]** Representative Crystal Types of Ferroelectrics: Properties of Rochelle Salt and Barium Titanate, Ferroelectric Displacive Transitions, Landau Theory of Phase Transition: Second-Order Transitions; First-Order Transitions, Antiferroelectricity, Ferroelectric Domains,	15

	Piezoelectricity, Electrostriction, Applications of Ferroelectric Crystals.	
3	**Diamagnetism and Paramagnetism [Course Outcome(s): CO406D.5 & CO406D.6]** Langevin's Theory of Diamagnetism, Quantum Theory of Diamagnetism: Mononuclear Systems, Langevin's Theory of Paramagnetism, Quantum Theory of Paramagnetism: Rare Earth Ions; Hund Rule; Iron Group Ions; Crystal Field Splitting, Van Vleck Paramagnetism, Nuclear Paramagnetism, Cooling by Adiabatic Demagnetization, Paramagnetic Susceptibility of Conduction Electrons.	15
4	**Ferromagnetism and Antiferromagnetism [Course Outcome(s): CO406D.7 & CO406D.8]** Ferromagnetic Order: Weiss Theory of Ferromagnetism; The Exchange Interaction; The Heisenberg Model, Ferrimagnetic Order: Curie Temperature and Susceptibility of Ferrimagnets, Antiferromagnetic Order, Ferroelectric Domains: Anisotropy Energy; The Bloch Wall; Origin of Domains; Coercivity and Hysteresis, Spin Waves: Magnons in Ferromagnets; The Bloch $T^{3/2}$ Law, Determination of Magnetically Ordered Structures, Some New Magnetic Materials: GMR-CMR Effects.	15

TEXT BOOKS

1. **S. Blundell**, Magnetism in Condensed Matter, Oxford, UK, 1st Edition, 2001.
2. **M.E. Lines and A. M. Glass**, Principles and Applications of Ferroelectrics and Related Materials, Oxford University Press, UK, 2001.
3. **M. A. Omar**, Elementary Solid State Physics, Pearson, India, 1st Edition, 2002.
4. **B. D. Culity and C. D. Grahim**, Introduction to Magnetic Materials, Wiley, USA, 2nd Edition, 2008.
5. **K. Uchino**, Ferroelectric Devices, CRC Press publication, Taylor and Francis Group, 2nd Edition, 2010.
6. **C. Kittel**, Introduction to Solid State Physics, John Wiley and Sons, USA, 8th Edition, 2012.
7. **M. P. Marder**, Condensed Matter Physics, Wiley, USA, 2nd Edition, 2015.

VACUUM SCIENCE AND THIN FILM TECHNOLOGY

<table>
<tr><td rowspan="2">Scheme Version:

2021-2022</td><td rowspan="2">Name of the Subject:

Vacuum Science and Thin Film Technology</td><td>L</td><td>T</td><td>P</td><td>C</td><td rowspan="2">Semester:

IV (2nd Year)</td><td>Contact hours per week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>Total Hours: 60</td></tr>
<tr><td rowspan="2">Subject Code:

SBS PHY 01 407
DCEC 3104</td><td rowspan="2">Applicable to Programs:

M.Sc. Physics</td><td rowspan="2">Evaluation (Total Marks): 100</td><td>CIE</td><td>30 Marks</td><td colspan="3">Examination Duration: 3 hours</td></tr>
<tr><td>TEE</td><td>70 Marks</td><td colspan="3">Pre-requisite of course:</td></tr>
<tr><td>Course Description</td><td colspan="7">The central objective of the course is to provide basic understanding of physics and technology behind thin film growth. Possible applications demonstrating novel material designs and case studies in technological areas of current interest will be discussed.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">• Understand vacuum fundamentals essential to operating, maintaining, designing, or using vacuum systems.
• Know the working principles and limitations of pumps, gauges, and other vacuum system components.
• Learn the design concepts involved in matching equipment and instrumentation to applications.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="7">On completion of this course, student will learn:

CO407.1 Understand the Kinetic Theory of Gases, mean free path and the physical concepts behind the thin film depositions.

CO407.2 Understand the kinetic theory of nucleation, growth and diffusion phenomenon

CO407.3 Understand the basics of vacuum science and technology, Vacuum pumps and gauges and use of various vacuum based techniques for development of thin film-based</td></tr>
</table>

	materials, structures, and plasma devices and systems. **CO407.4** Familiarize with the physical concepts of lithography behind the solid-state electronics devices design patterns. **CO407.5** Understand certain experimental techniques for characterization of thin films for their structural, morphological, surface topology, electrical, mechanical and optical properties. **CO407.6** Design protocols for thin film deposition, characterization and various applications.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
1.	**The physics of gases and vacuum systems: [Course Outcome (s): CO407.1 & CO407.2]** Gas kinetics, Maxwell-Boltzmann distribution, molecular impingement flux, Knudsen equation, mean free path, transport properties, Evaporation: thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, deposition monitoring techniques, Deposition: adsorption, surface diffusion, nucleation, structure development, interfaces, stress, adhesion.	15
2.	**Vacuum Science and deposition techniques: [Course Outcome (s): CO407.3]** Basics of vacuum science, creation of vacuum using different pumps, vacuum gauges, vacuum leak detection, helium leak detector, residual gas analyzer. Thermal evaporation and electron beam evaporation system, idea of DC and R.F. sputtering system, Methods of producing thin films using Physical vapour deposition, Chemicals Vapour Deposition and spray pyrolysis methods, Molecular Beam Epitaxy and Laser Ablation methods for thin film deposition.	15

3.	**Lithography: [Course Outcome (s): CO407.4 & CO407.5]** Importance of lithography, Basic steps of lithography, Substrate preparation methods, Positive photoresist, Negative photoresist, photoresist Processing, photoresist coating methods, Resist Exposure (single, bi-layer and multi-level photoresist exposure) and Resist Development, soft backing and hard baking, Etching, Types of lithography, Photolithography, Idea of electron beam lithography, Idea of an X-ray lithography, Interference Lithography, Step Growth, Nano imprint, Self-Assembly, Nano templates.	15
4.	**Thin Film Analysis and Applications: [Course Outcome (s): CO407.6]** Film analysis: structure-thickness, topography, inhomogeneity, crystallography, bonding, point defects, composition, optical, electrical and mechanical behavior of thin films. Thin film technology applications: optical windows, integrated circuits, micro-electro-optomechanical systems and photovoltaics.	15

REFERENCE BOOKS

1. Chopra, K.L., Thin Film Phenomena, Robert E. Krieger publishing, 1969.
2. Smith, D.L., Thin-Film Deposition: Principles and Practice, McGraw-Hill, 1995.
3. Hummel, R. E. and Guenther, K.H., Handbook of Optical Properties: Thin Films for Optical Coatings, Volume 1, CRC Press, 1995.
4. Ohring, M., The Materials Science of Thin Films, 2nd Edition, Academic press, 2002.
5. Soriaga, M.P., Stickney, J., Bottomley, L.A., and Kim Y.G, Thin Films: Preparation, Characterization, Applications, Springer Science 2011.

Advanced Carbon Materials

Scheme Version:	Name of the subject:	L	T	P	C	Semester:	Contact Hours per Week: 4
2021-22	Advanced Carbon Materials	3	1	0	4	I (1st Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 408 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks: 100)**	**CIE**	30 Marks	**Examination Duration:** 3 hours		
			TEE	70 Marks	**Prerequisite of Course:** None		
Course Description	This course aims to introduce students to the advanced carbon material that includes graphene, fullerenes, hierarchical carbon, and CNTs are referred to as strength of revolution and advancement in the era of material science and technology. In general, 20th century corresponds to plastic meanwhile 21st century will be named as "Century of Graphene" owing to its exceptional physical properties.						
Course Objective	On completion of the course, student would be able:						

	• To understand various properties of Graphene, CNTs and Fullerenes
Course Outcomes	On completion of the course, student would be able: **CO408D.1.** To understand the basic properties of carbon **CO408D.2.**To understand the various properties and applications of graphene **CO408D.3.**To understand the various properties and applications of CNT **CO408D.4.**To understand the various properties and applications of fullerenes

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours of Each Unit
1	**INTRODUCTION [Course Outcome(s): CO408D.1.]** Carbon atomic structure and hybridization, carbon on the Earth and in outer space, carbon in technology and economy, carbon isotopes: classification of carbon allotropes, conversion of one allotropic form into another, phase diagram of carbon, new carbon structures: discovery of C_{60}, Graphene and Nanotubes	**15**
2	**GRAPHENE [Course Outcome(s): CO408D.2.]** Structure of graphene; Preparation of graphene – synthesis of graphene by various physical and chemical methods and Purification; Electronic Properties – Band Structure of Graphene - Mobility and Density of Carriers - Quantum Hall Effect – Characterization of graphene: Raman Spectroscopy, Infrared Spectroscopy, Absorption and Photoluminescence Spectroscopy, Atomic Force Microscopy, Application of graphene	**15**
3	**CARBON NANOTUBES [Course Outcome(s): CO408D.3.]** The Structure of Carbon Nanotubes- Nomenclature, Structure of Single-Walled Carbon Nanotubes and Structure of Multiwalled Carbon Nanotubes; Synthesis of CNT by various physical and chemical methods and Purification, Characterization of Carbon Nanotubes: Raman and Infrared Spectroscopy of Carbon Nanotubes, Absorption and Emission Spectroscopy of Carbon Nanotubes, ESR-Spectroscopic Properties of Carbon Nanotubes.	**15**

	Application of CNTs	
4	**FULLERENES [Course Outcome(s): CO408D.4.]** Structure and Bonding- Nomenclature, The Structure of C60, Structure of Higher Fullerenes - Growth Mechanisms; Production and Purification- Fullerene Preparation by Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Production by Resistive Heating, Rational Syntheses; Physical Properties-, Spectroscopic Properties, Thermodynamic Properties; Chemical Properties- Hydrogenation and Halogenation, Nucleophilic Addition to Fullerenes. Application of Fullerenes	**15**

TEXT BOOKS

1. **M.S. Dresselhaus, G. Dresselhaus and P.C. Eklund,** Science of Fullerenes and Carbon Nanotubes, Elsevier, 1996.
2. **Yury Gogotsi**, Carbon Nanomaterials, Taylor and Francis, 2006.
3. **Francois Leonard,** The Physics of Carbon Nanotube Devices, Elsevier, 2008.
4. **Anke Krueger**, Carbon Materials and Nanotechnology, Wiley-VCH, 2010.
5. **D.R. Askeland**, **P.P. Phule**, **W.J. Wright**, The Science and Engineering of Materials, 6th ed., Cengage Learning, 2010.
6. **Jamie H. Warner, Franziska Schäffel, Mark H. Rümmeli,** Graphene: Fundamentals and emergent applications, Elsevier, 2013.
7. **T. Pradeep**, NANO: The Essentials- Understanding Nanoscience and Nanotechnology, McGraw Hill Education, 2017.
8. **Deborah D L Chung**, Carbon Materials: Science and Applications, World Scientific, 2019.

Minor Research Project

Scheme Version: 2021-22	**Name of the subject:** Minor Project		**L**	**T**	**P**	**C**	**Semester:**	**Contact Hours per Week:** 4
			0	0		4	IV (2nd Year)	**Total Hours:** 60
Subject Code: SBS PHY 01 409 DCEC 00016	**Applicable to Programs:** M.Sc. Physics		**Evaluation (Total Marks: 100)**	**CIE**	00	**Examination Duration:** 3 hours		
				TEE	100 Marks	**Prerequisite of Course:** None		
Course Description		The minor project topic will be decided on the basis of student skill and interest. On mentor will be allocated to student for discussion and direction.						

Course Objectives		• Student will have idea about the literature survey and how to write an overview.
Course Outcomes		After completion of this project, students will be able to learn about: **CO401.1.** Basic of literature review **CO401.2.** Learn how to do research **CO401.3.** How to write a report. **CO401.4.** Present the work done in minor project.

Evaluation: The evaluation will be done by a Departmental committee constituted by Head of the Department. Committee will award the grades based on quality of project work done and presentation made by student.

INTRODUCTION TO HYDROGEN ENERGY SYSTEMS

Scheme Version: 2021-2022	**Name of the Subject:** Introduction to Hydrogen Energy Systems	**L**	**T**	**P**	**C**	**Semester:**	**Contact hours per week: 4**
		3	**1**	**0**	**4**	**IV** (2nd Year)	**Total Hours: 60**
Subject Code: SBS PHY 01 410 DCEC 3104	**Applicable to Programs:** M.Sc. Physics	**Evaluation (Total Marks):** 100	**CIE**	**30 Marks**	**Examination Duration: 3 hours**		
			TEE	**70 Marks**	**Pre-requisite of course:** None		
Course Description	To introduce the concept of energy generation from Hydrogen as future fuel. To enlighten the knowledge of production, storage and transportation.						
Course Objectives	This course aim is to give insight of hydrogen production, storage and their application, as a future source of energy.						

Course Outcomes:	On completion of this course, student will learn: **CO410.1** The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues. **CO410.2** There is very good scope for saving energy, by using it judiciously. During these days of saving the environment, energy conservation plays a vital role. The government of India has passed Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. By observing energy efficient measures there is tremendous scope of saving energy in industry, built environment, transport etc. **CO410.3** To teach fundamentals of hydrogen energy as energy systems, production processes, separation and utilization that is necessary for taking some important elective subjects as well as to increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors. **CO410.4** This course has objectives to elaborate PG students regarding current trends in hydrogen energy architecture and following key concepts such as hydrogen storage and hydrogen sensing. **CO410.5**. To Provide adequate inputs on a variety of issues relating to safety guidelines, codes and standards in hydrogen energy systems.	
	COURSE SYLLABUS	
Unit No.	**Content of Each Unit**	**Hours of Each Unit**
5.	**Hydrogen energy pathways:[Course Outcome (s): CO410.1 & CO410.2]** **Hydrogen Energy Pathways-** Properties of hydrogen, Global and Indian hydrogen energy scenario, need for hydrogen, current uses, environmentally sustainable hydrogen, hydrogen as part of Climate Neutral Strategy. Hydrogen for mobility applications & vehicles, Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications.	15
6.	**Hydrogen production and separation: [Course Outcome (s): CO410.3]** **Hydrogen Production-**Production of hydrogen from hydrocarbons-oxidative and nonoxidative processes, coal. Hydrogen production using nuclear energy and renewables- wind, biomass, solar. **Hydrogen separation and purification-**Pressure swing adsorption, Solvent based absorption, membrane separation, cryogenic separation etc.	15
7.	**Hydrogen storage: [Course Outcome (s): CO410.4]** **Hydrogen Storage -**Types of hydrogen storage (Gaseous, Liquid, Solid hosts), Gibbs Phase Rule, Pressure-Composition-Temperature plots; Van't Hoff plots for absorption desorption enthalpies, Gravimetric capacities, Hysteresis in cycling, Joule-Thomson Effect, Non-ideal treatment of hydrogen gas Kinetics: Hydrogen absorption/desorption phenomena (chemisorption, nucleation and growth and diffusion), Kinetic models, Kissinger analysis for activation energy estimation, Hydrogen adsorption	15

	isotherms-BET, design and applications of storage systems, materials for hydrogen storage, Hydrogen storage for automobiles.	
8.	**Hydrogen sensing and safety**: **[Course Outcome (s): CO410.4& CO410.5]** **Hydrogen sensing-**Traditional methods of hydrogen sensing using thermal conductivity measurements or Gas Chromatography, Mass Spectroscopy or laser gas analysis; Solid state sensors- their working principle and applications at industrial scale. **Hydrogen Safety-**Physiological, physical and chemical hazards, hydrogen properties associated with hazards, Hazard spotting, evaluation and safety guidelines, Hydrogen safety codes and standards. Hydrogen safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management.	15

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9. TEACHING-LEARNING PROCESS

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

10. IMPLEMENTATION OF BLENDED LEARNING

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasises student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimises and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;

- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: Resolution no (c) as per minutes circulated by VC office**:** It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, be adopted

11. ASSESSMENT AND EVALUATION

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. KEYWORDS

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. REFERENCES

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- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

14. APPENDICES