NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

for Integrated M.Sc. Physics

(Effective from 2021-22)

DEPARTMENT OF PHYSICS

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society.

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Physics

VISION

Be on the forefront of applied research and dissemination of knowledge combining Science and Engineering Perspectives.

MISSION

Develop the scientific insight and technical competence of students for keeping abreast with the advancements in science and technology to meet the demands of industry and research.

Engage in research and development of new materials and technologies in thrust areas.

Design and Develop application specific electronic and photonic instrumentation.

Department of Physics:

The Department of Physics was established in 1959, the very year of inception of the then REC, Warangal. The department offers postgraduate and doctoral programs in addition to catering the physics requirements of engineering programs. The department has a strong team of 20 highly qualified and motivated faculty members with diversified research experience. The department has excellent infrastructure available for pursuing research in cutting edge technologies.

M.Sc. (Tech.) Engineering Physics, has been a flagship program of the department. The program was introduced in the year 1970 under UNESCO's sponsorship, with the active association of experts from UK and Russia. Further, M.Sc. (Tech.) is an industry-oriented program and is structured on par with the then PG programs of engineering with one full semester for dissertation work and eight weeks of sandwiched industrial training. The program of M.Sc. (Tech.) enjoys 100% job potential right from its inception with placements in the best of industry and R & D organizations within the country and abroad. Currently three specializations – electronics, photonics & Instrumentation are being offered.

Recognizing the need for creating a talent pool in physical sciences, in tune with NEP 2020,the department has introduced a 5-year integrated M. Sc program. Further, the department offers, branch specific engineering physics, open electives minors for all B.Tech. courses and electives to different M. Tech programs.

The department is actively engaged in research with number of sponsored R&D projects under execution. The specific areas of research include Materials for energy harvesting, Super capacitors, Glasses and Glass ceramics, Biomaterials, Luminescent materials, Ferroelectrics, Magnetic materials, Polymer degradation studies, Photonics, Electronics, Medical Instrumentation, tropospheric radio propagation, Fiber optic Sensors, High temperature measurement, Holographic NDT, Microcontrollers and communication, Nano Ferrites & Nano Composites, Nanophosphors & Bio Glass Ceramics, Optical system design, Organic Light Emitting Diodes, Organic, polymer & Dye-sensitized solar cells, Pressure sensing, Liquid Crystals, Microfluidics, Transparent conducting thin films, Vibration measurement, Theoretical physics ,statistical physics, soft matter , biophysics and other frontier areas .

A grant of Rs.2.75 Crores is recently received by the department under the first phase of FIST program of DST (Govt of India) to setup FE-SEM and XRD facilities. The department has liaison with reputed industries and R&D organizations like BEL, CSIR, DRDO, DST, BARC, ELOIRA, RCI, ARCI, CSIO, LRDE, IRDE, Maharashtra Bamboo Development Board, Simply Fresh, Nutranxt Biotech Pvt Ltd., Kataline Infra Products Pvt Ltd.

List of Programs offered by the Department:

Program	Title of the Program
M.Sc. Tech	Engineering Physics
Integrated M.SC	Physics
Ph.D.	Physics

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Program Educational Objectives

PEO1	Gain knowledge and insight into the advancements in physics and to understand various scientific problems and their solutions.
PEO2	To analyse a problem / solution, in the field of physics and discern it into basic modules and interpret its performance and limitations
PEO3	Design and develop solutions to the scientific / industrial problems involving physics
PEO4	To use modern software tools for modelling, simulation, design and analysis in research and development.
PEO5	Be a leader in research and development and project execution.

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO-5
MS1	**2**	**2**	**2**	**3**	**3**
MS2	**3**	**3**	**3**	**2**	**3**
MS3	**1**	**2**	**1**	**2**	**2**

Program Outcomes

PO-1	Acquire comprehensive knowledge in physics, chemistry and mathematics for understanding the scientific problems and their solutions
PO-2	Identify, formulate and analyse complex problems in physics.
PO-3	Develop solutions to physics related problems in industry and research.
PO-4	Use research-based knowledge and research methods including design of experiments, synthesis of materials, characterisation, analysis and interpretation of data in investigation and exploration.
PO-5	Use advanced tools and processes for modelling, simulation, analysis and interpretation of data in research and development.
PO-6	Understand the impact of developments in science and technology in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development
PO-7	Communicate effectively the complex phenomena through proper documentation, reports and presentations.
PO-8	Acquire the skills necessary for lifelong learning to keep abreast with the advances in physics and follow the emerging trends.

Course Structure

I - Year, I – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	MAI101	Differential and Integral Calculus	3	0	0	3	PCC
2	PHI101	Mechanics, Waves and Oscillations	3	0	0	3	PCC
3	CYI101	General Chemistry-I	3	0	0	3	PCC
4	EEI131	Basic Electrical Engineering	3	0	0	3	ESC
5	HSI131	Communicative English -I	2	0	2	3	HSC
6	HSI132	Sanskrit	3	0	0	3	HSC
7	PHI102	Mechanics, Waves and Oscillations Laboratory	0	0	3	1.5	PCC
8	CYI102	General Chemistry Laboratory-I	0	0	3	1.5	PCC
9	IC001	Induction program	0	0	0	0	MNC
10	IC101	EAA I	0	0	2	0	MNC
		Total	17	0	10	21	

I - Year, II – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	MAI151	Ordinary Differential Equations	3	0	0	3	PCC
2	PHI151	Heat and Thermodynamics	3	0	0	3	PCC
3	CYI151	General Chemistry-II	3	0	0	3	PCC
3	HSI181	Communicative English-II	2	0	2	3	HSC
4	SMI181	Organizational Structures and Human Resource Management	3	0	0	3	HSC
5	MAI152	Ordinary Differential Equations Laboratory Using Sympy	0	0	3	1.5	PCC
6	PHI152	Heat and Thermodynamics Laboratory	0	0	3	1.5	PCC
7	CYI152	General Chemistry Laboratory-II	0	0	3	1.5	PCC
8	IC151	EAA II	0	0	2	0	MNC
		Total	14	0	13	19.5	

II - Year, I – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	MAI201	Modern Algebra	3	0	0	3	PCC
2	PHI201	Optics	3	0	0	3	PCC
3	CYI201	Physical Chemistry	3	0	0	3	PCC
4	MEI231	Basic Mechanical Science	3	0	0	3	ESC
5	MAI202	Computer Programming and Problem Solving	3	0	0	3	ESC
6	MAI203	Computer Programming Laboratory	0	0	3	1.5	ESC
7	PHI202	Optics Laboratory	0	0	3	1.5	PCC
8	CYI202	Physical Chemistry Laboratory-1	0	0	3	1.5	PCC
9		Mandatory non credit course	1	0	0	0	MNC
		Total	16	0	9	19.5	

II - Year, II – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	MAI251	Linear Algebra	3	0	0	3	PCC
2	PHI251	Electricity and Magnetism	3	0	0	3	PCC
3	CYI251	Inorganic Chemistry	3	0	0	3	PCC
4	PHI252	Artificial Intelligence	3	0	0	3	ESC
5		Elective – I	3	0	0	3	PEC
6	MAI252	Linear Algebra using Scilab laboratory	0	0	3	1.5	PCC
7	PHI253	Electricity and Magnetism Laboratory	0	0	3	1.5	PCC
8	CYI252	Quantitative Analysis Laboratory	0	0	3	1.5	PCC
		Total	15	0	9	19.5	

III - Year, I – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	MAI301	Numerical Analysis	3	0	0	3	PCC
2	PHI301	Basic Electronics	3	0	0	3	PCC
3	CYI301	Organic Chemistry	3	0	0	3	PCC
4		Elective II	3	0	0	3	PEC
5		Elective III	3	0	0	3	PEC
6	MAI302	Numerical Methods Laboratory	0	0	3	1.5	PCC
7	PHI302	Basic Electronics Laboratory	0	0	3	1.5	PCC
8	CYI302	Organic Chemistry Laboratory	0	0	3	1.5	PCC
9	PHI348	Seminar I	0	0	2	1	SEM
9		Mandatory non credit course	1	0	0	0	MNC
		Total	16	0	11	20.5	

III - Year, II – Semester

S. No.	Course Code		L	T	P	Credits	Cat. Code
1	MAI351	Real Analysis	3	0	0	3	PCC
2		Elective IV	3	0	0	3	PEC
3		Elective V	3	0	0	3	PEC
4		Elective VI	3	0	0	3	PEC
5		Open Elective	3	0	0	3	OEC
6	PHI351	Advanced Physics Laboratory	0	0	3	1.5	PCC
7	CYI351	Analytical Chemistry Laboratory	0	0	3	1.5	PCC
8	PHI399	Mini Project Work	0	0	4	2	PCC
		Total	15	0	10	20	

Program Elective Courses (Common to Maths, Physics & Chemistry)

Elective-1(2 Year, 2Semester)		
Sl.No.	**Course Code**	**Course Title**
1	MAI261	Vector Calculus
2	MAI262	Theory of Equations
3	MAI263	Mathematical Modelling
Elective-2 (3 Year, 1Semester)		
1	PHI311	Modern Physics
2	PHI312	Condensed Matter Physics
3	PHI313	Renewable Energy Sources
Elective-3 (3Year, 1Semester)		
1	CYI311	Environmental Chemistry
2	CY1312	Statistical Treatment of Data and Quality Control in Chemical Analysis
3	CYI313	Applied Chemistry
Elective-4 (3 Year, 2Semester)		
1	MAI361	Analytical Solid Geometry
2	MAI362	Data Science
3	MAI363	Elementary Number Theory
Elective-5(3 Year, 2Semester)		
1	PHI361	Electronic Instrumentation
2	PHI362	Analytical Characterization Techniques
3	PHI363	Basic Photovoltaic Devices and Applications
4	PHI364	Fundamentals of Nanomaterials and Applications
Elective-6(3 Year, 2Semester)		
1	CYI361	Basic Organometallic Chemistry
2	CYI362	Chemical Education
3	CYI363	Bioorganic Chemistry
4	CYI364	Instrumental Analysis for Industrial Applications

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	PH16001	Mathematical Physics	3-0-0	3
2	PH16003	Quantum Mechanics	3-1-0	3
3	PH25001	Classical Mechanics	3-0-0	3
4	PH25003	Analog and Digital Electronics	3-0-0	3
5	PH250XX	Professional Elective-I	3-0-0	3
6	PH16007	Optical Physics Lab	0-1-2	2
7	PH25005	Analog and Digital Electronics Lab	0-1-2	2
			Total Credits	19

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	PH16002	Electromagnetic Theory	3-0-0	3
2	PH16004	Atomic and Molecular Physics	3-0-0	3
3	PH16006	Solid State Physics	3-0-0	3
4	PH170XX	Professional Elective-II	3-0-0	3
5	PH170XX	Professional Elective-III	3-0-0	3
6	PH25002	Atomic and Molecular Physics Lab	0-1-2	2
7	PH16012	Solid State Physics Lab	0-1-2	2
			Total Credits	19

9th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	PH25007	Statistical Mechanics	3-0-0	3
2	PH25009	Nuclear and Particle Physics	3-0-0	3
3	PH170XX	Professional Elective-IV	3-0-0	3
4	PH170XX	Professional Elective-V	3-0-0	3
5	PH170XX	Electronics / Photonics Lab-1	0-1-2	2
6	PH170XX	Electronics / Photonics Lab-2	0-1-2	2
7	PH25089	Seminar and Technical Writing	0-0-0	2
8	PH25091	Short Term Industrial / Research experience	0-0-0	2
			Total Credits	20

10th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	PH170XX	Professional Elective-VI	3-0-0	3
2	PH170XX	Professional Elective-VII	3-0-0	3
3	PH25094	Comprehensive viva	0-0-2	2
4	PH25098	Major Project	0-0-0	8
			Total Credits	16

Professional Elective Courses (for PG):

Professional Elective-I

S.No.	Code	Course Title
1	PH16005	Optical Physics
2	PH25021	Introduction to Soft Matter and Biophysics

Professional Elective-II

S.No.	Code	Course Title
1	PH17022	High speed data converters
2	PH17026	Lasers and Applications
3	PH17030	Computer organization and operation systems
4	PH17034	Fiber Optics

Professional Elective-III

S.No.	Code	Course Title
1	PH17028	Pulse Circuits
2	PH17032	Thin Film and Vacuum Techniques
3	PH15024	Structured Light

Professional Elective-IV

S.No.	Code	Course Title
1	PH17007	Linear Integrated Circuits
2	PH18025	Solar Energy Systems
3	PH17005	Optoelectronics
4	PH17025	Linear Integrated Circuit Applications

Professional Elective-V

S.No.	Code	Course Title
1	PH17017	Microprocessor Applications
2	PH18031	Smart Materials and Devices
3	PH17021	Optical Sensors

Professional Elective-VI

S.No.	Code	Course Title
1	PH15026	Fundamentals of VLSI
2	PH17006	Communication Systems
3	PH17012	Optical System Design
4	PH17040	Lasing Materials

Professional Elective-VII

S.No.	Code	Course Title
1	PH15028	Electronic Instrumentation
2	PH15030	Photonic Devices
3	PH15032	Research Methodology

Electronics/Photonics Laboratory

S.No.	Code	Course Title
1	PH17015	Linear Integrated Circuit Laboratory
2	PH17019	Microprocessor Applications Laboratory
3	PH17011	Optoelectronics Laboratory
4	PH17023	Optical Sensor Laboratory

Credits in Each Semester (First 3years-Commonto Maths,Physics& Chemistry)							
Cat. Code	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Sem-V**	**Sem-VI**	**Total**
PCC	12	13.5	12	13.5	13.5	8	72.5
ESC	3		7.5	3			13.5
PEC				3	6	9	18
OEC						3	3
HSC	6	6					12
MNC							-
SEM					1		1
Total	**21**	**19.5**	**19.5**	**19.5**	**20.5**	**20**	**120**

Credits in Each Semester (4th & 5th Year-Physics Specific)					
Cat. Code	**Sem-VII**	**Sem-VIII**	**Sem-IX**	**Sem-X**	**Total**
ASC	22	16	13		51
PEC		6	9		15
CVV				2	02
SEM		1	1		02
DW				10	10
Total	**22**	**23**	**23**	**12**	**80**

Credits in Each Semester -Total 5 Years											
Cat. Code	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Sem-V**	**Sem-VI**	**Sem-VII**	**Sem-VIII**	**Sem-IX**	**Sem-X**	**Total**
PCC	12	13.5	12.5	13.5	13.5	8					72.5
ASC							22	16	13		51
ESC	3		7.5	3							13.5
PEC				3	6	9		6	9		33
OEC						3					3
HSC	6	6									12
SEM					1			1	1		3
CVV										2	2
DW										10	10
MNC											
Total	**21**	**19.5**	**19.5**	**19.5**	**20.5**	**20**	22	23	23	12	**200**

PCC-Program Core Course
ASC-Advanced Science Course
PEC-Program Elective Courses
ESC-Engineering Science Courses
HSC-Humanity and Social Science Courses
OEC-Open Elective
CVV-Comprehensive Viva Voce
DW-Dissertation Work

DETAILED SYLLABUS

I SEMESTER

Course Code: MAI101	DIFFERENTIAL AND INTEGRAL CALCULUS	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	find the Taylors series expansion of a function
CO2	find the maxima and minima of functions of several variables
CO3	identify the convergence of an improper integral
CO4	evaluate the surface area and volume of a solid of revolution
CO5	compute the surface area and volume of regions using multiple integration

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	--	-	-	-
CO2	3	2	2	-	-	-	-	-
CO3	2	2	2	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-
CO5	3	2	2	-	-	-	-	-

Syllabus:

Differential Calculus:

Taylor's theorem with remainders, Taylor's and Maclaurin's expansions, Curvature and Evaluates, Asymptotes, Curve tracing.

Functions of several variables - partial differentiation, total differentiation, Euler's theorem and generalization, Change of variables – Jacobians, maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers

Integral Calculus:

Evaluation of lengths of plane curves, plane areas, volume and surface area of a solid of revolution

Convergence of Improper integrals, Beta and Gamma integrals, Elementary properties of Beta and Gamma integrals, Differentiation under integral sign.

Double and triple integrals, computation of surface areas and volumes using multiple integration, change of variables in double and triple integrals.

Learning Resources:

Text Books:

1. Differential Calculus, **Shanti Narayanan**, S. Chand and Co., 2021
2. Integral Calculus, **Shanti Narayanan**, S. Chand and Co., 2021

Reference Books:

1. Calculus, 9th Edition **George Thomas Thomas, J., Ross L. Finney,** Pearson, 1996
2. A Course in Calculus and Real Analysis, **Sudhir R. Ghorpade and B.V.Limaye**, Springer, 2018
3. A Course in Multivariable Calculus and Analysis, **Sudhir R. Ghorpade and B.V.Limaye**, Springer, 2009

Course Code PHI101	MECHANICS, WAVES AND OSCILLATIONS	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Understand integration of vectors and stoke's greens and gauss theorems
CO2	Identify and apply the laws of mechanics along with the necessary mathematics for solving numerical.
CO3	Understand physical characteristics of SHM and obtaining solution of the oscillator using differential equations.
CO4	Use Lissajous figures to understand simple harmonic vibrations of same frequency and different frequencies
CO5	Solve wave equation of a longitudinal and transverse vibrations.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	--	-	-	-
CO2	3	3	2	2	-	-	-	-
CO3	2	3	2	2	-	-	-	-
CO4	3	3	2	2	-	-	-	-
CO5	3	3	2	2	-	-	-	-

Scalar and Vector Fields:

Scalar and vector fields, gradient of a scalar field and its physical significance. Divergence and curl of a vector field and related problems, vector integration: line, surface and volume integrals. Stokes, Gauss and Greens theorems, Laws of motion, motion of variable mass system, motion of a rocket, multi-stage rocket, conservation of energy and momentum, definition of rigid body, rotational kinematic relations, and equation of motion for a rotating body, angular momentum and inertial tensor.

Central Forces:

Central forces – definition and examples, conservative nature of central forces, conservative force as a negative gradient of potential energy, equation of motion under a central force, gravitational potential and gravitational field, derivation of Kepler's laws. Galilean relativity, absolute frames, Michelson-Morley experiment, Postulates of special theory of relativity. Lorentz transformation, time dilation, length contraction, addition of velocities, mass-energy relation.

Simple Harmonic Oscillator

Simple harmonic oscillator and its solution, physical characteristics of SHM, torsion pendulum, - measurements of rigidity modulus, compound pendulum, measurement of 'g', Lissajous figures, damped harmonic oscillator and its solution, comparison with undamped harmonic oscillator, logarithmic decrement, relaxation time, quality factor, differential equation of forced oscillator and its solution, amplitude resonance, velocity resonance, coupled oscillators.

Transverse wave propagation

Transverse wave propagation along a stretched string, general solution of wave equation and its significance, modes of vibration of stretched string clamped at ends, overtones, energy

transport, transverse, longitudinal vibrations in bars- wave equation and its general solution, Boundary conditions, clamped free bar, free-free bar, bar supported at both ends.

Learning Resources:

Text books:

1. Fundamentals of Physics, **Halliday/Resnick/Walker** Wiley India, 10th Edition, 2013.
2. Berkeley Physics Course. Vol.1, Mechanics, **C. Kittel, W. Knight, M.A. Ruderman** - Tata-McGraw hill Company, fourth Edition 2008.

Reference books:

1. University Physics, **Hugh D. Young, Roger A. Freedman** Pearson Education ,14th Edition,2017.
2. An introduction to Mechanics, **Daniel Kleppner & Robert Kolenkow.** TMH,2017.

Online resources:

1. https://nptel.ac.in/courses/115/106/115106119/.
2. https://onlinecourses.nptel.ac.in/noc20_ph22/preview.

Course Code: CYI101	GENERAL CHEMISTRY-I	Credits 3-0-0:3

Pre-Requisites: none

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

CO1	Relate the basic concepts of chemistry to advanced chemistry concepts
CO2	Interpret the characteristics of bonds and the properties of elements
CO3	Apply the knowledge of stoichiometry in solving problems related to chemical reactions
CO4	Identify the physical states of matter based on their properties
CO5	Compare the periodic properties of elements in periodic table

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	1	2		-	-	-
CO2	2	2	1	2	-	-	-	-
CO3	2	2	1	1	-	-	-	-
CO4	2	1	1	2	-	-	-	-
CO5	2	1	1	2	-	-	-	-

Syllabus:

Atomic Structure and Stoichiometry: Review of Bohr's atomic model, Wave mechanical concept of the atom, De Broglie's Equation, Heisenberg's Uncertainty Principle, and Concept of Probability, Schrodinger Wave Equation, Probability Distribution of Electrons, Radial Probability Distribution, Angular Probability Distribution, Orbitals and quantum numbers. Revision of stoichiometry and mole concept (Definition and Numerical calculations), Chemical reactions and stoichiometric calculations.

Chemical Bonding: Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy, Madelung constant, Born-Haber cycle and its application, Solvation energy Covalent bond: Lewis structure, Valence Bond theory, hybridization, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules, Valence shell electron pair repulsion theory (VSEPR), Covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules and consequences of polarization, Ionic character in covalent compounds, Percentage ionic character from dipole moment and electronegativity difference, Qualitative idea of valence bond and band theories. Semiconductors and insulators, van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment.

Periodic Table - Periodicity of Elements: Brief discussion of the following properties of the elements, with reference to s & p-block and the trends shown, Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, Atomic and ionic radii, Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods, Electron gain enthalpy and

trends in groups and periods, Electronegativity, Pauling's/Mulliken's/ Allred Rochow's scales, Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity, Diagonal relationship, Inert pair effect.

Gaseous State: The gas laws, deviation of real gases from ideal behaviour (recapitulation)-compressibility factor (Z) van der Waals equation of state for real gases, discussion at different conditions and its limitation-other equations of state-Critical phenomenon, Andrew isotherms of CO_2 .van der Waals equation and critical state, derivation of relation between critical constants and van der Waals constants-critical compressibility factor-The law of corresponding states- liquefaction of gases.

Liquid state: Intermolecular forces, structural differences between solids, liquids and gases (recapitulation), Vacancy theory of liquids, free volume in a liquid, Physical properties of liquids- Vapor pressure, heat of vaporisation, vapor pressure vs temperature curves of some common liquids; surface tension, effect of temperature on surface tension and its determination using stalagmometer, parachor and heptachlor related to structural elucidation, Viscosity, viscosity coefficient, effect of temperature on viscosity and its determination using Ostwald's viscometer, structure related to viscosity.

Solid State: Classification of crystalline solids (recapitulation), Laws of crystallography-i. Law of constancy of interfacial angles ii. Law of symmetry-symmetry elements in crystals iii. Law of rationality of indices or intercepts, structure of crystals-space lattice, unit cell, Bravais lattices and seven crystal systems, description of orientation of lattice plane by its miller indices, band theory of solids, energy band theory of conductors, semiconductors and insulators

Learning Resources:

Text Books:

1. Concise Inorganic Chemistry, **J. D. Lee,** Wiley India, 2015, 5th Edition.
2. Unified Chemistry paper I and II, **O.P. Agarwal**, Jai Prakash Nath Publications, 2019, 3rd Edition.

Reference Books:

1. A textbook of Physical Chemistry, **K.L. Kapoor** Macmillan Publisher, 2019, Volume 1, 6th Edition.
2. Inorganic Chemistry: Principle of structure and reactivity, **Huheey, J. H.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K.**, Pearson Education India, 2006, 4th Edition.
3. Principles of physical chemistry, **Samuel H. Maron and Carl F. Prutton**, Oxford & IBH Publishing, 2017, 4th Edition.
4. TextBook of Physical Chemistry, **Puri, Sharma, Pathania**, Vishal Publishing Co. 2020, 48th Edition.

Course Code EEI131	BASIC ELECTRICAL ENGINEERING	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Analyze electric and magnetic circuits.
CO2	Identify the type of electrical machines for a given application.
CO3	Understand the ratings of electrical apparatus.
CO4	Identify meters for measuring electrical quantities

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2				
CO2	3	3	2	2				
CO3	3	3	2	2				
CO4	3	3	2	2				

Syllabus:

DC Circuits: Kirchhoff's Voltage and Current Laws, Superposition Theorem, Star-Delta transformations.

AC Circuits: Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of 1-phase series & parallel circuits.

Magnetic Circuits: Fundamentals and solution of Magnetic circuits, Concepts of self and mutual Inductances, Coefficient of coupling.

Single Phase Transformers: Principle of Operation, EMF equation, Phasor diagram, Equivalent circuit, determination of equivalent circuit parameters, calculation of Regulation & Efficiency.

DC Machines: Principle of operation, Classification, EMF and Torque Equations, Characteristics of Generators and Motors. Speed control methods.

AC Machines: 3-Phase Induction Motor- Principle of Operation, Torque – Speed characteristics, Slip-ring Induction motor, Introduction to synchronous machine (qualitative), applications of electrical machines.

Electrical Measuring Instruments: Moving Coil & Moving iron ammeters & voltmeters. Wattmeter, Digital multi meter (qualitative).

Electric Heating: Principles of resistance heating, induction heating and dielectric heating. (Qualitative).

Learning Resources:

Text Book:

1. Electrical & Electronic Technology, **Edward Hughes**, Pearson Education, 2016, 12th Edition.
2. Electrical Engineering Fundamentals, **Vincent Del Toro**, Pearson Education, 2015, 2nd Edition.
3. Electrical Machinery - Theory, Performance & Applications, **P.S. Bimhbra**, Khanna Publishers 2014, 7th edition.
4. Basic Electrical Engineering, **V N Mittle and Arvind Mittal**, Tata McGraw Hill, 2005, 2nd Edition.

Reference Books:

1. Basic Electrical Engineering, **U Bakshi & A. Bakshi**, Technical Publications, 2019, 2019-Edition.
2. Principals of Electrical & Electronics Engineering, **V. K Mehtha**, S. Chand Publications, New Delhi, 2010, 3rd Edition.
3. Electrical Machines, **A Fitzgerald, Charles Kingsley, Stephen Umans**, McGraw Hill Education, 2017, 6th edition.
4. Electric Machinery, **Stephen. J. Chapman**, McGraw Hill International Edition, 2017, 4th edition.

Online Resources:

1. https://nptel.ac.in/courses/108/108/108108076/

Course Code: HSI131	COMMUNICATIVE ENGLISH - I	Credits 2-0-2:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Infer explicit and implicit meaning of a given text
CO2	Build grammatically correct sentences using a variety of sentence structures and appropriate vocabulary
CO3	Demonstrate use of English speech sounds, stress and intonation in day-to-day situations/conversations/interactions
CO4	Develop active listening skills and strategies
CO5	Compose cohesive and coherent paragraphs, emails, and letters

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	1	--	-	-	-
CO2	2	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	2	2	2	1	-	-	-	-
CO5	2	2	2	1	-	-	-	-

Syllabus:

a) **Listening (Lab):** Types of listening- attentive, selective, pleasure; barriers to listening; effective listening strategies- Listening to motivational speeches.
b) **Speaking (Lab):** Ice-Breaking Activity, Introducing self and others
c) **Reading:** Intensive Reading Vs Extensive Reading, short stories, skimming
d) and scanning
e) **Writing:** Structure of a paragraph and types of paragraphs- descriptive, argumentative, narrative, expository, persuasive- writing self- profiles, writing prompts
f) **Grammar & Vocabulary:** Phrasal verbs, Verbs, Tenses (Present, Past & Future),
g) **Phonetics-Pronunciation:** Introduction to speech sounds -Vowels and Consonants
h) **(Lab)**

a) **Listening (Lab):** Short structured talks on specific topics. Task based listening activities.
b) **Speaking:** JAM Session- Hypothetical Situations, features of good conversation,
c) situational dialogues, greetings, taking leave, making requests and seeking permissions, role play, discussion in pairs/ small groups on specific topics
d) **Reading:** Reading for global comprehension, summarizing, paraphrasing- skimming-
   a. scanning
e) **Writing:** Interpreting visual information, predicting, advanced features of good writing – use of cohesive devices and connectives, use of discourse markers.
f) **Grammar & Vocabulary:** Nouns, Pre- fixes and suffixes, vocabulary building.
g) **Phonetics-pronunciation (Lab):** Intonation- errors in pronunciation, influence of Mother Tongue (MTI), common Indian variants in pronunciation- differences in British and American pronunciation

a) **Listening:** Listening to motivational videos (Steve Jobs, Mark Zukerberg, renowned
b) scientists- Einstein, C V Raman, Marie Curie, Grigori Perelman, Jennifer A. Doudna etc, Ted Talks) Listening for specific details. Listening Comprehension Tests. (Task based group activity)
c) **Speaking:** Telephone Etiquette, non-verbal communication, how to make effective formal presentations.
d) **Reading:** Identifying sequence of ideas; recognizing verbal techniques.
e) **Writing:** Official letter writing, e- mail etiquette, cover letter & resume writing- types- drafting e- resumes
f) **Grammar & Vocabulary:** Idioms and Phrasal Verbs, Synonyms & Antonyms, technical vocabulary
g) **Phonetics-Pronunciation(Lab):** Structure of syllables, word stress and rhythm, weak forms and strong forms in context, basic rules of word accent, stress shift

Learning Resources:

Text Books:

1. Infotech English, Maruthi Publications, Guntur, 2019
2. **Bailey, Stephen.** *Academic writing: A handbook for international students*. Routledge, 2014.

References:

1. **Raymond Murphy**, *Murphy's English Grammar,* Cambridge University Press 2004
2. **Meenakshi Raman, Sangeeta Sharma**, *Technical Communication: English Skills for Engineers*, Oxford University Press, 2009
3. **Michael Swan,** *Practical English Usage,* Oxford University Press, 1996
4. **Chase, Becky Tarver.** *Pathways: Listening, Speaking and Critical Thinking.* Heinley ELT; 2nd Edition, 2018.
5. **Louis Rogers, Skillful Level 2** Reading & Writing Student's Book Pack (B1) Macmillan Educational, 2013.
6. **Hewings, Martin.** *Cambridge Academic English (B2)*. CUP, 2012.

Online Resources:

1. www.enchantedlearning.com
2. https://www.englisch-hilfen.de/en/
3. https://www.bbc.co.uk/learningenglish/
4. https://in.usembassy.gov/education-culture/american-spaces/american-space-new-delhi/collection/

Course Code: HSI132	SANSKRIT	Credits: 3-0-0:3

Pre-Requisites: none

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

CO1	Familiar with Sanskrit language and its classical literature
CO2	Understand the structure of the verb forms in Sanskrit
CO3	Understand how Sanskrit as a language has a deep connection with our saṁskṛt
CO4	Appreciate the richness of our culture by way of teaching it apropos

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	2	2	-	--	-	-	-
CO2	1	2	2	-	-	-	-	-
CO3	2	2	2	-	-	-	-	-
CO4	1	2	2	-	-	-	-	-

Introduction to Sanskrit language, Devanagari script and Sanskrit alphabet. Vowels and consonants, pronunciation, classification of consonants, saṁyuktākṣaras (conjunct letters), introduction to śabdas of all the three genders, Ac-sandhis and hal-sandhis

Introduction to the verbs (of both ātmanēpadam and parasmaipadam) in 5 lakārams, tenses, voices, sarvanāma-śabdas, and usage of all the declensions

Introduction to Sanskrit Literature, Kathāmukham of Pañcatantram, and some subhāṣitams

Introduction to Kālidāsa, Meghadūtam - (English translation -Colonel H A Ouvry), verses form VālmīkiRāmāyaṇa and Bhagavatgītā

Learning Resources:

Text Books:
1) Saṃskṛtasvādhyāyaḥ - Published by Rashtriya Samskrita Samsthanam - New Delhi.
2) Abhyāsapustakam - Published by Samskrita Bharati –Bangalore.

Reference Books:
1) Samanvitha Sanskrit 1 - Published by Central Institute of Indian Languages – Mysore.
2) Surasaraswatisabha publications – Sringeri/ Bangalore.

Course Code PHI102	MECHANICS, WAVES AND OSCILLATIONS LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: none

Course Outcomes:

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

CO1	Measure different physical constants by simple and compound pendulum.
CO2	Measure the different modulus of the materials.
CO3	Study the different oscillations such as simple harmonic damped oscillations.
CO4	Measure moment of inertia of different objects.
CO5	Measure surface tension of different liquids.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	--	--	-	-
CO2	3	3	3	2	-	-	-	-
CO3	3	3	3	2	-	-	-	-
CO4	2	3	3	2	-	-	-	-
CO5	2	3	3	2	-	-	-	

List of Experiments:

1. Determination of “g” by simple and compound pendulum.
2. Moment of Inertia of a fly wheel.
3. Determine surface tension of a liquid through capillary rise method.
4. Determination of rigidity moduli by torsion Pendulum.
5. Study of Oscillations under bifilar suspension
6. Observation of Lissajous figures from CRO.
7. Velocity of transverse wave along a stretched string.
8. Study of damping of a bar pendulum.
9. Study of coupled oscillator.
10. Maxwell wheel for the verification of conservation of energy.
11. Determination of the shear modulus of steel, copper, aluminum and brass.
12. Determination of the centrifugal force as a function of the mass.

Learning Resources:

Text Books:

1. Physics Department Manual, NIT Warangal,2021
2. Advanced Practical Physics, **S.P. Singh**, Pragati Prakashan, Anu books, Meerut ,2019.

Reference books:

1. Practical Physics, R.**K Shukla, Anchal Srivastava**, New Age International Private Limited, 2008.
2. Berkeley Physics Course. Vol.1, Mechanics, **C. Kittel, W. Knight, M.A. Ruderman** - Tata-McGraw, 5th Edition 2008.

Online resources:

1. https://www.phywe.com/physics/thermodynamics/
2. https://vlab.amrita.edu/index.php?sub=1&brch=74

Course Code: CYI102	GENERAL CHEMISTRY LABORATORY-I	Credits 0-0-3:1.5

Pre-Requisites: none

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

CO1	Acquire hands on experience in experimental measurement of physical quantities and in the semi micro analysis of mixture of cations and anions
CO2	Interpret the chemistry involved in the separation and identification of individual cations and anions in a mixture
CO3	Analyse the influence of interfering ions on identification of ions
CO4	Determine basic characteristics of liquids experimentally
CO5	Verify laws and theories of electrolytes experimentally using concepts of electrochemistry

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	2		-	1	-
CO2	2	2	2	1		-	-	-
CO3	2	2	2	2		-	-	-
CO4	2	2	1	2		-	-	-
CO5	2	1	2	1		-	-	-

Syllabus:

1. Demonstration and concept of good lab practices including safety, glassware handling, chemical nature understanding, chemical handling, chemical /glassware waste management, Error Analysis, notebook maintenance.
2. **Qualitative analysis:**
3. Semi micro analysis of mixtures and Group separation of cations
4. Anions : Nitrate (NO_3^-), Sulfate (SO_4^{2-}), Nitrite (NO_2^-), Chloride (Cl-), Bromide (Br−), Iodide (I-Acetate (CH_3COO^-), Carbonate (CO_3^{2-}), Sulphide (S^{2-}), Bromate (BrO_3^-), Iodate (IO_3^-), Phosphate (PO_4^{3-}). Cation: Silver (Ag^+), Potassium (K^+), Sodium (Na^+), Lead (Pb^{2+}), Copper (Cu^{2+}), Cadmium (Cd^{2+}), Tin (Sn^{2+}), Iron (Fe^{3+}), Chromium (Cr^{3+}), Cobalt (Co^{3+}), Nickel (Ni^{2+}), Manganese (Mn^{2+}), Zinc (Zn^{2+}), Barium (Ba^{2+}), Strontium (Sr^{2+}), Calcium (Ca^{2+}), Ammonium (NH_4^+).
5. Qualitative analysis of mixture of inorganic substances containing six radicals (interfering acid radicals like phosphate, fluoride and mixture of acid radicals like carbonate, sulfite, sulfide, nitrate, chloride, bromide, phosphate, arsenate, nitrate, iodate and sulfate)
6. To study the variation of conductance of i. strong electrolyte (ex. KCl) ii. Weak electrolyte (ex. CH_3COOH) with concentration and to verify DHO equation
7. Verification of Kohlrausch's Law (Determination of eq. conductivity of a weak electrolyte at infinite dilution).
8. Determination of the specific and molar conductance, degree of dissociation and dissociation constant of a weak acid and to verify the Ostwald's dilution law for a given weak electrolyte.
9. Determination of molecular weight of given volatile organic liquid by using ideal gas equation.

10. Determination of relative surface tension of a liquid with respect to water at room temperature by stalagmometer.
11. To determine the surface tension of methyl alcohol, ethyl alcohol and n-hexane at room temperature and also calculate the atomic parachors of C, H and Oxygen
12. Determination of relative viscosity of a given liquid with respect to water at room temperature by Ostwald's viscometer.

Learning Resources:

Text Books:

1. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, **G. Sevhla,** Longman Inc., 1979, 5th edition.
2. Physical Chemistry Laboratory Manual by Department of Chemistry, NITW.

Reference Books:

1. Experiments in Physical chemistry, **Shoemaker D.P., Garland C.W. and Nibler J.W.** McGraw Hill, 2008, 8th edition.
2. Advanced Practical Physical Chemistry, **J.B. Yadav**, Krishna's Educational Publishers, 2019, 38th Edition

Course Code: IC001	INDUCTION PROGRAM	Credits 0-0-0:0

Induction program for students to be offered right at the start of the first year.

Course Outcomes:

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

CO1	Identify the ethos and culture of the Institution
CO2	Practice professional discipline
CO3	Understand outcome based and education and the role of students
CO4	Develop any creative art or skill

Syllabus:

- **Assimilation of the ethos and culture of the institution**
  - Institutional Culture and Practices
- **Exposure to larger vision of life**
  - Based on large human good
- **Bonding**
  - Within the students and with teachers
- **Learning a creative arts / skill**
  - Painting, Sculpture, Dance, Music Production, Self-Defence, Clay modelling…
- **Regular life style and professional discipline**
  - Getting up early, sleeping on time, getting acclimatized to new place
- **Overcoming weakness in some essential professional skills (optional)**
  - Mathematics and English proficiency classes/sessions
- **Outcome based education:**
  - Introduction to OBE, Role of students

Activities/ Content of the Program

- Physical activity
- Creative Arts
- Universal Human Values
- Literary
- Proficiency Modules
- Lectures by Eminent People
- Visits to local Areas
- Familiarization to Dept./Branch & Innovations

Course Code: IC101	EXTRA ACADEMIC ACTIVITY - I	Credits 0-0-2:0

Course Outcomes:

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

CO1	Develop the attitude of sportsmanship, fairness and team spirit
CO2	Demonstrate good health, comradeship and spirit of healthy competition
CO3	Positive and deep impact on the holistic development of the personality
CO4	Improve productivity and foster social harmony
CO5	Spread a strong message of peace, friendship and understanding among the people
CO6	Develop enthusiasm and inspiration, progress and prosperity of the nation

Activities/Content of the Program

- Introduction to Physical Education
- Physical Fitness& Wellness Lifestyle
- Training Methods in Physical Education
- Test & Measurements
- Formal Activities
- Training and practice in Sports and games based on one's own interest
- Conducting Intramurals, Extramural Competition/Open Tournaments

I YEAR II SEMESTER

Course Code: MAI151	ORDINARY DIFFERENTIAL EQUATIONS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Test the plausibility of a solution to a differential equation which models a physical situation.
CO2	Understand situations involving exponential growth or decay and second order physical systems
CO3	Understand existence and uniqueness of solutions
CO4	Solve homogeneous and non-homogeneous linear differential equations with constant coefficients
CO5	Solve second order linear differential equations with variable coefficients

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	2	-	-	-	-
CO5	3	2	2	2	-	-	-	-

Syllabus:

Differential Equations of first order: Linear Vs. Nonlinear Equations; Homogeneous Differential Equations, Differential Equations Reducible to Homogeneous Form - Exact differential equations, Integrating Factors - Linear equation, Reducible to Linear Form: Bernoulli's equations, Total Differential Equations. Existence and uniqueness of solutions (statement only); equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type; Applications: Newton's law of cooling, Law of natural growth and decay, orthogonal trajectories.

Differential Equations of Higher Order: Solution of homogeneous linear differential equations with constant coefficients, Solution of Non-homogeneous linear differential equations with constant coefficients, Legendre's equation, Cauchy-Euler equation;
Second order linear differential equations with variable coefficients by the following methods: (i) complementary function is given, (ii) reducing to normal form, (iii) change of independent variable (iv) variation of parameters

Learning Resources:

Text Books:

1. Differential Equations, **Bronson Richard,** Schaum Series, 4/e 3rd Edition, 2010,
2. Differential Equations with Applications and Historical Notes, **George F. Simmons,** McGraw-Hill, 2nd Edition, 2003.
3. Elementary differential equations and boundary value problems, **William E. Boyce and Richard C. Diprima**, Wiley, 2009.

Reference Books:

1. Ordinary and Partial Differential Equations, **M.D. Rai Singhania,** S. Chand and Co., 2019.
2. Ordinary Differential Equations, **Morris Tenenbaum and Harry Pollard**, Dover Publications, 1985.

Course Code: PHI151	HEAT AND THERMODYNAMICS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Gain knowledge in Kinetic theory of gases.
CO2	Understand the nature of thermodynamic properties of matter like internal energy, enthalpy, entropy, temperature, pressure and specific volume.
CO3	Understand the significance of first law and second of thermodynamics and their applications.
CO4	Understand the process of thermal conductivity, viscosity and diffusion in gases.
CO5	Understand the interrelationship between thermodynamic functions and ability to use such relationships to solve practical problems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	--			
CO2	3	3	3	2	-			
CO3	3	2	2	2	-			
CO4	3	3	3	2				
CO5	3	3	2	2				

Syllabus:

Introduction to thermodynamic system, Zeroth law of thermodynamics, isothermal and adiabatic processes, indicator diagram–reversible and irreversible processes, Carnot's engine, Carnot's theorem, Second law of thermodynamics, Entropy, entropy measurement, entropy and disorder, entropy of universe, temperature entropy diagram.

Thermodynamic potentials – Maxwell's relations– Gibb's Helmholtz equation– importance Clausius Clapeyron equation, Stefan Boltzmann's law, ratio of specific heats, difference of two specific heats for a perfect gas, Joule Kelvin effect and its expression, Joule Kelvin effect for perfect gas and van der wall's gas. First order and second order phase transitions,
Different methods of liquification's of gases, liquefaction of air by Linde's and Claude's methods, production of low temperatures, adiabatic demagnetization, refrigeration, working of vapor compression machine and vapor absorption machine.

Black body radiation, Stefan's law, distribution of energy in black body spectrum, statement of Wein's and Rayleigh-Jean's Law. Plank's quantum theory of radiation, derivation of Plank's Law. Wien's and Rayleigh-Jean's Law from Plank's radiation law.

Maxwell Boltzmann distribution law, Application to an ideal gas, MB distribution law of molecular speeds, mean speed, rms speed and most probable speed of a molecule, relation between them, quantum statistics, Bose Einstein distribution law, energy distribution of photon gas, Fermi Dirac distribution law, Fermi energy of electron gas.

Learning Resources:

Text books:

1. Heat and Thermodynamics, **Brij Lal, N. Subrahmanyam, P.S. Hemne** , S Chand &co, 4th edition,2001.
2. Heat and Thermodynamics by **Mark W. Zemansky**, Mc Graw Hill,5th edn,2017.

Reference books:

1. Fundamentals of Thermodynamics by **Claus Borgnakke**, Wiley publisher,2020.
2. Principles of Thermodynamics, **Jean-philippe ansermet, Sylvain d. Brechet**, Cambridge University Press,2019
3. Thermal Physics, **Robert F. Sekerka**, Elsevier, 2015.

Online resources

1. https://onlinecourses.nptel.ac.in/noc20_ce27/preview
2. https://onlinecourses.nptel.ac.in/noc21_me35/preview

Course Code: CYI151	GENERAL CHEMISTRY-II	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand concepts of hybridization, bonding and physical properties of organic compounds
CO2	Identify the type of intermediates formed in the sequence of organic reactions and their stability
CO3	Interpret the distribution of solute between two immiscible solvents
CO4	Utilize the concept of physical organic chemistry in organic reactions for understanding the synthesis and reactivity of various functional groups
CO5	Apply phase rule to different systems for isolating the components
CO6	Apply the concepts of colloids and adsorption in commercially viable technologies

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	2	-	-		-
CO2	2	2	2	1	-	-		
CO3	2	2	1	1	-	-		
CO4	3	2	1	2		-		
CO5	2	2	1	2	-	-		
CO6	2	2	2	2	-	-		

Syllabus:

Bonding and physical properties of organic molecules: Atoms, molecules, bonding, polar and nonpolar molecules, intermolecular forces, solubility, Nomenclature of simple organic compounds (acyclic, cyclic). Concept of hybridization, resonance, orbital pictures of bonding (sp3, sp2, sp, C-C, C-N & C-O system). Inductive effect, bond polarization, and polarizability, steric inhibition of resonance. Hückel's rules for aromaticity & anti-aromaticity, homo-aromaticity. Physical properties of bond distance, bond angles, mp/bp & dipole moment in terms of structure and bonding. Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity.

Basic reaction mechanism and intermediates: Mechanism classifications - ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism. Reactive intermediates: carbocation (carbenium and carbonium ions), carbanions, carbon radicals, carbenes, nitrenes-structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate (elementary idea)

Nature of reaction energy and kinetic considerations: Chemical kinetics, equilibria and energetics of reactions Thermodynamics, kinetics, enthalpy, entropy, free energy, exergonic and endergonic reactions Isotopic effect, Linear free energy relationships-Hammett equation (substitution constant and reaction constant), Taft treatment of polar effects in aliphatic compounds, Curtin-Hammett principle, catalysis and principle of microscopic reversibility.

Chemistry of organic functional groups: Alkanes, olefins, alkynes, halides, alcohols, phenols, ketones, aldehydes, carboxylic acids, ethers, derivatives of carboxylic acids, amines, nitro, azo and cyano compounds; synthesis and basic reactivity with mechanisms.

Solutions: Types of solutions, concentration, solubility (recapitulation)- liquid-liquid mixtures (completely miscible liquids)- Raoult's law, Ideal and Non-ideal solutions, vapor pressure-composition diagrams, fractional distillation; Partially miscible liquids-Phenol-water system, Triethylamine-water system, nicotine-water system; completely immiscible liquid mixtures-Nernst's distribution law and its limitations, Applications of Nernst distribution law.

Phase rule: Phase, components, Degree of freedom, conditions for Equilibrium between phases, Gibbs Phase rule, Phase equilibria of one component system-water system, Phase equilibria of two component system-simple Eutectic-Pb-Ag system-desilverisation of lead.

Colloids and Surface Chemistry: Definition, classification, Properties of colloids-kinetic, optical and electrical properties (recapitulation)-solid in liquids (sols)-preparation, protective action-gold number, liquids in liquids (emulsions), types, preparation, emulsifier; liquid in solids (gel), classification, preparation and properties; applications of colloids, Micelles (surfactants) and reverse micelles: Definition, classification, mechanism of their formation, cleaning action of soap, critical micelle concentration and factors affecting it. **Surface chemistry**: Adsorption and its types, factors influencing adsorption (**recapitulation**) Freundlich adsorption isotherm, Langmuir theory of unilayer adsorption isotherm, applications.

Learning Resources:

Text Books:

1. Unified Chemistry paper I and II, **O.P. Agarwal,** Jai Prakash Nath Publications, 2019, 3rd edition.
2. Organic Chemistry, **R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee**, 7th Edition, Pearson Education.

Reference Books:

1. Principles of physical chemistry, **Samuel H. Maron and Carl F. Prutton**, Oxford & IBH Publishing, 2017, 4th edition
2. A textbook of Physical Chemistry, **K.L. Kapoor** Macmillan Publisher India Limited, 2020 Volume 3, 5th edition.
3. Organic Chemistry, **T. W. Graham Solomons and C. B. Fryhle**, Wiley, 10th edition,.
4. Organic Chemistry**, I. L. Finar,** Vol-1, Pearson Education, 6th edition
5. Stereochemistry of Organic Compounds**, E. L. Eliel and S. H. Wilen**, Wiley.

Course Code: HSI181	COMMUNICATIVE ENGLISH - II	Credits 2-0-2:3

Pre-Requisites: NIL

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

CO1	Select appropriate listening and reading strategies to meet the academic and professional needs.
CO2	Acquire proficiency in oral and written communication
CO3	Apply various techniques for effective oral presentations and group discussions.
CO4	Demonstrate neutral accent while speaking, avoiding vernacular influence.
CO5	Draft well-structured reports, SOPs, reviews, and conference abstracts

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	1	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

a) **Listening (Lab): Listening** for global comprehension and summarizing
b) **Speaking (Lab)**: Discussing specific topics in pairs (or) small groups and reporting the discussion, complaining, apologizing.
c) **Reading:** Reading between the lines, Critical reading for evaluation.
d) **Writing:** SWOT Description and Analysis, Writing SOP, Letters for Internship/Fellowship.
e) **Grammar & Vocabulary:** Concord: Subject-Verb Agreement, Correction of sentence

a) **Listening (Lab):** Making predictions while listening to conversations (or) transactional dialogues.
b) **Speaking (Lab):** Role plays for practice of conversational English in academic contexts (formal and informal).
c) **Reading:** Intensive reading Vs extensive reading, reading biographies, magazines, books –fiction, non- fiction; skimming, scanning.
d) **Writing:** Writing reviews (books, biographies, short stories etc, writing technical reports- structure- feature- types- format and style
e) **Grammar & Vocabulary:** Gender inclusive language (gendered noun, gender-
f) neutral noun), quantifying expressions, adjectives, adverbs, degrees of comparison, advanced vocabulary, scientific vocabulary.

a) **Listening (Lab):** Identifying key terms, understanding concepts, interpreting the concepts
b) **Speaking (Lab):** Formal oral presentations on topics from academic contexts- prerequisites of a group discussion.

c) **Reading:** Reading comprehension, The RAP strategy for in depth reading, intensive reading and extensive reading
d) **Writing:** Writing conference abstracts, image description, poster presentation
e) **Grammar & Vocabulary:** Reported speech, reporting verbs for academic purposes, correction of sentences, vocabulary and scientific vocabulary.

Learning Resources:

Text Books:

1. Infotech English, Maruthi Publications, Guntur, 2019.
2. **Bailey, Stephen.** *Academic writing: A handbook for international students*. Routledge, 2014.

References:

1. **Raymond Murphy,** *Murphy's English Grammar,* Cambridge University Press 2004
2. **Meenakshi Raman, Sangeeta Sharma**, *Technical Communication: English Skills for Engineers*, Oxford University Press, 2009
3. **Michael Swan**, *Practical English Usage,* Oxford University Press, 1996
4. **Chase, Becky Tarver.** *Pathways: Listening, Speaking and Critical Thinking.* Heinley ELT; 2nd Edition, 2018.
5. **Louis Rogers**, Skillful Level 2 Reading & Writing Student's Book Pack (B1) Macmillan Educational, 2013.
6. **Hewings, Martin.** *Cambridge Academic English (B2)*. CUP, 2012.

Online Resources:

1. www.enchantedlearning.com
2. https://www.englisch-hilfen.de/en/
3. https://www.bbc.co.uk/learningenglish/
4. https://in.usembassy.gov/education-culture/american-spaces/american-space-new-delhi/collection/
5. https://www.talkenglish.com/speaking/basics/speaking_basics_ii.aspx.

Course Code: SMI181	ORGANIZATIONAL STRUCTURES AND HUMAN RESOURCE MANAGEMENT	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Understand organization structures and their implications
CO2	Plan and manage key human resource functions within organizations
CO3	Understand and apply the knowledge of behavioural dynamics for increased effectiveness
CO4	Analyse current trends and practices in HRM

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	1	--	-	-	-
CO2	2	2	2	2	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	1	2	2	1	-	-	-	-

Syllabus:

Organizations and Organization Theory; Organizational purpose and structural design – Fundamentals of organization structure; Types of organization structure; Organizational culture: Concept, characteristics, elements of culture, creating and sustaining organizational culture.

Human Resource Management- Concept, nature, scope, and objectives; Human resource planning - determining the demand for workforce, predicting the future supply; Job analysis and Job design.

Functions of HRM - Recruitment and selection, Training and Development- Methods and Evaluation of Training; Career Development and planning; Performance Appraisal- Methods, Performance Management, Compensation. Industrial relations – Trade unions, Collective bargaining.

Understanding individual behaviour, Leadership, Motivation, Teams & Team work, Contemporary trends in HRM: Diversity Management, Employee Engagement, HR analytics, Digital HRM, Green HRM

Learning Resources

Text Books:

1. Human Resource Management, **Dessler, G., & Varkkey ,B**. India: Pearson Education, 2020, 16th edition.
2. Organization Theory and Design, **Richard D.** Daft, Cengage Learning, 2019, 13th edition.

Reference Books:

1. Essentials of Management, **Harold Kooritz & Heinz Weihrich**,Tata McGraw-Hill, 2015

2. Organizational Behavior, **Robbins, Stephen, & Sanghi, S**, Pearson Education, 2019, 18th edition.
3. Organizational Behaviour, **Luthans, F,** McGraw Hill, 2018.
4. Human Resource Management, **Bohlander George W, Snell Scott A, Veena Vohra,** Cengage Learning, 2015.

Online Resources:

1. www.shrm.com
2. www.hrkatha.com
3. www.nationalhrd.com
4. www.nipm.com
5. www.istdindia.org

Course Code: MAI152	ORDINARY DIFFERENTIAL EQUATIONS USING SYMPY LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: none

Course Outcomes:

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

CO1	Acquire proficiency in using Symbolic Python (Sympy) to study Differential Equations
CO2	Demonstrate the use of Sympy to understand and interpret the core concepts in Differential Equations
CO3	Find general and particular solutions of first and second order Differential Equations and to sketch the graph for solutions
CO4	Apply Sympy to learn applications of Differential Equations from real world

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	2	-	-	-	-

Syllabus:

- Introduction to Python, basic concepts, Arithmetic, parentheses and rounding errors, variables and objects,
- Formatting text and numbers, arrays, input data, symbolic computations
- 2D and 3D Plotting
- Algebra Symbolic math with Sympy
- Visualize data with graphs using Sympy.
- Differentiation and integration using Sympy
- Verifying whether the given curves are solutions to the differential equations.
- General solution of a first order differential equation and plotting the solutions
- Applications of First Order Differential Equations
- Sketch Orthogonal Trajectories.
- To solve the initial value problems and sketch the solution curve.
- General solution of a second order differential equation and plotting the solutions
- To solve the boundary value problems and sketch the solution curve.

Course Code: PHI152	HEAT AND THERMODYNAMICS LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: none

Course Outcomes:

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

CO1	Understands different heat transfer mechanisms.
CO2	Learn to measure the thermal conductivity metals, glasses.
CO3	Learn to measure the molar heat capacities of air.
CO4	Understands to black body radiation
CO5	Understand Seebeck, Joule-Thomson and Peltier effect.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	3	1	--			
CO2	3	2	2	2	-			
CO3	2	2	3	2	-			
CO4	2	3	2	1				
CO5	2	3	3	2				

List of Experiments:

1.Study of Thermal conduction of solid bodies (metals and glasses).
2.Determination of Thermal conductivity of metals (Wiedmann-Franz law).
3.Study of phase changes of materials.
4.Determination of adiabatic coefficient of various gases.
5.Determination of specific heat of water.
6.Determine the molar heat capacities of air at constant volume C_v and at constant pressure C_p.
7.Determination of the Joule-Thomson coefficient of N_2 and CO_2.
8.Study of Peltier effect (a) cooling engine, (b) heat pump
9.Black Body Radiation: Determination of Stefan's Constant.
10.Verification of Newton's Law of Cooling.
11.Coefficient of thermal conductivity of a bad conductor using Lee's disc apparatus.
12.Study of Stirling engine working.

Learning Resources:

Text Books:

1. Heat and Thermodynamics Lab Manual, Department of Physics, NITW,2021
2. Advanced Practical Physics, **S.P. Singh**, Pragati Prakashan, Anu books, Meerut, 2019.

Reference books:

1. Practical Physics, **R.K Shukla**, Anchal Srivastava, New Age International Private Limited,2008.

Web resources:

1. https://www.phywe.com/physics/thermodynamics/
2. https://vlab.amrita.edu/index.php?sub=1&brch=194

Course Code: CYI152	GENERAL CHEMISTRY LABORATORY-II	Credits 0-0-3:1.5

Pre-Requisites: none

Course Outcomes:

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

CO1	Understand the effect of impurity on Critical Solution Temperature, Eutectic temperature and molecular weight
CO2	Understand the organic chemistry laboratory safety protocols and physical constant of organic compounds
CO3	Develop the skill in obtaining data and to verify the adsorption isotherm for adsorption processes.
CO4	Apply the concept of Nernst distribution law to understand the distribution of a solute in two immiscible liquids
CO5	Apply various purification methods in the separation of organic mixtures
CO6	Apply various chromatographic methods in the separation if organic compounds

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	1	2	-	-		
CO2	2	1	1	2		-		
CO3	2	1	1	1	-	-		
CO4	2	1	2	1	-	-		
CO5	2	2	1	2	-	-		
CO6	2	2	1	2	-	-		

Syllabus:

1. Determination of critical solution temperature of phenol-water system.
2. To study the effect of impurities (sodium chloride and succinic acid) on the critical solution temperature of phenol-water system
3. To study the distribution of acetic acid between water and cyclohexane
4. To study the distribution of benzoic acid between water and cyclohexane
5. To obtain Equilibrium phase diagram to determine eutectic point
6. To determine the Enthalpy of neutralization and Enthalpy of ionization of Weak Acid and Weak Base
7. Verification of Freundlich's Adsorption isotherm for the adsorption of acetic acid on charcoal
8. General instructions: Laboratory safety for organic chemistry, handling the chemicals and glassware, importance of materials safety data sheets
9. Physical constants of organic compounds: Study of polarity, melting point, boiling points, density, viscosity, and other physical parameters
10. Purification Methods of Organic Compounds: Distillation, Crystallization, Fractional crystallization, Sublimation
11. Distillation methods: Simple distillation, Vacuum, fractional and Steam distillation and Soxhlet extraction
12. Crystallization and Sublimation: Crystallization of single and mixture of compounds (solubility dependent), fractional crystallization of organic compounds, Sublimation of organic / inorganic compounds (Naphthalene, Camphor, $AlCl_3$, $ZnCl_2$)
13. Separation of Organic compounds by chromatographic methods: Paper and Thin layer

chromatography, Column chromatography (Single compound), Column chromatography (Mixture of compounds)

Learning Resources:

Text Books:

1. Physical Chemistry Laboratory Manual by **Amritha Anand, Ramesh Kumari**, Wiley distributors, Dreamtech Press, 2019
2. Physical Chemistry Laboratory Manual by Department of Chemistry, NITW.
3. Practical Organic Chemistry-**G. Mann & B.C Saunders**, ELBS Edition and Longman Group Limited, 2002

Reference Books:

1. Advanced Practical Physical Chemistry **J.B. Yadav**, Krishna's Educational Publishers, 2019, 38th Edition
2. Text Book of Practical Organic Chemistry, **Vogel A.I.,** ELBS, 2004, 5th Edition

Course Code: IC151	EXTRA AVADEMIC ACTIVITY-II	Credits 0-0-2:0

Course Outcomes:

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

CO1	Develop the attitude of sportsmanship, fairness and team spirit
CO2	Demonstrate good health, comradeship and spirit of healthy competition
CO3	Positive and deep impact on the holistic development of the personality
CO4	Improve productivity and foster social harmony
CO5	Spread a strong message of peace, friendship and understanding among the people
CO6	Develop enthusiasm and inspiration, progress and prosperity of the nation

Activities/ Content of the Program

- Health Education &Personal Hygiene
- Nutrition and Balanced Diet.
- First Aid & Injury Management
- Human Posture
- Yoga
- Self Defense
- Training and practice in Sports and games based on one's own interest
- Conducting Intramurals, Extramural Competition/Open Tournaments

II year I semester

Course Code: MAI201	MODERN ALGEBRA	Credits 3-0-0:3

Pre-Requisites: none

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

CO1	Discover the binary operations as basic entities which give specific mathematical structures to a set
CO2	Understand the group structure and possible subgroups
CO3	Analyze the structure of rings and subrings
CO4	Classify the groups and rings using isomorphisms between the respective mathematical structures
CO5	Adapt with mathematical abstractness

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	2	-	-	-	-
CO5	3	2	2	2	-	-	-	-

Syllabus:
Groups: Binary operation, Definition and examples of Groups, preliminary lemmas; dihedral groups, symmetric groups, the quaternion group as special examples;
Subgroups - Abelian and non-Abelian groups, Cyclic groups; Equivalence Relations and Partitions; Cosets, Lagrange's Theorem and its consequences on finite groups; a counting principle; Normal Subgroups and Quotient Groups; Centralizers, Normalizers, Centre of a group;

Mappings between Groups: Homomorphism between groups, kernel of a group, fibres of homomorphisms, isomorphism, fundamental theorem of isomorphism on groups; Automorphisms; Cayley's Theorem; Permutation groups;

Rings: Definition of rings and various examples; units & zero divisors of a ring; special classes of rings (viz., division ring, integral domain, field), characteristic of an integral domain; homomorphisms on rings; Ideals and Quotient rings;

Learning Resources:
Text Books:
1. Topics in Algebra, **I. N. Herstein**, Wiley, 1975, Second Edition
2. Abstract Algebra, **David S. Dummit & Richard M. Foote**, Wiley, 2004, Third Edition

Reference Books:
1. A Course in Abstract Algebra, **Vijay K. Khanna & S. K. Bhambri**, Vikas Publishing House, 2013, Fourth Edition
2. Contemporary Abstract Algebra, **Joseph A. Gallian**, Cengage Learning, 2013, Eight Edition
3. A First Course in Abstract Algebra, **John B. Fraleigh**, Pearson, 2013, Seventh Edition

Course Code: PHI201	OPTICS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand the concepts of geometrical optics, its construction and importance in optical instruments.
CO2	Understand and minimize the aberrations in lenses and its applications
CO3	Explain the physics of image formation based on the fundamental principles of optics
CO4	Analyze the intensity variation of light due to polarization, interference and diffraction.
CO5	Analyze the optical applications using the concepts of interference, diffraction and polarization.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	--			
CO2	3	2	2	2	-			
CO3	3	3	2	2	-			
CO4	3	2	2	2				
CO5	3	3	2	2				

Syllabus:

Geometric Optics : Optical path, Fermat's principle of Extreme path, applications, Law of reflection, refraction, cardinal points of an optical system, Image formation, Magnification, Cardinal points of a thick lens, focal length of a thick lens, Bi-convex lens, power of a thick lens, Telescopes types, advantages. Translation matrix, refraction matrix, system matrix for thick and thin lens, system matrix for two thin lenses. Dispersion by a prism, dispersive power, angular and chromatic dispersions.

Aberrations in lenses: Aberrations in lenses, Chromatic Aberration, Achromatic Combination of lenses, Monochromatic defects, Spherical aberration, Astigmatism, Coma, Curvature and Distortion, Minimizing aberration.

Interference Huygens's wave theory of light-Laws of reflection and refraction.- Division of amplitude and wave front; Phase change on reflection: Stokes' treatment; Interference in Thin Films: parallel and wedge-shaped films; Fringes of equal inclination (Hai dinger Fringes); Fringes of equal thickness (Fizeau Fringes); Michelson Interferometer– Application; Fabry-Perot interferometer.

Diffraction : Fresnel and Fraunhofer classes of diffraction, Fraunhofer diffraction at single ,double ,multiple slits and circular aperture. Diffraction grating- Determination of wavelength of light using diffraction grating (Normal incidence and Minimum deviation); Resolving power; Rayleigh's criterion –limits of resolution for telescopes and microscope, Zone plate-construction and its comparison with convex lens.

Polarization : Polarization of light; Malus law; polarization by reflection; Brewster's law; Analysis of linearly and circularly polarized light; Polarization by double refraction and Huygen's theory; Nicol prism, Half wave and Quarter wave plates; Optical activity and Fresnel's theory, laurents half shade polarimeter; Biquartz polarimeter.- Photo Elasticity-Polariscope.

Learning Resources:

Text Books:

1. Optics, **Ajoy Ghatak**, TMGHill,3rd edition,2015.
2. Fundamentals of Optics, **Francis Arthur Jenkins, Harvey Elliott White**, McGraw-Hill 5th edn,2018

Reference Books:

1. Optics **- Hecht and Zajak**; Addison-Wesley,3rd edition,2015.
2. Engineering Physics by **V. Rajendran**, Tata McGraw-Hill Education,2009.

Online Resources:

1. https://nptel.ac.in/courses/122/107/122107035/
2. https://isaacphysics.org/concepts/cp_diffraction
3. https://www.rp-photonics.com/

Course Code: CYI201	PHYSICAL CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: NIL

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

CO1	understand the differences among the colligative properties of solutions
CO2	Identify the unique vocabulary of thermodynamics for explaining the basic concepts associated with it
CO3	Apply the laws of thermodynamics to closed and open systems undergoing different thermodynamic processes and evaluate the feasibility of a thermodynamic cycle
CO4	Analyze the types of reactions and theories of reaction rates
CO5	Perceive the theories of ionization and electrochemistry for analysing electrochemical processes

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	1	-	-		-
CO2	2	1	2	2	-			-
CO3	2	1	1	1	-			-
CO4	2	2	2	1				-
CO5	2	1	1	2				-

Syllabus:

Dilute Solutions and Colligative Properties: Solutions; Colligative Properties: Lowering of Vapour Pressure: Roult's Law, Derivation and limitations, Osmotic Pressure: Osmosis, Reverse osmosis, isotonic solutions, Measurement of osmotic pressure, Van't Hoff theory for dilute solutions, relationship between osmotic pressure and lowering of vapour pressure; Elevation in Boiling Point: determination and, relationship with relative lowering of vapour pressure and with osmotic pressure; Depression in freezing point: determination, relationship with molality, Relationship with lowering of vapour pressure and with osmotic pressure. Molecular weight determination using the colligative properties. Abnormal behaviour of solutions: Van't Hoff factor, Degree of Association and Dissociation.

Thermodynamics: First Law of Thermodynamics: Enthalpy, Heat Capacity of a System, Relation between Cp and Cv. Joule-Thomson Effect, Work Done in Reversible and Irreversible Isothermal Expansion of an Ideal Gas and in Adiabatic Reversible Expansion, Thermochemistry: Heat of Reaction, Kirchoff's Equation, Laws of Thermochemistry, Bond Energy, Second Law of Thermodynamics: Spontaneous, Irreversible Process, The Carnot Cycle, The Concept of Entropy, Entropy Change in a Reversible and Irreversible Process, Entropy Change of Accompanying Phase Change, mixing, Work Function, Helmholtz Free Energy, Variations of Free Energy with Temperature and Pressure, Gibbs-Helmholtz Equations, Clausius-Clapeyron equation, Van't Hoff Isotherm, Van't Hoff Isochore.

Electrochemistry: Basics of Electrochemistry, conductance, Arrhenius theory of ionization of weak electrolytes and Ostwald's dilution law; Transport Numbers, Hittorf Method, Abnormal Transport Numbers, Kohlrausch Law of Independent Migration of Ions and ppplications, Conductometric Titrations. Theories of Ionization: Arrhenius Theory of Electrolytic Dissociation, Ostwald's Dilution Law, Debye-Huckel Theory of Strong Electrolytes, Interionic

Atmospheric Theory, Debye-Huckel-Onsagar Equation; Ionic Equilibria: Relative Strengths of Acids and Bases, Dissociation of Weak Acid and a weak Base, Dissociation of Water, Common Ion Effect, Isohydric Solutions, Buffer Solutions, Henderson Equation, Solubility Product; Hydrolysis of Salts, Indicators, Choice of Indicators; Electrochemical Cells and Electromotive Force: Electrochemical Cells, Representation of Electrochemical Cells, Single Electrode Potential, Electrochemical Series, Electrode Potentials, Cell Potentials, Reference Electrodes (Hydrogen Electrode, Calomel Electrode), Potentiometric Titrations.

4: Chemical Kinetics: Basics; First Order Reactions, 'Pseudo first order reactions-Hydrolysis of methyl acetate, inversion of cane sugar, problems. Second Order Reactions, Second order reaction-derivation of equation of rate constant, numerical problems, Methods of Determining Order of a Reaction, Effect of Temperature on Reaction Rates. Laws of Photochemistry, Quantum Efficiency or Quantum Yield, Photosensitization, Photo inhibitors. Theories of Reaction Rates: collision theory and transition state theory (mathematical treatment). Catalysis.

Learning Resources:

Text Books:

1. Unified Course in Chemistry-3, **O. P. Agarwal**, Jai Prakash Nath Publication, 2018.
2. Physical Chemistry: **G.M. Barrow** Tata McGraw-Hill Education, 2008, 6 th edition.
3. Principles of Physical Chemistry: **S. H. Maron, C. F. Prutton**, Macmillan, 1965, 4th edition.

Reference Books:

1. Physical Chemistry **P. Atkins and J. de Paula, W. H. Freeman**, 2006, 8th edition.
2. Chemical Kinetics and Reaction Dynamics, **S. K. Upadhyay**, Springer, Netherlands, 2006.
3. Electrochemical Methods: Fundamentals and Applications, **A.J. Bard and L.R. Faulkner**, Wiley, 2000, 2nd edition.
4. Physical Chemistry, **K. J. Laidler and J. H. Meiser**, Houghton Mifflin Company, Boston, 1999, 3rd edition.

Course Code MEI231	BASIC MECHANICAL SCIENCE	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand basics of thermodynamics and components of a thermal power plant
CO2	Identify engineering materials, their properties, manufacturing methods encountered in engineering practice
CO3	Understand mechanism of power transfer through belt, rope, chain and gear drives
CO4	Understand basics of manufacturing process, Automobile Engineering

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	2	2	1	--	-	-	-
CO2	1	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	1	2	2	1	-	-	-	-

Syllabus:

Engineering Materials: Introduction to Engineering Materials, Classification and Properties

Manufacturing Processes: Castings - Patterns & Moulding, Hot Working and Cold Working, Metal Forming processes: Extrusion, Drawing, Rolling, Forging, Welding - Arc Welding & Gas Welding, Soldering, Brazing.

Machine Tools: Lathe - Types - Operations, Problems on Machining Time Calculations, Drilling M/c - Types - Operations, Milling M/c - Types - Operations - Up & Down Milling, Shaping M/c -Operations- Quick Return Mechanism, Planer M/c.- Operations-Shaper Vs Planer, Grinding M/c-Operations. Introduction to NC/CNC Machines, 3D Printing

Power Transmission: Transmission of Power, Belt Drives, Gears and Gear Trains -Simple Problems

Fasteners and Bearings: Fasteners - Types and Applications, Bearings - Types and Selection,

Thermodynamics: Energy Sources - Conventional/Renewable, Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law - Cyclic process, Change of State, C_p, C_v, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - T-S and P-V diagrams.

Thermal Power Plant: Layout of Thermal Power Plant & Four circuits - Rankine cycle, T-S & P-V diagrams, Boilers - Babcock & Wilcox, Cochran Boilers, Comparison of Fire Tube &Water Tube Boilers, Steam Turbines - Impulse Vs. Reaction, Compounding - Pressure & Velocity Compounding, Condensers - Jet Condenser and Surface Condenser; Cooling Towers

I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences Refrigeration: Vapor Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants

Heat Transfer: Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient – problems

Automobile Engineering: Layout of an Automobile, Transmission, Clutch, Differential, Internal Expanding Shoe Brake

Learning Resources:

Text book:

1. Elements of Mechanical Engineering- **M.L.Mathur,F.S.Mehta and R.P.Tiwari**,Jain Brothers, New Delhi

Reference books:

1. Engineering Heat Transfer-**Gupta** ; Prakash,New chand Bros.,New Delhi

Course Code: MAI202	COMPUTER PROGRAMMING AND PROBLEM SOLVING	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Understand the development of Computers
CO2	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO3	Explore the internals of computing systems to suitably develop efficient algorithms
CO4	Examine the suitability of data types and structures to solve specific problems
CO5	Apply control structures to develop modular programs to solve mathematical problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	--	-	-	-
CO2	3	2	3	1	-	-	-	-
CO3	2	3	2	2	-	-	-	-
CO4	3	2	3	3	-	-	-	-
CO5	3	3	2	3	-	-	-	-

Syllabus:

Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

Number systems and data representation, Basics of C, Basic data types.

Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Functions – Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion,

Introduction to pointers. Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions Matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays, String processing, File operations.

Structures - Declaration, Nested Structures, Pointer to Structure, Structure in function argument, function returning structure, Problems on Complex numbers, Date, Time.

Learning Resources:

Text Books:

1. The C programming language, **Brian W Kernighan & Dennis Ritchie**, 2nd Edition, Pearson, 2015.
2. A text book on C: Fundamentals, data structures and problem solving, **Karthikeyan E**, PHI, 2008

Reference Books:

1. C - The Complete Reference**, Herbert Schidt,** Mc Graw Hill, 4th Edition, 2017
2. Let us C, BPB, **Yashavant Kanetkar**, 16th Edition, 2017
3. Handbook on computer science and IT, **B Singh**, Shree Hari Publications, 2021

Course Code: MAI203	COMPUTER PROGRAMMING LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Design and test programs to solve mathematical and scientific problems
CO2	Develop and test programs using control structures
CO3	Develop the programs using pointers
CO4	Implement modular programs using functions
CO5	Develop programs using structures

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	1	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Using C, the students have to write

- Programs on elementary problems
- Programs on conditional control constructs.
- Programs on loops (while, do-while, for).
- Programs using user defined functions and library functions.
- Programs on arrays, matrices (single and multi-dimensional arrays).
- Programs using pointers (int pointers, char pointers).
- Programs on string processing
- Programs on structures.

Course Code: PHI202	OPTICS LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand phenomenon based on light and related theories
CO2	Get skills to identify and apply formulas of optics and wave physics
CO3	Understand the applications of diffraction and polarization
CO4	Understand the applications of interference in design and working of interferometers.
CO5	Understand the resolving power of different optical instruments.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	1	--			
CO2	2	3	3	1	-			
CO3	2	3	3	1	-			
CO4	2	3	3	1				
CO5	2	3	3	1				

List of Experiments:

- To determine the refractive index of a prism by using a spectrometer.
- To find the wavelength of white light by a plane transmission diffraction grating.
- To find the specific rotation of sugar solution by using a polarimeter.
- To find the wavelength of Sodium light by Newton's ring.
- To verify the expression for the resolving power of a Telescope.
- To find refractive index of the given liquid samples and find Molar refraction and specific refraction
- Polarization of Light & Verification of Malus Law
- Determination the wavelength of He-Ne laser using diffraction grating.
- Spectrometer- Determination of Cauchy's constants
- Dispersive power of a prism
- Determination of numerical aperture and acceptance angle of the optical fiber using laser
- Determination of thickness of thin wire–Air Wedge
- Brewster's Angle determination

Learning Resources:

Text Books:

1. Optics Lab Manual by Department of Physics, NITW 2021.
2. Engineering Physics Practical, **S. K. Gupta**, Ninth Edition, Krishna Prakashan Media publishers, 2010

Reference Books:

1. A Text Book of Practical Physics, **Indu Prakash and Ramakrishna**, 11th Edition, 2011, Kitab Mahal, New Delhi
2. Materials Science and Engineering: An Introduction, **Callister, Jr. W.D.**, Seventh Edition, Wiley, New York, 2007

Online Recourses:

1. https://vlab.amrita.edu/index.php?sub=1&brch=281
2. https://vlab.amrita.edu/index.php?sub=1&brch=189

Course Code: CYI202	PHYSICAL CHEMISTRY LABORATORY-I	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Relate qualitative and quantitative concepts of physical chemistry for solving problems in physical chemistry with appropriate methodologies
CO2	Demonstrate procedures and methods applied in analytical and practical tasks of physical chemistry
CO3	Identify the appropriate instrumental technique to measure the physical property of interest
CO4	Apply the scientific process in the design, conduct, evaluation and reporting of experimental investigations
CO5	Assess and mitigate risks when working with chemicals and hazardous substances

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	2	1	2	-	-		-
CO2	1	1	1	1	-	-		
CO3	1	1	1	1	-	-		
CO4	1	2	1	1	-	-		
CO5	1	2	2	1	-			

Syllabus:

- pH-Metric Titration for pKa of a Monobasic Acid and Poly Basic acid.
- Determination Buffer Action and Buffer Capacity of various Buffers.
- Verification of Ostwald's dilution law and determination of pKa of weak acid, pKb of weak base.
- Determination of the Molar Mass of a Compound by Freezing Point Depression.
- Determination of isoelectric point of amino acid using pH metry and conductometry.
- Corrosion
- Potentiometric Titration of Chloride and Iodide
- Kinetics of Hydrolysis of Ester
- Blue Printing
- Determination of Coagulation Values of Different Electrolytes for Negative/Positive Sol.
- Determination of solubility of benzoic acid at different temperature and to determine enthalpy change of dissolution process.
- Determination of Heat of solution of KNO_3/ NH_4Cl.
- Determination of the bimolecular rate constant of a reaction using colorimetry.
- Study the influence of ionic strength on the solubility of CaSO4 and hence determine its thermodynamic solubility product and mean ionic activity.

Learning Resources:

Text Books:

1. Experiments in Physical chemistry, **Shoemaker D.P., Garland C.W. and Nibler J.W.** McGraw Hill, 2008, 8th edition.
2. Systematic Experimental Physical Chemistry by **S.W. Rajbhoj and T.K. Chondheka**, Anjali Publication, 2013, 3rd edition.

Reference Books:

1. A Collection of Interesting General Chemistry Experiments, **A. J. Elias,** Universities Press, 2007, Revised Edition.
2. Practical Physical Chemistry, **Alexander Findley**, Wiley, 1972, 9th Edition.
3. Experiments in Physical Chemistry, **R.C. Das and B. Behera**, Tata McGraw- Hill, 1984.

II year II semester

Course Code: MAI251	LINEAR ALGEBRA	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Demonstrate the knowledge of vector space and subspaces.
CO2	Find rank and nullity of a linear transformation and the corresponding matrix.
CO3	Test the consistency of system of linear algebraic equations.
CO4	Solve eigenvalue problems.
CO5	Illustrate the concept of inner products and orthogonalization.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	1	-	-	-	-
CO5	3	2	2	2	-	-	-	-

Syllabus:

Vector Spaces and Linear Transformations: Vector spaces, Subspaces, Linear dependence and independence, Span of a set, Basis and dimension, Direct sum, Quotient space. Linear transformations, Range and null space, Rank and nullity, Matrix representation of linear transformations, Change of basis.

System of Linear Equations: Elementary row operations, Row echelon form, Row reduced echelon form, Determinant, Rank of a matrix, Inverse of a matrix by elementary operations. Solutions of Homogeneous and Non-homogeneous linear system of equations.

Diagonalization of Matrices: Characteristic equation, Eigenvalues and eigenvectors of a matrix, Cayley-Hamilton Theorem and its use in finding inverse of a matrix. Diagonalization of square matrices. Basic matrices and their properties.

Inner Product Spaces: Inner products, Norm and angle, Orthogonal and orthonormal sets, Gram-Schmidt orthogonalization, Orthogonal and orthonormal bases.

Learning Resources:

Text Books:

1. Linear Algebra, M. Thamban Nair and Arindama Singh, Springer, 2018.
2. Linear Algebra, Stephen H. Friedberg, Arnold J. Insel, and Lawrence E. Spence, Pearson Education, 4th edition, 2002.
3. Introduction to Linear Algebra, Gilbert Strang, Wellesley-Cambridge Press, 4th edition, 2009.

Reference Books:

1. Linear Algebra, **K. Hoffman and R. Kunze**, Pearson Education, 2nd edition, 2005.

2. Linear Algebra, **S. Lang**, Undergraduate Texts in Mathematics, Springer-Verlag, 1989.

Online Resources:

1. http://www-math.mit.edu/~gs/
2. https://nptel.ac.in/courses/111/106/111106051/

Course Code: PHI251	ELECTRICITY AND MAGNETISM	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

After successful completion of the course, the student will be able to:

CO1	Demonstrate the application of Coulomb's law for the electric field.
CO2	Understand the relation between electric field and potential.
CO3	Calculate the magnetic forces that act on moving charges and the magnetic fields
CO4	Apply Gauss's law of electrostatics to solve a variety of problems.
CO5	Understand the concepts of induction and self-induction.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	3	--			
CO2	3	3	2	2	-			
CO3	3	2	2	2	-			
CO4	3	3	2	1				
CO5	3	3	2	1				

Syllabus:

Electrostatics : Electric Field and Electric Potential- Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry; Electrostatics- Coulomb's law and applications, Laplace's and Poisson equations, The Uniqueness Theorem, Potential and Electric Field due to an arbitrary charged wire, sphere, disc, electric dipole, Force and Torque on a dipole, Energy stored in an electric field; Electrostatic energy of system of charges- Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor, Capacitance of a system of charged conductors, Parallel-plate capacitor.

Magnetism : *Magnetic Field*- Lorentz force, Biot-Savart's Law, Magnetic force between current elements, Ampere's Circuital Law, Maxwell's corrections in Ampere's law; Curl and Divergence of B, vector potential, magnetic flux, Calculation of B for circular and solenoid currents, Magnetic Force on (i) point charge (ii) current carrying wire (iii) between current elements. Torque on a current loop in a uniform Magnetic Field; Intensity of magnetization, Relation between B, H and M.

AC & DC currents: *Steady currents*-Electric current and drift velocity, current density, equation of continuity, electric resistivity and conductivity, Wiedemann-Frenz Law; *Alternating Current*- Mean and r.m.s value of current, emf with sinusoidal wave form, Reactance, Impedance, Phase angle, power dissipation in AC circuit, Power factor, vector diagram, Faraday's Law, Lenz's Law, Self Inductance and Mutual Inductance, LR, CR and LCR, Resonance, Q-factor -Transformer and motors.

Electromagnetic Waves: Maxwell's Equations, Displacement current term, Plane Electromagnetic Waves, Energy Carried by Electromagnetic Waves, Momentum and Radiation Pressure, The Electromagnetic Spectrum.

Learning Resources:

Text Books:

1. Electricity and Magnetism, **Edward M. Purcell**, Cambridge Press, 3rd edition,2013.
2. Introduction to Electrodynamics**, D.J. Griffiths**, Cambridge Press4th edition, 2017

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, **S.Mahajanand Choudhury**, Tata McGraw Hill, 2012.
2. Electricity and Magnetism, **J.H.Fewkes & Yearwood.** Vol.I, Oxford Univ. Press, 2005.
3. Problems and Solutions in Electromagnetics by **Ajoy Ghatak, K Thyagarajan & Ravi Varshney,** Viva Books Private Limited, 2015.

Online Resources:

1. https://ocw.mit.edu/courses/physics/8-022-physics-ii-electricity-and-magnetism-fall-2004/lecture-notes/
2. https://examupdates.in/electricity-and-magnetism-notes/

Course Code: CYI251	INORGANIC CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	understand the basic principles related to structure and bonding of s & p block elements
CO2	acquire knowledge about the synthesis and reactivity of s and p block elements
CO3	understand the general chemistry of d and f block elements
CO4	know various methods of purification of metals from ores
CO5	apply theories of bonding in the interpretation of colour and magnetic properties of coordination compounds

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	1	1	-	-	-	-
CO2	1	1	1	2	-	-	-	-
CO3	1	1	1	1	-	-	-	-
CO4	1	1	1	2	-	-	-	-
CO5	1	1	1	1	-	-	-	-

Syllabus:

Main group: Chemistry of boron and aluminium (hydrides and halides): Synthesis, structure(bonding) and reactivity, Polyhedral boranes (Boron clusters) and carboranes: Synthesis, classification, structures(Wade's rule), MNO rules, styx code, Borazine: Synthesis and reactivity, Oxides of silicon (silicates, silicones): preparation, classification and applications,

Phosphorus Nitrogen and Sulphur Nitrogen rings, Isolobal analogy, Chemistry of Xenon: Xenon fluorides, Structure and bonding.

Transition and Inner Transition Metal Chemistry: d-block elements:General chemistry: oxidation state, complex formation, color and magnetic properties, Group wise chemistry: oxidation state, complex formation, color and magnetic properties, organometallic compounds and their biological importance, f-block Elements: Lanthanides: Oxidation state, separation colour and magnetic properties- lanthanide contraction, uses, Actinides: General properties.

General Principles of Metallurgy: Chief modes of occurrence of metals based on standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent, Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold, Methods of purification of metals: Electrolytic process, van Arkel-de Boer process and Mond's process, Zone refining.

Coordination Chemistry: Jorgenson chain theory, Werner's theory, Nomenclature of

coordination compounds, Stereochemistry of coordination compounds, coordination numbers of 4, 5 and 6, Various types of isomerism in coordination complexes, Sidzwick Effective Atomic Number (EAN) concept-Calculations of EAN for metal complexes-Limitations-Electroneutrality principle, Theories of metal-ligand bonding in transition metal complexes-Valence bond theory of coordination compounds, high-spin and low-spin complexes, hybridization and structures of octahedral, tetrahedral and square-planar complexes-Limitations of valence bond theory, Crystal-field theory- Qualitative idea about d-orbital splitting in octahedral, tetrahedral and square planner complexes, explanation of magnetism, geometry and colour of coordination compounds, CFSE and its calculation in different stereo chemistries, Weak field and strong field, Low spin and high spin complexes, Pairing energy, Molecular orbital theory, LCAO rules, MOED of octahedral, tetrahedral and square-planar complexes.

Learning Resources:

Text Books:

1. Concise Inorganic Chemistry, **J. D. Lee**, Wiley India, 2015, 5th edition.
2. Inorganic chemistry, Catherine **E. Housecroft and A. G. Sharpe**, Pearson, 2018, 5th edition.

Reference Books:

1. Inorganic Chemistry: Principle of structure and reactivity, **Huheey, J. H.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K.,** Pearson Education India, 2006, 4th edition.
2. Inorganic Chemistry, **D. F. Shriver and P. W. Atkins**, Oxford University Press, 2006, 4th edition.

Course Code: PHI252	ARTIFICIAL INTELLIGENCE	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand underlying principles of AI & ML
CO2	Gain intuition to successfully apply AI & ML to variety of problems
CO3	Extract useful information from the large data
CO4	Identify problems that can be easily handled by AI & ML
CO5	Use AI & ML for solving real world problems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	--			
CO2	3	3	3	2	-			
CO3	3	3	3	2	-			
CO4	3	3	3	2				
CO5	3	3	3	2				

Syllabus:

Artificial Intelligence: Introduction, Foundations of AI, History of AI, State of the art.

Dimensionality Reduction techniques: Singular Value Decomposition, Principal Component Analysis, Fourier and Wavelet Transforms.

Machine Learning: Types of ML: Supervised, unsupervised and Reinforcement learning, Classification and Regression, ML Algorithm: Linear Regression, Decision Tree, Support Vector Machine, *k*-means clustering, *k*-nearest neighbour.

Deep Learning: The perceptron, Activation functions, Building neural network with perceptron, Single layer neural network, multilayer neural network, Training neural network: Loss Optimization, Gradient descent, Back propagation, Types of neural network: ANN, CNN, RNN.

AI in Sciences: Machine learning in Physical, Chemical and Mathematical Sciences.

Learning Resources:

Text Books:

1. Artificial Intelligence: A Modern Approach, **S. J. Russell and P. Norvig**, 2010, third edition.
2. MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, **Phil Kim**, Apress, 2017, first edition.

References:

1. Deep Learning, **I. Goodfellow, Y. Bengio & A. Courville**, MIT Press, 2016.

2. Data Science from Scratch, **J. Grus,** O'Reilly Media, 2019.

Online Resources:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-034-artificial-intelligence-fall-2010/
2. http://introtodeeplearning.com/

Course Code: MAI261	VECTOR CALCULUS	Credits 3-0-0:3

Pre-Requisites: MAI101

Course Outcomes:

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

CO1	find the derivative along a curve and directional derivatives.
CO2	calculate and interpret gradient, divergence, curl and their related vector Identities
CO3	familiar with line, surface and volume integrals along with its applications.
CO4	use theorems of Gauss, Green and Stokes to compute integrals.
CO5	realize the way of vector calculus to addresses some of the problems of physics.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	1	-	-	-	-
CO5	3	2	2	2	-	-	-	-

Syllabus:

Vector differentiation: Introduction –Scalar and vector valued point functions, Derivatives, Curves, Tangents and length, Velocity and acceleration, Curvature and torsion of a curve, Level surfaces. Gradient of a scalar field and its geometrical interpretation, Directional derivative, Divergence of a vector field and its applications, Curl of a vector field and its applications, Vector identities.

Vector integration: Line integrals, Line integral independent of path, Work done by force, Circulation, Double Integrals, Green's theorem in the plane, Surfaces and surface integrals, Triple integrals, Divergence theorem of Gauss, Stoke's theorem, Verification and problems based on these theorems.

Curvilinear Coordinates: Orthogonal curvilinear coordinates, Conditions for orthogonally fundamental triad of mutually orthogonal unit vectors. Gradient, Divergence, Curl and Laplacian operators in terms of orthogonal curvilinear coordinates, cylindrical polar coordinates and Spherical polar coordinates.

Learning Resources:

Text Books:

1. A Textbook of Vector Calculus, **Shanti Narayan & PK Mittal**, S Chand & Co Ltd,

2005.
2. Introduction to vector analysis, **Harry F. Davis and Arthur David Snider**, Allyn and Bacon Inc, Boston, 1975, 3rd Edition.

Reference Books:

1. Vector Analysis: An Introduction to Vector-Methods and Their Various Applications to Physics and Mathematics, **Joseph George Coffin**, John Wiley & Sons, Inc., 1911, 2nd Edition
2. Vector Calculus, **P.C.Matthews**, Springer Undergraduate Mathematics Series, Springer-Verlag London, 1998, 1st Edition.
3. Vector Analysis, **Murray Spiegel, Seymour Lipschutz and Dennis Spellman,** Schaum's Outlines Series, 2017, 2nd Edition.

Course Code: MAI262	THEORY OF EQUATIONS	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	by using the concepts learnt the students are expected to solve some of the polynomial equations.
CO2	use the Descartes's rule of sign to find the nature of roots
CO3	Location of the roots of an equation.
CO4	understand Cardon's, Ferrari's and Descartes' method to find roots of cubic and biquadratic equations
CO5	Illuminating sequel to geometry, algebra and analytic geometry.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	2	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Graphical representation of a polynomial – Maxima and minima values of polynomials - Theorems relating to the real roots of equations - Existence of a root in the general equation - Imaginary roots – Theorem determining the number of roots of an equation – Equal roots – Imaginary roots occurring in pairs - Synthetic division - Diminishing the roots of equation by a given number.

Formation of equation whose roots are functions of the roots of a given equation - Descartes' rule of signs for positive roots - Descartes' rule of signs for negative roots - The fundamental theorem of algebra.

Relations between the roots and coefficients of equation and related theorems - Applications of the theorem - Depression of an equation when a relation exists between two of its roots – The cube roots of unity - Symmetric functions of the roots - Common roots and multiple roots .

Transformation and numerical solution of algebraic equations – Location of the roots of an equation – Binomial and reciprocal equations – Solutions of cubic equations (Cardon's method) - Ferrari's and Descartes' solution of biquadratic equations.

Learning Resources:

Text Books:

1. Theory of equations, **H.W. Turnbull, Oliver and Boyd**, Edinburgh and London, Interscience Publishers Inc, 1952, 4th Edition.
2. An introduction to the modern theory of equations, **Florian Cajori**, The Macmillan Company, New York, London, 1919

Reference Books:

1. Theory of Equations, **C. C. Mac Duffee**, John Wiley, New York; Chapman & Hall, London, 1954.
2. Higher Algebra, **Hall and Knight**, MacMillan and Co., 1989, 3rd Edition.
3. First Course in the Theory of Equations, **Leonard Eugene Dickson**, John Wiley & Sons, Inc. New York; Chapman & Hall, London, 1992.

Course Code: MAI263	MATHEMATICAL MODELLING	Credits 3-0-0:3

Pre-Requisites: none

Course Outcomes:

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

CO1	Interpret the need of modelling and various aspects of modelling process
CO2	Learn population models , epidemic models and pharmacokinetics models
CO3	Develop models for blood flows and other bio-fluid flow models
CO4	Learn Simulation models
CO5	Learn about model fitting

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	1	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Introduction --- Modelling Using Proportionality, Modelling Using Geometric Similarity.

Some Models: Microbial population models – Single species non-age-structured population models – age structured population models – two species population models – multispecies population models – optimal exploitation models – epidemic models – models in genetics – mathematical models in pharmacokinetics – models for blood flows – models for other biofluids – diffusion and diffusion reaction models – optimization models in biology and medicine.

Simulation Modelling: Simulating Deterministic Behaviour, Area Under a Curve, Generating Random Numbers, Simulating Probabilistic Behaviour,

Model Fitting: Fitting Models to Data Graphically, Analytic Methods of Model Fitting.

Learning Resources:

Text Books:

1. *Mathematical models in Biology and Medicine*, **J.N.Kapur**, Affiliated East-West Pvt. Ltd., 2010
2. *Concepts of Mathematical Modelling*, **W.J.Meyer**, McGraw Hill, 1985

3. *Mathematical Modelling: Principles and Applications,* **Frank R Giordano, William P Fox, Steven B Horton and Maurice D Weir**, Cengage Learning, 2014

Reference Books:

1. Mathematical Modelling with Case Studies, **B.Barnes and G.R.Fulford,** CRC press, 2009, 3rd Edition
2. Mathematical Modelling: A Graduate Textbook, **Seyed M. Moghadas, Majid Jaberi-Douraki,** Wiley, 2018

Online Resources:

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-021j-introduction-to-modeling-and-simulation-spring-2012/
2. https://ocw.mit.edu/courses/mathematics/18-s096-topics-in-mathematics-with-applications-in-finance-fall-2013/video-lectures/lecture-9-volatility-modeling/
3. https://ocw.mit.edu/courses/sloan-school-of-management/15-023j-global-climate-change-economics-science-and-policy-spring-2008/lecture-notes/lec3.pdf

Course Code: MAI252	LINEAR ALGEBRA USING SCILAB LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Acquire proficiency in using Scilab to study Matrices
CO2	Demonstrate the use of scilab to understand and interpret the core concepts in linear algebra
CO3	Find general solution of system of linear equations
CO4	Apply Scilab to decompose the matrices, finding eigen values and eigen vectors

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	1	-	-	-	-

Syllabus:

- Introduction to Scilab - The Scilab Environment – manipulating the command line, working directory, comments, variables, the scilab menu bar,
- Scalars & Vectors – introduction, initializing vectors in scilab, mathematical operations on vectors, relational operations on vectors, logical operations on vectors, built-in logical functions.
- Mathematical functions on scalars and complex numbers
- Arithmetic operators for Vectors, Matrices, basic matrix processing.
- Finding inverse, determinant, transpose, exponentiation of a Matrix etc
- Reducing to Row/Column echelon form
- Linear combination and Solving linear equations
- Matrix factorization (for example, Cholesky, LU, SVD)
- Eigen values and eigen vectors
- Finding the orthogonal basis
- Subspace intersection, sum and intersection of subspaces

Course Code: PHI253	ELECTRICITY AND MAGNETISM LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: none

Course Outcomes:

After successful completion of the course, the student will be able to:

CO1	Demonstrate the construction, functioning and uses of different electrical bridge circuits, and electrical devices.
CO2	Analyse the experimental data, sources of error and their estimation in detail
CO3	Understand the characteristics of RC and LRC circuit.
CO4	Understand the concepts of self-induction and mutual induction via standard methods.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	1	--			
CO2	2	3	3	2	-			
CO3	2	3	3	2	-			
CO4	2	3	3	1				

List of Experiments:

Measurements with a multimeter.

1. Study characteristics of a series RC circuit.
2. Measurement of response curve of a Series LCR circuit and determine the (a) Resonantfrequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
3. Measurement of response curve of a parallel LCR circuit and determine the (a) Anti-resonant frequency and (b) Quality factor Q.
4. Measurement of low resistance using Carey foster bridge.
5. Measurement of field strength B and its variation in a solenoid
6. Determine self-inductance of a coil by Anderson's bridge.
7. Verification of superposition and maximum power transfer theorems.
8. Determine self-inductance of a coil by Rayleigh's method.
9. Determine the mutual inductance of two coils by Absolute method.
10. Determination of the resistance of a galvanometer by Kelvin's method using P. O box.
11. Study of rise and decay of current in LR circuit with a source of constant EMF.
12. Determination of velocity of sound in air.
13. Study of electromagnetic induction and verification of Faraday's law.

Learning Resources:

Text Books:

1. Electricity and Magnestism Lab Manual, Department of Physics,NITW,2021
2. A Text Book of Practical Physics, **Indu Prakash and Ramakrishna,** 11th Edition, 2011, Kitab Mahal, New Delhi

Reference Books:

1. Physics through experiments, **B Saraf**, Vikas Publications , 1987.
2. Advanced practical physics, **S.P Singh**, Pragathi Publications, 2019.

Online Resources:

1. https://examupdates.in/electricity-and-magnetism-notes/#Electricity-and-magnetism-Laboratory-introduction
2. https://ocw.mit.edu/courses/physics/8-02x-physics-ii-electricity-magnetism-with-an-experimental-focus-spring-2005/labs/802x.pdf

Course Code: CYI252	QUANTITATIVE ANALYSIS LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: none

Course Outcomes:

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

CO1	Get hands on experience in the volumetric analysis and gravimetric analysis
CO2	Acquire the knowledge in estimation of metal content in ores
CO3	Understand principles of volumetric titrations such as permanganometry, dichrometry, iodometry and complexometry
CO4	Determine metal ion contents by gravimetric analysis
CO5	Analyze water samples for their hardness and alkalinity

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	1	1		-	-	-
CO2	1	1	2	1		-	-	-
CO3	1	2	1	1		-	-	-
CO4	1	1	2	2	-	-	-	-
CO5	2	2	2	2	-	-	-	-

Syllabus:

Titrimetry:

1. Determination of concentration of a mixture of acids by volumetric method
2. Determination of total alkalinity of water
3. Determination of Mn^{2+} in pyrolusite by permanganometric method
4. Determination of Fe^{2+} in hematite by dichrometric method
5. Determination of available chlorine from bleaching powder
6. Determination of total hardness of water by complexometric method
7. Determination of Al^{3+} by back titration method
8. Determination of Zn^{2+} by precipitation titration method
9. Determination of lead and tin in a mixture: analysis of Solder
10. Determination of phenol by volumetric method
11. Determination of urea by volumetric method

Gravimetry:

12. Determination of sulphate by semigravimetric method
13. Determination of aluminium by oxine method
14. Determination of nickel by DMG method

Analysis of mixture:

15. Separation and estimation of Cu^{2+}- Ni^{2+} mixtures by volumetric and gravimetric method

Learning Resources:

Text Books:

1. Vogel's Textbook of Quanitative Chemical Analysis, **G H Jeffery, J Bassett, J Mendham and R C Denney,** Longman Inc., 1989, 5th edition
2. Laboratory manual, Department of Chemistry, NITW, 2020.

Reference Books:

1. A Collection of Interesting General Chemistry Experiments, **Elias, A. J.,**Universities Press (India) Pvt. Ltd., 2002.
2. Inorganic Experiments, **J. D. Woolins**, John Wiley & Sons, 2010, 3rd edition.
3. Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience, **Z. Szafran; R. M. Pike; M. M. Singh**, Wiley, 1991, 1st edition.

III Year I Semester

Course Code: MAI301	NUMERICAL ANALYSIS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	find the roots of nonlinear equations numerically
CO2	solve the system of equations
CO3	interpolate the given data and approximate the function by a polynomial
CO4	evaluate the definite integrals numerically
CO5	solve the initial value problems numerically

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	1	2	2	--	-	-	-
CO2	2	2	2	2	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	2	2	1	2	-	-	-	-
CO5	2	3	2	2		-	-	-

Syllabus:

Solution of nonlinear and transcendental equations: Bisection method, secant method, Regula-falsi method, Newton-Raphson method

Solution of linear system of equations: Gauss elimination method with and without pivoting, Gauss-Jordan method, LU decomposition, Cholesky method, Partition method Gauss-Jacobi and Gauss-Seidel method iteration methods, Power method to find the largest Eigen value

Interpolation: Newton's divided difference interpolation, Newton's Forward, Newton's backward, central differences (Gauss forward, Gauss backward, Sterling's and Bessel's) interpolation, Lagrange interpolation

Numerical Differentiation: Finite difference approximations for first and second order derivatives.

Numerical Integration: Newton-Cotes formula: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Boole's and Weddle's formulas.

Numerical Solution of Ordinary differential equations:Taylor's method, Euler's method, Modified Euler's method, 4th order Runge-Kutta method to solve initial value problems.

Learning Resources:

Text Books:

1. *Introductory Methods of Numerical Analysis,* **S. S. Sastry**, PHI, 2012
2. Introduction to Numerical Analysis, **F. B. Hildebrand**, Dover Publications Inc, 2003

Reference Books:

1. Introduction to Numerical Analysis, **Atkinson**, Dover Publications Inc, 2008
2. Numerical Analysis, **Francis Scheid**, Schaum's Outline Series,1988
3. *Numerical Methods for Engineers and Scientists,* **M. K. Jain, SRK Iyengar and R.K Jain,** New Age International, 2008.

Course Code: PHI301	BASIC ELECTRONICS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand operating principles of electronic components like diode, Zener diode, BJT and FET
CO2	Comprehend the functioning and biasing of transistors and study their characteristics
CO3	Comprehend the I-V characteristics of BJT, FET and J-FET devices
CO4	Understand functioning of amplifiers and oscillators and be able to design related circuits as well
CO5	Understand and appreciate number systems and the functioning of basic logic gates

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	--			
CO2	3	2	2	2	-			
CO3	3	2	2	2	-			
CO4	3	2	2	2				
CO5	3	2	2	2				

Syllabus:

PN Junction Diode: Basics, ideal diode, PN junction diode, V-I characteristics, Zener diode, Half, full wave (center tapped and Bridge) rectifiers, RC and LC filters, Design of un-regulated DC power supply, Clipping and Clamping circuits, voltage multiplier circuits.

BJT: Construction and Operation, CE, CB and CC characteristics, DC load line and bias point, fixed, emitter feedback, collector feedback, and voltage divider biasing circuits, Thermal stability, switching circuits, Constant Current sourcs, transistor power dissipation, switching.

Field effect transistors (FET): JFET, Construction, Working, and characteristics, Biasing in ohmic and active regions, Trans-conductance, amplification and switching, MOSFET, CMOS introduction.

Amplifiers and Oscillators: Classification, RC-coupled CE amplifier – frequency response,. Feedback circuits, noise, input and output impedances. Emitter follower and Darlington pair. RC oscillators- RC phase shift and Wien's bridge oscillators, LC oscillators- Hartley and Colpitt oscillators.

Digital Electronics: Binary, octal, decimal and hexadecimal number systems, Booleon algebra, -Basic and Universal Gates, Half adder, Full adder and parallel adder logic circuits. Logic families and their characteristics.

Learning Resources:

Text Books:

1. Electronic Devices and Circuits by **David A. Bell** ,Oxford University Press, 5th Ed,2008.
2. Electronic Principles by **Albert Malvino & David**, Tata McGraw-Hill, 5th edn,2016

Reference Books:

1. Electronic Devices and Circuit Theory by **Robert L. Boylestad, Louis Nashelsky** ,pearsond education,5th edn,2013.
2. Millman's Electronic Devices and Circuits by **Jacob Millman, Chrisots C.Halkias,Satyabrata Jit.** TMGHill,2nd edition,2007.

Online Resources:

1. https://nptel.ac.in/courses/117/103/117103063/
2. https://nptel.ac.in/courses/117/107/117107095/

Course Code: CYI301	ORGANIC CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: NIL

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

CO1	Understand the redox processes in organic compounds
CO2	Able to select and use appropriate oxidizing or reducing agent for a particular transformation
CO3	Understand structural and chemical properties of heterocyclic compounds and use them for the synthesis of a drug or a molecule with materials property
CO4	Realize the change in the biological or materials property of a molecule based on the stereochemistry of molecules
CO5	Importance of stereochemistry in organic chemistry, Naming, preparation and separation of stereo chemicals at industrial scale
CO6	Effect of UV-Visible, IR and radio waves on organic molecules and use these radiations to determine the structure of organic compounds by UV-Vis, IR and NMR spectral methods

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	1	1	-			
CO2	1	2	1	1	-			
CO3	1	1	1	1	-			-
CO4	1	3	1	1	-			-
CO5	1	2	1	1				-
CO6	-	1	1	1				-

Syllabus:

Oxidation Reactions: Introduction to redox process in organic chemistry, Oxidation of sp^3 carbon (conversion of saturated carbon in to unsaturated carbon), C-X bond formation (Appel reaction), Oxidation of sp^3 carbon (benzylic and allylic carbons) using $KMnO_4$, MnO_2, SeO_2, Oxidation of sp^2 carbon: Epoxidations, Aziridinations, Dihydroxylations ($KMnO_4$, OsO_4; Woodward and Prevost reactions, Oxy-mercuration, $Pb(OAc)_4$, Oxidative dissociation of C-C bond (HIO_4), C-C double bond (Ozonolysis), Oxidation of alcohols: Using chromium reagents (CrO_3, Jones), General mechanism, Modified chromium reagents (PCC, PDC), Swern oxidation (activation of DMSO)

Reduction Reactions: Hydrogenation of unsaturated system (homogeneous and heterogeneous conditions, Hydrogenation of unsaturated system (dissolving metals), cleavage of ethers (HI), Reduction of halogenated compounds (Sn reagents), reduction of carbonyl compounds using boron based hydride reagents (Boranes, $NaBH_4$, 9-BBN, Disiamyl borane, Thexyl borane, Catechol borane), Reduction of carbonyl compound using aluminum

based hydride reagents ($LiAlH_4$, DIBAL, Super hydride), Reduction of nitro compounds and nitriles

Heterocyclic Compounds: Systematic nomenclature of heterocyclic compounds (HantzschWidman, replacement and fusion methods), biological importance of heterocyclic compounds. Preparation & Properties of Pyrrole, Furan, Thiophene, Preparation & Properties of Pyridine, Piperidine, Preparation & Properties of Indole, Quinoline, Isoquinoline, Coumarin.

Optical isomerism: Introduction to chiral molecules and optical isomerism, projection formulae optical activity, specific rotation, Enantiomer & Diastereomers, Meso compound, Racemic mixture, Symmetry elements, classifications of chiral molecules based on symmetry (dissymmetric and asymmetric molecules) and energy criterion, Relative configuration (D,L-configuration), Absolute configuration (R, S- configuration) (CIP rules), Racemization and Resolution methods, Erythro, Threo-nomenclature, Geometrical isomerism (Cis, Trans-isomerism & E,Z-nomenclature), Conformational analysis of ethane, butane and cyclohexane, **Axis of chirality:** elongated tetrahedron, examples of axis of chirality, R,S-nomenclature of biphenyls (atropisomerism), Buttressing effect, allenes, spiro compounds etc., **Plane of chirality**: paracyclophanes, ansa compounds, helicity (plus and minus helices), hexahelicene.

Introduction to Organic Spectroscopy: Electromagnetic spectrum, Franck-Condon principle, Born-Oppenheimer approximation. **UV-Visible spectroscopy:** Beer-Lambert law, Types of electronic transitions, effect of conjugation, concepts of chromophores and auxochromes, bathochromic, hypochromic, hyper chromic shifts, Woodward-Fieser rules of dienes. **Infra-Red Radiation spectroscopy (IR):** Dipole moment, molecular vibrations, Hooke's law (calculation of wavenumber), IR selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, functional group region, Fermi resonance, characteristic absorptions of various functional groups and Interpretation of IR spectra of simple organic compounds. **NMR spectroscopy:** Principle of NMR spectroscopy, Processional frequency, NMR equation, orientation of protons in the magnetic field, Nuclear spin quantum numbers of various nuclei, relaxation processes, number of signals, chemical shift, factors affecting the chemical shift, spin-spin coupling, Coupling constant (J), applications of NMR spectroscopy.

Learning Resources:

Text Books:

1. Reaction Mechanism in Organic Chemistry, **S.M. Mukherjee and S. P. Singh**, Macmillan India Limited, 2009.
2. Some Modern Methods of Organic Synthesis **W. Carruthers,** 4th Edition Cambridge University Press, Cambridge,.2007.

Reference Books:

1. Stereochemistry of Organic Compounds, **P. S. Kalsi**
2. Applications of Spectroscopy to Organic Compounds, **Silvestin & Bacceler**, Pergaman Press, 2003.
3. Organic Synthesis, **Michael B. Smith**, 2nd Edition, Mc Graw-Hill, 2004
4. Organic Spectroscopy, **William Kemp**, Macmillan, 3rdEdn.,2009.

Online Resources:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm (A virtual Textbook of Organic Chemistry)

Course Code: PHI311	RENEWABLE ENERGY SOURCES	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand the Need, importance and scope of non-conventional and alternate energy resources
CO2	Understand role significance of solar energy.
CO3	Understand the role of ocean energy in the Energy Generation and importance of Wind Energy
CO4	get the utilization of Biogas plants and geothermal energy
CO5	Comprehend the concept of energy Conservation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	--			
CO2	3	2	2	-	-			
CO3	3	2	2	-	-			
CO4	3	2	2					
CO5	3	2	2					

Syllabus:

SOLAR ENERGY: Solar Radiation, Measurements of Solar Radiation, Flat Plate And Concentrating Collectors, Solar Direct Thermal Applications, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation, Solar PV Applications.

WIND ENERGY: Wind Energy Estimation, Types of Wind Energy Systems, Performance, Site Selection, Details of Wind Turbine Generator.

OCEAN ENERGY: Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.

BIO-MASS: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gasdigesters, gas yield, combustion characteristics of bio-gas, utilization for cooking.

GEOTHERMAL ENERGY: Resources, types of wells, methods of harnessing the energy, scope in India.

ENERGY CONSERVATION: Principles of energy conservation, the different energy conservation appliances, cooking stoves, Benefits of improved cooking stoves over the traditional cooking stoves.

Learning Resources:

Text books:

1. Non-Conventional Energy Sources by **G.D. Rai,** Khanna Publishers, 3rd edn, 2011.
2. Non-Conventional Energy Resources, by **B H KHAN**, McGraw Hill, 2nd Edition, 2009.

Reference Books:

1. Renewable Energy Resources, **Twidell and Wier**, CRC Press(Taylor & Francis) , 2008
2. Biomass Renegerable Energy, **D.O.hall and R.P. Overeed**, John Wiley and Sons , 2008

Online resources:

1. https://nptel.ac.in/courses/115/105/115105127/
2. https://nptel.ac.in/courses/103/103/103103206/

Course Code: PHI312	CONDENSED MATTER PHYSICS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	To have a basic knowledge of crystal systems and spatial symmetries
CO2	Formulate basic models for electrons and lattice vibrations for describing the physics of crystalline materials.
CO3	Develop an understanding of the relation between band structure and the electrical/optical properties of a material.
CO4	To know Bloch's theorem and what energy bands are and know the fundamental principles of semiconductors
CO5	To know the fundamentals of dielectric and ferroelectric properties of materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	--			
CO2	3	2	2	-	-			
CO3	3	2	2	-	-			
CO4	3	2	2					
CO5	3	2	2					

Syllabus:

Crystallography: basis and lattice- Crystal structure with examples— External symmetry elements, Point groups, Direct periodic lattice, Basic concept of aperiodicity, Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Intensity of Bragg scattering from a unit cell and extinction conditions.

Lattice Vibrations: Elastic waves, Enumeration of modes, Density of states of a continuous medium, Specific heat models of Einstein and Debye, Concept of phonon, Lattice waves, Lattice dynamics of crystals with up to two atoms per primitive basis, Density of states of a lattice, Thermal Conductivity, Scattering of X-rays, neutrons and light by phonons.

Electronic Properties of Solids: Electrons in periodic potential, Band Theory, Tight Binding, Cellular and Pseudo potential methods, Symmetry of energy bands, density of states, Fermi surface.

Magnetism & Superconductivity: Introduction to types of magnetism, Curie-Weiss Law, Magnetic Domains & Hysteresis, Zero resistance, Meissner effect, Thermodynamics of the superconducting transition, Electrodynamics of superconductivity, BCS theory of superconductivity, Josephson effect.

Dielectric Properties of Matter Dielectric Polarization and Polarization Charges. Gauss' Law in dielectrics, Displacement vector D and E. Capacitor filled with dielectrics. Dielectric Susceptibility, permittivity and Dielectric Constant. Clausius-Mossotti Relation. Langevin theorem of poor dielectrics.

Learning Resources:

Text Books:

1. Introduction to Solid State Physics, **Kittel, C.,** Wiley, 8th Edition, 2008. .
2. Elementary Solid State Physics, **Omar, M. A.,** Pearson, 6th edn,2017.

Reference Books:

1. Solid State Physics (Introduction to the theory**), James Patterson, Bernard Bailey**, Springer Verlag Berlin Heidelberg, 2010.
2. Crystallography Applied to Solid State Physics; **Verma & Srivastava**; New Age; 1991

Online Recourses:

1. Rangarajan, G., Condensed Matter Physics, NPTEL Course Material, Department of Physics, Indian Institute of Technology Madras, https://nptel.ac.in/courses/115106061/.
2. https://www.edx.org/course/topology-in-condensed-matter-tying-quantum-knots

Course Code: PHI313	MODERN PHYSICS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1	Understand the main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics.
CO2	Describe the main features of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
CO3	Apply the basic properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
CO4	Estimate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay..
CO5	Understand the concepts of fission and fusion

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	--			
CO2	3	2	2	1	-			
CO3	3	2	2	2	-			
CO4	3	2	2	1				
CO5	3	2	2	2				

Syllabus:

Failures of classical mechanics- Quantum theory of Light, Planck's quantum, Planck's constant and light as a collection of photons, Photo-electric effect and Compton scattering, Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra.

Wave Particle Duality, matter waves and De Broglie wavelength; Davisson-Germer experiment. wave packets. Superposition of two waves, Group and Phase velocities. Heisenberg Uncertainty Principle, Illustration of the Principle through Experiments. Two slit interference experiment with photons, atoms & particles, eigen values and eigen functions, normalization; Schrodinger equation-particle in a box, Particle in finite potential well-Quantum mechanical tunneling.

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph,semi-empirical mass formula and binding energy.

Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Classification of Elementary Particles.

Learning Resources:

Text Books:

1. Concepts of Modern Physics, **Arthur Beiser**, McGraw-Hill.5th edition,2015.
2. Quantum Physics, Berkeley Physics,Vol.4. **E.H. Wichman**, 2008, Tata McGraw-Hill Co.
3. Modern Physics, **R.A. Serway, C.J. Moses, and C.A.Moyer**, 2005, Cengage Learning.

Reference Books:

1. Modern Physics **– Bernstein, Fishbane and Gasiorowicz** ,pearson edn, 4th edn 2015
2. Modern Physics, **J.R. Taylor, C.D. Zafiratos, M.A. Dubson**, PHI Learning.,3rd edn,2012.
3. Theory and Problems of Modern Physics, Schaum`s outline, **R. Gautreau and W. Savin,**TMH, 2nd Edn,2011.

Online Resources:

1. http://web.sbu.edu/physics/courses/physics-203p.pdf
2. https://drive.google.com/file/d/1OPregBXJ2ldBYeoWh1v9KCxQwzvzlYqY/view
3. http://higgs.physics.ucdavis.edu/9D_part1.pdf

Course Code: CYI311	ENVIRONMENTAL CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: NIL

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

CO1	Identify relationship between chemical exposure and effects on physiological systems
CO2	Understand causes and effects of environmental pollution and mitigation strategies
CO3	Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil)
CO4	Describe water purification and waste treatment processes and the practical chemistry involved
CO5	Discuss local and global environmental issues based on the knowledge gained throughout the course

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	1	1	1	-	-		-
CO2	2	1	2	1		-		-
CO3	2	2	2	1		-		-
CO4	2	2	2	1		-		-
CO5	2	2	1	1	-	-		-

Syllabus:

Chemistry of Atmosphere: Origin, composition and structure of atmosphere-particles, ions and radicals in the atmosphere, Greenhouse effect-Causes, consequences and abatement of Greenhouse effect-Ozone depletion- Causes, consequences and abatement of ozone depletion, Photochemical smog-Effects and control.

Air Pollution-Monitoring and Control: Air sampling techniques-Sources and effects, of oxides of sulphur, oxides of nitrogen, oxides of carbon, Monitoring of air pollutants by Instrumental methods, Monitoring and Control of particulate pollution- Monitoring of air pollutants by Instrumental methods, Control of air pollution by raw material change, process

modification, adsorption, absorption and combustion methods.

Water Pollutants and waste water treatment: Unique characteristics of water; Water and the Living Environment; Water and the Non-living Environment, The Different Types of Pollutants; Chemical Pollutants; Physical Pollutants; Physiological Pollutants; Thermal Pollution, Pollution indicators, Dissolved Oxygen; Biological Oxygen Demand; Chemical Oxygen Demand, Waste water: Constituents – Microorganisms, Solids, Inorganic constituents, Organic matter, Water Quality requirements, pH values of Wastes and Receiving water, Suspended solids, preliminary, primary, secondary, tertiary treatment, Waste water from some typical industries, sources, characteristics, effect and treatment.

Soil chemistry: Nature and composition of soil, Acid base and ion exchange reactions in soil, macronutrients in soil, Micronutrients in soil, Nitrogen, phosphorous and potassium in soil, Fertilizers, wastes and pollutants in soil, Soil loss and degradation, Agriculture and health.

Solid Waste Management and environmental impact assessment: Solid waste disposal and management: classification and origin, methods of solid waste disposal, Microbiology involved in solid waste disposal, Environmental Impact Assessment, Environmental Impact Assessment process in India-Environmental acts and rules.

Learning Resources:

Text Books:

1. Fundamental Concepts of Environmental Chemistry, **G.S. Sodhi**, Narosa publishing House, 2005, 2nd edition.
2. Waste water treatment, **M.N. Rao and A.K. Datta**, Oxford Publications, 2013, 3rd edition.

Reference Books:

1. Environmental Science and Engineering, **J. Glynn Henry and Garry W. Heinke**, Prentice-Hall, Inc., New Jersey, USA, 1996, 2nd edition.

Course Code: CYI312	STATISTICAL TREATMENT OF DATA AND QUALITY CONTROL IN CHEMICAL ANALYSIS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand the importance of statistics in the chemical analysis
CO2	Identify the errors occurring in the measurements and related data treatment
CO3	Apply statistical tools for improving the quality of analytical measurements
CO4	Choose the appropriate analytical method for the calibration and proper use of the instruments
CO5	Develop a standard method for the optimization of experimental procedures in analytical chemistry

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	-	3		-		
CO2	2	2	-	2		-		
CO3	2	1	2	2		-		
CO4	1	2	1	1		-		
CO5	2	1	2	2		-		

Syllabus:

Errors in Data Analysis: Accuracy and Precision; Errors and Error Distributions; Propagation of error, signal vs noise, Statistical Treatment of Data; Gaussian Curve, Finite Data Analysis; Standard Deviation; Standard Deviation for Computed Results, Significant Figures and Rounding the Results. LOD and LOQ, Numerical Problems related to Chemical Analysis.

Significance tests: Comparison tests - Q-test, z-test, t-test (normal t-test and t-set for means), F-test outliers.

Quality Control in Chemistry: Quality control methods – Introduction, Control Charts – Shewart Charts for Mean values and Ranges, Numerical calculations.

Analytical methods. Various types of analytical methods, Calibration of instruments, Calibration methods. Standard addition, External standard, Internal standard and dilution methods.

Standard Method Development and Validation: Optimization of experimental procedures in analytical chemistry, response surfaces, specific examples.

Learning Resources:

Text Books:

1. Fundamentals of Analytical Chemistry, **Skoog D. A., West D M, Holler, F J and Crouch S R**, Saunders College Publishing, 2004, 8thEdn.
2. Waste water treatment, **M.N. Rao and A.K. Datta,** Oxford Publications, 2013, Third edition.

Reference Books:

1. Modern Analytical Chemistry, **David Harvey**, McGraw Hill-Education., 2000, International Edition.
2. Quality Assurance and Quality Control in the Analytical Chemical Laboratory, **Piotr Konieczka and Jacek Namiesnik**, CRC Press, 2009, 2nd Edition.

Course Code: CYI313	APPLIED CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Apply the theoretical knowledge of organic chemistry for the synthesis of molecules with industrial importance
CO2	Use the knowledge of organic chemistry in paint, agriculture, and cosmetic industry
CO3	Understand the essentials of organic chemistry in drug synthesis
CO4	Use the knowledge of organic chemistry for the development of sustainable synthetic processes
CO5	Apply the knowledge of organic chemistry in food industry

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	3	2	1				
CO2	2	2	1	1	-			-
CO3	3	1	2	1	-			-
CO4	2	3	2	1	-			-
CO5	1	2	1	1				-

Syllabus:

Paints, Varnishes and Soaps: **Paints & Varnishes:** Primary constituents of paints, Dispersion medium (solvent), binder Pigments, formulation of paints and varnishes. Requirements of a good paint. **Surface Coatings**: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives. **Soaps:** manufacture of soaps by hot and cold process, classification of soaps, cleansing of soap and classification of detergents (anionic and cationic).

Fertilizers and Pesticides: **Fertilizers:** natural fertilizers, nitrogenous fertilizer (NH_4NO_3, urea), phosphatic fertilizer (superphosphate, TSP, polyphosphate), potash fertilizer (KCl, KNO_3, K_2SO_4), bio fertilizers. **Pesticides:** classification, structure of some important

pesticides (DDT, BHC, allethrin and pyrethrin). **Insecticides:** Pesticides – classification of Insecticides, fungicides, herbicides as organic and inorganic – general methods of application and toxicity. Safety measures when using pesticides. **Insecticides**: Plant products – Nicotine, pyrethrin – Inorganic pesticides – borates. Organic pesticides – D.D.T. and BHC. **Fungicides and Herbicides:** Fungicide: Sulphur compounds, Copper compounds, Bordeaux mixture. Herbicides: Acaricides – Rodenticides. Attractants – Repellents. Preservation of seeds.

Chemistry of Essential oils, Perfumes and Cosmetics: **Essential oil:** Definition–occurrences–Methods of production from plants–Steam distillation and expression method. **Perfumes:** Formulations–Requirements for a good perfume–Compositions of perfumes–classification of perfumery materials–animals-synthetic formulations–manufacturing and packaging process of perfumes. **Cosmetics:** Face cream–Sun screen lotion–shaving cream–composition and formulation–Uses and hazards, Sprayer–Hand lotion–nail lacquers–nail bleaches–hair oil–hair dyes–composition and formulations–Uses and hazards

Chemistry of Drugs: Classification of drugs based on structure and action: Antibacterial: sulfa drugs, synthesis of sulfathiazole, sulfapyridine, Antibiotics: β-Lactam antibiotics and synthesis of penicillin, chloramphenicol, Antiviral drugs: Azidothimidine, acyclovir; Antipyretics: Paracetamol, Analgesics: Analgine, Non-steroidal anti-inflammatory drugs: Ibuprofen, Antimalarial: Chloroquine, Antacids: Ranitidine

Engineering Materials: Energy materials, soft materials, smart materials, organic electronics, semiconductors, insulators, corrosion inhibitors

Introduction to Green Chemistry: Principles of green chemistry (12 principles), Green reagents (water and bio-based), solvents (green solvents eg. Water), and alternative reaction media (ionic liquids), multicomponent reactions, atom economy (examples: Diels-Alder reaction, Claisen rearrangement), sustainable organic chemistry

Food Chemistry: **Flavouring agents:** Definition of flavours–Classification–Chemical composition–common characteristics–Formulations–Uses and hazards, Preserving agents, antioxidants, ***Sugar industry*****:** Double sulphitation process. Refining and grading of sugar. Saccharin: synthesis and use as a sugar substitute – aspartame (structure and synthesis). Ethanol: manufacture from molasses by fermentation.

Learning Resources:

Text Books:

1. Synthetic Organic Chemistry, **G. R. Chatwal and Gurudeep**, Himalaya Publishers, 2009.
2. Medicinal Chemistry, **Ashutoshkar**, New Age Publications, 5th Ed. 2010
3. New trends in green chemistry: **V. K. Ahluwalia, M. Kidwai**, New Age Publications, 2004
4. Food Science, **Srilakshmi B.,** New age International Pvt. Ltd. Publishers, III ed. 2003.

Reference Books:

1. Edition Polymers: Chemistry and Physics of Modern Materials, 3rd Edition, **John W. Nicholson**, Royal Society of Chemistry, 2012.
2. High-Performance Organic Coatings, Ed. by **A S Khanna**, Elsevier, 2008.
3. Green Chemistry: Theory and Practice. **P.T. Anastas and J.C. Warner.** Oxford University Press, 2000.
4. Food Chemistry, By **H.D. Belitz, Werner Grosch, Peter Schieberle**, 4th Edition, Springer Science & Business Media, 2009.

Course Code: MAI302	NUMERICAL METHODS LABORATORY	Credits 3-0-0:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	solve algebraic, transcendental equation
CO2	solve the system of equations
CO3	find the various orders of finite differences values
CO4	evaluate the definite integrals numerically
CO5	solve the initial value problems numerically

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	2	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Programs Based on Numerical methods using FORTRAN.

1. Programs for solution of quadratic equation
2. Solution of algebraic and transcendental equations
3. Gauss-Seidel iteration method
4. Gaussian elimination
5. Inverse of a matrix
6. Formation of finite differences table
7. Lagrange's interpolation
8. Numerical integration
9. Euler's and modified Euler's methods
10. Runge-Kutta 4th order method

Course Code PHI302	BASIC ELECTRONICS LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Comprehend the operating principles of electronic components like resistor, diode, LED etc.
CO2	Design circuits for studying the characteristics of rectifier diode, LED and photo-diodes
CO3	Analyse output wave forms and also measure voltage and current of half and full wave rectifiers
CO4	Verify the characteristics of NPN (CE, CB and CC configurations) transistor and FET
CO5	Verify truth tables of basic digital logic gates and troubleshoot related circuits in general

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	1	--			
CO2	2	3	3	1	-			
CO3	2	3	3	1	-			
CO4	2	3	3	1				
CO5	2	3	3	1				

Experiments:

1. Obtain I-V characteristics of semiconductor rectifier diode, LED, and Photo-diode
2. To observe waveform at the output of half wave rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
3. To observe waveform at the output of full wave rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
4. To observe waveform at the output of bridge rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
5. To construct clamper circuits on breadboard and to observe waveforms at the output of clamper circuits
6. To construct clipper circuits on breadboard and to observe waveforms at the output of clipper circuits
7. To obtain common emitter, common base and common collector characteristics of NPN transistor

8. To design and construct common emitter amplifier circuit on breadboard and to measure gain at different frequencies and to plot the frequency response
9. To understand the working of transistor as a switch. To draw DC load line for given circuit.
10. To observe input-output waveforms of common collector (CC) amplifier and to measure gain of amplifier at different frequencies and to plot the frequency response
11. To obtain characteristics of field effect transistor (FET) and to measure gain of FET common source (CS) amplifier.
12. To construct and verify truth table of basic digital logic gates OR, AND, NOT, NAND, NOR, EX-OR, EX-NO

Learning Resources:

Text Books:

1. Electronics Lab Manual, Department of Physics, NITW,2021
2. Experiments Manual for Use with Electronic Principles By **Albert Paul Malvino, Patrick Hoppe, David J. Bates** ,MCG Hill, 2015

Reference Books:

1. Problems and Solutions in Basic Electronics, **Albert Malvino & David J Bates** McGraw Hill Education, Special Indian edition,2011.
2. Electronic Devices and Circuits with simulation by **Jacob Millman, Chrisots C. Halkias, Satyabrata Jit.**TMGHill, 2009.

Online Resources:

1. http://vlabs.iitkgp.ac.in/be/

Course Code: CYI302	ORGANIC CHEMISTRY LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

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

CO1	Understand the physical properties and solubility of the organic molecules
CO2	Identify the organic compounds using chemical tests
CO3	Understand the reactivity of functional groups present in the molecules
CO4	Use the derivatization techniques to confirm the compound present in given mixture
CO5	Apply the experimental organic chemistry for the preparation of value added product
CO6	Apply the knowledge of organic chemistry for the separation of compounds from a complex mixture

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	1	1	-			
CO2	2	2	2	1	-			
CO3	2	1	3	1	-			-
CO4	2	3	1	1	-			-
CO5	2	2	2	1				-
CO6	1	1	1	1				-

Syllabus:

Binary mixtures: Separations of two components mixture of organic compounds and systematic identification of each of the component (organic compounds) by using: Preliminary examination, identification of extra elements

Binary mixtures: Separations of two components mixture of organic compounds, common functional group tests, specific functional group tests-preparation

Binary mixtures: Separations of two components mixture of organic compounds and systematic identification: rationale derivatives (at least two) and final identification of given compounds by checking melting points of its derivatives (and comparing with literature):

Mixture for analysis: strong acid + neutral, base + neutral, weak acid + neutral, amino acid + neutral, carbohydrate + neutral

Strategy and planning of an organic experiment based on synthesis: Calculations, Preparation of polymer (Bakelite), Preparation of Dye (Azo dye); Drug (Aspirin), Preparation of a pesticide, conducting polymer (polypyrrole/polyaniline).

Learning Resources:

Text Books:

1. Practical Organic Chemistry-G. Mann & B.C Saunders, ELBS Edition and Longman Group Limited, 2002
2. Text Book of Practical Organic Chemistry, Vogel A.I., 5th Edition, ELBS, 2004.

III Year II Semester

Course Code: MAI351	REAL ANALYSIS	Credits 3-0-0:3

Pre-Requisites: MAI101

Course Outcomes:

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

CO1	Describe the fundamental properties of real numbers that underpin the formal development of real analysis
CO2	Apply the understanding of the theory of sequences and series
CO3	Understand the concepts related to metric spaces such as continuity.
CO4	Apply the mean value theorems and the fundamental theorem of calculus to problems in the context
CO5	Adapt with the skills in constructing mathematical arguments

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	1	-	-	-	-
CO3	2	2	2	1	-	-	-	-
CO4	3	2	2	1	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Sequence and Series of Real Numbers: Equivalence and countability of sets, real numbers, least upper bounds and greatest lower bounds;

Sequences of real numbers – convergence and divergence of sequences, bounded and monotone sequences, operations on sequences, limit superior and limit inferior, Cauchy sequences;

Series of real numbers – convergence and divergence, series with non-negative terms, alternating series, conditional and absolute convergence of series, rearrangement of series, Tests of absolute convergence – comparison test, ratio test, root test; powers series and radius of convergence; series whose terms form a non-increasing sequence; summation by parts;

Metric Spaces and Continuous Functions: Limit of a function on the real line; metric spaces; point set topology on metric spaces; open sets; closed sets; limits in metric spaces; continuous functions on metric spaces;

Calculus: Definition of Riemann integral; existence; properties of Riemann integral; derivatives; mean value theorems; fundamental theorem of calculus;

Learning Resources:

Text Books:

1. Methods of Real Analysis, **Richard R. Goldberg**, John Wiley & Sons, Reprint by Oxford and IBH Publishing, 2020, Second Edition

Reference Books:

1. Introduction to Real Analysis, **Robert G. Bartle & Donald R. Sherbert**, Wiley India, 2014, Fourth Edition
2. A Basic Course in Real Analysis, **Ajit Kumar & S. Kumaresan**, CRC Press, 2016 Special Indian Edition
3. Mathematical Analysis, **Tom M. Apostol**, Addison-Wesley, 1974, Second Edition

Course Code: MAI361	ANALYTICAL SOLID GEOMETRY	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	To understand the fundamental concepts of 3D geometry
CO2	To describe some of the surfaces using 3D geometry
CO3	To explain the properties of planes, lines, spheres and cones.
CO4.	To interpret the problems geometrically and then to get the solution.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	2	-	-	-	-

Syllabus:

The Plane: Equation of plane in terms of its intercepts on the axis, Equations of the plane through the given points, Length of the perpendicular from a given point to a given plane, Bisectors of angles between two planes, Combined equation of two planes, Orthogonal projection on a plane.

Sphere: Definition-The Sphere through four given points-Equations of a Circle - Intersection of a Sphere and a Line - Equation of a tangent Plane - Angle of Intersection of Two Spheres - Radical Plane.

Cones: Definition-Condition that the General Equation of second degree Represents a Cone -Cone and a Plane through its Vertex - Intersection of a Line with a Cone - The Right Circular Cone.

Cylinders: Definition of a cylinder. Equation to the cylinder whose generators intersect a given conic and are parallel to a given line, Enveloping cylinder of a sphere. The right circular cylinder. Equation of the right circular cylinder with a given axis and radius.

Learning Resources:

Text Books

1. *Analytical Solid Geometry,* **Shanti Narayan and P K Mittal**,*S. Chand Limited, 2007* (7th edition).
2. Elementary Treatise on Coordinate Geometry of Three Dimensions, **R. J. T. Bell**, Macmillan India Ltd, 1994.

Reference Books:

1. *A Text Book of Analytical Geometry of Three Dimensions*, **P.K. Jain and Khaleel Ahmed** Wiley Eastern Ltd., 1999.

Course Code: MAI362	DATA SCIENCE	Credits 3-0-0 :3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Interpret the basic concepts and applications of Data Science
CO2	Learn about the basic concepts of Mathematics and Statistics
CO3	Interpret the Visualization and Communicating data
CO4	Learn the essentials of Machine Learning and its applications
CO5	Explain the thematic ideas of Data Science

CO-PO/ Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	2	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Basics of Data Science (DS): Introduction to DS, Venn Diagram of DS, Terminologies, Case Studies, Types of data, structured Versus unstructured data, quantitative Versus qualitative data, the four levels of data, five steps of DS.

Mathematical Basics: Probability theory including random variables, conditional probability, Bayes law, concentration of measure, martingales; graph theory including basic definitions, spanning trees, connectivity, cuts; elementary spectral graph theory.

Basic Statistics: Measures of Central tendency, Measures of Dispersions, Concepts of Estimations and Confidence Intervals

Communicating Data: Visualizations of data, Scatter plots, Line plots, Bar charts, Histograms, Box plots . Frequency distribution of Categorical data, Best practices for graphing Categorical data.

Machine learning (ML) essentials: Types of ML, Linear regression, Logistic regression, Simple Applications, Naïve Bayes classification, Decision trees, k-means clustering

Thematic ideas for DS: Data Imputation, Bootstrapping, Cross-Validation, Kernel trick/Lifting to higher dimension, Boosting

Learning Resources:

Text Books

1. Principles of Data Science, **Sinan Ozdemir, Packt**, 2016
2. Data Science Fundamentals and Practical Approaches, **Gypsy Nandi & Rupam K Sharma,** BPB, 2020
3. Data Visualization Handbook, **J Koponen & J Hidden**, CRC Press, 2019

Reference Books:

1. Practical Statistics for Data Scientists, **Peter Bruce**, Oreilly, 2020, 2nd Edition
2. Data Science and Big Data Analytics, EMC Education Services, Wiley, 2015
3. Introducing Data Science, **Davy C, Maysman A D B & Md Ali,** Dreamtech Press, 2016

Online Resources:

1. https://ocw.mit.edu/courses/mathematics/18-s096-topics-in-mathematics-of-data-science-fall-2015/
2. https://ocw.mit.edu/courses/sloan-school-of-management/15-075j-statistical-thinking-and-data-analysis-fall-2011/

Course Code: MAI363	ELEMENTARY NUMBER THEORY	Credits 3-0-0: 3

Pre-Requisites: MAI201

Course Outcomes:

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

CO1	Demonstrate the knowledge of distribution of prime numbers.
CO2	Utilize the Chinese remainder theorem to solve simultaneous linear congruences.
CO3	Illustrate number theoretic functions and their properties.
CO4	Solve equations involving quadratic residues.
CO5	Solve certain types of Diophantine equations.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--	-	-	-
CO2	3	2	2	2	-	-	-	-
CO3	2	2	2	2	-	-	-	-
CO4	3	2	2	2	-	-	-	-
CO5	3	2	2	1	-	-	-	-

Syllabus:

Divisibility: Division algorithm, Greatest common divisor, Euclidean algorithm, Least common multiple, Prime numbers and their properties, Fundamental theorem of arithmetic.

Congruences: Introduction to congruences, Linear congruences, The Chinese remainder theorem, Divisibility tests. Arithmetic functions and its properties, Mobius inversion formula, The Euler φ function and other multiplicative functions, Fermat's little theorem, Euler's theorem, and Wilson's theorem.

Quadratic Residues: Primitive roots, Quadratic residues, Legendre symbol, Law of quadratic reciprocity, The Jacobi symbol-properties.

Diophantine Equations: Diophantine equations, Pythagorean triples, Sums of squares.

Learning Resources:

Text Books:

1. An Introduction to the Theory of Numbers, **Ivan Niven, Herbert S. Zuckerman, and Hugh L. Montgomery**, Wiley, 5th edition, 1991.
2. Elementary Number Theory and its Applications, **Kenneth H. Rosen**, Addison-Wesley, 6th edition, 2011.

Reference Books:

1. The Higher Arithmetic: An Introduction to the Theory of Numbers, **H. Davenport, and James H. Davenport**, Cambridge University Press, 8th edition, 2008.
2. Elementary Number Theory, **David M. Burton**, Mc Graw Hill, 2011.

Online Resources:

1. https://ocw.mit.edu/courses/mathematics/18-781-theory-of-numbers-spring-2012/index.htm
2. https://nptel.ac.in/courses/111/103/111103020/

Course Code: PHI361	ANALYTICAL CHARACTERIZATION TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

After successful completion of the course, the student will be able to:

CO1	Describe and differentiate different analytical methods of characterizing materials.
CO2	Distinguish between qualitative and quantitative measurements and be able to effectively use them for research and analysis.
CO3	Understand and be able to apply the knowledge of theory and operational principles of analytical instruments.
CO4	Appreciate the relative strengths and limitations of different techniques.
CO5	Comprehend the concept of theory, method of calibration and operation of the instrument.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	--			
CO2	3	2	2	2	-			
CO3	2	2	2	2	-			
CO4	3	2	2	2				
CO5	3	2	2	1				

Syllabus:

OPTICAL CHARECTERIZATION TECHNIQUES: Electromagnetic spectrum- Spectral methods of analysis-Absorption spectroscopy -Emission Spectroscopy -Beer Lamberts Law. Ultraviolet-visible Spectrophotometer. IR Spectrophotometer: Sources and detectors -FTIR spectrometer. Fluorescence Spectroscopy: Emission of Radiation-Photoluminescence-Phosphorescence Mass spectrometry: Sources and detectors- operation and applications.

DIFFRACTION TECHNIQUES : X-Ray Diffraction (XRD): Bragg's Law-X-Ray Spectrophotometer-Identification of Phases-Determination of Size of Crystallites.
Electron Diffraction (ED): Instrumentation, working and applications.

SURFACE ANALYSIS TOOLS : Optical Microscope- Resolution Limit. Electron Microscopes: Scanning Electron Microscope and Transmission Electron Microscope. Scanning Probe Microscopes: Scanning Tunneling Microscope -Atomic Force Microscope.

THERMAL ANALYSIS TECHNIQUES : Thermogravimetric Analysis (TGA): Weight/mass loss of materials as a function of temperature. Differential Scanning Calorimetry (DSC): detection of phase transition- concept of glass transition temperature and melting point.

Learning Resources:

Text Books:

1. Handbook of Analytical Instruments, **R.S. Khandpur**, McGraw Hill, 2nd Edition, 2006.
2. Principles of Instrumental Analysis, **Skoog D.A and F.J. Holler, S.R. Crouch**, Cengage Learning, 2006.

Reference Books

1. Materials Characterization, **P.C. Angelo**, Elsevier, 2014.
2. Characterization of Materials (Materials Science and Technology: A Comprehensive Treatment,Vol 2A & 2B, VCH ,1992
3. Materials Characterization Techniques,**S Zhang, L. Li and Ashok Kumar**, CRC Press ,2008
4. Physical methods for Materials Characterization,**P.E. J. Flewitt and R K Wild**, IOP Publishing

Online Resources:

1. https://www.aif.ncsu.edu/mct/
2. https://tdx.cat/bitstream/handle/10803/8595/13.pdf?sequence=16

Course Code: PHI362	ELECTRONIC INSTRUMENTATION	Credits 3-0-0:3

Pre-Requisites: NIL

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

CO1	Understands the principle of Oscilloscopes and Wave analysers
CO2	Identifies the suitable signal source for various applications
CO3	Configure and operate the spectrum and network analysers in real life applications
CO4	Customize software and modular measurement hardware to create user-defined measurement systems, called virtual instruments
CO5	Able to calibrate various practical instruments

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	2	--			
CO2	3	3	3	2	-			
CO3	3	3	3	1	-			
CO4	2	3	3	2				
CO5	2	3	4	2				

Syllabus:

Oscilloscopes and logic analyzers: Basic operation and advanced techniques, digital storage oscilloscope- sampling methods; controls- display, vertical, horizontal, trigger and acquisition controls; Measurements- voltage, time, frequency, pulse, rise time and fully automated measurements. Logic analyzer- types, logic timing analyzer (LTA), logic state analyzer (LSA), block diagram, interfacing.

Signal sources and arbitrary waveform generators: Introduction, fixed and variable AF oscillator, standard signal generator, laboratory type signal generator, AF sine and square wave generator, function generator, square and pulse generator, sweep generator, arbitrary waveform generators.

Spectrum and network analyzers: Wave analyzers- resonant, frequency selective, heterodyne- applications; Harmonic distortion analyzer, Spectrum analyzers, applications of spectrum analyzers, fundamental principles of network analyzer.

Virtual instrumentation: Personal computer for data acquisition and instrument control, instrument drivers and driver software. application software lab view.

Calibration of instruments: Calibration of practical instruments, types of DMM, general DMM calibration requirements, calibration of oscilloscopes, calibration of high-speed DSO's automated calibration and calibration software.

Learning Resources:

Text Books:

1. Digital and analogue instrumentation: testing and measurement**, Kularatna, A.D.V.N**, Prentice Hall India, 2001.
2. Electronic Instruments and Instrumentation Technology, **M.M.S. Anand**, PH India, 2005.

Reference Books:

1. Electronic Instrumentation, **H.S. Kalsi**, Mc Graw Hill Education, 2015, 3rd ed.
2. Electronic Instruments and Measurements, **David A. Bell**, Oxford Higher Education, 2015, 3rd Ed.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105153/

Course Code: PHI363	BASIC PHOTOVOLTAIC DEVICES AND APPLICATIONS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Fundamentals of PV systems and its various applications.
CO2	The principle of direct solar energy conversion to power using PV technology.
CO3	The structure, materials and operation of solar cells, PV modules, and arrays.
CO4	The socio-economic and environmental merits of photovoltaic systems for a variety of applications.
CO5	The prospects of photovoltaic technology for sustainable power generation.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	2	--			
CO2	3	3	3	2	-			
CO3	3	3	3	1	-			
CO4	2	3	3	2				
CO5	2	3	4	2				

Syllabus:

Introduction: Semiconductors, PN junction, abrupt and graded junctions, junction in equilibrium, biasing, energy band diagram, hetero and Schottky junctions, built-in voltage, junction capacitance.

The Photovoltaic (PV) Effect: Need for Solar cells, Various generations of solar cells, photovoltaic effect - Principle, design and working of solar cells, energy level alignment, basic equations, characteristics, efficiencies.

Physical Aspects of Solar Cell Efficiency: Energy losses in solar cells, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, Effect of irradiation, temperature and relative humidity.

Design, Fabrication and Applications of PV cells: Design and various fabrication techniques for solar PV systems, Building-integrated photovoltaic unit, stand-alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Learning Resources:

Text Books:

1. *Solid State Physics*. By **Ashcroft, N., and D. Mermin**, Holt, Rinehart and Winston, 3rd edition,2021
2. *Photovoltaic Materials by* **Bube R.** *Imperial college press,1998.*

References:

1. *Introduction to Solid State Physics* by **Kittel, Charles** 8th ed. John Wiley & Sons, 2004.
2. Photovoltaic Solar Energy: From Fundamentals to Applications by **Angèle Reinders, Pierre Verlinden, Wilfried van Sark**, Wiley publishers,· 2017

Online Resources:

1. https://www.nrel.gov/docs/legosti/old/1448.pdf

Course Code: PHI364	FUNDAMENTALS OF NANOMATERIALS AND APPLICATIONS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand why nanomaterials exhibit varying properties compared to their bulk counterparts
CO2	Distinguish various nanostructured materials based on size, shape, properties and functionalities
CO3	Comprehend and choose appropriate method for synthesis of nano-structured materials
CO4	Understand characterization techniques and estimate grain size and bandgap using formulations
CO5	Understand and appreciate applications of various nanomaterials in a variety of fields

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	2	--			
CO2	3	3	3	2	-			
CO3	3	3	3	1	-			
CO4	2	3	3	2				
CO5	2	3	4	2				

Syllabus:

Introduction to miniaturization: Historical background, Development of nanomaterials, units, Scaling laws, organization of matter- atoms, molecules, clusters and supramolecules.- Structure and Bonding, Hierarchical, molecular and crystalline structures - Bulk to surface transition, Quantum size effects, density of states, band gap and dimensionality, surface reconstruction, self-assembly.

Classification of Nanomaterials: Nomenclature of nanomaterials, 2D materials, Carbon based materials, self-assembled nanomaterials, core-shell particles, Nano metals, Nano-composites, contemporary nano-structured / nano-dimensional thin films

Physical and chemical methods for synthesis of Nanomaterials: Top down and bottom up approaches - Mechanical milling, evaporation, IGCT, vapour transport, molecular beam epitaxy, laser deposition, Colloidal and sol-gel techniques, size distribution, properties variation and yield of nanomaterials, Bio-inspired and template methods.

Nanomaterial characterization techniques: X-Ray Diffraction, Grain Size estimation, UV-Vis spectroscopy, Effect of grain size - Scanning and Transmission electron microscopy, Particle size analyzer, scanning probe/tunneling and Atomic force microscopy and surface techniques.

Applications of Nanomaterials: Mechanical, magnetic, electrical, optical, biocompatibility, toxicity, chemical, gas and bio-sensing, battery and energy harvesting applications, textiles, cosmetics, drug delivery, Magnetic hyperthermia, defense, and other contemporary applications.

Learning Resources:

Text Books:

1. Nanotechnology: principles and practices by **Sulabha K. Kulkarnl**, Springer publications, 3rd edition,2019.
2. NANO, The Essentials, **T. Pradeep**, Tata McGraw-Hill, 2008

Reference Books:

1. *Nanophysics and Nanotechnology,* **Edward L. Wolf**, Wiley-VCH, 3rd edition,2015.
2. Springer Handbook of Nanomaterials, **-by Robert Vajtai**, 2013.
3. Nanotechnology the whole story, -by **B. Rogers, J Adams and S. Pennathur**, CRC Press, 2013.

Online Resources:

1) https://www.understandingnano.com/resources.html
   https://www.classcentral.com/subject/nanotechnology

Course Code: CYI361	BASIC ORGANOMETALLIC CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand the structure and bonding aspects of organometallic compounds
CO2	Apply different electron counting rules to predict the shape/geometry of metal carbonyl clusters
CO3	Predict the chemical behavior and reactivity of main group and transition metal organometallic compounds
CO4	Establish the structure-reactivity/activity relationship in organometallic chemistry
CO5	Apply the above concepts to different catalytic reactions

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	1	-	-	-	-
CO2	2	2	2	1	-	-	-	-
CO3	2	1	1	2	-	-	-	-
CO4	2	1	1	2	-	-	-	-
CO5	1	2	1	2	-	-	-	-

Syllabus:

Introduction: Definition, History and Importance of Organometallic Chemistry, Revision of 18-electron rule, Spectator ligands: Phosphine and N-Heterocyclic carbenes.

Reactions in Organometallic Chemistry: Oxidative addition and reductive elimination, insertion and elimination reactions, Ligand substitution reactions, Fluxionality.

Metal sigma and pi complexes: alkyls, Alkene and alkyne: Synthesis, bonding and reactivity β-hydride elimination, Agostic alkyls, Cyclic and acylclic polyenes: Cyclopentadiene-Synthesis, structure and properties of sandwich compounds, Ferrocene-preparation, properties, structure, bonding and MOED of ferrocene. Arene sandwich compounds, Allyl and 1,3 butadiene: Synthesis, bonding and reactivity, Davies Green Mingo rules.

Metal-Ligand multiple bonds and clusters: Carbenes and Carbyne complexes: Synthesis and reactivity of carbine and carbine complexes, Metal clusters: Dinuclear, multinuclear clusters.

Main group organometallics: Structure and bonding Organolithium, Organomagnesium, organoaluminum.

Learning Resources:

Text Books:

1. Basic Organometallic Chemistry- Concepts, Synthesis and Applications, **BD Gupta and AJ Elias**, Universities Press Private Limited, India, 2011.
2. The Organometallic Chemistry of the Transition Metals, **Robert H. Crabtree**, Wiley, 2014, 6th edition.

Reference Books:

1. Inorganic Chemistry, **Catherine E. Housecroft and Alan G. Sharpe**, Pearson, 2018, 5th edition.
2. Inorganic Chemistry, **D. F. Shriver and P. W. Atkins**, Oxford University Press, 2006, 4th edition.

Course Code: CYI362	CHEMICAL EDUCATION	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Appreciate the General Attributes that Make Chemistry the Central Science
CO2	Appreciate the Involvement of Both Amazements and Hazards in Chemical Practices
CO3	Justify the Importance of Experiments in Making Chemical Concepts Understood
CO4	Use various Tools and Models as Means of Understanding Chemistry and Upload Videos
CO5	Teach Chemistry with Confidence if Chooses teaching of Chemistry as a Profession

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	1		-	-	-
CO2	2	2	2	1			-	-
CO3	2	1	1	2			-	-
CO4	2	1	1	2		-	-	-
CO5	1	2	1	2		-	-	-

Syllabus:

Chemistry as the Central Science: Uniqueness of Chemical Stoichiometry, Chemistry of Inanimate and Living Materials, Chemistry and Civilization, Chemistry in Product Industry, UN Slogan, '*Chemistry- Our Life and Our Future*'; *Amazements in Chemistry*: Amusement in Chemistry Classroom, Chemistry and Magic.

Thrust Areas of Chemical Research: Topic by Relevance to Health, Nutrition, Energy, Environment, Sanitation, Technology, Rural Employment, Harnessing Natural Resources.

IPR and Patents in Chemical Research and Innovations: Intellectual Property Rights in Chemical Innovations and Products, Patent Paradigms

Virtual Reality and Computational Tools: Models and Simple Demonstrations, Chemical Databases, Molecular Modeling, Online Chemistry Learning, Chemistry Lecture Videos, Chemical Docking, 2D and 3D Graphs and Steriodiagrams and Optical Devices.

Chemical Journalism: Chemical Research Literature, Chemistry Book Writing and Documentation, Syllabi for Teaching Chemistry to Engg, Medicine, Chemical Physics.

Learning Resources:

Text Books:

1. Chemical Education, **S. Ladage and S.D. Samant**, Narosa Publishing House, 2012.
2. Essentials of Chemical Education, **H. D Barke, G. Harsch, S. Schmid and H. Gerdau**, Springer, 2015.

Reference Books:

1. Multiple Representations in Chemical Education: Models and Modeling in Science Education, **J. K. Gilbert, and D. Treagust**, Springer, 2009.
2. All About Chemistry; Big Questions, **Robert Winston, D.K.** Children, 2015.

Course Code: CYI363	BIOORGANIC CHEMISTRY	Credits 3-0-0:3

Pre-Requisites: NIL

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

CO1	Understand the importance of building blocks and molecular recognitions. recognitions.
CO2	Classify structure and functions of different bioorganic molecules
CO3	Familiar with structure and functions of plant and animal cells.
CO4	Understand the physiological role of RNA, DNA and enzymes
CO5	Apply enzyme catalysis in industrial applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	1	-	-	-	-
CO2	2	2	2	1	-	-	-	-
CO3	2	1	1	2	-	-	-	-
CO4	2	1	1	2	-	-	-	-
CO5	1	2	1	2	-	-	-	-

Syllabus:

Introduction to Bioorganic Chemistry: Overview of bioorganic chemistry- historical connection between organic and biological chemistry; weak interactions in organic and biological systems; proximity effect in organic chemistry; molecular recognition; chemistry of the living cells; analogy between biochemical and organic reaction.

Amino acids, peptides and proteins: Amino acids: structure, acid-base chemistry, and

chemical synthesis; Asymmetric Synthesis of Amino Acids, Proteins and Peptides: Introduction, Quaternary Structure of Proteins, Protein Purification Methods, amino acid analysis and peptide sequencing; peptide bond formation and coupling reagents-carbodiimides and phosphonium reagents; orthogonal protecting groups; solid-phase peptide synthesis: (Fmoc/Boc strategies); native peptide ligation; cyclic peptides; enzyme chemistry; Introduction, proteases and phosphotases; Enzyme Inhibiton and Drug design; proteins as drug targets, Enzyme technology, Enzyme catalysis; Biomimetic Polyene Cyclisation; Squalene biosynthesis

Lipids and fatty acids: Introduction, classification and functions of lipids. Saturated and unsaturated fatty acids. Essential fatty acids. Triacylglycerides and their properties

Carbohydrates: Introduction to carbohydrates; structure, configuration and conformation; common protecting groups and protecting group strategies; glycosylation: general concepts, various methods of glycoside bond formation; strategies in oligosaccharide synthesis: automated and enzymatic approaches; glycoconjugates: glycolipids and glycoproteins; fundamentals of glycobiology; tools for glycomics; carbohydrate based drug discovery.

Nucleosides, nucleotides and nucleic acids: Introduction to nucleic acids: biological importance, discovery, structure; chemical synthesis of nucleosides and protecting groups for nucleobase, sugar and phosophates; solution and solid phase synthesis of oligonucleotides: PCR; enzymatic synthesis of nucleic acids; principle behind sequencing; nucleic acid as drug targets.

Learning Resources:

Text Books:

1. Bioorganic Chemistry-A chemical Approach to Enzyme Action, **Hermann Dugas**, Springer, 1999, 3rd Edition
2. Principles of Biochemistry, CBS, **Lehninger, Nelson and Cox**, 2001, 2nd edition.

Reference Books:

1. Biochemistry, **Harpe**r, McGraw-Hill, 2012, 29th Edition.
2. The organic chemistry of enzyme-catalyzed reactions, **Richard B.Silverman**, 1999, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/104/103/104103018/

Course Code: CYI364	INSTRUMENTAL ANALYSIS FOR INDUSTRIAL APPLICATIONS	Credits 3-0-0:3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Explain the theoretical principles behind the instrumental techniques and their applications
CO2	Model concepts and techniques in instrumental analysis independently towards industrial applications
CO3	Analyze instrumental results for deriving conclusions with relevance to experimental evidences
CO4	Assess the appropriateness of an instrumental method for the analysis of samples in various formats and from complex matrices
CO5	Design experimental methodology for determining analytes of interest of domestic and industrial applications

Course Articulation Matrix :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	1		-	-	-
CO2	2	2	2	1		-		-
CO3	2	1	1	2		-	-	-
CO4	2	1	1	2				-
CO5	1	2	1	2				-

Syllabus:

UV-Visible Spectrophotometry and Fluorescence: Overview of bioorganic chemistry-historical connection between organic and biological chemistry; weak interactions in organic

Beer-Lambert's law, Instrumentation of Absorption Spectrophotometer, Quantitative analysis, limitations, Enzyme linked immunosorbent analysis (ELISA), Molecular fluorescence, influencing factors, basic instrumentation, standardization, quantitative methods, Applications, Diagnostics of biomarkers.

Thermoanalytical methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications.

Chromatography methods: Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications, Capillary Electrophoresis: Principle and application.

Surface area and Particle size Analyses: BET- Principle, Pore width, particle size and surface area analysis, Dynamic light scattering – Principle, instrumentation and applications.

X-ray spectroscopic and diffraction methods: X-ray absorbance and fluorescence, Principle, instrumentation, quantitative analysis. X-ray diffraction, Principle, Crystal structure and size analyses. Medical diagnostics, Analysis of geological samples and ores.

Microscopic methods: SEM, Principle, Sample preparations, Surface morphology and particle size analysis, TEM, Principle, Sample preparation, Surface morphology, Structural determination of nanoparticles. Metal and non-metal nanocomposites, industrial materials.

Atomic spectrometry and atomic absorption: Atomization, Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects. Analysis of geological samples and ores.

Electroanalytical methods: Ion selective electrodes, Electrochemical sensors, Ion selective and Potentiometric sensors, Amperometry, Principles, Applications

Learning Resources:

Text Books:

1. Principles of Instrumental Analysis, **Douglas A. Skoog, F. James Holler, Stanley R. Crouch**, Cengage Learning India, 2020, 7th Edition.
2. Physical Methods for Chemists, **Russel S. Drago**, Saunders College Publishing, 2016, 2nd Edition.

Reference Books:

1. Instrumental Methods in Food and Beverage Analysis (Developments in Food Science), **D L B Wetzel** (Editor), George Charalambous (Editor), Elsevier, 1998.
2. The Analysis of Controlled Substances (Analytical Techniques in the Sciences (AnTs), **Michael D. Cole** (Author), Wiley, 2003.
3. A Practical Guide to Instrumental Analysis, **Erno Pungor** (Author), **G. Horvai** (Author), CRC Press, 2020.

Course Code: PHI351	ADVANCED PHYSICS LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Practical Exposure to different equipment.
CO2	Obtains practical knowledge about interferometer.
CO3	Practically understands the working of photo diode.
CO4	Learns to handle multimeter and CRO
CO5	experimentally demonstrate the concept of quantization of energy levels by simulation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	2	--			
CO2	2	3	3	2	-			
CO3	2	3	3	2	-			
CO4	3	3	3	2				
CO5	3	3	3	2				

List of Experiments:

1. Determination of plank constant by photo electric effect.
2. Determination of I – V characteristics of photo diode.
3. Fabrication and characterization of solar cell
4. Franck-Hertz Experiment
5. To experimentally demonstrate the concept of quantization of energy levels according to Bohr's model of atom.
6. Millikan's oil drop experiment
   a) To experimentally demonstrate the concept of Millikan's oil drop experiment.

b) To find the terminal velocity of the drop.) To find the charge on a drop.
7. Michelson's Interferometer-
   a) Determine the wavelength of light from a monochromatic source
   b) Determine the Refractive index of glass plate
8. Demonstration of X-Ray Diffractometer
9. Demonstration of UV-VIS spectrometer
10. Demonstration of Field Emission Scanning Electron Microscope
11. Demonstration of, FTIR
12. Measurement of different parameters by using Multimeter
13. Measurement of different parameters by using CRO and storage Oscilloscope

Learning Resources:

Text Books:

1. Physics Laboratory Manual by Physics Department, NIT Warangal,2021.
2. Practical Physics by **P.R. Sasi Kumar**, PHI publications, first edition,2011

Reference Books:

1. Practical Physics by **G.L. Squire**, Cambridge University press, fourth edition,2001.
2. Engineering Physics Practical by **Dr.S.K. Gupta** Krishna Prakashan Publications, ninth edition,2010

Online Resources:

1. https://nptel.ac.in/courses/115/105/115105110
2. Amrita virtual labs.

Course Code: CYI351	ANALYTICAL CHEMISTRY LABORATORY	Credits 0-0-3:1.5

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Show hands on experience to utilize various instruments for chemical analysis
CO2	Outline in detail the importance and accuracy of the instruments
CO3	Apply the knowledge in estimation of metal ions using instruments
CO4	Analyse emission and excitation spectra in evaluating photostability and photo reactivity
CO5	Determine biological and chemical oxygen demands of waste water for structuring treatment process

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	1	1		-	-	-
CO2	1	2	2	1		-	-	-
CO3	1	2	1	1		-	-	-
CO4	1	1	2	2	-	-	-	-
CO5	1	1	1	1	-	-	-	-

Syllabus:

1. Determination of dissolved oxygen and BOD of a water sample by Winkler's method
2. Determination of COD of a waste water sample by volumetric method
3. Verification of Beer-Lambert's law using permanganate solution
4. Simultaneous determination of Mn^{7+} and Cr^{6+} by spectrophotometric method

7th Semester

PH16001 **3-0-0 (3)**

Mathematical Physics

Pre-Requisites: None

Course Outcomes:

CO-1	Handle vector equations in generalized coordinates.
CO-2	Apply Fourier & Laplace transforms to solve problems.
CO-3	Solve arbitrary order linear differential equations with constant coefficients.
CO-4	Apply the concepts of probability and statistics to interdisciplinary problems.
CO-5	Apply mathematical physics to solve real life problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	-	-	-	-	-
CO-2	3	2	1	-	-	-
CO-3	2	3	2	-	-	-
CO-4	3	3	3	2	2	-
CO-5	3	3	2	2	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Generalized Coordinates: Recapitulation of Vector Algebra, Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Directional derivatives. Vector identities. Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Gauss' divergence theorem, Green's and Stokes Theorems and their applications

Fourier Transformations: Fourier Integral theorem, Fourier Transform (FT), Examples, FT of derivatives, IFT, Convolution Theorem, Properties of FT (translation, change of scale, complex conjugation), Application of FT to differential equations: 1D Wave and Diffusion/Heat flow Equations. Solution of ordinary and partial differential equations.

Laplace Transformations: Laplace Transforms (LT) of Elementary functions, Properties of LT: Change of Scale Theorem, Shifting Theorem, Derivatives, and Integrals of LTs. Inverse LT, Application of LT to Differential Equations: LCR, D-SHO

Differential Equations: Recapitulation of ODE; Differential operators; Common partial differential equations of physics; Techniques for solving partial differential equations; General solution; Homogeneous and non-homogeneous equations; Sturn-Liouville theory; Green function technique; Solution using Fourier transform; Nonlinear equation.

Probability and Statistics: Random Variables – Discrete and Continuous, Probability Distributions – Probability Mass Function; Probability Density Function and Cumulative (distribution) function and their properties, change of variables, Bivariate random variables, Joint Probability Density Functions, Marginal and Conditional Distributions, Moments & generating functions, Central Limit Theorem.

Learning Resources:

Text Books:

1. Mathematical Methods for Physicists, Arfken G, Weber H, and Harris F, Academic Press, 7th edition, 2013.

2. Vector Analysis, Schaum's Outlines Series, Murray Spiegel, Seymour Lipschutz, and Dennis Spellman, McGraw Hill Education, 2nd edition, 2017.

Reference Books:

1. Mathematical Physics: Applications and Problems, V. Balakrishnan, Ane Books, 1st edition, 2021.
2. Mathematical Methods for Physics and Engineering, Riley K F, Hobson M P, and Bence S J, Cambridge University Press, 3rd Edition, 2011.
3. Mathematical Methods in the Physical Sciences, Mary L. Boas, Wiley, 3rd edition, 2006.

Others Suggested Readings:

1. https://nptel.ac.in/courses/115/106/115106086/
2. https://onlinecourses.nptel.ac.in/noc21_ma27/preview

PH16003 **3-0-0 (3)**

Quantum Mechanics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the evolution of quantum mechanics.
CO-2	Solve potential well problems using Schrödinger wave equation.
CO-3	Analyse the commutation relations between spin and angular momentum.
CO-4	Apply variational principle and perturbation theory to standard systems as appropriate.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	1	-	-	-
CO-2	2	3	1	-	-	-
CO-3	2	3	1	-	-	-
CO-4	1	2	-	3	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Origin of Quantum Mechanics and One-Dimensional Problems: The development of quantum physics, basic preliminaries, wave particle duality, one dimensional Schrodinger equation, the free particle problem in one dimension, wave packets and group velocity. One-dimensional problems: Potential well of infinite and finite depths/potentials and the linear harmonic oscillator.

Three-Dimensional Problems: Angular momentum-I and rotation. Three-dimensional Schrodinger equation: Particle in a box with applications to the free electron model, particle in a spherically symmetric potential problem and the hydrogen atom problem.

Dirac's bra-ket algebra: Linear harmonic oscillator problem using bra-ket algebra, creation and annihilation operators, transition to the classical oscillator, coherent states.

The angular momentum-II: The angular momentum problem using bra-ket algebra, ladder operators, angular momentum and spin matrices. The Stern Gerlach and magnetic resonance experiments. Addition of angular Momenta and Clebsch Gordon coefficients.

Approximation methods: Perturbation theory, the variational principle and their applications.

Learning Resources:

Text Books:

1. Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, Trinity Press, 6th edition, 2020.
2. Introduction to Quantum Mechanics, David J. Griffiths and D. F. Schroeter, Cambridge University Press, 3rd edition, 2018.

Reference Books:

1. Quantum Mechanics: Concepts and applications, Nouredine Zettilli, John Wiley & Sons, 2nd edition, 2009.
2. Quantum Mechanics, G. Aruldhas, PHI Learning Private Ltd, 2nd edition, 2009.

Others Suggested Readings:

1. http://www.nptelvideos.in/2012/11/quantum-mechanics-and-applications.html
2. https://nptel.ac.in/courses/122/106/122106034/

PH25001 **3-0-0 (3)**

Classical Mechanics

Pre-Requisites: None

Course Outcomes:

CO1	Equipped to handle problems in modern classical mechanics
CO2	Apply the Lagrangian and Hamiltonian approach to classical problems
CO3	Solve particle system problems with constraints
CO4	Concepts of phase space and its dynamics
CO5	Applicable to understand condensed matter, high energy, statistical, quantum physics, and cosmology.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	2	3	1	-	-	-
CO3	2	3	1	-	-	-
CO4	1	2	-	3	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Selected mathematical physics topics: Generalized coordinates, calculus of variations. Gradient, divergence and curl theorem.

Review of Newton's laws of motion: work-energy theorem, conservative and non-conservative forces, and the concept of the potential energy function. Constraints, generalized coordinates, virtual displacements, the principle of virtual work, D'Alembert's principle, Lagrangian, and Lagrange equations. Variational principles and Lagrange's equations.

The central force problem: Derivation of Kepler's laws for the gravitational problem. Rotating frames of references, and pseudo forces. The kinematics and dynamics of rigid-body motion. Moment of inertia tensor, principal axes, and Euler's equations. The torque-free motion of a rigid body. Dynamics of a heavy symmetrical top with one fixed point. Theory of small oscillations.

Legendre transformation and Hamilton's equations of motion: Phase space and phase space trajectory. Canonical transformations and Poisson's brackets. Hamilton-Jacobi theory and action-angle variables.

Learning Resources:

Text Books:

1. An Introduction to Classical Mechanics (2nd ed), by D. Kleppner and R. Kolenkow, Cambridge University Press (2014).
2. Classical Mechanics (3rd ed), by H. Goldstein, C. Poole, and J. Safko, Pearson Education (2007).
3. N. C. Rana and P. S. Joag, Classical Mechanics.

Reference Books:

1. L. D. Landau and E. M. Lifshitz, Mechanics.
2. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics.
3. K. C. Gupta, Classical Mechanics of Particles and Rigid Bodies.

PH25003 **3-0-0 (3)**

Analog and Digital Electronics

Pre-Requisites: None

Course Outcomes:

CO1	Use of different semiconductor devices (Diodes, BJT and FET) in the circuits.
CO2	Examine the characteristics of various biasing transistors circuits (BJT and FET).
CO3	Implement the transistor circuits in the real-time applications.
CO4	Study the structure of various number systems and their applications in digital design.
CO5	Design and analyse various combinational and sequential circuits and timing problems.

Syllabus:

P-N Junction diode: P-N Junction diode characteristics, diode equation, ideal versus practical, diode capacitances, Temperature effect, Diode applications: series & parallel combinations, Half-wave-, full-wave-, and bridge- rectifier power supplies. Clippers and Clampers, voltage multipliers (Half and full wave doubles, and multipliers). Filters (C, L, π), load-line analysis. Zener diode characteristics, Zener voltage regulator. Tunnel Diode, Varactor Diode, SCR and photo diodes.

Bipolar Junction Transistor and Field Effect Transistor: BJT construction and operations (pnp and npn), Input and output (CB, CE, and CC) characteristics, α and β Parameters and their relations. *DC biasing BJTs, BJT AC analysis and amplifiers*: ac- domain analysis, hybrid- and r_e- equivalent models for CB and CE configurations. Small signal and high-frequency BJT amplifiers. Practical applications Field Effect Transistor: Construction and working of n-channel and p-channel JFET, Pinch- off voltage, Transfer characteristics, DC and AC analysis of various FET Biasing configurations, Small signal model of JFET. Construction, working, and transfer characteristics of MOSFET. FET Amplifiers: FET Common source small signal and high frequency amplifiers. Practical applications.

Basic logic circuits: Logic gates (AND, OR, NOT, NAND, NOR, Ex-OR, ExNOR and their truth tables), Universal Gates, Laws of Boolean algebra, De-Morgan's theorem, KMap, Simplification by boolean theorems. Logic Families: Introduction to digital logic family such as RTL, DTL, TTL, ECL, their comparative study, Basic circuit, performance characteristics, Wired logic, open collector output.

Combinational Logic: The Half adder, the full adder, subtractor circuit. Multiplxer demultiplexer, decorder, BCD to seven segment Decorder, Encoders. Flip flop and Timing circuits: set-reset laches, D-flipflop, R-S flip-flop, J-K Flip-flop, Master slave Flip flop, edge triggered flip-flop, T flip-flop.

Registers & Counters: Synchronous/Asynchronous counter operation,Up/down synchronous counter, application of counter, Serial in/Serial out shift register, Serial in/Serial out shift register, Serial in/parallel out shift register, parallel in/ parallel out shift register, parallel in/Serial out shift register, Bi-directional register.

Learning Resources:

Text books:

1. Integrated Electronics Analog Digital Circuits, Jacob Millman and D. Halkias, McGraw Hill.
2. Electronic Devices & Circuit Theory – Robert L Boylstad, Louis Nashelsky – Prentice Hall India Pvt. Ltd. Publications.
3. Electronic Devices & Circuits – Oxford University Press – David A Bell – 2010
4. Digital Fundamentals by Morris and Mano, PHI Publication

Reference Books:

1. Digital Fundamentals by FLOYD & JAIN, Pearsons Publications.
2. Fundamentals of Logic Design by Charles H. Roth Thomson.
3. Electronic Devices and Circuits, Balbir kumar, Shail B.Jain, PHI Privated Limted, Delhi.
4. Fundamental of digital circuits by A.ANANDKUMAR,PHI Publication
5. Electronic Devices and Circuits, S.Salivahanan,N.Suresh kumar, McGraw Hill.

PH16007 **0-1-2 (2)**

Optical Physics Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Select optical and mechanical housing for conducting experiments.
CO-2	Use the optical instruments judiciously.
CO-3	Use electronic circuitry required in optical experiments.
CO-4	Design experiments to verify principles of optics.
CO-5	Apply optical techniques for applications in metrology.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	1	1	1	3
CO-2	3	2	1	1	1	3
CO-3	2	3	3	3	2	2
CO-4	2	3	3	3	1	2
CO-5	1	2	2	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Determination of Wavelength of Light and Spacing between etalon using Fabry-Perot interferometer
2. Determination of Beam Parameters (Beam Waist, Gaussian profile) of a He-Ne Laser
3. Determination of wavelength of light and thickness of transparent glass plate using Michelson's Interferometer
4. Polarization and applications
    a. Verification of Malus Law
    b. Determination of refractive index of glass plate- Brewster's law
5. Determination of refractive index of liquids using Newton's Rings
6. a) Measuring the line spectra of various liquids using a prism spectrometer
   b) Determining the refractive index and dispersion of liquids using a prism spectrometer
7. Quarter-wavelength and half-wavelength plate
8. Interference at Fresnel's biprism with an He-Ne laser
9. Determination of the line splitting of two spectral lines using a Michelson interferometer

Learning Resources:

Text Books:

1. Fundamentals of Photonics, B. E. A. Saleh and M. Carl Teich, John Wiley & Sons, New York, 2nd Ed., 2007.
2. Optics, E. Hecht, Pearson Education, 5th Ed., 2016.

Reference Books:

1. Hand Book of Optics, Volume I - Geometrical and Physical Optics, Polarized Light, Components and Instruments, Third Edition by Michael Bass
2. Fundamentals of Optics, Fourth Edition by Francis A. Jenkins, Harvey E. White

Others Suggested Readings:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/index.html
2. https://www.rp-photonics.com/
3. https://ricktu288.github.io/ray-optics/
4. https://phet.colorado.edu/en/simulation/geometric-optics

PH25005 **0-1-2 (2)**

Analog and Digital Electronics Lab

Pre-Requisites: **None**

CO1	Characterize semiconductor devices in the circuits.
CO2	Verify the biasing characteristics of transistors.
CO3	Design the amplifiers using BJT and FET
CO4	Verify Truth-table of logic gates (Universal gates)
CO5	Construct and verify various combinational and sequential circuits.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	1	1	3
CO2	3	2	1	1	1	3
CO3	2	3	3	3	2	2
CO4	2	3	3	3	1	2
CO5	1	2	2	2	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Experiments:

1. Voltage-Divider bias – DC analysis
2. CE Transistor Amplifier – Voltage gain, Frequency Response and band width.
3. Field Effect Transistor (FET) Characteristics, Common Source FET Amplifier- Voltage gain, Frequency Response.
4. Verification of Universal gates
5. Adder and Subtractor (Half- and Full-) using logic gates.
6. Verification of Truth table of Flip-flops (JK, RS).
7. Combinational circuits – BCD to 7 segment LED display.
8. Sequential circuits – Shift register.
9. Verification of Counters (up/down, ripple).
10. Decoders/Encoders using logic gates

Learning Resources:

Text Books:

1. Electronics Lab Manual, Department of Physics, NITW,2021.
2. Experiments Manual for Use with Electronic Principles By Albert Paul Malvino, Patrick Hoppe, David J. Bates ,MCG Hill, 2015.
3. Digital Fundamentals by Morris and Mano, PHI Publication.
4. Electronic Devices and Circuits Theory, Boylsted, Prentice Hall Publications.

Reference Books:

1. Problems and Solutions in Basic Electronics, Albert Malvino & David J Bates McGraw Hill Education, Special Indian edition,2011.
2. Electronic Devices and Circuits with simulation by Jacob Millman, Chrisots C. Halkias, Satyabrata Jit.TMGHill, 2009.
3. Digital Design – M. Marries Mano.
4. Digital Fundamaentals by FLOYD & JAIN, Pearsons Pub 4. Fundamentals of Logic Design by Charles H. Roth Thomson.

8th Semester

PH16002 **3-0-0 (3)**

Electromagnetic Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Understand Maxwell's equations in electromagnetic wave propagation.
CO-2	Analyse boundary conditions of dielectric to dielectric and dielectric to conductor interfaces.
CO-3	Estimate the characteristic parameters of EM Wave
CO-4	Understand reflection, refraction, total internal reflection and Polarisation of plane waves.
CO-5	Apply electromagnetic field theory for wave guide applications and Optical Fibres.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	2	2	2	3
CO-2	3	3	-	2	1	1
CO-3	2	2	-	-	-	1
CO-4	1	2	2	1	2	1
CO-5	3	3	2	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Maxwell's Equations: Review of basic electromagnetic principles, deduction of Maxwell's equations, differential, integral and cylindrical coordinate form, boundary conditions.

Electromagnetic waves: propagation of plane electromagnetic wave in free space, wave equation for conducting medium, conductors and dielectrics, polarization, directional cosines, reflection and refraction of plane waves, reflection at normal and oblique incidence, Fresnel's equations, polarization by reflection, total internal reflection.

Pointing vector: pointing theorem and power flow, power loss in a plane conductor.

Wave guides: Parallel plane wave guides, TE, TM waves, transmission properties of TE, TM waves, voltage, current and power relations, rectangular wave guide, TE, TM waves, TE, TM waves in circular wave guides, attenuation factor and Q of wave guide, Propagation in wave guides with dielectric medium, dielectric slab wave guide.

Inhomogeneous wave equation: Inhomogeneous wave equation it's solution. Lineard-Wiechert potentials. Field of a uniformly moving charge. Fields of an accelerated charge, Radiation from a charge at low velocity. Radiation from a charge at linear motion and circular motion or orbit. Bremsstrahlung-Cerenkov radiation.

Learning Resources:

Text Books:

1. Introduction to Electrodynamics. J. Griffiths, PHI,4th edition, 2012
2. Electromagnetic waves and Radiating Systems, E. C. Jordan, K.G. Bahmain, PHI,2nd Edition, 2011.

Reference Books:

1. Classical Electromagnetic Radiation, M. A Hearld, JB Marion, Dover books, 3rd edition, 2012
2. Classical Electrodynamics, J. D. Jackson, Wiley, 3rd Ed, 2012.

Others Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104099/
2. http://courseware.cutm.ac.in/courses/electromagnetic-field-theory-transmission-lines/

PH16004 **3-0-0 (3)**

Atomic and Molecular Physics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the quantum aspects of atoms and molecules.
CO-2	Estimate energy level splitting of atoms in the presence of external electric and magnetic fields using quantum treatment.
CO-3	Comprehend the working principles of IR, UV-VIS, Microwave, Raman and NMR spectroscopic techniques.
CO-4	Apply the spectroscopy to study the properties of atoms and molecules.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	1	1	1	1
CO-2	3	3	2	2	1	1
CO-3	3	2	2	1	1	1
CO-4	3	3	3	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Theory of atoms: Quantum states of electron in atoms, Hydrogen atom spectrum, Electron spin, Stern-Gerlach experiment, Spin-orbit interaction, two electron systems, LS-JJ coupling schemes Fine structure, Spectroscopic terms and selection rules, Hyperfine structure, Exchange symmetry of wave functions, Pauli's exclusion principle, Periodic table, Alkali type spectra, Equivalent electrons, Hund's rule

Interaction of atoms with electric and magnetic field: Magnetic effects, Processional motion, Spin-orbit interaction, fine structure, Influence of external magnetic and electric field: Zeeman Effect, Paschen-Back effect, Stark Effect, g-factor. General factors influencing spectral line widths (collisional, Doppler Heisenberg), transition probability, population of states, Beer- Lambert law

Microwave and IR Spectroscopy: Rotational spectra of diatomic molecules, Classification of molecules, Effect of isotopic substitution, Rotational spectra, Non rigid rotator, Information derived from rotational spectra, Microwave spectroscopy & Instrumentation

IR Spectroscopy: The Vibrating diatomic molecule, Simple Harmonic Oscillator, Anharmonic Oscillator, The diatomic vibration-rotator spectra of diatomic molecules, Analysis by IR spectroscopy.

Raman Spectroscopy and Electronic Spectroscopy of Molecules: *Raman spectroscopy:* Raman Effect, Quantum theory of Raman Effect, Rotational and vibrational Raman shifts of diatomic molecules, Selection rules.

***Electronic spectroscopy of molecules*:** Electronic spectra of diatomic molecules, Born-Oppenheimer Approximation, The Franck Condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic vibration transitions

NMR: Basic principles, Classical and quantum mechanical description, Bloch equations, Spin-spin and spin-lattice relaxation times, Chemical shift and coupling constant.

Learning Resources:

Text Books:

1. Introduction to Atomic Spectra, H.E. White, McGraw Hill,5th edition, 1999
2. Molecular structure & spectroscopy, G. Aruldhas; PHI,2nd edition,2008.

Reference Books:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Robert Eisenberg and Robert Resnick, John Wiley & Sons, 2nd edition,2004
2. Principles of Magnetic Resonance, C.P. Slitcher, Springer Publications, 3rd edition,2013

Others Suggested Readings:

1. https://nptel.ac.in/courses/115/101/115101003/
2. nptel videos https://www.youtube.com/watch?v=CzM-F28a0Uk

PH16006 **3-0-0 (3)**

Solid State Physics

Pre-Requisites: None

Course Outcomes:

CO-1	Analyse crystal structure of materials using appropriate diffraction methods.
CO-2	Understand the physics of semiconductor devices.
CO-3	Understand optical and dielectric properties of solids.
CO-4	Comprehend magnetic properties of materials.
CO-5	Understand superconductivity and its applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	2	1	2	1
CO-2	2	2	1	1	1	2
CO-3	3	2	2	2	1	1
CO-4	3	2	2	2	2	2
CO-5	3	3	2	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Crystallography: Review on crystal and crystal structures, X-ray diffraction- Laue equations, Bragg's law, Laue-, powder- and Single crystal X-ray diffractometers, diffract diffractometers space, Ewald's sphere, limiting sphere. Electron and neutron diffraction.

Fundamental of semiconductor materials - Elemental and compound semiconductors, intrinsic and extrinsic materials, Direct and indirect band-gap semiconductors, Heavily doped semiconductors. Charge carrier in semiconductors: mobility, impurity band conduction, The Bloch theorem, Bloch functions Semiconductor Bloch equation, transport properties, Excess Carriers in Semiconductors, Review of the Kroning-Penney model, Brillouin zones, Number of states in the band, effective mass concept density of states, equilibrium distribution functions; Fermi energy, carrier statistics in equilibrium, Hall effect, Quantum Hall Effect and its applications.

Optical properties in solids: Drude model, ionic conduction, optical absorption in metals, insulators and semiconductors, Excitons, Photoluminescence phenomena. Dielectric properties of solids: Local fields, Clausius Mosotti relation, Dispersion relations of dielectrics. Ferromagnetism, Weiss theory of Ferrites: Types of ferrites, structures, properties, and applications, Garnets.

Superconductors: Review of superconductivity, Type I and Type II superconductors, London equations, thermodynamics of superconductors, BCS theory, Quantum tunnelling, AC and DC Josephson effect, SQUIDS, High Tc super conductors, Applications.

Learning Resources:

Text books:

1. Elementary Solid-State Physics, M. Ali Omar, Pearson Publications, fourth edition, 2005.
2. Solid State Physics, by. S. O. Pillai, New Age International Pvt. Ltd, seventh edition 2015.

3. Introduction to Magnetic Materials, B. D. Cullity, C.D. Graham, Willey and IEEE Press, second edition,2009.

Reference Books:

1. Introduction to Solid State Physics, Kittel , Wiley, India, eighth edition,2012.
2. Solid State Physics by A.J.Dekker, Macmillan, seventh edition, India, 2015.

Others Suggested Readings

1. https://onlinecourses.nptel.ac.in/noc21_ph21/preview
2. https://onlinecourses.nptel.ac.in/noc21_ph30/preview

PH25002 **3-0-0 (3)**

Atomic and Molecular Physics Laboratory

Pre-Requisites: None

Course Outcomes:

CO1	Determine of e/m of electron and lande's g-factor by Zeeman effect
CO2	Determine electron charge by Millikan's Experiment.
CO3	Verifyling electron spin roperties
CO4	Learning characterization techniques using NMR.
CO5	Develop expertise in spectroscopy and calculating dissociation energy

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	2	2	1	1
CO3	3	2	2	2	1	1
CO4	3	2	1	1	1	1
CO5	3	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Experiments:

1. Zeeman effect Experiment kit
2. Millikan oil drop experiment
3. NMR Experiment
4. Electron spin resonance
5. Determination of dissociation energy and anharmonicity constant of the iodine molecule by analysing its absorption spectra
6. Beer Lamberts Law
7. Rydberg constant
8. Constant Deviation spectrometer

PH16012 **0-1-2 (2)**

Solid State Physics Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Determine energy band gap of semiconductors using two-probe and four-probe methods.
CO-2	Determine the conductivity, carrier concentration and mobility of semiconductors using Hall effect.
CO-3	Prepare nano crystalline materials.
CO-4	Characterize materials using XRD and FTIR techniques.
CO-5	Evaluate magnetic and dielectric properties of solids.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	2	2	1
CO-2	3	3	2	2	1	1
CO-3	3	2	2	2	1	1
CO-4	3	2	1	1	1	1
CO-5	3	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Experiments:

1. Temperature dependence on resistance and determination of energy gap, E.g. by two probe technique
2. Study of surface structures of specimens by trinocular Microscope method
3. Determination of Dielectric behaviour of the sample, finding Ferro electric Curie temperature
4. Determination of energy gap of semiconductor by four probe methods
5. Study of Thermoelectric behaviour of semiconductor and ferrite samples
6. Determination of lattice constant of cubic crystals using X-ray film and comparator method
7. Study of characteristics of magnetic core in the inductor-determining Curie temperature
8. Preparation of crystals by pressing and sintering technique
9. Hall effect – Determination of the concentration of charge carriers
10. Determination of the Plank's constant using photoelectric effect
11. Determination of velocity of ultrasound in liquid and compressibility of liquid

Learning Resources:

Text books:

1. Elementary Solid-State Physics, M. Ali Omar, Pearson Publications, fourth edition, 2005.
2. Solid State Physics, by. S. O. Pillai, New Age International Pvt. Ltd, seventh edition 2015.

Reference Books:

1. Introduction to Solid State Physics, Kittel, Wiely, India, eighth edition,2012.

2. Solid State Physics by A.J. Dekker, Macmillan, seventh edition, India, 2015.

Others Suggested Readings:

1. https://www.vlab.co.in/broad-area-physical-sciences
2. https://vlab.amrita.edu/

9th Semester

PH25007 **3-0-0 (3)**

Statistical Mechanics

Pre-Requisites: PH2501

Course Outcomes:

CO1	Equipped with thermodynamics principles with microscopic explanation
CO2	The probabilistic and statistical approach to thermodynamics
CO3	Concepts of ensembles for different systems
CO4	A true theory of Phase Transition
CO5	Use this technique to solve problems in magnetic, soft matter, etc systems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	2	3	1	-	-	-
CO3	2	3	1	-	-	-
CO4	1	2	-	3	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Revision of Thermodynamics: Zeroth law, First law, Second law, Carnot cycle, Claussius theorem, reversible work, and heat transfer. Entropy. Extensivity — Euler and Gibbs-Duhem relations. Ideal gas. Response functions. Stability conditions, second law, and positivity of response functions. Thermodynamic potentials. Maxwell's relations.

Probability Theory and Generating Functions: Elementary aspects of probability theory: Empirical versus theoretical probabilities, equal a priori probabilities. Probability distribution functions, and cumulative distribution functions. Characteristic function and moments. Cumulant generating function and cumulants. Transformation of variables and corresponding distributions. Central limit theorem statement and explaining its significance. The problem set should clarify the procedure of attaining the central limit result, starting from various initial distributions, using asymptotic analysis of integrals.

Microcanonical and Canonical Ensemble: Statistical Ensembles: Microscopic dynamics and Liouville's theorem. Different hypotheses of Boltzmann lead up to the formula of Entropy in terms of the number of configurations in an isolated system. Microcanonical ensemble. Example of an ideal gas. The entropy of mixing. Canonical Ensemble, and partition function. Asymptotic analysis and relation to thermodynamic free energy. Fluctuation of energy and fluctuation-response relationship. Ideal gas in the canonical ensemble.

Grand Canonical and Gibbs Ensemble: Gibbs ensemble for fluids. Volume fluctuations. Ideal gas. Gibbs ensemble for a magnetic system. Non-interacting spins. Grand canonical ensemble. Number fluctuations. Ideal gas. Connection of ensembles through inverse transforms. The problem set may clarify ideal gases in various situations including constant gravity, freely jointed polymer chains, magnetic systems, and classical oscillators.

Phase Transition: Phases of Matter, Order of phase transition, Continuous and discontinuous phase transition. Order parameter, Comparison of phase transition in the magnetic and solid-liquid-gas system. 1D Ising model.

Learning Resources:

Text Books:

1. F. Reif, Fundamentals of Statistical and Thermal Physics
2. R.K. Pathria, Statistical Mechanics, 2nd Ed
3. Kerson Huang, Statistical Mechanics

Reference Books:

1. M. Plischke and B. Bergersen, Equilibrium Statistical Physics.
2. J. K. Bhattacharjee, Statistical Physics: Equilibrium and Non-Equilibrium Aspects.
3. S-K. Ma, Statistical Mechanics.

PH25009 **3-0-0 (3)**

Nuclear and Particle Physics

Pre-Requisites: None

Course Outcomes:

CO1	Identify the strengths and limitations of various nuclear models
CO2	Work on elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement results.
CO3	Demonstrate the ability to critically evaluate the results in nuclear and particle physics.
CO4	Apply the knowledge of basic laws of conservation and momentum in the determination of particle properties and properties of processes in the subatomic world.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	2	3	1	-	-	-
CO3	2	3	1	-	-	-
CO4	1	2	-	3	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

General Properties Of The Nucleus: Introduction – The nuclear radius, nuclear mass, packing fraction and binding energy, nuclear angular momentum, parity and symmetry, magnetic dipole moment and electric quadrapole moment. Nuclear Two-Body Problem: The Deuteron- Introduction, Simple theory of Deuteron, Spin dependence of Nuclear forces, Tensor Forces.

Nuclear Models And Nuclear Reactions: Introduction, the nuclear Shell or independent particle model, The Liquid Drop Model and semi-empirical binding energy formula, the collective nuclear model for the nuclear reactions. Reaction Dynamics: Q-equation, The compound nucleus, cross sections for nuclear reactions, Compound nucleus formation and break-up, stripping and photo-nuclear reactions.

Elementary Particles: Stable particles against decay through nuclear forces – parameters: Mass, particles and anti-particles, strangeness, decay times. Conservation Laws: conservation of Baryons, conservation of strangeness, conservation of parity and isotopic spin, Stable particles: Mass-less Bosons, Leptons, Mesons, Baryons. Resonance and short-lived Particles: Detection method for very short-lived particles, discovery of unstable particles, significance of short-lived particles.

Particle Detectors and Accelerators: Particle detectors: Gas filled detectors, solidstate detectors, Scintillation counter Nuclear Emulsions. High-energy particle detectors, Cerenkov detectors. Bubble chamber and Cloud chamber. Particle accelerators- Ion sources, Direct current accelerators, The Cyclotron. The linear accelerators, Betatron. The electron sychrotron. The protan synchrotran.

Learning Resources:

Text books:

1. Introduction to Nuclear Physics. Herald Enge, Addison-Wesley, New York.
2. The Atomic Nucleus. R. D. Evans, McGraw Hill Co. New York.

Reference Books:

1. The Fundamental Particles, C.E.Swartz, Addison-Wesley, London.
2. The Physics of Elementory Particles. Tassies, Longman Group London.
3. Nuclear Physics. Irving Kaplan, Oxford& IBH Co. New Delhi.
4. Physics of the Nucleus. A. Preston, Addison-Wesley, London.

PH17015 **0-1-2 (2)**

Linear Integrated Circuits Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO1	Evaluate the performance of op-amp amplifiers.
CO2	Analyse linear and non-linear circuits using op-amps.
CO3	Design active filters and waveform generators using op-amps.
CO4	Construct astable and monostable multivibrator circuits using 555 timer for various applications.
CO5	Evaluate the performance of IC voltage regulators.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	-	-
CO2	2	2	2	2	1	1
CO3	2	2	3	3	2	2
CO4	2	2	3	3	3	2
CO5	2	1	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Experiments:

1. Inverting and non-inverting amplifier using IC 741- Study of frequency response.
2. Determination of slew rate and CMRR of Op-amp.
3. Summing, scaling and averaging amplifier with Op-amp.
4. Integrator using Op-amp.
5. Differentiator using Op-amp.
6. Wein-bridge oscillator.
7. Design of Butterworth second order Low-pass and High-pass filters.
8. Design of Band-pass filters.
9. Precision rectifiers.
10. Monostable multivibrator applications using 555 timer.
11. Astable multivibrator applications using 555 timer.
12. Three terminal voltage regulators (fixed and variable).

Learning Resources:

Text Books:

1. Op–Amps and Linear integrated circuits, Ramakanth, A. Gayakwad, Prentice Hall ofIndia, New Delhi, 2000, Fourth Edition.
2. Operational Amplifiers & Linear Integrated Circuits: Theory and Application, James M.Fiore, Dissidents publisher, 2020, Third edition.

Reference Books:

1. Design with Operational Amplifiers and Analog Integrated Circuits, Sergio Franco, McGraw Hill, 2014, Third Ed.
2. Operational Amplifiers with Linear Integrated Circuits, William D. Stanley, PearsonEducation India, 2004, Fourth Edition.

Others Suggested Readings:

1. http://www.dissidents.com/resources/LaboratoryManualForOperationalAmplifiersAndLinear ICs_3E.pdf
2. https://milneopentextbooks.org/operational-amplifiers/

PH17011 **0-1-2 (2)**

Optoelectronics Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO1	Set optical and mechanical housing for an experiment
CO2	They will be able to describe the light-current-voltage relationships of LEDs, laser diodes, and photodiodes and demonstrate how to measure associated parameters.
CO3	Set up and analyse different fiber optics experiments.
CO4	Design the basic optics experiments to verify various laws and principles
CO5	Develop optics-based techniques in real life applications purposes.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	3	3	3	3
CO4	3	3	3	2	2	2
CO5	3	3	3	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Experiments:

1. Determination of different parameters of solar cell
2. Determination of current-voltage characteristics of Photo diode
3. Determination of current-voltage characteristics of phototransistor
4. Determination of current-voltage characteristics of LEDs
5. Determination of stokes parameter.
6. Determination of current-voltage characteristics of LDR
7. To find the wavelength of monochromatic light using Fresnel's Bi-prism.
8. Measurement of the degree of temporal coherence of unpolarized light beams.
9. Study the Acoustic optic effect in liquid.

Learning Resources:

Text Books:

1. Optoelectronics, E. Rosencher and B. Vinter, Cambridge University Press 2002.
2. Physics of optoelectronics, M. A. Parker, CRC Press, 2005, first edition.

Reference Books:

1. Optoelectronics, J. Hawkes and J. Wilson, Prentice Hall, 3rd edition 2018.
2. Semiconductor Optoelectronic Devices, Bhattacharya Pallab , Pearson, 2nd edition,2017.
3. Handbook of Optoelectronics, Vol. 1: Concepts, Devices, and Techniques,

John P. Dakin, Robert Brown, CRC Press, 2017.

Others Suggested Readings:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/index.html
2. https://www.rp-photonics.com/

PH17019 **0-1-2 (2)**

Microprocessor Applications Laboratory

Pre-Requisites: None

Course Outcomes:

CO1	Obtains the knowledge of program writing for microprocessor using microprocessor kit and simulation software
CO2	Develops ALP for various applications using 8086 microprocessors.
CO3	Understands the interfacing concepts of different devices with 8086 microprocessors.
CO4	Obtains the knowledge of simulations for different applications.
CO5	Develops testing and experimental procedure on microprocessor and analyse their operation in different applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	3	2	1	1	2	3
CO3	3	2	1	1	2	3
CO4	2	1	3	3	1	2
CO5	3	1	3	3	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Experiments:

The following experiments will be done using the microprocessor kit and software.

1.Develop and Test an ALP for addition, multiplication of 8 bit and 16-bit numbers
2. Develop and Test an ALP to evaluate a given athematic expression.
3. Develop and Test an ALP to pick out largest and smallest number from a given set of numbers.
4. Develop and Test an ALP to arrange given data in ascending and descending order
5. Develop and Test an ALP to find factorial of a given number.
6. Develop and Test an ALP to convert numbers from BCD to unpacked BCD
7. Develop and Test an ALP to move data from one place to another place
8. Develop and Test an ALP to generate different delay procedures:
9. Develop and Test an ALP to design a digital clock with hours, minutes and seconds.

The following interfacing experiments will be done using kit, interfacing modules and keil software.

1. Interface given DAC module. Develop and Test required AP to generate different wave forms with different characteristics
2. Interface given ADC module and convert different analog values into digital values. Develop and Test required ALP.
3. Interface given stepper motor module. Develop and Test required ALP for different speeds in different directions.
4. Interface given LCD display module. Develop and Test required ALP to display different characters
5. Interface given proximity sensor module. Develop and Test required ALP
6. Interface given RTD module. Develop and Test required ALP to show the temperature.

Learning Resources:

Text Books:

1. The 8088 and 8086 Microprocessors: Programming, Interfacing, Software, Hardware, and Applications, Avtar Singh and Walter A. Triebel, N.K. Srikanth, Pearson education, Second Edition, 2014.
2. Assembly programming and the 8086 microprocessor, D. S. Jones, Oxford science publications, Fourth Edition, 1999.

Reference Books:

1. Microprocessors and Interfacing By N Senthil Kumar, M Saravanan, S. Jeevananthan, Satish shah, OUP India, Second Edition, 2012.
2. 8086/8088 User's Manual, Programming and hardware reference, Intel corporation, Third Edition, 2007.

Others Suggested Readings:

2. https://emu8086-microprocessor-emulator.en.softonic.com
3. https://www.masm32.com

PH17023 **0-1-2 (2)**

Optical Sensors Laboratory

Pre-Requisites: None

Course Outcomes:

CO1	Set optical and mechanical housing and associated arrangements for an experiment
CO2	Develop fiber optic based optoelectronic sensors
CO3	Analyse different parameters of sensing components regarding photonics.
CO4	Design the basic optics experiments to verify various laws and principles

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	3
CO2	3	3	3	2	1	3
CO3	3	3	3	3	2	3
CO4	3	3	3	3	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Experiments

1. Determination of refractive-index of given liquid using optical fibre.
2. Study Proximity Sensor using optical fibre.
3. An experimental observation of temperature and strain sensing using FBG with theoretical verifications.
4. Ratiometry detector by varying source voltage and micro bending.
5. Determine the grating pitch using optical fibre.
6. To Study effects of Polarization of light under pressure on Optical Fibre.
7. Fiber optic moving reflector displacement sensor.
8. Characterize LED based sensor
9. Single mode-multimode- single mode (SMS) fiber sensor prob fabrication using Fiber Arc Splicer and Characterization of SMS
10. Characterize Long period Grating Fiber optic

sensor**Learning Resources:**

Text Books:

1. Fundamentals of Photonics, B. E. A. Saleh & M. C. Teich, Wiley, Third edition, 2019.
2. Optoelectronics-An Introduction, J.Wilson & J. F. B. Hawkes, PHI, 3rd edition, 2001.

Reference Books:

1. Fiber Optic Sensors: Principles and Applications by Banshi Dhar Gupta.

Others Suggested Readings:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/index.html
2. https://www.rp-photonics.com/

PH25089 **0-0-0 (2)**

Seminar and Technical Writing

Pre-Requisites: None

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-
CO-2	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-
CO-3	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

PH250091 **0-0-0 (2)**

Short Term Industrial / Research Experience

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	3							3				
CO-2	2	2	2	2	2			3	3		3	3				
CO-3						3	3					3				
CO-4										3		3				

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

10th Semester

PH25094 **0-0-2 (2)**

Comprehensive Viva-Voce

Pre-Requisites: None

Course Outcomes:

CO-1	Comprehend the knowledge gained in the course work
CO-2	Demonstrate the ability in problem solving
CO-3	Communicate effectively using appropriate terminology

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	--	--
CO-2	3	3	3	3	--	--
CO-3	2	2	2	2	--	--

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Comprehensive viva-voce each student will be evaluated for their overall comprehension of the course work and laboratory training that they have undergone. The students will be expected to answer questions orally, write down simple equations, draw plots, schematics, write simple code etc. as questioned by the panel. Assessment will be done by the panel based on the student response.

PH25098 **0-0-0 (8)**

Major Project

Pre-Requisites: None

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic
CO-2	Review literature to identify gaps and define objectives & scope of the work.
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives
CO-4	Analyze the results to draw valid conclusions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2			2	1		1	3	1	1	2				
CO-2	2	2			1	2	1	1	2	2		3				
CO-3	2	2	3	3	3	2	2	2	2	1	3	2				
CO-4	2	2		3	3				2	2		3				

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project.

Professional Electives for PG

PH16005 **3-0-0 (3)**

Optical Physics

Pre-Requisites: None

Course Outcomes:

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

CO-1	Understand the basic principles governing the optical instruments.
CO-2	Explain the physics of image formation and its applications.
CO-3	Analyse optical systems using principles of optics.
CO-4	Apply quantum optics to lasers and Q-switching.
CO-5	Gain insight into the phenomena of superluminal velocities and slow light.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	1	1	1	3
CO-2	3	1	1	1	1	3
CO-3	2	3	3	3	2	2
CO-4	3	1	1	2	2	2
CO-5	3	1	1	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Coherence and Interferometry: Interference between coherent waves, Coherence of waves in space and time, Physical origin of line widths, Quantification of the concept of coherence, Temporal coherence, Spatial coherence, Monochromatic plane wave as perfectly coherent wave, Fluctuations in light beams, Two-beam interferometry, Common path interferometers, Radar interferometry, Interference by multiple reflections, Berry's geometrical phase in interferometry, Laser Interferometer Gravitational wave Observatory (LIGO).

Theory of Diffraction: Some general diffraction principles, The scalar-wave theory of diffraction, Fraunhofer diffraction in optics, Examples of Fraunhofer diffraction by one- and two-dimensional apertures, Fresnel diffraction by linear systems, Propagation of a Gaussian light beam and its importance.

Polarization in Anisotropic Media: Polarized light in isotropic media, Production of polarized light, Wave propagation in anisotropic media (a generalized approach), Double image prism, Electromagnetic waves in an anisotropic medium, Interference of polarized lights, Practical applications of polarized lights.

Image Formation and Dispersion: The diffraction theory of image formation, Abbe sine condition, Rayleigh criterion for limit of resolution, The resolution limit of optical instruments, Applications of the Abbe theory: Holography, Phase and group velocities in dispersive media, Superluminal propagation in a quarter-wave stack and slow light.

Quantum Optics and Laser Q-switching: Quantization of the electromagnetic field, Plane wave modes in a linear cavity, Interaction of light with matter, Principle of laser Q-switching, Effects of Q-switching on laser parameters, Methods of Q-switching and gain.

Learning Resources:

Text Books:

1. Optical Physics, A. Lipson, S. G. Lipson and H. Lipson, Cambridge Press, 4th Ed., 2010.
2. Optics, E. Hecht, Pearson Education, 5th Ed., 2016.

Reference Books:

1. Fundamentals of Photonics, B. E. A. Saleh and M. Carl Teich, John Wiley & Sons, New York, 2nd Ed., 2007.
2. Optics, Ajoy Ghatak, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 3rd Ed., 2006.
3. Optics, Miles V. Klein, Thomas E. Furtak, Wiley India Pvt Ltd., New Delhi, 2nd Ed., 2011.

Others Suggested Readings:

1. https://studiousguy.com
2. https://phet.colorado.edu

PH25021 **3-0-0 (3)**

Introduction to Soft Matter and Biophysics

Pre-Requisites: PH1606

Course Outcomes:

CO1	Analyze the phenome logical aspect of Soft Condensed Matter Physics
CO2	To introduce Physics students to the emerging interdisciplinary area of biological physics
CO3	Using physical concepts to gain quantitative understanding of biological phenomena
CO4	Application in real life problem, such as kinetics of drug delivery, transport processes

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	3	2	1	1	2	3
CO3	3	2	1	1	2	3
CO4	2	1	3	3	1	2
CO5	3	1	3	3	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Biophysics: Spatial and temporal scales, Random walks and diffusion in biology, FRAP, cell signaling. Thermodynamic foundations, Structure and organization of the cell, molecular forces, Review of Thermodynamics and Probability, Thermodynamic potentials, Random variables, Gaussian and Poisson distributions, fluctuations, Entropy and Free Energy

Polymer Physics Model, Hamiltonian, Persistence Length, Freely Jointed Chain, Freely Rotating Chain, Worm Like Chain, Force-extension behavior, Entangled Polymer, Biopolymers, DNA, Chromosome, Chromatin

Fick's laws: Brownian Motion, Non-equilibrium Statistical Physics, Langevin Dynamics, Fluctuation-Dissipation Theorem, Diffusion and capture processes, Mean capture times, Fluid flows in biology, viscosity, Biological applications of diffusion, Fokker-Plank Equation

Biological dynamics and rate equations: Pattern formation in biology, Reaction-diffusion systems, Phenomenology of soft condensed matter systems, intermolecular forces, viscoelasticity, ordering in soft matter

Calculation of Diffusion Constant: Mean Squared Displacement, Time Averaged Mean Squared Displacement, Van Hob correlation function, Non-gaussianity function, Ergodicity Breaking

Learning Resources:

Text Books:

1. The Theory of Polymer Dynamics Front Cover Masao Doi, Sam F. Edwards, Clarendon Press, 1988
2. Physical Biology of the Cell Paperback – by Rob Phillips, Jané Kondev, 2012

Reference Books:

1. Introduction to Polymer Physics, David I. Bower, Cambridge, 2002
2. International Review of Cell and Molecular Biology, Hancock and Jeon, Elsevier, 2014

PH17022 **3-0-0 (3)**

High Speed Data Converters

Pre-Requisites: **PH1702**

Course Outcomes:

CO1	Understand basic principles of data converters.
CO2	Comprehend the working of Analog to Digital and Digital to Analog converters.
CO3	Understand high speed data converters.
CO4	Evaluate the performance of data converters

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	3	2	1	1	2	3
CO3	3	2	1	1	2	3
CO4	2	1	3	3	1	2
CO5	3	1	3	3	1	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Ideal data conversion, The sampling operation, Sampling theorem, Sampling of bandpass signals, The reconstruction operation, The quantization operation, Coding, Under sampling and oversampling, Decimation and interpolation.

Performance Metrics: Resolution and sampling rate, Signal-to-noise-and-distortion ratio (SNDR or SINAD), Spurious-free dynamic range (SFDR) , HD2 and HD3, Differential operation, Intermodulation distortion (IMD), Relationship between HD and IMD, Differential and integral non-linearity (DNL and INL) Relationship between SFDR and INL, HD2 and HD3 INL patterns, Saw-tooth INL pattern, Offset and gain error, Jitter, Analysis, Intuitive perspective, Jitter measurement, Types of random jitter, Jitter and phase noise, Bit error rate (BER), Power consumption and figure of merit.

DIGITAL TO ANALOG CONVERTERS (DACS): Principles and design of – weighted resistor, R–2R ladder, inverted R-2R ladder, monolithic DAC – Parameter specifications.

ANALOG TO DIGITAL CONVERTERS (ADCS): Classification of A/D converters, Principles and design of- Flash, Counter, Servo tracking, Successive approximation, Integrating type– Charge balancing, dual slope integration ADCs- MAX5893 High Speed A/D, Parameter specifications.

Learning Resources:

Text Books:

1. High Speed Data Converters, Ahmed M.A. Ali, IET Publisher, 2016.
2. Data Converters, Franco Maloberti, Springer, 2010.

Reference Books:

1. Data Conversion Handbook-Analog Devices Inc., Walt Kester Editor, Elsevier, 2005.
2. Data Converters, GB Clayton. John Wiley, First Edition, 1982.

Others Suggested Readings:

1. https://www.pdfdrive.com/data-conversion-handbook-e158476438.html
2.https://www.analog.com/media/en/training-seminars/design-handbooks/Data-Conversion-Handbook.pdf

PH17026 **3-0-0 (3)**

Lasers and Applications

Pre-Requisites: PH16002

Course Outcomes:

CO1	Understands the fundamental of lasers
CO2	Understands applications of lasers in atmospheric studies
CO3	Understands the applications of lasers in material processing
CO4	Understands the space applications of lasers
CO5	Understands defence applications of lasers

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	3	2	1	1	2	3
CO3	3	2	1	1	2	3
CO4	2	1	3	3	1	2
CO5	3	1	3	3	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Quantum Theory of Laser: Radiative and Non-radiative decay of excited state atoms – Emission Broadening and linewidth – Radiation and Thermal equilibrium – Conditions for laser action – Laser Oscillation above threshold - Laser Amplifiers – Requirements for obtaining population inversion – Rate Equations for three and four level systems – Laser pumping requirements – Laser Cavity modes – Stable resonators – Gaussian beams- Special Laser Cavities – Q-switching and Mode locking – Generation of ultrafast Optical pulses- Pulse compression.

Lasers in Atmospheric Studies- Laser for detection and ranging- LIDAR: applications- Doppler wind LIDAR, Differential Absorption LIDAR for water vapour monitoring.

Laser application in material processing: — CO_2, YAG, Excimer, Ruby lasers-[material processing, Cutting, Welding, drilling, micro machining] — Interaction of laser radiation with matter, Heat Flow Theory, Process characteristics etc.

Lasers for space applications: — free space communication, laser propulsion, laser ignition, Optical Rotation sensors and their applications for space navigation: Sagnac Interferometers and their applications for space, Ring Laser gyros- Laser Resonator Design, Laser Frequency stabilization techniques, Ring resonator — stable and unstable and their application in Ring Laser Gyros.

Laser Target Designators and Laser-Guided Weapons: Laser Guidance, Laser target designators, laser guided missiles, laser guided bomb. Laser beam riding of missiles. Laser & electro-optic surveillance systems, IR guidance.

Learning Resources:

Text Books:

1. Laser Principles, Types & Applications, K R Nambiar, New Age International, 2006.
2. Lasers Theory and Applications, A K Ghatak and K Thyagarajan, McMillan, 2003.

Reference Books:

1. Quantum Electronics, Amnon Yariv, John Wiley, 1989.
2. Lasers, Siegman, Anthony E, California/University of Science Books, 1986.
3. Physics of gas lasers, Bennett, W R/Montroll, Elliot W, New York/Gordon andBreach,1977.

Others Suggested Readings:

1. https://nptel.ac.in/courses/104/104/104104085/
2. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13/

PH17030 **3-0-0 (3)**

Computer Organization and Operating Systems

Pre-Requisites: None

Course Outcomes:

CO1	Understand the functional units and their interconnection
CO2	Identify the hardware and software techniques for improving the performance of the computer.
CO3	Estimate the average waiting time in CPU scheduling for improving the efficiency.
CO4	Examine the multithreading issues.
CO5	Predict the process scheduling issues and give the remedies.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	-
CO2	3	3	3	3	-	1
CO3	3	3	3	2	2	1
CO4	3	2	2	2	2	1
CO5	3	2	1	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Computer hardware and software: Fundamental units, bus structures, addressing methods, main memory operations, instructions, addressing modes, assembly language, basic input and output operations, stack and queues, subroutines.

Micro programmed control Input-Output organization: Accessing I/O devices, interrupts, DMA, I/C hardware, standard I/O interfaces.

Pipelining: Basic concepts, instruction queue, branching, data dependency, influence ofpipelining on instruction set design, multiple execution units, Performance considerations.

Computer peripherals: I/O devices, On-line storage system, performance considerations.

Operating System Concepts: Introduction and various types of systems, OS services, system calls, system programs, system structure, virtual machines, system design and implementation, system generation.

Process Management: Process concept, Process scheduling, Operations on process, Inter process communication.

Threads: Multi-threading models.

CPU scheduling: Scheduling criteria algorithms, multiple processor scheduling, real time scheduling, algorithm evaluation, process-scheduling models.

Learning Resources:

Text Books:

1. *Computer organization*, Carl, Hamacher, Z. Vranesic, S. Zaky, Tata McGraw-Hill New Delhi, 2011, 5th Edition.

2. *Operating systems concepts*, Silberschatz, Galvin, Gagne, Wiley India, New Delhi, 2011,8th Edition.

Reference Books:

1. Fundamentals of Computer Organization and Architecture, Mostafa Abd-El-Barr and Hesham El-Rewini, Wiley-Interscience, 1st edition, 2005.

2. Operating Systems- Internals and Design Principles, William Stallings, Pearson, Seventh Edition. 2012.

Others Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105163/

2. https://www.geeksforgeeks.org/computer-organization-and-architecture-tutorials/

PH17034 **3-0-0 (3)**

Fiber Optics

Pre-Requisites: **PH16002**

Course Outcomes:

CO-1	Understand the physics of Optical fibers
CO-2	Recognize the materials and designs of optical fibers
CO-3	Explore the components and devices for fiber optic technology
CO-4	Apply the optical fibers for communication and sensing technology

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	1
CO2	3	3	3	2	1	1
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fiber Optics Theory: Overview of the technology of fiber optic cables including a description of the components, history, and advantages of fiber optic cables, Electromagnetic theory of guided wave optics, Mode analysis, the properties of light absorption, dispersion, nonlinearly.

Fiber Optics Cable Design: Basic construction of fiber optic cables including the types of cables, cable properties, and performance characteristics, Materials of Optical fiber, Multimode, single mode step-index and graded index fibers, and fabrication procedures.

Fiber Optic Components: Connectors, fiber optic splices, connectors, couplers and the types of connections they form in systems, extrinsic and intrinsic coupling losses, fiber alignment and fiber mismatch problems, and fiber optic mechanical and fusion splices. Test devices, optical time-domain reflectometry (OTDR).

Optical Fiber Technology: Fiber lasers, Fiber Bragg Grating, Fiber optic device, Applications of Optical fiber, Fiber Optic Communications, Fiber networks, Fiber Sensors, Fiber Optic Image delivery Systems

Learning Resources

Text Books:

1. Ajoy Ghatak and K. Thyagarajan, An Introduction to Fiber Optics, Cambridge University Press, 2017, Fifth Edition.
2. Jeff Hecht, Understanding Fiber Optics, Createspace Independent Pub, 2015, Fifth Edition.

Reference Books:

1. Gerd Keiser, Optical Fiber Communications, Mc Graw-Hill International, Third Edition, 2000.
2. B. D. Gupta, Fiber Optic Sensors: Principles and Applications, New India Publishing Agency, 2005.

Others Suggested Readings:

1. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13/

PH17028 **3-0-0(3)**

Pulse Circuits

Pre-Requisites: PH16010

Course Outcomes:

CO1	Understand and analyse the responses of first order RC low pass and high pass filters for standard inputs.
CO2	Analyse clipping and clamping circuits
CO3	Design Multivibrator and sweep circuits
CO4	Comprehend Time-base generators.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	3	2	1	1	2	3
CO3	3	2	1	1	2	3
CO4	2	1	3	3	1	2
CO5	3	1	3	3	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Linear Wave Shaping: High pass and low pass RC circuits and their response for Sinusoidal, Step, Pulse, Square, & Ramp inputs, High pass RC network as Differentiator, Low pass RC circuit as an Integrator, RL and RLC Circuits and their response for Step Input, Ringing Circuit.

Clipping and Clamping circuits Clipping-Diode clippers-The transient clipper-Comparators-Breakaway diode and amplifier-Diode-Differentiator Comparator-Application of Voltage comparators. The clamping operation, Clamping circuits –Clamping circuit theorem- Synchronized Clamping-Transistor switch with inductive load.

Multivibrators: The monostable mutivibrator-The emitter-coupled monostable multivibrator- Triggering of monostable multivibrator-The astable collector coupled multivibrator-The stable states of a bistable multivibrator-A fixed biased transistor bistable multivibrator-methods of improving resolution-symmetrical triggering-Schmitt Trigger circuits.

Time base Generators: General features of time base signal-Methods of generating time- based waveform-unijunction transistor-Miller and Bootstrap time base generators-Current time-based generators-A simple current sweep

Synchronization and Frequency Division: Pulse Synchronization of Relaxation Devices, Frequency division in Sweep Circuit, Astable Relaxation Circuits, Monostable Relaxation Circuits as Dividers, stability of Relaxation dividers Synchronization of a Sweep Circuit with Symmetrical Signals, Sine wave frequency division with a Sweep Circuit.

Learning Resources:

Text books:

1. Pulses, Digital and Switching waveforms by Jacob Milliman, Herbert Taub & M.S.PrakashRao Mc-Graw hill, fourth edition, 2008.

2. Pulses and Digital Circuits A. Anand Kumar, PHI Learning,2012

Reference books:

1. Pulse and Digital Circuits by K.Venkata Rao, K.Rama Sudha, G.Manmadha Rao, Pearson education, first edition,2010.

2. High Speed pulse techniques by J.A.Coekin ,Elsevier science publication, third edition,2013.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117/106/117106086/

PH17032 **3-0-0 (3)**

Thin Films and Vacuum Techniques

Pre-Requisites: None

Course Outcomes:

CO-1	Understand generation and monitoring of high vacuum using pumps and gauges
CO-2	Explain the influence of growth process on the properties of thin films
CO-3	Identify vacuum related flaws in standard physical vapour deposition units
CO-4	Select appropriate PVD/CVD technique for the deposition of thin films
CO-5	Determine grain size, texture coefficient, sheet resistance, thickness and band-gap of thin films

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	3	3	1	1
CO-2	3	2	1	1	2	3
CO-3	3	2	1	1	2	3
CO-4	2	1	3	3	1	2
CO-5	3	1	3	3	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of Vacuum science: Fundamentals of Vacuum-types of flow-Viscous, Lamellar and molecular fluid region, Conductance, Mean-free path, Medium, High and Ultra-high vacuum pumps, (Working principle of Rotary pump, Diffusion pump, Turbo-molecular pump and Ti sublimation pump). Vacuum Measuring Gauges-principle, calibration and electronics read out (Pirani gauge and Penning gauge). Types of O-Rings, valves and clamps – Thermal vacuum bake-out.

Introduction to Thin Films: Film Formation - Types of Growth Modes (Volmer - Weber, Frank - van der Merwe, Stranski-Krastanov), Factors influencing film growth and quality, Types of Films – Polycrystalline, Epitaxial growth, textured growth - Substrate cleaning procedure - Thickness measurement techniques (quartz micro-balance, stylus profiler and optical interference techniques). Film adhesion, abrasion and hardness.

Thin films Coating Techniques: Physical coating techniques-Thermal Evaporation (Working principle and Standard Operational Procedure), e-Beam Evaporation, Sputtering (Ion beam sputtering, RF and DC Magnetron Sputtering), Pulsed Laser Deposition, Clean room and architecture of modern-day coating plants.

Chemical coating techniques-Spin coating, Sol-gel dip coating, Spray Pyrolysis-Viguie Spitz mechanism, Electro-deposition, Molecular Beam Epitaxy, CVD and MOCVD processes and systems.

Characterization of Thin films: Texture coefficient, Standard deviation and grain size (from grazing incidence XRD), Stress and strain in thin films, Sheet resistance measurement of thin films (Four Probe method), Surface composition, morphology and roughness (using SEM and AFM and appropriate software), Optical transmittance, reflectance and Band gap estimation (from UV-Vis data), Electrical transport property by Hall effect measurement.

Learning Resources:

Text Books:

1. Milton Ohring, Materials Science of Thin Films, Academic Press, San Diego, 2002.
2. Krishna Seshan (Ed.) Handbook of Thin-Film Deposition Processes and Techniques, Noyes Publications-William Andrew Publishing, Norwich, New York, U.S.A., 2002.

Reference Books:

1. Handbook of Thin Film Technology- Leon –Imaissel & Reihard Glang –Mc Graw –Hill Book Company -1970
2. D.M. Hoffman, B. Singh, J.H. Thomas, Handbook of Vacuum Science and Technology, Academic Press 1998.
3. Mironov V. L.: Fundamentals of Scanning Probe Microscopy. Tekhnosfera, Moscow 2004.

Others Suggested Readings:

1. https://www.svc.org/Education/SVC-Education-Program.cfm
2. http://technology.niagarac.on.ca/courses/phtn1432/#notes

PH15024 **3-0-0 (3)**

Structured Light

Pre-Requisites: **Fundaments of Photonics**

Course Outcomes:

CO1	Understand underlying principles and advantages of structured light
CO2	Learn new concept on optical angular momentum
CO3	Able to engineer light's degree-of-freedom
CO4	Apply the structure light to solve state-of-the art problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	1	3
CO2	3	2	2	3	1	3
CO3	3	3	3	3	2	3
CO4	2	3	3	3	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Phase Structured Electromagnetic Waves: Introduction to Vortices in Nature. Young's Interferometer and Phase Singularities, General Solution of the Wave Equation. Laguerre–Gaussian, Hermite-Gaussian Beams and its superposition, Bessel Beams and other families of Structured Light Beams.

Optical Angular Momentum: Momentum and Angular Momentum in Wave Fields, Orbital and Spin Angular Momentum, Angular Momentum of Laguerre–Gaussian Beams, Intrinsic and Extrinsic Angular Momentum, Measurements and Experiments on Light's Angular Momentum.

Polarization Structured Electromagnetic Waves: Theory of Optical polarization, Stokes Parameters and the Poincaré Sphere, Polarization Singularities: C-Points and L-Lines, Generic Features of Polarization Singularities, Higher-Order Polarization Singularities, Poincaré Beams, Vector Beams.

Applications of Structured Light: Orbital Angular Momentum in Optical Communication, Optical Tweezers, Optical Vortex Trapping and the Dynamics of Particle Rotation, Recent applications and Roadmap on Structured light.

Learning Resources:

Text Books:

1. Gbur J. B. *Singular Optics*, CRC Press (2017).
2. Andrews D. L. *Structured Light and its Applications*, Academic Press, 2008.

References:

1. Soskin M. S. and Vasnetsov M. V., *Singular Optics*, in Progress in Optics Vol. 42 (2001).
2. Forbes, A., de Oliveira, M. & Dennis, M.R. Structured light. Nat. Photonics 15, 253–262 (2021).

Others Suggested Readings:

1. M. J. Patgett, *Structured light concepts and theory, light twist OAM* in International School on Parametric Non-Linear Optics (ISPNLO 2016) (https://www.youtube.com/watch?v=V06Cs7Cuk7c).
2. A. Forbes, *Structured Light with Digital Holograms*, Optica.
3. (https://www.optica.org/History/Biographies/bios/Andrew_Forbes?videoId=625126721000)
   A. Forbes, *Structured Light: Tailored for purpose* (https://www.youtube.com/watch?v=MmW6AxVp2Ds)

PH17007 **3-0-0 (3)**

Linear Integrated Circuits

Pre-Requisites: **PH16010**

Course Outcomes:

CO1	Design inverting and non-inverting amplifiers using operational amplifiers.
CO2	Design op-amp circuits for linear and non-linear operations.
CO3	Design active filters and waveform generators using op-amps.
CO4	Develop applications using 555 timer, 566 PLL, and voltage regulator ICs.
CO5	Evaluate the performance of op-amp circuits.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	1	1	1		
CO2	3	2	2	2	2	1	1
CO3	3	2	2	3	3	2	2
CO4	2	2	2	3	3	3	2
CO5	3	2	1	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fundamentals of Operational amplifiers: Op-amp- Internal circuit –Block diagram representation of op-amp- Stages of op-amp-Ideal op-amp, Basic differential amplifier- transfer characteristics, differential mode gain, common mode gain, circuits for improving CMRR, Practical op-amp - Open loop & closed loop configurations – measurement of Op-amp parameters, DC & AC performance characteristics of op-amp — Frequency compensation.

Applications of op-amps: Voltage follower - Summing, scaling & averaging amplifiers - ACamplifier. Linear Applications: Instrumentation Amplifiers- V-to-I & I-to-V converters- Differentiators & Integrators.

Non-linear Applications: Precision Rectifiers, peak detectors, Wave Shaping Circuits (Clipper and Clampers) — Log and Antilog Amplifiers — Analog voltage multiplier circuit and its applications, Phase sensitive detector (PSD), Comparators and its applications – Sample and Hold circuit.

Active Filters and Waveform Generators: Active Filters: Active Network Design – FilterApproximations-Design of LPF, HPF, BPF and Band Reject Filters – All Pass filters and higher order filters and their design, VCVS and IGMF configurations.Waveform Generators: Sine-wave Generators-Wein-bridge Oscillator– Square / Triangle / Saw-tooth Wave generators. IC XR-2206 function generator and its applications.

Specialized IC applications: IC 555 Timer: Monostable operation and its applications — Astable operation and its applications. Phase Locked Loop (PLL): Operation of basic PLL-Closed loop analysis of PLL- IC 565 and its applications.

IC Voltage Regulators: Voltage Regulators: Basics of Voltage Regulator – IC Regulators(78xx, 79xx, LM 317, LM 337, 723)-Switching Regulators.

Learning Resources:

Text Books:

1. Operational Amplifiers & Linear Integrated Circuits: Theory and Application, James M.Fiore, Dissidents publisher, Third edition,2020.

2. Op–Amps and Linear integrated circuits, Ramakanth, A.Gayakwad, Prentice Hall ofIndia, New Delhi, 2000, Fourth Edition.

Reference Books:

1. Operational Amplifiers, George B. Clayton and Steve Winder,,Newnes-Elsevier, 2011,Fifth Edition.
2. Design with Operational Amplifiers and Analog Integrated Circuits, Sergio Franco, McGraw Hill, 2014, Third Ed.
3. Operational Amplifiers with Linear Integrated Circuits, William D. Stanley, PearsonEducation India, 2004, Fourth Edition.

Others Suggested Readings:

1. https://open.umn.edu/opentextbooks/textbooks/operational-amplifiers-linear-integrated- circuits-theory-and-application-3e
2. https://easyengineering.net/operational-amplifiers-by-clayton/#Download_Link

PH18025 **3-0-0 (3)**

Solar Energy Systems

Pre-Requisites: None

Course Outcomes:

CO1	Outline the technologies that are used to harness the power of solar energy.
CO2	Understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO3	Comprehend the challenges in sustainable energy processes, perform cost analysis, design photovoltaic systems for different applications meeting residential and industrial needs, predict and test performance.
CO4	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials.
CO5	Illustrate the concepts of direct energy conversion systems & their applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	-	-
CO2	3	3	2	2	-	-
CO3	2	2	2	2	2	-
CO4	1	2	2	1	2	1
CO5	1	1	1	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Solar Energy: Fundamentals of Solar Energy-Spectral Irradiance, Terrestrial Solar Radiation, Atmospheric effects, Air Mass, The Sun's Position, Solar Radiation on a Tilted Surface, Solar Insolation, Measurement and Analysis of Solar Irradiance.

Solar Photovoltaics: Solar Cell and its operation, Solar technologies, Silicon solar structure and parameters, efficiency of solar and spectral response; Solar cell design principles-light trapping, optical losses, anti-reflection coatings, Top contact design, Metal Grid Pattern. Environmental and safety issues, Cell passivation.

Solar PV Modules and PV Systems: PV Module Circuit Design-Module Structure, Packing Density, Interconnections, Mismatch and temperature effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module; Solar PV systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

Storage in PV Systems: Battery Operation, Types of Batteries, Battery parameters,Application and selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV system.

Solar Thermal Systems: Design of Solar Thermal Systems-Solar concentrators, Storage of solar generated heat; Hybrid systems-combinations of solar thermal and solar cell systems.

Learning Resources:

Text Books:

1. Solar Cells: Operating Principles, Technology and system Applications, Martin A. Green, Published by the University of New South Wales, 1st edition,1998.

2. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 1st edition, 2000.

Reference Books:

1. Photovoltaic Engineering Handbook, F. Lasnier and T. G. Ang, IOP Publishing UK, 1st edition, 1990.
2. Semiconductor Devices, Physics, and Technology, S. M., Sze, New York, NY: Wiley, Second Edition, 2001.

Others Suggested Readings:

1. https://energyeducation.ca/encyclopedia/Photovoltaic_system
2. https://www.open.edu/openlearn/nature-environment/environmental-studies/energy-resources-solar-energy/content-section-1

PH17005 **3-0-0 (3)**

Optoelectronics

Pre-Requisites: **PH16002**

Course Outcomes:

CO1	Understand the properties of wave guides, optical fibers and guided modes
CO2	Select LEDs for different applications based on their structure and working
CO3	Identify semiconductor Lasers for application in sensing and communication
CO4	Understand photo detectors and their applications
CO5	Comprehend light modulators and their applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	1
CO2	3	2	2	2	2	2
CO3	3	3	2	2	2	2
CO4	3	2	2	2	2	1
CO5	3	3	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Light Propagation in Wave Guides: Introduction-Some physical properties of wave guides and optical fiber-Maxwell's Equations-Guided modes in planar waveguides-Optical confinement factor-Guided modes in optical fiber-waveguide couplers.

Optical sources: Introduction, Direct and indirect Band gap Semiconductors-Doped Semiconductors-PN Junction, Carrier Lifetime and Photoconductivity, Direct Recombinationof Electrons and Holes, Indirect Recombination; Trapping, Steady State Carrier Generation; Quasi-Fermi Levels, Photoconductive Devices, Diffusion and Recombination; The Continuity Equation. The Haynes–Shockley Experiment, Requirements of optical emitter-Advantages of LEDs-Material systems for LEDs- LED operation-Carrier injection and spontaneous emission- LED Structures -Hetro junction LEDs-Surface emitting and Edge Emitting LEDs-Quantum efficiency and LED Power- LED performance considerations and applications- Optical Absorption, Luminescence, Photoluminescence, Electroluminescence.

Semiconductor Lasers: Introduction- Lasing in pumped active medium-Threshold condition-Semiconductor Laser Rate equations-Quantum Efficiency-Resonant frequencies and spectrum of Laser Diode-Laser Diode structures and radiation patterns-Buried Heterostructures-VCSE laser-Distributed feedback Lasers-DBR Lasers Temperature dependence of Laser output-Direct Analog and Digital Modulation-Laser Noise.

Light Detectors: Introduction-Detector performance parameters-Thermal Detectors-Image Intensifiers-Thermoelectric detectors-Pneumatic detectors-Pyroelectric detectors-Photo emissive detectors-Vacuum photodiodes-and photomultipliers and their performance-Photoconductive detectors-PN-Photodiode-I-V Characteristic-PIN Photodiode-Operation- Photocurrent and responsivity-Avalanche Photodiode-Responsivity-Noise sources in photodetectors-S/N calculation-Detector response Time and Bandwidth.

Modulators: Introduction - Electro Optic and Kerr modulators-Magneto Optic and Acoustic Optic Modulators-Photonic Switches and Applications.

Learning Resources:

Text books:

1. Optoelectronics-An Introduction-J. Wilson; J.F.B. Hawkes, PHI,3rdedn, 2001.
2. Fundamentals of Photonics. B.E.A. Salesh; M.C.Teich,John Wiley,2nd edition,2012.

Reference Books:

1. Optical Fiber Communications, G.Keiser, Springer 4th edition,2017.
2. Hand book of optoelectronics John P Dakin, Robert G W Brown,CRC Press,2nd edition,2017.

Others Suggested Readings:

1. https://nptel.ac.in/courses/115/102/115102026/

PHI-PH17025 **3-0-0 (3)**

LINEAR INTEGRATED CIRCUIT APPLICATIONS

Pre-Requisites: PH2301

Course Outcomes:

CO-1	Design inverting and non-inverting amplifiers using operational amplifiers.
CO-2	Design op-amp circuits for linear and non-linear operations.
CO-3	Design active filters and waveform generators using op-amps.
CO-4	Develop applications using 555 timer, 566 PLL, and voltage regulator ICs.
CO-5	Evaluate the performance of op-amp circuits.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	2	1	1	1	1		
CO-2	3	2	2	2	2	1	1
CO-3	3	2	2	3	3	2	2
CO-4	2	2	2	3	3	3	2
CO-5	3	2	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of Operational amplifiers: Op-amp- Internal circuit –Block diagram representation of op-amp- Stages of op-amp-Ideal op-amp, Basic differential amplifier- transfer characteristics, differential mode gain, common mode gain, circuits for improving CMRR, Practical op-amp - Open loop & closed loop configurations – measurement of Op-amp parameters, DC & AC performance characteristics of op-amp – Frequency compensation.

Applications of op-amps: Voltage follower - Summing, scaling & averaging amplifiers - AC amplifier. Linear Applications: Instrumentation Amplifiers- V-to-I & I-to-V converters- Differentiators & Integrators.

Non-linear Applications: Precision Rectifiers, peak detectors, Wave Shaping Circuits (Clipper and Clampers) – Log and Antilog Amplifiers – Analog voltage multiplier circuit and its applications, Phase sensitive detector (PSD), Comparators and its applications – Sample and Hold circuit.

Active Filters and Waveform Generators: Active Filters: Active Network Design – Filter Approximations-Design of LPF, HPF, BPF and Band Reject Filters – All Pass filters and higher order filters and their design, VCVS and IGMF configurations.

Waveform Generators: Sine-wave Generators-Wein-bridge Oscillator– Square / Triangle / Saw-tooth Wave generators. IC XR-2206 function generator and its applications.

Specialized IC applications: IC 555 Timer: Monostable operation and its applications – Astable operation and its applications. Phase Locked Loop (PLL): Operation of basic PLL-Closed loop analysis of PLL- IC 565 and its applications.

IC Voltage Regulators: Voltage Regulators: Basics of Voltage Regulator – IC Regulators (78xx, 79xx, LM 317, LM 337, 723)-Switching Regulators.

Text Books:

1. Operational Amplifiers & Linear Integrated Circuits: Theory and Application, James M. Fiore, Dissidents publisher, Third edition,2020.
2. Op–Amps and Linear integrated circuits, Ramakanth, A. Gayakwad, Prentice Hall of India, New Delhi, 2000, Fourth Edition.

Reference Books:

1. Operational Amplifiers, George B. Clayton and Steve Winder,,Newnes-Elsevier, 2011, Fifth Edition.
2. Design with Operational Amplifiers and Analog Integrated Circuits, Sergio Franco, Mc Graw Hill, 2014, Third Ed.
3. Operational Amplifiers with Linear Integrated Circuits, William D. Stanley, Pearson Education India, 2004, Fourth Edition.

Other Suggested Readings:

1. https://open.umn.edu/opentextbooks/textbooks/operational-amplifiers-linear-integrated-circuits-theory-and-application-3e
2. https://easyengineering.net/operational-amplifiers-by-clayton/#Download_Link

PH17017 **3-0-0 (3)**

Microprocessors and Applications

Pre-Requisites: **PH17001**

Course Outcomes:

CO1	Understand the architecture of 8086 microprocessor.
CO2	Write Assembly Language Program for 8086 microprocessors.
CO3	Interface peripheral devices 82C55, 8279, 8254 with microprocessor.
CO4	Transfer data using 8237 DMA controller.
CO5	Understand the evolution of advanced microprocessor architectures

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	3
CO2	3	3	3	2	2	3
CO3	3	3	3	2	2	3
CO4	3	1	2	3	2	2
CO5	3	1	2	2	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

The Microprocessor and its Architecture: Introduction to Microprocessor - 8086 Microprocessor architecture –Real mode memory addressing-Data addressing modes –Programming memory – addressing modes –Stack memory addressing modes.

Assembly Language Programming: Data movement instructions-Architecture and logical instructions –program control instructions- program examples.

Memory and Basic I/O interface: Memory devices – Memory mapping and interfacing-Basics of I/O interface- Programmable Peripheral Interface 82C55 -Interfacing of stepper motor-8279 Programmable Keyboard/Display Interface – 8254 Programmable Interval Timer-16550 Programmable Communication Interface.

Interrupts and DMA Basic Interrupt Processing-External Hardware interrupts-8259A Programmable Interrupt Controller-Basic DMA operation-The 8237 DMA Controller-Shared Bus Operation.

Advanced Processor Technologies: Introduction to 80386 Microprocessor, Special registers of 386,386 Memory Management, Features of Pentium-Pentium Memory Management-Super Scale Processors-Multicore processing-MMX and SSE technologies- Beyond Pentium more advanced processors.

Learning Resources:

Text Books:

1. The Intel Microprocessors, Barry B. Brey, Pearson Education, Eighth Edition, 2013.
2. Microprocessors and Interfacing, Douglas V Hall and SSSP Rao, SIE publications, Third Edition, 2017.

Reference Books:

1. Advanced Microprocessors and Peripherals, K. Bhurchandi and A.K. Ray, TMH publications, Third Edition, 2017.
2. The x86 Microprocessor, Architecture, Programming and Interfacing, Lyla B Das, Pearson education, Second Edition, 2014.

Others Suggested Readings:

1. www.intel.com
2. www.pearsoned.co.in/barrybbrey

PH17021 **3-0-0 (3)**

Optical Sensors

Pre-Requisites: None

Course Outcomes:

CO1	Understand the essential characteristics of light matter interaction for optical sensing
CO2	Analyze the working and performance of free space optical sensors
CO3	Design fiber optics sensors for analyzing physical parameters like temperatures, strain
CO4	Determine the applications of optical sensors for mechanical, civil and biological measurements

Syllabus:

Introduction to light matter interaction: how light properties e.g. Intensity, phase, polarizations modified in presence of sensing elements; physical, chemical and biological sensing materials; optical source and detectors.

Free space optical sensor: photodetector based optical sensors; though beam and retro beam sensors; Light dependent resistor, photocell; Optical counters.

Fiber optic sensor: Principle of Fiber optics sensor; sensing components; Intensity modulated interferometric sensor; design of temperature and strain measuring fiber optic sensor; Fiber Bragg grating sensing; distributed sensor

Optical sensor applications: Optical sensor for precision measurements; Structural health monitoring; Fluorescent detectors; Surface Plasmon Resonator; optical coherent tomography; confocal microscopy; endoscopy; near field imaging; Image sensing and CCD device

Learning Resources:

Text Books:

1. Optical Sensors: Basics and Applications"Jörg Haus, Wiley-VCH, GmBH (2010)
2. Fiber Optic Sensors Based on Plasmonics" B.D. Gupta, S.K. Srivastava and R. Verma, World Scientific Pub. Co. (2015).

References Books:

"Optical Sensors: Industrial, Environmental and Diagnostic Applications" Edited by R. Narayanswamy, Springer (2004)

PH18031 **3-0-0 (3)**

Smart Materials and Devices

Pre-Requisites: **None**

Course Outcomes:

CO1	Understand the significance and Pre-Requisites of smart materials.
CO2	Understand the necessity for new and novel materials in our day-to-day scenario.
CO3	Understand the need for the development of self-healing technologies and biomaterials for healthcare.
CO4	Understand about the smart gels and textiles for many exotic applications.
CO5	Understand the urge for self-expanding implants and basics of personalized smart devices

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	3	3	3	2	1	2
CO3	2	3	3	1	2	2
CO4	3	2	1	2	2	2
CO5	1	3	3	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Pre-Requisites of Smart Materials: Smart materials, properties and requirement for smart system, Classification of smart materials, Production of smart materials, Merits and demerits of smart materials, Applications of smart materials.

New Materials – Why do we need them? Need for new materials, Piezoelectric materials, Electro strictive materials, Magneto strictive materials, Rheological materials, Thermo responsive materials, Electrochromic materials, Fullerenes, Biomimetic materials, Quantum tunnelling composite etc., Requirements in Industry, Engineering, Medicine, Sports, Cosmetics, Food, Agriculture, Textiles, Energy conservation and Construction.

Smart Materials for Self-Healing Technologies: Introduction, Self-healing process, Materials for self-healing, Biomaterials, Need for biomaterials, Examples of uses of biomaterials, Material attributes for biomedical applications, Biocompatibility, Biomaterials science, Classes of Biomaterials.

Smart Gels and Textiles for Exotic Applications: Smart gels, Aerogels, Super hydrophobicity, Measurement of hydrophobicity, Self-cleaning technologies, Smart textiles, Applications in sports, Healthcare, Firefighting, Military/Security, etc.

Smart Self-Expanding Implants and Devices: Shape Memory Alloys (SMA), One-way and two-way memory effect, Pseudo elasticity, Preparation and properties of SMA, Practical limitations, Magnetic putty, Applications of SMA, Components of a smart device, Characteristics, Examples of smart devices, Personalization of smart devices.

Learning Resources:

Text Books:

1. Materials that Move: Smart Materials, Intelligent Design, Bengisu, Murat; Ferrara, Marinella, Springer International Publishing, 1st edition, 2018.
2. Encyclopedia of Smart Materials, Schwartz, Mel, Ed., John Wiley and Sons, 1st edition, 2002.

Reference Books:

1. Intelligent Materials, Shahinpoor, Mohsen; Schneider, Hans-Jorg, Eds., RSC Publishing, , 1st edition, 2007.
2. Smart Structures: Physical Behaviour, Mathematical Modelling and Applications, Gaudenzi, Paolo, John Wiley & Sons, 1st edition, 2009
3. A Review of Shape Memory Alloy Research, Applications and Opportunities, Mohd Jani, Jaronie; Leary, Martin; Subic, Aleksandar; Gibson, Mark A, Materials & Design. 56: 10781113 (2014)

Others Suggested Readings:

1. http://pubs.rsc.org/bookshop/collections/series?issn=2046-0066
2. www.ted.com/talks/anna_ploszajski_smart_materials/

PH15026 **3-0-0 (3)**

Fundamentals of VLSI

Pre-Requisites: **None**

Course Outcomes:

CO1	Realize the concepts of digital building blocks using MOS transistor.
CO2	Design combinational MOS circuits and power strategies.
CO3	Design and construct Sequential Circuits and Timing systems.
CO4	Design arithmetic building blocks and memory subsystems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	1	-
CO2	3	2	1	2	1	1
CO3	3	2	2	2	-	2
CO4	3	2	3	1	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

INTRODUCTION TO MOS TRANSISTOR: MOS Transistor, CMOS logic, Inverter, Pass Transistor, Transmission gate, Layout Design Rules, Gate Layouts, Stick Diagrams, Long- Channel I-V Charters tics, C-V Charters tics, non ideal I-V Effects, DC Transfer characteristics, RC Delay Model, Elmore Delay, Linear Delay Model, Logical effort, Parasitic Delay, Delay in Logic Gate, Scaling.

COMBINATIONAL MOS LOGIC CIRCUITS: Circuit Families: Static CMOS, Ratioed Circuits, Cascade Voltage Switch Logic, Dynamic Circuits, Pass Transistor Logic, Transmission Gates,Domino, Dual Rail Domino, CPL, DCVSPG, DPL, Circuit Pitfalls. Power: Dynamic Power, Static Power, Low Power Architecture.

SEQUENTIAL CIRCUIT DESIGN: Static latches and Registers, Dynamic latches and Registers, Pulse Registers, Sense Amplifier Based Register, Pipelining, Schmitt Trigger, Monostable Sequential Circuits, Astable Sequential Circuits. Timing Issues: Timing Classification of Digital System, Synchronous Design.

DESIGN OF ARITHMETIC BUILDING BLOCKS AND SUBSYSTEM: Arithmetic Building Blocks: Data Paths, Adders, Multipliers, Shifters, ALUs, power and speed trade-offs, Case Study: Design as a trade-off.

Designing Memory and Array structures: Memory Architectures and Building Blocks, Memory Core, Memory Peripheral Circuitry.

Learning Resources:

Text Books:

1. CMOS VLSI Design: A Circuits and Systems Perspective, Neil H.E. Weste, David MoneyHarris, Pearson, 4th Edition, 2017.
2. Digital Integrated Circuits: A Design perspective, Jan M. Rabaey, Anantha Chandrakasan,

Borivoje. Nikolic, Pearson, 2nd Edition, 2016.

Reference Books:

1. Application Specific Integrated Circuits, M.J. Smith, Addisson Wesley, first edition, 1997
2. CMOS Digital Integrated Circuits: Analysis & Design, Sung-Mo kang, Yusuf leblebici, Chulwoo Kim, McGraw Hill Education, 4th edition, 2013.
3. Modern VLSI Design: System on Chip, Wayne Wolf, Pearson Education, 3rd edition, 2007.

Others Suggested Readings:

1. https://nptel.ac.in/courses/117/101/117101004/.

PH17006 **3-0-0 (3)**

Communication Systems

Pre-Requisites: None

Course Outcomes:

CO1	Understand Communication systems,
CO2	Estimate noise in communication systems
CO3	Comprehend Amplitude and Frequency modulation and demodulation methods
CO4	Distinguish between Pulse Amplitude, Pulse with and Pulse Position modulation.
CO5	Comprehend digital communication formats

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	3	2	1	1	2	3
CO3	3	2	1	1	2	3
CO4	2	1	3	3	1	2
CO5	3	1	3	3	1	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Communication Systems and Noise Calculations: Bandwidth and information capacity--Electronic Communication Systems-Need for modulation- - Linear Summing-Nonlinear Mixing- Voltage and current models of a noisy resistor- Addition of noise due to several sources- Thermal noise calculations-SNR, Noise Figure - experimental determination of NF, Noise temperature

Analog Modulation Schemes and Radio Receivers: Amplitude modulation spectra of DSB-FC, DSB-SC, SSB-SC -Generation and demodulation. Generation and detection of VSB Signals-ISB-System. Spectral features of FM and PM- .FM generation -direct and indirect methods -NBFM, WBFM, FM Detection (Slope detection, Foster- Seeley, Ratio type, PLL). TRF and super heterodyne receivers-AGC and delayed AGC

Pulse Modulation Schemes: Introduction: The sampling theorem- Pulse Communication: Pulse Amplitude Modulation (PAM) Fundamentals, generation and detection – Pulse Time Modulation (PTM-PWM, PPM)-generation and detection – Pulse code Modulation (PCM)- Comparison of various Pulse Communication System (PAM – PTM – PCM).

Digital Communication System Formats: Modulation Formats: Introduction to Constellation diagram. Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Binary FSK -Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM), M-ary schemes.

Learning Resources:

Text Books:

1. Electronic Communication Systems, George Kennedy, Bernard Davis, TMH,4th edition,1999.
2. Electronic Communication Systems-Fundamentals through Advanced, Wayne Tomasi, Pearson Education, 6th edition,2009.

Reference Books:

1. Modern Digital and Analog Communication Systems, B.P.Lathi, Zhi ding Oxford University Press, Fourth Edition, 2011.
2. Communication Systems, Symon Haykin, Michael Mohar; Wiley publications, Fifth Edition, 2013.

Others Suggested Readings:

1. https://nptel.ac.in/courses/117/102/117102059/
2. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee08/

PH17012 **3-0-0 (3)**

Optical Systems Design

Pre-Requisites: None

Course Outcomes:

CO1	Analyse the optical systems with ray tracing
CO2	Analyse Optical systems for and make corrections
CO3	Judge the quality of optical systems by determining OPD, MTF and OTF.
CO4	Understand Catadioptric systems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	1	1
CO2	3	3	3	3	2	2
CO3	3	3	3	2	2	2
CO4	3	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

First Order Optics: Ray Tracing of Paraxial Ray, Graphical Ray Tracing, Trigonometrical Ray Tracing at a Spherical Surface, Magnification and the Lagrange Theorem, The Gaussian Optics of a Lens System, First-Order Layout of an Optical System

Aberrations: Symmetrical Optical Systems, Aberration Determination Using Ray Trace Data, Spherical Aberration, Surface Contribution Formulas, Zonal Spherical Aberration, Primary Spherical Aberration, Design of a Spherically Corrected Achromat, Coma and the Sine Condition, The Optical Sine Theorem, The Abbe Sine Condition, Astigmatism and the Coddington Equations, The Petzval Theorem, Curvature and Distortion, Chromatic Aberration, Chorochromatic of a Cemented Doublet, Contribution of a Single Surface to the Primary

Stops, Apertures, Pupils and Diffraction: The Aperture Stop and Pupils, The Field Stop, Vignetting, Glare Stops, Cold Stops, and Baffles, The Telecentric Stop, Apertures and Image Illumination—f-Number and Cosine-Fourth, Depth of Focus, Diffraction Effects of Apertures, Resolution of Optical Systems

Wave-Front Aberrations and MTF: Optical Path Difference: Focus Shift, Optical Path Difference: Spherical Aberration, Aberration Tolerances, Image Energy Distribution (Geometric), Spread Functions—Point and Line, Geometric Spot Size Due to Spherical Aberration, The Modulation Transfer Function, Square-Wave vs. Sine-Wave Targets, Special Modulation Transfer Functions: Diffraction-Limited Systems, Radial Energy Distribution, Point Spread Functions for the Primary Aberrations.

Mirror and Catadioptric Systems: Comparison of Mirrors and Lenses, Ray Tracing a Mirror System, Single-Mirror Systems, Single-Mirror Catadioptric Systems, Two-Mirror Systems,Multiple-Mirror Zoom Systems

Learning Resources:

Text Books:

1. Lens Design Fundamentals, Rudolf Kinslake, R. Barry Johnson, SPIE Press, SecondEdition,

2010.
2.Modern Optical Engineering, W.J. Smith, Mc Graw Hill, Fourth Edition, 2008.

Reference books:

1. Optical System Design, Biljana Tadic-Galeb, Paul Yoder, and Robert
2. E Fischer, McGraw-Hill Education, Second Edition, 2008.
3. Principle of Optics, B. K. Mathur, Gopal press, Second Edition, 1970.

Others Suggested Readings:

1. https://spie.org/education/courses/coursedetail/SC003?f=InCompany
2. https://3doptix.com/pages/optical-design-software

PH17040 **3-0-0 (3)**

Lasing Materials

Pre-Requisites: None

Course Outcomes:

CO1	Select the solid-state laser for different applications based on material design, mechanical design, host material, doping ions and other properties
CO2	Understand different types of Garnet lasers and applications
CO3	Comprehend fluorides laser crystals and applications
CO4	Understand the mechanism of energy transfer in lasers
CO5	Understand different types of two micron lasers and applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	1	2	1	1
CO3	2	3	2	2	1	1
CO4	3	3	3	2	2	1
CO5	3	3	2	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Solid State Laser Materials: Properties, Optics, Material design, Mechanical design, Doping Ions, Laser host materials, General Properties of Hosts, Optical properties, Chemical properties, Mechanical properties, Thermal properties, Photo physics of Solid-State Laser Materials: Nonradiative Transition, Energy gap and temperature dependence of multi phonon relaxation, Temperature dependence of nonradiative relaxation

Garnet Crystals as Laser Hosts: Physical Characteristics of Garnets and Mixed Garnets, Chromium- and Neodymium-Doped Garnets, Disordered (Mixed) Garnets, Glass and Crystalline Ceramics, Yb-YAG Laser

Fluoride Laser Crystals: YLiF4 (YLF), Thermal and Mechanical Properties of YLF, Estimate of thermal load at fracture, Nonradiative Losses in YLF, Neodymium-Doped YLF, Holmium Doped YLF, Thulium-Doped YLF, Other Fluorides Crystals, Cascade Emission, Up conversion, Applications to up conversion

Energy Transfer: Introduction, Radiative Energy Transfer, Nonradiative Energy Transfer, Basic mechanisms of energy transfer, Resonant energy transfer, Exchange interaction, Phonon assisted energy transfer, Pathways of excited state relaxation, Statistical model (Inokuti Hirayama model)

Two-Micron Lasers: Holmium- and Thulium-Doped Crystals: Introduction, Advantages of the Holmium Laser, Utilizing energy transfer, Conventional Pumping CW laser operation, Pulsed operation of holmium lasers, Diode Pumping, End-pumped 2 um lasers, Side-pumped 2 um lasers.

Learning Resources:

Text book:

1. Yehoshua Y. Kalisky, The Physics and Engineering of Solid-State Lasers, PIE, 2005

Reference Books:

1. Fuxi Gan, Laser Materials, 1995

PH15028 **3-0-0 (3)**

Electronic Instrumentation

Pre-Requisites: None

Course Outcomes:

CO1	Understand the principle of Oscilloscopes and Wave analysers
CO2	Identify the suitable signal source for various applications
CO3	Make use of the spectrum and network analysers
CO4	Combine software and modular measurement hardware to create user-defined measurement systems, called virtual instruments
CO5	Design to calibrate various practical instruments

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	1	1
CO2	3	2	3	1	2	2
CO3	2	3	1	3	3	1
CO4	1	2	2	2	3	1
CO5	2	1	1	3	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Oscilloscopes and logic analyzers: Basic operation and advanced techniques, digital storage oscilloscope- sampling methods; controls- display, vertical, horizontal, trigger and acquisition controls; Measurements- voltage, time, frequency, pulse, rise time and fully automated measurements. Logic analyzer- types, logic timing analyzer (LTA), logic state analyzer (LSA), block diagram, interfacing.

Signal sources, arbitrary waveform generators and pattern generators: Introduction, fixed and variable AF oscillator, standard signal generator, laboratory type signal generator, AF sine and square wave generator, function generator, square and pulse generator, sweep generator, arbitrary waveform generators.

Spectrum and network analyzers: Wave analyzers- resonanant, frequency selective, heterodyne- applications; Harmonic distortion analyzer, Spectrum analyzers, applications of spectrum analyzers, fundamental principles of network analyzer.

Virtual instrumentation: Personal computer for data acquisition and instrument control, instrument drivers and driver software, GPIB – VXI, PCI and PXI bus standards, applicationsoftware lab view.

Calibration of instruments: Calibration of practical instruments, types of DMM, general DMM calibration requirements, calibration of oscilloscopes, calibration of high-speed DSO's automated calibration and calibration software.

Learning Resources:

Text Books:

1. Digital and analogue instrumentation: testing and measurement, Kularatna, A.D.V.N,Prentice Hall India, 1st edition, 2001.
2. Electronic Instruments and Instrumentation Technology, M.M.S. Anand, PH India, 1stedition, 2005.

Reference Books:

1. Electronic Instrumentation, H.S. Kalsi, Mc Graw Hill Education, 3rd edition, 2015.
2. Electronic Instruments and Measurements, David A. Bell, Oxford Higher Education, 3rdedition, 2015.

Others Suggested Readings:

1. https://drive.google.com/file/d/1w7LSIAx3B-II06YjHr0f7WgI8_-Tyyil/view

PH15030 **3-0-0 (3)**

Photonic Devices

Pre-Requisites: None

Outcomes:

CO1	Understand various aspects and applications of photonic components and devices
CO2	Differentiate the features and applications of active and passive photonic devices
CO3	Analyze the micro optic component for photonic technology
CO4	Determine usages of components for fiber optic technology

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	-	-
CO2	3	3	2	1	2	-
CO3	3	2	1	1	2	-
CO4	3	3	1	1	2	--
CO5	3	3	2	1	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction Active and Passive Photonic devices: Applications, Micro optic devices, Waveguide Mechanism, Waveguides, Multilayer Structures, Couple mode theory and couplers, Leaky Structures, Optical channels and routers, Optical switches, Optical buffers

Fiber optic devices: Device applications of Optical fibers, Special Fiber, Photonic Crystal Fiber, Photonic Bandgap fiber, Bragg Fiber, Fiber Bragg Grating, Long period grating, Optical fiber tapering, Erbium doped fiber amplifier, Fiber laser

Novel Photonic devices: Photonic band gap and Periodic photonic crystals, Theory of Plasmonic and Plasmonic devices, Slow light photonic device

Quantum Optical Devices: Single-photon emitters, Photon pair sources, Low noise photodetectors, Photon counter, Optical Traps, Systems for quantum Cryptography including quantum key distribution

Learning Resources:

Text Books:

1. Introduction to Fiber Optics, Ajoy Ghatak and K Thyagarajan, Cambridge University Press,1998.
2. Fundamentals of Photonics, BMA Saleh and MC Teich, John Wiley, NY, 2007.
3. Optical Electronics, A Ghatak and K Thyagarajan, Cambridge University Press, 1989.
4. Applied optics fundamentals and device applications, Mark A.Mentzer, , CRC Press, 2011.

Reference books:

1.
2. Photonics essentials, Thomas P.Pearsall, 2 Ed, Mc-Graw Hill, 2010.
3. Fundamentals of Optical waveguides, K Okamota, Academic Press, 2006.

Others Suggested Readings:

1. https://www.edx.org/course/optical-materials-and-devices

PH15032 **3-0-0 (3)**

Research Methodology

Pre-Requisites: **Basic knowledge of the English language is needed.**

Course Outcomes:

CO1	Students shall get acquainted with the selection of the research problem, its analysis, carrying out relevant literature survey, and reviewing
CO2	Understand the fundamentals of research writing, analysis, approach, defining specific objectives, design of experiment, etc.
CO3	Demonstrate research writing styles and use the features of scientific writing, defining specific objectives, design of experiments, analysis & presentation of experimental and theoretical studies
CO4	Students shall be trained on writing scientific articles, proposals, defining specific objectives, estimation of budget, etc
CO5	Students shall be exposed to the classification of IPRs, identification in their research, patent drafting and filing processes, national and international policies on IPR, etc.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	1
CO2	3	2	2	2	1
CO3	2	3	2	3	1
CO4	3	3	2	2	2
CO5	3	3	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Research Methodology: Types of Research, Differentiating Scientific Writing from Academic Writing, English for Research Writing – examples in Research papers, Scientific articles, reports and patents. Research keywords, literature survey methods, research objectives, research design/plan, choosing experimental methods, data collections and analysis, Research ethics – conflict of interest issues, citation of prior art, plagiarism & permissible similarity in writing, Similarity checking tools.

Effective Scientific Writing: Elements of writing Paragraphs, writing with precision, conciseness, and coherence, Editing and Proofing, Components of research article - title, abstract, introduction, objectives, methods, results, tables, figures, graphs, discussion, summary, acknowledgment, in-text citations, reference list, and appendix.

Presentation and Publication of Research Articles: Importance of publishing research, research writing templates, style and structure, developing various sections outlines, identifying research problem, framing research questions, highlighting key findings, reviewing / peer reviewing. Indexing, choosing journals to publish, and publication in journals. Focus on conferences and workshops - Oral presentation skills – Post-presentation of research outcome – Abstracts & extended abstracts – Proceedings of technical deliberation

- conference proceedings and in book or as book chapters.

Compilation of Thesis and Research Proposals: Components of Thesis - Title, abstract, keywords, introduction, citations, introduction, objectives, methods, results, tables figures, graphs, discussion summary, and references. Instructions to authors for writing a research paper. Components of proposal document- Title, aim, research background, project outline, research methodology & budgeting, time schedule, deliverables, and references.

Intellectual Property Rights: Classification of IPs - identification of IP values in research outcome – Prior art search – Open source and commercial search engines. Patents and Trade Marks - National and institutional IPR Policies – Patent filing procedures.

Learning Resources:

Text Books:

1. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International, 4th Edition, 2018
2. Research Methodology a step-by step guide for beginners, Ranjit Kumar, SAGE Publications Ltd, 3rd Edition, 2011.

Reference Books:

1. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009.

2. Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.

Others Suggested Readings:

1. https://owl.purdue.edu/owl/general_writing/common_writing_assignments/research_papers/index .html