CURRICULUM & SYLLABI

M. SC. (Tech.) ENGINEERING PHYSICS

Effective from AY: 2024-25



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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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
Engineering 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.

Program: M.Sc. (Tech.) Engineering Physics

Program Educational Objectives

PEO-1	Gain knowledge and insight into the various fields of Engineering Physics and be able to understand various Scientific / Engineering problems and their solutions.
PEO-2	Be able to analyse a problem / solution, in the fields of Photonics, Electronics and Instrumentation and discern it into basic modules and interpret its performance and limitations.
PEO-3	Design and develop solutions to the Scientific / Industrial problems in the chosen specialization of Photonics, Electronics and Instrumentation
PEO-4	Be able to use modern software tools for analysis, design and development in the areas of Photonics, Electronics and Instrumentation
PEO-5	Be a leader in multidisciplinary research and development and project execution.

Program Articulation Matrix

PEO / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
Generate a specialized cadre of civil engineers by imparting quality education and training	3	3	3	3	2
Attain international standards in teaching, research and consultancy with global linkages	3	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: M.Sc., (Tech.) Engineering Physics

Program Outcomes

PO-1	Acquire comprehensive knowledge in the areas of Engineering Physics for understanding and addressing the multidisciplinary problems.
PO-2	Identify, formulate and analyse complex scientific / engineering problems using the knowledge gained in Engineering Physics, Photonics, Electronics and Instrumentation.
PO-3	Design and Develop integrated solutions and systems for the multidisciplinary problems involving Photonics, Electronics and Instrumentation.
PO-4	Investigate complex research problems and provide suitable solutions using advanced tools and processes.
PO-5	Communicate effectively the complex multidisciplinary problems through proper documentation, reports and presentations.
PO-6	Acquire the skills necessary for lifelong learning to remain relevant and keep the competitive edge in future.

CURRICULUM
M. Sc. (Tech.) Engineering Physics

1st Semester

S.No	Course Code	Course Title	L-T-P	Credits
1	PH1601	Mathematical Physics	3-0-0	3
2	PH1603	Quantum Mechanics	3-0-0	3
3	EE1261	Network Analysis	3-0-0	3
4	PH1605	Optical Physics	3-0-0	3
5	ME1161	Engineering Drawing	1-0-4	3
6	PH1607	Optical Physics Laboratory	0-1-2	2
7	PH1609	Network Analysis Laboratory	0-1-2	2
			Total Credits	19

2nd Semester

S.No	Course Code	Course Title	L-T-P	Credits
1	PH1602	Electromagnetic Theory	3-0-0	3
2	PH1604	Atomic and Molecular Physics	3-0-0	3
3	PH1606	Solid State Physics	3-0-0	3
4	PH1608	Transducer Technology	3-0-2	4
5	PH1610	Electronic Devices and Circuits	3-0-0	3
6	PH1612	Solid State Physics Laboratory	0-1-2	2
7	PH1614	Electronic Devices and Circuits Lab	0-1-2	2
8	PH1690	Seminar and Technical Writing - 1	0-0-2	1
			Total Credits	21

3rd Semester

S.No.	Course Code	Course Title	L-T-P	Credits
1	PH1701	Switching Theory and Logic Design	3-0-0	3
2	PH1703	Materials Science and Engineering	3-0-0	3
3	PH1705	Optoelectronics	3-0-0	3
4	PH1707	Linear Integrated Circuits	3-0-2	4
5	PH1709	Computer programming for Physics	3-0-2	4
6	PH1711	Optoelectronics Lab	0-1-2	2
7	PH1713	Switching Theory and Logic Design Lab	0-1-2	2
			Total Credits	21

4th Semester (Electronics and Instrumentation Specialization)

S.No.	Course Code	Course Title	L-T-P	Credits
1	PH1702	Structured Digital System Design	3-0-0	3
2	PH1704	Microprocessors and Interfacing	3-0-0	3
3	PH1706	Communication Systems	3-0-0	3
4	PH17XX	Professional Elective – I	3-0-0	3
5	PH17XX	Professional Elective – II	3-0-0	3
6	PH1708	Digital System Design Laboratory	0-1-2	2
7	PH1710	Microprocessors and Interfacing Laboratory	0-1-2	2
8	PH1782	Fractal Course	1-0-0	0.5
			Total Credits	19.5

4th Semester (Photonics Specialization)

S.No.	Course Code	Course Title	L-T-P	Credits
1	PH1712	Optical System Design	3-0-0	3
2	PH1714	Optical Instruments	3-0-0	3
3	PH1716	Fourier Optics and Holography	3-0-0	3
4	PH17XX	Professional Elective – I	3-0-0	3
5	PH17XX	Professional Elective – II	3-0-0	3
6	PH1718	Optical System Design Laboratory	0-1-2	2
7	PH1720	Optical Instruments Laboratory	0-1-2	2
8	PH1782	Fractal Course	1-0-0	0.5
			Total Credits	19.5

5th Semester (Electronics and Instrumentation Specialization)

S. No	Course Code	Course Title	L-T-P	Credits
1	PH1801	Digital Signal Processing	3-0-0	3
2	PH1803	Microcontrollers and Applications	3-0-0	3
3	PH18XX	Professional Elective – III	3-0-0	3
4	PH18XX	Professional Elective – IV	3-0-0	3
5	PH18XX	Professional Elective – V	3-0-0	3
6	PH1805	Digital Signal Processing Laboratory	0-1-2	2
7	PH1807	Microcontroller Applications Laboratory	0-1-2	2
8	PH1893	Comprehensive Viva Voce	0-0-0	2
9	PH1883	Fractal Course	1-0-0	0.5
			Total Credits	21.5

5th Semester (Photonics Specialization)

S. No	Course Code	Course Title	L-T-P	Credits
1	PH1809	Optoelectronic Sensing and MOEMS	3-0-0	3
2	PH1811	Optical Elements Production & Testing	3-0-0	3
3	PH18XX	Professional Elective – III	3-0-0	3
4	PH18XX	Professional Elective – IV	3-0-0	3
5	PH18XX	Professional Elective – V	3-0-0	3
6	PH1813	Optoelectronic Sensing Laboratory	0-1-2	2
7	PH1815	Fourier Optics and OEPT laboratory	0-1-2	2
8	PH1893	Comprehensive Viva Voce	0-0-0	2
9	PH1883	Fractal Course	1-0-0	0.5
			Total Credits	21.5

6th Semester (All Specializations)

S. No	Course Code	Course Title	L-T-P	Credits
1	PH1898	Dissertation	0-0-0	14
		Total	0-0-0	14

Professional Elective Courses (Electronics and Instrumentation Specialization):

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	PH1722	High Speed Data Converters
2	PH1724	Semiconductor Physics and Devices
3	PH1726	Lasers and Applications
Professional Elective-II		
S.No.	**Code**	**Course Title**
1	PH1728	Pulse Circuits
2	PH1730	Computer Organisation and Operating Systems
3	PH1732	Thin Films and Vacuum Techniques

Professional Elective-III		
S.No.	**Code**	**Course Title**
1	PH1821	Advanced Communication Systems
2	PH1823	Designing with FPGA and CPLDs
3	PH1825	Solar Energy Systems

Professional Elective-IV		
S.No.	**Code**	**Course Title**
1	PH1827	VLSI Design
2	PH1829	Satellite Communication
3	PH1831	Smart Materials and Devices
Professional Elective-V		
S.No.	**Code**	**Course Title**
1	PH1833	Data Communication
2	PH1835	Embedded Systems
3	PH1837	Nanomaterials and Devices
4	PH1839	Data driven engineering physics

Professional Elective Courses (Photonics Specialization):

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	PH1734	Fiber Optics
2	PH1736	Polarization Optics
3	PH1726	Lasers and Applications

Professional Elective-II		
S.No.	**Code**	**Course Title**
1	PH1738	Nonlinear Optics
2	PH1740	Lasing Materials
3	PH1732	Thin Films and Vacuum Techniques
Professional Elective-III		
S.No.	**Code**	**Course Title**
1	PH1841	Photonic Integrated Circuits
2	PH1843	Quantum Optics
3	PH1825	Solar Energy Systems

Professional Elective-IV		
S.No.	**Code**	**Course Title**
1	PH1845	Illumination and light Design
2	PH1847	Silicon Photonics
3	PH1849	Nanophotonics

Professional Elective-V		
S.No.	**Code**	**Course Title**
1	PH1851	Biophotonics
2	PH1853	Display Technologies
3	PH1837	Nanomaterials and Devices
4	PH1839	Data driven engineering physics

The Overall Credit Structure

Course Category	Credits
Program Core	74
Engineering Science	08
Professional Elective	15
Seminar and Technical Writing	02
Fractal Course	01
Comprehensive Viva-Voce	02
Dissertation	14
Total Graded Credit Requirement	116

SYLLABI

M.Sc. (Tech.) Engineering Physics

1st Semester

PH1601 **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.

Other Suggested Readings:

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

PH1603 **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.

Other Suggested Readings:

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

EE1261 **3-0-0 (3)**

Network Analysis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Simplify DC networks and analyze them using loop and node equations anddetermine the dual of a given network
CO-2	Analyze magnetic circuits, and electric circuits with sinusoidal excitation along with the phenomenon of resonance
CO-3	Formulate the dynamic equations of electric circuits using differential equationsand simplify their solutions using Laplace.
CO-4	Simplify the analysis of electric circuits using network theorems and Two port Networks.

Course Articulation Matrix:

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

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

Syllabus:

Circuit Elements and Relations: Types of circuit components, Types of Sources and Source Transformations, Star-delta transformation, KVL and KCL with dependent and independent Sources, DC circuit analysis, Formation of loop and node equations. Graph of a network- incidence matrix, Dual networks.

Magnetic Circuits: Concept of MMF, flux and magnetic reluctance, self and mutual inductances, Dot convention, coefficient of coupling and coupled circuits.

Steady State Analysis of Circuits for Sinusoidal Excitations: Concept of phasor, Single phase Series, Parallel, Series Parallel circuits, Concept of power factor, Solution of AC networks using mesh and nodal analysis, Phasor diagrams. Resonance: Series and Parallel resonance, Bandwidth, Q-factor and selectivity.

Time Domain Analysis: Solution of network equations in time domain, Classical differential-equations approach, Initial conditions & evaluation, applications to simple RLCcircuits only.

Applications of Laplace Transforms in Circuit Theory: Laplace transforms of various signals of excitation, Laplace transformed networks.

Network Theorems: Superposition theorem, Thevenin‘s theorem, Norton‘s theorem, Maximum power transfer theorem, Milliman‘s theorem, Tellegen‘s theorem.Two port parameters: Relationship of two port variables, Short circuit admittance parameters, open circuit impedance parameters, Transmission parameters, Hybrid parameters, Interrelationships, parallel connections of two port networks.

Learning Resources:

Text Books:

1. Network Analysis, M. E. Van Valkenburg, Prentice Hall India, 3rd edition, 2012.
2. Circuit Theory Analysis and Synthesis, A. Chakrabarti, Dhanpati Rai Publications, 4thedition, 2018.

Reference Books:

1. Introduction to Electric Circuits, R. C. Dorf, and J.A. Svoboda, John Wiley & Sons Inc., 3rd edition, 2004.
2. Basic Circuit Theory, Charles A Desoer, Ernest S Kuh, McGraw Hill, 2nd edition, 2010.

Other Suggested Readings:

1. National Programme on Technology Enhanced Learning (NPTEL) Online courses, Branch- Electrical Engineering, Course- Network Analysis.
2. https://nptel.ac.in/courses/108/105/108105159/

PH1605 **3-0-0 (3)**

Optical Physics

Pre-Requisites: **None**

Course Outcomes:

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.

Other Suggested Readings:

1. https://studiousguy.com
2. https://phet.colorado.edu

ME1161 **1-0-4 (3)**

Engineering Drawing

Pre-Requisites: None

Course Outcomes:

CO-1	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions
CO-2	Classify the systems of projection with respect to the observer, object and the reference planes
CO-3	Construct orthographic views of an object when its position with respect to the reference planes is defined
CO-4	Analyse the internal details of an object through sectional views
CO-5	Develop 3D Isometric View from 2D orthographic views

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
CO-1	1	1	1	-	-	-	1	1	3	3	-	-	1	-	-
CO-2	1	1	1	-	-	-	1	1	3	3	-	-	-	-	-
CO-3	1	1	1	-	-	-	1	1	3	3	-	-	-	-	-
CO-4	1	1	1	-	-	-	1	1	3	3	-	-	-	-	-
CO-5	1	1	1	-	-	-	1	1	3	3	-	-	-	-	-

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

Syllabus:

Introduction: Drawing instruments and their uses, Types of lines, Lettering, General rules for dimensioning, Geometrical constructions using instruments. **(Conventional)**

Orthographic Projection: Methods of projection, Principles of Orthographic projection, First angle versus third angle of projection, Six views of an object, Conventions. **(Conventional)**

Projection of Points: Projections of points when they are situated in different quadrants. **(Conventional)**

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces. **(Conventional)**

Fundamentals of AutoCAD: Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES **(AutoCAD)**

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes. **(AutoCAD)**

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes. **(AutoCAD)**

Section of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section. **(AutoCAD)**

Isometric Views: Isometric axes, Isometric lines, Isometric Planes, Isometric scale, Isometric Views, Isometric projections. **(AutoCAD)**

Learning Resources:

Text Books:

1. N.D.Bhatt. and V.M.Panchal, Engineering Graphics, Charotar Publishers, 2016, 53rd Edition

Reference Books:

1. B. Agarwal, Engineering Drawing, 2015, McGraw Hill Education, 2015, 2nd Edition
2. S. Tickoo, Auto CAD 2017 for Engineers & Designers, Dreamtech, 2016, 23rd Edition

PH1607 **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

Other 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

PH1609 **0-1-2 (2)**

Network Analysis Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine network parameters using mesh and node analysis.
CO-2	Analyze steady state dc networks.
CO-3	Analyze steady state ac networks.
CO-4	Evaluate the transient response of networks.

Course Articulation Matrix:

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

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

List of experiments:

1. Design a circuit and verification of Kirchhoff's Laws: Mesh Analysis.
2. Design a circuit and verification of Kirchhoff's Laws: Node Analysis.
3. Design a circuit and verification of Superposition theorem.
4. Design a circuit and verification of Maximum power transfer theorem.
5. Design a circuit and verification of Thevenin's theorem.
6. Design a circuit and verification of Norton's theorem.
7. Design a circuit and verification of Super node.
8. Design a circuit and verification of Reciprocity theorem.
9. Design a circuit and verification of Norton's theorem.
10. RC circuit as a filter.
11. Frequency response of RLC circuit.
12. Response of RC circuit for step input and determination of time constant and capacitance.

Learning Resources:

Text Books:

1. Circuit Theory Analysis and Synthesis, A. Chakrabarti, 4th Edition, 2018.
2. Circuits and Networks: Synthesis & Analysis, A. Sudhakar & S. Shyammohan Pillai, 3rd Edition, 2017.

Reference Books:

1. M. E. Van Valkenburg, Network Analysis, Prentice Hall India, 3rd Edition, 2012.
2. R. C. Dorf, J.A. Svoboda, Introduction to Electric Circuits, John Wiley & Sons Inc., UK, 2004.

Other Suggested Readings:

1. Virtual Labs, An initiation by Ministry of Education
   https://www.vlab.co.in/
2. National Programme on Technology Enhanced Learning (NPTEL) Online courses, Branch- Electrical Engineering, Course- Network Analysis
   https://nptel.ac.in/courses/108/105/108105159/

2nd Semester

PH1602 **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.

Other suggested Readings:

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

PH1604 **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

Other Suggested Readings:

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

PH1606 **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.

Other Suggested Readings

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

PH1608 **3-0-0 (3)**

Transducers Technology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand mechanical, electrical and advanced transducers
CO-2	Identify transducers for measuring physical parameters for specific performance
CO-3	Evaluate the performance of transducers
CO-4	Interface sensors using LAabVIEW

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	3
CO-4	2	3	3	2	3	3

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

Syllabus:

Introduction to transducers: General measurement system, Sensor and transducers definition, classification of transducers, mechanical transducers, electrical transducers, active and passive, analog and digital transducers, general characteristics of transducers, criteria fortransducer selection.

Mechanical Transducers: Bimetallic strip, Liquid and gas based thermometers, Piezometer, U- tube manometer, well type manometer, Inclined manometer, differential pressure manometer, Bourdon tube, Bellows, Capsules, diaphragm, Springs, Cantilever beams, Dial gauge, Proving ring, Hydraulic force transducers, Pitot tube, Venture, orifice plate, nozzle, rotating vane meter, rotameter, turbine flow meter, hydrometer, U-type weighing system, u type viscometer, rotational viscometer, falling sphere viscometer, advantages and disadvantages of mechanical transducers.

Electrical Transducers: Classification of electrical transducers, passive transducers, resistive transducers, RTD, Thermistor, Hot wire resistance transducers, Strain gauges, Gauge factor, load cell, Piezo resistivity, Photo resistivity, Capacitive transducers, dielectric, proximity transducer, Inductive transducers: synchro‘s, eddy current transducers, LVDT, RVDT, Digital transducers, Active transducers, Thermoelectric; thermocouple, Thermopiles, Piezoelectric transducers, pyroelectric transducers.

Advanced transducer: Ultrasonic transducers, Coriolis flow meter, SAW transducers, Radiation transducers, Fiber optic transducers, Hall effect transducer, Gyroscopic sensor, Bio-Sensors, Water quality sensors, Gas sensors: Metal oxide, capacitive, calorimetric, MEMS transducers, Graphical interfacing of sensors systems using LabVIEW and Arduino,Sensors in IoT technology.

Learning Resources:

Text Books:

1. Transducers and Instrumentation, DVS Murthy, Prentice Hall India Learning PrivateLimited, 2nd edition, 2008.
2. Handbook of Sensors and Transducers, Gavin Lawrence, Oxford Book Company, 2019.

Reference Books:

1. Sensors and Transducers, D Patranabis, Prentice Hall India Learning Private Limited, 2nd edition, 2003.
2. Transducers Engineering, S Vijayachitra, Prentice Hall India Learning Private Limited, 2nd edition, 2016.
3. Instrument Transducers: An Introduction to Their Performance and Design, H.K.P. Neubert, Oxford University press, 2nd edition, 1999.

Other Suggested Readings:

1. https://www.ni.com/en-in/shop/labview.html
2. https://slcoep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineeri ng.

PH1610 **3-0-0 (3)**

Electronic Devices and Circuits

Pre-Requisites: **EE1261**

Course Outcomes:

CO-1	Understand the characteristics of diode, BJT, FETs, UJT, Diac and Triac.
CO-2	Analyse small signal amplifiers using BJTs and FETs.
CO-3	Design small signal amplifiers using BJTs and FETs for a given specification.
CO-4	Understand the role of feedback in amplifiers
CO-5	Design class A, B, AB and C types of power amplifiers

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	2	3	2	1	1	1
CO-3	3	3	3	2	2	1
CO-4	2	1	1	1	1	1
CO-5	2	1	1	1	1	1

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

Syllabus:

PN Diode: Characteristics –Biasing, Diode Switching Times, DC load line Analysis, Temperature Effects, Applications – Half Wave, Full Wave, Bridge Rectifiers Filters – Chipping and Damping Circuits – Voltage Multiplier Circuits. Zener Diodes, Characteristics, Zener Voltage Regulator circuits.

Bipolar Junction Transistors *(BJT):* Construction and operation, Characteristics - CE, CB & CC Configurations, DC Load Line, B J T Biasing circuits, Comparison of Bias Circuits, Thermal Stability, Analysis of B J T biasing circuits (AC), Frequency responses.

Field Effect Transistors (FET*)*: JFET Construction and Working- Characteristics, DC analysis, Biasing circuits. MOSFETS – Enhancement and Deflection Modes. F E T Biasing circuits. AC Analysis of different biasing circuits, Frequency response of Amplifiers.

Feedback – Gain with Feedback – Effect of Feedback on the Basic Amplifier –Series Voltage Negative Feedback, Emitter Current Feedback circuit.

Power Amplifier: Class A, Transformers Coupled Class – A amplifier, Class B and Class B Push Pull Power amplifiers. *Other Semiconductor Devices*: Thyristors – SCR, Triac, Diac, U J T, P U T and their applications.

Learning Resources:

Text Books:

1. Electronic Devices & Circuits – Oxford University Press – David A Bell ,5th edn,2010.
2. Electronic Devices & Circuit Theory – R L Boylstad, Nashelsky – pearson,10th edn,2012.

Reference Books:

1. Electronic Devices &Circuit: Basic Electronic Course –Octavio Hun- Independent Publishers,2021
2. Electronic Devices & Circuits –Jacob Milliman, C.C.Halkias, Styabratajit, McGrow Hill .2nd edition,2008.

Other Suggested Readings:

1. National Programme on Technology Enhanced Learning (NPTEL) Online courses, Branch-Electrical Engineering. https://nptel.ac.in/courses/117/103/117103063/

PH1612 **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.

Other Suggested Readings:

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

PH1614 **0-1-2 (2)**

Electronic Devices and Circuits Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine characteristics of various semiconductor devices.
CO-2	Evaluate the performance of small signal and feedback amplifiers with BJT and FET.
CO-3	Design and construct BJT and FET amplifiers using different biasing techniques.
CO-4	Design and construct diode circuits for given application.

Course Articulation Matrix:

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

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

List of experiments:

1. PN Junction Diode Characteristics
2. Zener Diode Characteristics and Voltage Regulation.
3. Half Wave Rectifier with & without filter – Load Regulation and Ripple Factor.
4. Full Wave Rectifier with & without filter – Load Regulation and Ripple Factor.
5. Bridge Rectifier with & without filter – Load Regulation and Ripple Factor.
6. Transistor Characteristics – Common Base (CB) configuration.
7. Transistor Characteristics – Common Emitter (CE) configuration.
8. Transistor Characteristics – Common Collector (CC) configuration.
9. CE BJT Transistor - Voltage-Divider bias configuration.
10. CE Transistor Amplifier – Voltage gain, Frequency Response and band width.
11. Field Effect Transistor (FET) Characteristics.
12. FET - Voltage-Divider bias configuration.
13. Common Source FET Amplifier- Voltage gain, Frequency Response.
14. RC Coupled Amplifier.
15. Current series Feedback Amplifier.
16. Voltage series Feedback Amplifier.

Learning Resources:

Text Books:

1. Electronic Devices & Circuits – Oxford University Press – David A Bell ,5th edn,2010.
2. Electronic Devices & Circuit Theory – R L Boylstad, Nashelsky – pearson,10th edn,2012.

Reference Books:

1. Electronic Devices &Circuit: Basic Electronic Course –Octavio Hun- Independent Publishers,2021
2. Electronic Devices & Circuits –Jacob Milliman. Halkias, Styabratajit, McGrow Hill .2nd edition,2008.

Other Suggested Readings:

1. http://vlabs.iitkgp.ac.in/be/#
2. https://www.vlab.co.in/

PH1690 **0-0-2 (1)**

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
CO-1	2	--	2	--	--	3
CO-2	2	--	2	--	--	3
CO-3	2	--	2	--	--	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

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a wellorganized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO/Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

3rd Semester

PH1701 **3-0-0 (3)**

Switching Theory and Logic Design

Pre-Requisites: **PH1610**

Course Outcomes:

CO-1	Apply Boolean theorems and postulates to minimize logic expressions.
CO-2	Design encoders, decoders, multiplexers and application specific combinational logic circuits.
CO-3	Design counters, shift registers and application specific sequential logic circuits.
CO-4	Understand different logic families and interfacing between them.
CO-5	Understand the basic software tools for the design and implementation of digital circuits and systems.

Course Articulation Matrix:

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

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

Syllabus:

Number Systems and Codes: Analog vs Digital, Positional Number Systems, Binary, Octal and Hexadecimal Numbers, Numbers System Conversions, Arithmetic operation of Binary, Octal and Hexadecimal Numbers, Representation of Negative Numbers, Binary codes, Gray code, Error codes Character codes.

Switching Algebra and Logic simplification: Axioms, Single variable theorems, two-and three-variable theorems, n-variable theorems, Duality, Basic gates, Universal gates, Standard representation of Logic functions, canonical sum, canonical product, Logic simplification using Boolean algebra, Karnaugh maps (2,3,4,5,6), Quine-McCluskey Method.

Combinational Logic Circuits and Design: Adders, Subtractors, Decoders, Encoders, Multiplexers, Demultiplexers, Comparators, Parity Circuits, Three-state Devices, designing combinational logic circuits.

Sequential Logic Circuits and Design: Bistable elements, Latches and Flip-Flops, Flip flop conversions, Ripple Counters, Synchronous and Asynchronous counters, Shift Registers, Ring Counters and Johnson Counters, Clocked Synchronous State-Machine Structure, Clocked Synchronous State-Machine Design, designing sequential Melay and Moore circuits.

Digital circuits and Logic Families: Logic families, CMOS Logic Families and their electrical characteristics, TTL Families, Interfacing logic families, CMOS: Logic levels, Basic Inverter circuit, NAND, NOR Gates, Fan-In, Non-Inverting Gates, CMOS Transmission Gates, Three state outputs, Schmitt-Trigger inputs.

Learning Resources:

Text Books:

1. John F Wakerly, Digital Design: Principles and Practices, Pearson Education, 2008, Fourth edition.
2. Thomas Floyd, Digital Fundamentals, Pearson Education, 2017,11Th edition.

Reference Books:

1. Moss, Gregory L. Tocci, Ronald J.; Widmer, Neal S, Digital systems: principles and applications, Pearson Education, 2017, 12th edition.
2. M Morris Mano; Michael D Ciletti, Digital Design, Pearson Education, 2007, 4th edition.

Other Suggested Readings:

1. https://www.multisim.com/get-started/
2. https://www.digitalelectronicsdeeds.com/downloads.html

PH1703 **3-0-0 (3)**

Materials Science and Engineering

Pre-Requisites: PH1606

Course Outcomes:

CO-1	Classify imperfections in solids.
CO-2	Compute critically resolved shear stress and grain size of materials.
CO-3	Understand nucleation, growth, crystallization and diffusion phenomena in solids.
CO-4	Estimate composition of phases from a phase diagram.
CO-5	Identify materials and engineering processes for industrial applications.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Imperfections in solids: Structure of crystalline and non-crystalline solids; Bonding Forces and Energies; Primary Interatomic Bonds; Secondary Bonding or van der Waals Bonding; Points defects and its thermodynamics. Dislocations and geometry of dislocations. Grain boundaries: Terminology and Definitions, Low and High angle grain boundaries. Computation of Resolved Shear Stress and Stress-to-Initiate-Yielding. Tensile strength and Ductility determination. Estimation of Grain Size. Solid solutions - Hume-Rothrey Rules**.**

Phase Transformations: Kinetics of phase transformations, Nucleation and Growth, homogeneous and heterogeneous nucleation, energies involved in homogeneous nucleation, kinetic consideration of Critical Nucleus Radius and Activation free energy.

Diffusion and growth Kinetics: Diffusion: Diffusion mechanisms, Steady and non-steady state diffusion, Fick's Law of Diffusion, Factors including diffusion, doping in semiconductors, The atomic model of diffusion, Determination of diffusion flux and constant, Activation energy.

Phase Diagrams: Solubility limits, Phase Equilibria, Unary phase diagram, Gibbs phase rule, Lever rule, interpretation of phase diagrams, Determination of phase amounts, Equilibrium and non-equilibrium solidification, Binary eutectoid and peritectic reactions, Ternary phase diagrams, and its applications, Estimation of phases, temperatures and compositions from phase transformations.

Industrial Applications and Materials Selection: Phase transformations of Fe-C Alloys, Microstructural and property changes, Determination of relative amounts of ferrite, cementite and pearlite, Isothermal and continuous cooling transformations, Tempered Martensite, Solidification and Crystallization. Glass transition. Classification of materials. Applications.

Learning Resources:

Text Books:

1. Material Science & Engineering: An Introduction, **by** William D. Callister, John Wiley &5th edition, 2016.
2. Material Science and Engineering: V. Raghavan, A First Course, Prentice Hall India,6th edtion,2015.

Reference Books:

1. Fundamentals of Material Science & Engineering, William F. Smith, McGraw Hill International Edition,6th edn, 2018.
2. Engineering Materials: An Introduction to their Properties, Applications, and Design, Ashby, M. F. and D. R. H. Jones, Butterworth-Heinemann, Oxford, England ,4th edition,2012.
3. The Science and Engineering of Materials, Askeland, D.R., P. P. Fulay, and W. J. Wright, Cengage Learning, 6th edition, 2011.

Other Suggested Readings:

1. https://www.webelements.com/
2. https://periodic-table-explorer.en.uptodown.com/windows

PH1705 **3-0-0 (3)**

Optoelectronics

Pre-Requisites: PH1605, PH1602

Course Outcomes:

CO-1	Understand the properties of wave guides, optical fibers and guided modes
CO-2	Select LEDs for different applications based on their structure and working
CO-3	Identify semiconductor Lasers for application in sensing and communication
CO-4	Understand photo detectors and their applications
CO-5	Comprehend light modulators and their applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	2	1	1	1
CO-2	3	2	2	2	2	2
CO-3	3	3	2	2	2	2
CO-4	3	2	2	2	2	1
CO-5	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 Recombination of 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.

Other Suggested Readings:

1. https://nptel.ac.in/courses/115/102/115102026/

PH1707 **3-0-2 (4)**

Linear Integrated Circuits

Pre-Requisites: **PH1610**

Course Outcomes:

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

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.

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 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

PH1709 **3-0-2 (4)**

Computer Programming for Physics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Develop algorithms for mathematical and scientific problems.
CO-2	Explore alternate algorithmic approaches to problem solving.
CO-3	Understand the components of computing systems.
CO-4	Choose data types and structures for problem solving.
CO-5	Develop modular programs using control structures.
CO-6	Develop programs in C^{++} to solve physics 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	-	-
CO-5	3	3	3	2	1	-
CO-6	3	3	2	2	2	1

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

Syllabus:

Programming Environment: Basic hardware, software, high level programming, problem solving, algorithm, program design, software life cycle, basics of C++ language, testing and debugging.--

Basic of C++ language: Number representation, Basic data types - int, float, double, char, bool, void. Flow of Control - Conditional statements - If-else, Switch-case constructs, Loops - while, do while, for. Functions - user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion.

Arrays: Arrays - Single, Multi-Dimensional Arrays, initialization, accessing individual elements, passing arrays as parameters to functions. Pointers and Dynamic Arrays - Multidimensional Dynamic Arrays, creation and deletion of single and multi-dimensional arrays.

Files I/O, Structure and Classes: C Strings, Standard String Class I/O Streams, stream flags, stream manipulators, formatted I/O, binary I/O, Character I/O, File I/O - Opening, closing and editing files. Structures and Classes - Declaration, member variables, member functions, access modifiers, inheritance, function overloading, overriding, redefinition, virtual functions, operator overloading, polymorphism - compile time and runtime binding.

Miscellaneous Simulation Tools: Molecular dynamics, Monte Carlo simulation, GNU Plot, Merssen-Twister Random Number, Basics of LINUX operating System.

Learning Resources:

Text Books:

1. Problem solving with C++, Walter Savitch, Parson education, 9th Ed., 2014.
2. Big C++, Cay Horstmann, Timothy Budd, Wiley Indian,3rd Edition, 2006.

Reference Books:

1. Data structures and algorithm analysis in C++, M.A.Weiss, Pearson Publications,4th edition,2012.
2. Computational Physics, Jos Thijssen , Cambridge University Press, 2nd edition,2007.

Other Suggested Readings:

1. https://www.learncpp.com/
2. https://www.cplusplus.com/doc/tutorial/

PH1711 **0-1-2 (2)**

Optoelectronics Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Set optical and mechanical housing for an experiment
CO-2	They will be able to describe the light-current-voltage relationships of LEDs, laser diodes, and photodiodes and demonstrate how to measure associated parameters.
CO-3	Set up and analyse different fiber optics experiments.
CO-4	Design the basic optics experiments to verify various laws and principles
CO-5	Develop optics-based techniques in real life applications purposes.

Course Articulation Matrix:

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

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

List of 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.

Other Suggested Readings:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/index.html
2. https://www.rp-photonics.com/

PH1713 **0-1-2 (2)**

Switching Theory and Logic Design Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Test the functionality of ICs and electronic components
CO-2	Design combinational and sequential circuits using simulation software such as Deeds, LT spice and NI-Multisim.
CO-3	Design and construct combinational and sequential circuits and evaluate their performance.
CO-4	Debug digital circuits.
CO-5	Able to identify and prevent various hazards and timing problems in a digital design.

Course Articulation Matrix:

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

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

Experiments:

The following experiments will be done using (a) trainer kit, (b) Multisim/Deeds software.

1. (a) Verify the truth tables of basic and universal gates, (b) Implementation of basic gates using universal gates.
2. Design and implement (i) Half Adder & Full Adder using a) basic gates. b) NAND gates (ii) Half subtractor & Full subtractor using a) basic gates b) NAND gates
3. Design and implement (a) 4-bitParallelAdder/Subtractor, (b) BCD adder
4. Design and implement code conversion circuits (a) Binary to Grey and vice versa, (b) BCD to Decimal (seven segment display), (c) binary to octal and vice versa, (d) decimal to octal.
5. Design and implement prime number detection circuit.
6. Design and implement even and odd parity circuits.
7. Design and implement different comparator circuits
8. Design and implement different (2X1, 4X1,8X1,16X1,32X1) multiplexers.
9. Design and implement different (1X2, 2X4, 3X8, 4X16, 5X32) decoders.
10. Design and implement 2 and 4 input priority encoders.

11. Realize the following flip-flops using NAND Gates. a) RS, JK, D & T, and Master-Slave Flip-Flop.
12. Realize the following shift registers (i) SISO (ii) SIPO (iii)) PISO (iv) PIPO (v) Ring (vi) Johnson counter.
13. Design and implement different mod counters (a) synchronous, (b) Asynchronous.
14. Design and implement Different Flip Flop conversions circuits.
15. Melay and Moore circuit design for sequency detection.
16. Design of basic gates using CMOS transistors and verify the truth table.
17. Testing CMOS family IC Characteristics.

Learning Resources:

Text Books:

1. Digital Design: Principles and Practices, John F Wakerly, Pearson Education, Fourth edition, 2008.
2. Digital Fundamentals, Thomas Floyd, Pearson Education, 11Th edition, 2017.

Reference Books:

1. Digital systems: principles and applications, Moss, Gregory L.; Tocci, Ronald J.; Widmer, Neal S, Pearson Education, 12th edition, 2017.
2. Digital design, M Morris Mano; Michael D Ciletti, Pearson Education, 4th edition, 2007.

Other Suggested Readings:

1. https://www.multisim.com/get-started/
2. https://www.digitalelectronicsdeeds.com/downloads.html

4th Semester
(Electronics and Instrumentation)

PH1702 **3-0-0 (3)**

Structured Digital System Design

Pre-Requisites: **PH1701**

Course Outcomes:

CO-1	Design advanced digital circuits using PAL.
CO-2	Understand the basics of Hardware Description Languages.
CO-3	Understand types of modelling, modules, functions of Verilog HDL
CO-4	Design and develop the combinational and sequential circuits using Verilog HDL
CO-5	Simulate, synthesize, and program their designs on a development board

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:

Advanced combinational logic circuit design: Simple Programmable Logic Devices, Complex Programmable Logic Devices, Field-Programmable Gate Arrays, Programmable Logic Software's, Data Storage, Semiconductor Memory Basics, Random-Access Memory, Read-Only Memory, Programmable ROMs, The Flash Memory, Memory Expansion.

Role of HDL: Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis, Functional Verification, System Tasks, Programming Language Interface (PLI), Module, Simulation and Synthesis Tools, Keywords, Identifiers, White Space Characters, Comments, Numbers, Strings, Logic Values, Strengths, Data Types, Scalars and Vectors, Parameters, Operators.

Gate level modelling: AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tri-State Gates, Array of Instances of Primitives, Design of Flip-flops with Gate Primitives, Delays, Strengths and Construction Resolution, Net Types, Design of Basic Circuits. Modelling at Dataflow Level, Introduction, Continuous Assignment Structure, Delays and Continuous Assignments, Assignment to Vectors, Operators

Behavioural Modelling: Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, Assignments with Delays, Wait construct, Multiple Always Blocks. Designs at Behavioural Level, Blocking and Non-Blocking Assignments, The case statement, Simulation Flow if and if-else constructs, Assign-De-Assign construct, Repeat construct, for loop, the Disable construct, While loop, Forever loop, Parallel Blocks, Force-Release construct, Event.

Learning Resources:

Text Books:

1. Design through Verilog HDL, T.R. Padmanabhan, B. Bala Tripura Sundari, Wiley Education, 3rd edition,2009.
2. Verilog HDL – Samir Palnitkar, Pearson Education, 2nd edition,2009.

Reference Books:

1. Fundamentals of Logic Design with Verilog Design– Stephen. Brown and Zvonko Vranesic, TMH, 2nd Edition, 2010.
2. The Verilog Hardware Description Language, Donald E. Thomas, Philip R.Moorby,springer science, 3rd edition,2013.
3. Digital Design: Principles and Practices, John F Wakerly, Pearson Education, Fourth edition, 2008

Other Suggested Readings:

1. https://www.xilinx.com/products/design-tools/vivado.html
2. https://www.intel.com/content/www/us/en/software/programmable/quartus-prime/model-sim.html.

PH1704 **3-0-0 (3)**

Microprocessors and Interfacing

Pre-Requisites: PH1701

Course Outcomes:

CO-1	Understand the architecture of 8086 microprocessor.
CO-2	Write Assembly Language Program for 8086 microprocessors.
CO-3	Interface peripheral devices 82C55, 8279, 8254 with microprocessor.
CO-4	Transfer data using 8237 DMA controller.
CO-5	Understand the evolution of advanced microprocessor architectures

Course Articulation Matrix:

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

Other Suggested Readings:

1. www.intel.com
2. www.pearsoned.co.in/barrybbrey

PH1706 **3-0-0 (3)**

Communication Systems

Pre-Requisites: **PH1610, PH1707**

Course Outcomes:

CO-1	Understand Communication systems,
CO-2	Estimate noise in communication systems
CO-3	Comprehend Amplitude and Frequency modulation and demodulation methods
CO-4	Distinguish between Pulse Amplitude, Pulse with and Pulse Position modulation.
CO-5	Comprehend digital communication formats

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:

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.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117/102/117102059/
2. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee08/

PH1708 **0-1-2 (2)**

Digital System Design Laboratory

Pre-Requisites: **None**

Course Outcomes:

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

CO-1	Design and test advanced digital design circuits using PAL
CO-2	Use different HDL simulation software's.
CO-3	To write Verilog code for combinational circuits and sequential circuits
CO-4	Design and verify the functionality of digital circuits using test benches.
CO-5	Identify the suitable Abstraction level for a particular digital design.

Course Articulation Matrix:

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

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

Experiments:

The following experiments will be done using (a) trainer kit, (b) Simulation software.

1. Design and implement barrel shifter.
2. Design and implement logic functions using PAL
3. Design and implement logic functions using PLA.
4. Hands on training on Verilog simulators.
5. Write and verify the Verilog code for basic gates using data flow modelling
6. Write and verify the Verilog code for universal gates.
7. Write and verify the Verilog code for basic gates using structural data flow modelling
8. Write and verify the Verilog code for different SOP and POS expressions
9. Write and verify the Verilog code for half and full adder using data flow modelling
10. Write and verify the Verilog code for half and full subtractor using data flow modelling
8. Verilog program for 4-bit binary adder using Structural modelling.
9. Verilog program for 4-bit comparator using data flow modelling.
10. Verilog program for 8:3 encoder using behavioural modelling.
11. Verilog program for 8-bit priority encoder using behavioural modelling.
12. Verilog program for 3:8 decoder using behavioural modelling.
13. Verilog program for bcd-to-seven segment display using behavioural modelling.
14. Verilog program for multiplexer using data flow modelling.
15. Verilog program for de-multiplexer using data flow modelling.
16. Verilog program for all flip-flops.
17. Verilog program for shift-register operations.

18. Verilog program in structural modelling for 4-bit ripple counter.
19. Verilog program for synchronous counters.
20. Verilog program for even and odd parity generator using data gate level modelling.
21. Verilog program for mealy model using state machine approach.

Learning Resources:

Text Books:

1. Verilog HDL Design Examples, Joseph Cavanagh, CRC press, 2018.
2. Verilog quickstart, James M. Lee, kluwer academic publishers, 2002.

Reference Books:

1. Verilog HDL, Samir Palnitkar, Pearson Education, Second Edition, 2009.
2. Advanced Digital Design with Verilog HDL, Michael D. Ciletti, PHI, 3rd edition,2011.
3. Verilog HDL Synthesis: A Practical Primer, J. Bhasker, Star Galaxy publishing,4th edition2018.

Other Suggested Readings:

1. https://www.multisim.com/get-started/
2. https://www.digitalelectronicsdeeds.com/downloads.html

PH1710 **0-1-2 (2)**

Microprocessors and Interfacing Laboratory

Pre-Requisites: **None**

Course Outcomes:

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

CO-1	Obtains the knowledge of program writing for microprocessor using microprocessor kit and simulation software
CO-2	Develops ALP for various applications using 8086 microprocessors.
CO-3	Understands the interfacing concepts of different devices with 8086 microprocessors.
CO-4	Obtains the knowledge of simulations for different applications.
CO-5	Develops testing and experimental procedure on microprocessor and analyse their operation in different applications.

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**

Experiments:

The following experiments will be done using the 8051-microcontroller kit & keil 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.

Other Suggested Readings:

1. https://emu8086-microprocessor-emulator.en.softonic.com
2. https://www.masm32.com

PH1782 **1-0-0 (0.5)**

Fractal Course I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Physics.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

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
CO-1	3	3	3	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	2	2	3	-	-	-	-	-	-
CO-3	-	-	3	2	2	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-

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

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Physics and related technology and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Physics Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

4th Semester
(Photonics)

PH1712 **3-0-0 (3)**

Optical System Design

Pre-Requisites: **PH1605**

Course Outcomes:

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

CO-1	Analyse the optical systems with ray tracing
CO-2	Analyse Optical systems for and make corrections
CO-3	Judge the quality of optical systems by determining OPD, MTF and OTF.
CO-4	Understand Catadioptric systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	2	1	1
CO-2	3	3	3	3	2	2
CO-3	3	3	3	2	2	2
CO-4	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, Second Edition, 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.

Other Suggested Readings:

1. https://spie.org/education/courses/coursedetail/SC003?f=InCompany
2. https://3doptix.com/pages/optical-design-software

PH1714 **3-0-0 (3)**

Optical Instruments

Pre-Requisites:PH1605, PH1705

Course Outcomes:

CO-1	Understand Autocollimators, Refractometers, Ellipsometers and radiometry in optical systems
CO-2	characterize optical materials using Interferometric techniques
CO-3	Identify suitable optical instrument for ophthalmic applications
CO-4	Assess surface profile of optical elements using optical metrology
CO-5	Comprehend Infrared Instrumentation for applications in space

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Radiometry in optical systems: Radiometry of extended sources, Illuminators, Optical filters; Magnifiers and Eyepieces, Afocal systems, Autocollimators, Schlieren systems, Refractometers, Ellipsometers

Spectroscopic instrumentation: Fabry-Perot interferometer, diffraction gratings, Fourier transform spectroscopy;

Interferometric instrumentation for testing: Shearing, polarization interferometers; Scanning microscopy, Imaging modes, depth discrimination, super resolution, practical aspects, measurements on semiconducting devices

Opto-medical Instruments: Keratometry, ophthalmoscopes, optometers, optical coherence tomography, Infrared instrumentation: I.R. telescopes, focal plane arrays, cryo-cooling systems, Space optics, Satellite cameras

Optical metrology: Surface inspection, optical gauging and profiling, techniques for non-destructive testing, Moire self-imaging and speckle metrology.

Learning resources

Text books:

1. Geometrical and Instrumental Optics, D. Malcara, Academic press, first edition, 1988.
2. Applied Optics & Optical Engineering – Vol. 4 & 5, R. Kingslake, Academic press, 1980.

Reference books:

1. Elements of Modern Optical Design, D.C. O'Shea, John Wiley, second edition, 1985.
2. Optical Techniques for industrial inspection, P. Cielo, Academic press, 1988.
3. Geometrical Optics: Lectures in Optics (Volume 2), George Asim Ellis, SPIE Press, 2020.

Other Suggested Readings:

1. https://drive.google.com/drive/folders/1O6xhnmcgfd64FuVtiveNdLSp8Gma3L32?usp=sharing
2. https://www.coursera.org/lecture/first-order-optical-system-design/introduction-to-geometrical-optics-LcIdb

PH1716 **3-0-0 (3)**

Fourier Optics & Holography

Pre-Requisites: **PH1605**

Course Outcomes:

CO-1	Gain in-depth knowledge of scalar diffraction theory
CO-2	Calculate field at any point in space-time, given the initial field
CO-3	Apply Fourier transforms for modelling physical optical systems
CO-4	Model diffraction limited optical systems
CO-5	Develop and analyse optical imaging systems
CO-6	Generate a hologram using MATLAB

Course Articulation Matrix:

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

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

Syllabus:

Foundation of Scalar Diffraction Theory: Maxwell equations, Wave equation, Helmholtz equation, Fresnel-Kirchhoff diffraction theory, Rayleigh-Sommerfeld diffraction formulation.

Fresnel and Fraunhofer Diffraction: Fresnel-Kirchhoff diffraction integral, Huygens-Fresnel principle, Fresnel approximation, Fresnel diffraction Integral, Fraunhofer approximation, Fraunhofer diffraction integral.

Examples of Fresnel diffraction: Square/circular Aperture and angular spectrum interpretation, Sinusoidal amplitude grating etc. Examples of Fraunhofer diffraction: Square/circular Aperture, Sinusoidal amplitude/phase grating etc.

Optical Fourier transform and Imaging System: Fourier transforming properties of the lens, Single lens & 4f-imaging, impulse response, point spread function, Diffracted limited imaging systems: Abbey & Rayleigh theory of image formation, Coherent and incoherent imaging.Frequency response for diffraction limited coherent/incoherent imaging, amplitude transfer function, and optical transfer function.

Holography: Wave front reconstruction: Gabor & Leith-Upatnieks Hologram, Different types of holograms: Fresnel, Fraunhofer, Fourier, Rainbow, Multiplex, Embossed Hologram, Computer generated hologram.

Learning Resources:

Text Books:

1. Introduction to Fourier Optics, J. P. Goodman, WH Freeman, Fourth edition, 2017.
2. Basics of Holography, P. Hariharan, Cambridge University Press, First edition, 2002.

Reference books:

1. Fundamentals of Photonics, B. E. A. Saleh & M. C. Teich, Wiley, Third edition, 2019.
2. Optics, A. Ghatak, McGraw Hill, Seventh edition, 2020.
3. Optics, E Hecht, Pearson, Fifth edition, 2016.

Other Suggested Readings:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-71-optics-spring-2009/index.htm
2. https://ocw.mit.edu/courses/media-arts-and-sciences/mas-450-holographic-imaging-spring-2003/

PH1718 **0-1-2 (2)**

Optical System Design Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design the layout of basic lenses and mirrors
CO-2	Trace the light rays through the optical elements and calculate the aberrations
CO-3	Assemble the lenses and mirrors to form the optical systems
CO-4	Calculate the aberrations present in the optical system and can correct it.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

List of Experiments:

1. Ray tracing through lenses and mirrors
2. Calculation of EFL, BFL and FFL of a lens and mirror.
3. Calculation of spherical aberration and correction by lens bending
4. Calculation of chromatic aberration of a lens/lens system
5. Sphero chromatism and its calculation
6. Design of spherically corrected achromatic doublet
7. Design of eye-pieces
8. Calculation of Coma, Astigmatism and Field curvature (simulation)
9. Design of a telescope for given magnification and correcting the aberrations
10. Design of Cooke triplet
11. Design of aplanatic objective
12. Design of apochromatic objective
13. Primary lateral colour
14. Basics of Freeform optics
15. Developing optics for Projectors, and Illumination systems
16. Hands on experience on optical system design software

Learning Resources:

Text Books:

1. Modern Lens Design, W. J. Smith, 2nd Edition, McGraw-Hill, 2004.
2. Introduction to Lens Design, J. M. Geary, William, Bell Publisher, 2002.

Reference Books:

1. Handbook of Optical Engineering, D. Malacara, CRC Press; 1st edition, 2001.
2. Modern optical engineering, W. J. Smith, McGraw-Hill, 4th Edition, 2008.
3. Introduction to Lens Design, Jose Sasian, CUP, 2019.

Other Suggested Readings:

1. First Order Optical System Design by Amy Sullivan at Coursera (https://www.coursera.org/learn/first-order-optical-system-design)
2. Lens Design fundamentals – online course by Zemax Corporation (https://opticsacademy.zemax.com/path/optical-system-design-learning-plan-recommended)

PH1720 **0-1-2 (2)**

Optical Instruments Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Learn to measure refractive index, concentration of liquids by abbe refractometer
CO-2	Learn to measure thickness, refractive index of thin films by using ellipsometry.
CO-3	Learn to handle various interferometers to measure optical properties of materials
CO-4	Adopt various interferometric techniques for optical shop testing.
CO-5	Develop optics-based techniques for the metrology applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Experiments:

1. To find the refractive index of given liquid samples using Abbe's refractometer.
2. To determine the thickness of thin film samples using Variable Angle Ellipsometry.
3. To measure the thickness (of wire, hair etc.) using the air wedge technique.
4. To measure the optical flatness of different surfaces using Fizeau Interferometer.
5. Using Mach-Zehnder Interferometer
    a. To determine wavelength of laser beam.
    b. To study refractive index change in air under different pressures and determine refractive index of air.
6. Strain measurement using diffraction strain gauge.
7. To determine the optical measurements by using Shear plate interferometer
8. To determine the optical flatness using Jamin interferometer
9. To determine the Resolving Power of a Microscope and telescope.
10. To determine the optical measurements (flatness, deviation) by using Auto-collimation method.

Learning Resources:

Text Books:

1. Geometrical and Instrumental Optics, D. Malacara, Academic Press, 1st edition, 1988.
2. Applied optics and optical engineering, R. Kingslake, Academic Press, 1980.

Reference Books:

1. Hand book of optics Vol. 2, Michael Bass, McGraw-Hill Education, 2010.
2. Optical shop testing, D. Malacara, Wiley publishers, 2006.
3. A Practical Guide to Experimental Geometrical Optics, Yuriy A. Garbovskiy, Anatoliy V. Glushchenko, CUP, 2017.

Other Suggested Readings:

1. https://vlab.amrita.edu/?sub=1
2. https://www.leybold-shop.com/physics/physics-experiments/optics/geometrical-optics.html

PH1782 **1-0-0 (0.5)**

Fractal Course I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Physics.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

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
CO-1	3	3	3	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	2	2	3	-	-	-	-	-	-
CO-3	-	-	3	2	2	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-

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

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Physics and related technology and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Physics Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

5th Semester
(Electronics and Instrumentation)

PH1801 **3-0-0 (3)**

Digital Signal Processing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Find DFT of a given signal through Fast Fourier Transform Techniques
CO-2	Designs FIR and IIR type digital filters using transformation techniques
CO-3	Identifies various structures and their realisations for Digital Filters
CO-4	Understand the concepts of Finite Word Length Effects and Errors in Digital Filters
CO-5	Apply Z-Transform for the analysis of Discrete-Time signals and Systems

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO-1	3	3	3	2	-	-
CO-2	3	3	2	2	-	-
CO-3	3	3	1	2	1	1
CO-4	3	2	1	1	2	1
CO-5	3	2	3	1	2	1

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

Syllabus:

The Z Transform: Introduction-Definition of Z Transform and ROC of Finite and Infinite duration sequences, properties, Inverse Z- Transform- Examples.

Discrete Fourier Transform and Fast Fourier Transform: Introduction, Fundamentals of CTFT and DTFT, Definition of DFT and its Inverse, Direct evaluation of DFT and IDFT, Properties of DFT, Circular Convolution, Filtering Long Duration Sequences- Overlap and ADD- Overlap and Save Methods- The Fast Fourier Transform, Summery Steps of Radix-2 DIT-FFT, and Radix-2 DIF-FFT Algorithms, and Butterfly Diagrams, IDFT using FFT algorithms, Examples.

Design of IIR and FIR Filters: Introduction, Analog Filter Specifications and Classification- Design of Low Pass Butterworth and Chebyshev Filters, Design of Digital Filters using Backward Difference, Bilinear, Impulse Invariant and matches Z-Transforms Advantages and Disadvantages of IIR Filters. Concept of Linear Phase, Frequency Response of Linear Phase FIR Filters, Designing FIR Filters using Fourier Series, Windows, and Frequency sampling Methods, Examples.

Realisation of Digital Filters: Introduction, Direct Form-I and II, Cascade Lattice and Parallel form Realisation of IIR Filters, Realisation of Linear –Phase FIR Filters, FIR and IIR Lattice Structures, Examples.

Finite Word Length Effects in Digital Filters: Introduction, Quantisation Noise, Input, and Product Quantisation Error, Signal Scaling, Quantisation errors in Floating-Point Realisation of IIR Filters, Finite Word Length Effects in FIR Digital Filters, Quantisation Effects in the Computation of the DFT, Quantisation Errors in FFT Algorithms, Examples. Fixed- and Floating-point Digital Signal Processors. Applications of Digital Signal Processing.

Learning Resources:

Text Books:

1. Digital Signal Processing-Principles, Algorithms and Applications – John G. Proakis, Dimitris G.Manolakis, PHI 2000.
2. Digital Signal Processing – A Computer-Based Approach, Sanjit K. Mitra, Tata Mc Graw Hill, 2007.

Reference Books:

1. Digital Signal Processing-Theory, Analysis, and Digital-Filter Design- B.Somanathan Nair- PHI-2004.
2. Digital Signal Processors-Architectures, Implementations and Applications-Sen M.Kuo, Woon-Seng Gan-Pearson-2005
3. Discrete-Time Signal Processing", A.V.Oppenheim, R.W. Schafer and J.R. Buck, 8th Indian Reprint, Pearson, 2004.

Other suggested Readings:

1. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/
2. https://www.analog.com/en/design-center/landing-pages/001/beginners-guide-to-dsp.html

PH1803 **3-0-0 (3)**

Microcontrollers and Applications

Pre-Requisites: **PH1704**

Course Outcomes:

CO-1	Understands the architecture of 8051 microcontroller and finds the difference.
CO-2	Imparts the knowledge of instruction set of 8051
CO-3	Develops the skill in simple program writing for 8051
CO-4	Gets the knowledge of interfacing different real time devices.
CO-5	Imparts the knowledge of advanced microcontrollers for real time applications

Course Articulation Matrix:

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

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

Syllabus:

The 8051 Architecture: Difference between microprocessors and microcontrollers-Overview of different microcontrollers-8051 Internal architecture – I/O pins- Memory organization – I/O ports – Serial I/O, Timers and Counters –Interrupts –Connecting External Memory

Assembly Language programming of 8051: Internal and External Data transfer instructions-Addressing modes, external data moves, code memory moves, push and pop instructions, Data Exchanges-Logical and Arithmetic operations -Jump and Call operations – example programs.

Hardware and Software Aspects of Interfacing: Interfacing of LCD, Key Board- Interfacing display devices, LED, LCD, seven segment display-Interfacing ADC, DAC, Sensors, Interfacing relays, opto-couplers, stepper motor and DC motors- Interface Protocols**:** Serial protocols: RS232, I^2C, CAN, USB

Wireless protocols: IrDA, Bluetooth, IEEE 802.11

The 8051 Variants, AVR, PIC Microcontrollers: Overview of 8051 variants from NXP, Atmel, Dallas and Silicon. Overview of AVR microcontrollers.PIC Microcontrollers- PIC 18F452 Device overview -Programming model of PIC 18 family, Different registers- Data memory -Program memory, I/O ports -Special features of Pic Microcontrollers-CCP-PWM-USART, A/D module, MSSP-few programming examples of PIC Microcontrollers.

8051 programming in C: Data types and time delay in 8051-C, I/O programming in 8051C, Logic operations in 8051 C, Data conversion programs in 8051 C, Accessing code ROM space in 8051 C.

Learning Resources:

Text Books:

1. The 8051 Microcontroller and Embedded System, Muhammad Ali Mazidi, Pearson education, 3rd edition, 2014.
2. The 8051 Microcontroller Architecture, Programming and Applications, Kenneth J. Ayala, Thomas Delmar learning, 5th edition, 2008.

Reference Books:

1. The 8051 Microcontroller based Embedded Systems, Manish K Patel, TMH, third edition, 2014.
2. 8051 Microcontrollers, S.P.Gimenez, Springer, first edition, 2019.
3. 8051 Microcontrollers, Subrata Ghoshal, Pearson education, second edition, 2014.

Other Suggested Readings:

1. www.intel.com/8051
2. www.microchip.com.
3. https://onlinecourses.nptel.ac.in/noc20_ee42

PH1805 **0-1-2 (2)**

Digital Signal Processing Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Finds Linear and Circular Convolution and Correlation of two sequences using MATLAB
CO-2	Find DFT of a given signal through Fast Fourier Transform Techniques
CO-3	Designs FIR and IIR type digital filters using transformation techniques
CO-4	Designs various structures and their realisations for Digital Filters
CO-5	Apply Z-Transform for the analysis of Discrete-Time signals and Systems

Course Articulation Matrix:

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

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

List of Experiments:

1. Direct form – I, II form realization of the given IIR system function.
2. Plot pole-zero of a given FIR filter.
3. Design Blackman, Hanning, Hamming and Gaussian window and plot them using filter design tool.
4. Design an FIR filter with side lobe attenuation of 40 dB using Kaiser Window.
5. Design low pass butter worth digital filter with given specification using impulse invariance method.
6. Design a high pass elliptical filter with given specification using impulse invariance method.
7. Design a band pass chebychev-2 filter with given specification using impulse invariance method.
8. The time shifting and frequency shifting property of DTFT.
9. The Linear and circular convolution, correlation of two sequences using DFT.

Learning Resources:

Text Books:

1. Digital Signal Processing – A Computer Based Approach, Sanjit K. Mitra, Tata Mc Graw Hill, 4th edition, 2013.
2. Digital Signal Processing-Principles, Algorithms and Applications, John G. Proakis, Dimitris G. Manolakis, PHI, 4th edition, 2007.

Reference Books:

1. Digital Signal Processors-Architectures, Implementations and Applications, Sen M.Kuo, Woon-Seng Gan-Pearson-2005
2. Digital Signal Processing-Theory, Analysis and Digital-Filter Design, B. Somanathan Nair, PHI, 2004.
3. Discrete-Time Signal Processing, A.V. Oppenheim, R.W. Schafer and J.R. Buck, 8th Indian Reprint, Pearson, 2004.

Other Suggested Readings:

1. https://engineering.purdue.edu/VISE/ee438L/
2. https://www.iitk.ac.in/ee/digital-signal-processing-lab

PH1807 **0-1-2 (2)**

Microcontrollers and Applications Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Obtains the skills of ALP, C programming writing for 8051 microcontrollers.
CO-2	Obtains programming skills to solve scientific problems using 8051 programming.
CO-3	Understands the interfacing concepts of different devices with 8051 microcontrollers.
CO-4	Obtains the knowledge of simulations for different applications.
CO-5	Develops testing and experimental procedure on microcontroller and analyse their operation in real time applications.

Course Articulation Matrix:

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

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

Syllabus:

The following experiments will be done using ALP and C language.

1. Develop and test a program to generate 10KHz wave.
2. Develop and test a program for 16-bit Atraumatic operations.
3. Develop and test a program for sorting of Array
4. Develop and test a program for searching a character in a string.
5. Develop and test a program for string manipulations.
6. Develop and test a program to arrange given data in ascending and descend orders.
7. Develop and test a program to pick out largest and smallest numbers in an array.
8. Develop and test a program for digital clock

The following interfacing experiments will be done using interfacing modules, with keil software and ALP.

1. Interface given DAC module, Develop and Test required AP to generate different wave forms with different characteristics and generate a square wave of 10 KHz.
2. Interface different display devices like LED, LCD and seven segment display.
3. Interface different motors like stepper motor, DC motor, servo motor.
4. Interface given LCD display module. Develop and Test required ALP to display different characters
5. Interface the given relay.
6. Interface the given traffic light controller module.
7. Implementation of serial communication using 8051 serial port and recording data in pen drive.

8. Interfacing of ADC module and to read digitized analog values.

Learning Resources:

Text Books:

1. 8051 Microcontroller an application-based introduction, David calcutt, Frederick cowan, Elsevier imprint, first edition,2004.
2. Microcontroller projects in c for 8051, Dogan Ibrahim, Newnes publications, second edition, 2003.

Reference Books:

1. 8051 microcontroller interrupts, instructions, programming and interfacing, Subrata Ghoshal, second edition, 2014.
2. Edsim51's guide to the 8051, James Rogers, Create space independent publishers, first edition, 2009.

Other Suggested Readings:

1. https://www.keil.com/
2. www.raisonance.com

PH1893 **0-0-0 (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.

PH1883 **1-0-0 (0.5)**

Fractal Course II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Physics.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

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
CO-1	3	3	3	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	2	2	3	-	-	-	-	-	-
CO-3	-	-	3	2	2	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-

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

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Physics and related technology and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Physics Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

5th Semester
(Photonics)

PH1809 **3-0-0 (3)**

Optoelectronic Sensors and MOEMS

Pre-Requisites: **PH1705**

Course Outcomes:

CO-1	Understand the fundamental concepts of Optoelectronic Sensors
CO-2	Apply the optical fibers for optoelectronic sensor design
CO-3	Analyse the FBG and LPG based sensor architecture
CO-4	Understand the LED based sensor and Image sensor
CO-5	Understand the features and application of MOEMs

Course Articulation Matrix:

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

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

Syllabus:

Introduction to Sensor: Basics of sensors, sensing parameters, Modulators; Introduction to Optoelectronic Sensors

Fiber Optic Sensors: Fundamentals of fibre technologies, basic classifications, Intensity and phase modulated sensors, Interferometry and polarization-based sensors, Fiber optic gyro, various types of sensors and their design characteristics, Introduction to special types of fiber for sensor application

Optoelectronic Sensor designing: FBG and LPGs and their sensor applications**,** Introduction to the analyzing equipment like Optical spectrum analyzer, OTDR and Interrogator. Practical implementation of photonic sensor in health monitoring and stress analysis, Optical switching and multiplexing architectures, distributed sensors, Optical actuation and control, Intelligent Surveillance with opto electronic sensor

LED Sensor and Image sensor: Imaging and display technologies, CCD Technology, Optical scanning and printing, Introduction to some display tools.

MOEMs: Introduction to MOEMs, Micro Optics, design, fabrication and implementations of MOEMs systems. Challenges and example studies and applications.

Learning Resources:

Text Books:

1. Optical Fiber Sensors" Vol I & II, Edited by Brian Culshaw and Jhon Dakin, 1989.
2. MOEMS: Micro-Opto-Electro-Mechanical System edited by M. E. Motamedi, Springer, 2005.

Reference books:

1. Fiber Optic Sensors: An Introduction for Engineers and Scientists, Second Edition Editor(s): Eric Udd William B. Spillman Jr., John Wiley & Sons, Inc.
2. Fiber optic Sensors Second Edition, Edited by Shizhuo Yin, Paul B. Ruffin, Francis T.S. Yu, T&C publisher, 2008.

Other suggested Readingss:

1. https://www.sciencedirect.com/topics/materials-science/optoelectronic-sensor

PH1811 **3-0-0 (3)**

Optical Elements Production and Testing

Pre-Requisites: **PH1703**

Course Outcomes:

CO-1	Understand types of IR materials, optical crystals, optical plastics, metals, their properties and applications
CO-2	Select production methods for Optical glass, optical crystals, IR materials and Optical plastics
CO-3	Identify the shop supplies for making optical components
CO-4	Analyse/ Validate the optical components by Interferometry, spherometry, autocollimator and surface analyser
CO-5	Design optical systems

Course Articulation Matrix:

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

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

Syllabus:

Optical glass: types, composition, chemical behaviour, mechanical and thermal properties, low expansion materials, fused quartz, crystal quartz, mirror materials.

IR materials: Ge-Si – gallium arsenide, zinc selenide, zinc sulphide, optical crystals, alkaline earth fluorides, Alkali Halides, KDP and homologs, optical plastics, metal optics, ceramic materials.

Material production:
(a) glass making, dry and continuous tank methods, limitations, inspection for flaws
(b) IR materials manufacturing, chemical vapor deposition, CZ method, float zone refining, casting of silicon, horizontal Bridgeman, liquid encapsulated Czochralski.
(c) Growth methods for optical crystals, hydrothermal process, heat exchanger method, solution grown crystals.

Optical shop supplies: abrasives, polishing compounds, pitch, cements, coolants and solvents.

Tools and fixtures: spherical and plano tools, spot blocks, diamond tools

Optical fabrication: shaping-milling-grinding-polishing, centering, cementing, thin film coating

Optical shop testing: interferometric testing, spherometers, autocollimator, surface analysis, testing after assembly.

Learning Resources:

Text Books:

1. Hank H. Karow, Fabrication Methods for Precision Optics, John Wiley and Sons, New York, 1993

Reference Books:

1. David Malacara, Optical shop testing, John Wiley and Sons, New York, 1992.
2. Marvin J. Weber, Handbook of Optical Materials

Other suggested Readings:

1. Michael Hausner, Optics Inspections and Tests: A Guide for Optics Inspectors and Designers

PH1813 **0-1-2 (2)**

Optoelectronic Sensing Laboratory

Pre-Requisites: **None**

Course Outcomes:

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

CO-1	Set optical and mechanical housing and associated arrangements for an experiment
CO-2	Develop fiber optic based optoelectronic sensors
CO-3	Analyse different parameters of sensing components regarding photonics.
CO-4	Design the basic optics experiments to verify various laws and principles

Course Articulation Matrix:

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

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

List of 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.

Other Suggested Readings:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/index.html
2. https://www.rp-photonics.com/

PH1815 **0-1-2 (2)**

Fourier Optics and OEPT laboratory

Pre-Requisites: **None**

Course Outcomes:

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

CO-1	Learns the methods of preparation of optical glass, optical crystals and IR materials
CO-2	Learns cutting, grinding and polishing different optical elements
CO-3	Learns to test the optical elements
CO-4	Design different types of optical elements
CO-5	Application of optical elements

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**

List of experiments:

1. Synthesis and characterization of optical glass
2. Synthesis and characterization of optical crystal
3. Synthesis and characterization of ceramics
4. Synthesis and characterization of IR element
5. Cutting, grinding and polishing of different optical elements
6. Testing of optical elements
7. Fresnel diffraction from arbitrary shape aperture
8. Fraunhofer diffraction from arbitrary shape aperture
9. 2f imaging system
10. 4f imaging system
11. Spatial filtering of an image
12. Optical vortex field reconstruction using vortex hologram

Learning Resources:

Text Books:

1. Fabrication Methods for Precision Optics, Hank H. Karow, John Wiley and Sons, 1st edition, 2004.
2. Optical shop testing, David Malacara, John Wiley and Sons, 3rd Edition, 2013.

Reference Books:

1. Materials Science and Technology of Optical Fabrication, Tayyab I. Surat Wala, Wiley-American Ceramic Society, 1st edition, 2018.

2. Micro optics Technology: Fabrication and Applications of Lens Arrays and Devices (Optical Engineering), Nicholas F. Borrelli, CRC Press, 1st edition, 1999.

Other suggested Readings:

1. https://spie.org/education/courses/coursedetail/SC003?f=InCompany
2. https://onlinecourses.nptel.ac.in/noc20_ee48/preview

PH1893 **0-0-0 (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.

PH1883 **1-0-0 (0.5)**

Fractal Course II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Physics.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

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
CO-1	3	3	3	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	2	2	3	-	-	-	-	-	-
CO-3	-	-	3	2	2	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-

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

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Physics and related technology and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Physics Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

Professional Electives
(Electronics and Instrumentation)

PH1722 **3-0-0 (3)**

High Speed Data Converters

Pre-Requisites: PH1702

Course Outcomes:

CO-1	Understand basic principles of data converters.
CO-2	Comprehend the working of Analog to Digital and Digital to Analog converters.
CO-3	Understand high speed data converters.
CO-4	Evaluate the performance of data converters

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:

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.

Other 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

PH1724 **3-0-0 (3)**

Semiconductor Physics and Devices

Pre-Requisites: PH1610

Course Outcomes:

CO-1	Understand conjugated organic semiconductors and their properties.
CO-2	Comprehend inorganic semiconductor devices.
CO-3	Comprehend the working of OLED, OPV and OTFTs.
CO-4	Estimate electronic transitions in organic semiconductors using spectroscopic methods.

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:

Semiconductors: Various bondings; Basics of semiconductors, potential barrier, barrier height; Mobility; Trapping, Ohmic and Schottky contacts, PN diode, PIN diode.

Organic Semiconductors: Bonding and antibondings; Hybridization of orbitals – sp^2 hybridization; HOMO, LUMO; Excited states in organic semiconductors; Energy transfer processes; Electronic transitions – Fluorescence and phosphorescence. Small molecules; Polymers; Dendrimers.

Charge transport in Organic Semiconductors: Defects and trapped charge; Charge injection at organic surface; Carrier transport properties; Carrier recombination mechanism, Photo absorption – UV-visible absorption spectroscopy; Photoemission process – emission spectroscopy, time resolved photoluminescence spectroscopy.

Organic Semiconductor Devices: Structure and design of devices, OLEDs – Requirements of different layers in the device; Limitations; Electroluminescence; Efficiencies; PMOLED and AMOLED; White OLEDs for lighting applications; Basics, designing, Characterization, and efficiencies of OPVs and OTFTs and their applications.

Learning Resources:

Text Books:

1. Electronics process in organic crystals and polymers, M. Pope and C. E. Swenberg, New York, Oxford University Press, Second Edition, 1999.
2. Physics of Organic semiconductors, Wolfgang Brutting, Wily-VCH Verlag GmbH & Co., Germany, Second Edition, 2012.

Reference Books:

1. Introduction to Flat Panel Displays, Jiun-Haw Lee, David N. Liu, Shin-Tson Wu, Wiley, 2nd edition,2020.
2. Electronic Information Display Technologies,T J Nelson and J R Wullert II , World Scientific, 1997.
3. Light emitting diodes, E. Fred Schubert, Cambridge University Press, Second Edition, 2006

Other Suggested Readings:

1. Organic Light Emitting Diodes (OLEDs), Intech Publishers, Edited: Marco Mazzeo, Europe.https://www.intechopen.com/books/organic-light-emitting-diode
2. OLEDs. https://oled.com/oleds/

PH1726 **3-0-0 (3)**

Lasers and Applications

Pre-Requisites: **PH1602, PH1705**

Course Outcomes:

CO-1	Understand the theory and working of CO_2, Rare earth doped-YAG, Excimer and Ruby lasers and their applications in material processing
CO-2	Understand LIDAR and its applications in atmospheric studies
CO-3	Understand inertial navigation using ring laser gyro.
CO-4	Understand laser guided weapons and electro-optic surveillance systems

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:

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, Springer publications, 2nd edtion,2010

Reference Books:

1. Quantum Electronics, Amnon Yariv, John Wiley, 2nd edition,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 and Breach,1977.

Other Suggested Readings:

1. https://nptel.ac.in/courses/104/104/104104085/
2. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13/

PH1728 **3-0-0(3)**

Pulse Circuits

Pre-Requisites: **PH1610**

Course Outcomes:

CO-1	Understand and analyse the responses of first order RC low pass and high pass filters for standard inputs.
CO-2	Analyse clipping and clamping circuits
CO-3	Design Multivibrator and sweep circuits
CO-4	Comprehend Time-base generators.

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:

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/

PH1730 **3-0-0 (3)**

Computer Organization and Operating Systems

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the functional units and their interconnection
CO-2	Identify the hardware and software techniques for improving the performance of the computer.
CO-3	Estimate the average waiting time in CPU scheduling for improving the efficiency.
CO-4	Examine the multithreading issues.
CO-5	Predict the process scheduling issues and give the remedies.

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	-	1
CO-3	3	3	3	2	2	1
CO-4	3	2	2	2	2	1
CO-5	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 of pipelining 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.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105163/
2. https://www.geeksforgeeks.org/computer-organization-and-architecture-tutorials/

PH1732 **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.

Other Suggested Readings:

1. https://www.svc.org/Education/SVC-Education-Program.cfm
2. http://technology.niagarac.on.ca/courses/phtn1432/#notes

PH1821 **3-0-0 (3)**

Advanced Communication Systems

Pre-Requisites: PH1610, PH1706

Course Outcomes:

CO-1	Understand the concepts of measure of information, Shannon's theorem and entropy
CO-2	Understand PCM and its variants, Eye Patterns
CO-3	Analyze Line and Error control coding
CO-4	Understand and apply the digital modulation and demodulation techniques
CO-5	Understand the advantages of spread spectrum techniques and performance of spread spectrum, PN codes in jamming, noise etc., use multi user communications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Concept & Measure of information: Source Coding, Error Free Communication over a noisy channel, Shannon -Hartley Law-Channel capacity—Practical communication system in light of Shannon Theorem-Bandwidth Efficiency. Information Content of a Signal-Entropy, information rate - source coding -Shannon Fano and Huffman source coding-Lampel ZIV source coding

PCM-Elements of PCM systems: PCM transmitter & Receiver -Classification of Quantization Process-working principle -transmission BW in a PCM System-Quantization Noise in PCM-Non-Uniform Quantization-Commanding-different types-drawbacks of PCM-Delta Modulation-Delta sigma modulation-DPCM-ISI and Eye patterns

Line Coding: Discrete PAM -Line coding and properties - unipolar / bipolar NRZ, RZ - Bipolar NRZ – Manchester -HDB -Power spectra of Various line codes-–– Nyquist criterion for distortion less transmission – Pulse shaping - Error Control Coding, linear block codes, cyclic codes, convolution codes, Viterbi decoding algorithm

Digital Modulation/ demodulation Techniques: QAM, BPSK, QPSK, DEPSK, DPSK, MSK, M-ray-FSK, M-ray-PSK, BFSK of various digital modulation techniques. Coherent and non-coherent detection of ASK, FSK, PSK, QPSK, DPSK., performance of communication system with channel noise, Optimum Binary Receiver.

Principles of Spread Spectrum: Model of a Spread Spectrum Digital Communication System, Direct Sequence Spread Spectrum Systems, Effect of De-spreading on a narrowband Interference, Probability of error (statement only), Some applications of DS Spread Spectrum Signals, Generation of PN Sequences, Frequency Hopped Spread Spectrum, Introduction to CDMA, Overview of latest trends in digital communication. Advanced Mobile Phone System (AMPS) – Global System for Mobile Communications (GSM) –Cellular Concept and Frequency Reuse – Channel Assignment and Hand – Overview of Multiple Access Schemes – Bluetooth.

Learning Resources:

Text Books:

1. S. Haykin, “Digital Communications”, John Wiley, 2005
2. B. Sklar, “Digital Communication Fundamentals and Applications”, 2nd Edition, Pearson Education, 2009
3. B.P.Lathi, “Modern Digital and Analog Communication Systems” 3rd Edition, Oxford University Press 2007.
4. J.G Proakis, “Digital Communication”, 4th Edition, Tata Mc Graw Hill

PH1823 **3-0-0 (3)**

Designing with FPGA And CPLDs

Pre-Requisites: **PH1702**

Course Outcomes:

CO-1	Identifies different types of programmable logic devices
CO-2	Compares the Performance of Different Types of FPGA and their Programming Technologies
CO-3	Compares the Performance of Different Types of CPLD and their Programming Technologies
CO-4	Able to apply knowledge gained in software-hardware integration
CO-5	Able to design, test and implement FPGA/CPLD based projects

Course Articulation Matrix:

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

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

Syllabus:

Programmable logic Devices: ROM, PLA, PAL, CPLD, FPGA – Features, Architectures, Programming, Applications and Implementation of MSI circuits using Programmable logic Devices.

CPLD and FPGA: Introduction to Complex Programmable Logic Devices (CPLD) and Filed Programmable Gates Arrays (FPGA)-CPLD Architectures-Function Blocks-I/O Blocks-Clock Drivers-Inter connect-CPLD Technology and Programmable Elements-Embedded Devices-FPGA Architecture-Configurable logic Blocks-Configurable I/O Blocks-Embedded Devices-Programmable Inter Connect-Clock Circuitry.

Universal Methodology for Programmable Devices: UDM and UDM-PD Concepts-Writing a Specification-Specification Review-Choosing Device and Tools-Design-Verification-Final Review.

Hardware Description Languages: Top-Down Design-Synchronous Design-Floating Nodes-Bus Contention-Design for Test (DFT)-Testing Redundant logic – Observable Nodes-Scan Techniques-Built in Self-Test (BIST)

Case studies: Design considerations using CPLDs and FPGAs of parallel adder cell, parallel adder sequential circuits, counters, multiplexers, parallel controllers. Today and Future: Cores- Special I/O Devices-New Architectures-ASIC with Embedded FPGA Cells.

Learning Resources:

Text Books:

1. Designing with FPGAs and CPLDs, Bob Zeidman, CRC press, first edition, 2017.
2. Digital System Design with FPGAs and CPLDs, Ian Grout, Elsevier publications, first edition, 2008.

Reference Books:

3. FPGAs world class designs, Clive Max Field, Elsevier publications, 2009.
4. Designing with FPGAs and CPLDs, Jesse H. Jenkins ,Prentice Hall,1994.

Other Suggested Readings:

1. www.cs.umd.edu/class/sum2003/cmsc311/Notes/Comb/pla.html
2. www.eng.ucy.ac.cy/theocharides/Courses/ECE664/L5.pdf

PH1825 **3-0-0 (3)**

Solar Energy Systems

Pre-Requisites: **None**

Course Outcomes:

CO-1	Outline the technologies that are used to harness the power of solar energy.
CO-2	Understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO-3	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.
CO-4	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials.
CO-5	Illustrate the concepts of direct energy conversion systems & their applications.

Course Articulation Matrix:

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

Other 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

PH1827 **3-0-0 (3)**

VLSI DESIGN

Pre-Requisites: **None**

Course Outcomes:

CO-1	Realize the concepts of digital building blocks using MOS transistor.
CO-2	Design combinational MOS circuits and power strategies.
CO-3	Design and construct Sequential Circuits and Timing systems.
CO-4	Design arithmetic building blocks and memory subsystems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	-	1	-
CO-2	3	2	1	2	1	1
CO-3	3	2	2	2	-	2
CO-4	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 Money Harris, 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.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117/101/117101004/.

PH1829 **3-0-0 (3)**

Satellite Communication

Pre-Requisite: **PH1706**

Course Outcomes:

CO-1	Understands working principle and operation of various sub systems of a satellite
CO-2	Applies various communication techniques for various satellite applications
CO-3	Analyses and designs satellite communication link.
CO-4	Learn advanced techniques and regulatory aspects of satellite communications.
CO-5	Understand the role of satellite in various applications.

Course Articulation Matrix:

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

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

Syllabus:

Introduction: Introduction to Satellite Communications-Early History of satellite communications-Basic satellite system definitions-Satellite Orbits- Kepler's laws-Orbital parameters-Geometry of Geo synchronous links-Satellite sub systems-satellite bus-satellite payload.

The Space Segment: Introduction-The Power Supply-Attitude Control-Station Keeping-Thermal Control-TT&C Subsystem-Transponders-The Antenna Sub system.

The Earth Segment: Introduction-Receive only home TV systems-Outdoor unit-Indoor unit for analog TV-Master antenna TV System-Communication antenna TV system-Trans receive Earth Stations.

The Space Link: Introduction- Equivalent Isotropic Radiated Power- Transmission Losses- The Link-Power Budget Equation-System Noise- Carrier to Noise Ratio-The Uplink-Downlink - Combined Uplink and Downlink *C/N* Ratio.

Satellite Access: Introduction-Single Access-Preassigned FDMA-Demand-Assigned FDMA-FDMA downlink analysis-TDMA-On-Board Signal Processing for FDMA/TDM Operation-Satellite-Switched TDMA -Code-Division Multiple Access.

Satellite Applications: INTELSAT series-Mobile satellite services-VSAT-GSM-GPS-INMARSAT-LEO-MEO-Satellite Navigational System-DBS-DTH-DAB-TV (BTV)-GRMSAT-Specialized Services.

Learning Resources:

Text Books:

1. Satellite Communication's & System Engineering, Louis.J. Ippolito.Jr, Wiley publications, 2nd edition,2017.
2. Satellite communications, Dennis Roddy, John Coolen, Pearson Publication, 4th edition, 2014.

Reference books:

1. Satellite Communication Systems, Design Principles,M. Richharia, MacMillan publications, 2nd edition,1999.
2. Satellite communications, Timothy Pratt, Charles Bostion, JeremyAllnutt, Wiley Student Edition, 2nd edition, 2008.

Other Suggested Readings:

1. https://www.isro.gov.in/applications/satellite-communication
2. https://nptel.ac.in/courses/117/105/117105131/

PH1831 **3-0-0 (3)**

Smart Materials and Devices

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the significance and pre-requisites of smart materials.
CO-2	Understand the necessity for new and novel materials in our day-to-day scenario.
CO-3	Understand the need for the development of self-healing technologies and biomaterials for healthcare.
CO-4	Understand about the smart gels and textiles for many exotic applications.
CO-5	Understand the urge for self-expanding implants and basics of personalized smart devices

Course Articulation Matrix:

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

Other Suggested Readings:

1. http://pubs.rsc.org/bookshop/collections/series?issn=2046-0066
2. www.ted.com/talks/anna_ploszajski_smart_materials/

PH1833 **3-0-0 (3)**

Data Communications

Pre-Requisites: **PH1706**

Course Outcomes:

CO-1	Understands the underlying structure of networks and how they operate in relation to OSI model
CO-2	Describe layered communication, the process of encapsulation, and message routing in network equipped devices using appropriate protocols
CO-3	Compares different types of data communication networks
CO-4	Analyses the different issues related to internetworking
CO-5	Understands the different concepts involved in satellite communications

Course Articulation Matrix:

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

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

Syllabus:

Basic Concepts of Data Communication: Introduction – Data communication networks –Standards – ISO reference model –Functions of Layers –Basics of Data Transmission –Asynchronous and Synchronous Data Transmission-Error Detection methods –Data compression –Communication Control Devices –Data modems- Asynchronous and Synchronous, low speed, medium speed and High-speed modems

Protocol Basics and Data link Protocols: Introduction –Error Control – Idle RQ –Continuous RQ protocols – Link Management –Data link Protocols – Character and Bit Oriented Protocols.

Local area networks, packet-switched and frame relay networks: Medium Access Control -LAN performance - LAN standards IEEE 802.2 -IEEE 802.3 CSMA/CD -IEEE 802.4 token bus -IEEE 802.5 token ring -Wireless LANs**.** Switched communications -X.25 packet-switched networks - Frame relay networks and traffic management.

Internetworking: Requirements, Techniques-Internet security protocols: TCP/IP suite- Internet Protocol - Routing protocols -Transport layer protocols -Virtual private networks -Real-Time Transport Protocol and Voice over IP- Multi Protocol Label Switching (MPLS) 3-Packet over SDH/SONET -IP security.

Learning Resources:

Text Books:

1. Data communications, Computer networks and Open Systems –Fred Halsall Pearson Education, 6th edition 2013.

2. Data Communications for Computer Networks - -Michael Duck & Richard Read , Pearson, 2nd Edition 2003.

Reference books

1. Advanced Electronic Communication Systems –Wayne Tomasi, 8th edition, PHI 2009
2. Data Communication and Networking by Behrouz A. Forouzan 4th edition,2017.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105183/

PH1835 **3-0-0(3)**

Embedded Systems

Pre-Requisites: **PH1702**

Course Outcomes:

CO-1	Understands the concepts of embedded systems
CO-2	Able to write programs for embedded systems
CO-3	Understands interfacing of IO and other devices.
CO-4	Able to apply knowledge gained in software-hardware integration
CO-5	Able to design, test and implement embedded systems in team-based projects

Course Articulation Matrix:

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

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

Syllabus:

Introduction to Embedded Systems: Embedded systems vs general computing systems-History of Embedded Systems-Classification of Embedded Systems-Major Application Areas of Embedded Systems-Core of an Embedded System-Memory-Sensors and Actuators-Communication Interface-Embedded Firm Ware-Other system Components.

Embedded Systems with 8-bit Microcontrollers: Characteristics and Quality Attributes of Embedded systems- Factors to be considered in selecting a controller-designing with 8051 microcontroller-Fundamental issues in Hardware Software Co-design- Computational Models in Embedded Design-Introduction to Unified modelling language.

Embedded Firmware Design and Development: Embedded hardware design and development-Electronic Design Automation Tools-Schematic Design using OrCAD Capture CIS-Embedded Firm ware design approaches-Embedded firmware development languages-

Embedded System Development Environment: The Integrated Development Environment-Types of Files generated on Cross-compilation-Simulators, Emulators and Debugging-Product Enclosure Design Tools-Product Enclosure Development techniques-The embedded product development life cycle (EDLC)-Objectives and Different phases of EDLC.

Learning Resources:

Text Books:

1. Introduction to Embedded Systems, Shibu-TMH publications, 2nd edition, 2017.

2. Embedded Systems, Raj Kamal, TMH Publications, 4th edition, 2020.

Reference Books:

1. Making Embedded Systems, Elecia White-O'Reilly publications, first edition,2012.
2. Building Embedded Systems Programmable Hardware, Changyi GU, Apress publications, first edition, 2016.

Other Suggested Readings:

1. https://courses.edx.org/courses/.

PH1839 **3-0-0 (3)**

Nanomaterials and Devices

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the luminescence phenomenon in bulk and nanoforms.
CO-2	Understand the synthesis processes of phosphors at lower dimensions.
CO-3	Understand the importance of photometry and colorimetry in day-to-day scenario.
CO-4	Understand the structures of typical inorganic pc-LEDs and their characteristics
CO-5	Understand the basics of device physics and different strategies of making white-LEDs

Course Articulation Matrix:

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

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

Syllabus:

Fundamentals of Luminescence: Absorption and emission of light, electronic states and optical transition of solid crystals, Selection Rules, Luminescence of a localized centre, Impurities and luminescence in semiconductors, Luminescence mechanisms, Factors affecting the emission colour, Excitation energy transfer and cooperative optical phenomena, Inorganic electroluminescence, Luminescence quantum yield and quenching processes.

Phosphors at Lower Dimensions: Introduction to nanostructured materials and quantum dots, Structure and properties relationship, Quantum confinement effects on band gap, Relaxation processes of excitons, General synthesis routes: Top-down and bottom-up approaches, Types of surface passivation, Optical properties and applications

Materials for phosphor-converted LEDs: Inorganic LED structures and efficiencies, Typical LEDs and their characteristics, Requirements of colour conversion phosphors, Phosphor synthesis, Single and multi-phosphor converted LEDs, Quantum Dots LEDs.

Photometry and Colorimetry: Photopic and scotopic visions, photometric parameters and their measurement methods, colorimetry parameters, Colour space & its evolution by CIE, Measurement of CIE colour coordinates, Correlated colour temperature (CCT), and Colour rendering index (CRI), Spectral power distribution of LEDs.

Phosphor-converted LEDs and Other Devices: Phosphors for converting the colour of light emitted by inorganic LEDs, Commonly, used dopants in colour conversion phosphors, Strategies for generating white light from LEDs, Design and placement of phosphor in LEDs, Characteristics of n-UV and blue to white LEDs, Applications of white and coloured LEDs, Future Prospects of other devices.

Learning Resources:

Text Books:

1. Luminescence of Inorganic Solids, Paul Goldberg, Academic Press, 1st edition, 1966.
2. Solid State Luminescence: Theory, Materials and Devices, A. H. Kitai, Ed., Springer, second edition, 2012.

Reference Books:

1. Luminescence of Liquids and Solids and its Practical Applications, Peter Pringsheim and Marcel Vogel, Interscience Publishers, 1st edition,1943.
2. Phosphor Handbook, William M. Yen, Shigeo Shionoya, Hajime Yamamoto, CRC Press, second edition, 2006.
3. Handbook of Luminescence, Display Materials and Devices, 3-Volume set, Hari Singh Nalwa, Lauren Shea Rohwer, American scientific publishers, 2003.

Other Suggested Readings:

1. https://www.britannica.com
2. https://www.rp-photonics.com

PH1839 **3-0-0 (3)**

Data Driven Engineering Physics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand underlying principles of AI & ML
CO-2	Gain intuition to successfully apply AI & ML to variety of problems
CO-3	Extract useful information from the large data
CO-4	Identify problems that can be easily handled by AI & ML
CO-5	Use of AI & ML for solving practical problems.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Definition and foundations of AI, State of the art.

Machine Learning: Types of ML: Supervised, Unsupervised and Reinforcement learning, Classification and Regression, ML Algorithms, Challenges with ML: Overfitting and Underfitting, Dimensionality reduction techniques: SVD, PCA and Wavelet Transform, Hyperparameter tuning.

Deep Learning: State-of-the-Art. 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, Learning rate, Gradient descent algorithms, Minibatches, Neural network in practice: Overfitting, Regularization, Types of neural network: ANN, CNN, RNN. Transfer Learning, Pre-trained networks: AlexNet

AI for Engineering Physics: Signal and image Processing, optical communications, quantum communications, Quantum Computing, Outlook and challenges.

Learning Resources:

Text Books:

1. S. J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Pearson Education Limited, 2016, Third Edition.
2. S. L. Brunton and J. N. Kutz, Data-Driven Science and Engineering, Cambridge University Press, 2019, 1st Edition.

3. Phil Kim, MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, Apress, 2017, 1st Edition.

Reference Books:

1. I. Goodfellow, Y. Bengio & A. Courville, Deep Learning, MIT Press, 2016, 1st Edition.
2. J. Grus, Data Science from Scratch, O'Reilly Media, 2019, 2nd Edition.
3. G. Carleo, et. al., Machine learning and the physical sciences, Rev. Mod. Phys. 91, 045002 (2019).

Other Suggested Readings:

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

Professional Electives
(Photonics)

PH1734 **3-0-0(3)**

Fiber Optics

Pre-Requisites: **PH1602**

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:

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

Other Suggested Readings:

1. https://www.rp-photonics.com/

PH1736 **3-0-0 (3)**

Polarization Optics

Pre-Requisites: **PH1605**, **PH1602**

Course Outcomes:

CO-1	Describe all possible polarization states mathematically.
CO-2	Develop mathematical model for interaction of matter with polarized light.
CO-3	Apply polarization concept to real world problems
CO-4	Relate polarization with the concept of coherence.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Mathematical description of polarized light: Polarization ellipse, Derivation of Stokes parameters, Stokes's vector, Measurement of Stokes parameters, Poincare Sphere, Pancharatnam-Berry phase. Mueller matrices, Jones vector, Jones matrix.

Polarized light-matter interaction: Polarization reflection and refraction from dielectric and metal surface. Polarized light-anisotropic media interaction: Birefringence, compensators. Dichroism. Optical activity. Polarization modulation: Electro-optic. Magneto-optic. Liquid crystal.

Polarimetry & Ellipsometry: Stokes's polarimetry, Mueller matrix polarimetry, Imaging polarimetry, Ellipsometry.

Elementary theory of polarization of stochastic electromagnetic beams: $\mathbf{2} \times \mathbf{2}$ Correlation matrix, Stokes Parameters and the Coherency Matrix, Stokes Parameters and the Pauli Matrices. Introduction to Unified theory of polarization and coherence.

Learning Sources:

Text Books:

1. Polarized Light, D. Goldstein, CRC Press, third edition, 2010.
2. Fundamentals of Polarized Light, C. Brosseau, John Wiley & Sons, first edition, 1998.

Reference books:

1. Fundamentals of Photonics, B. E. A. Saleh & M. C. Teich, Wiley, Third edition, 2019.
2. Optics, E Hecht, Pearson, Fifth edition, 2016.
3. Optics, A. Ghatak, McGraw Hill, Seventh edition, 2020.

Other Suggested Readings:

1. https://ocw.mit.edu/courses/physics/8-03sc-physics-iii-vibrations-and-waves-fall-2016/part-iii-optics/
2. https://ocw.mit.edu/courses/mechanical-engineering/2-71-optics-spring-2009/index.htm

PH1726 **3-0-0 (3)**

Lasers and Applications

Pre-Requisites: **PH1602**, **PH1705**

Course Outcomes:

CO-1	Understand the theory and working of CO_2, Rare earth doped-YAG, Excimer and Ruby lasers and their applications in material processing
CO-2	Understand LIDAR and its applications in atmospheric studies
CO-3	Understand inertial navigation using ring laser gyro.
CO-4	Understand laser guided weapons and electro-optic surveillance systems

Course Articulation Matrix:

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

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 Sources:

Text Books:

1. Laser Principles, Types & Applications, K R Nambiar, New Age International, 2004.
2. Lasers: Theory and Applications, A K Ghatak and K Thiagarajan, 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 and Breach,1977.

Other Suggested Readings:

1. https://nptel.ac.in/courses/104/104/104104085/
2. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13/

PH1738 **3-0-0 (3)**

Nonlinear Optics

Pre-Requisites: **PH1605, PH1602**

Course Outcomes:

CO-1	Understand nonlinear optical phenomena and correlate it with physical systems
CO-2	Analyse nonlinear optical devices.
CO-3	Generate second and third harmonics using nonlinear crystals
CO-4	Understand quantum nonlinear effects and their applications

Course Articulation Matrix:

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

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

Syllabus:

Nonlinear Optical Susceptibility: Linear and nonlinear susceptibility, Description of nonlinear optical processes, Nonlinear susceptibility in centrosymmetric and non-centrosymmetric media, Miller's rule, Formal definition and properties of nonlinear susceptibility.

Electromagnetic theory of Nonlinear Optics: Wave equation for nonlinear optical media, coupled wave equations, Phase matching and quasi phase matching conditions and challenges, Manley-Rowe Relations.

Second order and Third order Nonlinear Effects and phenomena: Sum frequency generation, Second harmonic generation, Difference frequency generation and parametric amplification, Optical parametric oscillator, Intensity dependent refractive index, self-phase modulation, supercontinuum generation, spatial and temporal soliton, Optical Phase conjugation, Stimulated Raman scattering.

Quantum Nonlinear Effects: Schrödinger Equation Calculation of the Nonlinear Optical Susceptibility, Electromagnetically Induced Transparency, Spontaneous Parametric Down Conversion, Nonlinear Optics in the Two-Level Approximation

Learning Resources:

Text Books:

1. Nonlinear Optics, Robert W. Boyd, Academic Press, 2020, Fourth edition.
2. Fundamentals of Nonlinear Optics, P. E. Powers & J. W. Haus, CRC Press, 2017, 2nd edition.

Reference books:

1. Nonlinear Fiber Optics, G. P. Agrawal, Academic Press, 2007, Fourth edition.
2. Fundamentals of Photonics, B. E. A. Saleh & M. C. Teich, Wiley, 2019, Third edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/115/105/115105105/
2. https://nptel.ac.in/courses/115/102/115102022/

PH1732 **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	3	1	1	-	-	-
CO-2	1	1	-	-	-	-
CO-3	2	3	2	2	1	2
CO-4	3	2	1	1	-	1
CO-5	2	3	2	1	1	2

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's data), Electrical transport property by Hall effect measurement.

Learning Sources:

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.

Other Suggested Readings:

1. https://www.svc.org/Education/SVC-Education-Program.cfm
2. http://technology.niagarac.on.ca/courses/phtn1432/#notes

PH1841 **3-0-0 (3)**

Photonic Integrated Circuits

Pre-Requisites: **PH1605, PH1705**

Course Outcomes:

CO-1	Summarize the fundamental concept of optical waveguides
CO-2	Construct the different types of optical waveguides
CO-3	Analyse the design and working of photonic integrated circuits
CO-4	Construct the couplers, modulators and devices for communication applications

Course Articulation Matrix:

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

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

Syllabus:

Introduction to Guided Optics: Brief history of optical communication, Advantages of integrated optics configuration, Guided TE and TM Modes of Symmetric and anti-symmetric planar waveguides: Step-index and graded- index waveguides. Strip and channel waveguides, Beam propagation method.

Integrated Optical Devices: Directional couplers, Applications as power splitters, Y-junction, optical switch; modulators, filters, A/D converters, Mode splitters, Mach-Zehnder interferometer based devices. Acousto-optic waveguide devices. Arrayed waveguide devices, Nano-photonic-devices: Metal/dielectric plasmonic waveguides, Surface Plasmon modes, applications in waveguide polarizers.

Materials for PIC: Glass, lithium niobate, silicon, compound semiconductors. Fabrication of integrated optical waveguides and devices. Lithography, deposition.

Waveguide characterisation: prism coupling, grating and tapered couplers, Nonlinear effects in integrated optical waveguides, Types and Applications.

Learning Resources:

Text Books

1. H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.
2. C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.
3. José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford Univversity Press, 2020

Reference Books

1. A Ghatak and K Thyagarajan, Optical Electronics, Cambridge University Press, 1989.
2. T. Tamir, Guided wave opto-electronics, Springer Verilag, 1990
3. K. Okamota, Fundamentals of Optical waveguides, Academic Press, 2006.

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/108/108/108108174/

PH1843 **3-0-0 (3)**

Quantum Optics

Pre-Requisites: **PH1605**

Course Outcomes:

CO-1	Understand quantum optics and its applications
CO-2	Classify the properties of light based on photon statistics
CO-3	Distinguish the physical phenomena behind the weak and strong filed atom-photon interactions
CO-4	Apply the principles of quantum optics to quantum cryptography
CO-5	Adopt the concept of quantum bits to quantum computing

Course Articulation Matrix:

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

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

Syllabus:

Photon counting statistics: Classification of light by photon statistics, Thermal light, Chaoticlight, Theory of Photodetection, Shot noise in quantum aspects

Resonant light atom interaction: Weak field and strong fields interaction, Baloch sphere, Atomin cavities, cold atoms, laser cooling, Bose Einstein condensation

Quantum cryptography: Basic principles, Quantum key distribution, Single photon source anddetectors.

Quantum computing: Quantum bits, Quantum logic gates and circuits, decoherence and error correction, Application of quantum computers, Entangle states, Generation of Entangled photon pairs, Teleportation

Learning Resources:

Text Books:

1. Quantum Optics, Mark Fox, Oxford University Press, 2005.
2. The Quantum theory of Light, R. Loudon, Oxford University Press, 2000.

Reference books:

1. Introductory *Quantum Optics,* C. C. Gerry and P. L. Knight, Cambridge University Press, 2004.
2. Quantum Optics, M.O. Scully, Cambridge University Press, 2004.

Other suggested Readings:

1. https://www.coursera.org/learn/quantum-optics-single-photon
2. https://www.coursera.org/learn/quantum-optics-two-photons

PH1825 **3-0-0 (3)**

Solar Energy Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Outline the technologies that are used to harness the power of solar energy.
CO-2	Understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO-3	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.
CO-4	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials.
CO-5	Illustrate the concepts of direct energy conversion systems & their applications.

Course Articulation Matrix:

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

Other 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

PH1845 **3-0-0 (3)**

Illumination and Light Design

Pre-Requisites: **PH1712**

Course Outcomes:

CO-1	Design various application specific lens
CO-2	Understand the fundamental of non-imaging optics and freeform optics
CO-3	Gain the knowledge of illumination systems
CO-4	Design various reflectors for solar collectors
CO-5	Understand the automotive lighting and vision

Course Articulation Matrix:

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

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

Syllabus:

Basic Quantities in Illumination: Flux and Irradiance, Solid Angle, Intensity, Radiance, Projected Solid Angle, Solid Angle and Projected Solid Angle, Spectroradiometric and Radiometric Quantities,Photometric Quantities, Matrix of Basic Quantities, Photopic and Scotopic Vision, Luminous Efficacy, Typical Values of Illumination Quantities, Averaged LED Intensity, Color, Light Source Color, Chromaticity Diagram, Color Temperature and CCT, Dominant Wavelength and Purity, Surface Color, Color of Fluorescent Surfaces, Color Rendering and CRI, Calculating CRI and Problems with CRI; Sources for Illumination, Light Emitting Diodes (LEDs) Illumination Properties of Materials

Illumination Transfer and Illumination in Imaging Systems and Nonimaging systems: Lambertian and Isotropic Models, Known Intensity, Known Flux and Known Radiance, Form Factor and Average Projected Solid Angle, Configuration Factor, Useful Configuration Factor, Useful Form Factor, Irradiance from a Uniform Lambertian Disk, Cosine Fourth and Increase Factor, Known Irradiance. ω, Ω, NA, and f/# for a Circular Cone, Invariance of Radiance, Image Radiance, Limitations on Equivalent Radiance, Image Irradiance, Flux and Étendue, Generalized Étendue, Concentration, Skew Invariant

Lighting Designs: Fibers, Lightpipes, and Lightguides, Spherical Reflector, Abbe Illumination, Köhler Illumination, Ellipsoidal and Paraboloidal Mirrors, Spectral Control and Heat Management, Searchlight, Bent Lightpipes, Lenslet Arrays, Source Modeling Overview, LED Modeling, Nonimaging Compound Concentrators, Displays, Architectural Illumination Daylight Compensation, Exterior Lighting, Roadway Lighting

Characterizing Illumination Systems: Mapping Flat-Fielding Sources, Goniophotometers, Types A, B, C Goniometer Coordinate Systems, “Snapshot” Goniophotometers.

Learning Resources:

Text Books:

1. R. J. Koshel, Ed., Illumination Engineering: Design with Nonimaging Optics, Wiley, 2013.

2. Burkard Wördenweber, Jörg Wallaschek, Peter Boyce, Donald D. Hoffman,

Automotive Lighting and Human Vision, Springer, 2007.

Reference Books:

1. R. Winston, J. C. Miñano, P. Benitez, Nonimaging Optics, Elsevier Academic Press, 2004.

2. V. Arecchi, T. Messadi, and R. J. Koshel, Field Guide to Illumination Optics, SPIE Press, 2007.

Other Suggested Readings:

1. https://www.stevens.edu
2. https://www.udemy.com/course/non-imaging-optical-design-using-zemaxopticstudio/

PH1847 **3-0-0 (3)**

Silicon Photonics

Pre-Requisites: **PH1605**, **PH1606**

Course Outcomes:

CO-1	Explain the operating principles of silicon photonic devices
CO-2	Comprehend fundamentals of silicon waveguides for photonic applications.
CO-3	Choose couplers and interconnects for silicon photonic applications
CO-4	Comprehend working of integrated silicon light sources and photo-detectors
CO-5	Illustrate silicon photonic device fabrication techniques

Course Articulation Matrix:

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

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

Syllabus:

Introduction to Optical properties of Silicon, Limitations of Electronics, Need of Silicon Photonics, Challenges and future aspects.

Silicon Optical waveguide; Fundamentals of guided waves, Waveguide materials; Planar, Rib, Ridge, Strip Waveguides; waveguide losses and polarization issues, Effect of stress and birefringence; Resonant Waveguide Structures.

Wave guiding devices; Directional, Star, Multimode, Y-Junction couplers; Coupling schemes of waveguides; Horizontal and Vertical coupling; Prism and grating coupling; coupling ports.

Source and Detectors; Silicon Integrated Light Sources, Properties of Silicon Nanocrystals, Light emitting germanium, Silicon Lasers, Hybrid III-V/silicon light sources; Silicon Germanium Photo-detectors, Silicon Nitride in Silicon Photonics.

Fabrication Techniques: Etching of Silicon, Sputtering, Epitaxial growth, Molecular Bean Epitaxy, Lithography; Integration and packaging methods

Learning Resources:

Text Books:

1. Daryl Inniss & Roy Rubenstein, Silicon Photonics Fueling the Next Information, Elsevier 2017.
2. Lorenzo Pavesi & David J. Lockwood, "Silicon Photonics III Systems and Application, 2016.
3. G. P Reed and A. P. Knights, *Silicon Photonics: An Introduction, Willey*, 2005.
4. L. Pavesi and D. J. Lookwood, *Silicon Photonics*, Springer, 2008.

Reference Books:

1. G T Reed, "Silicon Photonics: The state of the art", Wiley 2008
2. L Pavesi & G Guillot, "Optical Interconnects: The Silicon Approach", Springer 2006
3. M J Deen & P K Basu, "Silicon Photonics: Fundamentals and Devices", Wiley 2012
4. H Zimmermann, "Integrated Silicon Optoelectronics", Springer 2010
5. Silicon Photonics Design – From Devices to Systems, Lukas Chrostowski and Michael Hochberg, Cambridge Press, 2015.

Other Suggested Readings:

1. https://aimphotonics.academy/education/student-resources/online-courses
2. https://www.synopsys.com/glossary/what-is-silicon-photonics.html
3. https://www.edx.org/course/silicon-photonics-design-fabrication-and-data-ana
4. https://www.nature.com/subjects/silicon-photonics

PH1849 **3-0-0 (3)**

Nanophotonics

Pre-Requisites: **PH1605**

Course Outcomes:

CO-1	Understand the physics of nanotechnology, optical behaviour of nanomaterials and their synthesis methods.
CO-2	Explain the importance of lower-dimension materials for the realization of novel photonic devices, and systems.
CO-3	Understand the intuitive concepts of nanophotonics using the concept of near-field optics.
CO-4	Understand the present status of research and development in nanophotonics and related technologies
CO-5	Familiarize with nanophotonic fabrications, novel nanophotonic devices and their applications

Course Articulation Matrix:

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

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

Syllabus:

Nanotechnology and Nanomaterials: Introduction to Nanotechnology, Physics of Nanotechnology, 0D, 1D, 2D, 3D nanomaterials, Synthesis methods of Nanomaterials, Physical properties of Nanomaterials, Optical behaviors of Nanamaterials, Applications.

Photonics at Lower Dimensions: Metal-dielectric interaction, Origin of plasmonics, Surface plasmon resonance, Plasmonic devices and their fabrication techniques and applications.

Near Field Optics: Introduction to Nanophotonics and its true nature, Behavior of light at lower dimension, Physical aspects of near field, Near field microscopy, Advantages and limitations, Principles of nanofabrication using optical near fields.

Fundamentals of Nanophotonic Fabrication: Adiabatic and non-adiabatic nanofabrication's, Regulating the size and shape of nanoparticles, Self-assembling method via optical near field interactions, Photolithography, Nanophotonic device fabrication.

Learning Resources:

Text Books:

1. Principles of Nanophotonic, Motoichi Ohtsu, Kiyoshi Kobayashi, Tadashi Kawazoe, Takashi Yatsui and Makoto Naruse, CRC Press, 1st edition,2008.
2. Nanophotonics, Paras N. Prasad, John Wiley & Sons, 3rd edition, 2008.

Reference Books:

1. Introduction to Nanophotonic, S. V Gaponenko, Cambridge University Press, 1st edition, 2010.
2. Nano photonics, Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande and Ariel Levenson, ISTE Ltd, 2006.
3. Progress in Nano photonics 6, Takashi Yatsui, Springer, 2021.

Other Suggested Readings:

1. http://nanophotonics.iitd.ac.in
2. https://www.stevens.edu

PH1851 **3-0-0 (3)**

Biophotonics

Pre-Requisites: **PH1605**

Course Outcomes:

CO-1	Understand basics of biology, the interaction of light with cells and tissues.
CO-2	Demonstrate the characteristics and properties of various bioimaging techniques used in biomedicine.
CO-3	Analyze optical properties of tissues.
CO-4	Apply light to illness diagnosis and therapy.
CO-5	Identify antibodies and apply them in various bio sensing techniques.

Course Articulation Matrix:

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

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

Syllabus:

Fundamentals of Biology: Basics of Cells and Cell structure, Cellular processes in living body, Protein classification, Types of tissues – Functions.

DNA & RNA: How to use light to find out information of our genomes: DNA sequencing, DNA replication/repair, Virus detection and identification using PCR, Differences between tissues, DNA to RNA transcription, Count RNA numbers in cells/tissues: qPCR and RNA-FISH.

Proteins: Enzyme, antibody, Every cell has different gene expression level: Flow cytometry, Dissect folding dynamics of proteins: Single molecule FRET.

Bioimaging*:* Bright-field/Phase contrast/Dark-field/DIC microscopy, Raman imaging (SRS microscopy), Fluorophores (Green fluorescent proteins), Epi/Confocal/TIRF microscopy, confocal microscopy, Electron Microscopes: TEM & SEM, Bioimaging applications: Cellular, Tissue and In Vivo imaging.

Diagnosing & Treatment of diseases with light: Endoscopy, Optical coherence tomography (OCT): Application to ophthalmology, Photoacoustic tomography: Application to early cancer detection, Killing cancer cells with light: Photodynamic therapy, Tissue engineering with light.

Biosensors: Fiber-Optic Sensors, SPR Biosensors, Laser Tweezers, Mach Zehnder Interferometer for sensing, Fabry Perot Interferometer for sensing, Tetrahertz spectroscopy and Imaging.

Learning Resources:

Text Books:

1. Introduction to Biophotonics, Paras N. Prasad (2003)
2. Biophotonics: Concepts to Applications, Gerd Keiser (2016)
3. Physical Biology of the Cell, Rob Phillips (2012)

4. Fundamentals of Biomedical Optics, Caroline Boudoux (2017)

Reference Books:

1. Diaspro, A., ed., Confocal and Two-Photon Microscopy: Foundations Applications, and Advances, John Wiley & Sons, (2002)

2. Ligler, F. S. and Rawe-Taitt, C. A., eds, Optical Biosensors: Present and Future, Elsevier (2002)

3. Greulich, K. O., Micromanipulation by Light in Biology and Medicine, Birkhäuser Verlag (1999)

4. Gould,T. J., Hess, S.T., Bewersdorf, J., Ed.: Yarmush, ML, Optical Nanoscopy: From Acquisition to Analysis , Annual Review Of Biomedical Engineering, 14, 231-254 (2012) 5. Optical Sensors: Industrial, Environmental and Diagnostic Applications" Edited by R. Narayanswamy, Springer (2004)

Other Suggested Readings:

1. http://www.microscopyu.com
2. https://open.oregonstate.education/aandp/chapter/1-1-how-structure-determines-function/
3. https://training.seer.cancer.gov/anatomy/

PH1853 **3-0-0 (3)**

Display Technologies

Pre-Requisites: **PH1605**, **PH1610**

Course Outcomes:

CO-1	Understand optics for use in displays.
CO-2	Understand the principles of addressing passive, active and the importance of the TFTs.
CO-3	Imbibe the knowledge of early display devices to modern display technologies.
CO-4	Comprehend the display technologies such as LCD, inorganic/organic devices
CO-5	Gain knowledge on designing the new display devices for cost effective, environmentally friendly future display applications.

Course Articulation Matrix:

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

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

Syllabus:

Introduction: Properties of light, Vision and perception, Light detection and sensitivity of eyes, Light sources, Standard and advanced measurement procedures - Units and definition, Wide viewing angle, Etching (wet & dry) of thin films, patterning, photolithography - Pixels, pixel geometry, Array of pixels - size, resolution, Aspect ratios, Color depth, Standard definition, High definition.

Technologies: Passive and active matrix driving technology, Direct driving, Transistor switch addressing, Field emission displays, plasma displays - Applications, Display technology dependant issues.

LCDs: Generations of Display devices, Energy aspects of displays, Touch screen, Fundamentals of liquid crystals, Liquid crystal molecules and geometries, Twisted nematic structures, LCD structure, Backlight and transreflective types, LCD Panel, Panel interfacing, Applications - micro to Gigantic displays.

Electroluminescent (EL) Displays: Electroluminescence from inorganic PN junction diode, Display panel structures, driving pixels, TFT switching, panel interfacing - Applications. Electroluminescence from organic semiconductors, basics of organic semiconductors, electronic transitions in organic semiconductors, Organic display devices, Green technologies in displays, Panel and interfacing, Low power consumption - Applications.

Advanced Display devices: Next generation Flexible displays, 3D displays, MEMS based displays, Autostereoscopic 3D cinema technology, Quantum dot-based displays, Hybrid displays, Cost-effective display marketing.

Learning Resources:

Text Books:

1. Janglin Chen, Wayne Cranton, Mark Fihn, Handbook of Visual Display Technology, Sprinter Publication.

2. Organic Light emitting diodes, edited by Marco Mazzae, INTECH publication, 2010.Physical Biology of the Cell, Rob Phillips (2012
3. Peter J. Collings and Michael Hird, Introduction to Liquid Crystals, Taylor and Francis, 1997.

Reference Books:

1. S. T. Lagerwall, P. G. Rudquist, D. S. Hermann: "Liquid crystals", in Encyclopaedia of optical Engineering, Marcel Dekker Inc. 2003)

2. D. Demus et al. (editors) Handbook of Liquid Crystals, Volume 1-3, Wiley VCH, 1998

Electronic image display (by Jon C. Leachtenauer)

3. Display systems: design and applications (Edited by Lindasay W. MacDonald and Anthony C. Lowe)

PH1837 **3-0-0 (3)**

Nano Materials and Devices

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand The Luminescence Phenomenon In Bulk And Nanoforms.
CO-2	Explain The Basic Principles Of Phosphors At Lower Dimensions.
CO-3	Gain Insight Into The Fundamentals Of Photometry And Colorimetry.
CO-4	Analyse The Structures Of Typical Inorganic Pc-Leds And Their Characteristics
CO-5	Comprehend The Device Physics And Strategies Of Making White-Leds

Course Articulation Matrix:

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

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

Syllabus:

Fundamentals of Luminescence: Absorption and emission of light, Electronic states and optical transition of solid crystals, Selection Rules, Luminescence of a localized center, Impurities and luminescence in semiconductors, Luminescence mechanisms, Factors affecting the emission color, Excitation energy transfer and cooperative optical phenomena, Inorganic electroluminescence, Luminescence quantum yield and quenching processes.

Phosphors at Lower Dimensions: Introduction to nanostructured materials and quantum dots, Structure and properties relationship, Quantum confinement effects on band gap, Relaxation processes of excitons, General synthesis routes: Top-down and bottom-up approaches, Types of surface passivation, Optical properties and applications

Materials for phosphor-converted LEDs: Inorganic LED structures and efficiencies, Typical LEDs and their characteristics, Requirements of color conversion phosphors, Phosphor synthesis, Single and multi-phosphor converted LEDs, Quantum Dots LEDs.

Photometry and Colorimetry: Photopic and scotopic visions, photometric parameters and their measurement methods, colorimetry parameters, Color space & its evolution by CIE, Measurement of CIE color coordinates, Correlated color temperature (CCT), and Color rendering index (CRI), Spectral power distribution of LEDs.

Phosphor-converted LEDs and Other Devices: Phosphors for converting the color of light emitted by inorganic LEDs, Commonly used dopants in color conversion phosphors, Strategies for generating white light from LEDs, Design and placement of phosphor in LEDs, Characteristics of n-UV and blue to white LEDs, Applications of white and colored LEDs,Future Prospects of other devices.

Learning Resources:

Text Books:

1. Luminescence of Inorganic Solids, Paul Goldberg, Academic Press, 1st edition,1966.

2. Solid State Luminescence: Theory, Materials and Devices, A. H. Kitai, Ed., Springer,

2nd edition, 2012

Reference Books:

1. Luminescence of Liquids and Solids and its Practical Applications, Peter Pringsheim and Marcel Vogel, Interscience Publishers, 1943.

2. Phosphor Handbook, William M. Yen, Shigeo Shionoya, Hajime Yamamoto, CRC Press, 2nd edition, 2006.

3. Handbook of Luminescence, Display Materials and Devices, 3-Volume set, Hari Singh Nalwa, Lauren Shea Rohwer, American scientific publishers, 2003.

Other Suggested Readings:

1. https://www.britannica.com
2. https://www.rp-photonics.com

PH1839 **3-0-0 (3)**

Data Driven Engineering Physics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand underlying principles of AI & ML
CO-2	Gain intuition to successfully apply AI & ML to variety of problems
CO-3	Extract useful information from the large data
CO-4	Identify problems that can be easily handled by AI & ML
CO-5	Use of AI & ML for solving practical problems.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Definition and foundations of AI, State of the art.

Machine Learning: Types of ML: Supervised, Unsupervised and Reinforcement learning, Classification and Regression, ML Algorithms, Challenges with ML: Overfitting and Underfitting, Dimensionality reduction techniques: SVD, PCA and Wavelet Transform, Hyperparameter tuning.

Deep Learning: State-of-the-Art. 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, Learning rate, Gradient descent algorithms, Minibatches, Neural network in practice: Overfitting, Regularization, Types of neural network: ANN, CNN, RNN. Transfer Learning, Pre-trained networks: AlexNet

AI for Engineering Physics: Signal and image Processing, optical communications, quantum communications, Quantum Computing, Outlook and challenges.

Learning Resources:

Text Books:

1. S. J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Pearson Education Limited, 2016, Third Edition.
2. S. L. Brunton and J. N. Kutz, Data-Driven Science and Engineering, Cambridge University Press, 2019, 1st Edition.
3. Phil Kim, MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, Apress, 2017, 1st Edition.

Reference Books:

1. I. Goodfellow, Y. Bengio & A. Courville, Deep Learning, MIT Press, 2016, 1st Edition.
2. J. Grus, Data Science from Scratch, O'Reilly Media, 2019, 2nd Edition.
3. G. Carleo, et. al., Machine learning and the physical sciences, Rev. Mod. Phys. 91, 045002 (2019).

Other Suggested Readings:

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