CURRICULUM AND SYLLABUS

B.Sc. (Honours/ Honours with research) Programme
in
Applied Physics with a minor in
Scientific Computing / Astrophysics

REGULATIONS

for students admitted from the year 2024

PROGRAM OUTCOMES (PO)

Students of all Integrated/PG degree Programmes at the time of graduation will be able to:

PO1. Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2. Problem Solving: Understand and solve problems of relevance to society to meet the specified needs using the knowledge, skills and attitudes acquired from humanities/ sciences/ mathematics/ social sciences.

PO3. Computational Thinking: Understand data-based reasoning through translation of data into abstract concepts using computing technology-based tools.

PO4. Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

PO5. Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO6. Effective Citizenship: Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

PO7. Global Perspective: Understand the economic, social, and ecological connections that link the world's nations and people.

PO8. Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

PO9. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO10. Self-directed and Life-long Learning: Acquire the ability to engage in independent and Lifelong learning in the broadest context of socio-technological changes.

PO11. Employment Ready Skills: knowledge and a basket of essential skills, required to perform effectively in a defined job relating to the chosen fields of study.

PO12. Research Related Skills: the ability to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships.

PO13. Digital Literacy: Use ICT in a variety of learning and work situations, access, evaluate, and use a variety of relevant information sources, and use appropriate software for analysis of data.

PO14. Leadership and Responsibility: Mapping out the tasks of a team or an organization and setting direction. formulating an inspiring vision and building a team that can help achieve the vision, motivating and inspiring team members to engage with that vision, using management skills to guide people to the right destination.

PO15. Coordinating and Collaborating: work effectively and respectfully with diverse teams, facilitate cooperative or coordinated effort on the part of a group, act together as a group or a team in the interests of a common cause, and work efficiently as a member of a team.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: Students will demonstrate proficiency in mathematics and the mathematical concepts needed for a proper understanding of physics.

PSO2: Students will demonstrate knowledge of classical mechanics, electromagnetism, quantum mechanics, and thermal and statistical physics, and be able to apply this knowledge to analyze a variety of physical phenomena and related subjects.

PSO3: Students will acquire experimental skills that enable them to take precise measurements in labs and analyze the measurements to draw valid conclusions. In addition, students will exhibit skills in solving problems numerically using computerprogramming, plotting tools, and related software.

PSO4: Use of in-house laboratory setup for building instrumentation, and skills for Integrating and interpreting data and to Evaluate the research findings in materials sciences and astrophysics.

PSO5: Students will show enhanced oral and written scientific communication skills and be able to think critically and work independently as well as in a team and play beneficial role in society as a person with a better scientific outlook.

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CURRICULUM

2024 admission onwards

1. Curriculum

Course Code	Course Title	L T P	Cr	Course Code	Course Title	L T P	Cr
SEMESTER 1				**SEMESTER 2**			
24ENG101	English I	2 0 0	2	24ENG111	English II	1 0 2	2
	Language I	2 0 0	2		Language II	2 0 0	2
24CHY101	Chemistry I	3 0 0	3	24CHY111	Chemistry II	3 0 0	3
24PHY101	Problem Solving and Computer Programming: Introduction to Python	3 0 0	3	24PHY111	Biomedical instrumentation	3 1 0	4
24MAT104	Matrices and Vector Calculus	3 1 0	4	24MAT114	Trigonometry and Differential Equations	3 1 0	4
24PHY102	Mechanics and Properties of Matter	3 1 0	4	24PHY112	Basics of Electricity and Magnetism	3 1 0	4
24CHY181	Chemistry Lab I	0 0 2	1	24CHY182	Chemistry Lab II - Instrumental	0 0 2	1
24PHY181	Problem-Solving and Computer Programming Lab	0 0 2	1	24PHY182	Physics Lab I - Mechanics and Properties of Matter	0 0 2	1
22ADM101	Foundations of Indian Heritage	2 0 1	2	22ADM111	Glimpses of Glorious India	2 0 1	2
22AVP103	Mastery Over Mind	1 0 2	2	24CUL100	I AM TECH		P/F
	TOTAL		**24**		**TOTAL**		**23**
SEMESTER 3				**SEMESTER 4**			
24PHY201	Optics and Wave Motion	3 1 0	4	24PHY211	Introduction to Quantum Physics	3 1 0	4
24PHY202	Basic Electronics	3 1 0	4	24PHY212	Intermediate Mechanics	3 1 0	4
24PHY203	Basic experimental techniques in physics	3 1 0	4	24PHY213	Mathematical Physics II	3 1 0	4
24PHY204	Mathematical Physics I	3 1 0	4	24PHY282	Physics Lab III - Optics	0 0 2	1
24ENV200	Environmental Science and Sustainability	3 1 0	4	24PHY298*	Open Elective II / MOOC*	3 0 0 / 0 1 2	3
24PHY281	Physics Lab II – Heat, Electricity and Magnetism	0 0 2	1	23LSK211	Life Skills II	1 0 2	2
	Open Elective I	3 0 0 / 0 1 2	3		Amrita Value Programme II	1 0 0	1
23LSK201	Life Skills I	1 0 2	2		Minor Course I	3 1 0/3 0 2	4
	Amrita Value Programme I	1 0 0	1				
	TOTAL		**27**		**TOTAL**		**23**
SEMESTER 5				**SEMESTER 6**			
24PHY301	Atomic and Molecular Physics	3 1 0	4	24PHY311	Solid State Physics	3 1 0	4
24PHY302	Thermal Physics	3 1 0	4	24PHY312	Classical Mechanics	3 1 0	4
24PHY303	Electrodynamics	3 1 0	4	24PHY313	Nuclear and Particle Physics	3 1 0	4
24PHY304	Advanced Electronics	3 1 0	4	24PHY382	Physics Lab V – Basic Electronics	0 0 2	1
24PHY381	Physics Lab IV – Modern Physics	0 0 2	1		Minor Course III	3 1 0/3 0 2	4
	Open Elective III	3 0 0 /0 1 2	3		Minor Course IV	3 1 0/3 0 2	4
23LSK301	Life Skills III	1 0 2	2				
	Minor Course II	3 1 0/3 0 2	4				
	TOTAL		**26**		**TOTAL**		**21**
					***Exit with a 3-year UG Degree**		**144**
SEMESTER 7				**SEMESTER 8**			
24PHY401	Quantum Mechanics	3 1 0	4		Elective II	3 0 0	3
24PHY402	Research Methodology	2 1 1	4		Elective III	3 0 0	3
24PHY481	Physics Lab VI – Advanced Electronics	0 0 4	2	24PHY498	Project		10
24PHY482	Physics Lab VII - Advanced Physics Lab	0 0 4	2		TOTAL		16
	Elective I	3 0 0	3		**Exit with a 4-year UG Degree (Honours)		183
	Minor Course V	3 1 0/3 0 2	4	24PHY499	Dissertation		16
24PHY496$ /24PHY497*	Internship$ / Project*		4		TOTAL	16	
	TOTAL		**23**				
					*****Exit with a 4-year UG Degree (Honours with Research)**		**183**

* The student will be awarded a 3-year bachelor's degree after six semesters of study.

**The student will be awarded a 4-year bachelor's degree (Honours) after eight semesters of study.

$ Internship may be carried out during the summer, after the end of the 6th semester. The Credit will be given in the following 7th semester.

2. Interdisciplinary Minor Courses

Course Code	Course Title	L T P	Cr
Course Requirements for Minor in Scientific Computing			
Mandatory Courses for Minor in Scientific Computing (12 Credits)			
Course Code	**Course Title**	**L T P**	**Cr**
24CSA230	Introduction to Data Structures and Algorithms (Physics)	3 0 2	4
24MAT230	Numerical Methods	3 0 2	4
24PHY230	Computational Methods in Physics	3 0 2	4
Scientific Computing Soft Core Options (any two) (6/8 Credits)			
24CSA343	Introduction to Machine Learning	3 0 2	4
24CSA344	Advanced Machine Learning	3 0 2	4
24MAT347	Optimization Techniques	3 0 2	4
24PHY331	Principles of Remote Sensing	2 0 2	3
24PHY332	Advanced Remote Sensing§ (Prereq: Principles of Remote Sensing)	3 0 2	4
24PHY333	Satellite Meteorology	3 0 2	4
24PHY334	Numerical Weather Prediction	3 0 2	4
	Total Credits for Minor in Scientific Computing		**19/20**
Course Requirements for Minor in Astrophysics			
Mandatory Courses for Minor in Astrophysics (12 Credits)			
24PHY241	Introduction to Astrophysics	3 1 0	4
24PHY242	Introduction to Indian Astronomy	3 1 0	4
24PHY243	Astronomical Techniques	3 0 2	4
Astrophysics Soft Core Options (any two) (8 Credits)			
24PHY341	Planetary Sciences	3 1 0	4
24PHY342	Stellar Structure and Evolution	3 1 0	4
24PHY343	Formation, Structure and Dynamics of Galaxies	3 1 0	4
24PHY344	General Relativity and Cosmology	3 1 0	4
24PHY345	Computational Methods in Astronomy	3 1 0	4
24PHY333	Satellite Meteorology	3 0 2	4
	Total Credits for Minor in Astrophysics		**20**

Students can decide on any minor courses in the 3rd semester. All the five Interdisciplinary Minor Courses are completed at the end of the seventh semester.

§ May be offered once in two years depending on availability and demand and subject to other constraints. Certain courses are either only in odd or even semesters.

3. Discipline Specific Elective (DSE)

Electives (I, I, III)

Course Code	Course Title	L T P	Cr	Course Code	Course Title	L T P	Cr
24PHY431	Introduction to Photonics	3 0 0	3	24PHY447	Physics of Cold Atoms and Ions	3 0 0	3
24PHY432	Biophotonics	3 0 0	3	24PHY448	Introduction to Quantum Computing	3 0 0	3
24PHY433	Nanophotonics	3 0 0	3	24PHY449	Quantum Electrodynamics	3 0 0	3
24PHY434	Physics of Semiconductor Devices	3 0 0	3	24PHY450	Quantum Optics	3 0 0	3
24PHY435	Principles of Lasers and Laser Applications	3 0 0	3	24PHY451	Computational Methods for Physicists	3 0 0	3
24PHY436	Nonlinear Optics	3 0 0	3	24PHY452	FOSS in Physical Sciences	2 0 2	3
24PHY437	Nonlinear Dynamics	3 0 0	3	24PHY453	Introduction to Nanophysics and Applications	3 0 0	3
24PHY438	Optical Engineering	3 0 0	3	24PHY454	Concepts of Nanophysics and Nanotechnology	3 0 0	3
24PHY439	Fibre-optic Sensors and Applications	3 0 0	3	24PHY455	Thin Film Technology	3 0 0	3
24PHY440	Fibre Optics and Technology	3 0 0	3	24PHY456	Micro and Nano Magnetism Materials and its Applications	3 0 0	3
24PHY441	Fundamentals of Plasma Physics	3 0 0	3	24PHY457	X-ray Diffraction and its Applications	3 0 0	3
24PHY442	Space Physics	3 0 0	3	24PHY458	Methods of Experimental Physics	3 0 0	3
24PHY444	Physics of the Atmosphere	3 0 0	3	24PHY459	Solar energy conversion	3 0 0	3
24PHY445	Elementary Meteorological Theory	3 0 0	3	24PHY460	Fabrication of Advanced Solar cell	3 0 0	3
24PHY446	Nuclear Physics	3 0 0	3				

Discipline Specific Elective courses will be chosen from the above list that focus on the applied aspects of physics toward advanced technology.

Open electives offered by the department							
24OEL331	Atmospheric Physics	3 0 0	3	24OEL336	Physical Sciences For All	3 0 0	3
24OEL332	Indian Contribution to Science	3 0 0	3	24OEL337	Physics of the Earth	3 0 0	3
24OEL333	History and Philosophy of Science	3 0 0	3	24OEL338	Physics For All	3 0 0	3
24OEL334	Non-conventional energy resources	3 0 0	3	24OEL339	Physics in everyday life	2 0 1	3
24OEL335	Science, Society and Culture	3 0 0	3				

4. Languages

	Paper I				Paper II		
24MAL101	Malayalam I	2 0 0	2	24MAL111	Malayalam II	2 0 0	2
24HIN101	Hindi I	2 0 0	2	24HIN111	Hindi II	2 0 0	2
24KAN101	Kannada I	2 0 0	2	24KAN111	Kannada II	2 0 0	2
24SAN101	Sankrit I	2 0 0	2	24SAN111	Sanskrit II	2 0 0	2
24TAM101	Tamil I	2 0 0	2	24TAM111	Tamil II	2 0 0	2
24ENG100	Additional English – I	2 0 0	2	24ENG110	Additional English - II	2 0 0	2

AMRITA VALUE PROGRAMMES FOR UG PROGRAMMES

Course Code	Title	L-T-P	Credits
22ADM201	Strategic Lessons from Mahabharatha	1-0-0	1
22ADM211	Leadership from Ramayana	1-0-0	1
22AVP210	Kerala Mural Art and Painting	1-0-0	1
22AVP201	Amma’s Life and Message to the modern world	1-0-0	1
22AVP204	Lessons from the Upanishads	1-0-0	1
22AVP205	Message of the Bhagavad Gita	1-0-0	1
22AVP206	Life and Message of Swami Vivekananda	1-0-0	1
22AVP207	Life and Teachings of Spiritual Masters of India	1-0-0	1
22AVP208	Insights into Indian Arts and Literature	1-0-0	1
22AVP213	Traditional Fine Arts of India	1-0-0	1
22AVP214	Principles of Worship in India	1-0-0	1
22AVP215	Temple Mural Arts in Kerala	1-0-0	1
22AVP218	Insights into Indian Classical Music	1-0-0	1
22AVP219	Insights into Traditional Indian Painting	1-0-0	1
22AVP220	Insights into Indian Classical Dance	1-0-0	1
22AVP221	Indian Martial Arts and Self Defense	1-0-0	1
22AVP209	Yoga and Meditation	1-0-0	1

5. Open Electives

† One Open Elective course has to be taken by each student, at the 3rd, 4th, and 5th semester, from the list of Open electives offered by other departments of the school.

6. Evaluation Pattern

50:50 (Internal: External) (All Theory Courses)

Assessment	Internal	External
Mid Term	30	
*Continuous Assessment (CA)	20	
End Semester		50

80:20 (Internal : External) (Lab courses and Lab based Courses having 1 Theory hour)

Assessment	Internal	External
*Continuous Assessment(CA)	80	
End Semester		20

70:30 (Internal : External) (Lab-based courses having 2 Theory hours/ Theory andTutorial); Theory - 60 Marks; Lab - 40 Marks

Assessment	Internal	External
Mid Term	20	
*Continuous Assessment(Theory) (CAT)	10	
Continuous Assessment(Lab) (CAL)	40	
End Semester		30

65:35 (Internal : External) (Lab based courses having 3 Theory hours/ Theory and Tutorial)

Theory- 70 Marks; Lab- 30 Marks

Assessment	Internal	External
Mid Term	20	
*Continuous Assessment(Theory) (CAT)	15	
Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignment, Seminar, Projects, and Reports

7. Grading

Based on the performance in each course, a student is awarded at the end of the semester, a letter grade in each of the courses registered. Letter grades will be awarded by the Class Committee in its final sitting, without the student representatives. The letter grades, the corresponding grade points and the grade description are as follows:

Letter Grade	Grade Point	Grade Description
O	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0.00	Fail

Grades O to P indicate successful completion of the course.

8. Cumulative Grade Point Average (CGPA)

The overall performance of a student at any stage of the Degree programme is evaluated by the Cumulative Grade Point Average (CGPA) up to that point of time.

$$CGPA = \frac{\sum(C_i x Gr_i)}{\sum C_i}$$

Where

C_i = Credit for the i^{th} course in any semester
Gr_i= Grade point for the i^{th} course
Cr. = Credits for the Course
Gr. = Grade Obtained

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SYLLABI

2024 admission onwards

Physics Courses (Discipline Specific Core)

Semester 1

24PHY101 Problem Solving and Computer Programming: Introduction to Python 3 0 0 3

Prerequisites
The students should have studied any basic computer language as a prerequisite for the course.

Course Objective:
Having successfully completed this module, the student will be able to: use Python as a tool to solve Physics problems, learn using a high-level programming language without actually going through the logic behind the equations that are to be coded, understand basic mathematics, develop familiarity and equips them to code a large number of physics problems and learn how to obtain results and plots using the software.

Unit 1
Introduction to Python Programming
History of Python Programming Language, Thrust areas of Python in physics, Integrated Development Environments, installation and use of Python distribution: Anaconda, Spyder, Jupiter notebooks.

Fundamental programming with Python:
Designing a Program, identifiers, keywords, operators, and expressions. Arithmetic, Logical and Assignment operators, Precedence, Data types: Basic data types: Strings and numbers, displaying an output, type conversion, basic string operations& methods, format specifiers.

Unit 2
Tuples, Lists & Dictionaries
Tuples: immutable sequences, creating tuple, basic tuple operations.
Lists: mutable sequences, basic list operations, List methods Dictionaries: basic dictionary operations, dictionary method User input variable.

Unit 3
Control structures
Decision Structures: If, If ----else, if ….elif…..else, nested if decision flow statements.
Repetition Structures: condition controlled: while loop. Count controlled: for loop, sentinals, continue and break statements, try and except statements.

Unit 4
Functions & Files
Built-in function, modules, void function, flow charting, hierarchy charts, Local variables and scope, passing an argument function, value returning functions, Random number generation. Files: introduction to file input and output.

Unit 5
Scientific computing packages
Numpy: -Array object, creating array, matrix, indexing, slicing, resizing, reshaping, arithmetic operations, functions, matrices, and vector operations.
Matplotlib: basic plotting,
Scipy: Linear algebra operations, equation solving.

Course Outcomes
At the end of the course students will be able to:
CO1: Master the fundamentals of writing Python scripts and executing simple Python programs.
CO2: Use basic mathematical methods in Python to solve physical problems
CO3: Write Python functions to facilitate code reuse.
CO4: be fluent in the use of procedural statements, assignments, conditional statements, loops, function calls, and sequences. Be able to design, code, and test small Python programs based on physical systems.
CO5: Use python libraries like NumPy, SciPy, etc to mathematically evaluate physical systems

Skills Acquired: Develop logical skills in applying and analyzing problems in physics by computing techniques.

Textbook
1. Mark Lutz, "Learning Python" O'Reilly Media,2013.

References
1. Robert Johansson, "Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib" Apress, 2019.
2. Rubin H. Landu, Manuel J. Paez, and Cristian C. Bordeianu, "Computational Physics Problem solving with Python" - Third Edition, Wiley VCH, 2015.

24PHY102 Mechanics & Properties of Matter 3 1 0 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: one-dimensional motion and dependence of force on position, velocity and time, two-dimensional motion, and rotational dynamics.

Unit 1
Physical quantities, dimensional analysis, significant figures. Motion in 1D: One-dimensional Kinematics: instantaneous velocity and acceleration, Kinematics in 2D: Projectile Motion, Uniform circular Motion, relative motion.

Unit 2
Newton's Laws of Motion Forces, Frictional Forces, and Dynamics of uniform circular motion. Work, Kinetic Energy, Work-Energy Theorem, Potential Energy, Conservation of Energy Newton's law of gravitation, Motion in uniform gravitational field.

Unit 3
Centre of Mass, Conservation of linear momentum, collisions, systems with variable mass.
Rotational motion about a fixed axis: Rotational variables, linear vs angular variables; rotational kinetic energy, rotational inertia; torque, Conservation of Angular momentum, Newton's II law for rotation; rotational work; Application to pulley with mass.

Unit 4
Stress, Strain, Hooke's law Elastic properties of matter.

Kinematics of moving fluids, Equation of continuity, Euler's equation, Bernoulli's equation and applications; Viscosity and viscous flow, drag force, flow through a circular tube – Poiseuille equation, Elementary discussions of laminar flow vs turbulence, Reynolds number, Navier-Stokes equation.

Unit 5

Rolling without slipping on horizontal and inclined surfaces; conservation of angular momentum; An overview of rotations about asymmetric axis, rate of change of angular momentum in three dimensions, torque; precession of spinning tops; Equilibrium of simple systems.

Oscillations: simple harmonic motion, linear spring and Hooke's law, spring-mass system, angular frequency, period, phase, connection with uniform circular motion, angular oscillations and torsion pendulums, small oscillations, average kinetic and potential energies, damped and forced oscillations, resonance, superposition.

Course Outcomes

At the end of the course students will be able to:

CO1. To apply dimensional analysis and vector approach in solving problems.

CO2. Understand and analyze 2 and 3-dimensional translational motion problems including conservation laws.

CO3. Analyze rotational motions and apply it to rotational dynamics including rotationalinertia.

CO4. Understand and apply the universal law of gravitation to solve problems.

CO5. Apply Hooke's laws and get elastic constants and apply law of buoyancy, Archimedes principle, Bernoulli's theorem in problem-solving in fluids in motion.

Textbooks:

1. David Halliday, Robert Resnick & Jearl Walker, Fundamentals of Physics, JohnWiley, 9E, 2012.

References:

1. Kittel et al, Mechanics, Berkeley Physics Course Vol-1, Tata McGraw Hill, 2011.
2. R.P. Feynman, R. P. Leighton and M. Sands, Feynman Lectures on Physics Vol.1,Narosa, 2003
3. F. W. Sears, M. W. Zemansky and H. D. Young, University Physics, Narosa, 2011.
4. D. S. Mathur, Elemants of Properties of Matter, S. Chand, 2010.

Semester 2

24PHY111	Biomedical Instrumentation	3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the Physiology of the heart, lung, blood circulation and respiration including different transducers used, various sensing and measurement devices of electrical and non-electrical origin, modern methods of imaging techniques, medical assistance techniques and therapeutic equipment's.

Unit 1

Introduction

Cell and its structure, Resting and Action Potential, Nervous system and its fundamentals, Basic components of a biomedical system, Cardiovascular systems, Respiratory systems, Kidney and blood flow, Biomechanics of bone, Biomechanics of soft tissue, Basic mechanics of spinal column and limbs, Physiological signals and transducers - Transducers – selection criteria – Piezo electric, Ultrasonic transducers - Temperature measurements - Fibre optic temperature sensors.

Unit 2

Measurement of non-electrical parameters

Measurement of blood pressure - Cardiac output - Heart rate - Heart sound - Pulmonary function measurements – spirometer – Photo Plethysmography, Body Plethysmography – Blood Gas analyzers, pH of blood –measurement of blood pCO_2, pO_2, finger-tip oxymeter - ESR, GSR measurements.

Unit 3

Measurement of electrical parameters

Electrodes – Limb electrodes –floating electrodes – pregelled disposable electrodes - Micro, needle, and surface electrodes – Amplifiers, Preamplifiers, differential amplifiers, chopper amplifiers – Isolation amplifier - ECG – EEG – EMG – ERG – Lead systems and recording methods – Typical waveforms - Electrical safety in a medical environment, shock hazards – leakage current-Instruments for checking safety parameters of biomedical equipment.

Unit 4

Imaging Modalities and Analysis

Radiographic and fluoroscopic techniques – Computer tomography – MRI – PET-SPECT-Ultrasonography – Endoscopy – Thermography –Different types of biotelemetry systems - Retinal Imaging - Imaging application in Biometric systems - Analysis of digital images

Unit 5

Life Assisting, Therapeutic and Robotic Devices

Pacemakers – Defibrillators – Ventilators – Nerve and muscle stimulators – Diathermy – Heart – Lung machine – Audio meters – Dialyzers – Lithotripsy - ICCU patient monitoring system - Nano Robots - Robotic surgery – Advanced 3D surgical techniques- Orthopedic prostheses fixation.

Course Outcomes:

At the end of the course, students will be able to:

CO1: Know the basic concepts of Anatomy & Physiology.

CO2: acquire adequate knowledge about different types of Electrodes, Transducers, and Amplifiers.

CO3: Understand the important and modern methods of imaging techniques.

CO4: Comprehend the Human Assist Devices.

CO5: Have adequate knowledge of Therapeutic Equipments.

Textbooks:

1. Leslie Cromwell, Biomedical Instrumentation and Measurement, Prentice Hall of India, New Delhi,2007.

2. M. Arumugam, ‘Bio-Medical Instrumentation’, Anuradha Agencies, 2003.

3. Khandpur R.S, Handbook of Biomedical Instrumentation, , Tata McGraw-Hill, New Delhi, 2 Edition, 2003

References:

1. John G. Webster, Medical Instrumentation Application and Design, John Wiley and sons, NewYork,

1998.
2. Duane Knudson, Fundamentals of Biomechanics, Springer, 2nd Edition, 2007.
3. Suh, Sang, Gurupur, Varadraj P., Tanik, Murat M., Health Care Systems, Technology and Techniques, Springer, 1st Edition, 2011.
4. Ed. Joseph D. Bronzino, The Biomedical Engineering Handbook, Third Edition, Boca Raton, CRC Press LLC, 2006.
5. Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, John Wiley and Sons, New York, 4th Edition, 2012

24PHY112 Basics of Electricity and Magnetism 3 1 0 4

Course Objective

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Vector algebra and vector calculus from the perspective of electrodynamics, Coulomb's law, Superposition principal concept of electric field, Potential formalism and its importance, working of capacitors and RC circuits, Magnetic fields and their origin, Ohm's law, Faraday's law, Lenz's law and working of LC, LR, LCR circuits.

Unit 1
Electrostatics

Coulomb's law. Superposition principle. Electric field – discrete and continuous distribution, Gauss's law, Applications of Gauss's law.

Unit 2
Potential

The curl of electric field, Electric potential, meaning of electric potential, Equipotential surfaces, Potential of localized charge distribution, Work and energy in electrostatics, Energyof a point charge distribution, Energy of continuous charge distribution, Conductors and Capacitors, Charging and discharging of RC Circuit.

Unit 3
Magnetostatics

Magnetic fields, Magnetic forces, Currents, Biot-Savart law, Ampere's law.

Unit 4
Electrodynamics

Ohm's law, EMF, Motional EMF. Electromagnetic induction: Faraday's law, Lenz's law, induced electric field, Examples of LC, LR, LCR circuits.

Unit 5

Maxwell's equations: displacement current, Maxwell's equations in integral form. Elementary discussions on gradient, curl and divergence of vector fields, divergence and Stokes' theorems and differential forms of Maxwell’s equation, motivation on its consequences: electromagnetic and optical phenomena in nature.

Course Outcomes:
At the end of the course, students will be able to:
CO1. Apply vector calculus to electricity and magnetism.
CO2. Solve problems on electricity and magnetism based on the theory.
CO3. Apply the basic laws of electricity and magnetism to related phenomena.

Textbooks:

1. Introduction to Electrodynamics – David J. Griffiths, 4th edition, Pearson Publication.
2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of physics, 9thEdition, John Wiley, 2012.

References:

1. Richard P. Feynman, Robert P. Leighton and Matthew Sands, Feynman Lectures onPhysics Vol.1, 1E, Narosa Publishing House, 2008.

Semester 3

24PHY201	Optics and Wave Motion	3 1 0	4

Course Objective
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Geometrical optics, wave equation, Simple and damped Harmonic Oscillations, interference and diffraction, and polarization in terms of the wave model.

Unit 1
Geometrical optics:
Fermat's principle- Laws of reflection and refraction. Images formed by a plane mirror, Spherical mirror, Spherical refracting surfaces, Thin lens, system of thin lens- Lens aberrations, Matrix methods in optics, determining Cardinal points, Microscopes, Telescopes- reflecting type

Unit 2
Wave Motion:
One dimensional wave equation, Differential wave equation, Simple Harmonic motion (SHM), superposition of two or more SHMs. Lissajous figures. standing wave and resonance. Group velocity and phase velocity, Energy density and energy transmission in waves, Sound waves, Doppler effect in Sound.

Unit 3
Interference:
Wave nature of light, Spatial and temporal coherence (qualitative treatments), Wave division interference –Young’s experiment, Interference pattern from double-slit- Intensity distribution, Fresnel’s double mirror, Fresnel’s biprism, Amplitude division interference: fringes from equal thickness films, unequal thickness film, phase change on reflection, Michelson’s Interferometer.

Unit 4

Diffraction:

Fraunhoffer diffraction –single, double and multiple slits, circular aperture, Resolution of imaging system, diffraction grating, resolving power of grating. Bragg's Law,Fresnel diffraction: straight edge, circular aperture.

Unit 5

Polarization:

Introduction, Polarization sheets, Polarization by reflection, double refraction, Angular momentum of light, Polarization by scattering, linear, circular, and elliptic polarization, optical rotation.

Course Outcomes:

At the end of the course, students will be able to:

CO1. Understand the concepts of reflection, refraction, image formation with mirrors, spherical refracting surfaces, lens systems and aberrations using ray theory of lightand describe the working of optical instruments.

CO2. Understand the Simple Harmonic Motion (SHM) and explain the nature of wave motion, superposition of waves and working real systems.

CO3. Comprehend wave theory of light and phenomena such as interference, diffraction andpolarization, birefringence in terms of wave mode.

CO4. Describe the operation of optical devices, including polarizers, retarders, modulators and interferometers.

Textbooks:

1. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of Physics, 10th Ed.,JohnWiley, 2013.
2. A.K. Ghatak, Introduction to Modern optics, 5th Ed., Tata McGraw Hill, 1977.
3. Hecht, Optics, 4th Ed., Pearson Education, 2008.

References:

1. Bahaa E. A. Salesh, Fundamentals of photonics, 2nd Ed., Wiley Interscience, 2007.
2. Richard P. Feynman, Robert. P. Leighton and Matthew Sands, Feynmann Lectures onPhysicsVol.1, Narosa Publishing House, 2008.
3. Grant R. Fowls, Introduction to Modern Optics, 2nd Ed., Dover Publications, Inc., USA,1989.
4. M. Born and E. Wolf, Principles of Optics, 7th Ed., Cambridge University Press, 2002.
5. S. C. Lipson and H. Lipson, Optical Physics, Cambridge University Press, 2011.

24PHY202	Basic Electronics	3 1 0 4

Course objectives: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: analysis and construction of various DC circuits for multiple applications.

Unit 1

Introduction: Circuit Theory: Nodal and Mesh analysis, current and Voltage sources, Thevenin's theorem, Norton's Theorem, Open and closed circuit.

Semiconductors: Intrinsic and extrinsic semiconductors, Doping in a semiconductor, PN Junction, Diode: forward and reverse biasing and energy bands.

Unit 2

Diodes and Transistors: Diode characteristics, Ideal diode, rectifiers and filters, Clippers and clampers, Zener diode; Line and load regulation, Optoelectronic devices: LED, Photodiode, Schottky diode.

Transistor: Bipolar Junction Transistor, Transistor biasing, Load line analysis, Operating points, Transistor amplifier: current and voltage amplifiers.

Unit 3

JFET: Construction, biasing and applications in switches, variable resistance and choppers

MOSFET: Characteristics and operation of D- MOSFET & E- MOSFET, Digital switching using MOSFET, CMOS Applications -Thyristors: Four-layer diode, Silicon controlled rectifier.

Unit 4

Integrated Circuits: Differential amplifier, Operational Amplifier, Characteristics of ideal op-amp, negative feedback, filters, nonlinear op-amp circuits: Adder, Subtractor, Integrators, Differentiator.

Unit 5

Digital Logic: Logic Gates and Networks, Boolean algebra, Synthesis gates using NAND and NOR gates. Digital logic circuits CMOS and Bipolar (TTL), Combinational logic, and sequential logic.

Combinational logic and Sequential logic circuits: Counters & Flip Flops.

Course Outcomes

At the end of the course, students will be able to:

CO1. Analyze DC circuits using circuit theory and its applications.

CO2. Analyze and construct diode-based DC and AC circuits.

CO3. Analyze and construct the DC-biased BJT transistor circuit.

CO4. Analyze AC parameters of BJT amplifier circuits under small AC signal mode.

CO5. Analyze a complete DC-based Operational amplifier circuit.

Textbooks:

1. Fundamental of Electrics circuits: C. K. Alexander and M. N. O. Sadiku, Third edition, Tata McGraw Hill.
2. The Art of Electronics: P. Horwitz and W. Hill (1989) 2nd edition, Cambridge University Press.
3. Electronic Devices and Circuits: Robert L. Boylestad & Louis Nashelsky.
4. Digital Principles and Their Applications: Donal P. Leach, Albert Paul Malvino and Gautam Saha (2006) Tata McGraw Hill.
5. Electronic Principles: A. Malvino and D. Bates (2006) 7th edition, McGraw-Hill.

24PHY203	Basic Experimental Techniques in Physics	3 1 0	4

Course Objectives: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: calculation of errors in measurements, error propagation analysis using linear regression and to Estimate the goodness of fits, basic electronics instrumentation- pick out signal from noise, description of noise, optimizing and signal averaging, vacuum generation, pressure and temperature measurements.

Unit 1

Error analysis: Introductory probability – Random experiment, discrete random variable, continuous random variable, probability distributions, Definition of mean, median, mode, standard deviation and standard error. Definition of Errors: Random error and systematic error, Uncertainties, precision and accuracy, reporting errors (error bars), Error Propagation.

Unit 2

Data analysis: Curve fitting, Linear regression analysis, goodness of fits (χ^2), correlation analysis with relevance to simple physics experiments.

Unit 3

Signals and Systems: Extraction of signal from noise Signal to noise ratio, Types of noise, Addition of noisy waveforms and optimizing of S/N ratio, signal averaging, waveform recovery.

Grounding and Shielding: Methods of safety grounding, Energy coupling. Shielding- Electrostatic shielding. Electromagnetic Interference.

Unit 4

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of the measurement.

Unit 5

Vacuum physics: Definition of pressure - Kinetic theory of gases, average velocity, mean free path, impingement rate, creation of vacuum using different pumps. Measurement of pressure- Pressure gauges – All direct and indirect gauges. Measurement of temperature - Thermocouples (basic principle and construction), creation of low temperature.

Course Outcomes

At the end of the course students should be able to

CO1. Calculate errors in measurements and the error propagation.

CO2. Understand the errors in simple linear systems and estimate the goodness of fits.

CO3. Understand the basics of Extraction of signal from noise and the various Grounding and Shielding techniques.

CO4. Understand the basics of a digital multimeter.
CO5. Understand vacuum techniques, pressure, and temperature measurements.

Textbooks:

2. John. R Taylor, An introduction to error analysis: The study of uncertainties in physical measurements, University Science Books, 1997
3. Paul Horowitz, Winfield Hill, The Art of Electronics, 2nd Ed., Cambridge University Press, 1989.
4. Milton Ohring, Materials Science of Thin Films, 2nd Ed., Academic Press, 2001.
5. John H. Moore, Christopher C. David, and Michael A. Coplan, Building Scientific Apparatus, 4th Ed., Cambridge University Press, 2017.

References:

1.Philip Bevington, D. Keith Robinson, Data Reduction and Error Analysis for the physical sciences, 3rd Ed., McGraw-Hill Education, 2002.
2. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill

3. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.

24PHY204	Mathematical Physics I	3 1 0	4

Course objectives: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Use and application of mathematical tools that are essential for solving a range of problems in different branches of physics like quantum mechanics, electrodynamics, statistical mechanics and other fields of theoretical physics.

Unit 1

Mathematical Preliminaries: Infinite Series - Fundamental Concepts, Geometric Series, Harmonic Series, Comparison Test-Convergent and divergent of infinite series, Power Series-Exponential and Logarithmic Functions, Special Integrals- exponential and gaussian integrals, Gamma function, Beta Function, factorials, Sterling formula; Basic properties of Dirac delta function and Kronecker delta.

Unit 2

Fourier analysis and Transforms: Periodic Functions, Fourier Series, Fourier coefficients, Dirichlet conditions, functions of any Period p =2L, Even and Odd Functions, Complex Fourier Series, Fourier Integrals, Sine and Cosine Integrals, Fourier Transforms, Properties of Fourier transforms, Fourier Convolution Theorem, Parseval's theorem.

Unit 3

Laplace Transforms: Laplace Transforms, Linearity, First Shifting Theorem(s-shifting), Transforms of Derivatives and Integrals. ODEs, Unit Step Function. Second Shifting Theorem(t-shifting), Dirac-Delta Function, Laplace convolution Theorem.

Unit 4

Ordinary Differential Equations: differential operators, review of methods for 1st order and 2 nd order homogeneous and inhomogeneous linear ODEs, important examples in physics; solution using Laplace Transforms. Differentiation and Integration of Transforms, , Laplace convolution Theorem, Initial and

Final Value Theorems, , Periodic Functions, Solving Linear Ordinary Differential Equations with Constant Coefficients.

Unit 5

Partial Differential Equations: Basic Concepts, First order equations, Second order equations, Separation of variables, Laplace and Poisson equation. Modelling; Vibrating String, Wave Equation, Separation of Variables, Use of Fourier Series, Heat Equation; Solution by Fourier Series.

Course Outcomes:

At the end of the course Students will be able to:

CO1. Develop real and complex Fourier series methods to generate required function.
CO2. Understand 1D Fourier transforms and how to solve problems using them.
CO3. Understand how to do the Laplace transform and solve problems using them.
CO4. Apply the mathematical tools of Fourier series, Fourier transforms and Laplace transforms to solve linear ordinary and partial differential equations.

Textbooks:

1. E Kreyszig, Advanced Engineering Mathematics, 10^{th} Ed., John Wiley and Sons,2015.
2. Arfken & Weber, Mathematical Methods for Physicists, 7E
3. P. P. G. Dyke,An Introduction to Laplace Transforms and Fourier series, 2^{nd}Ed.,Springer, 2014.
4. Larry C. Andrews and Bhimson, K. Shivamoggi, The Integral Transforms forEngineers, Prentice Hall India Learning Private Limited, 2003.

Semester 4

24PHY211	Introduction to Quantum Physics	3 1 0	4

Course objectives: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: atomic physics, and quantum mechanics, Theoretical and experimental studies to understand observable properties of matter in terms of microscopic constituents, the use of quantitative reasoning to solve modern physics problems.

Unit 1

Origin of quantum theory: The correspondence principle, Black body radiation, photo-electric effect, Compton Effect – pair production and annihilation, De-Broglie hypothesis, description of waves and wave packets, group velocities. Evidence for wave nature of particles: Davisson-Germer experiment, Heisenberg uncertainty principle.

Unit 2

Atomic structure: Historical Development of atomic structures: Thomson's Model, Rutherford's Model: Scattering formula and its predictions, atomic spectra - Bohr's Model, Sommerfield's Model, nuclear motion, and atomic excitation, X-Ray spectrum, Application: Lasers.

Unit 3

Quantum mechanics: Wave function, Probability density, normalization, expectation values - Schrodinger equation – time-dependent and independent, Linearity and superposition, stationary states, energy eigenvalue equation, eigenvalues, eigenstates, and quantization of energies. Application of 1D Schrodinger Wave equation: Free particle, Particle in a box, Finite potential well, Tunnel effect, Harmonic oscillator.

Quantum theory of the hydrogen atom: Schrodinger wave equation in spherical coordinates, separation of variables, quantization of energy and orbital angular momentum, classification of energy eigenstates, spectroscopic notation.

Unit 4

Angular momentum: Angular momentum and magnetic moment, Stern-Gerlach Experiment, angular momentum quantization, angular momentum operators, Azimuthal angular momentum eigenvalues and eigenstates; uncertainty relations with position, momentum, and angular momentum.

Schrodinger equation in central fields, Total angular momentum eigenvalues and eigenfunctions– spherical harmonics, vector model, rotational quantum states of molecules.

Spin angular momentum: states and eigenvalues, spin magnetic moment, spin-orbit coupling energy, addition of Spin and angular momentum in the vector model.

Unit 5

Many electron atoms: Identical particles, permutation symmetry, two-electron systems, symmetric and anti-symmetric wave functions and spin states, Pauli principle. Qualitative discussions of states of helium and many-electron atoms.

Course Outcomes:

At the end of the course Students will be able to:

CO1: comprehend a simple, clear, and mathematically uncomplicated explanation of physical concepts connected with theories of elementary quantum mechanics.

CO2: Understand the development of physical concepts of modern physics.

CO3: Understand the concepts of atomic phenomena, energy quantization and application of Schrodinger's theory to Hydrogen atom.

CO4: Understand angular momentum, commutation relations, eigenvalues and eigen functions; understand Spin, eigenvalues and spin states, addition of angular momentum and spin and spin-orbit coupling in the vector model.

Textbooks:

1. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, TataMcGraw-Hill, 7thEd., 2017.

2. Robert Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles, 2ndEd., Wiley, Reprint: 2012

3. D. Griffiths, Quantum Mechanics, 2E, Person

References:

1. Kenneth Krane, Modern Physics, 2nd Ed., John Wiley and Sons, 1996

2. Raymond A. Serway, Moses, Moyer, Modern Physics, 3rd Ed., Thomson Learning, 2005

3. T. Thornton and A. Rex, Modern Physics for Scientist and Engineers, 2nd Ed., Fort Worth:Saunders, 2000.

4. R.P. Feynman, Feynman Lectures in Physics, Vol. 3.

24PHY212	Intermediate Mechanics	3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Dynamics of various systems in motion, rigid body dynamics, Conservation of Energy, Accelerating Frames of References, and Lagrange's method for simple dynamical systems.

Unit 1

Conservation of Energy: Work & Kinetic Energy, Conservative forces, Potential Energy, Work-Energy Theorem, Conservation of Energy, Energy Diagrams, Determining the Motion using Energy Integral. Relativistic Dynamics.

Gravitational Field: Law of Gravitation, Gravitational Field, Gravitational Potential, Gravitational Field Equations, Motion in a gravitational field.

Unit 2

Rotational Dynamics of Rigid Bodies: Conservation of Angular momentum, Moment of Inertia, Rotational Kinetic Energy, Torque and Work-Energy Theorem, Properties of Centre of mass, Orthogonal Transformations, Euler Angles, Inertia Tensor, Parellel Axis Theorem, The Euler Equations.

Unit 3

Accelerating Frames of References: Linearly accelerating Reference Frame, Rotating Coordinate Frame, Fictitious Forces, Coriolis Force, Tides, Foucault Pendulum.

Unit 4

The Lagrangian Method: Calculus of Variation, The Lagrangian, Lagrange's Equations, Degrees of Freedom, Generalized momentum & Hamilton's Equations.

Unit 5

Special theory of relativity: Correspondence principle - reference frame, inertial systems and Galilean transformations, postulates of special theory of relativity, Michelson-Morley experiment and its consequences, Lorentz transformations, Length contraction, Time dilation, relativistic velocity addition, simultaneity, relativistic Energy and momentum, mass–energy equivalence, particles with zero rest mass, relativistic Doppler effect.

Course Outcomes:

At the end of the course, students will be able to:

CO1. Apply the concepts of Newtonian formalism in solving dynamical problems.

CO2. Understand the concept of constraint, principle of least action and formulation of Lagrange's method and apply Lagrange's equation for simple dynamical systems.

CO3. Understand Central force and its application in Kepler's problem and scatteringproblems.

CO4. Use the Centre of mass and laboratory frames of references in solving problems.

CO5. Understand the basics of rotating frames of references and Euler angles and Euler'sequations.

Textbooks:

1. P. Hamill, Intermediate Dynamics, Jones & Bartlett, 2010.

2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, 2008.

3. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, TataMcGraw-Hill,

7th Ed., 2017.

References:

1. John Taylor, Classical Mechanics, University Science Books, 1E, 2004.
2. Classical Mechanics, J.C. Upadhyaya. Himalaya Publishing House, 3rd edition , 2023.
3. S T Thomton and J B Marion, Classical Dynamics of Particles and Systems, Brooks Cole,1E, 2009.
4. Walter Greiner, Classical Mechanics: Point Particles and Relativity, Springer – Verlag,1E, 2004.

24PHY213	Mathematical Physics II	3 1 0	4

Course Objective: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Use and application of mathematical tools that are essential for solving a range of problems in different branches of physics like quantum mechanics, electrodynamics, statistical mechanics and other fields of theoretical physics.

Unit 1

Vector calculus: Review of basic properties, Vectors in 3-D space, coordinate transformations, Differential Vector Operators-Gradient, Divergence, Curl, Further properties, Vector Integration-Line integrals, Surface Integrals, Volume Integrals, Integral Theorems-Gauss' Theorem, Green's Theorem, Stokes' Theorem, Scalar potential, Vector Potential, Curvilinear coordinates.

Unit 2

Special Functions: Power series solutions to second order ODEs; Legendre equation, Leibniz' Rule for differentiating Products, Legendre polynomials, Rodrigues formula, generating function, orthogonality, Associated Legendre Polynomials, Spherical harmonics.

Unit 3

Bessel's equation, Rodrigues formula, generating function, orthogonality, Generating function, other kinds of Bessel functions, orthogonality, Hermite polynomials; Laguerre functions, Fourier, Legendre, Bessel and other series, Sturm-Liouville equations, Orthogonality.

Unit 4

Complex numbers and their geometric Representation, Polar form of complex numbers, Powers and roots, Derivative of an analytic function, Cauchy-Riemann equations, Laplace equation, Harmonic functions, Exponential function, Trignometric and Hyperbolic functions, Euler formula, Logarithm. Green's Theorem in the Plane, Complex Form of Green's Theorem, Line integral in the complex plane, Cauchy's Integral theorem, Cauchy's Integral formula for the derivatives of an analytic function.

Unit 5

Singularities, multiple valued functions and branch point and branch-cuts; Complex power series, convergence, radius of convergence; Taylor & Laurent series; Residue Integration method, Formulas for residues, Residue Theorem, Residue Integration of Real Integrals

Course Outcomes:
At the end of the course, students should be able to
CO1. To understand the basics of tensor calculus and familiarize with a range of Mathematical methods that are essential for studying different branches of physics.

CO2. To develop independent problem-solving ability and enhance conceptual understandingusing several mathematical techniques.

CO3. To develop required mathematical skills to study and solve problems in quantum mechanics, electrodynamics, statistical mechanics, and other fields of theoreticalphysics.

Textbooks:

1. M Boas, Mathematical Methods in Physical Sciences, Wiley Indian Reprint 3E, 2006.
2. Arfken & Weber, Mathematical Methods for Physicists, Elsevier Indian Reprint, 7thEd., 2012.
3. E. Keyszig, Advanced Engineering Mathematics, 10E, Wiley India

References:

1. Riley K F, Hobson M P, Bence S J, Mathematical Methods for Physics andEngineering, CUP, 3E, 2010
2. Mathews J and Walker R L, Mathematical Methods of Physics, Pearson India, 2E,2004.
3. R. Shankar, Basic Training in Mathematics: A Fitness Program for Science Students
4. Mathews and Walker, Mathematical Methods in Physics, 2E.
5. Murray R Spiegel, Seymour Lipschutz, Schaum's Outline of Vector Analysis, 2ndEd., Schaums' Outline Series, 2009.
6. Murray Spiegel, Vector Analysis And An Introduction To Tensor Analysis, TataMcgraw Hill. 1989
7. Morton Hamermesh, Group Theory and its Application to Physical Problems, ReprintEd., Addison-Wesley Publishing Company Inc. 1989.

Semester 5

24PHY301	Atomic and Molecular Physics	3 1 0	4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: atomic structure and the interaction between atoms and fields, electronic transitions, atomic spectra, excited states, hydrogenic and multi-electron atoms, molecular degrees of freedom (electronic, vibrational, and rotational), and molecular spectroscopy.

Unit 1
One electron atoms, Schrodinger equation for one-electron atoms, Interaction of electromagnetic radiation with single electron atoms, Transition rates, dipole approximation, and dipole selection rules, photoelectric effect.

Unit 2
Hydrogen like systems, Spectra of monovalent atoms, quantum defect, Penetrating and non-penetrating

orbits, Fine structure of hydrogenic atoms, Relativistic correction to spectra of hydrogen atom, Hyperfine structure, Lamb shift.

Unit 3

Zeeman effect, Paschen-Back effects, Stark effects, Helium atom: para and ortho states, ground state, singly and doubly excited states. Spectra of many-electron atoms ideas only.

Unit 4

Elements of Molecular Spectroscopy – Molecular Bond, Hydrogen Molecule, Complex Molecules.

Rotational Energy Levels: rotation of molecules, rotational spectra, diatomic molecules. Microwave spectroscopy - instrumentation and analysis.

Vibration Energy Levels: Vibrating diatomic molecule, diatomic vibrating rotator, vibration-rotation spectrum of carbon monoxide, IR spectroscopy - instrumentation and analysis.

Raman spectra: Pure rotational Raman spectra, Vibrational Raman spectra, the polarization of light, and Raman effect.

Unit 5

Electronic Energy Levels: electronic spectra of diatomic molecules, Franck–Condon principle.

Nuclear spin and applied field, Nuclear Magnetic Resonance (NMR)-resonance condition; relaxation processes - Chemical shift; CW NMR spectrometer.

Electron Spin Resonance (ESR)- Principle of ESR; ESR spectrometer.

Course Outcomes:

At the end of the course, students will be able:

CO1. To acquire knowledge on the fundamental physics of atoms and molecules and their interaction with electromagnetic waves.

CO2. To solve problems related to the physics of monovalent atoms and molecules, and hydrogen atom spectra.

CO3. To understand the influence of external fields on atoms.

CO4. To understand the fundamentals of Molecular Spectroscopy comprising rotational, vibrational, and electronic energy levels.

CO5. To acquire knowledge of the various spectroscopic techniques and their instrumentation.

Textbooks:

1. Introduction of Atomic Spectroscopy: White, McGraw-Hill Inc.US; 1st Edition, 1934.
2. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, 2nd Ed. (1983), Pearson Education.
3. Concepts of Modern Physics, Arthur Beiser, Tata McGraw Hill, 6th Edition, 2009.
4. Fundamentals of molecular spectroscopy- C. Banwell and E. Maccash (Mc Graw Hill, 2013).
5. Introductory Quantum Mechanics, R.L. Liboff, Addison-Wesley (2002).

References:

1. Atoms, Molecules and Photons - Wolfgang Demtroder (Springer, Second edition, 2006).
2. Atomic Physics, C. J. Foot (Oxford, First edition 2005).
3. Group theory and Quantum Mechanics-M. Tinkham (Dover Publications, First edition, 2003).
4. Chemical applications of group theory-F Albert Cotton (Willey, Third edition, 2015).

24PHY302	Thermal Physics	3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: fundamental laws of thermodynamics, concepts of temperature, internal energy, heat, entropy and the thermodynamic potentials, thermodynamic concepts to topics such as heat engines, the expansion of gases and changes of phase.

Unit 1

Introduction to Thermodynamics: Zeroth Law of thermodynamics, Extensive and intensive variables, work, Quasi static process, Reversible and Irreversible process with examples.

Heat and First Law of thermodynamics: Work and Heat, Adiabatic work, Internal energy, Mathematical formulation of first law, Differential form of first law. heat**:** Heat capacity and its measurement, Specific heat capacity.

Unit 2

Second Law of thermodynamics: Conversion of work into heat, Reversible and Irreversible process with examples. Carnot's Theorem. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Clausius statement of second law, Refrigerator, Equivalence of Kelvin-Planck and Clausius statement.

Concept of Entropy, Clausius theorem, Clausius inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Unit 3

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Joule Thomson cooling, Temperature inversion, First and second order Phase Transitions with examples.

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases.

Unit 4

Kinetic Theory of Gases

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Critical Constants. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. P-V diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

Unit 5

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof).

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.
Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy.

Course Outcomes:
At the end of the course students will be able to:
CO1: Understand all the concepts needed to state the laws of thermodynamics, such as 'thermodynamic equilibrium', 'exact' and 'inexact' differentials and 'reversible' and'irreversible' processes, internal energy, entropy, temperature, free energies.
CO2: Demonstrate and apply laws of thermodynamics in thermodynamic derivatives, including several 'material properties' such as heat capacity, thermal expansivityand compressibility, and solve problems in which such derivatives appear.
CO3: Apply the concepts and laws of thermodynamics to solve problems in thermodynamicsystems such as gases, heat engines and refrigerators etc
CO4: Apply the concepts and laws of thermodynamics to understand the kinetic theory of gases.
CO5. Apply the concepts and laws of thermodynamics to solve problems in thermodynamicsystems such as gases, heat engines and refrigerators etc.
CO6. Describe micro and macro states and fundamental postulates, statistical approach to thermodynamics – statistical mechanics, apply to ideal gas and other systems.

Textbooks:
1. M. W. Zemansky and R. H. Dittman, Amit K. Chattopadhyay, Heat and thermodynamics,8th edition, Tata McGraw- Hill, 2011.

2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of Physics,10th Edition,John Wiley, 2012.

3. R.K. Pathria, Statistical Mechanics, 3E, Elsevier India.

References:
1. Walter Greiner, Ludwig Neisse, Horst Stocker, Thermodynamics and statisticalmechanics, 1st Ed, Springer, 1995,3rd reprint 2001.

2. Sears.F.W and Salinger.G.L,Thermodynamics Kinetic Theory and StatisticalThermodynamics,3rd Ed, Addison Wesley,1998.

3. Hugh.D. Young and Freedman, Sears& Zemansky's University Physics, 13th Ed,Pearson, 2013.

4. Richard P. Feynman, Robert. P. Leighton and Matthew Sands, Feynman Lectures onPhysics, Vol.1, 1E, Narosa ,2008.

5. P.K.Nag, Basic & Applied Thermodynamics,2nd edition McGraw Hill Education; 2017.

6. Kerson Huang, Statistical Mechanics, 2E, Wiley India, 1987.

24PHY303	**Electrodynamics**	**3 1 0 4**

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Electric Potentials, Boundary conditions, Maxwell's equations, Various techniques of solving Laplace equation, Electric field in matter, Magnetic field in matter, Maxwell's equations in matter,

Poynting’s Theorem, Maxwell’s Stress Tensor, Conservation of Momentum, Angular momentum.

Unit 1

Review of electric potential, boundary conditions, Poisson's and Laplace equation, Laplace equation in one, two and three dimensions, Boundary conditions and Uniqueness theorem, Conductors and second Uniqueness theorem, Review of Electrostatics and Magnetostatics, Maxwell's equations, Maxwell's equations: Electrodynamics before Maxwell, Maxwell's correction to Ampere's law, Magnetic charge.

Unit 2

Techniques of solving Laplace equation, Numerical methods: Finite difference method, Relaxation method, other methods of finding the potentials: Method of images, Separation of variables, Spherical co-ordinates, Multipole expansion, Electric field of a dipole.

Unit 3

Electric field in matter: Induced dipoles, Polarization, Field of polarized Object, Bound charges, Physical interpretation of bound charges, Field inside a dielectric, Electric displacement, Linear dielectrics, Boundary value problem with linear dielectrics, Energy in dielectric systems, Force on dielectrics.

Unit 4

Magnetic field in matter: Diamagnets, Paramagnets, Ferromagnets. Torques and Forces on Magnetic dipoles, Effect of magnetic field on atomic Orbits, Magnetization, Bound currents, Physical interpretation of bound currents, Magnetic field inside matter, Ampere's law in magnetized materials, Linear and Nonlinear media: Magnetic susceptibility and permeability. Ferromagnetism.

Unit 5

Maxwell's equations in matter, Boundary conditions, Review of Maxwell’s equations, The Continuity Equation, Poynting’s Theorem, Newton’s Third Law in Thermodynamics, Maxwell’s Stress Tensor, Conservation of Momentum, Angular momentum.

Course Outcomes:

At the end of the course, students will be able:

CO1. To understand and familiarize the fundamental concepts of mathematical background such as vector algebra, coordinate system, gradient, divergences, fundamentalprinciples of calculus and Dirac delta function.

CO2. To Learn the fundamental principles, develop knowledge on theoretical concepts of electrostatics, boundary conditions and its important applications in evaluatingelectric field in vacuum as well as in dielectric medium.

CO3. To develop critical thinking, learn various techniques and ability to solve variousproblems related to electric potential and hence electric field.

CO4. To emphasis the knowledge in magnetostatics, magnetic field in medium, Electromagnetic induction and Maxwell’s equation.

Textbooks:

1. Introduction to Electrodynamics – David J. Griffiths, 4^{th} Ed., Pearson Publication, 2015.

2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of physics, 10^{th}Edition,John Wiley, 2017.

References:

1. Richard P. Feynman, Robert P. Leighton and Matthew Sands, Feynman Lectures onPhysics Vol.1, 1E, Narosa Publishing House, 2008.
2. J.D. Jackson, Classical Electrodynamics, 3^{rd} Ed., Wiley, 2007.

24PHY304	**Advanced Electronics**	**3 1 0 4**

Prerequisite: Basic of Electronics

Course Objective: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: construction of Analog and digital circuits for various applications.

Unit 1

Inductors & Capacitors: Series and Parallel Capacitors, Series and Parallel Inductors, Integrator, Differentiator.
First-Order Circuits: Source-free RL, RC Circuit, Step Response of an RC and RL Circuits, First-order Op Amp Circuits.

Unit 2

Second order circuits: Source-Free Series RLC and Parallel RLC Circuit, Step Response of Series RLC and Parallel RLC Circuits. Second-Order Circuits, Second-Order Op Amp Circuits.
Sinusoids and Phasors: Phasors, Phasor Relationships for Circuit elements, Impedance and Admittance Frequency response: Series and parallel Resonance, passive low pass, high pass, band pass and band stop filters, Active first order low pass, high pass, Bandpass, and band rejection filters.

Unit 3

Analog to digital conversion, digital to Analog conversion, microcontrollers, Arduino, and raspberry pi based programmable circuits.

Unit 4

Clocks and Timing Circuits: 555 Timer: monostable, Bistable, and Astable multivibrators, and function generators. BJT and FET amplifier circuits, audio and high-frequency amplifier circuits, Oscillators modulators, and demodulators.
Optoelectronic Devices: photodiodes, light emitting diodes, solar cells response characteristics.

Unit 5

Data-Processing Circuits: Multiplexers, Demultiplexer, Decoder, Encoder, Programmable Array Logic and applications.

Course Outcomes:

After the completion of the course, the student will be able to:
CO1: attain a fundamental understanding of the operation of digital circuit logic.
CO2: Explain the principles involved in measurement system connected with various technologies.
CO3: Analyse the mechanisms involved in the measurement systems used in connection with various sensing technologies.
CO4: Understand the operation of microcontroller-based development platforms to interface sensors.
CO5: Apply the knowledge of measurements digital logic and other electronic circuits to develop data

acquisition systems.

Textbooks:

1. C. K. Alexander and M. N. O. Sadiku, Fundamental of Electrics circuits, 5th Ed, McGraw Hill Education, 2013.
2. P. Horwitz and W. Hill, The Art of Electronics, 3rd Ed, Cambridge University Press, 2015.
3. Robert L. Boylestad & Louis Nashelsky, Electronic Devices and Circuits, 11th Ed, Pearson Education India, 2015.
4. Donal P. Leach, Albert Paul Malvino and Gautam Saha, Digital Principles and their Applications, 8th Ed, McGraw Hill Education, 2015.

References:

1. B.G. Streetman & S.K. Banerjee, Solid State Electronic Devices, 6th edition, Pearson, 2005.

Semester 6

24PHY311	Solid State Physics	3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: fundamental concepts of crystal structure, crystal structure analysis using X-ray diffraction methods, lattice dynamics and theory of specific heat, band theory of crystals, basics of dielectric polarization and the properties of superconducting materials**,** basics of Magnetic Properties of matter.

Unit 1

Solids: amorphous and crystalline materials, Reflection, and rotation symmetries -lattice translation vectors, lattice and basis, unit cell and lattice parameters, primitive cell, crystal systems and lattices; directions, and planes: miller indices and interplanar spacing. Reciprocal vectors and reciprocal lattices, Brillouin zone, reciprocal lattice to SC, BCC, and FCC lattices. calculation of atomic packing factor and coordination number for cubic and hexagonal close-packed structures.

Determination of crystalline structure: X-ray diffraction by Crystals. Bragg's Law, The Laue equations.

Unit 2

Lattice Dynamics: Lattice Vibrations and Phonons: Dynamics of Linear Mono-atomic and Diatomic Chains. Acoustical and Optical Phonons. Phonon Spectrum in Solids (Qualitative approach).

Specific heat of solids: Classical model-Dulong and Petit's Law, Einstein theory of specific heat, The Debye model: Debye T^3 law.

Unit 3

Free electrons in crystals: Classical free electron model (qualitative), The bound state of an electron in a box with periodic boundary condition (1D and 3D), Degenerate electron gas and its properties – Fermi energy, Fermi velocity, degeneracy pressure; The density of states calculations for electron gas. Fermi-Dirac distribution. The electronic specific heat.

Band theory: Bloch theorem, Kronnig Penny model, Classification of solids: metals, semiconductors and insulators, effective mass. Superconductivity (qualitative)- bound electron pairs.

Unit 4
Dielectric Properties of Matter: Polarization, Macroscopic electric field, Local electric field at an atom- Lorentz field, Depolarization field, Dielectric constant and polarizability, electronic polarizability, classical theory of electronic polarizability, dipolar polarizability – Langevin-Debye equation.
Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Curie-Weiss law and ferroelectric domains, PE hysteresis loop.

Unit 5
Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia–and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

Course Outcomes:
At the end of the course, students should be able:

CO1. To understand crystalline symmetry, crystal planes and directions, reciprocal lattice, and the use of X-ray diffraction to identify crystal structure.

CO2. To Understand and apply the concepts of lattice vibrations, phonon spectrum and lattice specific heat.

CO3. To Understand the properties of electrons in the periodic potentials and band structure of electronic energies for nearly free electrons and tightly bound electrons and thus to classify solids into metals, semiconductors, and insulators.

CO4. To Describe the basics of Polarization and dielectric properties.
CO5. To Describe the basics of Magnetization and magnetic Properties.

Textbooks:

1. Arthur Beiser, Concepts of Modern Physics, Tata McGraw- Hill,6th Ed., 2008

2. Robert Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids,Nuclei and particles,2nd Ed., Wiley, Reprint: 2012
3. Charles Kittel, Introduction to Solid State Physics, Wiley, 8th Ed., Reprint: 2016.

References:
1. Kenneth Krane, Modern Physics, 2nd Ed., John Wiley and Sons, 1996
2. Solid State Physics, M.A. Wahab, 2011, Narosa Publications
2. Raymond A. Serway, Moses, Moyer, Modern Physics, 3rd Ed., Thomson Learning, 2005
3. T. Thornton and A. Rex, Modern Physics for Scientist and Engineers, 2nd Ed., Fort Worth:Saunders, 2000.

24PHY312 Classical Mechanics 3 1 0 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Lagrangian and Hamiltonian formulations and their applications, generating functions, canonical transformations and Poisson Brackets, Central Force Problem, and Rotational Motion.

Unit 1

Constrained Motion: Constraints, Classification of Constraints, Principal of Virtual Work, D'Alembert's principal and its applications.

Unit 2

Lagrangian formulation: Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic- coordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation, velocity dependent potential.

Unit 3

Hamilton's formulation: Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles and light rays.

Unit 4

Canonical Transformations: Generating function, Conditions for canonical transformation and problem.

Poisson Brackets: Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (Statement only), invariance of PB under canonical transformation.

Unit 5

Central Force Problem:

Kepler's laws, Orbital Dynamics, Stability.

Rotational Motion:

Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum.

Course Outcomes:

At the end of the course students will be able to

CO1. Understand the basic conservation laws in physics and the concept of phase portrait.

CO2. Understand and apply the Lagrangian formalism to simple dynamical systems.

CO3. Apply Hamilton's equations and solve dynamical systems.

CO4. Apply the properties of Poisson's bracket and canonical transformations forsolving simple systems.

CO5. Apply the theory of Rigid body dynamics and analyze the motion of rigidbodies.

CO6. Apply small oscillation theory developed in getting the frequencies of different of modes of oscillations in a coupled systems.

Textbooks:

1. Goldstein, Classical Mechanics, Addison – Wesly, 2E, 1980.

References:

1. Landau and Lifshitz, Mechanics, Butterworth-Heinemann, 3, 1976

2. S T Thomton and J B Marion, Classical Dynamics of Particles and Systems, BrooksCole, 1E, 2009

3. Walter Greiner, Classical Mechanics: Systems of Particle and Hamiltonian Dynamics,Springer – Verlag, 1E, 2004.

24PHY313 Nuclear and Particle Physics 3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: nuclear structure, various particle interactions, nuclear forces, Radioactive Decay, Nuclear Reactions, and the fundamentals of particle physics.

Unit 1
Basic Concepts: History and Overview, Units and Dimensions, Nuclear Properties, Radius, Mass and Abundance of nuclides, Binding energy, Angular Momentum, Spin and Parity, Electromagnetic moments, and Nuclear excited states.

Unit 2
Nuclear Structure: The Deuteron, Nucleon-Nucleon Scattering, Proton-Proton and Neutron neutron interactions. Properties of Nuclear Forces, The Exchange Force Model, Nuclear Models, Liquid-Drop Model, Shell Model, Collective Model of the Nucleus.

Unit 3
Radioactive Decay: Alpha Decay, The Q-value of alpha decay, Gamow's theory of alpha decay, Beta decay, Fermi theory of beta decay, Parity violation in beta decay, Gamma Decay, Internal conversion, Nuclear Isomers.

Unit 4
Nuclear Reactions: The Optical Model, The Compound Nucleus and Direct Reactions, Resonance Reactions, Heavy-Ion Reactions, Nuclear Fission, Characteristics of Fission, Energy in Fission, Nuclear Fusion, Characteristics of Fusion, Solar Fusion.

Unit 5
Particle Physics: Particle Interactions and Families, Symmetry and Conservation laws, Standard Model, Quark Dynamics, Grand Unified Theories.

Course Outcomes:
After completion of the course student should be able to:
CO1: Understand the key ideas and terminologies of nuclear physics.
CO2: Understand various nuclear models and solve various problems related to nuclearstructure.
CO3: Analyze and solve problems related to nuclear reactions.
CO4: Understand basic aspects of particle physics.

Textbooks:
1. S. Krane, Introductory Nuclear Physics, 2nd Ed., Wiley India Pvt Ltd, 2013.

References:
2. V. Devanathan, Nuclear Physics, Narosa Publishing House, 2012.

Semester 7

24PHY401	Quantum Mechanics	3 1 0 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: basic and applied quantum mechanics, one-dimensional problems of quantum mechanics, physical problems in a few selected topics like quantum angular momentum, one and two-body problems etc.

Unit 1:
Mathematical Introduction
Linear Vector Spaces: Basics, Inner Product Spaces, Dual Spaces and the Dirac Notation, Subspaces, Linear Operators, Matrix Elements of Linear Operators, Active and Passive Transformations, The Eigenvalue Problem, Functions of Operators and Related Concepts, Generalization to Infinite Dimensions.

Unit 2:
Review of Classical Mechanics
The Principle of Least Action and Lagrangian Mechanics, The Electromagnetic Lagrangian, The Two-Body Problem, The Hamiltonian Formalism, The Electromagnetic Force in the Hamiltonian Scheme, Cyclic Coordinates, Poisson Brackets, and Canonical Transformations, Symmetries and Their Consequences.

The Postulates of Quantum Mechanics
The Postulates, Discussion of Postulates I-III, The Schrödinger Equation, The Free Particle, The Particle in a Box, The Continuity Equation for Probability, The Single-Step Potential, The Double-Slit Experiment, Absence of degeneracy in one-dimensional bound states, Ehrenfest's theorem.

Unit 3:
The Harmonic Oscillator
Review of the Classical Oscillator, Quantization of the Oscillator (Coordinate Basis), TheOscillator in the Energy Basis, and Passage from the Energy Basis to the X Basis.
Derivation of the Uncertainty Relations. (2 hours)

Unit 4:
Systems with N Degrees of Freedom
N- Particles in One Dimension, More Particles in More Dimensions, Identical Particle.
Symmetries and Their Consequences
Overview, Translational Invariance in Quantum Theory, Time Translational Invariance, Parity Invariance, Time-Reversal Symmetry.

Unit 5:
Rotational Invariance and Angular Momentum
Translations in Two Dimensions, Rotations in Two Dimensions, The Eigenvalue Problem of Angular Momentum in Three Dimensions, The Eigenvalue Problem of L^2 and L_z. Solution of Rotationally Invariant

Problems.

The Hydrogen Atom

The Eigenvalue Problem, The Degeneracy of the Hydrogen Spectrum, Numerical Estimates and Comparison with Experiment, Multi electron Atoms and the Periodic Table.

Course Outcomes

At the end of the course students will be able to

CO1. Understand and familiarize the mathematical background (Hilbert space) in which thebasic and applied quantum mechanics are framed.

CO2. Apply the various postulates of quantum mechanics to one- and three-dimensionalproblems.

CO3. Understand the basic concepts of angular momentum and improve problem-solving Skills.

Textbooks:

1. R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2nd Ed., 2005.
2. JJ Sakurai, Modern Quantum Mechanics, Pearson, 1st Ed., 1994.

References:

1. S Gasiorowicsz, Quantum Physics, Wiley India, 2E
2. L I Schiff, Quantum Mechanics, TMH, 3E, 2010.
3. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005.

Semester 8

24PHY498	PROJECT	10 cr

Students choosing a 4-Year Bachelor’s degree (Honours), shall decide on it at the end of the 6th semester. These students shall execute a project and earn 10 credits. The proposed project work will get initiated at the beginning of the 7th semester and is to be completed and credited during the 8th semester. The project work involves simple experimental/ simulation methods in various research and development institutes or existing research laboratories at university departments for solving research problems. The project work will be supervised by a faculty from physics department and periodical reviews of the work accomplished will be conducted by a panel involving minimum of three faculty members. The student should give a presentation of the work carried out at the end of the 8th semester to a panel of experts.

Course Outcomes

At the end of the course students will be able

CO1. To understand the fundamental physical concepts and their applications in real-time problems.

CO2. To develop scientific knowledge that leads to innovation.

CO3. To develop communication and report-writing skills.

24PHY499 Dissertation 16 cr

Students choosing a 4-Year Bachelor's degree (Honours with Research) shall decide on it at the end of the 6th semester. These students shall execute a project and earn 14 credits. The proposed project work will get initiated at the beginning of the 7th semester and is to be completed and credited during the 8th semester. They are required to take up research projects under the guidance of a faculty member or from various research and development institutes. The research outcomes of their project work may be published in peer-reviewed journals or may be presented in conferences /seminars or may be patented. The project work aims to give more detailed exposure to the student for research methodology. This can include literature survey, review, data collection, and theoretical/ experimental work on small parts of research in area chosen by the faculty guiding the project work. If the project to be carried out at other institutions/ laboratories, the experts from these institutions are to be associated in choosing the research topic and its execution.

Course Outcomes

At the end of this course, students will be able to

CO1. Understand and practice scientific recording and reporting.

CO2. Apply and use the methods of analytical, logical and scientific reasoning that have been taught in the various subjects to address a relevant real time problem withclear objectives, depth and a well-articulated roadmap.

CO3. Gain better knowledge of the use of analytical, theoretical, and experimental tools to solve/design/study a problem/system.

CO4. Enhance presentation and communication skills.

Core research Courses for Honours with Research

Semester 7

24PHY402	Research Methodology	2 1 1	4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: various methods of scientific research, tools and statistics used in research, ethics in research, and communication of research work.

Unit 1
The method of scientific research: Overview of research methods in science – selection of topic, hypothesis, experiment, analysis, and results; improvement of experiments; safety and ethics. nonexperimental or theoretical research, critical thinking, investigation of scientific epistemology, group research, and teamwork.

Unit 2
Ethical aspects: Scientific ethics, ethics of the researcher, conduct guidelines, ethical standards of publication, plagiarism, scientific fraud, and malpractice.

Unit 3
Communication: Dissemination of results, technical and scientific documents, Graphs, tables, etc. - Quality and impact factor of journals, h-index-Predatory journals. Structure of scientific/technical documents: - preparation of written documents (research articles, reports), techniques of oral presentation and defense of research works, other formats (posters, flash presentations, etc.), skills for academic writing and speaking, online communication technologies, peer evaluation procedures.

Unit 4
Error Analysis: Errors- Uncertainties in Measurements, different types of experimental errors: systematic and random error, Significant Digits, precision, accuracy, Propagation of errors and uncertainties, error bars, Mean, Median, and Standard Deviation, Expectation value, Histograms, and distributions.

Unit 5
Statistics: Measurements and sampling data, Normal distribution, Weighted average, Binomial distribution, Gauss distribution, Poisson Distribution, least-square fitting linear and non-linear curve fitting, Chi-Squared (χ^2) test for a distribution, Covariance, and Correlation.

Course Outcomes:
At the end of the course, students will be able:
CO1. To Familiarize the methods of scientific research.
CO2. To understand the ethical aspects in research
CO3. To familiarize the tools of journal communication and presentation.
CO4. To understand errors in measurements, propagation of errors in physical measurements, use of mathematical models to describe physical phenomena, curve fitting, and data analysis.
Textbooks:
1. Michael P Marder, Research Methods for Science, CUP (2011).
2. P. Bevington, D.K. Harikatha, Data Reduction and Error Analysis for the Physical Sciences, Mc-Graw Hill, 2002.
References:
1. Research Methodology: Methods and Techniques by C. R. Kothari, new age International Publishers. 2004.

Physics Major labs
Semester 1

24PHY181 Problem Solving and Computer Programming Lab 0 0 2 1

1. Running instructions in Interactive interpreter and a Python Script.
2. Scientific problem solving using various data types.
3. Demonstrate the use of tuples & list by programing simple physics concepts.
4. Demonstrate the use of dictionaries by programing simple physics concepts.
5. Scientific problem solving using decision making (if,,if else, if elif ….else).
6. Scientific problem-solving using looping (while, for).
7. Defining mathematical functions applied in physics, creating functions and executing it.
8. Creating multidimensional arrays using NumPy library and perform operations with examples from physical systems.
9. Solving differential equations, basic calculus using SciPy library.
10. Plotting a data using matplotlib.

Course Outcomes
At the end of the course, students will be able:
CO1: to understand Python programming basics, Read, write, and execute simple Python programs.
CO2: to acquire skill in computer programming concepts like data types.
CO3: to be fluent in the use of procedural statements—assignments, conditional statements, loops, function calls —and sequences. Be able to design, code, and test small Python programs based on physical systems.
CO4: to be familiar with the use of the Python packages NumPy & matplotlib and be able to Apply the knowledge in scientific computing.

Semester 2

24PHY182 Physics Lab. I - Mechanics & Properties of Matter 0 0 2 1

1. Compound pendulum measurement of ‘g’ symmetric oscillation.
2. Studies with Rigid pendulum.
3. Young’ Modulus Uniform bending.
4. Young’ Modulus Cantilever.
5. Torsion pendulum.
6. Studying the flow of liquid through capillary tube.
7. Studying the liquid flow through series and parallel combinations of capillaries.
8. Studying the laws of vibration on a non-metallic string with Melde’s apparatus.
9. Studies on exciting the different modes of sonometer wire.
10. Studying the mass on a spring.
11. Velocity of sound in air-Kundt’s tube (Ultra sonic).
12. Determination of surface tension on a mercury drop.
13. Study of collisions in two dimensions.

Course Outcomes:
At the end of the course students will be able to:

CO1. apply the knowledge gained from mechanics course which they had studied.
CO2. analyze and understand the fundamental concepts of mechanics andproperties of matter by performing experiments.
CO3. interpret the data and perform error analysis.

Semester 3

24PHY281	**Physics Lab. II – Heat, Electricity and Magnetism**	**0 0 2**	**1**

1. Thermal conductivity of a bad conductor – Lee's disc method.
2. Spherical calorimeter – specific heat capacity.
3. Thermal conductivity of good conductor – Forbe's method.
4. Studying the variation of total thermal radiation with temperature.
5. Verification of Joule's Law of Heating.
6. Potentiometer calibration, potential drop Calibration of Ammeter and voltmeter.
7. Calibration of thermocouple using potentiometer.
8. Specific resistance Carry forester bridge.
9. Studying the field along the axis of the coil.
10. Mapping of electric field.
11. Studying of Mutual inductance.
12. Deducing the magnetic properties of a sample from its Hysteresis curve on CRO.
13. Studying the charging and discharging and Energy dissipation of capacitor in RC circuits.
14. Studying the amplitude response and phase relation of V_R V_C and V_L in LCR series resonance circuit.

Course Outcomes
At the end of the course students will be able to
CO1. Map Electric and Magnetic fields.
CO2. Independently carry out simple electrical, heat experiments and analyze the data.
CO3. Comprehend the corresponding topics in theory course through the experimentsperformed.

Semester 4

24PHY282	**Physics Lab III – Optics**	**0 0 2**	**1**

1. Determination of focal length of combination of lenses and nodal distance using nodalslide Assembly.
2. Studying the resolving power of a telescope.

3. Studying the dispersive power of prism.
4. Studies on Newton's ring experiment.
5. Studying the Interference fringes in Wedge shaped films.
6. Studying the diffraction by grating – Using Spectrometer at minimum deviation condition.
7. Studying the degree of polarization of light reflected at various incident angles & verifying the Law of Malus.
8. Determination of refractive index of the liquids by applying Snell's law.
9. Diffraction at single, double and multiple slits using laser - studying the intensitydistribution.
10. Diffraction at circular aperture using laser and estimation of unknown particle size.
11. Optical Fiber - Measuring the numerical aperture, beam profile and bending loss.
12. Assembling a Michelson Interferometer and measuring glass refractive index.

Course Outcomes:
At the end of the course students will be able to:
CO1. Apply the basic knowledge gained from optics course to perform optics experiments in the laboratory.
CO2. Present experimental data in various appropriate forms like tabulation and plots.
CO3. Analyze, interpret, and summarize the experimental results.
CO4. Clearly communicate the understanding of various experimental principles,instruments/setup, and procedure.

Semester 5

24PHY381	Physics Lab IV - Modern Physics	0 0 2	1

1. Studying the Energy gap of semiconductors
2. To estimate the value of Planck's constant
3. To estimate the value of Rydberg's constant
4. Estimation of Charge of electron – Thomson's method
5. Studying the Hall Effect and estimation of Hall voltage, Hall Coefficient and number of charge carriers.
6. Studying the characteristics of Photoelectric effect.
7. Studying the characteristic of solar cell Studying the characteristic of photodiode, phototransistor, LDR and opto coupler.
8. Studying the thermal Expansion of crystal Using Interference fringes.
9. Michelson Interferometer – to find the refractive index of transparent material.
10. Fabry Perot Interferometer

Course Outcomes:
At the end of the course students will be able to:
CO1. Demonstrate the usage of various instruments thereby improving theirexperimental skills.
CO2. Familiarize the error analysis and report the result with more precession.
CO3. Comprehend the theoretical concepts by performing the correspondingexperiments.
CO4. Improve various skills such as observation, analysis, pictorial representation ofthe data etc.
CO5. Verify theoretical concepts learnt through experiments and compare theirproximities.

Semester 6

24PHY382 Physics Lab V - Basic Electronics 0 0 2 1

1. Design and performance study of active filters (Low pass, high pass, band pass, band rejection)
2. Characteristic of Zener diode, and voltage regulation using Zener diode (Line and load regulation).
3. bridge rectifier and regulator circuits using CRO.
4. Construction of Power supply, Dual supply with 12 V - IC regulator.
5. Study of frequency response of transistor amplifier.
6. Basic Op–amp circuits-Inverting and non- inverting amplifier, Summing and difference amplifier.
7. Multi vibrators Astable, Monostable and Bistable-Using 555 -Timers.
8. Combination of gate universal- NAND and NOR as universal building blocks and verification of DeMorgan's theorem
9. Flip flops, RS JK Master slave
10. Half adder and Subtractor
11. Counters 4 bits
12. Encoders and Decoders 4 bits
13. full adder IC 7483s
14. Registers 4 bits

Course Outcomes:
At the end of the course students will be able to:

CO1. Acquire basic knowledge on the working of various semiconductor devices.
CO2. Develop analyzing capability in Diode rectification and BJT amplifier circuits.
CO3. Design and test various basic linear application circuits and active filters using Operational amplifiers.
CO4. Develop the skill to build and troubleshoot the Analog circuits.
CO5. Acquire knowledge on basic digital electronic gates and perform combinational logicalcircuits.
CO6. Explain the experimental results in the laboratory with theoretical analysis.

Semester 7

24PHY481 Physics Lab VI – Advanced Electronics 0 0 4 2

1. Design and study of CE amplifier with and without feedback.
2. Two stage amplifiers
3. Power amplifier
4. Differential amplifier
5. Voltage regulated power supplies with Zener diodes and transistors.
6. Design of basic DL, TI, and TTL logic gates
7. RS and JK flip flops using NOR- NAND gates.

8. Schmitt trigger using op-amp.
9. Uses of IC 741
10. Phase shift oscillator
11. 555 timers
12. Three terminal IC voltage regulator
13. Familiarization of 8085 kit and programming
14. A/D and D/A converters
15. Control of stepper motor.

Course Outcomes:
At the end of the course students will be able to:

CO1. Apply the technical knowledge gained from electronics courses that they have studied in the design and analysis of circuits.

CO2. Analyze and design simple circuits using diodes and transistors as well as higher-level Circuits employing integrated-circuit operational amplifiers according to the required specifications and evaluate combinational and sequential logical digital circuits.

CO3. Program and construct applications using a microcontroller (Arduino).

24PHY482	Physics Lab VII Advanced Physics Lab	0 0 4	2

1. Current-Voltage characteristics of DC glow discharge
2. Calibration of a vacuum gauge (Pirani) with the aid of a McLeod gauge.
3. Mass susceptibility of paramagnetic Liquid substance by Quinkes's method
4. Studying the Hall Effect parameters
5. Elastics Constants – Elliptical and Hyperbolic Fringes
6. Skin depth in Al using electromagnetic radiation.
7. Thermionic Emission
8. Verification of Bohr's theory Franck – Hertz Experiment.
9. Stefan's constant – Black body radiation.
10. Study of plasma density, plasma conductivity, and plasma temperature by glowing discharge method.
11. Van der Pauw method or Four Probe Method – Measurement of resistivity and Hall Coefficient of Thin Film.
12. e/m by Millikan oil drop method.
13. Counting statistics, G.M. tube.

Course Outcomes:
At the end of the course students will be able to:

CO1. To expertise the usage of instruments and improve their skills pertaining to it.

CO2. To expertise the methods of error analysis and familiarize them to report their result with more precision.

CO3. To comprehend the theoretical concepts by doing the corresponding experiments.

CO4. To develop various skills such as observation, analysis, pictorial representation of the Data etc.

CO5. To verify or reproduce the concepts and results learned in theory by performing Experiments and comparing their proximities.

Interdisciplinary Minor Courses

(i) Course Requirements for Minor in Scientific Computing

24CSA230	Introduction to Data Structures and Algorithms (Physics)	3 0 2	4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: basic data structures, ability to implement algorithms for the creation, insertion, deletion, searching, and sorting of each data structure, Analysis and comparison of algorithms, and example programs.

Unit 1
Basic concepts of data structures and abstract data types; Basic analysis of algorithms: notions of time and space complexities, asymptotic analysis and notations, efficiency of algorithms. Review of recursion techniques.

Unit 2
Stacks, LIFO; Linked Lists, Queues, and basic operations associated with these structures, algorithms, and applications.

Unit 3
Sorting and searching algorithms: Bubble sort, insertion sort; Divide and conquer strategy; merge sort, quick sort. Linear search, binary search, breadth first and depth first search algorithms, pattern matching algorithms. Other problem-solving strategies: Greedy Method –Fractional knapsack problem, scheduling problem.

Unit 4
Tree: definition and properties, basic tree traversals, Binary Tree, data structure for representing trees, Binary Search Tree, array-based implementation.

Unit 5
Graphs: data structure for graphs, graph traversals, directed acyclic graphs, weighted graphs, shortest paths, minimum spanning trees.
A term project may be given during the last third of the semester on the implementation of some data structure and a simple application carried out in groups of two to four students.

Course Outcomes
At the end of the course, students will be able to
CO1. develop knowledge of basic data structures for storage and retrieval of ordered or unordered data.
CO2. develop a knowledge of applications of data structures including the ability to implement algorithms for the creation, insertion, deletion, searching, and sorting of each data structure.
CO3. Analyze and compare algorithms for efficiency using asymptotic notations.
CO4. Program examples requiring the implementation of the above data structures.

Textbooks:
1. Goodrich M T, Tamassia R and Michael H. Goldwasser, “Data Structures and Algorithms in Python”, Wiley

publication, 2016.

References:

1. Clifford A. Shaffer, “Data Structures and Algorithm Analysis”, Third Edition, Dover Publications, 2012.
2. Tremblay J P and Sorenson P G, “An Introduction to Data Structures with Applications”, Second Edition, Tata McGraw-Hill, 2002

24MAT230	Numerical Methods	3 0 2 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: numerical methods to understand the concept of Calculus, polynomials, system of equations and differential equations.

Unit 1

Solution of Nonlinear Equations: Bisection and False position Methods, Newton Raphson and Secant Methods, Rate of Convergence.

Unit 2

Solution of Linear Systems AX=B and Eigen value problems Direct methods, Gaussian Elimination, Gauss Jordan method, LU Factorisation, Jacobi & Gauss Seidel iterative Methods.

Unit 3

Interpolation, Curve Fitting: Taylor’s Series calculation of Functions, Lagrange’s Polynomial Approximation and Interpolation, Newton Polynomial Approximation using divided differences and Interpolation, Error, Newton-Gregory forward and backward difference interpolation, Hermite interpolation, Piecewise and Spline interpolation, Polynomial approximation and Weierstrass theorem, Principle of Least Squares.

Unit 4

Numerical Differentiation and Integration: Numerical Differentiation using Lagrange, Finite difference interpolation and Undetermined coefficient method, Numerical Integration using Newton-Cotes method, Gauss-Legendre Integration method, Trapezoidal and Simpson method, Quadrature, Composite Trapezoidal and Simpson’s Rule, Romberg Integration, Orthogonal polynomials and Gaussian integration.

Unit 5

Solution of Ordinary Differential Equations: Euler method, Modified-Euler, midpoint method, Taylor series method, Runge-Kutta methods, Error analysis.

Lab Exercises to be done Using Python

1. Bisection and False position Methods.
2. Newton Raphson and Secant Methods.
3. Gaussian Elimination, Gauss Jordan method, LU Factorization
4. Iterative Methods for Solving Linear Equations.
5. Polynomial Approximation and Interpolation Methods 1
6. Polynomial Approximation and Interpolation Methods 2

7. Numerical Differentiation.
8. Numerical Integration 1
9. Numerical Integration 2

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the basic concepts of root finding methods, system of equations and their solutions.
CO2. Understand the concepts of interpolation and construction of polynomials.
CO3. Application of numerical methods to understand the concept of Calculus (Differentiation and Integration).
CO4. Application of numerical concepts to solve ODEs and PDEs.
CO5. Usage of software tools to solve various problems numerically.

Textbooks:
1. Jain M.K., Iyengar S.R.K. and Jain R.K., Numerical Methods for Engineering and Scientific Computation, 3rd edition, New Age International (P), New Delhi, 1995.

References:
1. Qingkai Kong, Timmy Siauw, Alexandre Bayen, Python Programming and Numerical Methods: A Guide for Engineers and Scientist, Academic Press (2020)
2. Jan Kiusalaas, Numerical Methods in Engineering with Python 3, 3rd Ed, CUP (2013)
3. Alex Gezerlis, Numerical Methods in Physics with Python, Cambridge University Press (2020)
4. Mahendra Verma, Practical Numerical Computing Using Python: Scientific & Engineering Applications, Self-Published
5. John H. Mathews, Kurtis D. Fink, Numerical Methods Using Matlab, 4E, Prentice-Hall.
6. Rudra Pratap, Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers, Oxford University Press, 2005.

24PHY230	**Computational Methods in Physics**	**3 0 2**	**4**

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: computer programming using Python/MATLAB to solve scientific problems in physics.

Unit 1
Introduction to scientific computing, number representation in computers and roundoff error.
Review of programming basics: Algorithms and flowchart, data types, control statements, functions, arrays, classes, input/output, reading and writing files, graphs, and data visualizations.
Optional: Parallelization of code for multi-core computing.

Unit 2
Ordinary differential equations: Initial value problems - Euler and Picard Methods, convergence, stability, Runga-Kutta, Verlet, Predictor-corrector methods; Shooting methods.
Sample applications: Projectile Motion, Nuclear decay, Pendulum with dissipation, Lorentz model, Kepler

problem and planetary orbits; Shooting method – eigenvalues and eigenfunctions of bound quantum states of a particle in one-dimensional potentials or equivalent applications or scattering states in a spherical potential.

Unit 3

Roots of an equation: bisection, Newton-Raphson, Secant Methods.

Numerical integration: Mid-point, Trapezoidal, and Simpson's rules, errors.

Sample applications: Energy Eigenvalues of the square well potential, First-order perturbation correction to energy, Magnetic field produced by current.

Unit 4

Partial Differential Equations: discretization, Finite difference method, relaxation methods, stability, Crank-Nicholson method, Spectral methods.

Sample applications: Solving Laplace's equation, Diffusion Equation, Wave Equation, Schrodinger equation, Poisson equation, ground water dynamics, wave-packets in a quantum mechanics – step or barrier potentials.

Unit 5

Stochastic Simulations: Random numbers, Pseudo Random number generators, Distributions, Methods of generating random numbers that simulate non-uniform distributions; transformation method and relaxation method; Monte-Carlo integration.

Sample applications: Random Walk and Diffusion, Cluster Growth Models, Ising Model.

A term project may be given during the last third of the semester, carried out in groups of two to four students.

Course Outcomes:

At the end of the course, students will be able to

CO1. Write basic programs using concepts of computer programming using Python/MATLAB.

CO2. Solve ordinary differential equations using numerical methods. Utilize the concepts of numerical stability and convergence to analyse each of the methods.

CO3. Solve roots of nonlinear equations and apply them to find eigenvalues in simple quantum mechanical potential well problems, estimate integrals using numerical methods with applications in physics and applied fields.

CO4. Apply finite difference methods to approximate boundary value problems with applications in physics and applied fields.

CO5. Understand and apply stochastic simulation methods to problems of interest in physics and applied fields.

References:

1. An Introduction to Computational Physics – Tao Pang.
2. Paul Devries and Javier Hasbun, A First Course on Computational Physics.
3. Nicholas Giordano and Hisao Nakanishi, Computational Physics (2nd Ed.), PrenticeHall.

24CSA343	Introduction to Machine Learning	3 0 2	4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: fundamentals of basic machine learning algorithms and mathematical framework for machine learning, artificial neural networks for machine learning applications and the design and implementation of the right machine learning algorithm for a given real world problem.

Unit 1
Introduction: Basic definitions, types of learning, hypothesis space and inductive bias, evaluation, cross validation. Simple Linear regression, Multiple linear regression, Extensions of the linear model, Classification: overview, Logistic regression, Linear discriminant analysis, comparison of classification methods.

Unit 2
Resampling methods: Cross validation and the bootstrap, Linear model selection and Regularization: Subset selection, Shrinkage methods, Dimension reduction methods, Considerations in high dimensions.

Unit 3
Polynomial regression, step functions, basis functions, regression splines, smoothing splines, local regression, generalized additive models for regression and classification problems, Regression trees, Classification trees, comparison of trees and linear models, Bagging, Random Forests, Boosting.

Unit 4
Support Vector Machines: Hyperplane, Maximum Margin Classifier, Support Vector Classifiers, Support Vector Machines, One vs One Classification and One vs All Classification.
Relationship to Logistic Regression. Unsupervised Learning: Principal Component Analysis and its applications, K-Means Clustering and Hierarchical Clustering.

Unit 5
Neural Networks: Introduction, Projection Pursuit Regression, Neural Networks, Fitting Neural Networks, some issues in Training Neural Networks-Starting Values, Overfitting, Scaling of the Inputs, Number of Hidden Units and Layers, Multiple Minima.

Introduction to Machine Learning Lab to be performed:
1. Introduction to R: Basic Commands, Graphics, Indexing Data, Loading Data.
2. Linear Regression: Libraries, Simple Linear Regression, Multiple Linear Regression.
3. Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis.
4. Cross Validation and Bootstrap, Validation set approach, Leave-One-Out Cross Validation
5. K-Fold Cross Validation, Bootstrap.
6. Subset Selection Methods, Best Subset Selection, Forward and Backward Stepwise Selection.
7. Ridge Regression and the Lasso.
8. Principal Components Regression, Partial Least Squares.
9. Non-Linear Modelling, Polynomial Regression and Step Functions, Splines, GAMS.
10. Decision Trees, Fitting Classification Trees and Regression Trees, Bagging and Random Forests

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the domain of machine learning with respect to the regression and classification and its huge potential for providing solutions to real-life problems.
CO2. Have a good understanding of the fundamental issues and challenges in basic machine learning algorithms in terms of data, model selection, and complexity.
CO3. Understand the problem of Curse of Dimensionality and different methods to tackle it.
CO4. Understand the mathematical framework for machine learning (both supervised and un-supervised

learning) and methods to tackle underfitting & overfitting.

CO5. Learn the motivation and theory behind learning artificial neural networks for machine learning applications.

CO6. Be able to design and implement the right machine learning algorithm for a given real world problem.

Textbooks:

1. G. James, R. Tibshirani, An Introduction to Statistical Learning: with applications in R, Springer.

References:

1. T. Hastie, R. Tibshirani, Elements of Statistical Learning: Data mining, Inference and Predicton, Springer.
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press.
3. Tom M. Mitchel, Machine Learning, McGraw Hill Education, India.
4. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, Prentice Hall of India, 3rd Ed. (2014).
5. Ethem Alpaydin - Machine Learning, revised and updated edition (The MIT Press Essential Knowledge series), The MIT Press (2021)
6. Duda R., Hart P., Stork D., Pattern Classification, 2nd Ed., Wiley Inter science (2000)
7. https://sebastianraschka.com/pdf/lecture-notes/stat451fs20/01-ml-overview__notes.pdf
8. https://onlinecourses.nptel.ac.in/noc22_cs97/preview.

24CSA344 Advanced Machine Learning 3 0 2 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: single layer and multi-layer neural networks, artificial neural network, deep neural networks, CNN, and FFN, recurrent neural networks and its applications.

Unit 1

Machine learning Basics and introduction, Capacity, Overfitting and underfitting, Hyperparameters, Estimator, Bias and Variance, Maximum likelihood estimation, Stochastic Gradient descent

Unit 2

Deep feedforward networks, Learning XOR, Hidden units, Architecture design, Backpropagation.

Unit 3

Regularization, L1 and L2 regularization, Noise robustness, semi supervised learning, Parameter typing and sharing, Sparse representation, Dropout.

Unit 4

Optimization, Challenges in neural network optimization, Parameter initialization strategy, Adaptive learning rates, Optimization algorithms.

Unit 5

Convolution operator, Pooling, Structured outputs, Efficient convolution algorithms, Unsupervised features, Convolution Neural networks, Recurrent Neural Networks, Encoder decoder, LSTM and memory architectures, Optimization for long term dependency.

Advanced Machine Learning Lab to be performed

1. Support Vector Classifier, Support Vector Machine, ROC Curves, SVM with Multiple Classes.

2. Principal Component Analysis and Clustering.
3. Overfitting and Underfitting Bias and Variance.
4. Gradient Descent Algorithm.
5. Backpropagation.
6. Neural Network Optimization 1.
7. Neural Network Optimization 2.
8. Convolution Neural networks.
9. Recurrent Neural Networks.
10. LSTM and memory architectures.

Course Outcomes:
At the end of the course, students will be able to
CO1. To understand the computing capacity of single layer neural networks, and the need for multi-layer neural networks.
CO2. Learn to tackle the under-fitting, overfitting, and getting into local optimal solutions when learning an artificial neural network.
CO3. Learn about the deep neural networks, CNN to understand how it differ from a deep traditional FFN both in terms of the number of parameters to be learned and in terms of the learning by back-propagation.
CO4. Learn to design and use CNN both as a stand-alone classifier and in transfer learning settings.
CO5. Learn the necessary theory behind different recurrent neural networks and its applications to sequential data analysis.

References:
1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press. (Chapters 5-10).
2. “Deep Learning with Python” by Francois Chollet
3. “Machine Learning with PyTorch and Sci-kit Learn” by Sebastian Raschka.

24MAT347	Optimization Techniques	3 0 2	4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: various single and multivariable Optimization Techniques, constrained optimization techniques and their applications.

Unit 1
Introduction to Optimization, Historical Development, Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Optimization Techniques.

Unit 2
Classical Optimization Techniques-Single-Variable Optimization, Multivariable Optimization with no constraints, Multivariable Optimization with Equality Constraints, Solution by Direct Substitution, Solution by the Method of Constrained Variation, Solution by the Method of Lagrange Multipliers, Multivariable Optimization with Inequality Constraints, Kuhn– Tucker Conditions, Constraint Qualification, Convex Programming Problem.

Unit 3
Single Variable Optimization- Optimality criteria, bracketing methods-exhaustive search method, bounding

phase method- region elimination methods- interval halving, Fibonacci search, golden section search, point estimation-successive quadratic search, gradient based methods.

Unit 4

Multivariable Optimization, optimality criteria, unconstrained optimization-solution by direct substitution, unidirectional search-direct search methods, evolutionary search method, simplex search method, Hook-Jeeves pattern search method, gradient based methods-steepest descent, Cauchy's steepest descent method, Newton's method, conjugate gradient method constrained optimization. Multivariable Optimization with no constraints. Multivariable Optimization with Equality Constraints, Solution by Direct Substitution

Unit 5

Solution by the Method of Lagrange Multipliers- Multivariable Optimization with Inequality Constraints, Kuhn–Tucker Conditions, Constraint Qualification, Convex Programming Problem

Practical/Lab to be Performed Using MATLAB/Python

1. To determine local/Relative optima of a given unconstrained problem.
2. Test whether the given function is concave/convex.
3. Test whether the given matrix is positive definite/negative definite/semi positive definite/ semi negative definite
4. Solution of optimization problems using Karush-Kuhn-Tucker conditions
5. Find optimal solution of single variable functions using (i) Exhaustive search methods, (ii) Bounding phase method (iii) Region elimination method interval halving, (iv) Fibonacci search (v) Golden section search (vi) Point estimation-successive quadratic search (vii) Gradient based methods
6. Find optimal solution of two variable problems based on the methods (i) Hook-Jeeves pattern search method (ii) Gradient based methods-steepest descent (iii) Cauchy's steepest descent method (iv) Newton's method (v) Conjugate gradient method-constrained optimization

Course Outcomes:

At the end of the course, students will be able to

CO1. Understand different types of Optimization Techniques in engineering problems. Learn Optimization methods such as Bracketing methods, Region elimination methods, Point estimation methods.

CO2. Learn gradient based Optimizations Techniques in single variables as well as multivariables (non-linear).

CO3. Understand the Optimality criteria for functions in several variables and learn to apply OT methods like Unidirectional search and Direct search methods.

CO4. Learn constrained optimization techniques. Learn to verify Kuhn-Tucker conditions and Lagrangian Method.

CO5. Familiarize the concept of optimization in practical applications to find the best feasible solutions in practical applications.

Textbooks:

1. Edwin K.P. Chong and Stanislaw H. Zak (2004), An introduction to optimization, 2nd Ed, Wiley Inter-science.
2. S.S Rao (2009) Engineering Optimization: Theory and Practice, John Wiley & Sons, Inc.

References:

3. Kalyan Moy Deb (2004) Optimization for engineering design algorithms and examples, Practice Hall of India, New Delhi.

4. M. Asghar Bhatti (2000), Practical optimization methods, Springer-Verlag.

24PHY331 Principles of Remote Sensing 2 0 2 3

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: fundamental remote sensing concepts, interaction of electromagnetic spectrum with various media, sensors and image acquisition, and acquiring of remote sensing images.

Unit 1
Introduction, definition, history of satellite remote sensing, Electromagnetic spectrum, radiation laws, The Radiative Transfer Equation, interaction with atmosphere, interaction with surfaces, Surface Reflection, Spectral Response and Spectral Signature, Spectral, Spatial, Temporal and Radiometric resolutions.

Unit 2
Satellite sensors: Orbits and Platforms for earth observation, sensors and scanners, spectral sensitivity, band combinations-optical imagery, stereo photogrammetry.
Digital imagery: spectral sensitivity, digital data formats, band combination - multispectral imagery, radiometric corrections. Elementary image processing: histogram operations, filter operations, image fusion, geometric operations, visual image interpretation.

Unit 3
Active and passive microwave remote sensing: basics of RADAR and LIDAR, radiometry, spectrometers, image restorations and atmospheric corrections, Thermal imagery: basic theory, blackbodies and emissivity, processing of thermal data.

Unit 4
Commonly used multi-spectral remote sensing satellite systems: LANDSAT, SPOT, ENVISAT, RADARSAT, IRS, IKONOS, SENTINEL Family, RISAT, RESOURCESAT etc.

Course Outcomes:
At the end of the course, students will be able to
CO1. Define the concepts of remote sensing and applications.
CO2. Describe electromagnetic spectrum and the interactions with various media.
CO3. Detail the various sensors and image acquisition.
CO4. Acquire remote sensing images from common multispectral platforms.
CO5. Apply the basics of image processing to remote sensing images.

Textbooks:
1. George Joseph and C Jaganathan, Fundamentals of Remote Sensing, Universities Press, India.
2. Barrett, E. C., Introduction to environmental remote sensing, Routledge (2013).
3. Chuvieco, Emilio, Fundamentals of satellite remote sensing: An environmental approach, CRC press (2016).
4. Lillesand, T., Kiefer, R. W., & Chipman, J, Remote sensing and image interpretation. John Wiley & Sons (2015).
5. Campbell, J. B., & Wynne, R. H. (2011). Introduction to remote sensing. Guilford Press.

24PHY332 Advanced Remote Sensing 3 0 2 4

Prerequisite: Principle of Remote Sensing

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Image processing, Hyper-spectral Remote Sensing, RADAR Techniques, and LiDAR.

Unit 1
Image processing: Image registration – definition principle and procedure - Fundamental of image recertification, interpolation- intensity interpolation- Radiometric & geometric correction of remotely sensed data. Basic statistical concept in DIP and use of probability methods in DIP- Image enhancement techniques - an overview-Contrast enhancement - linear and nonlinear, histogram equalisation and density slicing Spatial filtering and edge enhancement, Multi image manipulation – addition, subtraction, and band rationing; Image Classification: supervised and unsupervised learning techniques.

Unit 2
Hyper-spectral Remote Sensing: Hyper-spectral Imaging: Hyper spectral concepts, data collection systems, calibration techniques, data processing techniques; pre-processing, N-dimensional scatterplots, Special angle mapping, Spectral mixture analysis, Spectral Matching, Mixture tuned matched filtering, Classification techniques, airborne and spaceborne hyperspectral sensors, applications. High-resolution hyperspectral satellite systems: Sensors, orbit characteristics, description of satellite systems, data processing aspects, applications.

Unit 3
RADAR Techniques: Fundamentals of RADAR, SAR Interferometry, and SAR imagery; Introduction to SAR sensors and platforms Applications of RADAR -soil response-vegetation response- water and ice response- urban area response coherence maps, DEM generation, interferogram and displacement maps SAR Interferometry (InSAR, DInSAR) and Polarimetry: [fundamental concept, application]

Unit 4
LiDAR: Principles of LiDAR, LiDAR sensors and platforms, LiDAR data view, processing, and analysis, LiDAR applications: topographic mapping, vegetation characterization, and 3-D modelling of urban infrastructure.

Skills acquired: Theoretical and practical knowledge of acquiring and processing RADAR, LIDAR and hyperspectral data.

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand concepts of Radar systems and their application.
CO2. Gain knowledge in the principles of Lidar data and interpretation.
CO3. Understand the various application domains of hyperspectral remote sensing.
CO4. Gain exposure to various image processing techniques.

Textbooks/References:

1. John A Richards and Xiuping Jia, Remote Sensing Digital Image Analysis: An Introduction.
2. Floyd M. Handerson and AnthonyJ.Lewis, “Principles and applications of Imaging RADAR”, Manual of Remote sensing, 3rd edition, vol.2, ASPRS, Jhumurley and Sons, Inc, 1998.
3. Ian Faulconbridge, Radar Fundamentals, Argos Press, 2002.
4. Philippe Lacomme,Jean clande Marchais,Jean-Philippe Hardarge and Eric Normant, Air and spaceborne radar systems - An introduction, Elsevier publications 2001.
5. Roger J Sullivan, Knovel, Radar foundations for Imaging and Advanced Concepts, SciTech Pub, 2004.
6. Marcus Borengasser and William C., Hungate and Russel Watkins, “Hyper spectral Remote sensing: principles and application” CRC, 2008.
7. Pinliang Dong and QiChen., Lidar remote sensing and applications ISBN 9781138747241 Published December 12, 2017, by CRC Press220 Pages 40 Color & 143 B/W Illustrations.

24PHY333 Satellite Meteorology 3 0 2 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Remote Sensing, Meteorological Satellites, Satellite-derived products, Basic Principles of Sounding, and Interpretation of Satellite Images.

Unit 1
Remote Sensing: Principles of remote sensing, Application in meteorology, Introduction to satellite meteorology, Orbital mechanics.

Unit 2
Meteorological Satellites: Polar, geostationary, and low-inclination orbits, Current and future meteorological satellites of the world. Payloads on meteorological satellites, INSAT, Kalpana, Meteosat, GOES, Himawari, FY, NOAA, Metop, Megha Tropiques, Scatsat-1, Oceansat, Exposure to fundamental concepts like resolution, calibration, navigation, registration, NEDT (Noise equivalent differential temperature).

Unit 3
Satellite derived products, SST, CTT, CTP AOD, OLR, AMV and wind derived Products, UTH, Rainfall products (IMSRA &HE), Fog, Snow, Rainfall Products, Concepts of Image Enhancement techniques, and RGB Images from Imager & Normalized Difference of Vegetation Index (NDVI) from CCD etc. and their application in forecasting/ nowcasting.

Unit 4
Basic Principles of Sounding: Processing of data from infrared and microwave sounders. Retrieval of products from sounders, Temperature and humidity profiles and total ozone. Interpretation and use of sounder products.

Unit 5
Interpretation of Satellite Images: Characteristics of various channels, Identification of typical clouds and weather systems from cloud imageries, Satellite bulletin and its interpretation. Tropical cyclones, their identification and grading using Dvorak’s technique. Interpretation of microwave channel images. Image Enhancement Techniques, Interpretation of Imagery and Products (like RGB) from INSAT/Foreign Satellites, Satellite based tools for nowcasting, Concept of rapid scan images and its use, Assimilation of satellite data in NWP models, Use of satellite in very short-range forecast to now casting.

Course Outcomes:
At the end of the course, students will be able to
CO1. Explain the basic principles of remote sensing.
CO2. Discuss the various meteorological satellite systems.
CO3. Produce various satellite derived products.
CO4. Interpret observations from in situ and satellite sensors.

References:
1. Kidder, S. Q., KIDDER, R. M., & Haar, T. H. V. (1995). Satellite meteorology: an introduction. Gulf Professional Publishing.
2. Kelkar R R (2017) Satellite meteorology, CRC Press.
3. Bowman, K., & Yang, P. (2015). Satellite Meteorology and Atmospheric Remote Sensing: An Introduction, Wiley-VCH.
4. Hoffman, R. R., & Markman, A. B. (Eds.). (2019). Interpreting remote sensing imagery: human factors. CRC press.

24PHY334 Numerical Weather Prediction 3 0 2 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: PDE in meteorology and various Operational Numerical Models, Parameterization of physical processes, Data Assimilation, and Post-processing of NWP Products.

Unit 1
Numerical Methods: Basic concepts about different methods for solving model equations: Finite difference method. Implicit & semi-implicit scheme. Numerical stability criterion (CFL). Spectral method.

Unit 2
Operational Numerical Models: Operational NWP modelling system: Global Forecast System, Regional and mesoscale forecast system (WRF, ARPS), Nowcast model, Climate Forecast System, Ensemble prediction system, multi-model ensemble technique, Cyclone model Hurricane WRF, vortex relocation and initialization, Antarctica model Polar WRF, Storm Surge modelling, Ocean State modelling, Crop Weather Model.

Unit 3
Parameterization of physical processes: Basic concepts of Planetary boundary layer, Land surface processes, Convection (Deep cumulus and shallow convection), Large scale condensation, Radiation (short wave & long wave parameterization), Cloud Radiation interaction, Dry and moist convective adjustment processes, Cloud microphysical parameterization.

Unit 4
Data Assimilation: Different objective analysis schemes, Cressman techniques, OI scheme (Optimum interpolation). Global Data Assimilation System: Decoding and quality control of GTS conventional/non-conventional observations (including Radar and satellite data), Regional and global data assimilation system: variational data assimilation, 3D vibrational data assimilation, technique (WRF Var).

Unit 5

Post-processing of NWP Products: Different products: Direct and Derived, Post processing of model output: Model output verification: Forecast skills, Forecast errors, Systematic errors, Bias correction. Down scale of NWP model like location specific forecast, Statistical interpretation, NWP products for aviation services, hydrological services, NWP products for localized severe weather, monsoon rainfall prediction, prediction of Western disturbances. NWP based objective cyclone forecast system, NWP based location specific forecast, GIS application for NWP, NWP products in Web.

Practical

Basics of Linux O.S, Configuration of WRF model, Experiment with nesting and nest down techniques, sensitivity experiments for physical parameterization. Model diagnosis: Illustration of NWP products, Case study of monsoon depression, cyclonic storm, localized severe weather with the use of derived products like divergent, vorticity, flow pattern, precipitable water content, vertically integrated moisture flux, rainfall etc

Course Outcomes:

At the end of the course, students will be able to

CO1. Apply the techniques of solving PDEs for meteorological equations.
CO2. Experiment with different modelling systems.
CO3. Explain the concepts of parameterization of physical processes in weather models.
CO4. Summarize the concepts of data assimilation.
CO5. Interpret numerical weather model outputs.

References:

1. Chandrasekar, A. (2022). Numerical Methods for Atmospheric and Oceanic Sciences. Cambridge University Press.
2. Coiffier, J. (2011). Fundamentals of numerical weather prediction. Cambridge University Press.
3. Warner, T. T. (2010). Numerical weather and climate prediction. Cambridge university press.
4. Stensrud, D. J. (2009). Parameterization schemes: keys to understanding numerical weather prediction models. Cambridge University Press.

(ii) Course Requirements for Minor in Astrophysics

24PHY241	Introduction to Astrophysics	3 1 0	4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: basic astronomical background and the physical properties of solar system, planets, stars, galaxies and the Universe.

Unit 1:
Introduction: Scales and Dimensions, Cardinal directions, zenith, horizon, Night Sky, pole star at any location, Constellations; Daily motion of celestial objects: Earth, Sun, and the Solar System, and diurnal circles, Seasons - phases of the Moon - the Moon's orbit and eclipses - timekeeping (sidereal vs synodic period). Basic time units: Day, Month and Year.
Celestial Mechanics: Elliptical orbits, Gravitational Kepler's law, Virial Theorem (qualitative approach).

Unit 2:
Physical processes in the solar system: Tidal forces, Physics of the planetary atmosphere.
Terrestrial Planets: Mercury, Venus, Earth, Mars, and the Moon. The realms of Giant planets, Minor bodies of the solar system: Meteorites, Asteroids, Minor planets and Comets: Individual Minor Planets, Comas and Tails of Comets, Planetary Rings. characteristics of extrasolar planet system.

Unit 3
Stars: Measuring stellar characteristics (temperature, distance, luminosity, mass, size) - HR diagram - stellar structure (equilibrium, nuclear reactions, energy transport) - stellar evolution.

Unit 4
Galaxies: Our Milky Way, Galactic formation, morphology, and kinematics, Nature of Galaxies, Galactic evolution.

Unit 5
Universe: Big Bang - history of the Universe, Expansion of the Universe - redshifts – supernovae.

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the basic stellar measurements, Constellations, characteristics of the celestial bodies, and the Celestial Mechanics.
CO2. Identify Physical processes in the solar system and characteristics of Terrestrial and extrasolar Planets.
CO3. Comprehend the basic of Stellar Parameters.
CO4. Understand the nature of galaxies.
CO5. Understand the nature and origin of universe.

Textbooks:
1. An Introduction to Astronomy and Astrophysics, Pankaj Jain. 2015 by Taylor & Francis Group, LLC
2. An Introduction to Modern Astrophysics, Second Edition, Bradley W. Carroll, Dale A. Ostlie, 2007, Pearson Education, Inc.

References:
1. Shu, F., The Physical Universe, University of California, 1982.
2. Harwit, M. Astrophysical Concepts, 3rd ed, Springer-verlag, 2006.

3. Padmanabhan, T., Theoretical Astrophysics, Vols.1-3, Cambridge University Press, 2005.

24PHY242 Introduction to Indian Astronomy 3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: various milestones in the Indian Astronomy such as Vedic and Siddhāntic Astronomy, Solar and Lunar Eclipses, Diurnal problems, Nīlakaṇṭha Somayājī's revised planetary model, Tripraśna topics, calculations of Rāśis, Lagna, and Eclipse, The Vākya system, various Astronomical Instruments, and the 18th and 19th century Indian Astronomy.

Unit 1

Vedic Astronomy: Astronomical concepts in Vedic literature regarding the Sun, Moon, Stars, Earth. Months, seasons, year. 27 nakṣatras. Ecliptic and ayana. Planets, Comets etc. Pole star in an earlier era. Nakṣatra division of the ecliptic and motion of the Sun along it in Vedāṅga Jyotiṣa (VJ) and other texts. VJ calendar. VJ computations. Duration of a day. Better value for a year in Vedic literature.

Siddhāntic astronomy: Earlier Siddhāntas and Pañcasiddhāntikā. Introduction of trigonometry, Indian jyā–astronomy. Āryabhaṭīya. Mahāyuga. (Kalpa etc., and smaller units of time can be introduced at this stage). Revolution numbers of planets. Ahargaṇa and Mean longitudes, Examples. Obtaining the true longitudes by applying corrections to mean longitudes.

Epicycle models: Manda correction (Equation of centre) in detail and its significance. Latitude of Moon. Śīghra correction to planets and their significance: Essential features only with the aid of diagrams and final formulae. Latitudes of planets. Precession of equinoxes— Nirayana and Sāyana longitudes.

Nature and organisation of texts. Sūtra (algorithmic) format. Siddhānta, Tantra, Karaṇa and Vākya texts. Sāraṇis or Tables.

Unit 2

Indian Calendar: Pañcāṅga. Adhikamāsas. Solar and Luni-Solar systems.

Solar and Lunar Eclipses: Angular diameters of the Sun, Moon and Earth's shadow. Possibility of eclipses. Finding the middle of an eclipse by iteration. Amount of obscuration at any time.

Tripraśna Topics (Diurnal problems): Description of the celestial spheres and various circles. Similarity to modern description. Determination of the East-West directions. Derivation of the expression for the declination in terms of the longitude. Shadow of a gnomon. Equinoctial day when the locus of the tip of the shadow is a straight line. Finding the latitude. Mid-day shadow. Finding the declination. Relation between time and the shadow at an arbitrary instant (no derivation).

Unit 3

Planetary longitudes and latitudes and Nīlakaṇṭha Somayājī's revised planetary model: True longitudes of planets: Manda and Śīghra corrections in detail. Geometrical description. Comparison with Kepler's model. Latitudes of planets. Nīlakaṇṭha Somayājī's revision of the planetary model: Nīlakaṇṭha's analysis of the motion of the interior planets (Mercury and Venus). Comparison with Tycho Brahe model and the Kepler model.

Rates of motion of planets: Idea of derivative in finding the Mandagatiphala (manda-correction to the mean rate of motion). The correct formula due to Nīlakaṇṭha. True rates of motion of planets: Correct expression due to Bhāskara. Application to calculate retrograde motion of planets.

Unit 4

Tripraśna topics: Latitudinal triangles (of Bhāskara) and applications. Agrajyā or the distance between the rising-setting line and the east-west line. Correction to the east-west line due to change in Sun's declination. Zenith distance in terms of the declination, hour angle and latitude ($\cos z = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos H$). Derivation of this formula as in Siddhāntaśiromaṇi. Relation among Śaṅkutala (Śaṅkvagra), Bhujā, Agrajyā and its applications.

Rising times of Rāśis and finding Lagna: Relation between the right ascension and longitude and rising times of rāśis at the equator. Rising times at an arbitrary latitude. Finding the Lagna at any instant after Sunrise (approximate).
Eclipse calculations: Details of calculations of the middle of a lunar eclipse and half-durations iteratively, using the correct expression for the rate of motion of the Moon. Parallax and the calculation of the middle of a solar eclipse.

Unit 5
The Vākya system: Longitude of the Sun from the 'subtractive minutes' at any time ('Bhūpajña etc. vākyas). Vākyas for zodiacal transit times ('Śrīrguṇamitra' etc.). Longitude of the Moon using the Candravākyas ('gīrnaśreyaḥ' etc). More accurate values due to Mādhava.
Astronomical Instruments: Gnomon. Cakra and Dhanur yantras for measuring the zenith distance of the Sun. Approximate and exact times from a 'yaṣṭi'. Phalakayantra to measure the hour angle. Equatorial sundial to measure time. Clepsydra for measuring time. Celestial globe and Armillary sphere for explaining celestial coordinates and various circles.
Indian Astronomy in the 18th and 19th centuries: Astronomical endeavours of Savai Jayasiṃha. Samrat-yantra and other instruments in the observatories of Jayasiṃha. European observers on the simplicity and accuracy of Indian eclipse computations. The work of Śaṅkaravarman and Candraśekhara Sāmanta. Efforts to update the Indian calendar.

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the Astronomical concepts in Indian Vedic literature regarding seasons, months, year, and the use of Siddhāntic astronomy for trigonometry and longitudes.
CO2. Comprehend the concepts of Indian Calendar system, Solar and Lunar Eclipses, and the Tripraśna Topics (Diurnal problems).
CO3. Understand the concepts of Nīlakaṇṭha Somayājī's revised planetary model and its comparison with western models.
CO4. Understand the calculations in Tripraśna topics, finding Rāśis, and Lagna, and Eclipse.
CO5. Understand and familiarize the Vākya system for finding Longitude of the Sun and moon, various astronomical Instruments such as Cakra, Dhanur yantras, yaṣṭi, Phalakayantra, sundial, Clepsydra, Celestial globe and Armillary sphere.

Textbooks:

1. Ganita Yukti Bhasa by K.V. Sarma
2. S. Balachandra Rao, Indian Astronomy-Concepts and Procedures, M.P. Birla Institute of Management, Bengaluru, 2014.
3. S. N. Sen and K. S. Shukla, Eds., History of Astronomy in India, 2nd Ed., INSA, New Delhi, 2001

References:

1. K. Ramasubramanian, A. Sule and M. Vahia, Eds. History of Astronomy: A Handbook, SandHI, I.I.T Bombay and T.I.F.R., Mumbai, 2016.
2. Āryabhaṭīya of Āryabhaṭa, Edited with translation and notes, K. S. Shukla and K. V. Sarma, Indian National Science Academy, New Delhi, New Delhi, 1976.
3. B.V. Subbarayappa and K.V. Sarma, Indian Astronomy: A Source Book, Nehru Centre, Bombay, 1985.
4. Tantrasaṅgraha of Nīlakaṇṭha Somayājī, Translation and Notes, K. Ramasubramanian and M.S. Sriram, Hindustan Book Agency, New Delhi 2011 (Rep. Springer, New York 2011)

5. Karaṇapaddhati of Putumana Somayājī, Translation and Notes, R. Venkateswara Pai, K. Ramasubramanian, M.S. Sriram and M. D. Srinivas, Hindustan Book Agency, New Delhi, 2018 (Rep. Springer, New York 2018)

24PHY243 Astronomical Techniques 3 0 2 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the Celestial Sphere and observations, Telescopes types, Astrometry, Photometry, Detectors for electromagnetic spectrum.

Unit 1
The Celestial Sphere: The Greek tradition, The Copernican Revolution, Positions on the Celestial Sphere, Physics and Astronomy
Observations: Electromagnetic Waves, Electromagnetic Spectrum, Observations at Visible Frequencies, Theoretical Limit on Resolution, Seeing.

Unit 2
Telescopes: The classic Newtonian telescope, The Cassegrain telescope, Catadioptric telescopes, The Schmidt camera, The Schmidt–Cassegrain telescope, The Maksutov–Cassegrain telescope, Active and adaptive optics, Some significant optical telescopes: Gemini North and South telescopes, The Keck telescopes, The South Africa Large Telescope (SALT), The Very Large Telescope (VLT), The Hubble Space Telescope (HST). The future of optical astronomy: Radio telescopes, The feed and low noise amplifier system, Radio receivers, Telescope designs, Large fixed dishes, Telescope arrays, Very Long Baseline Interferometry (VLBI), The future of radio astronomy, Observing other wavebands: Infrared – Sub-millimetre wavelengths. The Spitzer space telescope, Ultraviolet, X-ray, and gamma-ray observatories.

Unit 3
Astrometry: Coordinate Systems- The Horizontal System, Equatorial Coordinate System, Ecliptic System, Galactic Coordinate System, and Super galactic Coordinate System. Space Velocity and Proper Motion of Stars: Doppler Effect, Parallax, Aberration.

Unit 4
Photometry: Introduction, Flux Density and Intensity, Blackbody Radiation, Energy Density in an Isotropic Radiation Field, Magnitude Scale: Apparent, and absolute Magnitude, Color Index, Bolometric Magnitude. Stellar Temperature: Effective Temperature, and Color temperature, the connection between color and Temperature. Application of Plank’s Radiation law in astrophysical systems.

Unit 5
Detectors: Detectors for optical and infrared regions, Application of CCD's to stellar imaging, photometry, and spectroscopy, Techniques of observations of astronomical sources from space in infrared. EUV, X-ray, and gamma-ray regions of the electromagnetic spectrum. (Working Principle only).

Practical/Lab to be Performed

- *To estimate the temperature of an artificial star by photometry*
- *Characteristics study of a CCD camera*

- *To study the solar limb darkening effect*
- *Polar alignment of an astronomical telescope*
- *To estimate the relative magnitude of a group of stars*
- *To study the atmospheric extinction for different colors*
- *To study the effective temperature of stars by B-V photometry*
- *To estimate the night sky brightness with a photometer*
- *To estimate the distance to the moon by parallax method*
- *To estimate the distance to a Cepheid variable*
- *To study the variability of delta Scuti type stars*
- *To study the variability of RS CVn binaries*
- *Polarization of day/moon light Rayleigh scattering*

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the observations of electromagnetic spectrum, and locating objects based on the Celestial Sphere.
CO2. Familiarize Some significant optical and radio telescopes.
CO3. Understand the various Coordinate Systems used for the precise measurements of the positions and movements of stars and other celestial bodies.
CO4. Understand the stellar flux, temperature, and brightness of a star using photometric techniques.
CO5. Understand the principles of electromagnetic Detectors.

Textbooks:

1. An Introduction to Modern Astrophysics, Second Edition, Bradley W. Carroll, Dale A. Ostlie, 2007, Pearson Education, Inc.
2. Introduction to Astronomy and Cosmology, Ian Morison, Wiley (UK), 2008.
3. C.R. Kitchin, Astrophysical Techniques, CRC press.

References:

1. M. Longair, High Energy Astrophysics vol 1, Cambridge University Press
2. An Introduction to Astronomy and Astrophysics, Pankaj Jain. 2015 by Taylor & Francis Group, LLC

24PHY341	Planetary Sciences	3 1 0	4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Planetary Properties, Dynamics of Planetary bodies, Solar Heating and Energy Transport mechanisms, Planetary structure, and Planet Formation.

Unit 1:
Introduction: A Brief History of Planetary Sciences, Inventory of the Solar System, Planetary Properties: Orbit, Mass, Size, Rotation, Shape, Temperature, Magnetic Field, Surface Composition, Surface Structure, Atmosphere, Interior. Formation of the Solar System.

Unit 2:
Dynamics: The Two-Body Problem, The Three-Body Problem, Perturbations and Resonances, Stability of the Solar System: Orbits of the Eight Planets, Survival Lifetimes of Small Bodies. Dynamics of Spherical Bodies: Moment of Inertia, Gravitational Interactions.

Unit 3

Solar Heating and Energy Transport: Energy Balance and Temperature: Thermal (Blackbody) Radiation, Albedo, Temperature. Energy Transport, Conduction, Convection - Adiabatic Gradient, and Radiation. Greenhouse Effect.

Unit 4

Planetary structure and Atmospheres: Atmospheric Composition, Clouds, Meteorology, Photochemistry, Molecular and Eddy Diffusion, Atmospheric Escape.
Planetary Surfaces and Interiors: Mineralogy and Petrology: Minerals, Rocks, Material under High Temperature and Pressure, Cooling of a Magma. Planetary Interiors, Surface Morphology, Impact Cratering.
Sun, Solar Wind and Magnetic Fields: The Sun, The Interplanetary Medium, Planetary Magnetospheres, Generation of Magnetic Fields.

Unit 5

Planet Formation: Solar System Constraints, Star Formation: A Brief Overview, Evolution of the Protoplanetary Disk, Growth of Solid Bodies, Formation of the Terrestrial Planets, Formation of the Giant Planets, Planetary Migration, Small Bodies Orbiting the Sun, Planetary Rotation satellites of Planets and of Minor Planets, Exoplanet Formation Models, Confronting Theory with Observations.
Planets and Life: Drake Equation, What Is Life? Biological Thermodynamics, Why Carbon and Water?, Circumstellar Habitable Zones, Planetary Requirements for Life.

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the basic Planetary Properties and the formation of Solar System.
CO2. Understand the Dynamics of Two-Body and Three-Body Problem, and of Spherical Bodies.
CO3. Comprehend the ideas of Energy Transport mechanisms.
CO4. Familiarize the structure and Atmosphere of planets, the Surfaces and Interiors of planets, and the generation of Solar Wind and Magnetic Fields in sun.
CO5. Understand the concept of Planet Formation.

Textbooks:
1. Fundamental Planetary Sciences, Physics, Chemistry, and Habitability. Jack J. Lissauer, Imke de Pater. University Printing House, Cambridge CB2 8BS, United Kingdom, 2019.

References:
1. The Solar System: Therese Encrenaz and Jean-Pierre Bibring (Latest Edition) - Astronomy and Astrophysics Library, Springer.
2. The Origin and Evolution of the Solar System: Michael M. Woolfson - IoP CRC Press.
3. Moons and Planets, W.K. Houtmann, Wadsworth Publishing Company 4th Ed.
4. Exoplanets - Edited by Sara Seager - University of Arizona Press 2011.

24PHY342 Stellar Structure and Evolution 3 1 0 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the classification of binary stars and stellar parameters, the stellar atmospheres, structure,

evolution and the models, star formation to death and life cycle.

Unit 1

Binary systems and stellar parameters: Classification of binary stars – Mass determination using Visual binaries – Eclipsing, spectroscopic binaries – Search for extrasolar planets.

Classification of Stellar Spectra: Formation of Spectral lines – Hertzprung-Russell diagram. Stellar Atmospheres: Description of the Radiation Field, Stellar Opacity, Radiative Transfer, Transfer Equation, Profiles of Spectral Lines.

Unit 2

The Interiors of Stars: Hydrostatic Equilibrium, Pressure Equation of State, Stellar Energy Sources, Energy Transport and Thermodynamics, Stellar Model Building, The Main Sequence.

The Sun: Solar Interior, Solar Atmosphere, Solar Cycle.

Unit 3

The Interstellar Medium and Star Formation: Interstellar Dust and Gas, The Formation of Protostars, Pre-Main-Sequence Evolution.

Main Sequence and Post-Main-Sequence Stellar Evolution: Evolution on the Main Sequence, Late stages of stellar evolution, Stellar Clusters.

Unit 4

Stellar Pulsation: Observations of pulsating stars – Physics of stellar pulsation – Modeling stellar pulsation – non-radial stellar pulsation.

Fate of Massive Stars: Post-Main-Sequence Evolution of Massive Stars, The Classification of Supernovae, Core-Collapse Supernovae, Gamma-Ray Bursts, Cosmic Rays; Observational tests of stellar evolution theory.

Unit 5

Degenerate Remnants of Stars: The discovery of SIRIUS B, White Dwarfs, Physics of Degenerate Matter, Chandrasekhar Limit, Cooling of White Dwarfs, Neutron Stars, Pulsars.

General Theory of Relativity and Black Holes: General theory of relativity, Intervals and Geodesics, Black holes.

Close Binary Star Systems and Evolution: Gravity in close binary star systems, Accretion disks, White dwarfs in semi-detached binaries, Type Ia supernovae, Neutron stars, and Black holes in Binaries.

Course Outcomes

At the end of the course, students will be able to:

CO1. Understand the Binary systems and stellar parameters.

CO2. Know the Interiors of Stars and Sun.

CO3. Comprehend the Interstellar Medium and Star Formation.

CO4. learn the Stellar Pulsation and Fate of Massive stars.

CO5. Understand the Degenerate Remnants of Stars and Black Holes.

Textbooks

1. An Introduction to the Theory of Stellar Structure and Evolution, Dina Prialnik, second edition, Cambridge University Press, 2011.
2. An Introduction to Modern Astrophysics, Second Edition, By Carroll B.W., Ostlie D.A., Pearson Addison Wesley

References:

1. Introduction to Stellar Astrophysics, Volume 3, Stellar structure and evolution, By Erika Bohm-Vitense,

Cambridge University Press
2. The Physical Universe: An Introduction to Astronomy by F. H. Shu, 1982, University Science Books.

24PHY343 Formation, Structure and Dynamics of Galaxies 3 1 0 4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: observational facts about galaxies and structures of and Evolution the universe, structures of morphology and different types of galaxies and their clustering, cosmological perturbations, gravitational collapse and collision less dynamics in the formation of a galaxy.

Unit 1
Milky Way galaxy: Counting the stars in the sky, Morphology of galaxy, Kinematics of the Milky Way, Galactic center.
Nature of Galaxies: Hubble sequence, Spiral and Irregular Galaxies, Spiral Structure, Elliptical Galaxies.
Galactic Evolution: Interactions of galaxies, Formation of Galaxies.

Unit 2
Structure of the universe: Extragalactic Distance Scale, Expansion of the Universe, Clusters of Galaxies.
Active Galaxies: Observations of active galaxies, A unified model of active galactic nuclei, Radio Lobes and Jets, using Quasars to probe the universe.

Unit 3
Cosmological Perturbations: Newtonian Theory of Small Perturbations, Relativistic Theory of Small Perturbations, Linear Transfer Functions, Statistical Properties, The Origin of Cosmological Perturbations.

Unit 4
Gravitational Collapse and Collision less Dynamics: Spherical Collapse Models, Similarity solutions for spherical collapse, Collapse of Homogeneous Ellipsoids, Collision less Dynamics, Collision less Relaxation, Gravitational Collapse of the Cosmic Density Field.
Probing the cosmic density field: Large-Scale Mass Distribution, Large-Scale Velocity Field, Clustering in Real Space and Redshift Space, Clustering Evolution, Galaxy Clustering, Gravitational Lensing, Fluctuations in the Cosmic Microwave Background.

Unit 5
Formation and Structure of Dark Matter Halos: Density Peaks, Halo Mass Function, Progenitor Distributions and Merger Trees, Spatial Clustering and Bias, Internal Structure of Dark Matter Halos, The Halo Model of Dark Matter Clustering.
Formation and Evolution of Gaseous Halos: Basic Fluid Dynamics and Radiative Processes, Hydrostatic Equilibrium, The Formation of Hot Gaseous Halos, Radiative Cooling in Gaseous Halos, Thermal and Hydrodynamical Instabilities of Cooling Gas, Evolution of Gaseous Halos with Energy Sources, Observational Tests.

Course Outcomes:
At the end of the course, students will be able to:
CO1. Understand the star's life cycle from formation to death.
CO2. Understand the Structure of the universe and the methods of observations of active galaxies.
CO3. Understand the Origin and nature of Cosmological Perturbations.
CO4. Learn the fundamentals of Gravitational Collapse and Collision less Dynamics.
CO5. Understand the formation and structure of Dark Matter Halos and evolution of Gaseous Halos.

References:

1. Galaxy Formation and Evolution by Houjun Mo, Frank Van Den Bosch, Simon White, Cambridge University Press, 2010.
2. An Introduction to Modern Astrophysics, Second Edition, By Carroll B.W., Ostlie D.A., Pearson Addison Wesley.
3. Extragalactic Astronomy and Cosmology, An Introduction, by Peter Schneider, Springer
4. Galactic Dynamics (Second Edition), by James Binney & Scott Tremaine, Princeton University Press.

24PHY344	General Relativity and Cosmology	3 1 0	4

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: general relativity, spacetime curvature, applications of General Relativity to classical cosmology.

Unit 1
Introduction to general relativity (GR): Space, time and gravitation, Non-Euclidean geometries, Gravity, geometry and dynamics.
Vectors and tensors: Space-time metric, Contravariant and Covariant vectors, Tensors.
Covariant differentiation: concept of general covariance, Parallel transport, covariant derivative, Riemannian geometry, locally inertial coordinate systems.

Unit 2
Curvature of spacetime: Parallel propagation around finite curves, Symmetries of R_{iklm}, Ricci and Einstein tensors, Bianchi identities, Geodesics, Geodesic deviation.
Spacetime symmetry: Displacement of spacetime, Killing vectors, Homogeneity and isotropy, Spacetime of constant curvature, Symmetric subspaces.
Physics in curved spacetime: Principle of equivalence, uniformly accelerated frame, energy-momentum tensors.

Unit 3
Einstein's equations: Heuristic approach, Hilbert action principle, Newtonian approximation.
Schwarzschild solution: Exterior and interior solution, Motion of a test particle, Motion of a test particle.
Experimental tests of general relativity: PPN parameters, Gravitational redshift, precession of the perihelion of Mercury, bending of light, Radar echo delay.

Unit 4

Classical cosmology: Robertson-Walker metric, Dynamics of the expansion, big bang misconceptions, Observations in cosmology.

Gravitational lensing: Simple lens models, Observations of gravitational lensing, Microlensing, Dark-matter mapping.

Age and Distance scales: Methods for age determination, Large-scale distance measurements, local distance scale, direct distance determinations.

Unit 5

Observational cosmology: Background radiation, Intervening absorbers, Evidence for dark matter, Baryonic and non-baryonic dark matter.

Galaxies and their evolution: Galaxy population, Optical and infrared observations, Luminosity functions, Evolution of galaxy stellar populations, Galaxies at high redshift.

Course Outcomes:

At the end of the course, students will be able to

CO1. Gain knowledge of general relativity, Vectors and tensors and Covariant differentiation.

CO2. Learn curvature of space-time, Space-time symmetry and Physics in curved space-time.

CO3. Have knowledge of mathematical tools and physics laws to understand the nature of galaxies and their clustering.

CO4. Comprehend Classical cosmology and Gravitational lensing.

CO5. Have knowledge of Observational cosmology and Galaxies and their evolution.

References:

1. A First Course in General Relativity, Second Edition, by Bernard F. Schutz, Cambridge University Press
2. Introduction to general relativity: spacetime geometry by Sean Carroll
3. Cosmological Physics by J. A. Peacock, Cambridge University Press
4. An Introduction to Relativity, J. V. Narlikar, Cambridge University Press, 2010
5. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993

24PHY345 Computational Methods in Astronomy 3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Computational Methods used in Astronomy such as Partial Differential Equations, Numerical modelling, N-Body Particle Methods, Particle Hydrodynamics problems, N-body simulations, and its various applications.

Unit 1

Basic Equations: Boltzmann equation, Conservation Laws of Hydrodynamics, Validity of the Continuous Medium Approximation, Eulerian and Lagrangian formulation of hydrodynamics, Viscosity and Navier-Stokes equations, Radiation transfer, Conducting and Magnetized media.

Numerical approximations to Partial Differential Equations: Numerical modelling with FDE, Difference quotient, Discrete Representation of Variables, Functions, and Derivatives, Stability of Finite-Difference Method, Physical Meaning of Stability Criterion, Diffusion, Dispersion, and Grid Resolution Limit.

Unit 2

***N*-Body Particle Methods:** Introduction to the *N*-Body Problem, Euler and Runge–Kutta Methods, Description of Orbital Motion in Terms of Orbital Elements, Few-Body Problem: Bulirsch–Stoer Integration, Lyapunov Time Estimation, Symplectic Integration, *N*-Body Codes for Large *N*. Close Encounters and Regularization, Force Calculation: The Tree Method and Fast Fourier Transforms.

Smoothed Particle Hydrodynamics: Rudimentary SPH, Colliding Planets: An SPH Test Problem, Improvements to Rudimentary SPH.

Unit 3

Grid-Based Hydrodynamics: Steepening of sound waves, Ranking-Hugoniot conditions, shock tube and Riemann problem, Simple Lagrangian Hydrocode, Basic Eulerian Techniques, Adaptive Mesh Refinement, Multidimensional Eulerian Hydrocode, 2 ½ -Dimensional Simulations, Rayleigh-Taylor Instability, Supernova explosion, Protostar collapse and Disk formation.

Unit 4

Source Term Modelling: Radiative Transfer: Ray Tracing Approach, Flux limited diffusion, Operator Splitting (Strang Splitting Method), Turbulent Forcing Particle Based Methods: Algorithms for N-body simulations, Smoothed Particle Hydrodynamics, Kernel Smoothing methods, Algorithms for Particle in Cell Method (PIC).

Unit 5

Applications: Solver for Advection and Burger Equation, Astrophysical Fluid Instabilities, Time evolution of the Trojan satellites of Jupiter using N-body simulations, Setting Cosmological Initial condition, N-body simulation for a pressureless fluid, Modelling 1D spherical collapse under self-gravity, spherically symmetric blast wave for supernova remnants, 1D radiative transfer modelling for Ionization.

Course Outcomes

At the end of the course, students will be able to

CO1. Understand Eulerian and Lagrangian formulation of hydrodynamics, and Numerical approximations to Partial Differential Equations.

CO2. Solve N-Body Particle Methods and Smoothed Particle Hydrodynamics.

CO3. Have knowledge of Grid-Based Hydrodynamics.

CO4. Comprehend the various approaches in Source Term Modelling.

CO5. Solve Advection and Burger Equation.

References:

1. G R Liu and M B Liu P. Bodenheimer, G. P. Laughlin, M. Rozyczka, T. Plewa, H. W Yorke, Numerical Methods in Astrophysics: An Introduction CRC Press; 1st edition.

2. E. F. Toro, Riemann Solvers and Numerical Methods for Fluid Dynamics: A Practical Introduction Publisher: Springer; Softcover reprint of hardcover 3rd edition.

3. C.K. Birdsall, A.B Langdon Plasma Physics via Computer Simulation Publisher: CRC Press; 1st edition.

4. G. R. Liu and M. B. Liu, Smoothed Particle Hydrodynamics: A Meshfree Particle Method Publisher, World Scientific Publishing Co Pte Ltd.

Elective Courses (Discipline Specific Elective)

24PHY431	Introduction to Photonics	3 0 0	3

Unit 1
Laser sources and detectors:
Laser fundamentals - Einstein's coefficients, gain coefficient, laser rate equations, optical resonator, Q-factor and stability of optical resonator - modes of laser resonator, Q-switching and mode locking, Properties of lasers - coherence, line width and divergence,

Unit 2
Laser systems - Ruby laser, He-Ne laser, dye laser, Argon ion laser, free electron laser. Laser, applications - Material processing, holography, LIDAR, Biomedical applications, laser fusion, laser cooling and Bose-Einstein condensates - Photo detectors and display devices, photodiodes, APD, PMT, CCD, PIN photo diodes.

Unit 3
Optical fibre and its applications. Fibre Optics - classification of fibres - step index, graded index fibres, Numerical aperture, modes in optical fibre, single mode and multi-mode fibre, evanescent modes, losses in fibres - bending and coupling losses, dispersion in fibres, polarization maintaining fibres.

Unit 4
Fibreoptic sensors - advantages of FOS, intensity modulated sensors, interferometric sensors, rotation sensors, biosensors - Optical Communication - Optical communication - advantages, modulation, time division and wave length multiplexing.

Unit 5
Physical origin of nonlinear optical coefficients, second order optical nonlinearity, propagation of EMW through NLO medium, optical second harmonic generation, phase matching conditions, Third order NLO, intensity dependent refractive index, Four wave mixing and optical phase conjugation.

Course Outcomes
At the end of the course, students will be able to
CO1. Understand and analyze the problems related to Laser parameter, lasing mechanism and their usage.
CO2. Understand and analyze the basic parameters of optical fibers and signal transitionthrough optical fibers.
CO3. Understand and analyze the basic problems in usage of optoelectronic devices, itslimitations and usage parameters.
CO4. Understand and analyze the non linear behavior of light in different medium and itsconsequences.

References:

1. Photonics: Optical Electronics in Modern communication (6th Edition,2007), Ammon Yariv, Pochi yeh, oxford university.
2. Lasers: Fundamentals and Applications (2nd Edn (1981), Springer (New York)

3. Quantum Electronics (3rd Edn), 1989, Amman Yariv, John Wiley & Sons

24PHY432	Biophotonics	3 0 0	3

Unit 1

Photobiology: Interaction of light with cells and tissues, Photo–processes in Biopolymers, human eye and vision, photosynthesis. Photo-excitation: free space propagation, optical fiber delivery system, articulated arm delivery, hollow tube wave-guides. Optical coherencetomography, special and time-resolved imaging, fluorescence resonance energy transfer (FRET) imaging, nonlinear optical imaging, Bio-imaging:

Unit 2

Transmission microscopy, Kohler illumination, microscopy based on phase contrast, dark- field and differential interference contract microscopy, fluorescence, confocal and multi- photon microscopy. Applications of bio-imaging: Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging.

Unit 3

Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, biosensors based on fibre optics planar waveguides, evanescent waves, interferometry and surface Plasmon resonance. Flow cytometry: Basics, fluorochromes for flow cytometry, DNA analysis.

Unit 4

Laser activated therapy: Photodynamic therapy, photo-sensitizers for photodynamic therapy, applications of photodynamic therapy, two photon photodynamic therapy. Tissue engineering using light: Contouring and restructuring of tissues using laser, laser tissue regeneration, femto-second laser surgery.

Unit 5

Laser tweezers and laser scissors, design of laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, lasers for genonmocs and proteomics, semiconductor quantum dots forbio imaging, metallic nano-particles and nano-rods for bio-sensing. Photonics and biomaterials: Baceria as bio-synthesizers for photonic polymers.

Course Outcomes

At the end of the course, students will be able to

CO1. Understand the interaction of light with cells and tissues, photo-excitation and opticalimaging.

CO2. Acquire knowledge on the use of microscopic techniques for analyzing the biologicalmaterials and bio-imaging.

CO3. Gain knowledge on photonic biosensors, laser activated therapy, optical tweezers andmodern biophotonic techniques.

Textbooks:

1. Introduction to Bio-photonics- V N Prasad (Wiley-Interscience April 2003).

2. Biomedical photonics: A Handbook - Tu Vo Dinh (CRC Press, Boca Raton, FL 2003).

References:

1. A Handbook of Optical Biomedical diagnostics, SPIE press monograph vol pm 107.
2. Biomedical Optics - Principles and Imaging - Lihong V and Hsin-IWU, Wiley Interscience1st ed, 2007.
3. Optical coherence Tomography - Principles and Applications – Mark E.Brezinski,(Academic press 1st ed, 2006).
4. Biophysics - An Introduction - Rodney cotterill, (John Wiley Student edition).

24PHY433	Nanophotonics	3 0 0	3

Unit 1
Introduction to nanoscale interaction of photons and electrons. Near field interaction and microscopy - near field optics and microscopy - single molecule spectroscopy - nonlinear optical process.

Unit 2
Materials for nanophotonics - quantum confinement - optical properties with examples - dielectric confinement - super lattices - organic quantum confined structures.

Unit 3
Plasmonics - metallic nanoparticles and nanorods - metallic nanoshells - local field enhancement - plasmonic wave guiding - applications of metallic nanostructures.

Unit 4
Nanocontrol of excitation dynamics - nanostructure and excited states - rare earth doped nanostructures - up converting nanophores - quantum cutting. Growth and characterization of nanomaterials – epitaxial – PLD – nanochemistry – XRD – XPS – SEM – TEM – SPM.

Unit 5
Concept of photonic band gap – photonic crystals – theoretical modeling – features optical circuitry - photonic crystal in optical communication - nonlinear photonic crystal - applications. Nanoelectronic devices – Introduction - single electron transistor. Basic ideas ofnanolithography and biomaterials - nanophotonics for Biotechnology and Nanomedicine – nanophotonics and the market place.

Course Outcomes
At the end of the course, students will be able to
CO1. Understand the nanoscale interaction of photons and electrons and familiarize withnear field optics and microscopy techniques.
CO2. Apply the knowledge of quantum confinement to understand nanostructures used inphotonics.
CO3. Understand nano control of excitation dynamics and various growth andcharacterization techniques of nanomaterials.
CO4. To comprehend the concept of photonic band gap in crystals to apply for variousapplications.

Textbooks:

1. Paras N. Prasad, Nanophotonics, Wiley Interscience, 2004.

2. Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge UniversityPress, 2006.

References:

1. Herve Rigneault, jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson,Nanophotonics, ISTE Publishing Company, 2006.
2. Surface Plasmon Nanophotonics, Mark L. Brongersma, Pieter G. Kik, Springer-Verlag, 2006.
3. Photonic Crystals, by John D. Joannopoulos, Robert D. Meade, Joshua N. Winn Prinenceton University Press.

24PHY434	Physics of Semiconductor Devices	3 0 0	3

Unit 1
Unit cell, Bravais lattices, crystal systems, Crystal planes and Miller indices, symmetry elements. Defects and imperfections – Point defects, line defects, surface defects and volume defects.

Unit 2
Electrical Conductivity: Classical free electron theory – Assumptions, drift velocity, mobility and conductivity, drawbacks. Quantum free electron theory – Fermi energy, Fermi factor, carrier concentration. Band theory of solids – origin of energy bands, effective mass, distinction between metals, insulators and semiconductors.

Unit 3
Theory of Semiconductors: Intrinsic and extrinsic semiconductors, band structure of semiconductors, carrier concentration in intrinsic and extrinsic semiconductors, electrical conductivity and conduction mechanism in semiconductors, Fermi level in intrinsic and extrinsic semiconductors and its dependence on temperature and carrier concentration. Carrier generation - recombination, mobility, drift-diffusion current. Hall effect.

Unit 4
Theory of p-n junctions – diode and transistor: p-n junction under thermal equilibrium, forward bias, reverse bias, carrier density, current, electric field, barrier potential. V-I characteristics, junction capacitance and voltage breakdown - Bipolar junction transistor, p-n-p and n-p-n transistors: principle and modes of operation, current relations. V-I characteristics. Fundamentals of MOSFET, JFET. Heterojunctions – quantum wells.

Unit 5
Optical devices: optical absorption in a semiconductor, e--hole generation. Solar cells – p-n junction, conversion efficiency, heterojunction solar cells. Photo detectors– photo conductors, photodiode, p-i-n diode. Light emitting diode (LED) – generation of light, internal and external quantum efficiency.
Modern Semiconducting Devices: CCD-Introduction to nano devices, fundamentals oftunneling devices, design considerations, physics of tunneling devices.

Course Outcomes
At the end of the course, students will be able to

CO1. Gain knowledge related to the fundamentals of crystal structures and defects.
CO2. Understand and describe the classical and quantum free electron theory and the bandtheory of solids.
CO3. Acquire and comprehend knowledge on different types of semiconductors anddetermination of carrier concentration, carrier generation - recombination mechanisms.
CO4. Understand the theory and operations of p-n junction diode, bipolar and fieldeffect transistors.
CO5. Apply the acquired semiconductor knowledge to understand the operations of optoelectronic semiconductor devices and solving problems.

Textbooks:

1. C Kittel, "Introduction to Solid State Physics", Wiley, 7th Edn. 1995.
2. DA Neamen, "Semiconductor Physics and Devices", TMH, 3rd Edn. 2007.

References:

1. SM Sze, "Physics of Semiconductor Devices", Wiley, 1996.
2. P Bhattacharya, "Semiconductor Opto-Electronic Devices", Prentice Hall, 1996.
3. MK Achuthan & KN Bhat, "Fundamentals of Semiconductor Devices", TMH, 2007.
4. J Allison, "Electronic Engineering Materials and Devices", TMH, 1990.

24PHY435 Principles of Lasers and Laser Applications 3 0 0 3

Unit 1
Review of basic concepts and principles of laser: Introduction to light and its properties: Reflection, Refraction, Interference, Diffraction and Polarization. Photometry – calculation of solid angle. Brewster's law. Snell's law and, its analysis.
Introduction to Lasers: Interaction of radiation with matter - Induced absorption, spontaneous emission, stimulated emission. Einstein's co-efficients. Active material. Population inversion concept and discussion about different techniques. Resonant cavity.

Unit 2
Gain mechanism, Threshold condition for population inversion, Emission broadening-line width, derivation of FWHM. Natural emission line width as deduced by quantum mechanics. Additional broadening process: collision broadening, broadening due to dephasing collision, amorphous crystal broadening, Doppler broadening and broadening in gases due to isotope shifts. Saturation intensity of laser, condition to attain saturation intensity. Properties – Coherence, Intensity, directionality, monochromaticity and Focussibility. Laser transition – Role of electrons in laser transition, levels of laser action: 2 level, 3 leveland 4 level laser system.

Unit 3
Types of Lasers: Solid State lasers: (i) Ruby laser – Principle, Construction, working and application. (ii) Neodymium (Nd) lasers. Gas laser: (i) He-Ne laser - Principle, Construction, working and application. (i) CO2 laser - Principle, Construction, working and application. Liquid Chemical and Dye lasers. Semiconductor laser: Principle, Characteristics, Diode lasers, homo-junction and hetero-junction lasers,

high power semi-conductor diode lasers.

Unit 4
Applications in Communication field: Laser Communication: Principle, construction, types, modes of propagation, degradation of signal, Analogue communication system, digital transmission, fiber optic communication.

Unit 5
Applications of lasers in other fields: Holography: Principle, types, intensity distribution, applications. Laser induced fusion. Harmonic generation. Laser spectroscopy. lasers in industry: Drilling, cutting and welding. Lasers in medicine: Dermatology, cardiology, dentistry, and ophthalmology.

Course Outcomes
At the end of the course, students will be able to

CO1. Comprehend the basic principles of geometrical, wave optics and laser radiation.
CO2. Apply the knowledge of optics and quantum mechanics to analyze the processes involved in light amplification and oscillation.
CO3. Understand the characteristics of laser radiation and working of various types of lasers.
CO4. Apply the knowledge of laser characteristics to understand its use in medical field, industry, and communication.

References:

1. William T Silfvast, "Laser Fundamentals",2nd Ed., Cambridge University Press, UK(2008).
2. BB Laud, "Lasers and Non-linear Optics", New Age International (P) Ltd., New Delhi.(2011).
3. Andrews, "An Introduction to Laser Spectroscopy (2e)", Ane Books India (Distributors).
4. KR Nambiar, "Lasers: Principles, Types and Applications", New Age International (P)Ltd., New Delhi (2009).
5. T Suhara, "Semiconductor Laser Fundamentals", Marcel Dekker (2004).

24PHY436	Nonlinear Optics	3 0 0	3

Unit 1
Introduction to Nonlinear Optics:
Brief review of electromagnetic waves – Wave propagation in an anisotropic crystal - Nonlinear optical effects - Polarization response of materials to light, Harmonic generation.

Unit 2
Second order effects:
Second harmonic generation - Sum and difference frequency generation - Phase matching - Parametric amplification, parametric fluorescence and oscillation; Concept of quasi-phase matching; Periodically poled materials and their applications in nonlinear optical devices.

Unit 3
Third order effects:

Third harmonic generation – bistability - self focusing, Self-Phase modulation, Temporal and spatial solitons, Cross Phase modulation, four wave mixing, Phase conjugation.

Unit 4
Multiphoton Processes:
Two photon process - Theory and experiment - Three photon process, Parametric generation of light - Oscillator - Amplifier - Stimulated Raman scattering - Intensity dependent refractive index optical Kerr effect - photorefractive, electron optic effects.

Unit 5
Nonlinear Optical Materials:
Basic requirements - Inorganics - Borates – Organics Urea, Nitro aniline - Semi organics - Thiourea complex - X-ray diffraction FTIR, FINMR- Second harmonic generation - Laser induced surface damage threshold.

Course Outcomes
At the end of the course, students will be able to
CO1. will gain understanding of the concepts that underly the study of dynamical systems.
CO2. will be able to analyse the second and third nonlinear optical responses of the material using symmetry.
CO3. will be able to apply the optical response principles to phenomena based on frequencyconversion, electro-optic effect, nonlinear index of refraction, and four-wave mixing.
CO4. describe ultrafast nonlinear propagation dynamics of ultra-short pulses in wave guides in the presence of dispersion including self-phase modulation, soliton propagation and stimulated Raman scattering.
CO5. Gain understanding about the various materials that exhibit nonlinear properties inview of material science.

Textbooks:
1. Robert W. Boyd, Nonlinear Optics, 2nd Ed., Academic Press, 2003.
2. D.L. Mills, Nonlinear Optics – Basic Concepts, Springer, 1998.
3. B.B. Laud, Lasers and Nonlinear Optics, 2nd Ed. New Age International (P) Ltd., 1991.

References:
1. A Yariv, Quantum Electronics, John Wiley, NY, 1989.
2. A Ghatak and K Thyagarajan, Optical Electronics, Cambridge Univ Press, 1989.
3. Scully and M S Zubairy, Quantum optics, Cambridge Univ. Press, 1997.

24PHY437 Nonlinear Dynamics 3 0 0 3

Unit 1
Introduction, Phase Space, and Phase Portraits: Linear systems and their classification; Existence and uniqueness of solutions; Fixed points and linearization; Stability of equilibria; Pendulum and Duffing oscillator, Lindstedt's method; Conservative and reversible systems.

Unit 2

Limit Cycles: The van der Pol oscillator, Method of Averaging; Relaxation oscillators; Weakly nonlinear oscillators; Forced Duffing oscillator, Method of Multiple Scales; Forced van der Pol oscillator, Entrainment; Mathieu's equation, Floquet Theory, Harmonic Balance.

Unit 3

Bifurcations: Saddle-node, transcritical, and pitchfork bifurcations; Center manifold theory; Hopf bifurcation; Global bifurcations; and Poincaré maps.

Unit 4

Nonlinear Normal Modes: Nonlinear Normal Mode manifolds of multidegree-of-freedom systems; external and internal resonances; and Energy transfer through nonlinear interactions.

Unit 5

Chaotic Dynamics: Lorentz equations; Lorentz map; Logistics map; Lyapunov Exponents; fractal sets and their dimensions; box, pointwise and correlation dimensions; strange attractors; and forced two-well oscillator.

Course Outcomes

At the end of the course, students will be able to

CO1.will gain understanding about sources and propagation of optical electromagnetic waves.

CO2.will be able to find fixed points and determine their stability, analyze limit cycles and their stability.

CO3. will be able to analyze the various types of bifurcations in one dimension (saddle node, transcritical, and pitchfork) and two dimensions (homoclinic, degenerate, and Hopf).

CO4. Gain an understanding of the properties of the most important strange attractors in discrete and continuous time.

Textbooks:

1. Richard H. Rand, Lecture Notes on Nonlinear Vibrations, version 52, 2005. Available online athttp://audiophile.tam.cornell.edu/randpdf/nlvibe52.pdf.

2. S.H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology,Chemistry and Engineering, Perseus Books Publishing, 2000.

References:

1. J.C. Sprott, Chaos and Time-Series Analysis, Oxford University Press, 2003.

2. G.L. Baker and J.P. Gollub, Chaotic Dynamics, 2nd edition, Cambridge University Press,New York, 1996.

3. Edward Ott, Chaos in Dynamical Systems, Cambridge, 1993.

4. K.T. Alligood, T.D. Sauer, and J.A. Yorke, CHAOS - An Introduction to Dynamical Systems, Springer, 1996.

5. D. Kaplan and L. Glass, Understanding nonlinear dynamics, Springer-Verlag, New York,1995.

6. J.M.T. Thompson and H.B. Stewart, Nonlinear dynamics and chaos, John Wiley and Sons,New York, 1986.

24PHY438 Optical Engineering 3 0 0 3

Unit 1

Review of Geometrical Optics, Gaussian optics, geometrical aberrations: Review of Physical Optics: waves, Interference – Young's experiment, fringe visibility, Michelson interferometer, Mach-Zehnder interferometer, two beam interference, multiple beam interference and optical thin film: Diffraction – Fraunhofer and Frenel diffractions, Fresnel– Kirchoff integral, Fourier transform in Fraunhofer diffraction, Fresnel zone plate, spatial and temporal coherence and coherence Measurement, Polarisation, Black Body radiation, Quantum nature of light.

Unit 2

Introduction to optical instruments: magnifiers, telescopes and microscopes, the human eye and projection systems as optical instruments, optical components: principles and operations of light sources – Lamps, LED, lasers and super continuum sources, principles and operation of detectors – photoconductive detectors, photodiodes, photomultipliers, IR detectors, charge-coupled devices and detector arrays, noise and sensitivity of detectors, Recording media, Prisms, Gratings, Polarizing elements.

Unit 3

Spatial light modulators: acousto-optic modulators, magneto-optic modulators, pockel's readout optical modulators, liquid crystal light valves, micro channel plate spatial light modulators, Photo plastics devices, deformable mirror array devices, optical discs and photorefractive crystals.

Unit 4

Holography; on axis holography, off–axis holography, holographic magnifications, reflection holography, rainbow holography, one-step rainbow holograms, colour holography and photorefractive holograms.

Unit 5

Signal processing: optical system under coherent and incoherent illumination, coherent optical signal processing, spatial filter, joint transform correlator, white-light optical signal processing, hybrid optical signal processing and photorefractive matched filters: fiber optics; fiber construction, fiber waveguides, types of optical fiber, optical fiber communications – fiber communication systems, splices and connectors, couplers and switches, time and wavelength – division multiplexing, coherent light wave communication, and fibre sensors.

Course Outcomes

At the end of the course, students will be able to

CO1. Comprehend the basics of geometrical and wave optics to explain interference, diffraction and polarization.

CO2. Understand the basic principles and operation of various optical and electro-opticdevices.

CO3. Apply the optics knowledge to describe optical processes like holography, opticalsignal processing and optical communication.

CO4. Analyze the working of various optical instruments.

References:

1. FTS Yu and X. Yang, Introduction to optical engineering, Cambridge Univ. press (1997).

2. Sirohi, R. S. and Kothiyal, M.P. Optical Components, Measurement techniques, andsystems, Marcel Dekker, Inc., New York (1991).
3. Malacara, D. Geometrical and Instrument Optics. (Vol 25. Methods of experimental physics).

24PHY439	Fibre Optic Sensors and Applications	3 0 0	3

Unit 1
MM and SM fibers for sensing, Lasers & LEDs suitable for sensing, PIN & APDs for fiber optic sensing. Principles of electro optic modulators bulk & integrated optic modulators. Optical sensor types, advantages and disadvantages of fiber optic sensors, Sensor system performance: basic specifications, Intensity modulated sensors, reflective concept, micro- bend concept, evanescent fibers sensors, polarization modulated sensors.

Unit 2
In-fiber Bragg grating based sensors – sensing principles – temperature and strain sensing, integration techniques, cross sensitivity, FBG multiplexing techniques. Long period fiber grating sensors - temperature and stain sensing, refractive index sensing, optical load sensors and optical bend sensors.

Unit 3
Interferometric sensors, Mach-Zehnder & Michelson interferometric sensors, theory- expression for fringe visibility, Fabry-Perot fiber optic sensors – theory and configurations, optical integration methods and multiplication techniques, application– temperature, pressure and strain measurements, encoded sensors.

Unit 4
Sagnac interferometers for rotation sensing fiber gyroscope sensors – Sagnac effect – open loop biasing scheme – closed loop signal processing scheme – fundamental limit – performance accuracy and parasitic effects – phase-type bias error – shupe effect – anti- shupe winding methods – applications of fiber optic gyroscopes. Faraday effect sensors. Magnetostriction sensors - Lorentz force sensors.

Unit 5
Biomedical sensors, sensors for physical parameters, pressure, temperature, blood flow, humidity and radiation loss, sensors for chemical parameters. pH, oxygen, carbon, dioxide, spectral sensors. Distributed fiber optic sensors – intrinsic distributed fiber optic sensor – optical time domain reflectometry-based Rayleigh scattering – optical time domain reflectometry based Raman scattering – optical time domain reflectometry – quasi – distributed fiber optic sensors. An overview on the optical fiber sensors in nuclear power industry, fly-by light aircraft, oil field services, civil and electrical engineering, industrial and environmental monitoring.

Course Outcomes
At the end of the course, students will be able to
CO1. Understand and gain knowledge on the technical aspects of electro-optic modulators and different types of fiber optical sensors.
CO2. Acquire knowledge on the working principle of grating based and interferometricfiber optic sensors.

CO3. Understand the basic concepts of biomedical and distributed fiber optic sensors andtheir industrial applications.

Textbooks:

1. Francis T.S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York,2002.
2. Dakin J and Culshow B., (Ed), Optical fiber sensors, Vol. I, II, III, Artech House, 1998.
3. Pal B.P, Fundamentals of fiber optics in telecommunication and sensor systems, WileyEastern, 1994.

References:

1. Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, JohnWiley and Sons Ltd., 2001.
2. Eric Udd (Ed), Fiber optic sensors: An introduction for engineers and scientists, John Wiley, and Sons Ltd., 1991.
3. B.D Gupta, Fiber optic Sensors: Principles and applications, New India PublishingAgency, New Delhi., 2006.
4. Bio-medical sensors using optical fibers, Report on progress in physics Vol 59.1,1996.

24PHY440 Fibre Optics and Technology 3 0 0 3

Unit 1

Classification of fibers: based on refractive index profiles, modes guided applications and materials. Fibers for specific applications: polarization maintaining fibers (PMF), dispersion shifted and dispersion flattened fibers, doped fibers. Photonic crystal fibers, holly fibers.

Fiber specifications: Numerical aperture of SI and GI fibers, Fractional refractive index difference, V–parameter, Cut off wavelength, dispersion parameter, bandwidth, rise time and Non linearity coefficient.

Unit 2

Impairment in fibers: group velocity dispersion (GVD), wave guide and modal dispersions. Polarization mode dispersion (PMD), Birefringence – liner and circular.

Fiber drawing and fabrication methods: modified chemical vapor deposition (MCVD) and VAD techniques.

Unit 3

Mode theory of fibers – different modes in fibers. Dominant mode, Derivations for modal equations for SI and GI fibers. Approximate number of guided modes in a fiber (SI and GI fibers). Comparison of single mode and multimode fibers for optical communications. LED and LD modulators. Coupling of light sources to fibers – (LED and LD) – Derivations required. Theory and applications of passive optical components: connectors, couplers, splices, Directional couplers, gratings: FBGs and AWGs, reflecting stars: Optical add drop multiplexers and SLMs.

Unit 4

Active components: Optical Amplifiers (OAS) - Comparative study of OAS - SLAs, FRAs, FBAs EDFAs and PDFAs based on signal gain, pump efficiency, Noise Figure, Insertion loss and bandwidth. Design and Characterization of forward pumped EDFAs.

Unit 5

Fiber measurements: Attenuation measurement – cut back method. Measurement of dispersion – differential group delay, Refractive index profile measurement. Numerical aperture (NA) measurement, diameter measurement, mode field diameter (MFD) measurement, V-Parameter, Cut off wavelength Measurement, splicing and insertion losses, OTDR – working principle and applications. OSA - Basic block schematicand applications in measurements. (John M senior).

Course Outcomes

At the end of the course, students will be able to

CO1. Acquire knowledge on the fiber classification and characteristics of optical fibers.

CO2. Describe the optical fiber fabrication process, theory of different modes and themodulators.

CO3. Understand and Gain knowledge on the passive and active components of fiber optictechnology and the methods to determine the fiber quality.

Textbooks:

1. Gerd Keiser, Optical Fiber communications, McGraw Hill, 200.
2. Maynbav, Optical Fiber Technology, Pearson Education, 2001.
3. John M senior, Optical fiber communications, PHI, 1992.

References:

1. Joseph C Palais, Optical Fiber communications, Pearson Education.1998.
2. Dennis Deriikson, Fiber optic test and measurement, Prentice hall,1998.
3. David Bailey and Edwin wright, practical Fiber optics, Elsevier 2003.
4. Franz and Jain, optical Fiber communication systems and Components, Naros Publishers,2004.
5. Ajoy Ghatak and K.Thyagarajan, Introduction to Fiber optics: Cambridge universitypress,1999.

24PHY441	**Fundamentals of Plasma Physics**	**3 0 0 3**

Unit 1

Introduction – Spatial scale of an unmagnetized plasma – Debye Length, time scale plasmaperiod, gyro radius and gyrofrequency of magnetized plasma, single particle motion in prescribed fields- ExB, grad-B, Curvature and polarization drifts, magnetic moment, adiabatic invariants of particle motion, magnetic mirror.

Unit 2

Kinetic theory of plasmas, Boltzmann equation, Maxwell-Boltzmann distribution, Vlasovdescription of collision less plasmas, Moments of the Boltzmann equation, Systems of macroscopic equations: Cold and Warm plasma models.

Unit 3

Plasmas as fluids - Two fluid description, equation of motion, Drifts perpendicular to B,parallel pressure balance.

Unit 4

Single fluid theory of plasmas: Magneto hydrodynamics (Hydro magnetic, MHD).

Unit 5
Introduction to waves in plasmas, waves in cold magnetized and unmagnetized plasma, Fourier representation, Dispersion relation, Waves in hot (magnetized) plasmas, Landau Damping, CMA diagram, Instabilities, MHD Waves, Alfven Waves, MHD discontinuities.

Course Outcomes
At the end of the course, students will be able to
CO1. identify, using fundamental plasma parameters, under what conditions an ionized gasconsisting of charged particles (electrons and ions) can be treated as a plasma.
CO2. distinguish the single particle approach, fluid and kinetic approach to describedifferent plasma phenomena.
CO3. determine the motion of charged particles moving in uniform or slowly varyingelectric and magnetic fields.
CO4. understand the physical mechanism and properties of the electrostatic andelectromagnetic waves propagating in magnetized and non-magnetized plasmas.
CO5. familiarity with important plasma instabilities and the concept of Landau damping.

Textbooks/References:

1. Umran S. Inan & Marek Golkowski, Principles of Plasma Physics forEngineers and Scientists, Cambridge, 2011.
2. Francis F. Chen, Introduction to Plasma Physics and controlled fusion, Springer, 2006.
3. D.A. Gumett & A. Bhattacharjee, Introduction to Plasma Physics, CUP, 2006.
4. Boyd, T.J.M., and Sanderson, J.J.: The Physics of plasmas, CUP, 2003.
5. Krall, N.A, Trivelpiece, A.W., Principles of plasma physics, McGraw Hill, 1973.
6. Stix, T.H., Waves in plasmas, Springer, 1992.

24PHY442	Space Physics	3 0 0 3

Unit 1
Brief history of solar-terrestrial physics – The variables Sun and the heliosphere, Earth’s space environment and upper atmosphere**.**

Unit 2
Space plasma physics - single particle motion, plasma state, Fluid description, MHD & kinetic theory, Applications.

Unit 3
Solid wind & Interplanetary Magnetic field (IMF), Shocks and Instabilities in space.

Unit 4
Solar wind interactions with magnetized planets - Introduction, planetary magnetic fields, spherical harmonic expansions, geomagnetic field and its measurements, variations in Earth's field.

Unit 5
Magnetosphere - Dynamics, SW-magnetosphere interactions; Ionospheres, Currents in space and Ionosphere; Neutral atmosphere -Dynamics.

Course Outcomes

At the end of the course, students will be able to

CO1. Learn basic and advanced physics concepts in space physics.

CO2. Develop problem solving skills in the field of space physics.

CO3. Develop critical/logical thinking and scientific reasoning in space physics.

Textbooks/References:

1. Hannu E.J. Koskinen, Physics of Space Storms, Springer, 2011.
2. Molwin, M., An Introduction to Space Weather, CUP, 2008.
3. Kallenrode, M.B., Space Physics: An introduction to plasmas and particles in theHeliosphere and Magnetosphers, Springer, 3e, 2004.
4. Baumjohann, W. &Treumann, R.A., Basic Space Plasma Physics, Imperial College Press,1997.
5. Kivelson& Russell, Introduction to Space Physics, CUP, 1995.

24PHY444	Physics of the Atmosphere	3 0 0 3

Description:

The introduces to the students the basic concepts in the physics of the Earth's atmosphere. This course should help students do projects in weather systems.

Unit 1

Earth - Atmosphere system – Introduction, Composition and structure, Radiative equilibrium, Energy budget, General circulation, Historical perspectives, Weather & Climate Atmospheric thermodynamics – Ideal gas law, First law of thermodynamics, Atmospheric composition, Hydrostatic balance, Entropy & potential temperature, Parcel concepts, Available potential energy, Moisture in the atmosphere, Saturated adiabatic lapse rate, Tephigram, Cloud formation.

Unit 2

Atmospheric radiation – Basic physical concepts, Radiative transfer equation, basic spectroscopy of molecules, Transmittance, Absorption by atmospheric gases, Heating rates, Green house effect revisited, Simple scattering model.

Unit 3

Basic fluid dynamics – Mass conservation, material derivative, alternative form of continuity equation, equation of state for the atmosphere, Navier-Stokes equation, Rotating frames of reference, equations of motion in coordinate form, geostrophic and hydrostatic approximation, Pressure coordinates and geopotential, Thermodynamic energy equation; Atmospheric fluid dynamics – vorticity and potential vorticity, Boussinesq approximation, Quasigeostrophic motion, Gravity waves, Rossby waves, Boundary layers, Instability.

Unit 4

Stratospheric chemistry – Thermodynamics and chemical reactions, Chemical kinetics, Biomolecular reactions, Photo-dissociation, Stratospheric ozone, Transport of chemicals, Antarctic ozone hole.

Atmospheric remote sounding – Observations, remote sounding from space and ground; Atmospheric modeling – Hierarchy of models, Numerical methods, Uses of complex numerical models, Lab models.

Unit 5

Climate change – Introduction, energy balance model, some solutions of the linearised energy balance model, Climatic feedbacks, Radiative forcing due to increase in Carbon dioxide.

Projects based on Modules 4 and 5 (Reading a journal paper & reproducing calculations, Numerical modeling and / or data analyses).

Course Outcomes

At the end of the course, students will be able to

CO1. Gain a basic understanding of the Earth's atmospheric system – its structure and composition as well as the energy transfer and general circulation within it.

CO2. Apply the basics of thermodynamics to the atmospheric system, explain the basics of cloud formation.

CO3. describe the principle of radiative transfer in the atmosphere, the basic spectroscopy as applied to the atmospheric molecules, scattering of radiation in the atmosphere through the use of a simple scattering model.

CO4. describe the fundamentals of fluid dynamics, apply them to the atmospheric system, derive the equations of motion in the rotating frame of reference, describe the basic dynamics of weather systems.

CO5. describe the basic chemical kinetics and Ozone chemistry, apply the basics of thermodynamics, dynamics and chemical reactions to explain the processes and dynamics of air pollution.

CO6. describe the basics of atmospheric remote sensing.

CO7. describe the basics of atmospheric modeling and explain a few of numerical models.

CO8. Describe the basics of climate change.

CO9. Apply the basics of dynamics/thermodynamics/numerical modeling/remote sensing and successfully finish a small project by reading and reproducing the results of a published article.

Textbooks/References:

1. Andrews DG: An introduction to atmospheric physics, 2E, CUP, 2010.
2. Salby ML: Physics of the Atmosphere and Climate, CUP, 2012.
3. Holton JR: An introduction to Dynamic Meteorology, 4E, AP, 2004.
4. Wallace JM & Hobbs PV: Atmospheric Science-An Introductory Survey, 2E, AP, 2006.
5. Chandrasekar A: Basics of Atmospheric Science, PHI, 2010.

24PHY445	**Elementary Meteorological Theory**	**3 0 0 3**

Unit 1

Introduction: Introduction, Importance of Meteorology, Atmosphere and its composition. Meteorological elements : Pressure – definition, units of measurement. : Temperature – scales and conversion of one to the other : Humidity - Relative humidity, dew point and wet bulb temperature – definitions, units. : Wind - Definition of wind unit, Wind vane, Anemometer, Squall, Beaufort scale, Buys Ballot's law, Autographic record. : Clouds - Classification, types, description, amount, height of base and direction of movement. : Visibility - Definition, visibility land marks, night visibility.

Unit 2

Weather - Rain, drizzle, hail, haze, thunderstorm, fog mist, smog, dust storm. Present weather – description, definition of various weather phenomena, symbolic representation and past weather.

Unit 3

Indian climatology: Four seasons in India, (in brief) and outlines of weather associated with each season.

Unit 4

Meteorological Instruments : Thermometer – dry bulb, wet bulb, maximum, minimum – description, methods of working, reading, resetting, stevenson screen, exposure, care of instrument., Barometer – Fortin, Kew Pattern, description, reading, correction, reducing the value to mean sea level, QFF, QFE, QNH, Anemometer – description, working, exposure, recording of observation, Rain guage – working, measurement of rainfall, Psychrometer – Assman & Whirling, Autographic instruments – working of Barograph, thermograph, hygrograph, self recording rain gauge, sunshine recorder etc.

Course Outcomes

At the end of the course, students will be able to

CO1. Define and describe the parameters which determine the weather of a place.

CO2. Explain the characteristics of various weather phenomena.

CO3. Summarize the climatological features over India.

CO4. Collect and analyze meteorological observations.

References:

1. Chandrasekar, A. (2010). Basics of atmospheric science. PHI Learning Pvt. Ltd..
2. Ahrens, C. D., & Henson, R. (2016). Essentials of meteorology: An invitation to the atmosphere. Cengage Learning.
3. Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric science: an introductory survey (Vol. 92). Elsevier.
4. Harrison, G. (2015). Meteorological measurements and instrumentation. John Wiley & Sons.

24PHY446 Nuclear Physics 3 0 0 3

Unit 1

Two-nucleon scattering - partial wave analysis, effective range theory, coherent scattering,spin-flip and polarization, comparison of n-n and p-p scattering.

Unit 2

Nuclear reactions - reaction and scattering cross sections, compound nuclear reactions, resonance reactions, Breit-Weigner formula, experimental determination of resonance widths and shapes, statistical theory, optical model, transfer reactions, pick-up and stripping reactions, spectroscopic factors.

Unit 3

Heavy ion reactions - salient features at low, intermediate and high energies, classical dynamical model, heavy ion fusion, fusion excitation function, deep inelastic collision.

Unit 4

Some aspects of nuclear measurement techniques: (i) Detectors and electronics for high resolution gamma and charge particle spectroscopy; (ii) Fast neutron, detection (iii) Neutrino detection, (iv) Drift chambers, RICH, calorimeter.

Course Outcomes

At the end of the course, students will be able to

CO1. Get familiarize with the key ideas and application of scattering theory.

CO2. Developed analytical skills to solve problem related to nuclear reactions.

CO3. Learn basic principles and techniques related to nuclear detector and theirapplication.

Textbooks:

1. Nuclear Physics: L.R.B Elton
2. Nuclear reactions: Blatt and Weisskopf
3. Nuclear Theory - Roy and Nigam
4. Nuclear Physics - B. Cohen
5. Nuclear Physics - Preston and Bhaduri
6. Nuclear structure - Bohr and Mottelson
7. Nuclear structure - M. K. Pal
8. Techniques in experimental nuclear physics - Leo
9. Techniques in experimental nuclear physics - Knoll
10. Techniques in experimental nuclear physics - S.S. Kapur

24PHY447 Physics of Cold Atoms and Ions 3 0 0 3

Unit 1

Two level atom in a radiation field, Laser light pressure, Atoms in motion, Travelling wave and standing wave - Multilevel atoms, Alkali metal atoms, metastable noble gas atoms, Polarization and interference, Angular momentum and selection rules and Optical transitionsin Multilevel atoms.

Unit 2

Temperature and Thermodynamics in Laser Cooling, Kinetic Theory and the Maxwell- Boltzmann Distribution, Random Walks, The Fokker-Planck Equation and Cooling Limits, Phase Space and Liouville's Theorem.

Unit 3

Optical Molasses: Introduction, Low-Intensity Theory for a Two-Level Atom in One Dimension, Atomic Beam Collimation, Low-Intensity Case, Experiments in One- and Two- Dimensions, Experiments in Three-Dimensional Optical Molasses

Unit 4

Cooling below the Doppler limit - Magnetic trapping of neutral atoms. Optical TrapsMagneto optical traps - Evaporative cooling.

Unit 5

Applications to atom mirrors, lenses, atomic fountain, nano fabrication, atomic clocks and nonlinear optics

- Optical lattices - Bose Einstein condensation Entangled states and quantum computing.

Course Outcomes

At the end of the course, students will be able to

CO1. Able to define the concept of temperature at the level of few atoms.

CO2. Able to distinguish between classical and quantum phenomenona of multibodysystems.

CO3. Able to demonstrate the usefulness of the cold atom and cold ion techniques inspectroscopy over conventional methods.

Textbooks:

1. Laser cooling and trapping by H J Metcalf and Peter Van der Straten Springer-Verlag New York 1999.
2. Laser Manipulation of atoms and ions – Proceedings of the international school ofPhysics “Enrico Fermi” Course CXVII, Amsterdam (1993) North Holland.

24PHY448 Introduction to Quantum Computing 3 0 0 3

Unit 1

Introduction to quantum mechanics from a QI/QC perspective:

Classical information storage and bits, quantum states and qubits, vector spaces, basis, inner product; operators and matrix representations, outer products and projection operators; Hermitian, unitary and normal operators. Eigenvalues, eigenvectors, spectral decomposition; Functions of operators, unitary transformations. Expectation value of an operator, commutators, simultaneous eigenvectors, uncertainty relations. Polar and singular value decompositions, positive operators. Postulates of quantum mechanics. Many-particle composite states and tensor products. Pure and mixed states, density operators, expectation values and measurements, partial trace and reduced density operator, Bloch vector

Unit 2

Quantum Measurements:

Projective measurements of simple and composite systems, generalized measurements, positive operator-valued measures. Entanglement: EPR ideas – nonocality, Bell’s inequality, bipartite systems, Bell states, Schmidt decomposition

Unit 3

Quantum Gates and Circuits:

Classical logic gates, single cubit gates, basic quantum circuit diagrams, controlled gates, gate decomposition. Quantum Algorithms: Hadamard gates, phase gate, series and parallel operations, function evaluation, Deutsch-Jozsa algorithm, quantum Fourier transform, Shor’s algorithm, Quantum Searching and Grover’s Algorithm.

Unit 4

Introduction to teleportation and superdense coding. Introduction to quantum noise and error correction.

Unit 5

Introduction to quantum cryptography:

basics of encoding, RSA encryption basics, basics of quantum cryptography. Tools of quantum information theory: no-cloning theorem, trace distance, fidelity, entanglement of formation and concurrence, information content and entropy.

Course Outcomes

At the end of the course, students will be able to

CO1. Familiarize with basic mathematical tools and principles of quantum mechanics from a Quantum Information computing perspective.

CO2.Understand and apply concepts in measurements, Entanglement, quantum nonlocality and Bell's inequality.

CO3. Understand basics of quantum logic gates and quantum algorithms including Deutsch Jozsa and Shor's algorithms.

CO4. Understand and explain quantum teleportation and dense coding schemes, and quantum error correction mechanisms.

CO5. Understand the basics of quantum cryptography and quantum information tools such as no-cloning, Shannon measure of information content and entropy.

References:

1. David Mahon, Quantum Computing Explained, Wiley India.
2. Quantum Computation and Quantum Information: M.A. Nielsen and I.L. Chuang (2011), CUP.
3. P. Kaye, R. Laflamme, and M. Mosca, An Introduction to Quantum Computing, OUP, 2007.

24PHY449 Quantum Electrodynamics 3 0 0 3

Unit 1

Lorentz Covariance of the Dirac Equation: Covariant form of the Dirac equation, Proof of Covariance, Space Reflection, Bilinear Covariants, Solution of the Dirac Equation for a free particle: Plane wave Solutions, Projection Operators for Energy and Spin, Physical Interpretations of Free-particle solutions and packets.

Unit 2

The Foldy-Wouthuysen Transformation: Introduction, Free-particle Transformation, TheHydrogen atom Hole Theory: The problem of Negative Energy Solutions, Charge Conjugation, Vacuum Polarization, The time Reversal and other Symmetries

Unit 3

General Formulation of the Quantum Field Theory: Implication of the Description in Terms of Local Fields, Canonical Formulation and Quantization Procedure for particles, Canonical Formulation and Quantization for Fields, The Klein-Gordon Field: Quantization and Particle Interpretation, Symmetry of the States, Measurability of the Field and Microscopic Causality, Vacuum Fluctuations, The Charged Scalar Field, Feynman Propagator.

Unit 4

Second Quantization of the Electromagnetic Field: Quantum Mechanics of N-identical Particles, The Number Representation for Fermions, The Dirac Theory, Momentum Expansions, Relativistic Covariance, The Feynman Propagator.

Quantization of the Electromagnetic Field: Introduction, Quantization, Covariance of the Quantization Procedure, Momentum Expansions, Spin of the Photon, The Feynman Propagator for Transverse Photons.

Textbooks:

1. Bjorken & Drell: “Relativistic Quantum Mechanics”.
2. Bjorken & Drell: “Relativistic Quantum Fields”.

References:

1. Schweber, Bethe and Hoffmann: Mesons and Fields.
2. Sakural: Advanced Quantum Mechanics.
3. Lee: Particle Physics and Introduction to Field Theory.

24PHY450	**Quantum Optics**	**3 0 0 3**

Unit 1

Correlation functions of light waves. Spectral representation of mutual coherence function. Calculation of mutual intensity and degree of coherence, propagation of mutual intensity. Rigorous theory of partial coherence. Coherency matrix of a quasi-monochromatic plane wave. Stochastic description of light and higher order coherence effects.

Unit 2

Quantization of the radiation field, Quantum mechanical harmonic oscillator, the zero point energy, states of the quantized radiation field, single mode number states and phase states, coherent photon states.

Unit 3

Quantum theory of the laser: photon rate equations, time dependence of photon coherence, laser threshold condition, rate equations for atoms and laser photons, laser photon distribution, fluctuations in laser light and laser phase diffusion.

Unit 4

Statistical optics of photons: Photon coherence properties, photon counting, photon distribution for coherent and chaotic light, quantum mechanical photon counting distribution.

Unit 5

Super radiance: collective cooperative spontaneous radiation. Diecke's theory. Photon echoes. Quantum beats. Quantum chaos and instability hierarchies of laser light, chaos and its routes. Squeezed states of light.

Course Outcomes

At the end of the course, students will be able to

CO1. Comprehend and articulate the connection as well as dichotomy between theory of radiation and their energy quantization.

CO2. Learn to apply theory of coherence to compute the degree of coherence of light.

CO3. Understand the concept and technique of statistical optics of photons, quantumcounting of photon and their coherence properties.

References:
1. L. Mandel and E. Wolf, Coherence and Quantum Optics, Plenum (1973). 41
2. H. Haken, Light. Vol.1 & 2, North Holland (1981).
3. S.M. Kay and A. Maitland, Quantum Optics. Academic Press (1970).
4. R. Loudon, Quantum Theory of Light, Clarendon Press (1979).
5. J. Fox, (Ed.), Optical Masers, Interscience Publishers (1963).
6. R.G. Brewer and A. Mooradian, Laser Spectroscopy, Plenum (1974).
7. Laser Theory: Encyl. of Phy. Vol. 25/2C, Springer-Verlag (1976).
8. M.O. Scully, W.E. Lamb and M. Sargent III, Laser Physics, Addison Wesley (1974).
9. J. Jacob, M. Sargent III, Laser Applications to Optics and Spectroscopy, AddisonWesley (1975).
10. R.H. Pantell and H.E. Puthoff, Fundamentals of Quantum Electronics Wiley (1969).

24PHY451 Computational Methods for Physicists 3 0 0 3

Unit 1

Differentiation:

Numerical methods, forward difference and central difference methods, Lagrange's interpolation method.

Unit 2

Integration:

Newton-cotes expression for integral, trapezoidal rule, Simpson's rule, Gauss quadrature method.

Unit 3

Solution of Differential Equations:

Taylor series method, Euler method, RungeKutta method, predictor - corrector method.

Unit 4

Roots of Equations:

Polynomial equations, graphical methods, bisectional method, Newton-Raphson method, false position method.

Unit 5

Solution of simultaneous equations:

Elimination method for solving simultaneous linear equations, Gauss eliminations method, pivotal condensation method, Gauss-seidal iteration method, Gauss Jordan method, Matrix inversion method.
Eigen values and Eigen vectors of Matrix: Determinant of a matrix, characteristic equation of a matrix, eigenvalues and eigenvectors of a matrix, power method.

Course Outcomes:

At the end of the course, students will be able to

CO1. Learn basic concepts of numerical methods for differentiation and integration.

CO2. Learn numerical methods for solving algebraic and differential equations.

CO3. Apply to solve basic and advanced physics.

Textbooks:

Rubin H Landau & Manuel Jose Paez Mejia, "Computational Physics", John Wiley & Sons

References:

1. Suresh Chandra, "Computer Applications in Physics", Narosa Publishing House, NewDelhi
2. M Hijroth Jensen, Department of Physics, University of Oslo, 2003 (Available in the Web)

24PHY452	FOSS in Physical Sciences	2 0 2 3

Objective:

This course aims to introduce students to various Free and Open Source (FOSS) software, ultimately for solving Physics problems. Computation and data analyses, facilitated by the popularity of easy-to-use language such as Python, and R for Statistical Computing, have become crucial not just for Physics, but also across various fields. Often, multiple programs need to be combined into workflows. The ability to use GNU/Linux operating system and the various associated GNU packages such as command-line utilities via shell scripts facilitate workflows, besides allowing tasks to be automated and streamlined. LaTeX, the high-quality typesetting system is widely used in technical & scientific documentation in academia & across various disciplines. LaTeX skills thus help students to create professional documents & presentations. All these contribute towards professional careers in academia, as well as in information and communication technology (ICT) related fields.

Units1-2

Basics of Statistical computing with R programming language:

What is R?, Introduction; Variables & Data types; Inbuilt functions; Data Handling Basics : Preparing & Loading, Cleaning & Munging data &Visualization

Units 3-4

Introduction to GNU/Linux basics:

What is GNU/Linux?, Flavors; Files & processes, Directory structure; Starting terminal, Basic operations on files & directories, path names, . & ..; Redirecting i/o, pipes; Wildcards, filename conventions, Getting help; File system access rights (security), changing, Processes & Jobs, Background processes & Killing processes; Editors, GNU/Linux software packages: downloading & extracting source code, configuring & creating makefile, building package, Compiling & running software; Variables & Environment variables, Using & setting variables; History; Basic Shell Scripting.

Unit 5

Scientific writing using LaTeX:

What is LaTeX?, Basic typesetting: Sample document & key concepts, Styles, Environments; Typesetting equations: Examples, Equation environments, Customized commands, Miscellany; Further essential LaTeX: Document Classes & overall structure; Errors: Pinpointing errors, Common Errors, Warning Messages; Packages, Inputting files & pictures; Bibliography (BibTex); Making Index; Sample Article, Report & Presentation (with Beamer).

Course Outcomes:

At the end of the course, students will be able to

CO1. Understand the basics of R programming language & manipulate data within R.

CO2. perform basic data analysis procedures & Visualize data in R.

CO3. Evaluate GNU/Linux as an OS by demonstrating basic knowledge of working with GNU/Linux and it's use in Physics.

CO4. Use command line to complete a series of tasks (basic file management & navigation etc), besides demonstrating basic scripting.

CO5. Perform GNU/Linux commands to manipulate Physics Data files and export into other environments (such as R).

CO6. Use the preamble of LaTeX file to generate (scientific) document, report & presentation (Beamer).

CO7. Learn how to import graphics into a LaTeX document.

CO8. Define and use new commands within LaTeX.

CO9. Use BibTeX to maintain bibliographic information and to generate a bibliography for a particular document.

References:

1. "Python Data Science Handbook – Essential tools for working with Data" (Chapters 1-4) – VanderPlas, J; O'Reilly Media, 2016.

2. "Effective Computation in Physics" – Scopatz, A & Huff, K D; 1E, O'Reilly Media, 2015.

3. "R for Beginners" – Paradis, E (https://cran.r-project.org/doc/contrib/Paradis-rdebuts_en.pdf)

4. "R for Data Science : Import, Tidy, Transform, Visualize, and Model Data" – Wickham, H & Grolemund, G; 1E, O'Reilly Media, 2017.

5. "The Not So Short Introduction to LaTeX 2e" – Oetiker T, Partl H, Hyna I & Schlegl E; (https://mirror.unpad.ac.id/ctan/info/lshort/english/lshort.pdf).

6. "A Guide to LaTeX" – Kopka, H & Daly, P; Addison Wesley, 4E, 2003.

7. "More Math into LaTeX" – Gratzer G, 5E, Springer, 2016.

8. "Linux for Beginners: An Introduction to the Linux Operating System and Command Line" – Cannon J, Createspace Independent Publishers, 2014.

9. "Linux Pocket Guide : Essential Commands" – Barrett Daniel J, Schroff Publishers & Distributors, 2016

10: "Introduction to Computational Physics for Undergraduates" – Zubairi O & Weber F, ("The Linux/Unix Operating System", Chapter-1), Morgan & Claypool Publishers, 2018 (https://iopscience.iop.org/chapter/978-1-6817-4896-2/bk978-1-6817-4896-2ch1.pdf).

24PHY453 Introduction to Nanophysics and Applications 3 0 0 3

Unit 1

Introduction: relation of nano to other sciences - chemistry, biology, astronomy, geology,nano in nature.

Unit 2
Properties of nanomaterials: size effect, particle's size, shape, and density, melting point, surface tension, wettability, surface area and pore, composite structure, crystal structure, surface characteristics; mechanical, electrical, properties, and optical properties.

Unit 3
Synthesis of nanoparticles: Classification of fabrication methods – top-to-bottom and bottom-to-top approaches, physical and chemical methods of preparation: CVD, controlled precipitation, sol-gel method, PLD etc; Confinement of particles - low dimensional structures - quantum wells, wires and dots.

Unit 4
Characterization of nanoparticles: X-Ray diffraction, examples of XRD, Debye-Scherrer formula; FTIR: principle, methodologies and accessories; SEM: basics and primary mode of operation, applications; TEM: basic principles; STM: basic principles and instrumentation; AFM: basics, modes of operation and applications; Photoluminescence: basic principles.

Unit 5
Application of nanophysics: Carbon nanostructures: Fullerenes, CNTs and their applications; MEMS and NEMS devices; Quantum Cascade Lasers, Smart materials, GMR and Spintronic, multiferroics.

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand the fundamental physical principles, which govern properties of the condense matter and in particular the role of dimensionality on the mechanical, thermal, optical, electrical and magnetic properties of materials.
CO2. Understand the physical basis of new phenomena that appear when the linear dimension of an object or device shrinks below a micrometer.
CO3. Be familiar with the methods for fabrications of nanostructures.
CO4. Understand and be able to explain the principles of newly characterization techniques for imaging and analysis of nanostructures and Nanomaterials.
CO5. Understand and be able to explain the principles of operation of nanoelectronic and nanophotonic devices and be able to apply their knowledge for understanding further developments in this rapidly emerging area.

References:

1. Charles P Poole Jr. & Frank J Owens, Introduction to Nanotechnology, 1E, Wiley, 2007.
2. W.R Fahner (Ed.), Nanotechnology and Nano electronics, Springer, 2006.
3. M Hosokawa, et al, Nanoparticle Technology Handbook, Elsevier Publishers, 2007.
4. S.V. Gaponenko, P.L Knight & A. Miller, Optical Properties of SemiconductorNanocrystals, CUP, 1E, 2005.
5. T Pradeep, Nano: The Essentials, TMH, 1E, 2007.

24PHY454 Concepts of Nanophysics and Nanotechnology 3 0 0 3

Unit 1

Introduction: Introduction to nanotechnology, Comparison of bulk and nanomaterials - change in band gap - novel properties of nanomaterial, classification of nanostructured materials. Synthesis of nanomaterials - Classification and fabrication methods - Top down and bottom-up methods.

Unit 2

Concept of Quantum Confinement and Phonon Confinement: Basic concepts - excitons, effective mass, free electron theory and its features, band structure of solids. Bulk to nano transition - Density of states, quantum confinement effect - weak and strong confinement regime. Electron confinement in infinitely deep square well, confinement in two and three dimension. Blue shift of band gap, Effective mass approximation. Vibrational properties of Solids - Phonon Confinement effect and presence of surface modes.

Unit 3

Tools for Characterization: Structural - X-ray Diffraction, Surface analysis-Transmission Electron Microscope, Scanning Tunneling Microscope, Atomic Force Microscope. Optical studies - UV - Visible absorption, Photoluminescence, Raman spectroscopy.

Unit 4

Nanostructured Materials: Properties and Applications. Carbon nanotube - structure, electrical, vibration and mechanical properties. Applications of carbon nanotubes - Field emission and Shielding - computers - Fuel cells - Chemical sensors - Catalysis - Mechanical reinforcement. Quantum dots and Magnetic nanomaterials – Applications.

Unit 5

Nanoelectronics and Nanodevices: Impact of nanotechnology on conventional electronics. Nanoelectromechanical systems (NEMSs) - Fabrication (Lithography) and applications. Nanodevices - Resonant Tunnelling Diode, Quantum Cascade lasers, Single Electron Transistors - Operating principles and applications.

Course Outcomes:

At the end of the course, students will be able to

CO1. Understand the fundamental physical principles, which govern properties of the condense matter and in particular the role of dimensionality on the mechanical,thermal, optical, electrical and magnetic properties of materials.

CO2. Understand the physical basis of new phenomena that appear when the dimension of an object or device shrinks below a micrometer.

CO3. Familiarize the various methods for fabrication of nanostructures.

CO4. Understand and explain the principles of characterization techniques for the analysis of nanostructures and nanomaterials.

CO5. Understand and explain the principles of operation of nanoelectronics andnanophotonic devices.

Textbooks:

1. Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale Science andTechnology, John Wiley and Sons Ltd 2004.
2. W.R. Fahrner (Ed.), Nanotechnology and Nanoelectronics, Springer 2006.

References:

1.Charles P. Poole, Jr. Frank J. Owens, "Introduction to nanotechnology", AJohn Wiley 81 Sons, Inc., Publication.

2.T. Pradeep, "Nano the essentials understanding nanoscience and nanotechnology", Professor Indian Institute of Technology, Madras, Chennai,India.

24PHY455	**Thin Film Technology**	**3 0 0 3**

Unit 1

Preparation methods: Physical methods: thermal evaporation, cathodic sputtering, Molecular beam epitaxy and laser ablation methods. Chemical methods: electrolytic deposition, chemical vapour deposition.

Unit 2

Thickness measurement and Characterization: electrical, mechanical, optical interference, microbalance, quartz crystal methods. Analytical techniques of characterization: X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy.

Unit 3

Growth and structure of films: General Features - Nucleation theories – Effect of electron bombardment on film structure – Post-nucleation growth - Epitaxial film growth - Structural defects.

Unit 4

Properties of films: elastic and plastic behavior. Optical properties – Reflectance and transmittance spectra - Absorbing films - Optical constants of film material -Multilayer films - Anisotropic and isotropic films. Electric properties to films: Conductivity in metal, semiconductor and insulating films - Discontinuous films - Superconducting films.

Unit 5

Magnetism of films: Molecular field theory - Spin wave theory - Anisotropy in magnetic films - Domains in films - Applications of magnetic films. Thin film devices: fabrication and applications.

Course Outcomes

At the end of the course, students will be able

CO1. To understand the principle, differences and similarities, advantages, anddisadvantages of different thin film deposition methods.

CO2. To evaluate and use models for understanding nucleation and growth of thin films.

CO3. To analyze thin film properties to apply for various applications.
CO4. To improve problems solving skills related to evaluation of different properties of thin films.

Textbooks:

1. K.L. Chopra, Thin Film Phenomena, Mc Graw Hill (1983),
2. George Hass. Physics of Thin Films: Volumes 1':12. Academic Press (1963).

References:

1. K.L. Chopra and I.J. Kaur, Thin Film Solar Cells, Plenum Press (1983).
2. L.I. Maissel and Giang (Eds.), Handbook of Thin film Technology, Mc Graw Hill (1970).
3. J.C. Anderson, The Use of Thin Films in Physical Investigation, Academic Press (1966).
4. J.J. Coutts, Active and Passive Thin Film Devices, Academic Press (1978).
5. R.W. Berry, P.M. Hall and M.T. Harris, Thin Film Technology, Van Nostrand (1968). 47.

24PHY456 Micro and Nano Magnetism-Materials and its Applications 3 0 0 3

Required Knowledge
Scholars are expected to have completed the course Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics. They should be familiar with the motivations of quantum mechanics and its historical development such as the ultraviolet catastrophe; Young's double-slit experiment etc. They should be familiar with the concept of a wave function; wave function collapse, and the expression of observables as operators. They should be able to apply the Schrödinger Equation to simple potentials and also familiarity with mathematical concepts such as vector spaces and Fourier series. This course will have some overlap with Atomic Physics.

Intended Learning Outcomes
The aim of this course is to provide an introduction to the physics underlying properties of strongly correlated systems. The course also provides examples of how Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics can be applied in order to understand phenomena emergent in complex systems. By the end of the course, students should be able to: describe the key physical principles of magnetism; demonstrate a knowledge and understanding of the theory and applications of ferromagnetism and the macroscopic behavior of ferromagnets. Also by the end of the course, students should have acquired the problem solving skills, such as

1. Calculation of susceptibilities for different magnetic orderings;
2. Calculate spin wave dispersions for different magnetic structures;
3. Estimate reduction of magnetization
4. Estimate energies of nucleating a domain and forming a magnetic domain wall etc.

Course Outline:
Details of the course content are listed below:

Unit 1
Magnetism of electrons:
Introduction:-A brief history of magnetism; Magnetism and hysteresis; Magnet applications;

Magnetostatics:- The magnetic dipole moment; Magnetic fields; Maxwell's equations; Magnetic field calculations; Magnetostatic energy and forces
Orbital and spin moments; Magnetic field effects; Theory of electronic magnetism; Magnetism of electrons in solids; Magnetism of localized electrons on the atom: The hydrogenic atom and angular momentum; The many-electron atom; Paramagnetism; Ions in solids; crystal-field interactions

Unit 2

Ferromagnetism; Anti-ferromagnetism and other magnetic order

Mean field theory; Exchange interactions; Band magnetism; Collective excitations; Anisotropy; Ferromagnetic phenomena
Molecular field theory of antiferromagnetism; Ferrimagnets; Frustration; Amorphousmagnets; Spin glasses; Magnetic models

Unit 3

Micro and Nano-magnetism, domains and hysteresis:

Micromagnetic energy; Domain theory; Reversal, pinning and nucleation.

Nanoscale magnetism; Characteristic length scales; Thin films; Thin-film heterostructures; Wires and needles; Small particles; Bulk nanostructures; Magnetic resonance:- Electron paramagnetic resonance; Ferromagnetic resonance; Nuclear magnetic resonance; Other methods
Experimental methods: Materials growth; Magnetic fields; Atomic-scale magnetism; Domain-scale measurements; Bulk magnetization measurements; Excitations; Numerical methods

Unit 4

Magnetic materials:

Introduction; Iron group metals and alloys; Rare-earth metals and inter-metallic compounds; Interstitial compounds; Oxides with ferromagnetic interactions; Oxides with anti- ferromagnetic interactions

Applications of soft and hard magnets

Soft magnetic materials; applications:- Low-frequency and High-frequency applications Magnetic circuits; Permanent magnet materials; Static and Dynamic applications withmechanical recoil; Dynamic applications with active recoil; Magnetic microsystems

Unit 5

Spin electronics and magnetic recording:

Spin-polarized currents; Materials for spin electronics; Magnetic sensors; Magnetic memory;Magnetic recording Special topics:-Magnetic liquids; Magneto-electrochemistry Magnetic levitation;Magnetism in biology and medicine; Planetary and cosmic magnetism.

Course Outcomes

The aim of this course is to provide an introduction to the physics underlying properties of strongly correlated systems. The course also provides examples of how Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics can be applied in order to understand phenomena emergent in complex systems.
By the end of the course, students should be able to:

CO1. Describe the key physical principles of magnetism.

CO2. Demonstrate a knowledge and understanding of the theory and applications offerromagnetism and the macroscopic behavior of ferromagnets.

CO3. Acquire the problem solving skills, such as

i. Calculation of susceptibilities for different magnetic orderings;

ii. Calculate spin wave dispersions for different magnetic structures;

iii. Estimate reduction of magnetization

iv. Estimate energies of nucleating a domain and forming a magnetic domain wall etc.

Textbooks:

1. Magnetism and Magnetic Materials; J. M. D. COEY; CAMBRIDGE UNIVERSITYPRESS.
2. Text Book Of MagnetismBy R.K. Verma, DPH.
3. Magnetism Fundamentals, edited by Etienne Du Trémolet de Lacheisserie, Damien Gignoux, Michel Schlenker, Springer
4. Magnetism: From Fundamentals to Nanoscale DynamicsBy Joachim Stöhr, HansChristoph Siegmann; Springer
5. Introduction to Magnetism and Magnetic Materials, Second EditionBy David C. Jiles;Taylor and Francis
6. The Quantum Theory of Magnetism;By Norberto Majlis; World Scientific PublishingCo. Pte. Ltd

24PHY457 X-Ray Diffraction and its Applications 3 0 0 3

Unit 1

X-Ray Basics. The scattering of X-rays, Diffraction from a crystal. X-ray interaction with matter, X-ray sources, X-ray optics, X-ray detectors.

Unit 2

X-RAY DIFFRACTOMETERS. High-Resolution Diffractometers; Powder Diffractometers.

Unit 3

Applications To Materials Science: Structure Analysis; PhaseAnalysis; Preferred Orientation (Texture) Analysis.

Unit 4

Applications To Materials Science: Line Broadening Analysis. Line Broadening due to Finite Crystallite Size; Line Broadening due to Micro strain Fluctuations; Williamson-Hall Method; The Convolution Approach Instrumental Broadening; Relation between Grain Size-Induced and Micro strain-Induced Broadenings of X-Ray Diffraction Profiles.

Unit 5

Applications to materials science: residual strain/stress measurements. strain measurements in single-crystalline systems; residual stress measurements in polycrystalline materials. impact of lattice defects on x-ray diffraction.

Course Outcomes

At the end of the course the students will be able

CO1. To work with the fundamentals and applications of x-ray diffraction.

CO2. To apply the knowledge on x-ray sources and optics to explain experimentalarrangements in the field of modern x-ray physics.

CO3. To apply the knowledge on x-ray interaction with matter to explain different types ofanalytical methods that use x-ray radiation as a probe.

CO4. To acquire skills for independent research and presentation.

Textbooks/ References:

1. Emil Zolotoyabko, Basic Concepts of X-Ray Diffraction; John Wiley & Sons, 21-Apr-2014 – Science.
2. M. M. Woolfson; An Introduction to X-ray Crystallography; Cambridge University Press.
3. Werner Massa; Crystal Structure Determination; (March 31, 2004) ISBN-10: 3540206442.
4. Crystal Structure Analysis by: Jenny Glusker and Kenneth Trueblood (August 1992) ISBN-10: 0195035313.
5. Crystal Structure Analysis: Principles and Practice (International Union of Crystallography Monographs on Crystallography) by Peter Main, William Clegg, Alexander J. Blake, Robert O. Gould. (January 28, 2002) ISBN-10: 019850618X.
6. The Determination of Crystals Structures by: H. Lipson & W. Cochran (June 1966) ISBN- 10: 080140276X.
7. Fundamentals of Powder Diffraction and Structural Characterization of Materials by: Vitalij Pecharsky and Peter Zavalij (March 3, 2005) ISBN-10: 0387241477.
8. Structure Determination by X-ray Crystallography by: Mark Ladd and Rex Palmer (September 30, 2003) ISBN-10: 0306474549.
9. X-ray Structure Determination by: George Stout and Lyle Jensen (April 24, 1989) ISBN- 10: 0471607118.
10. X-ray Analysis and the Structure of Organic Molecules by: Jack Dunitz (December 16, 1996) ISBN-10: 3906390144.

24PHY458 Methods of Experimental Physics 3 0 0 3

Description: To build up the necessary background required to design and carry out important experiments, exposure to the physics behind recent experimental techniques. A reasonable section of topics may be chosen from below.

Unit 1

Measurements, uncertainties, error analysis, curve fitting; the value of "zero" in experimental physics, measurement of noise and analysis of noise, filtering and noise reduction, interference, shielding and grounding, phase sensitive detection and Phase locked loops; electrical measurements and precautions: I-V, C-V, resistivity.

Unit 2

Magnetic measurements and precautions: vibrating sample magnetometer, SQUID. Vacuum techniques: units, gauges, pumps, materials. Techniques of temperature measurements: very low, medium and very high-temperature thermometers, thermocouples, thermistors, pyrometer, spectroscopy.

Unit 3

Physical principles of transducers and sensors: temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors.

Unit 4

Thin film deposition methods: physical, e-beam, sputter, chemical vapor deposition, molecular beam epitaxy, spin coatings, dip coating, electroplating, electroless plating. Techniques of optical spectroscopy: UV-Vis absorption, photoluminescence, electroluminescence.

Unit 5

Advanced experimental techniques: AFM, atomic and molecular traps, NMR, nano-materials and devices, time-resolved measurements.

Course Outcomes

After successful completion of the course, students will be able to develop an understanding, and be able to

CO1. Classify and describe the concepts of errors and noise in measurements.
CO2. Calculate the errors in measurements.
CO3. Explain different kinds of techniques involved in measurements.
CO4.Explain the working of different transducers.
CO5. Explain thin film deposition and different characterisation techniques.

References:

1. Practical Physics: G.L. Squires (2001) 4 edition, Cambridge University Press
2. Experimental Physics: R.A. Dunlap (1988) 1 edition, Oxford University Press
3. Characterization of Materials: J.B. Wachtman and Z.H. Kalman (1992) Butterworth -Heinemann

24PHY459 Solar Energy Conversions 3 0 0 3

Unit 1

Introduction to Semiconductors: Types of semiconductors;, Density of States, electron and hole currents, Electron distribution function, Fermi Dirac Statistics, Drift and Diffusion currents, Semiconductor transport equations; Calculation of carrier and current densities, General solution for current density, Metal semiconductor junction, Semiconductor – semiconductor junctions, Analysis of the P-N-Junctions, p-n junction under dark and under illumination. The Solar Resource and types of solar energy converters, Requirements of an ideal photoconverter, Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell, Material and design issues; Shockley–Queisser limit, Beyond the limit. Optics in solar energy conversion, antireflection coatings, concentration of light: Light confinement, photon recycling, multiple exciton generation.

Unit 2

Silicon Solar cell, Mono -crystalline and poly–crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly–crystalline Si Ingots, Si–wafers, Si–sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, Process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact.

Unit 3

2nd generation solar cell, Thin film solar cell, Advantage of thin film, Thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, Plasma Enhanced, Hot Wire CVD, closed space sublimation, Ion Assisted Deposition, Substrate and Super -state configuration, Thin film module manufacturing, Thin film and Amorphous Si Solar cell, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell.

Unit 4

3rd generation Solar cell: Advances in Photovoltaics, Photochemical and photosynthetic energy conversion; DSSC, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multi junction tandem solar cells.

Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output, PV system configuration, standalone system with DC / AC load with and without battery, Hybrid system, Grid connected systems.

Course Outcomes

On completion of the course, the student will able to

CO1. Understand the basics of semiconductor physics and working principle of solarphotovoltaics.
CO2. Acquire knowledge on the fabrication of different types of solar cell and methods toenhance the efficiency of solar cell.
CO3. Understand recent trends and current research focus on the fabrication of solar cell.
CO4. Acquire basic practical knowledge for the use of solar cell and grid connectivity.

Textbooks /References:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press (2006).
2. Solar Energy Conversion (Second Edition): Richard C. Neville; Elsevier Science (1995).
3.Physics of solar cells: P. Wurfel (Wiley-VCH, 2013).
4. Solar cell device physics; J. Fonash(AP, 2010).
5. Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies andSystems: UIT Cambridge, (2016).

24PHY460	Fabrication of Advanced Solar cell	3 0 0 3

Unit 1

The Solar Resource and types of solar energy converters, Requirements of an ideal photoconverter, Principles of a solar cell design, material and design issues; Revisions of Semiconductor Physics, Physics of semiconductor Junctions; p-n junction under dark and under illumination, effect on junction characteristics, Other device structures. Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell.

Unit 2

Silicon Solar cell, Mono -crystalline and poly–crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly–crystalline Si Ingots, Si–wafers, Si–sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, Process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact.

Unit 3

2nd generation solar cell: Thin film solar cell, Advantage of thin film, Thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, Plasma Enhanced, Hot Wire CVD, closed space sublimation, Ion Assisted Deposition, Substrate and Super -state configuration, Thin film module manufacturing, Thin film and Amorphous Si Solar cell, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell.

Optics in solar energy conversion: antireflection coatings, concentration of light: Light confinement, photon recycling, multiple exciton generation.

Unit 4

3rd generation Solar cell: Advances in Photovoltaics, Photochemical and photosynthetic energy conversion; DSSC, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multijunction tandem solar cells;

Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output, PV system configuration, standalone system with DC / AC load with and without battery, Hybrid system, Grid connected systems.

Unit 5

Hand on experience on solar cell fabrication, DSSC fabrication, Perovskite solar cell fabrication, Thin film solar cell fabrication.

Course Outcomes

On completion of the course, the student will able to

CO1. Understand the basics of semiconductor physics and working principle of solarphotovoltaics.

CO2. Acquire knowledge on the fabrication of different types of Si solar cell and methods to enhance the efficiency of solar cell.

CO3. Understand recent trends and current research focus on the fabrication of solar cell.

CO4. Acquire knowledge on the fabrication of different types of advanced solar cell.

CO5. Acquire basic practical knowledge for the use of solar cell and grid connectivity.

Textbooks/References:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press (2006)
2. Crystalline Silicon Solar Cells, by A. Goetzberger, J. Knobloc h, and B. Voss (Wiley,1998)
3. Third Generation Photovoltaics: Advanced Solar Energy Conversion, by M. A. Green(Springer, 2006)
4. Semiconductor Materials for Solar Photovoltaic Cells; Paranthaman, M.P. (et al.) (Eds.)(2016)

Generic Elective Compulsory Courses

Semester 1

24CHY101	Chemistry I	3 0 0 3

Unit 1
Chemical Bonding
Review of orbital concept and electronic configuration, electrovalency and ionic bond formation, ionic compounds and their properties, lattice energy, solvation enthalpy and solubility of ionic compounds, covalent bond, covalency, orbital theory of covalency - sigma and pi bonds - formation of covalent compounds and their properties Hybridization and geometry of covalent molecules - VSEPR theory -polar and non-polar covalent bonds, the polarization of covalent bond – polarizing power, polarisability of ions and Fajan's rule, dipole moment, percentage ionic character from dipole moment, dipole moment and structure of molecules, coordinate covalent compounds and their characteristics, molecular orbital theory forH2, N2, O2 and CO, metallic bond - free electron, valence bond and band theories, weak chemical bonds – inter and intramolecular hydrogen bond - van der Waals forces.

Unit 2
Thermodynamic Parameters
Stoichiometry - mole concept, significance of balanced chemical equation – simple calculations - Conditions for occurrence of chemical reactions - enthalpy, entropy and free changes – spontaneity – Thermochemistry - heats of reactions - (formation, combustion, neutralization) - specific heats - variation of enthalpy change with temperature - Kirchhoff' relation (integrated form) - bond enthalpy and bond order - Problems based on the above.

Unit 3
Kinetics
Review of molecularity and order of a reaction, rate law expression and rate constant - first, second, third and zero order reactions, pseudo-first order reactions (pseudo-unimolecular reactions) - complex reactions - equilibrium and steady state approximations -mechanism of these reactions - effect of temperature on reaction rates - Arrhenius equation and its significance, Michaelis Menden kinetics-enzyme catalysis.

Unit 4
Electrochemistry
Electrolytes - strong and weak, dilution law, Debye-Huckel theory, faraday's laws, origin of potential, single electrode potential, electrochemical series, electrochemical cells, Nernst equation and its application, reference electrodes - SHE, Ag/AgCl, Calomel.

Unit 5
Photochemistry
Photochemistry, laws of photochemistry - Stark-Eistein law, Beer-Lamberts law, quantum efficiency-determination, photochemical processes - Jablonsky diagram, internal conversion, inter-system crossing, fluorescence, phosphorescence, chemiluminescence and photosensitization, photopolymerization.

Course Outcomes:

At the end of the course the student will be able to:
CO1. Understand the fundamental concepts of chemistry to predict the structure and properties of engineering materials.

CO2. Develop analytical skills to evaluate the cause, feasibility and course of chemical reactions.
CO3. Design and apply the idea of cutting-edge area of chemistry to solve basicscience related problems.

References:

1. Principles of Physical Chemistry, B.R. Puri, L.R. Sharma & M.S. Pathania, VishalPublications, 46th, 2013.
2. Principles of Inorganic Chemistry, B R. Puri, L.R. Sharma, Vishal Publications, 2008.

24CHY181	Chemistry Lab I	0 0 2 1

Course Objective

The objective of the laboratory sessions is to enable the learners to get hands-on experience on the principles discussed in theory sessions and to understand the applications of these concepts in engineering.

1. Acid base titration (double titration).
2. Complexometric titration (double titration).
3. Redox (permanganometry) titration (double titration).
4. Conductometric titration.
5. Potentiometric titration.
6. Colorimetric titration.

Course Outcomes:

At the end of the course the student will be able to:
CO1: Develop analytical skills for the determination of water quality parameter.
CO2: Understand the electrochemical principles of conductance and electrode potentials and its application in analytical science.
CO3. Develop analytical skills in the determination of rates of chemical reactions and its application.
CO4: Learn the basics of redox reaction and applying it for quantitative determination.
CO5: Create skills to convert basic chemical reactions to analytical application.

Semester 2

24CHY111	Chemistry II	3 0 0 3

Unit 1
Ionic equilibria

Electrolytes, strong and weak - specific, equivalent and molar conductances, equivalent conductance at infinite dilution and their measurement - Kohlrausch’s law and its applications-calculation of equivalent conductance at infinite dilution for weak Electrolytes and solubility of sparingly soluble salts - applications of conductivity measurement - conductometric titrations - acid-base precipitation and complexometric titrations, Common ion effect and its application, concept of pH, indicators, theories of indicators – buffers and their pH - Henderson equation.

Unit 2
Chemical equilibria

Law of mass action - equilibrium constant – Relation between K_p and K_c -Temperature dependence – The Van't Hoffs equation – Pressure dependence of the equilibrium constant K_p and K_c – Factors that change the state of equilibrium- Le-Chatelier’s principle and its application to chemical equilibria.

Unit 3

Basic concepts in Organic Chemistry

Composition of organic compounds – detection and estimation of elements- carbon– hydrogen -nitrogen, oxygen, sulphur, phosphorous, halogens – Calculation of empirical and molecular formula - determination of molecular weights – physical and chemical methods - empirical formula and molecular formula – Classification and Nomenclature of organic compounds. Organic reactions and their mechanisms: Electron displacement effects – inductive, electromeric, mesomeric and hyperconjugative. Reactive intermediates – carbocations, carbanions, free radicals and carbenes.

Unit 4

Acids, Bases and Non-aqueous solvents

Concepts of acids and bases – hard and soft acids and bases - Pearson's concept, HSAB principle and its application - basis for hard-hard and soft-soft interactions - non-aqueous solvents - general characteristics of non-aqueous solvent - melting point, boiling point, latent heat of fusion and vaporization, and dielectric constant - reactions such as complex formation, redox, precipitation and acid-base type in non-aqueous solvents like liquid ammonia, liquid SO_2 and liquid HF.

Unit 5

Coordination Chemistry

Werner's theory – Electronic interpretation of co-ordination compounds - EAN rule– types of ligands – Nomenclature, isomerism – stability of complexes – factors influencing stability – Application of coordination compounds in qualitative and quantitative analysis. Theories of bonding in coordination.

Course Outcomes:

At the end of the course the student will be able to:

CO1: To get profound knowledge on chemical and ionic equilibria including problem-solving skills.
CO2: To understand the fundamentals of organic chemistry.
CO3: To develop proficiency in theory behind basic chemical analytical techniques.
CO4: To learn the theory of the properties of different types of solutions.

Textbooks:

1. Puri, Sharma & Pathania, 'Principles of Physical Chemistry', 42nd edition, VishalPublishing Co, Delhi, 2007.
2. Morrison and R.N. Boyd, 'Organic Chemistry', 6th Edition, Prentice Hall, 1992.
3. Puri B R, Sharma L R, Kalia K K., 'Principles of Inorganic Chemistry', 23rd edition,Shoban Lal Nagin Chand & Co, New Delhi, 1993.

References:

1. S.F.A. Kettle, 'Physical Inorganic Chemistry', Spectrum, 1996
2. J. Clayden, N. Greeves, S. Warren and P. Wothers, 'Organic Chemistry', 2nd edition,Oxford University Press, 2012.
3. R.Stephen Berry, Stuart A. Rice & John Ross, 'Physical Chemistry', 2nd edition, OxfordUniversity press, 2000.

24CHY182	Chemistry Lab II – Instrumental	0 0 2	1

Course Objective

To enable the learners to get hands-on experience on principles discussed in theory sessions, use instruments spectroscopy, flame photometry etc. and to understand the applications of these concepts.

1. Determination equivalent conductance at infinite dilution of a strong electrolyte.
2. Conductometric titration of a mixture of strong and weak electrolytes.
3. Kinetics of acid catalysed ester hydrolysis.
4. Determination of solubility of sparingly soluble salt conductometrically.
5. Determination of molecular weight of a polymer through viscometry
6. Determination of concentration of ions by Spectrophotometer.

Course Outcomes

At the end of the course the student will be able to:

CO1. Learn and understand the working of basic instrumental techniques such as UV-Visible spectroscopy, flame photometry.

CO2. Able to estimate the conductivity of strong and weak electrolytes, solubility ofsparingly soluble salt, number of ions present in given solution using instrumental techniques.

CO3. Utilize the fundamental laboratory techniques for analysis, the amount of alkali and alkaline earth metal ion present, its concentration in the solution.

CO4. Able to analyze and gain experimental skill and apply the knowledge in day-to-day life.

Semester 1

24MAT104	Matrices and Vector Calculus	3 1 0	4

Unit 1

Matrices: Matrix, Algebraic operations, Transpose of a matrix, Inverse of a matrix, Properties of matrices, Kinds of matrices: Symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices, Orthogonal and unitary matrices, Determinant of a matrix, Properties of determinants.

Unit 2

Systems of Linear Equations: Linear System of Equations, Gauss Elimination, Consistency of a linear system of equations. Eigen value problems: Eigen values, Eigen vectors, Properties of Eigen values and Eigen vectors, Cayley-Hamilton theorem, Some Applications of Eigen value Problems, Similarity of Matrices, Diagonalization of a matrix, Quadratic forms, and Canonical form of a quadratic form.

Unit 3

Review of Conic Sections, Eccentricity, Quadratic Equations and Rotations. Parametrization of plane curves, Polar coordinates, Graphing in polar coordinates, Areas and Lengths in polar coordinates, Conic Sections in Polar Coordinates, Spherical polar coordinates, and Coordinate transformations.

Unit 4

Vector differentiation: Limit of a vector function – continuity and derivative of vector function - Geometrical and Physical significance of vector differentiation - Partial derivative of vector function – gradient and directional derivative of scalar point functions – Equations of tangent plane and normal line to a level surface. Divergence and curl of a vector point function – solenoid and irrational functions – physical interpretation of divergence and curlof a vector point function.

Unit 5

Integration of vector functions – Line, surface and volume integrals. Guass - Divergence Theorem – Green's Theorem – Stoke's Theorem (Statements only). Verification of theorems and simple problems.

Course Outcomes:

At the end of the course the student will be able to:

CO1: Understand the basic concepts of matrices, classification and determinants and its properties

CO2: Understand the concept of solutions to system of linear equations and their solutionsby using matrices.

CO3: Understand the notion of eigenvalues and eigenvectors, analyze the possibility of diagonalization and hence compute a diagonal matrix, if possible. Apply the knowledge of diagonalization to transform the given quadratic form into the principal axes form and analyze the given conic section.

CO4: Understand the vector functions, scalar and vector fields. Understand the derivatives of vector functions and its physical and geometrical interpretations. Understand the concept of gradient, divergence and curl and apply.

CO5: Understand the concept of line integrals surface and volume integrals and related theorems for evaluations.

Textbooks:

1. 'Advanced Engineering Mathematics', Erwin Kreyszig, John Wiley and Sons, 2002, 8thEdition.
2. Textbook of Matrix Algebra, Suddhendu Biswas, PHI, 2012.
3. Vector Calculus with Applications to Physics, Shaw James Byrnie - 2009
4. T. K. Manickavasakam Pillay, Vector Calculus, 2004.

Semester 2

24MAT114	Trigonometry and Differential Equations	3 1 0	4

Unit 1

Trigonometry: (Mathematics for Degree students, P.K. Mittal) Expansions of sin nθ, cosnθ, tan nθ in powers of Sinθ, Cosθ, Tanθ. Expansion of Sinnθ, Cosnθ, Sinmθ, Cosmθ in terms of sines and Cosines of Multiplies of θ – Power series for Sinθ, Cosθ, Tanθ - Hyperbolic Functions - Inverse Hyperbolic Functions - Logarithm of complex numbers - Summation of Trigonometric Series - Gregory Series - Euler Series.

Unit 2

Differentiation (Calculus, Thomas) Applications of Derivative: Mean Value theory – Concavity and Curve Sketching – Maxima and Minima.

Unit 3

Differential Equations of First Order: (Advanced Engineering Mathematics, E.Kreyszig) Formation of Differential Equations. Solutions of Differential Equations (Variable Separable, Homogeneous Equations and

Equations reducible to Homogeneous Form, Linear and Equations reducible to Linear Form, Exact Differential Equations and Equations reducible to Exact form). Differential Equations not of the first degree (solvable for 'p', solvable for 'y', solvable for 'x', Clairaut's Equation). Applications.

Unit 4

Differential Equations of Higher Order: (Advanced Engineering Mathematics, E.Kreyszig) Homogeneous Linear Differential Equations with Constant Coefficient and Euler- CauchyDifferential Equations, Basis of Solutions and Wronskian. Non- Homogeneous Equations - Method of Undetermined Coefficients and Method of Variation of Parameters.

Unit 5

Boundary Value Problems for Second Order Equations: Green's function, Sturm Comparison Theorems and Oscillations, Eigenvalue Problems. Applications.

Course Outcomes

At the end of the course the student will be able to:

CO1: Understand the basic trigonometric ratios, hyperbolic and inverse trigonometric andinverse hyperbolic functions.

CO2: Understand the concept of differentiabilty and its applications to find maxima andminima and curve sketching using first and second derivatives.

CO3: Understand the basic concepts of ODE, apply them in modeling and solving first order equations.

CO4: Recall the techniques of solving second order linear homogeneous ODE with constant coefficients. Understand and modify the above techniques for solving Euler-Cauchy equations. Understand and apply methods of undetermined coefficients and variation of parameters to solve the second order linear nonhomogeneous differential equations.

CO5: Understand the concept of solutions and obtain them by using boundary conditions.

Textbooks:

1. 'Calculus', G.B.Thomas Pearson Education, 2009, 11th Edition.
2. 'Advanced Engineering Mathematics', E.Kreyszig, John Wiley and Sons, 2002, 8thEdition.
3. 'Mathematics for Degree students', P.K.Mittal, S.Chand & Co, New Delhi.
4. "Mathematics for B.Sc.", Branch I Vol. I, Vol. II, P.Kandasamy and K.Thilagavathy,S.Chand & Co.

General / Open electives offered by the department

24OEL331	Atmospheric Physics	3 0 0 3

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the earth's atmosphere, atmospheric thermodynamics, atmospheric aerosols and analysis of its impact on the global climate, and the different methods of atmospheric observation.

Unit 1
Introduction to earth's atmosphere: main constituents of dry air, CO_2, ozone, water vapour, aerosols; vertical thermal structure of the atmosphere: troposphere, stratosphere, mesosphere, thermosphere and exosphere; environmental lapse rate, hydrostatic equilibrium, hydrostatic equation.

Unit 2
Atmospheric Thermodynamics: Gas Laws, Ideal Gas Law, Dalton's Law, First Law of Thermodynamics, equivalence between heat and work, thermal capabilities, isothermal, isochoric, isobaric transformation, adiabatic transformation, Poisson relation, thermodynamic properties of water, latent heat, Clausius- Clapeyron's relation, Approximation and consequences of Clausius-Clapeyron relation, moist air, mean molecular weight of dry and moist air.

Unit 3
Aerosol And Cloud: Classification of atmospheric aerosol, production and removal mechanisms, concentration and size distribution, adsorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Beer-Bouguer-Lambert Law.
Macro and microphysical characteristics of cloud: droplet growth and cloud dissipation mechanism, radiative transfer in cloudy atmosphere, role of aerosol and cloud in climate.

Unit 4
Atmospheric Observations
Meteorology: General principles of meteorological measurements and observational procedures, conventional and self-recording measurements of atmospheric variables, upper air measurements: pilot balloons, radio sonde, ozone sondes, GPS sonde.

Unit 5
Atmospheric Observations

Remote sensing: Introduction to surface based remote sensing, working principle and applications of various remote sensing methods - LIDAR, SONAR, Water RADAR, radiological satellites, multicancer radio-meters and their applications in the observation of weather parameters.

Course Outcomes

At the end of the course, students will be able to

CO1: get acquainted with the different layers of the atmosphere and the associated phenomenon.

CO2: Learn the thermodynamics of the atmosphere.

CO3. Identify the atmospheric aerosols and clouds and impact on climate.

CO4. Understand the principles and applications of remote sensing and meteorological measurements.

Textbooks:

1. Physics of the Atmosphere and Climate – Murray L. Salby, Cambridge University Press.
2. Introduction to Atmospheric Physics – D.G. Andrews, Cambridge University Press.

References:

1. An Introduction to Dynamic Meteorology- Vol. 1., James R. Holton.
2. Remote Sensing of Aerosols, Clouds and Precipitation – T. Islam, Y. Hu, A. A. Kokhanovsky, J. Wang (Eds.) Elsevier.

24OEL332	Indian Contribution to Science	3 0 0	3

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: ancient to modern Indian science, ancient discoveries, the ancient rituals and relations with modern methods, the Nobel Laurates of Indian origin, and the lives of Indian scientists.

Unit 1

India's Contribution to Science and Technology (from Ancient to Modern):

Pre independence: Water management, Iron and Steel, Farming Techniques and Fertilizers, Physics, Medicine and Surgery.

Post Independence: Atomic Energy, Space, Electronics and Information Technology, Oceanography, Biotechnology, Council of Scientific and Industrial Research, The beginning of Indian Astronomy, Chemistry in Early Literature, Medicinal Tradition in Ancient India.

Unit 2

Science in Ancient India:

Different studies on plants and animals, Biodiversity and folk traditions, Mathematics in India by early Indian astronomers, early historical period, classical period, Metallurgy in India.

Unit 3

Indian Traditional Knowledge:

About nature, flora and fauna, Sacred groves, wildlife, Bishnois of Rajasthan and conservation, Ayurveda, elements of nature, ways of treatment, medical instruments in ancient India, yoga, traditional knowledge in relation to science, customs, and beliefs in different parts of India, positive and negative side.

Unit 4

Nobel Laureates of Indian Origin:

Sir Ronald Ross, Sir C.V Raman, Subrahmanyan Chandrasekhar, Har Govind Khorana, Venkataraman Ramakrisnan, and their contributions.

Unit 5

Life of eminent Scientists of India and their contributions:

Sushruta, Bhaskara II, Aryabhatta, Jagadish Chandra Bose, Acharya Prafulla Chandra Roy, Birbal Sahni, P.C Mahalanobis, Meghnad Saha, Satyendra Nath Bose, Srinivas Ramanujam, Salim Ali, Panchanan Maheshwari, B.P Pal, Homi Jehangir Bhaba, Kalpana Chawla, Sunita Williams, Smt Anna Mani, E.K Janaki Ammal.

Course Outcomes

At the end of the course, students will be able to

CO1. To understand the development of science from ancient to modern India.

CO2. To acquire knowledge on different fields of science originated in ancient India.

CO3. To comprehend the traditional Indian customs and rituals, its relation to modern science.

CO4. To know about Nobel Laureates of Indian origin.

CO5. To know about the life of eminent scientists of Indian origin.

Textbooks:

1. A Short History of Science and Technology In India, Dr Sanjay Sen, Mahabeer Publications, 2019.
2. Doctors, Scientists, & Engineers of Ancient India, S, Narain, Kalpaz Publications, 2017.
3. From the Beginning of Time: Modern Science and the Puranic Universe, Ganesh Swaminathan, 2020.

References:

1. India's Glorius Scientific Tradition, Suresh Soni, Prabhat Prakashan, 2020
2. The Unknown, Chiranit Majumdar, Notion Press Media Pvt Ltd, 2022
3. Lilavati's Daughters: The Women Scientists of India, Edited by Rohini Godbole and Ram Ramaswamy, Published by Indian Academy of Sciences, ISBN 978-81-8465-005-1.

24OEL333 History and Philosophy of Science 3 0 0 3

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the Indian and Western contributions to the science and technology.

Unit 1

Why History of Science? Astronomy in the ancient world - people, theory and instruments (4 hours) - Astronomy across civilizations of the old world, main discoveries, their contribution and instruments during those times.

Unit 2

The Dark ages in Europe - the Arabian influence - The Islamic science, translations and original contributions of Arabians, dark ages Europe, logic, literature and scientific method, early universities of Europe.

Unit 3

Indian tradition in Science and Technology - an overview - Indian contributions in science and technology - mathematics, astronomy and other sciences.

Unit 4

Texts that changed the course of history science - Elements of Euclid, Aryabhatiya of Aryabhata, Brahmasputa Sidhanta of Brahmagupta, Yuktibhasa of Jyestadeva, Philosophiae Natturalis Principia Mathematica.

Unit 5

The Copernican revolution and the rise of modern science - The background of Copernican revolution, interaction between civilizations, the rise of modern sciences - when and why?

Course Outcomes

At the end of the course, students will be able to

CO1. Understand the ancient world astronomy, its revolution, and the main discoveries.

CO2. Understand the western contributions in science.

CO3. Comprehend the Indian tradition in Science and Technology

CO4. Understand the Indian texts that contributed significantly to history of science.

CO5. Understand the origin of modern science.

Text and Background Literature:

History and philosophy of science is yet to be established as full-fledged discipline. Asuggested anthology of reading materials:

1.Essential reading on history of sciences (in-house publication)

2.http://www.Open2.net/whattheancients/ (Documentaries)

24OEL334	**Non-Conventional Energy Resources**	**3 0 0 3**

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the depleting non-renewable energy sources and alternative energy sources, the different applications of renewable energy, wind energy, solar energy, ocean energy and its potential as an energy resource, geothermal energy, and hydro energy.

Unit 1

Fossil Fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy and their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in offshore wind energy, tidal energy, wind energy systems, solar energy, biomass, biochemical conversion, biogas generation, hydroelectricity

Unit 2

Solar Energy: Solar energy, its importance, storage of solar energy, solar pond, solar water heater, solar cooker, solar green houses, solar cell, absorption air conditioning, need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems.

Unit 3

Wind Energy Harvesting: Fundamentals of wind energy, wind turbines and different electrical machines in wind turbines, power electronic interfaces and grid interconnection topologies, wind energy conversion, windmill, basic components of windmill conversion system, types of wind mills, conversion and efficiency.

Unit 4

Ocean Energy: Ocean energy potential against wind and solar, wave characteristics and statistics, wave energy devices. Tide characteristics and statistics, tide energy technologies, ocean thermal energy, osmotic power, ocean biomass.

Unit 5

Geothermal Energy and Hydro Energy: Geothermal resources, geothermal technologies, Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Course Outcomes

At the end of the course, students will be able to

CO1. understand and appreciate the need to shift to renewable energy resources.

CO2. comprehend the fundamentals of solar energy generation.

CO3. appreciate the harvesting of wind energy.

CO4. develop fundamental ideas about energy in the ocean waves.

CO5. develop fundamental knowledge regarding geothermal energy and hydro energy.

Textbooks:

1. Non-conventional Energy Sources – G. D Rai, Khanna Publications, 2001.
2. Non-conventional Energy Resources – B. H. Khan, McGraw Hill, 3rd edition, 2017.

References:

1. Solar Energy – Suhas P. Sukhative, Tata McGraw Hill Publishing Company Limited.
2. Wind Energy System – Gary L. Johnson, Printice Hall Inc., New Jersey, 1985.

24OEL335	Science Society and Culture	3 0 0	3

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: sociology and social science, and to be organized in such a way that even students without any previous exposure to sociology could acquire an interest in the subject and follow it.

Unit 1

The nature of Sociology

The meaning of Sociology: Origin, Definition, Scope, Subject matter, Nature and relation of sociology with other social Sciences. Humanistic orientation to Sociological study.

Unit 2

Basic concepts

Society, community, Institution, Association, Group, Social structure, status and role, Human and Animal Society.

Unit 3

Institutions.

Family and kinship, religion, education, State.

Unit 4

The individual and Society.

Culture, Socialization, Relation between individual and society.

Unit 5

The use of Sociology.

Introduction to applied sociology - Sociology and social problems, Ecology and Environment: Pollution, Global warming and Greenhouse effect. Impact of Industrialization and Urbanization on Environment.

Course Outcomes

At the end of the course, students will be able to

CO1. Understand the origin, definition, and orientation of sociology.
CO2. Understand the Basic concepts of society.
CO3. Understand the association of an individual and Society.
CO4. Understand the use of Sociology.

References:

1. Harlambos, M - Sociology: Themes and perspectives, Oxford University Press.
2. Inkeles, Alex - What is Sociology, Prentice-Hall of India.
3. Jaiaram - What is Sociology, Macmillan.
4. Johnson, Harry M, Sociology: A Systematic Introduction, Allied Publishers.

24OEL337	Physics of the Earth	3 0 0 3

Course Objective:
Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the earth and the universe, its components, dynamical processes related to solid earth, hydrosphere, atmosphere and biosphere, different factors disturbing the earth's ecosystem.

Unit 1
The Earth and The Universe:
Origin of universe, creation of elements and earth. A holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography.
General characteristics and origin of the universe, the Big Bang Theory. Age of the universe and Hubble constant, formation of galaxies, earth's orbit and spin, Asteroids: origin, types and examples, meteorites origin, types and examples, earth in the solar system, origin, rotational and revolution parameters and its age.

Unit 2
Structure of the Earth:
Mass, size, shape, density, dimensions, topography, internal structure, origin of magnetic field, geothermal energy and its source.

Unit 3
The Hydrosphere: The oceans, their extent, depth, volume, chemical composition, river systems
The Atmosphere: Layers, variation of temperature with altitude, variation of density and pressure with altitude, cloud formation
The Cryosphere: Polar caps and ice sheets, mountain glaciers, permafrost.

Unit 4
Dynamical Processes:
The Solid Earth: convection of the earth's core and production of its magnetic field, mechanical layering of the earth, introduction of geophysical methods of earth investigation, concept of plate tectonics; types of earth movements, Earthquake and earthquake belts, Richter scale, geophones.
Hydrosphere: Ocean circulations, oceanic current system and effect of Corioli's force, tides, tsunamis.
The Atmosphere: Atmospheric circulation, weather and climate changes, earth's temperature and greenhouse effect
Biosphere: water cycle, carbon cycle

Unit 5

Contemporary dilemmas Disturbing the Earth: (a) human population dynamics (b) Atmosphere: greenhouse gas emissions, climate change, air pollution (c) Hydrosphere: fresh water depletion, water pollution (d) Geosphere: chemical effluents, nuclear waste (e) Biosphere: biodiversity loss, deforestation, Robustness and fragility of ecosystems.

Course Outcomes

At the end of the course, students will be able to

CO1. gain basic knowledge about the origin of universe, galaxies, and earth.

CO2. understand the structure of the earth.

CO3. understand the structure of Atmosphere, hydrosphere, and Cryosphere.

CO4: learn about dynamical processes related to the earth, Atmosphere, hydrosphere, and Cryosphere.

CO5. Identify different factors which create threats to the stability of our ecosystem.

Textbooks:

1. Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.

2. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, C. Emiliani, 1992, Cambridge University Press.

References:

1. The Blue Planet: An Introduction to Earth System Science, Brian J. Skimnner, Stephen C. Portere, 1994, John Wiley & Sons.

2. The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.

24OEL338	Physics for all	3 0 0 3

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: the states of matter, and properties of matter, Nature of light and lens system, and our galaxy.

Unit 1

States of Matter:

Three states of matter, properties of matter, surface tension, viscosity, fluid flow, capillary action, fluid pressure and thrust, Applications- Pascal’s law, Bernoulli’s principal.

Elasticity: Stress, Strain, stress-strain curve, types of moduli, Hook’s law, Elastic properties of matter, I-shape girder.

Unit 2

Light & lenses: Nature of light, properties: Reflection, refraction, diffraction, interference, scattering (elementary ideas only): blue color of sky, twinkling of stars. Mirage, rainbow,

Lens and system of lenses: concave and convex lenses: focal length, power of a lens, refractive index, defects of the eye: myopia, hypermetropia, presbyopia and astigmatism and their correction using lens.

Unit 3

Electricity: Voltage and current, Ohms law. Electric power (EB Bill), calculation of energy requirement of electric appliances – transformer, generator and induction stove.

Unit 4

Magnetism: Dia, para and ferro magnetic material, Domain theory, Storage devices. Electromagnetic induction, super conductivity, Properties of super conductor, Application: Maglev train.

Unit 5

Our Universe: Galaxies- Stars, Planets & satellites – solar system, lunar and solar eclipses, black holes. Artificial satellites: Geo stationary and Polar satellites.

Course Outcomes

At the end of the course, students will be able to

CO1. to understand the properties and states of matter.

CO2. to understand the concept of light and its uses in system of lenses.

CO3. to learn the concepts of electricity, magnetism and its relevance in daily activities

CO4. to comprehend the basics of our galaxy, solar system, and planets.

Textbooks:

1. Fundamentals of Physics with Applications by Arthur Beiser.
2. Optics by Ajay Ghatak, Tata McGraw-Hill publishing Co. Ltd., New Delhi (1998).
3. The Physics of Everyday Things, James Ka Kalios, RH US(2017) Physics in Everyday Life, Shaswant Goswami, Vedang Sati, (2016).

References:

1. Feynmann Lectures on Physics, Matthew Sands, Richard Feynmann and Robert B. Leighton Vol I, Vol II, Vol III.
2. Storm in a Teacup: The Physics of Everyday Life, Helen Czerski, Publisher Black Swan.

24OEL339	**Physics in everyday life**	**3 0 0 3**

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: systems of units, planetary motion, satellites and Global Positioning System, heat and thermodynamics and related applications in day today life, light and sound phenomenon.

Unit 1

Units and Measurements: CGS, FPS, MKS, SI system of units, their inter conversion relations, Dimensional formula of physical quantities. Dimension analysis and its applications to simple problems, Measured value and absolute value; Accuracy and Precision, Error in measurement and its Types, Error estimation formulae.

Unit 2

Mechanics: Scalar and Vector quantities, distance, displacement, speed, velocity, acceleration, Circular motion, rotational motion, preliminary idea of angular displacement, velocity, Planetary motion, Gravitational force, acceleration due to gravity in different places, concept of inertia, Newton's laws of motion.
Applications in real life: natural and artificial satellites, examples, introduction to global positioning system

Unit 3

Heat: Concepts of Heat and Temperature, Units of temperature: Centigrade, Fahrenheit and Kelvin scale, their inter-

conversion formulae, Heat transfer processes: conduction, convection and radiation, explanation of change of states of matter.
Applications in real life: Refrigerator, Air Conditioner, Microwave Oven.

Unit 4
Sound: Longitudinal nature of sound, Frequency, and its unit and Pitch, Loudness and Intensity, Production and detection of sound, Audible frequency range, infrasonic and ultrasonic sounds, Noise and Music.
Applications in real life: Principle of Loudspeaker and Microphone, Musical Instruments.
Industry application: Cutting, drilling, welding and NDT, and medical application: Scanning.

Unit 5
Light: Reflection, Refraction and Dispersion of light, Snell's law, formation of images by plane mirror, convex and concave mirror, formation of rainbow, scattering of colour during sunriseand sunset, blue colour of sky.
Applications in real life: Different types of light bulbs, Laser, LED, Color rendering Index, Display devices and panels.

Course Outcomes
At the end of the course, students will be able to
CO1. understand different systems of units.
CO2. basics of kinematics to relate with satellites and Global Positioning System.
CO3. understand the basic theory of heat, temperature, different scales and applications.
CO4. to apply the basics of sound waves in musical instruments **.**
CO5. to comprehend different phenomena of light and relate it with nature and applications.

Textbooks:

1. Conceptual Physics, Paul G. Hewitt, Pearson Education, 2017.
2. Physics Made Simple: A complete Introduction to the basic principles of this fundamental science, Christopher G. De Pree, Crown Publisher, 2005
3. Concept of Physics, H.C Verma, Bharat Bhawan Publisher, 2021

References:

1. The Basics of Physics, Rusty L. Myers, Greenwood Press, 2005
2. AK Basics of Physics, Anil Kumar Kakodiya, 2023.

24ENG101 **English I** **2 0 0 2**

Objectives:

To help students obtain an ability to communicate fluently in English; to enable and enhance the students' skills in listening, speaking, reading, and writing; to impart an aesthetic sense and enhance creativity

Cos	Course Outcomes
CO 1	Demonstrate competence in the mechanics of writing
CO 2	Summarise audio and written texts to convey messages effectively
CO 3	Apply mechanics of writing and AI tools to draft academic and professional documents
CO4	Organise ideas and thoughts for clear written and oral communication
CO 5	Critically evaluate literary texts

Unit I

Mechanics of writing - Parts of speech – use of prepositions, adjectives, adverbs and determiners – word order – collocation – concord (Subject-Verb, Pronoun-Antecedent) – kinds and patterns of sentences

Unit II

Tenses - Modal auxiliaries - Reported speech - Active and Passive Voice - Phrasal Verbs - Linkers/ Discourse Markers - Question Tags

Unit III

Pre-writing techniques - Paragraph writing – Cohesion – Development – types: definition, comparison, classification, contrast, cause and effect - Essay writing: Descriptive and Narrative - Introduction to the use of Gen AI in writing (AI tools, Do's and Don'ts while using AI, how to write prompts, etc.)

Unit IV

Listening comprehension (3 pieces – Do Schools kill creativity? By Sir Ken Robinson, Steve Jobs' 2005 Stanford Commencement Address, India Questions Dr Abdul Kalam- Aired August 2007) - Reading Comprehension – Skimming and Scanning- Inference and Deduction – Reading different kinds of material – Speaking**:** Narration of incidents / stories/ anecdotes.

Unit V

Shashi Tharoor – "'Kindly Adjust' to Our English

A. G. Gardiner – "A Fellow Traveller"

Ruskin Bond – "The Eyes Have It"

Mrinal Pande – "Girls"

W. H. Auden – "Unknown Citizen"

W H Davies - "Leisure"

References:

1. Murphy, Raymond, *Murphy's English Grammar,* CUP, 2004
2. Syamala, V. *Speak English in Four Easy Steps*, Improve English Foundation Trivandrum: 2006
3. Martinet, Thomson, *A Practical English Grammar*, IV Ed. OUP, 1986.
4. The Week - June 03, 2018, LAST WORD; https://www.theweek.in/columns/shashi-tharoor/2018/05/25/kindly-adjust-to-our english.html?fbclid=IwAR3IhtdXqvuV4ySECn9S7SA6HmCEYISyd1QHd3BlwKgiNKKwdkeSg3qWp-U/
5. A G Gardiner – *Leaves in the Wind*, Digicat (e-book), 2015
6. Ruskin Bond – *The Best of Ruskin Bond*; India Penguin. April 2016.
7. Mrinal Pande – *Stepping Out*; Penguin India; 2003
8. W H Auden – *Another Time*; Random House Pub; 1940
9. William H Davies – *Songs of Joy and Others*; Andesite Press, August 2017.
10. Sir Ken Robinson – "Do schools kill creativity?". https://go.ted.com/6WoC
11. Steve Jobs' 2005 Stanford Commencement Address. https://youtu.be/UF8uR6Z6KLc?si=1nMNYJOk3Yw7H7tF
12. India Questions Dr Abdul Kalam (aired: August 2007). https://youtu.be/erg3CmVm6M4?si=YudsxXZOFY1do91C

24ENG111 **English II** **1 0 2 2**

Objectives:

To train students to convey and document information in a formal environment; to facilitate them to acquire the skill of self-projection in professional circles; to inculcate critical and analytical thinking.

Cos	Course Outcomes
CO 1	Illustrate comprehension of the fundamentals of writing
CO 2	Analyse audio text focussing on English phonetics, pronunciation and meaning comprehension
CO 3	Apply theoretical knowledge to write professional documents
CO 4	Infer from current news to formulate ideas and opinions
CO5	Prepare appropriate content for mini project and make effective presentation

Unit I

Vocabulary Building: One-word substitutes; Antonyms and Synonyms; Words often Confused Error Analysis (Subject-Verb Agreement; Tense Sequence; Usage of Articles and Prepositions; Determiners; Redundancy); Modifiers (misplaced, dangling, etc.)

Unit II

Circulars; Memos; Formal Letter writing; e-Mail Etiquette; Instruction, Suggestion & Recommendation; Essay writing: Analytical and Argumentative

Unit III

Sounds of English: Stress, Intonation - Listening Comprehension (3 pieces – Women in Technology Panel discussion, India Questions Abdul Kalam, UPSC Topper Mock interview Akshat Jain) - Current News Awareness

Unit IV

Reports: Incident Report, Event Report

Situational Dialogue; Group Discussion (Opinion)

Unit V

Mini Project and Presentation

References:

1. Felixa Eskey. *Tech Talk*, University of Michigan. 2005
2. Michael Swan. *Practical English Usage*, Oxford University Press. 2005
3. Anderson, Paul. *Technical Communication: A Reader Centered Approach*, V Edition, Hercourt, 2003 .
4. Martinet, Thomson, *A Practical English Grammar*, IV Ed. OUP, 1986.
5. Raymond V. Lesikar and Marie E. Flatley. *Basic Business Communication*, Tata McGraw Hill Pub. Co. New Delhi. 2005. Tenth Edition.
6. Thampi, G. Balamohan. *Meeting the World: Writings on Contemporary Issues*. Pearson, 2013.
7. Lynch, Tony. *Study Listening*. New Delhi: CUP, 2008.
8. Kenneth, Anderson, Tony Lynch, Joan Mac Lean. *Study Speaking*. New Delhi: CUP, 2008.
9. Marks, Jonathan. *English Pronunciation in Use*. New Delhi: CUP, 2007.
10. Syamala, V. *Effective English Communication for You (Functional Grammar, Oral and Written Communication)*: Emerald, 2002.
11. Sample Question Papers from Competitive Examinations
12. Women in Technology Panel discussion
    https://youtu.be/T44XdGH5s-8?si=A1cDVEt777FH7vFR
13. India Questions Abdul Kalam
    https://youtu.be/erg3CmVm6M4?si=WjP_SV1vy6FrsGHg
14. UPSC Topper Mock interview, Akshat Jain
    https://youtu.be/lsJBGvyiAHI?si=L-u6kTadzJmghHLI

22ADM101	FOUNDATIONS OF INDIAN HERITAGE	L-T-P-C:2-0-1-2

Course Objective(s)

To introduce students to the depths and richness of the Indian culture and knowledge traditions, and to enable them to obtain a synoptic view of the grandiose achievements of India in diverse fields. To equip students with aknowledge of their country and its eternal values.

Course Outcomes

COs	Description
CO1	Increase student understanding of true essence of India's cultural and spiritual heritage.
CO2	Emancipating Indian histories and practices from manipulation, misunderstandings and other ideological baggage thus, shows its contemporary relevance.
CO3	Understand the ethical and political strategic concepts to induce critical approach to various theories about India.
CO4	Familiarize students with the multi dimension of man's interaction with nature, fellow beings and society in general.
CO5	Appreciate the socio-political and strategic innovations based on Indian knowledge systems. Gives an understanding of bringing Indian teaching into practical life.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	2	2	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	1	2	-	-	-	3	-	-	-
CO3	2	-	-	-	-	2	3	3	-	-	-	-	-	-	-
CO4	-	-	3	-	3	2	3	-	-	-	-	3	-	-	-
CO5	2	-	1	2	-	1	3	1	-	-	-	2	-	-	-

Syllabus

1. Chapter 1 - Educational Heritage of Ancient India
2. Chapter 2 - Life and Happiness
3. Chapter 3 - Impact of Colonialism and Decolonization
4. Chapter 4- A timeline of Early Indian Subcontinent
5. Chapter 5 - Indian approach towards life
6. Chapter 6 - Circle of Life
7. Chapter 7- Pinnacle of Selflessness and ultimate freedom
8. Chapter 8- Ocean of love; Indian Mahatmas.
9. Chapter 9 - Become A Strategic Thinker (Games / Indic activity)
10. Chapter 10 - Man's association with Nature
11. Chapter 11 - Celebrating life 24/7
12. Chapter 12 - Metaphors and Tropes
13. Chapter 13 - India: In the Views of foreign Scholars and Travellers.

Self-Study/ Self-reading

14. Chapter 14 - Personality Development Through Yoga.
15. Chapter 15 - Hallmark ofIndian Traditions: Advaita Vedanta, Theory of oneness
16. Chapter 16 - Conversations on Compassion with Amma

Textbooks/References

1. Foundations of Indian Heritage

Evaluation Pattern

Assessment	Weightage (%)
Midterm	30
Continuous Assessment	20
End Semester Exam	50
Total Marks	100

24ENV200	ENVIRONMENTAL SCIENCE AND SUSTAINABILITY	L-T-P-C:3-1-0-4

Course Objective:

To provide a general understanding of our environment, problems during exploitation of natural resources, the importance of biodiversity and the need for its conservation, pollution and its impacts, and approaches for environment sustainability.

Course Outcomes:

COs	Description
CO1	Understand the over-exploitation of our natural resources and the need for Sustainable development.
CO2	Understand the concept of ecosystem, its structure and function and threats to Ecosystems.
CO3	Understand the concept of bio-diversity, its importance and conservation.
CO4	Classify pollution and its impacts
CO5	Inferring different approaches for attaining environmental sustainability.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	0	0	0	1	1	1	0	1	1	1	1	1	1	0	0
CO2	1	1	0	1	1	1	1	1	2	1	1	1	1	1	1
CO3	1	1	0	1	1	1	1	1	2	1	1	1	1	1	1
CO4	2	2	0	1	1	1	1	1	2	1	1	1	1	1	1
CO5	2	2	1	2	2	2	1	2	2	1	1	1	1	2	2

Syllabus

Unit1

Multidisciplinary nature of environmental studies. Renewable and non-renewable Naturalresources. Overexploitation and conservation of the following natural resources -- forest,water,food,energy,mineral,andlandresources.Conceptofsustainability,sustainabledevelopment. Concept of three R’s (Reduce, Reuse, and Recycle). Concept of zero waste.Needforenvironmentaleducation.

Unit2

Conceptofecosystem.Components,structureandfunctionofanecosystem.Abriefdescription of forest ecosystem and desert ecosystem. Food chain and food web, EcologicalPyramids.BiogeochemicalCycles(examples-Carbon,NitrogenandPhosphorous).EcosystemServices(exampleforest).
Threatstoecosystems.Conservationofecosystems.

Unit3

Concept of Biodiversity, hot spots of biodiversity, India as a mega diversity nation, Threats tobiodiversity, Value of biodiversity, Brief description of economic valuation of biodiversity,Red Data Base and Red data Book, International Union for Conservation of Nature **(IUCN)**Red ListofThreatened Species(Briefdescription),Conservationofbiodiversity.

Unit4

Pollution of air, acid rain, global warming and climate change, ozone layer depletion, Waterpollution, Soil pollution. Industrial and urban solid wastes, Hospital wastes, Hazardous waste,Collection, segregation of solid wastes, Different household disposal methods for degradablesolid wastes, Commercial water purification devices for households, Plastic pollution, microplasticsandits environmentalandhealtheffects.E-waste.

Unit 5

Ecological foot prints-brief description of Carbon Footprint and Water Footprint, Linear and Circular resource management, System thinking, Industrial ecosystems, Environmental Impact Assessment (EIA), Environment Management Plan (EMP), Green Technology, Green Business, Green Accounting, Green Buildings, Eco-Labeling, Sustainable (Green) Cities. Role of individuals in the up keeping of environment.

Text Books:

1. Palanisamy P. N., Manikandan P., Geetha A., Manjula Ran – Environmental Science, Pearson Education.
2. Harikumar P.N., Susha D. And Manoj Narayanan K. S. – Environment management and human rights. Himalaya Publishing House.
3. Asthana D.K and Meera Asthana – A Textbook of Environmental Studies, S.Chand & Company Pvt Ltd. Ran Nagar, New Delhi -110055.

References:

1. Bala Krishnamoorthy – Environmental management: Text and Cases.PHI LearningPrivate Limited.
2. Jacob Thomas – Environmental management: Text and Cases. Pearson.
3. Rajagopaln R. – Environmental Studies: From crisis to cure. Oxford University Press

Evaluation Pattern

Assessment	Weightage (%)
Midterm	25
Continuous Assessment	25
End Semester Exam	50
Total Marks	100

22ADM111	GLIMPSES OF GLORIOUS INDIA	L-T-P-C:2-0-1-2

Course Objective(s)

To introduce students to the depths and richness of the Indian culture and knowledge traditions, and to enable them to obtain a synoptic view of the grandiose achievements of India in diverse fields. To equip students witha knowledge of their country and its eternal values.

Course Outcomes

COs	Description
CO1	This part deals with two topics: The Need to Become Fearless in Life and the Role or Status of Women in India.
CO2	This part deals with three topics: Teachings and Principles of Chanakya, Difference between the terms God and Iswara and Contribution of Bhagavad Gita
CO3	This area handles two important concepts: Indian Soft powers and A portrayal of how nature was preserved through the medium of Faith. Inner power is about never giving up on your dreams. To manifest more of what you desire in life, you must be prepared to embrace your inner power. You must be persistent if you wantto succeed. Maintain your modesty and never stop learning. Inner strength is an attitude to life. Faiths shape and direct how we think, act, and live our lives. However, faith's power is not solely spiritual. To preserve nature, our forefathers established systems and traditions based on faith. Our culture and faith are intricately bound to nature.
CO4	Two important topics are discussed here: A Brief history of Ancient Indian Cultures and a Discussion on Practical Vedanta. Indian culture is the legacy of the ethno-linguistically diverse country's social norms, moral principles, traditional practices, belief systems, political systems, artefacts, and technologies. Following every invasion or change of political control, new kingdoms carried their respective cultures with them, adding to the Indian culture. Vedanta is the philosophy of the Upanishads. Every soul possesses the potential to be divine. The objective is to manipulate this inner divinity by invoking both internal and external natural forces.
CO5	From this part, a student gets an insight into the contribution that India has made to the world. Moreover, foreign powers have been trying to humiliate and degrade India in front of the world for so long. However, it should be recognized that many inventions that are considered beneficial to the world today have been contributed by the great men of India.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	3	2	2	-	-	-	3	-	-	3	-	-	-
CO2	-	-	2	-	-	-	-	2	2	-	-	2	-	-	-
CO3	-	-	3	-	2	-	3	2	2	-	-	3	-	-	-
CO4	-	-	1	-	-	-	1	1	-	-	1	-	-	-	-
CO5	2	-	-	1	1	-	2	-	-	-	3	3	-	-	-

Syllabus

1. Chapter 1 - Face the Brutes
2. Chapter 2 - Role of Women in India
3. Chapter 3 - Acharya Chanakya
4. Chapter 4 - God and Iswara
5. Chapter 5 - Bhagavad Gita: From Soldier to Samsarin to Sadhaka

6. Chapter 6 - Lessons of Yoga from Bhagavad Gita
7. Chapter 7 - Indian Soft Powers: A Solution For Many Global Challenges
8. Chapter 8 - Nature Preservation through faith
9. Chapter 9 - Ancient Cultures what happened to them.
10. Chapter 10 - Practical Vedanta
11. Chapter 11 - To the World from India
12. Chapter 12 - IndianApproach to Science

Textbooks/References

1. Glimpses Of Glorious India

Evaluation Pattern

Assessment	Weightage (%)
Midterm	30
Continuous Assessment	20
End Semester Exam	50
Total Marks	100

22AVP103 Mastery Over Mind (MAOM) 1-0-2 2

1. Course Overview

Master Over the Mind (MAOM) is an Amrita initiative to implement schemes and organise university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3). This program as part of our efforts for sustainable stress reduction gives an introduction to immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety facilitating inner peace and harmony.

With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the understanding of experiential learning based on university's mission: "Education for Life along with Education for Living", and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

2. Course Syllabus

Unit 1 (4 hours)

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2 (4 hours)

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology. philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3 (4 hours)

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research.

TEXT BOOKS:

1.Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019

2.Swami Amritaswarupananda Puri ,"The Color of Rainbow " published by MAM, Amritapuri.

REFERENCES:

1.Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life"

Zondervan Publishers, February 2019
2.R Nagarathna et al, “New Perspectives in Stress Management “Swami Vivekananda Yoga Prakashana publications, Jan 1986
3. Swami Amritaswarupananda Puri “Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation”, August 2019
4. Swami Amritaswarupananda Puri “From Amma’s Heart - Amma’s answer to questions raised during world tours” March 2018
5. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.
6. Mata Amritanandamayi Devi “Compassion :The only way to Peace:Paris Speech”, MA Center, April 2016.
7. Mata Amritanandamayi Devi “Understanding and collaboration between Religions”, MA Center, April 2016.
8. Mata Amritanandamayi Devi “Awakening of Universal Motherhood: Geneva Speech” M A center, April 2016.

3. Evaluation and Grading

Internal			**External**	**Total**
Components	*Weightage*		Practical (attendance and class participation) 60%	100%
Quizzes(based on the reading material)	20%	40%		
Assignments (Based on webinars and lecture series)	20%			

4. Course Outcomes (CO)

CO1: Relate to the causes of stress in one’s life.
CO2: Experiment with a range of relaxation techniques CO3: Model a meditative approach to work, study, and life.
CO4: Develop appropriate practice of MA-OM technique that is effective in one’s life CO5: Inculcate a higher level of awareness and focus.
CO6: Evaluate the impact of a meditation technique

***Programme Outcomes(PO)**(As given by NBA and ABET)
PO1: Engineering Knowledge
PO2: Problem Analysis
PO3: Design/Development of Solutions
PO4: Conduct Investigations of complex problems
PO5: Modern tools usage
PO6: Engineer and Society
PO7: Environment and Sustainability
PO8: Ethics
PO9: Individual & Team work
PO10: Communication
PO11: Project management & Finance
PO12: Lifelong learning

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	3	3	3	2		-	2	3	-	3	-	3	-	-	-
CO2	3	3	3	2	2	_	2	3	3	3	-	3	-	-	-
CO3	3	3	2	2	2	2	2	3	3	3	-	3	-	-	-
CO4	3	3	3	2	-	2	3	3	3	3	-	3	-	-	-
CO5	3	2	2	2	-	2	-	3	2	2	-	2	-	-	-
CO6	3	2	2	2	3	2	_	3	2	2	-	2	-	-	-

22AVP201 Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

22ADM211 Leadership from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

22ADM201 Strategic Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

22AVP204 Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

22AVP205 Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

22AVP206 Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

22AVP207 Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

22AVP208 Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

22AVP209 Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

22AVP210 Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

22AVP213 Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

22AVP214 Principles of Worship in India

Indian mode of worship is unique among the world civilizations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realization of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

22AVP215 Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the Vasthupurusha.

22AVP218 Insights into Indian Classical Music

The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Saptatalas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.

22AVP219 Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Sixs limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

22AVP220 Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the AbhinavaBharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

22AVP221 Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala's traditional KalariPayattu. The course introduces the various exercise technique to make the body supple and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

23LSK201	Life Skills I	L-T-P-C: 1-0-2-2

Pre-requisite: An open mind and the urge for self-development, basic English language skills, knowledge of high school level mathematics.

Course Objective: To assist students in inculcating soft skills, developing a strong personality, empowering them to face life's challenges, improving their communication skills and problem-solving skills.

Course Outcomes

CO1: Soft Skills - To develop greater morale and positive attitude to face, analyze, and manage emotions in real life situations, like placement process.
CO2: Soft Skills - To empower students to create better impact on a target audience through content creation, effective delivery, appropriate body language and overcoming nervousness, in situations like presentations, Group Discussions and interviews.
CO3: Aptitude – To analyze, understand and solve questions in arithmetic and algebra by employing the most suitable methods.
CO4: Aptitude - To investigate and apply suitable techniques to solve questions on logical reasoning.
CO5: Verbal – To infer the meaning of words & use them in the right context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.
CO6: Verbal - To identify the relationship between words using reasoning skills. To develop the capacity to communicate ideas effectively.
Skills: Communication, self-confidence, emotional intelligence, presentation skills and problem-solving Skills.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	2	3	3	-	3
CO2	-	-	-	-	-	-	-	3	2	3	-	3
CO3	-	3	-	-	-	-	-	-	-	-	-	3
CO4	-	3	-	-	-	-	-	-	-	-	-	3
CO5	-	-	-	-	-	-	-	-	-	3	-	3
CO6	-	-	-	-	-	-	-	-	3	3	-	3

Syllabus

Soft Skills

Soft Skills and its importance: Pleasure and pains of transition from an academic environment to work-environment. New-age challenges and distractions. Learning to benefit from constructive criticisms and feedback. Need for change in mindset and up-skilling to keep oneself competent in the professional world.
Managing Self: Knowing oneself, Self-perception, Importance of positive attitude, Building and displaying confidence, Avoiding being overconfident, Managing emotions, stress, fear. Developing Resilience and handling failures. Self-motivation, Self-learning, and continuous knowledge up-gradation / Life-long learning. Personal productivity - Goal setting and its importance in career planning, Self-discipline, Importance of values, ethics and integrity, Universal Human Values.
Communication: Process, Language Fluency, Non-verbal, Active listening. Assertiveness vs. aggressiveness. Barriers in communication. Digital communication

Aptitude

Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.

Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.

Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.

Averages: Basics, and Weighted Average.

Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.

Logical Reasoning I: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding \& Decoding, Cryptarithmetic Problems and Input - Output Reasoning.

Verbal Skills

Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misused words, commonly confused words and wrong form of words in English.

Grammar (Basics): To learn the usage of grammar and facilitate students to identify errors and correct them.

Reasoning: Stress the importance of understanding the relationship between words through analogy questions. Emphasize the importance of avoiding the gap (assumption) in the argument/ statements/ communication.

Speaking Skills: Make students conscious of the relevance of effective communication in today's world through individual speaking activities.

Writing Skills: Introduce formal written communication and keep the students informed about the etiquette of email writing.

References:

1. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
2. The hard truth about Soft Skills, by Amazon Publication.
3. Verbal Skills Activity Book, CIR, AVVP
4. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
5. The BBC and British Council online resources
6. Owl Purdue University online teaching resources
7. www.thegrammarbook.com online teaching resources
8. www.englishpage.com online teaching resources and other useful websites
9. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
10. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
11. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
12. How to Prepare for Data Interpretation for the CAT, Arun Sharma.
13. How to Prepare for Logical Reasoning for the CAT, Arun Sharma.
14. Quantitative Aptitude for Competitive Examinations, R S Aggarwal.
15. A Modern Approach to Logical Reasoning, R S Aggarwal.
16. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

23LSK211	Life Skills II	L-T-P-C: 1-0-2-2

Pre-requisite: Willingness to learn, communication skills, basic English language skills, knowledge of high school level mathematics.

Course Objective: To help students understand the corporate culture and assist them in improving their group discussion skills, communication skills, listening skills and problem-solving skills.

Course Outcomes

CO1: Soft Skills - To improve the inter-personal skills, professional etiquette and leadership skills, vital for arriving at win-win situations in Group Discussions and other team activities.
CO2: Soft Skills - To develop the ability to create better impact in a Group Discussions through examination, participation, perspective-sharing, ideation, listening, brainstorming and consensus.
CO3: Aptitude - To interpret, critically analyze and solve questions in arithmetic and algebra by employing the most suitable methods.
CO4: Aptitude - To analyze, understand and apply suitable methods to solve questions on logical reasoning.
CO5: Verbal - To be able to use vocabulary in the right context and to be competent in spotting grammatical errors and correcting them.
CO6: Verbal - To be able to logically connect words, phrases, sentences and thereby communicate their perspectives/ideas convincingly.
Skills: Communication, etiquette and grooming, inter-personal skills, listening skills, convincing skills, problem-solving skill.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	2	3	3	2	3
CO2	-	-	-	-	-	-	-	2	3	3	2	3
CO3	-	3	-	-	-	-	-	-	-	-	-	3
CO4	-	3	-	-	-	-	-	-	-	-	-	3
CO5	-	-	-	-	-	-	-	-	-	3	-	3
CO6	-	-	-	-	-	-	-	-	3	3	-	3

Syllabus

Soft Skills

Professional Grooming and Practices: Basics of corporate culture, key pillars of business etiquette – online and offline: socially acceptable ways of behavior, body language, personal hygiene, professional attire and cultural adaptability and managing diversity. Handling pressure, multi-tasking. Being enterprising. Adapting to corporate life: Emotional Management (EQ), Adversity Management, Health consciousness. People skills, Critical Thinking and Problem solving.

Group Discussions: Advantages of group discussions, Types of group discussion and Roles played in a group discussion. Personality traits evaluated in a group discussion. Initiation techniques and maintaining the flow of the discussion, how to perform well in a group discussion. Summarization/conclusion.

Aptitude

Logarithms, Inequalities and Modulus: Basics

Sequence and Series: Basics, AP, GP, HP, and Special Series.

Time and Work: Basics, Pipes & Cistern, and Work Equivalence.

Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.

Logical Reasoning II: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives, Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.

Verbal Skills

Vocabulary: Help students understand the usage of words in different contexts.
Grammar (Medium Level): Train Students to comprehend the nuances of Grammar and empower them to spot errors in sentences and correct them.

Reading Comprehension (Basics): Introduce students to smart reading techniques and help them understand different tones in comprehension passages.

Reasoning: Enable students to connect words, phrases and sentences logically.

Oral Communication Skills: Aid students in using the gift of the gab to interpret images, do a video synthesis, try a song interpretation or elaborate on a literary quote.

References:

1. Adair. J., (1.986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
2. Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
3. The Hard Truth about Soft Skills, by Amazone Publication.
4. Verbal Skills Activity Book, CIR, AVVP
5. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
6. The BBC and British Council online resources
7. Owl Purdue University online teaching resources
8. www.thegrammarbook.com online teaching resources
9. www.englishpage.com online teaching resources and other useful websites
10. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
11. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
12. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
13. How to Prepare for Data Interpretation for the CAT, Arun Sharma.
14. How to Prepare for Logical Reasoning for the CAT, Arun Sharma.
15. Quantitative Aptitude for Competitive Examinations, R S Aggarwal.
16. A Modern Approach to Logical Reasoning, R S Aggarwal.
17. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

23LSK301	**Life Skills III**	**L-T-P-C: 1-0-2-2**

Pre-requisite: Team Spirit, self-confidence and required knowledge, basic English language skills, knowledge of high school level mathematics.

Course Objective: To help students understand the nuances of leadership, know the importance of working in teams, face challenging situations, crack interviews, improve communication skills and problem-solving skills.

<u>Course Outcomes</u>

CO1: Soft Skills - To acquire the ability to work in teams, present themselves confidently and showcase their knowledge, skills, abilities, interests, practical exposure, strengths and achievements to potential recruiters through a resume, video resume, and personal interview.
CO2: Soft Skills - To have better ability to prepare for facing interviews, analyse interview questions, articulate correct responses and respond appropriately to convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.
CO3: Aptitude - To manage time while arriving at appropriate strategies to solve questions in geometry, statistics, probability and combinatorics.
CO4: Aptitude - To analyze, understand and apply suitable methods to solve questions on data analysis and data sufficiency.
CO5: Verbal - To use diction that is less verbose and more refined and to use prior knowledge of grammar to correct/improve sentences.
CO6: Verbal - To understand arguments, analyze arguments and use inductive/deductive reasoning to arrive at conclusions. To be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.
Skills: Communication, teamwork, leadership, facing interviews and problem-solving.

<u>CO-PO Mapping</u>

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	2	3	3	-	3
CO2	-	-	-	-	-	-	-	2	3	3	-	3
CO3	-	3	-	-	-	-	-	-	-	-	-	3
CO4	-	3	-	-	-	-	-	-	-	-	-	3
CO5	-	-	-	-	-	-	-	-	-	3	-	3
CO6	-	-	-	-	-	-	-	-	3	3	-	3

Syllabus

<u>Soft Skills</u>

Team Work: Value of teamwork in organizations, Definition of a team. Why team? Effective team building. Parameters for a good team, roles, empowerment and need for transparent communication, Factors affecting team effectiveness, Personal characteristics of members and its influence on team. Project Management Skills, Collaboration skills.
Leadership: Initiating and managing change, Internal problem solving, Evaluation and co-ordination, Growth and productivity, Importance of Professional Networking.
Facing an interview: Importance of verbal & aptitude competencies, strong foundation in core competencies, industry orientation / knowledge about the organization, resume writing (including cover letter, digital profile and video resume), being professional. Importance of good communication skills, etiquette to be maintained during an interview, appropriate grooming and mannerism.

<u>Aptitude</u>

Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.

Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.

Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.

Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.

Data Interpretation: Tables, Bar Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, and other forms of data representation.

Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.

Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.

Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

<u>Verbal Skills</u>
Vocabulary: Create an awareness of using refined language through idioms and phrasal verbs.

Grammar (Advanced Level): Enable students to improve sentences through a clear understanding of the rules of grammar.

Reasoning Skills: Facilitate the student to tap his reasoning skills through Syllogisms, and critical reasoning arguments.

Reading Comprehension (Advanced): Enlighten students on the different strategies involved in tackling reading comprehension questions.

Public Speaking Skills: Empower students to overcome glossophobia and speak effectively and confidently before an audience.

Writing Skills: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style. Practice formal written communication through writing emails especially composing job application emails.

References:

1. Adair. J., (1.986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
2. Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
3. The Hard Truth about Soft Skills, by Amazone Publication.
4. Verbal Skills Activity Book, CIR, AVVP
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6. The BBC and British Council online resources
7. Owl Purdue University online teaching resources
8. www.thegrammarbook.com online teaching resources
9. www.englishpage.com online teaching resources and other useful websites
10. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
11. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
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17. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal.

<u>Evaluation Pattern</u>

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and test**

24MAL101 Malayalam I LTPC: 2 0 0 2

Course Objectives:

- To enable the students to acquire basic skills in functional language.
- To develop independent reading skills and reading for appreciating literary works.
- Enable students to communicate in the language they have studied in a range of contexts and for a variety of purposes
- To analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech

Course outcomes:
CO1: Develop the ability to read and critically appreciate a given text
CO2: Develop fluency in speaking the language
CO3: Ability to blend language and Indian spirituality.

Unit	Topic
1	**Adhyatmaramayanam,** Tharopadesam(Enthinnu Sokam….thulom) --------------------------------------- **Jnanappana** (sthanamanangal….Trishnakondubhramikkunnathokkeyum)
2	Modern Poets: Mampazham-Vyloppilly Sreedharamenon Critical analysis of the poem.
3	Short stories from period 1/2/3:**Poovanpazham-**Vaikaom Muhammed Basheer
4	Literary Criticism: **Bharatha Paryatanam-***Vyasante Chiri*–Ithihasa studies-Kuttikrishna Marar-Outline of literary Criticism in Malayalam Literature
5	Error-freeMalayalam: **1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha Malayalam – Writing-**a**. Expansion of ideas; **b**.PrecisWriting; **c**. Essay Writing

Text books/Reference :

1. Adhyatmaramayanam – Thunjath Ramanujan Ezhuthachan
2. Ramayanavichinthanam-Dr. A. M. Unnikrishnan
3. Thunjan Padhanangal-Prof.Panmana Ramachandran
4. Compleate Works including Jnanappana-Poonthanam
5. Vyloppilly-M.N.Vijayan
6. Vyloppilli-Vyakthi,Kavi-Dr.M.Leelavathi/S.Gupthan Nair
7. Basheerinte Poonkavanam-Prof.M.N.Karasseri
8. Basheer-Life & Works
9. Bharatha Paryatanam-Kuttikrishna Marar
10. Lavanyasastrathinte Yukthisilpam-Dr.Thomas Mathew

11)Thettillatha Malayalam – Prof.Panmana Ramachandran Nair(His all books on Error Free Malayalam)

24HIN101	HINDI I	2 0 0 2

Course Objective: The course will enable the students to understand the basics of grammar and usage, to appreciate the literary compositions, and to understand the intricacies of language and literature.

Course Outcomes: By the end of the course the students will be able to:

1. Distinguish various literary genres.
2. Explore tradition and culture through literature.
3. Apply the basics of grammar.
4. Critically analyse the prescribed literary texts.

UNIT 1

Hindi Sahithya ki Panch shresht Kahaniyam**:**

a.Sughmay Jeevan –Chandradhar Sharma ,Guleri

b.Dhan ki Bhent-Rabindranath Tagore

c.Anbola –Jayashankar Prasad

d.Swamini (Manasrovar bhagh-1) Premchand

UNIT 2.

Hindi Kavitha:

a.'Aarya" –Maithili Sharan Gupth

b. "Meribhi abha he Ismein' .,"Mubarak Ho Naya Saal"-_Nagarjun

c. "Nishaa Ki rod eta Rakesh- Nihar se'.,Shoonya Mandir meinBanoongi-Sandhya Geet se - Mahadevi varma

d.'KhoobLadi Mardani vahtho Jhansi Vali rani thi'-subhadra Kumari chohan

UNIT 3.

Hindi Ekanki**:**

a) Mohan Rakesh :Andeke Chilke

b) Vishnu Prabhakar :Sarkari Noukari

UNIT 4.

Grammar:1)Karak2) Upasarg3)Pratyay4)Vakya Rachana 5)Padaparichay.6)Sarvanam7)kriya 8)Adjective 9)Adverb10)Tenses

REFERENCE

1. Sugam Hindi Vyakarn, :Prof.Vanshidhar & Dharmapal Shastri
2. Vyavaharik Hindi Vyakarantatha Rachana: Dr.Hardev Bahari

Shiksharthi HindiVyakaran:Dr. Nagappa

3. Hindi Sahithya ki Panch shresht Kahaniyam**:** Edited by: Dr.Sachidanandh Shuklu

(Printed and Published by V&S publishers, Abridged, AnsariGanj, Delhi)

4. Hindi Samay.com,/Hindikahani.com/exotic indiaart.com

24KAN101	Kannada I	LTPC: 2 0 0 2

Objectives:

- To enable the students to acquire basic skills in functional language.
- To develop independent reading skills and reading for appreciating literary works.
- Enable students to communicate in the language they have studied in a range of contexts and for a variety of purposes
- To analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech

Course Outcome

CO1	Develop the ability to read, listen and write in Kannada and to understand and use the language in a variety of contexts and situations
CO2	To enable the learners to understand the grammatical structures of classes of words
CO3	Develop ability to speak fluently and interactively in both personal and professional context

Course Contents

UNIT – 1

Adalithadalli Kannadada balake: (Use of Kannada in business and administration)
Bhashe – swaroopa, stityantaragalu,
Aadu bhashe, pradeshika bhashe, Grantika bhashe
Paaribhaashika padagalu

UNIT – 2

Padagala rachane,deshiya – anya deshiya padagalu
Lekhana Chinnhegalu
Kannada bharavanigeya shuddha mattu ashuddha roopagalu,
Dwiruktigalu, jodunudigalu

UNIT – 3

Nudigattgalu, gaade vistarane
Listening to radio speech, tongue twister - practice

UNIT – 4

Patra Lekahna - aupachaarika haagu anoupachaarika
Kandikegala rachane
Prabandhagalu: vivaranaatmaka haagu niroopanatmaka

UNIT – 5

Poems

- Vachanagalu – kaalugalembavu gaali kandaya – Allamaprabhu,Ratnada sankoleyaadade todarallve – Akkamahadevi, ole hatti uridare nilabahudallade - Basavanna
- Keerthanegalu – Tanuva nirolagaddi phalavenu – Purandaradasa, Tallanisadiru kandya taalu manave - Kanakadaasa
- Tripadigalu – Saalavanu kombaaga haalogarundante - Sarvagna
- Janapada geetegalu - Yaake badtaadti tamma

Short stories

- Sambhanda – Shrikrishna Alanahalli
- Moksha – Sethuram

Prabandhagalu

- Namma Maneya Deepa – Ha.Ma.Nayak
- Bhadhuku Kanasalla, Ondhu Kale – N K Kulakarni

References:

1. H.S.Krishnaswamy Iyangaar – Adalitha Kannada – Chetana publication, Mysuru
2. Kannada Vyakarana mattu Rachane – N.Gopalakrishna Udupa, M.C.C.Publication
3. G.H.Naayak – Kannada Sanna Kathegalu – Chetana Book House
4. Shatamaanada Lalitha Prabandha – Gurulinga Kaapase - Karnataka Sahitya Academy
5. Naavalla – Kathasankalana – Sethuram
6. Basavannanavara Vachanagalu – G.V.Shastri – Paaru prakashana
7. Kannadada Balake – H.S.Krishnaswamy Iyangaar – Chetana book house
8. Sarvagnana Vachanagalu – Venkata Subbaiha, Vijayavaahini Publications

24SAN101 SANSKRIT I 2 0 0 2

Course Objectives:

- To enable the students to acquire basic skills in functional language
- To develop independent reading skills and reading for appreciating literary works.
- To analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech
- Grasp the connection between Sanskrit language and Indian philosophy

Course Outcomes:

CO 1 Read and understand Sanskrit verses and sentences and communicate in Sanskrit

CO 2 Imbibe values of life and Indian tradition propounded by the scriptures

Module I

Introduction to Sanskrit language, Devanagari script - Vowels and consonants, pronunciation, classification of consonants, conjunct consonants, words – nouns and verbs, cases – introduction, numbers, Pronouns, communicating time in Sanskrit. Practical classes in spoken Sanskrit

Module II

Verbs- Singular, Dual and plural — First person, Second person, Third person.

Tenses – Past, Present and future – Atmanepadi and parasmaipadi-karthariprayoga.

Module III

General group words for communication and moral stories.

Module IV

ChanakyaNeeti chapter III (part I), Bhagavad Gita chapter 14 (part I)

Module V

Translation of simple sentences from Sanskrit to English and vice versa.

24TAM101	TAMIL I	2 0 0 2

Course Objectives:

To teach Tamil for effective communication in different spheres of life: - cultural relations in society.

Course Outcomes:

1. Giving exposure to history of Tamil literature and Introduction of select Classics
2. Initiating Students to the spirit of Bhakti literature
3. Encouraging creativity of students by teaching Contemporary Literature poetry, modern poetry, Short Story, Prose, Novel, etc
4. Introduction of basic Grammar, Letter writing and essay writing skills of Tamil language.

அலகு-1

தமிழ்இலக்கியவரலாற்றில்சங்கஇலக்கியம்: முதல், இடை, கடைசங்கம்.

சங்கஇலக்கியங்கள்பத்துப்பாட்டு.

குறுந்தொகை (6,8பாடல்கள்),

புறநானூறு (184,192பாடல்கள்).

சங்கம்மருவியகாலஇலக்கியம்:

சிலப்பதிகாரம் (வழக்குறைக்காதை),

பதிணெண்கீழ்கணக்குநூல்கள்,

திருக்குறள் (மருந்து)

UNIT-1 History of Tamil Literature: First, Intermediate, Last sangam. Sangam Literature, Pattuppaattu. Kuṟuntogai, Puṟanaanuuru.

Literature of the Sangam Maruviya period – Silappathiagaram (vazhakkuraikaathai), PatiṇeṇkiizhKaṇakkuNuulkal. TirukkuṟaL (Marunthu)

அலகு 2

பக்திஇலக்கியம்:–

பன்னிருதிருமுறைகள்அறிமுகம்,

மாணிக்கவாசகர் (திருவாசகம்- சிவபுராணம்)

UNIT 2 Bhakti Literature – Introduction to PanniruThirumuraikal, Manikkavasagar (Thiruvasagam- Siva Puranam)

அலகு -3

தற்காலஇலக்கியம்:-

கவிதை : பாதியார் (குயில்பாட்டு), பாரதிதாசன் (தமிழின்இனிமை).

உரைநடை: ஞா.தேவநேயப்பாவாணர் (தமிழும்திரவிடமும்சமமா?),

பரிதிமாற்கலைஞர் (தமிழ்மொழியின்வரலாறு (ஆதிவரலாறு)).

சிற்பி (வள்ளுவர்வகுக்கும்இன்பம்)

சிறுகதை: அழகியபெரியவன் – (வனம்மாள்)

நாவல்: இமையம் (பெத்தவன்)

UNIT-3 Contemporary Literature: Poetry - Bharathiar(kuyilpāṭṭu), Bharathidasan (tamiḻiṉiṉimai, iṉpattamiḻ) Pattukottai Kalyanasundaram.

Prose: G. DevaneyaBhavanar (TamizhumDhiravidamumsamamaa?), Paritimāṟkalaiñar (paranarkettaparisu), chirbi (valluvarvakukkuminbam)

Short Story: Azhagiya Periyavan – (VanammaaL)

Novel: Imaiyam (Peththavan)

அலகு – 4தொல்காப்பியம்:

எழுத்து – பிறப்பியல்.

நிறுத்தக்குறிகள்மற்றும்

கடிதம்எழுதுதலும்கட்டுரைஎழுதுதலும்

UNIT – 4tolkāppiyam: Alphabet – piṟappiyal. Punctuation marks and Letter writing and essay writing.

REFERENCE

இமையம், *பெத்தவன்*, க்ரியாவெளியீடு 2019.

அழகியபெரியவன் ,*அழகியபெரியவன்கதைகள்*, நற்றிணைபதிப்பகம், 2016

சி.பாலசுப்பிரமணியன், *கட்டுரை-வளம்*, நறுமலர்ப்பதிப்பகம், பத்தாம்பதிப்பு 1994

பரிதிமாற்கலைஞர் ,*தமிழ்மொழியின்வரலாறு*, பூம்புகார்பதிப்பகம், ஆறாம்பதிப்பு 2013.

அகளங்கன், *பன்னிருதிருமுறை – அறிமுகம்*, இந்துமாமன்றம்வவுனியா, 1994

ரா. சீனிவாசன ,*தமிழ்இலக்கியவரலாறு* ,https://ta.wikisource.org/s/99uk

மாணிக்கவாசகர் (திருவாசகம்- சிவபுராணம்

பொன்மணிமாறன் “அடோன்தமிழ்இலக்கணம் “அடோன்பப்ளிஷிங்குரூப், வஞ்சியூர், திருவனந்தபுரம், 2007.

http:/www.tamilvu.org/libirary/libindex.htm.
http:/www.gunathamizh.com/2013/07/blog0post_24.html

24ENG100 **Additional English – I** **2 0 0 2**

Objectives:

- To expose students to various genres of English literature
- To expose the students to Indian English Writing of different timelines.
- To develop a sensibility to read and understand literary works.
- To introduce a few linguistic devices to enable them to appreciate literary forms stylistically

COs	Course Outcomes
CO 1	Identify and distinguish various genres of English Literature for better understanding
CO 2	Demonstrate an ability to comprehend and analyse literature independently
CO 3	Develop or enhance the ability to appreciate and use linguistic devices for stylistic analysis

Unit-I
Introduction to Literature – Nature & Elements of Literature, literature as an expression of personal & historic aspects. Narrative structure & technique. Introduction to Indian Literature: Pre-independence, postindependence, themes, writers, and problems.

Unit-II
Linguistic Devices: Theme, Diction, syntax & syntactical deviations, Rhetorical devices, figures of speech

Unit-III
Poetry:
The Frog and the Nightingale by Vikram Seth
An Indian Love Song *by Sarojini Naidu*
Death of the Wolf by Toru Dutt

Unit IV
Short stories:
Detail-
A Dog's Life by Mulk Raj Anand
Interpreter of Maladies by Jumpha Lahiri

Unit-V
Non-Detail Reading:
Three Persons by Vijay Sheshadri
The Wolf's Postcript To 'Little Red Riding Hood' **by Agha Shahid Ali**
The Naive Friends by Premchand
The Woman on Platform 8 by Ruskin Bond

Core Reading :

- Iyengar, Srinivasa **–** ***The Indian Contribution to English Literature.*** Karnatak ishing House, Bombay, 1945
- Iyengar, Srinivasa – ***Indian Writing in English : 1800-1980*** – Sterling Publishing House, 2019

References

- Seth, Vikram, ***Beastly Tales,*** Penguin India, 2013
- Naidu, Sarojini, ***The Golden Threshold*** 1905
- Dutt, Toru **-** ***A Sheaf Gleaned in French Fields*** 1876
- Anand, Raj Mulk, ***Selected Short Stories*** Penguin India, 2006
- Tagore, Rabindranath, ***Mashi and Other Stories,*** True Sign Publishing House, 2021
- Lahiri, Jumpha **-** ***Interpreter of Maladies*** Harpercollins Publishers India, 2005
- Sheshadri, Vijay – POETRY Magazine, December 2010
- Ali, Shahid Agha, ***The Wolf's Postcript To 'Little Red Riding Hood'*** Academy of American Poets, poets.org
- ***Premchand - , Mindfuel's 4 In 1 Story By Munshi Premchand - Power Of A Curse, The Naive Friends, A Complex Problem & A Lesson In The Holy Life*** **Mindfuel Publishers,** ***2020***
- *Bond, Ruskin* **-** ***The Woman on Platform 8,*** **The Illustrated Weekly of India**

Evaluation Pattern :

Assessment Component	Weightage
Continuous Evaluation (Class Tests, Assignment, Class Activity)	20
Mid Term Examination	30
End Semester Examination	50
Total	**100**

24MAL111 **Malayalam II** **LTPC: 2 0 0 2**

Course objective:

- To develop independent reading skills and reading for appreciating literary works.
- To develop elaboration and modernization of the vocabulary of a language
- To enable the students to plan, draft, edit & present a piece of writing.

Course outcomes:

CO1: Develop the ability to read and critically appreciate a given text
CO2: Develop fluency in communication
CO3: Develop interest in blending of language and Indian Spirituality
CO4: To enable the learners to understand the grammatical structures of classes of words

Unit	Topic
1	Memoirs-One of the Selecrtion from Chiudambara Smarana-Balachandran Chullikkadu-Critical analysis of his poetry)
2	Ancient Drama: ***Kerala Sakunthalam*** (Act 4), Kalidasan (Transilated by Attoor Krishna Pisharody).
3	Satire One of the Selection from Chemmanam Chacko,VKN Or Punathil Kunjabdulla- philosophical dimens of Satire
4	Part of an auto-biography/travelogue: **Valarnnu varunna oratmavu(from Kanneerum Kinavum)-VT Bhattathirippad**
5	Error-freeMalayalam: **1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha Malayalam – Writing-**a**. Expansion of ideas

Text books/Reference:

1) Hasa Sahithyam Kuttikrishna Mararu
2) Sakunthalam-Attoor/Kuttikrishna Marar
3) Kalidasa Hridayam-K.P.Narayana Pisharady
4) VKN-K.P.Appan
5) N.V.Krishna Warriar & Modern Poetry studies
6) Kanneerum Kinavum –V.T. Bhattathirippad
7) Adukkalayil Ninnu Arangatheykku-V.T.Bhattathirippadu
8) Nalla Malayalam- C.V.Vasudeva Bhattathiri
9) Tettum Sariyum-Prof. Panmana Ramachandran Nair

24HIN111	HINDI II	2 0 0 2

Course Objective: The course will allow students to apply grammar in language structures, appreciate the literary compositions and provide them with a good command over translation techniques.

Course outcomes: By the end of the course the students will be able to:

1. Understand the postmodern trends of literature...
2. 2.Explore tradition and culture through literature.
3. Apply ethical and professional translation strategies.
4. Demonstrate linguistic competence in written communication.

UNIT 1

Hindi Laghu Upanyas **:Mamatha Kaliya- ' Doud'**

UNIT 2

Hindi Natak**:** Swadesh Deepak- "Kort Marshal"

UNIT 3.

Adhunik Hindi Kavya a.Jayashankar Prasad-(Lahar, Aah!Vedhana Mili Vidayi)., b.Suryakanth Tripathi „Nirala"- (Anamika -4)., c.Subadhra Kumari , Chouhan- (Swadesh Ke Prathi, Smruthiyam), d.Gajanan Madhav Muktibodh- (ek swapna Katha)

UNIT 4.

A)Sankshepan,

B) .Anuvad: Paribhasha,Prakar,AnuvadKeLakshan,AnuvadKiAvashyakata,Passage (Translation)

c)Paragraph writing

D)Technical writing

REFERENCE

1. Prayojan Mulak Hindi Ke Naye Ayam : Dr. Pandit Banne
2. Prayojan Mulak Hindi Ki Nayi Bhumika : Kailash Nath Pandey
3. Prayojan Mulak Hindi Ke Vividh Roop : Dr. Rajendra Mishra, Rakesh Sharma
4. "Adhunik Kavya Sangraha" Edited by . Dr. Urvashi Sharma (Printed and Published by Malik & Company, Jaipur)
5. Hindi Samay.com,/Hindikahani.com/exotic indiaart.com

24KAN111 **Kannada II** **LTPC: 2 0 0 2**

Objectives:

- To develop the standard of orthography and spelling system.
- To develop independent reading skills and reading for appreciating literary works.
- To develop elaboration and modernization of the vocabulary of a language.
- To enable the students to plan, draft, edit & present a piece of writing.

Course Outcome

CO1	Develop the ability to read and critically appreciate a given text
CO2	Develop pattern of communication as required for different professional context
CO3	Develop fluency in speaking the language

Course Contents

UNIT – 1
Prabandhagalu

- Thotadacheya Bhoota – Kuvempu
- Bantu Bannada Holi – G. S. Shivarudrappa

UNIT – 2
Poems

- Ni hinga nodabayda Nanna – Da. Ra. Bendre
- Huttarihaadu – Panje Mangesh Rao
- Tungabadre – K.S.Narasimhaswamy
- Nanna Janagalu – Dr.Siddhalingaya

UNIT – 3
Novel

- Jugari Cross – Poornachandra Tejaswi

UNIT – 4

- Suttole
- Kadata
- prakatane
- Arjigalu
- Aadesha patraa

UNIT- 5

- Varadigalu
- Sanshikpta Baravanige
- Prabandhagalu: vaadaatmaka haagu vishleshanatmaka

References:

1. Jugari Cross – Poornachandra Tejaswi – Pustaka Prakashana
2. Shatamaanada Lalitha Prabandha – Gurulinga Kaapase - Karnataka Sahitya Academy
3. N.Gopalkrishna Adiga – Kannada Vyakarana mattu Rachane – MCC Publications
4. Maadhari Patragalu – S.R.Siddharaju – Kannada Saahitya Parishattu
5. H.S.Krishnaswamy Iyangar – Adalitha Kannada – Chetana publication, Mysuru

24SAN111 **SANSKRIT II** **LTPC: 2 0 0 2**

Module I

Seven cases, Avyayas, sentence making with Avyayas, Sapthakakaras.

Module II

Kthavathu Prathyaya, Upasargas, Kthvatha, Thumunnantha, LyabanthaPrathyaya. Three Lakaras – brief introduction, Lot lakara

Module III

New words and sentences for the communication, Slokas, moral stories, Subhashithas, riddles (Selected from the Pravesha Book)

Module IV

Introduction to classical literature, classification of Kavyas, classification of Dramas - Important five Mahakavyas

Module V

Translation of paragraphs from Sanskrit to English and vice versa

Module VI

Chanakya Neeti chapter III (Part II), Bhagavad Geeta chapter 14 (Part II)

Essential Reading:

1, Praveshaha; Publisher :Samskritabharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085
2, Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad
3, PrakriyaBhashyam written and published by Fr. John Kunnappally
4, Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston
5, Sabdamanjari, R.S. Vadyar and Sons, Kalpathi, Palakkad
6, Namalinganusasanam by Amarasimha published by Travancore Sanskrit series
7, SubhashitaRatnaBhandakara by Kashinath Sharma, published by Nirnayasagarpress

24TAM111	TAMIL II	2 0 0 2

Course Objective: The course will allow students to understandthewriting competency in Tamil literature.

Course outcomes: By the end of the course the students will be able to:

1. Introduction to Tamil Folklore
2. Learning the nuances of Tamil spiritual literature
3. Exposure to the advanced aspects of Tamil grammar
4. Imbibing the spirit of language through familiarising with linguistics, translation and creative writing

அலகு 1
சிற்றிலக்கியங்கள்அறிமுகம்: கலிங்கத்துப்பரணி (பபோர்பபோடியது), முக்கூடற்பள்ளு 35. நோட்டுபுறவியல்: வரரவிலக்கணம், நோட்டுபுறப்பபோடல்கள், கரதகள், கரதப்பபோடல்கள், பழமமோழி, விடுகரதகள், கரலகள்.

Introduction to CiRRilakkiyam: Kalingaththupparani (Poor Padiyathu) - MukkdaRpallu 35. Folklore: Definition, Folksongs - Stories – kathaipPaadal - pazhamozhi - vidukathai - kalaikaL.

அலகு 2
பக்திஇலக்கியம்: ஆண்டோள்முழுவரலோறு, திருப்போரவ (1,2,3,4)

அலகு 3
மதோல்கோப்பியம்: மபோருளிலக்கணம் - மோல்லிலக்கணம்

அலகு 4
மமோழிமபயப்பு: மமோழிமபயப்புவரககள், மமோழிமபயர்ப்பின்முக்கியதுவமும்பதரவயும், இயந்திரமமோழிமபயர்ப்பு, மகோள்ரககள், இலக்கியமமோழிமபயர்ப்பு. மமோழியியல்அறிமுகம்: மமோழியும்மமோழியியலும், பயன்போடுமமோழியின்தன்ரமகள் ,மமோழியியல்துரறகள். பரடப்புஉருவோக்குதல் (கருத்துபரிமாற்றம் - கவிரதஇலக்கியம்- அறிமுகம், விடுதரலக்குமுன்னும்பின்னும் - நாடகம் - சிறுகதத).

Translation: Types of translation - Importance and need of translation - Machine translation - Principles - Literary translation.
Introduction to Linguistics: Language and Linguistics- Linguistics – Characteristics of applied language – Fields of Linguistics. Creation of creativity (Exchange of ideas - introduction to poetry literature, before and after liberation - drama - short story).

REFERENCES

மு.வரதரோன்“ தமிழ்இலக்கியவரலோறு” ோஹித்யஅகமடமிபப்ளிபகஷன்ஸ் , 2012
மபோன்மணிமோறன் “அபடோன்தமிழ்இலக்கணம் “அபடோன்பப்ளிஷிங்குரூப், வஞ்சியூர், திருவனந்தபுரம், 2007. http:/www.tamilvu.org/libirary/libindex.htm.
http:/www.gunathamizh.com/2013/07/blog0post_24.html நோ.வோனமோமரல, “தமிழர்நோட்டுப்போடல்கள்” நியூமஞ்சுரிபுத்தகமவளியீட்டகம் 1964,2006
நோ.வோனமோமரல “பழங்கரதகளும், பழமமோழிகளும் ”நியூமஞ்சுரிபுத்தகமவளியீட்டகம், 1980,2008

24ENG110 **Additional English – II** **2 0 0 2**

Objectives:

- To expose the students to various genres of English Literature.
- To expose the students to Indian English Writing of different timelines.
- To develop sensibility to read and understand literature and thereby encourage them to be sensitive to the whole spectrum of human experience.

COs	Course Outcomes
CO 1	To demonstrate an ability to critically appreciate any literary text
CO 2	To exhibit an ability to narrate and express their thoughts and idea.
CO 3	To be able to evaluate and relate to common human experiences

Unit-I
Introduction:
Drama : Tragedy & Comedy, Characters, Setting
Prose: Fiction and Non-Fiction
Life Writing.: Biography, Autobiography, Memoirs

Unit-II
Essays:
Shashi Tharoor ***- A Child's Reading in India***
Sarvepalli Radhakrishnan ***- Gandhian Outlook***

Unit-III
Play: *Silence! The Court is in Session'* by Vijay Tendulkar

Unit-IV
Non-Detail reading:
Karma – Khushwant Singh
Kailash Satyarthi's Nobel Lecture on 10 December 2014 at Oslo City Hall, Norway
Of Mothers, among other things. By A.K. Ramanujan

Unit-V
Critical Appreciation and Creative Writing: Class Activity

Core Reading

- Habib, M.A.R, ***Literary Studies, A Norton Guide***, Norton & Co, 2020
- Naik, M.K., ***A History of Indian English Literature,*** Sahitya Academy

References:

- Tendulkar, Vijay, ***Silence! The Court is in Session,*** Oxford University Press, 1982
- *Tharoor, Shashi,* ***A Child's Reading in India,*** Washington Post, Dec 1991
- *Gandhi Outlook and Techniques* - Ministry of Education, January 1, 1953
- Singh, Khushwant, ***Collected Short Stories***, Ravi Dayal Publishers, 1989
- **Nobel Lecture – Audio** [https://www.youtube.com/watch?v=UNZNbcf5Hd8]

Assessment Component	Weightage
Continuous Evaluation (Class Tests, Critical Appreciation, Creative Writing)	20
Mid Term Examination	30
End Semester Examination	50
Total	**100**