NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

for M.Sc. Tech Engineering Physics

(Effective from 2021-22)

DEPARTMENT OF PHYSICS

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

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

MISSION

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

Vision and Mission of the Department
Department of Physics

VISION

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

MISSION

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

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

Design and Develop application specific electronic and photonic instrumentation.

Department of Physics:

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

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

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

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

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

List of Programs offered by the Department:

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

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Program Educational Objectives

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

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.

SCHEME OF INSTRUCTION

I – Year: I – Semester

S.No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH4101	Mathematical Physics	3	0	0	3	PCC
2	PH4102	Quantum Mechanics	3	0	0	3	PCC
3	EE4131	Electrical Circuits	3	0	0	3	ESC
4	PH4103	Optical Physics	3	0	0	3	PCC
5	ME4131	Workshop Practice	0	1	2	2	ESC
6	PH4104	Optics Laboratory	0	1	2	2	PCC
7	PH4105	Network Analysis Laboratory	0	1	2	2	ESC
		Total	**12**	**3**	**6**	**18**	

I – Year: II – Semester

S.No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH4151	Electromagnetic Theory	3	0	0	3	PCC
2	PH4152	Atomic and Molecular Physics	3	0	0	3	PCC
3	PH4153	Solid State Physics	3	0	0	3	PCC
4	ME4181	Engineering Graphics	0	2	4	4	ESC
5	PH4154	Electronic Devices and Circuits	3	0	0	3	ESC
6	PH4155	Solid State Physics Laboratory	0	1	2	2	PCC
7	PH4156	Electronic Devices and Circuits Lab	0	1	2	2	ESC
8	PH4198	Seminar I	0	0	2	1	SEM
		Total	**12**	**4**	**10**	**21**	

II – Year: I – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH5101	Switching Theory and Logic Design	3	0	0	3	ESC
2	PH5102	Materials Science	3	0	0	3	PCC
3	PH5103	Optoelectronics	3	0	0	3	PCC
4	PH5104	Linear Integrated Circuits	3	0	0	3	PCC
5	PH5105	Problem Solving with C++	3	0	0	3	ESC
6	PH5106	Linear Integrated Circuits Laboratory	0	1	2	2	PCC
7	PH5107	Switching Theory and Logic Design Lab	0	1	2	2	PCC
8	PH5108	Computer Programming Laboratory	0	1	2	2	ESC
		Total	**15**	**3**	**6**	**21**	

II – Year: II– Semester (Electronics Specialization)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH5251	Structured Digital System Design	3	0	0	3	PCC
2	PH5252	Microprocessors and Interfacing	3	0	0	3	PCC
3	PH5253	Communication Systems	3	0	0	3	PCC
4		Elective – I	3	0	0	3	PEC
5		Elective – II	3	0	0	3	PEC
6	PH5254	Digital System Design Laboratory	0	1	2	2	PCC
7	PH5255	Microprocessors and Interfacing Lab	0	1	2	2	PCC
8	PH5256	Communication Laboratory	0	1	2	2	PCC
9	PH5298	Seminar II	0	0	2	1	SEM
		Total	**15**	**3**	**8**	**22**	

II – Year: II– Semester (Photonics Specialization)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH5351	Optical System Design	3	0	0	3	PCC
2	PH5352	Optical Instruments	3	0	0	3	PCC
3	PH5353	Fourier Optics and Holography	3	0	0	3	PCC
4		Elective - I	3	0	0	3	PEC
5		Elective – II	3	0	0	3	PEC
6	PH5354	Optical System Design Laboratory	0	1	2	2	PCC
7	PH5355	Optical Instruments Laboratory	0	1	2	2	PCC
8	PH5356	Optoelectronics Laboratory	0	1	2	2	PCC
9	PH5398	Seminar II	0	0	2	1	SEM
		Total	**15**	**3**	**8**	**22**	

II– Year: II– Semester (Instrumentation Specialization)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH5451	Control systems	3	0	0	3	PCC
2	PH5452	Transducers Technology	3	0	0	3	PCC
3	PH5453	Microcontrollers	3	0	0	3	PCC
4		Elective I	3	0	0	3	PEC
5		Elective II	3	0	0	3	PEC
6	PH5454	Microcontrollers Laboratory	0	1	2	2	PCC
7	PH5455	Transducer Technology Laboratory	0	1	2	2	PCC
8	PH5456	Control System Laboratory	0	1	2	2	PCC
9	PH5498	Seminar II	0	0	2	1	SEM
		Total	**15**	**3**	**8**	**22**	

III– Year: I – Semester (Electronics Specialization)

S. No	Course Code	Course Title	L	T	P	Credits	Cat Code
1	PH6201	Digital Signal Processing	3	0	0	3	PCC
2	PH6202	Microcontrollers and Embedded Systems	3	0	0	3	PCC
3		Elective – III	3	0	0	3	PEC
4		Elective – IV	3	0	0	3	PEC
5		Elective – V	3	0	0	3	PEC
6		Elective – VI	3	0	0	3	PEC
7	PH6203	Digital Signal Processing Laboratory	0	1	2	2	PCC
8	PH6204	Microcontroller Applications Laboratory	0	1	2	2	PCC
9	PH6247	Comprehensive Viva Voce	-	-	-	2	CVV
		Total	**18**	**2**	**4**	**24**	

III Year I -Semester (Photonics Specialization)

S. No	Course Code	Course Title	L	T	P	Credits	Cat code
1	PH6301	Optoelectronic Sensing and MOEMS	3	0	0	3	PCC
2	PH6302	Optical Elements Production & Testing	3	0	0	3	PCC
3		Elective – III	3	0	0	3	PEC
4		Elective – IV	3	0	0	3	PEC
5		Elective – V	3	0	0	3	PEC
6		Elective – VI	3	0	0	3	PEC
7	PH6303	Optoelectronic Sensing Laboratory	0	1	2	2	PCC
8	PH6304	Fourier Optics and OEPT laboratory	0	1	2	2	PCC
9	PH6347	Comprehensive Viva Voce	-	-	-	2	CVV
		Total	**18**	**2**	**4**	**24**	

III – Year: I – Semester (Instrumentation Specialization)

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	PH6401	Analytical Instrumentation	3	0	0	3	PCC
2	PH6402	Process Instrumentation	3	0	0	3	PCC
3		Elective III	3	0	0	3	PEC
4		Elective IV	3	0	0	3	PEC
5		Elective V	3	0	0	3	PEC
6		Elective VI	3	0	0	3	PEC
7	PH6403	Analytical Instrumentation Laboratory	0	1	2	2	PCC
8	PH6404	Process Instrumentation Laboratory	0	1	2	2	PCC
9	PH6447	Comprehensive Viva Voce	-	-	-	2	CVV
		Total	**18**	**2**	**4**	**24**	

III – Year: II– Semester (All Specializations)

S. No	Course Code	Course Title	L	T	P	Credits	Cat code
1	PH6199	Dissertation Work (26 Weeks)	0	0	0	14	DW
		Total	**0**	**0**	**0**	**14**	

Cat. Code	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Total
Professional Core Courses (PCC)	11	11	13	15	10	--	60
Professional Elective Courses (PEC)	--	--	--	06	12	--	18
Engineering Science Core (ESC)	07	09	08	--	--	--	24
Dissertation Work (DW)	--	--	--	--	--	14	14
Comprehensive Viva-Voce (CVV)	--		--		02	--	02
Seminar- I & II (SEM)	--	01	--	01	--	--	02
Total	**18**	**21**	**21**	**22**	**24**	**14**	**120**

Program Elective Courses (Electronics Specialization)

Elective-1 (2 Year, 2 Semester)		
S. No	**Course Code**	**Course Title**
1	PH5261	High Speed Data Converters
2	PH5262	Organic Semiconductors and Devices
3	PH5263	Lasers and Applications
Elective-2 (2 Year, 2 Semester)		
1	PH5264	Pulse Circuits
2	PH5265	MATLAB
3	PH5266	Thin Films and Vacuum Techniques
Elective-3 (3Year, 1Semester)		
1	PH6211	Advanced Communication Systems
2	PH6212	Designing with FPGA and CPLDs
3	PH6213	Solar Energy Systems
Elective-4 (3Year, 1Semester)		
1	PH6214	Computer Organisation and Operating Systems
2	PH6215	VLSI Design
3	PH6216	Satellite Communication
4	PH6217	Smart Materials and Devices
Elective-5 (3Year, 1Semester)		
1	PH6218	Data Communication
2	PH6219	Embedded Systems
3	PH6221	Luminescence Materials and Devices
Elective-6 (3Year, 1Semester)		
1	PH6222	Fiber Optic Communication
2	PH6223	Digital Image Processing
3	PH6224	Artificial Intelligence and Machine Learning
4	PH6225	Arm 7 Architecture and programming

Program Elective Courses (Photonics Specialization)

Elective-1 (2 Year, 2 Semester)		
S. No	**Course Code**	**Course Title**
1	PH5361	Nonlinear Optics
2	PH5362	Polarization Optics
3	PH5263	Lasers and Applications
Elective-2 (2 Year, 2 Semester)		
1	PH5363	MATLAB for Photonics
2	PH5364	Adaptive Optics
3	PH5266	Thin Films and Vacuum Techniques
Elective-3 (3Year, 1 Semester)		
1	PH6311	Integrated Optics
2	PH6312	New Lasing Materials
3	PH6313	Quantum Optics
4	PH6213	Solar Energy Systems
Elective-4 (3Year, 1Semester)		
1	PH6314	Advanced Optical System Design
2	PH6315	Silicon Photonics
3	PH6316	Nanophotonics
4	PH6217	Smart Materials and Devices
Elective-5 (3Year, 1Semester)		
1	PH6317	Biophotonics
2	PH6318	Optical Microscopy
3	PH6319	Display Technologies
4	PH6321	Nanofibers Synthesis, Properties and Applications
5	PH6221	Luminescence Materials and Devices
Elective-6 (3Year, 1Semester)		
1	PH6222	Fiber Optic Communication
2	PH6322	Infrared Optics and Thermal Imaging
3	PH6224	Artificial Intelligence and Machine Learning
4	PH6323	Photonic Devices

Program Elective Courses (Instrumentation Specialization)

Elective-1 (2 Year, 2 Semester)		
S. No	**Course Code**	**Course Title**
1	PH5461	Data Acquisition Systems
2	PH5462	Signal Conditioning Circuits
3	PH5263	Lasers and Applications
Elective-2 (2 Year, 2 Semester)		
1	PH5265	MATLAB
2	PH5463	Non-Destructive Testing
3	PH5266	Thin Films and Vacuum Techniques
Elective-3 (3 Year, 1 Semester)		
1	PH6411	Electronic Instrumentation
2	PH6412	PC based Instrumentation
3	PH6213	Solar Energy Systems
Elective-4 (3 Year, 1 Semester)		
1	PH6413	Medical Instrumentation
2	PH6414	Telemetry and Telecommand
3	PH6217	Smart Materials and Devices
Elective-5 (3 Year, 1 Semester)		
1	PH6415	Data Communication
2	PH6416	Digital and Distributed Control systems
3	PH6221	Luminescence Materials and Devices
Elective-6 (3 Year, 1 Semester)		
1	PH6417	Supervisory Control and Data Acquisition (SCADA)
2	PH6201	Digital Signal Processing
3	PH6224	Artificial Intelligence and Machine Learning

DETAILED SYLLABUS

I semester

Course Code: PH4101	MATHEMATICAL PHYSICS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Handle vector equations in generalized coordinates.
CO2	Apply Fourier & Laplace transforms to solve problems.
CO3	Solve arbitrary order linear differential equations with constant coefficients.
CO4	Apply the concepts of probability and statistics to interdisciplinary problems.
CO5	Apply mathematical physics to solve real life problems.

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH4102	QUANTUM MECHANICS	Credits: 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the evolution of quantum mechanics.
CO2	Solve potential well problems using Schrödinger wave equation.
CO3	Analyse the commutation relations between spin and angular momentum.
CO4	Apply variational principle and perturbation theory to standard systems as appropriate.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus**:**

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.

Online Resources:

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

Course Code: EE4131	ELECTRICAL CIRCUITS	Credit: 3-0-0 :3

Pre-requisites: None

Course Outcomes:

After completion of the course, students will be able to

CO1	Simplify DC networks and analyze them using loop and node equations and determine the dual of a given network
CO2	Analyze magnetic circuits, and electric circuits with sinusoidal excitation along with the phenomenon of resonance
CO3	Formulate the dynamic equations of electric circuits using differential equations and simplify their solutions using Laplace.
CO4	Simplify the analysis of electric circuits using network theorems and Two port Networks.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	2
CO2	3	2	2	1	2	2
CO3	3	2	2	1	2	2
CO4	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, Initialconditions & evaluation, applications to simple RLC circuits 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, 4th edition, 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.

Online Resources:

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/

Course Code: PH4103	OPTICAL PHYSICS	Credits 3-0-0: 3

Pre-Requisites**:** None

Course Outcomes**:**

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

CO1	Understand the basic principles governing the optical instruments.
CO2	Explain the physics of image formation and its applications.
CO3	Analyse optical systems using principles of optics.
CO4	Apply quantum optics to lasers and Q-switching.
CO5	Gain insight into the phenomena of superluminal velocities and slow light.

Course Articulation Matrix**:**

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

Online Resources:

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

Course Code: ME4131	WORKSHOP PRACTICE	Credits 0–1– 2: 2

Pre-requisites**:** None

Course Outcomes**:**

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

CO1	Identify the hand tools and instruments to perform corresponding trades
CO2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3	Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4	Apply basic electrical engineering knowledge for house wiring practice

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Demonstration of safety practices and precautions to be observed in workshop.

Fitting Trade: Demonstration and practice of fitting tools, Preparation of T-Shape, Dovetail Joint

Carpentry: Demonstration and practice of carpentry tools, Preparation of Cross Half lap joint and Mortise Tenon Joint.

Plumbing: Demonstration and practice of Plumbing tools, Preparation of Pipe joints with coupling for same diameter and with reducer for different diameters.

Machine shop: Demonstration and practice on Lathe Machine, Preparation of work pieces involving Facing, Plane Turning, step turning, knurling and parting operations.

House Wiring: Demonstration and practice on Electrical tools, wiring and earthing, Exercises on Staircase Wiring & Godown wiring.

Power Tools: Demonstration and practice on Power tools (Bosch Power Tools) and Safety Practices.

Foundry Trade: Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns (Solid / Split Patterns). Demonstration of Sweep Moulding Process.

Welding Shop: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.

Sheet metal: Demonstration of & Practice on sheet metal tools. Practice on preparing required shapes from a sheet using appropriate tools.

Text Books:

1. Basic Workshop Technology: Manufacturing Process, Felix W.; Independently Published, 2019.
2. Workshop Processes, Practices and Materials; Bruce J. Black, Routledge publishers, 5th Edn. 2015.
3. Engineering Practices Laboratory Manual, Ramesh Babu.V., VRB Publishers Private Limited, Chennai, Revised Edition, 2013 – 2014.
4. Wiring Estimating, Costing and Contracting; Soni P.M. & Upadhyay P.A.; Atul Prakashan, 2021-22.

Reference Books:

1. A Course in Workshop Technology Vol I. & II, B.S. Raghuwanshi, Dhanpath Rai & Co., 2015 & 2017.
2. Elements of Workshop Technology, Vol. I & Vol. II by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 14th Edition
3. Engineering Practices Lab Manual; T.Jeyapoovan, Vikas Pub, 4th Edn...2008.

Online Resources:

1. Different Trade E-Books (Fitting, Plumbing, Welding, Carpentry, Foundryman, Turner and House Wiring etc.) developed by National Instructional Media Institute, Chennai. Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Govt. of India. (https://bharatskills.gov.in).

Course Code: PH4104	OPTICS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Select optical and mechanical housing for conducting experiments.
CO2	Use the optical instruments judiciously.
CO3	Use electronic circuitry required in optical experiments.
CO4	Design experiments to verify principles of optics.
CO5	Apply optical techniques for applications in metrology.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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

Online Resources:

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

Virtual labs:

1. https://ricktu288.github.io/ray-optics/
2. https://phet.colorado.edu/en/simulation/geometric-optics

Course Code: PH4105	NETWORK ANALYSIS LABORATORY	Credit: 0-1-2: 2

Pre-requisites: None

Course Outcomes:

After completion of the course, students will be able to

CO1	Determine network parameters using mesh and node analysis.
CO2	Analyze steady state dc networks.
CO3	Analyze steady state ac networks.
CO4	Evaluate the transient response of networks.

Course Articulation Matrix:

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

Online Resources:

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/

II Semester

Course Code: PH4151	ELECTROMAGNETIC THEORY	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand Maxwell's equations in electromagnetic wave propagation.
CO2	Analyse boundary conditions of dielectric to dielectric and dielectric to conductor interfaces.
CO3	Estimate the characteristic parameters of EM Wave
CO4	Understand reflection, refraction, total internal reflection and Polarisation of plane waves.
CO5	Apply electromagnetic field theory for wave guide applications and Optical Fibres.

Course Articulation Matrix:

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

Online Recourses:

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

Course Code: PH4152	ATOMIC AND MOLECULAR PHYSICS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the quantum aspects of atoms and molecules.
CO2	Estimate energy level splitting of atoms in the presence of external electric and magnetic fields using quantum treatment.
CO3	Comprehend the working principles of IR, UV-VIS, Microwave, Raman and NMR spectroscopic techniques.
CO4	Apply the spectroscopy to study the properties of atoms and molecules.

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH4153	SOLID STATE PHYSICS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Analyse crystal structure of materials using appropriate diffraction methods.
CO2	Understand the physics of semiconductor devices.
CO3	Understand optical and dielectric properties of solids.
CO4	Comprehend magnetic properties of materials.
CO5	Understand superconductivity and its applications.

Course Articulation Matrix:

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

Online resources

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

Course Code: ME4181	ENGINEERING GRAPHICS	Credits: 0-2- 4: 4

Pre-requisites**:** None

Course Outcomes**:**

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

CO1	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
CO2	Classify the systems of projection with respect to the observer, object and the reference planes.
CO3	Construct orthographic views of an object when its position with respect to the reference planes is defined.
CO4	Analyse the internal details of an object through sectional views.
CO5	Develop 3D Isometric View in relation with 2D orthographic views
CO6	Construct 2D (orthographic) and 3D (isometric) views in CAD environment.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales

Orthographic Projection: Principles of Orthographic projection, Four Systems of Orthographic Projection.

Projection of Points: Projections of points when they are situated in different quadrants.

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.

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

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.

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

Isometric Views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views – simple objects.

Auto-CAD Practice: Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES

Learning Resources:

Text Books:

1. N.D. Bhat and V.M. Panchal, Engineering Graphics, Charotar Publishers 2013
2. Prof. Sham Tickoo, *AutoCAD 2017 for Engineers & Designers*, 23ed, Dreamtech Press

Practice Schedule:

Session	Topic (s)
1	Using of Instruments, Lettering Practice.
2,3	Dimensioning, Geometrical Constructions & Polygons.
4	Projection of Points.
5	Projection of Lines-1.
6	Introduction to Auto-CAD, DRAW tools-1 and Practice
7,8,9	Projection of Lines-2, Trapezoidal Method, Traces.
10	Auto-CAD DRAW tools-2, MODIFY tools-1 and Practice
11	Auto-CAD : MODIFY tools -2, TEXT, DIMENSION, PROPERTIES and Practice
12,14	Projection of Planes.
13,15	Auto-CAD: Practice of Problems in Projection of Planes

Course Code: PH4154	ELECTRONIC DEVICES AND CIRCUITS	Credit: 3-0-0 :3

Pre-requisites: NA (EEE133)

Course Outcomes:

After completion of the course, students will be able to

CO1	Understand the characteristics of diode, BJT, FETs, UJT, Diac and Triac.
CO2	Analyse small signal amplifiers using BJTs and FETs.
CO3	Design small signal amplifiers using BJTs and FETs for a given specification.
CO4	Understand the role of feedback in amplifiers
CO5	Design class A, B, AB and C types of power amplifiers

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Detailed 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.

Online resources:

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

Course Code: PH4155	SOLID STATE PHYSICS LABORATORY	Credits 0-1-2: 2

Pre-requisites: None

Course Outcomes:

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

CO1	Determine energy band gap of semiconductors using two-probe and four-probe methods.
CO2	Determine the conductivity, carrier concentration and mobility of semiconductors using Hall effect.
CO3	Prepare nano crystalline materials.
CO4	Characterize materials using XRD and FTIR techniques.
CO5	Evaluate magnetic and dielectric properties of solids.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Experiments:

1. 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.

Online resources:

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

Course Code: PH4156	ELECTRONIC DEVICES AND CIRCUITS LABORATORY	Credit: 0-1-2: 2

Pre-requisites: None

Course Outcomes:

After completion of the course, students will be able to

CO1	Determine characteristics of various semiconductor devices.
CO2	Evaluate the performance of small signal and feedback amplifiers with BJT and FET.
CO3	Design and construct BJT and FET amplifiers using different biasing techniques.
CO4	Design and construct diode circuits for given application.

Course Articulation Matrix:

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

Online Resources:

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

III Semester

Course Code: PH5101	SWITCHING THEORY AND LOGIC DESIGN	Credits 3-0-0: 3

Pre-Requisites: EDC (PH4156)

Course Outcomes:

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

CO1	Apply Boolean theorems and postulates to minimize logic expressions.
CO2	Design encoders, decoders, multiplexers and application specific combinational logic circuits.
CO3	Design counters, shift registers and application specific sequential logic circuits.
CO4	Understand different logic families and interfacing between them.
CO5	Understand the basic software tools for the design and implementation of digital circuits and systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	1	1
CO2	3	3	3	1	1	1
CO3	3	3	3	2	2	1
CO4	3	2	2	2	2	1
CO5	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 logic 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. 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.
3. Switching and Finite Automata Theory, Niraj K. Jha, ZviKohavi, Cambridge University Press; 3rd edition, 2009.

Online Resources:

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

Course Code: PH5102	MATERIALS SCIENCE	Credits 3-0-0: 3

Pre-Requisites: SSP (PH4153)

Course Outcomes:

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

CO1	Classify imperfections in solids.
CO2	Compute critically resolved shear stress and grain size of materials.
CO3	Understand nucleation, growth, crystallization and diffusion phenomena in solids.
CO4	Estimate composition of phases from a phase diagram.
CO5	Identify materials and engineering processes for industrial applications.

Course Articulation Matrix:

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

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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.

Online Resources:

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

Course Code: PH5103	OPTOELECTRONICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), EMT (PH4151)

Course Outcomes:

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

CO1	Understand the properties of wave guides, optical fibers and guided modes
CO2	Select LEDs for different applications based on their structure and working
CO3	Identify semiconductor Lasers for application in sensing and communication
CO4	Understand photo detectors and their applications
CO5	Comprehend light modulators and their applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Light Propagation in Wave Guides: Introduction-Some physical properties of wave guides and optical fiber-Maxwell's Equations-Guided modes in planar waveguides-Optical confinement factor-Guided modes in optical fiber-waveguide couplers.

Optical sources: Introduction, Direct and indirect Band gap Semiconductors-Doped Semiconductors-PN Junction, Carrier Lifetime and Photoconductivity, Direct 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.

Online resources:

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

Course Code: PH5104	LINEAR INTEGRATED CIRCUITS	Credits 3-0-0: 3

Pre-Requisites: EDC (PH4154)

Course Outcomes:

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

CO1	Design inverting and non-inverting amplifiers using operational amplifiers.
CO2	Design op-amp circuits for linear and non-linear operations.
CO3	Design active filters and waveform generators using op-amps.
CO4	Develop applications using 555 timer, 566 PLL, and voltage regulator ICs.
CO5	Evaluate the performance of op-amp circuits.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Fundamentals of Operational amplifiers: Op-amp- Internal circuit –Block diagram representation of op-amp- Stages of op-amp-Ideal op-amp, Basic differential amplifier-transfer characteristics, differential mode gain, common mode gain, circuits for improving CMRR, Practical op-amp - Open loop & closed loop configurations – measurement of Op-amp parameters, DC & AC performance characteristics of op-amp – Frequency compensation.

Applications of op-amps: Voltage follower - Summing, scaling & averaging amplifiers - 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.

Online Resources:

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

Course Code: PH5105	PROBLEM SOLVING WITH C++	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Develop algorithms for mathematical and scientific problems.
CO2	Explore alternate algorithmic approaches to problem solving.
CO3	Understand the components of computing systems.
CO4	Choose data types and structures for problem solving.
CO5	Develop modular programs using control structures.
CO6	Develop programs in C^{++} to solve physics problems.

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH5106	LINEAR INTEGRATED CIRCUITS LABORATORY	Credits 0-1-2: 2

Pre-requisites: None

Course Outcomes:

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

CO1	Evaluate the performance of op-amp amplifiers.
CO2	Analyse linear and non-linear circuits using op-amps.
CO3	Design active filters and waveform generators using op-amps.
CO4	Construct astable and monostable multivibrator circuits using 555 timer for various applications.
CO5	Evaluate the performance of IC voltage regulators.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Experiments:

1. Inverting and non-inverting amplifier using IC 741- Study of frequency response.
2. Determination of slew rate and CMRR of Op-amp.
3. Summing, scaling and averaging amplifier with Op-amp.
4. Integrator using Op-amp.
5. Differentiator using Op-amp.
6. Wein-bridge oscillator.
7. Design of Butterworth second order Low-pass and High-pass filters.
8. Design of Band-pass filters.
9. Precision rectifiers.
10. Monostable multivibrator applications using 555 timer.
11. Astable multivibrator applications using 555 timer.
12. Three terminal voltage regulators (fixed and variable).

Learning Resources:

Text Books:

1. Op–Amps and Linear integrated circuits, Ramakanth, A. Gayakwad, Prentice Hall of India, New Delhi, 2000, Fourth Edition.
2. Operational Amplifiers & Linear Integrated Circuits: Theory and Application, James M. Fiore, Dissidents publisher, 2020, Third edition.

Reference Books:

1. Design with Operational Amplifiers and Analog Integrated Circuits, Sergio Franco, Mc Graw Hill, 2014, Third Ed.
2. Operational Amplifiers with Linear Integrated Circuits, William D. Stanley, Pearson Education India, 2004, Fourth Edition.

Online Resources:

1. http://www.dissidents.com/resources/LaboratoryManualForOperationalAmplifiersAndLinearICs_3E.pdf
2. https://milneopentextbooks.org/operational-amplifiers/

Course Code: PH5107	SWITCHING THEORY AND LOGIC DESIGN LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Test the functionality of ICs and electronic components
CO2	Design combinational and sequential circuits using simulation software such as Deeds, LT spice and NI-Multisim.
CO3	Design and construct combinational and sequential circuits and evaluate their performance.
CO4	Debug digital circuits.
CO5	Able to identify and prevent various hazards and timing problems in a digital design.

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH5108	COMPUTER PROGRAMMING LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Develop algorithms for mathematical and scientific problems.
CO2	Explore alternate algorithmic approaches for problem-solving.
CO3	Understand the components of computing systems.
CO4	Choose data types and structures to solve a mathematical and scientific problem.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

List of Experiments:

1. Program with input and output statement
2. Programs on control constructs with conditions.
3. Programs on loops (for, while, do-while, for).
4. Programs using the standard library and user-defined functions.
5. Programs on arrays (single and multi-dimensional arrays), matrices.
6. Programs using structures and pointers
7. Programs on Object and classes
8. Programs on generating random numbers, plotting: applied to real problems (e.g., Pi)
9. Solving Physics Problems
10. Basic program on Molecular Dynamics and Monte Carlo

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.

Online Resources:

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

IV Semester Electronics

Course Code: PH5251	STRUCTURED DIGITAL SYSTEM DESIGN	Credits 3-0-0: 3

Pre-Requisites: STLD (PH5101)

Course Outcomes:

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

CO1	Design advanced digital circuits using PAL.
CO2	Understand the basics of Hardware Description Languages.
CO3	Understand types of modelling, modules, functions of Verilog HDL
CO4	Design and develop the combinational and sequential circuits using Verilog HDL
CO5	Simulate, synthesize, and program their designs on a development board

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Online Resources:

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.

Course Code: PH5252	MICROPROCESSORS AND INTERFACING	Credits 3-0-0: 3

Pre-Requisites: STLD (PH5101)

Course Outcomes:

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

CO1	Understand the architecture of 8086 microprocessor.
CO2	Write Assembly Language Program for 8086 microprocessors.
CO3	Interface peripheral devices 82C55, 8279, 8254 with microprocessor.
CO4	Transfer data using 8237 DMA controller.
CO5	Understand the evolution of advanced microprocessor architectures

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

The Microprocessor and its Architecture: Introduction to Microprocessor - 8086 Microprocessor architecture –Real mode memory addressing-Data addressing modes – Programming memory –addressing modes –Stack memory addressing modes.

Assembly Language Programming: Data movement instructions-Architecture and logical instructions –program control instructions- program examples.

Memory and Basic I/O interface: Memory devices – Memory mapping and interfacing-Basics of I/O interface- Programmable Peripheral Interface 82C55 -Interfacing of stepper motor-8279 Programmable Keyboard/Display Interface – 8254 Programmable Interval Timer-16550 Programmable Communication Interface.

Interrupts and DMA Basic Interrupt Processing-External Hardware interrupts-8259A Programmable Interrupt Controller-Basic DMA operation-The 8237 DMA Controller-Shared Bus Operation.

Advanced Processor Technologies:
Introduction to 80386 Microprocessor, Special registers of 386,386 Memory Management, Features of Pentium-Pentium Memory Management-Super Scale Processors-Multicore processing-MMX and SSE technologies- Beyond Pentium more advanced processors

Learning Resources:

Text Books:

1. The Intel Microprocessors, Barry B. Brey, Pearson Education, Eighth Edition, 2013.
2. Microprocessors and Interfacing, Douglas V Hall and SSSP Rao, SIE publications, Third Edition, 2017.

Reference Books:

1. Advanced Microprocessors and Peripherals, K. Bhurchandi and A.K. Ray, TMH publications, Third Edition, 2017.
2. The x86 Microprocessor, Architecture, Programming and Interfacing, Lyla B Das, Pearson education, Second Edition, 2014.

Online Resources:

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

Course Code: PH5253	COMMUNICATION SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: EDC (PH4154), LICA (PH5104)

Course Outcomes:

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

CO1	Understand Communication systems,
C02	Estimate noise in communication systems
CO3	Comprehend Amplitude and Frequency modulation and demodulation methods
CO4	Distinguish between Pulse Amplitude, Pulse with and Pulse Position modulation.
CO5	Comprehend digital communication formats

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Communication Systems and Noise Calculations: Bandwidth and information capacity--Electronic Communication Systems-Need for modulation- - Linear Summing-Nonlinear Mixing- Voltage and current models of a noisy resistor- Addition of noise due to several sources- Thermal noise calculations-SNR, Noise Figure - experimental determination of NF, Noise temperature

Analog Modulation Schemes and Radio Receivers: Amplitude modulation spectra of DSB-FC, DSB-SC, SSB-SC -Generation and demodulation. Generation and detection of VSB Signals-ISB-System. Spectral features of FM and PM- .FM generation -direct and indirect methods -NBFM, WBFM, FM Detection (Slope detection, Foster- Seeley, Ratio type, PLL). TRF and super heterodyne receivers-AGC and delayed AGC

Pulse Modulation Schemes: Introduction: The sampling theorem- Pulse Communication: Pulse Amplitude Modulation (PAM) Fundamentals, generation and detection – Pulse Time Modulation (PTM-PWM, PPM)-generation and detection – Pulse code Modulation (PCM)-Comparison of various Pulse Communication System (PAM – PTM – PCM).

Digital Communication System Formats: Modulation Formats: Introduction to Constellation diagram. Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Binary FSK -Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth

Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM), M-ary schemes

Learning Resources:

Text Books:

1. Electronic Communication Systems, George Kennedy, Bernard Davis, TMH,4th edition,1999.
2. Electronic Communication Systems-Fundamentals through Advanced, Wayne Tomasi, Pearson Education, 6th edition,2009.

Reference Books:

1. Modern Digital and Analog Communication Systems, B.P.Lathi, Zhi ding Oxford University Press, Fourth Edition, 2011.
2. Communication Systems, Symon Haykin, Michael Mohar; Wiley publications, Fifth Edition, 2013.

Web Resources:

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

Course Code: PH5261	HIGH SPEED DATA CONVERTERS	Credits 3-0-0:3

Pre-Requisites: SDSD (PH5251)

Course Outcomes:

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

CO1	Understand basic principles of data converters.
CO2	Comprehend the working of Analog to Digital and Digital to Analog converters.
CO3	Understand high speed data converters.
CO4	Evaluate the performance of data converters

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

INTRODUCTION: Ideal data conversion, The sampling operation, Sampling theorem, Sampling of bandpass signals, The reconstruction operation, The quantization operation, Coding, Under sampling and oversampling, Decimation and interpolation.

Performance Metrics: Resolution and sampling rate, Signal-to-noise-and-distortion ratio (SNDR or SINAD), Spurious-free dynamic range (SFDR) , HD2 and HD3, Differential operation, Intermodulation distortion (IMD), Relationship between HD and IMD, Differential and integral non-linearity (DNL and INL) Relationship between SFDR and INL, HD2 and HD3 INL patterns, Saw-tooth INL pattern, Offset and gain error, Jitter, Analysis, Intuitive perspective, Jitter measurement, Types of random jitter, Jitter and phase noise, Bit error rate (BER), Power consumption and figure of merit.

DIGITAL TO ANALOG CONVERTERS (DACS): Principles and design of – weighted resistor, R– 2R ladder, inverted R-2R ladder, monolithic DAC – Parameter specifications.

ANALOG TO DIGITAL CONVERTERS (ADCS): Classification of A/D converters, Principles and design of- Flash, Counter, Servo tracking, Successive approximation, Integrating type– Charge balancing, dual slope integration ADCs- MAX5893 High Speed A/D, Parameter specifications.

Learning Resources:

Text Books:

1. High Speed Data Converters, Ahmed M.A. Ali, IET Publisher, 2016.
2. Data Converters, Franco Maloberti, Springer, 2010.

Reference Books:

1. Data Conversion Handbook-Analog Devices Inc., Walt Kester Editor, Elsevier, 2005.
2. Data Converters, GB Clayton. John Wiley, First Edition, 1982.

Online Resources:

1. Data Conversion Handbook by Analog Devices Inc. https://www.pdfdrive.com/data-conversion-handbook-e158476438.html
2. Data Converter (Analogue digital Conversion) by Walt Kester https://www.analog.com/media/en/training-seminars/design-handbooks/Data- Conversion-Handbook.pdf

Course Code: PH5262	ORGANIC SEMICONDUCTORS AND DEVICES	Credits 3-0-0:3

Pre-Requisites: EDC (PH4154)

Course Outcomes:

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

CO1	Understand conjugated organic semiconductors and their properties.
CO2	Comprehend inorganic semiconductor devices.
CO3	Comprehend the working of OLED, OPV and OTFTs.
CO4	Estimate electronic transitions in organic semiconductors using spectroscopic methods.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Online Resources:

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/

Course Code: PH5263	LASERS AND APPLICATIONS	Credits 3-0-0:3

Pre-Requisites: EMT (PH4151), OE (PH5103)

Course Outcomes:

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

CO1	Understand the theory and working of CO_2, Rare earth doped-YAG, Excimer and Ruby lasers and their applications in material processing
CO2	Understand LIDAR and its applications in atmospheric studies
CO3	Understand inertial navigation using ring laser gyro.
CO4	Understand laser guided weapons and electro-optic surveillance systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Quantum Theory of Laser: Radiative and Non-radiative decay of excited state atoms – Emission Broadening and linewidth – Radiation and Thermal equilibrium – Conditions for laser action – Laser Oscillation above threshold - Laser Amplifiers – Requirements for obtaining population inversion – Rate Equations for three and four level systems – Laser pumping requirements – Laser Cavity modes – Stable resonators – Gaussian beams- Special Laser Cavities – Q-switching and Mode locking – Generation of ultrafast Optical pulses- Pulse compression

Lasers in Atmospheric Studies- Laser for detection and ranging- LIDAR: applications- Doppler wind LIDAR, Differential Absorption LIDAR for water vapour monitoring.

Laser application in material processing: CO_2, YAG, Excimer, Ruby lasers-[material processing, Cutting, Welding, drilling, micro machining] – Interaction of laser radiation with matter, Heat Flow Theory, Process characteristics etc.

Lasers for space applications: free space communication, laser propulsion, laser ignition, Optical Rotation sensors and their applications for space navigation: Sagnac Interferometers and their applications for space, Ring Laser gyros- Laser Resonator Design, Laser Frequency stabilization techniques, Ring resonator – stable and unstable and their application in Ring Laser Gyros.

Laser Target Designators and Laser-Guided Weapons: Laser Guidance, Laser target designators, laser guided missiles, laser guided bomb. Laser beam riding of missiles. Laser & electro-optic surveillance systems, IR guidance.

Learning Resources:

Text Books:

1. Laser Principles, Types & Applications, K R Nambiar, New Age International, 2006.
2. Lasers: Theory and Applications, A K Ghatak and K Thyagarajan, 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.

Online resources:

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

Course Code: PH5264	PULSE CIRCUITS	Credits 3-0-0: 3

Pre-Requisites: EDC (PH4154)

Course Outcomes:

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

CO1	Understand and analyse the responses of first order RC low pass and high pass filters for standard inputs.
CO2	Analyse clipping and clamping circuits
CO3	Design Multivibrator and sweep circuits
CO4	Comprehend Time-base generators.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Linear Wave Shaping: High pass and low pass RC circuits and their response for Sinusoidal, Step, Pulse, Square, & Ramp inputs, High pass RC network as Differentiator, Low pass RC circuit as an Integrator, RL and RLC Circuits and their response for Step Input, Ringing Circuit.

Clipping and Clamping circuits Clipping-Diode clippers-The transient clipper-Comparators-Breakaway diode and amplifier-Diode-Differentiator Comparator-Application of Voltage comparators. The clamping operation, Clamping circuits –Clamping circuit theorem-Synchronized Clamping-Transistor switch with inductive load.

Multivibrators: The monostable mutivibrator-The emitter-coupled monostable multivibrator-Triggering of monostable multivibrator-The astable collector coupled multivibrator-The stable states of a bistable multivibrator-A fixed biased transistor bistable multivibrator-methods of improving resolution-symmetrical triggering-Schmitt Trigger circuits.

Time base Generators: General features of time base signal-Methods of generating time-based waveform-unijunction transistor-Miller and Bootstrap time base generators-Current time-based generators-A simple current sweep

Synchronization and Frequency Division: Pulse Synchronization of Relaxation Devices, Frequency division in Sweep Circuit, Astable Relaxation Circuits, Monostable Relaxation Circuits as Dividers, stability of Relaxation dividers Synchronization of a Sweep Circuit with Symmetrical Signals, Sine wave frequency division with a Sweep Circuit.

Learning Resources:

Text books:

1. Pulses, Digital and Switching waveforms by Jacob Milliman, Herbert Taub & M.S.PrakashRao Mc-Graw hill, fourth edition, 2008.
2. Pulses and Digital Circuits A. Anand Kumar, PHI Learning,2012

Reference books:

1. Pulse and Digital Circuits by K.Venkata Rao, K.Rama Sudha, G.Manmadha Rao, Pearson education, first edition,2010.
2. High Speed pulse techniques by J.A.Coekin ,Elsevier science publication, third edition,2013.

Web Resources:

1. https://nptel.ac.in/courses/117/106/117106086/

Course Code: PH5265	MATLAB	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Use MATLAB for analyse of scientific/engineering problems
CO2	Develop in-depth knowledge and concepts through MATLAB simulations
CO3	Develop numerical models to solve problems in Electronics
CO4	Design electronics systems using MATLAB

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

MATLAB & Simulink Overview: *MATLAB Primer:* Matrices & Arrays, Indexing, Data Visualization, Programming & Scripts. *Simulink:* Modelling in Simulink, Simple Model, Navigating a Simulink Model.

Signal & Image processing: *Signal Processing:* Creating and analysing signals, performing spectral analysis, Designing and analyzing filters, designing multirate filters, Designing adaptive filters. *Image Processing:* Importing and exporting, enhancing images, detecting edges & shapes, segmenting objects, Detecting, extracting, and matching image features

Control system design: Control System Design Overview, Model Representations, System Identification, Parameter Estimation, System Analysis, Linearization, PID Control in Simulink, Classical Control Design, Response Optimization, Controller Implementation.

Physical Modelling: Introduction to Simscape and the Physical Network Approach, Working with Simscape Components, Connecting Physical Domains, Combining Simscape Models and Simulink Models, Creating Custom Components with the Simscape Language

Application development: Using the App Designer Environment, Creating and Updating Plots, Creating Responsive Components, Managing Multiple Windows and Apps

Learning Resources:

Text Books:

1. MATLAB Primer, MathWorks, The MathWork, Inc., 2021.
2. Simulink User's Guide, MathWorks, The MathWork, Inc., 2021.

Reference Books:

1. Programming with MATLAB for Scientists, E. E. Mikhailov, CRC Press, First Edition, 2018.
2. MATLAB for Scientists and Engineers, Brian Hahn & Daniel Valentine, Elsevier Science, Seventh Edition, 2019.

Online Resources:

1. https://matlabacademy.mathworks.com/
2. https://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf

Course Code: PH5266	THIN FILMS AND VACUUM TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand generation and monitoring of high vacuum using pumps and gauges
CO2	Explain the influence of growth process on the properties of thin films
CO3	Identify vacuum related flaws in standard physical vapour deposition units
CO4	Select appropriate PVD/CVD technique for the deposition of thin films
CO5	Determine grain size, texture coefficient, sheet resistance, thickness and band-gap of thin films

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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.

Online Resources:

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

Course Code: PH5254	DIGITAL SYSTEM DESIGN LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Design and test advanced digital design circuits using PAL
CO2	Use different HDL simulation software's.
CO3	To write Verilog code for combinational circuits and sequential circuits
CO4	Design and verify the functionality of digital circuits using test benches.
CO5	Identify the suitable Abstraction level for a particular digital design.

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH5255	MICROPROCESSORS AND INTERFACING LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Obtains the knowledge of program writing for microprocessor using microprocessor kit and simulation software
CO2	Develops ALP for various applications using 8086 microprocessors.
CO3	Understands the interfacing concepts of different devices with 8086 microprocessors.
CO4	Obtains the knowledge of simulations for different applications.
CO5	Develops testing and experimental procedure on microprocessor and analyse their operation in different applications.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Experiments:

The following experiments will be done using the 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.

Online Resources:

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

Course Code: PH5256	COMMUNICATION LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand, design, analyse amplitude modulation and demodulation using different methods
CO2	Understand, design, and analyse and demodulation of DSB-SC
CO3	Study, design and analyse frequency modulation and demodulation using different techniques
CO4	Understand, design and analyse PAM, PPM, PWM, significance of pre and deemphasis circuits
CO5	Understand, design and analyse sampling theorem, digital modulation methods.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

LIST OF EXPERIMENTS

1. Study of Amplitude modulation and demodulation
2. Amplitude demodulation using envelope detector
3. Amplitude demodulation using synchronous detection
4. DSB-SC using a balance modulator/demodulator
5. Frequency modulation using IC 8038
6. Study of frequency demodulation
7. Study of Pulse Amplitude Modulation
8. Study of Pulse Position Modulation
9. Study of Pulse Width Modulation
10. Study of Pre-Emphasis and De-Emphasis
11. Experiment to verify the Sampling Theorem
12. Digital Modulation & Demodulation – ASK, PSK, BPSK. QPSK, FSK

Learning Resources:

Text Books:

1. Electronic Communication Systems, by George Kennedy, Bernard Davis, SRM Prasanna, TMH, Sixth Edition, 2017.

2. Electronic Communication Systems-Fundamentals through Advanced, Wayne Tomasi, Pearson Education, Sixth Edition, 2013.

Reference Books:

1. Modern Digital and Analog Communication Systems, B.P.Lathi, Zhi ding Oxford Univ Press, Fourth Edition, 2011.
2. Communication Systems, by Symon Haykin, Michael Mohar; Wiley publications, Fifth Edition, 2013.

Online Resources:

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

IV Semester Photonics

Course Code: PH5351	OPTICAL SYSTEM DESIGN	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103)

Course Outcomes:

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

CO1	Analyse the optical systems with ray tracing
CO2	Analyse Optical systems for and make corrections
CO3	Judge the quality of optical systems by determining OPD, MTF and OTF.
CO4	Understand Catadioptric systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

First Order Optics: Ray Tracing of Paraxial Ray, Graphical Ray Tracing, Trigonometrical Ray Tracing at a Spherical Surface, Magnification and the Lagrange Theorem, The Gaussian Optics of a Lens System, First-Order Layout of an Optical System

Aberrations: Symmetrical Optical Systems, Aberration Determination Using Ray Trace Data, Spherical Aberration, Surface Contribution Formulas, Zonal Spherical Aberration, Primary Spherical Aberration, Design of a Spherically Corrected Achromat, Coma and the Sine Condition, The Optical Sine Theorem, The Abbe Sine Condition, Astigmatism and the Coddington Equations, The Petzval Theorem, Curvature and Distortion, Chromatic Aberration, Chorochromatic of a Cemented Doublet, Contribution of a Single Surface to the Primary

Stops, Apertures, Pupils and Diffraction: The Aperture Stop and Pupils, The Field Stop, Vignetting, Glare Stops, Cold Stops, and Baffles, The Telecentric Stop, Apertures and Image Illumination—f-Number and Cosine-Fourth, Depth of Focus, Diffraction Effects of Apertures, Resolution of Optical Systems

Wave-Front Aberrations and MTF: Optical Path Difference: Focus Shift, Optical Path Difference: Spherical Aberration, Aberration Tolerances, Image Energy Distribution (Geometric), Spread Functions—Point and Line, Geometric Spot Size Due to Spherical Aberration, The Modulation Transfer Function, Square-Wave vs. Sine-Wave Targets, Special Modulation Transfer Functions: Diffraction-Limited Systems, Radial Energy Distribution, Point Spread Functions for the Primary Aberrations

Mirror and Catadioptric Systems: Comparison of Mirrors and Lenses, Ray Tracing a Mirror System, Single-Mirror Systems, Single-Mirror Catadioptric Systems, Two-Mirror Systems, Multiple-Mirror Zoom Systems

Learning Resources:

Text Books:

1. Lens Design Fundamentals, Rudolf Kinslake, R. Barry Johnson, SPIE Press, 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.

Online Resources:

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

Course Code: PH5352	OPTICAL INSTRUMENTS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), OE (PH5103)

Course Outcomes:

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

CO1	Understand Autocollimators, Refractometers, Ellipsometers and radiometry in optical systems
CO2	characterize optical materials using Interferometric techniques
CO3	Identify suitable optical instrument for ophthalmic applications
CO4	Assess surface profile of optical elements using optical metrology
CO5	Comprehend Infrared Instrumentation for applications in space

Course Articulation Matrix:

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

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.

Online sources:

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

Course Code: PH5353	FOURIER OPTICS & HOLOGRAPHY	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103)

Course Outcomes:

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

CO1	Gain in-depth knowledge of scalar diffraction theory
CO2	Calculate field at any point in space-time, given the initial field
CO3	Apply Fourier transforms for modelling physical optical systems
CO4	Model diffraction limited optical systems
CO5	Develop and analyse optical imaging systems
C06	Generate a hologram using MATLAB

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	1	2
CO2	3	3	3	2	3	3
CO3	3	3	3	1	1	2
CO4	3	3	3	2	2	3
CO5	3	3	3	2	3	2
CO6	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.

Online Resources:

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/

Course Code: PH5361	NONLINEAR OPTICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), EMT (PH4151)

Course Outcomes:

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

CO1	Understand nonlinear optical phenomena and correlate it with physical systems
CO2	Analyse nonlinear optical devices.
CO3	Generate second and third harmonics using nonlinear crystals
CO4	Understand quantum nonlinear effects and their applications

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH5362	POLARIZATION OPTICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), EMT (PH4151)

Course Outcomes:

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

CO1	Describe all possible polarization states mathematically.
CO2	Develop mathematical model for interaction of matter with polarized light.
CO3	Apply polarization concept to real world problems
CO4	Relate polarization with the concept of coherence.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	1	1
CO2	3	3	3	2	2	1
CO3	3	3	3	1	1	1
CO4	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: 2×2 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.

Online Resources:

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

Course Code: PH5263	LASERS AND APPLICATIONS	Credits 3-0-0: 3

Pre-Requisites: EMT (PH4151), OE (PH5103)

Course Outcomes:

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

CO1	Understand the theory and working of CO_2, Rare earth doped-YAG, Excimer and Ruby lasers and their applications in material processing
CO2	Understand LIDAR and its applications in atmospheric studies
CO3	Understand inertial navigation using ring laser gyro.
CO4	Understand laser guided weapons and electro-optic surveillance systems

Course Articulation Matrix:

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

Online resources:

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

Course Code: PH5363	MATLAB FOR PHOTONICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), EMT (PH4151)

Course Outcomes:

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

CO1	Use MATLAB for analyse of scientific/engineering problems
CO2	Develop in-depth knowledge and concepts through MATLAB simulations of optical systems
CO3	Develop numerical models to solve problems in Optics and Photonics
CO4	Design optical systems using MATLAB

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

MATLAB Overview: MATLAB Primer: Matrices & Arrays, Indexing, Data Visualization, Programming & Scripts. Image Processing: Basic Image Import, Processing, and Export. Getting Started with Simulink: Modelling in Simulink, Simple Model, Navigating a Simulink Model.

Geometrical Optics: Ray Transfer Matrix, Ray Tracing through Multiple Elements, Lens maker's Equation, Glass Equations.

Physical Optics: Interference & Diffraction: Young double slit, Fraunhofer & Fresnel diffraction from various apertures. Fourier image analysis. Imaging systems: Impulse response, Transfer function, Geometrical imaging, Diffraction limited Coherent & Incoherent imaging. Holography.

Beam Optics: Gaussian beam, Hermite-Gaussian beam, Laguerre-Gaussian beam, Bessel beam. Beam propagation simulation.

Polarization Optics: Modelling and Analysing Polarization, Double Refraction, Jones Calculus, Mueller Calculus, Jones-to-Mueller Transformation.

Learning Sources:

Text Books:

1. Optics Using MATLAB, S. W. Teare, SPIE Press, first edition, 2017.
2. Engineering Optics with MATLAB, T. C. Poon & T. Kim, World Scientific Publishing, first edition, 2006.

Reference books:

1. Computational Fourier Optics, D. Voelz, SPIE Press, first edition, 2011.
2. Fundamentals of Photonics, B. E. A. Saleh & M. C. Teich, Wiley, Third edition, 2019.

Online Resources:

1. https://in.mathworks.com/academia/courseware/teaching-physics-with-matlab.html
2. https://in.mathworks.com/help/phased/ug/modeling-and-analyzing-polarization.html

Course Code: PH5364	ADAPTIVE OPTICS	Credits 3-0-0: 3

Pre-Requisites: OP (P4103), EMT (PH4151)

Course Outcomes:

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

CO1	Understand the fundamentals of adaptive optics
CO2	Estimate atmospheric turbulence by analysing telescope images
CO3	Correct wavefronts using adaptive optics
CO4	Understand control systems for ground based and space-based systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Adaptive Optics: Atmospheric turbulence, source of turbulence: free atmosphere, mirror seeing, dome seeing, boundary layer, Reynolds number.

Optical effects of turbulence: derivation of: structure functions, covariance function, spatial coherence function, optical transfer function, effect of turbulence on spatial coherence function, effect of spatial coherence function on telescope resolution, derivation of fried parameter, isopalmitic angle, isokinetic angle, greenwood frequency, angle of arrival fluctuations and tip-tilt.

Adaptive Optical systems: phase conjugation, conventional and unconventional adaptive optics, wavefront sampling, Wave front Sensing: Active and Adaptive Optics- Interferometric techniques for wave front sensing, Hartmann, wavefront sensors. Indirect wave front sensing methods

Wave front correction: Test correction, multi-channel correction, segmented mirrors (MMDM) (SDM). Deformation mirrors, Bi-morphic corrections, membrane mirrors, Actuator deformable mirrors, Control systems – Principles of feedback control, Implementation aspects - ground based system and space-based system

Learning Sources:

Text Books:

1. Introduction to Adaptive Optics, Robert K Tyson, technical tutorial 41, SPIE press, 2000.
2. Adaptive optics for Astronomical telescope, John W. Hardy, Oxford University press, 1998.

Reference books:

1. Adaptive Optics in astronomy, Francois Ruddier, Cambridge University Press, 1999.
2. Selected papers of adaptive optics for atmospheric compensation, ames E, Pearson– SPIE proceedings-92 1994.
3. Principles of Adaptive Optics (Series in Optics and Optoelectronics), CRC Press, 3rd edition, 2010.

Online Resources:

1. https://www.coursera.org/lecture/astro/4-adaptive-optics-ZAsNZ
2. https://iopscience.iop.org/article/10.1086/684512 (Astronomical Adaptive Optics-review)

Course Code: PH5266	THIN FILMS AND VACCUM TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand generation and monitoring of high vacuum using pumps and gauges
CO2	Explain the influence of growth process on the properties of thin films
CO3	Identify vacuum related flaws in standard physical vapour deposition units
CO4	Select appropriate PVD/CVD technique for the deposition of thin films
CO5	Determine grain size, texture coefficient, sheet resistance, thickness and band-gap of thin films

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH5354	OPTICAL SYSTEM DESIGN LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Design the layout of basic lenses and mirrors
CO2	Trace the light rays through the optical elements and calculate the aberrations
CO3	Assemble the lenses and mirrors to form the optical systems
CO4	Calculate the aberrations present in the optical system and can correct it.

Course Articulation Matrix:

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

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.

Online Resources:

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)

Course Code: PH5355	OPTICAL INSTRUMENT LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Learn to measure refractive index, concentration of liquids by abbe refractometer
CO2	Learn to measure thickness, refractive index of thin films by using ellipsometry.
CO3	Learn to handle various interferometers to measure optical properties of materials
CO4	Adopt various interferometric techniques for optical shop testing.
CO5	Develop optics-based techniques for the metrology applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

List of 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.

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.

Online Resources:

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

Course Code: PH5356	OPTOELECTRONICS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Set optical and mechanical housing for an experiment
CO2	They will be able to describe the light-current-voltage relationships of LEDs, laser diodes, and photodiodes and demonstrate how to measure associated parameters.
CO3	Set up and analyse different fiber optics experiments.
CO4	Design the basic optics experiments to verify various laws and principles
CO5	Develop optics-based techniques in real life applications purposes.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

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.

Online Resources:

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

IV Semester Instrumentation

Course Code: PH5451	CONTROL SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Analyse Physical systems using mathematical modelling
CO2	Determine Transient and Steady State behaviour of systems
CO3	Analyse linear systems for steady state errors, absolute stability and relative stability
CO4	Design stable control systems
CO5	Design PID controllers

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
O1	3	2	2	2	2	1
CO2	3	2	2	2	1	1
CO3	3	2	2	1	1	1
CO4	3	2	1	1	1	1
CO5	3	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 -Substantially

Syllabus:

Introduction: Concepts of Control Systems- Open Loop and closed loop control systems and their differences- Different examples of control systems- Classification of control systems, Feed-Back Characteristics, Effects of feedback. Mathematical modelling of Physical Systems – Differential equations, Impulse Response and transfer functions.

Transfer Function Representation: Block diagram representation of systems considering electrical systems as examples -Block diagram algebra – Representation by Signal flow graph - Reduction using mason's gain formula.

Time Response Analysis: Standard test signals - Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems - Time domain specifications – Steady state response - Steady state errors and error constants – Effects of proportional- derivative, and integral Controllers.

Stability Analysis in S-Domain: The concept of stability – Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability. The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.

Frequency Response Analysis: Introduction, Frequency domain specifications-Bode diagrams- Determination of Frequency domain specifications and Phase margin and Gain

margin- Stability Analysis from Bode Plots. Polar Plots, Nyquist Plots Stability Analysis. Compensation techniques – Lag, Lead, and Lead-Lag Controllers design in frequency Domain, PID Controllers.

Learning Resources:

Text Books:

1. Control Systems Theory and Applications, S. K. Bhattacharya, Pearson, 3rd edition, 2013.
2. Automatic Control Systems, B.C. Kuo, Prentice Hall of India, 7th edition, 2009.

Reference Books:

1. Control Systems Engineering, I.J. Nagarath and M. Gopal, New Age Pub. Co., 2nd edition, 2008.
2. Control Systems, A. Ananad Kumar, Prentice Hall of India, 1st edition, 2007.

Online Resources:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-04a-systems-and-controls-spring-2013/

Course Code: PH5452	TRANSDUCERS TECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand mechanical, electrical and advanced transducers
CO2	Identify transducers for measuring physical parameters for specific performance
CO3	Evaluate the performance of transducers
CO4	Interface sensors using LAabVIEW

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	3
CO2	3	1	1	1	1	3
CO3	2	3	3	3	2	3
CO4	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 for transducer 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 Private Limited, 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.

Online Resources:

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

Course Code: PH5453	MICROCONTROLLERS	Credits 3-0-0: 3

Pre-Requisite: None

Course Outcomes:

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

CO1	Understand the architecture of 8086 microprocessor.
CO2	Understand the architecture of 8051
CO3	Write assembly language programs for 8051
CO4	Interface peripheral devices with 8051 microcontrollers
CO5	Develop skills in C language for programming 8051 microcontroller

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

The Microprocessor and its Architecture: Introduction to Microprocessor - 8086 Microprocessor architecture –Real memory addressing-Data addressing modes – Programming memory –addressing modes –Stack memory addressing modes.

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, Keyboard- Interfacing display devices, LED, LCD, seven segment display-Interfacing ADC, DAC, Sensors, Interfacing relays, opto-couplers, stepper motor and DC motors.

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 Intel Microprocessors, Barry B. Brey, Pearson Education, Eighth Edition, 2013.
2. The 8051 Microcontroller Architecture, Programming And Applications By Kenneth J. Ayala, Thomas Delmar learning, Fifth Edition, 2008.

Reference Books:

1. Advanced Microprocessors and Peripherals, K. Bhurchandi and A.K. Ray, TMH publications, Third Edition, 2017.
2. The 8051 Microcontroller based Embedded Systems, Manish K Patel, TMH, Third Edition, 2014.

Online Resources:

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

Course Code: PH5461	DATA ACQUISITION SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: SDSD (PH5251)

Course Outcomes:

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

CO1	Understand the operating principles of analog to digital and digital to analog converters.
CO2	Design data acquisition systems
CO3	Prepare the error budget for ADCs and DACs
CO4	Identify appropriate data converters for optimal performance

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

INTRODUCTION: Data Acquisition Systems- Objective of a DAS, Components used in DAS–DAS Hardware, 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, Accuracy and Precision, Noise, Settling Time, Acquisition Time.

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): Flash ADC, Flash ADC with interpolation, Counter ADC, Servo tracking ADC, Integrating type ADCs– Charge balancing, dual slope integration, Multi-step ADC, Sub ranging ADC, Folding ADC, Pipelined ADC, Successive approximation (SAR) ADC, Time-interleaved ADC, Sigma-delta ADC, Higher order and cascaded sigma-delta modulators, Discrete-time and continuous-time sigma-delta Modulators, Parameter specifications.

ERROR BUDGET OF DACs and ADCs: Error sources, error reduction and noise reduction techniques in DACs. Error budget analysis of DAS, case study of a DAC and an ADC.

DESIGN OF DATA ACQUISITION SYSTEMS: Introduction to the Design, Functional Design of High-Speed Computer-Based DAS, Requirements, Analysis of Accuracy (Static), Analysis

of Accuracy (Dynamic), Portable DAS, Design Guidelines for High-Performance, Multichannel DAS.

Learning Resources:

Text Books:

1. Data Acquisition Systems- From Fundamentals to Applied Design, Paolo Emilio and Maurizio. Springer, 2013.
2. D ata Converters, Franco Maloberti, Springer, 2007.

Reference Books:

1. Practical Data Acquisition for Instrumentation and Control Systems, John Park and Steve Mackay, Elsevier, 2003.
2. Data Acquisition and Conversion Handbook- A Technical Guide to A/D and D/A Converters and Their Applications, Datel-Intersil publishers, 2009.
3. Data Converters, GB Clayton. John Wiley, 3rd edition,1986.

Online Resources:

1. Data Conversion Handbook by Analog Devices Inc. Engineering https://www.pdfdrive.com/data-conversion-handbook-e158476438.html.
2. Data Acquisition Handbook https://www.mccdaq.com/pdfs/anpdf/Data-Acquisition-Handbook.pdf.

Course Code: PH5462	SIGNAL CONDITIONING CIRCUITS	Credits 3-0-0: 3

Pre-Requisites: EDC (PH4154)

Course Outcomes:

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

CO1	Understand the principles of signal conditioning circuits.
CO2	Design analog and digital signal conditioners.
CO3	Develop signal conditioning circuits for pressure and optical transducers.
CO4	Design fixed and variable voltage power supplies using voltage regulator ICs

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Instrumentation and measurement system, Sensors, Primary sensing principles, Sensor performance characteristics, Sensor interfacing and signal conditioning circuit, integrated sensor system.

Signal Conditioning Circuits: Signal conditioning circuits for resistive, capacitive, and inductive sensors, electromagnetic and self-generating sensors, Error and Non-linearity reduction, Differential measurements.

Signal Amplifiers: Non-idealities of Op-Amp, Effect of Non-idealities, Differential Amplifier, Trans-impedance Amplifier, Cascaded Amplifiers, CMRR, Performance Analysis of Amplifiers, Instrumentation amplifier, Charge amplifier, Programmable gain amplifier, Switched capacitor amplifier.

Interference and Noise: Interference types and reduction, Signal circuit grounding, Shield grounding, Isolation amplifier. Types of Noise and Noise Sources, Offset and Noise reduction techniques: Auto-zeroing (AZ), Chopper-stabilization (CHS), Correlated double sampling (CDS), Sigma-Delta modulation.

Learning Resources:

Text Books:

1. Sensors and Signal Conditioning, Ramon Pallas-Areny and John G. Webster, Wiley India Pvt Ltd, 2nd edition, 2012.
2. Analog Signal Processing, Ramon Pallas-Areny and John G. Webster, Wiley India Pvt Ltd, 2nd edition, 2012.

Reference Books:

1. Measurement systems- Application and Design, OEBELIN, E.O., McGraw Hill, 4th edition, 1990.
2. Handbook of Operational Amplifier Circuit Design, DAVID STOUT and MILTON KAUFMAN, McGrawHill, 1st edition, 1982.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105064/
2. https://education.ni.com/teach/resources/953/signal-conditioning.

Course Code: PH5263	LASERS AND APPLICATIONS	Credits 3-0-0: 3

Pre-Requisites: EMT (PH4151), OE (PH5103)

Course Outcomes:

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

CO1	Understands the fundamental of lasers
CO2	Understands applications of lasers in atmospheric studies
CO3	Understands the applications of lasers in material processing
CO4	Understands the space applications of lasers
CO5	Understands defence applications of lasers

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Quantum Theory of Laser: Radiative and Non-radiative decay of excited state atoms – Emission Broadening and linewidth – Radiation and Thermal equilibrium – Conditions for laser action – Laser Oscillation above threshold - Laser Amplifiers – Requirements for obtaining population inversion – Rate Equations for three and four level systems – Laser pumping requirements – Laser Cavity modes – Stable resonators – Gaussian beams- Special Laser Cavities – Q-switching and Mode locking – Generation of ultrafast Optical pulses- Pulse compression.

Lasers in Atmospheric Studies- Laser for detection and ranging- LIDAR: applications- Doppler wind LIDAR, Differential Absorption LIDAR for water vapour monitoring.

Laser application in material processing: – CO_2, YAG, Excimer, Ruby lasers-[material processing, Cutting, Welding, drilling, micro machining] – Interaction of laser radiation with matter, Heat Flow Theory, Process characteristics etc.

Lasers for space applications: – free space communication, laser propulsion, laser ignition, Optical Rotation sensors and their applications for space navigation: Sagnac Interferometers and their applications for space, Ring Laser gyros- Laser Resonator Design, Laser Frequency stabilization techniques, Ring resonator – stable and unstable and their application in Ring Laser Gyros.

Laser Target Designators and Laser-Guided Weapons: Laser Guidance, Laser target designators, laser guided missiles, laser guided bomb. Laser beam riding of missiles. Laser & electro-optic surveillance systems, IR guidance.

Learning Resources:

Text Books:

1. Laser Principles, Types & Applications, K R Nambiar, New Age International, 2006.
2. Lasers Theory and Applications, A K Ghatak and K Thyagarajan, McMillan, 2003.

Reference Books:

1. Quantum Electronics, Amnon Yariv, John Wiley, 1989.
2. Lasers, Siegman, Anthony E, California/University of Science Books, 1986.
3. Physics of gas lasers, Bennett, W R/Montroll, Elliot W, New York/Gordon and Breach,1977.

Online resources:

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

Course Code: PH5265	MATLAB	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Use MATLAB for analyse of scientific/engineering problems
CO2	Develop in-depth knowledge and concepts through MATLAB simulations
CO3	Develop numerical models to solve problems in Instrumentation
CO4	Use MATLAB for instrumentation control

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

MATLAB & Simulink Overview: MATLAB Primer Matrices & Arrays, Indexing, Data Visualization, Programming & Scripts. Simulink: Modelling in Simulink, Simple Model, Navigating a Simulink Model.

Signal & Image processing: Signal Processing: Creating and analysing signals, Performing spectral analysis, Designing and analyzing filters, Designing multirate filters, Designing adaptive filters. Image Processing: Importing and exporting, Enhancing images, Detecting edges & shapes, Segmenting objects, Detecting, extracting, and matching image features, Control system design, Control System Design Overview, Model Representations, System Identification, Parameter Estimation, System Analysis, Linearization, PID Control in Simulink, Classical Control Design, Response Optimization, Controller Implementation.

Physical Modelling: Introduction to Simscape and the Physical Network Approach, Working with Simscape Components, Connecting Physical Domains, Combining Simscape Models and Simulink Models, Creating Custom Components with the Simscape Language
Application development Using the App Designer Environment, Creating and Updating Plots, Creating Responsive Components, Managing Multiple Windows and Apps.

Learning Resources:

Text Books:

1. MATLAB Primer, MathWorks, The MathWork, Inc., 2021.
2. Simulink User's Guide, MathWorks, The MathWork, Inc., 2021.

Reference Books:

1. Introduction to Numerical and Analytical Methods with MATLAB for Engineers and Scientists, William Bober, CRC Press, 2nd edition, 2013.
2. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Rudra Pratap, Oxford,1st edition, 2010.

Online Resources:

1. https://matlabacademy.mathworks.com/
2. https://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf.

Course Code: PH5463	NON-DESTRUCTIVE TESTING	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Obtain in-depth knowledge of conventional and advanced techniques of non-destructive testing.
CO2	Investigate complex engineering components and structures using NDT.
CO3	Communicate effectively the non-destructive testing procedures and results
CO4	Understand the application of magnetic particle test, ultrasonic test, X-ray and Gamma ray radiography, leak test, eddy current test.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Defectology, types of discontinuities, outline of strength, hardness, fatigue, creep, damping capacity, texture, and corrosion resistance, welding defects, casting defects.

Magnetic Particle testing: Introduction of magnetism and ferromagnetic materials, circular and longitudinal magnetization techniques, materials, equipment**,** calibration, capabilities of equipment**,** magnetic particle inspection of castings and welding, dry continuous method, wet residual method, interpretation and evaluation of test indications**,** principles and methods of demagnetization**,** residual magnetism, applicable codes and standards.

Eddy Current Testing: Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Ultrasonic Testing Basics of Ultrasonic Waves: modes of sound wave generation, Acoustic impedance, attenuation of ultrasonic waves, generation of ultrasonic wave-Couplants, ultrasonic transducers, transducer operation and equipment, measurements, sensitivity, and calibration. Pulse echo system- principle and methods, pulse echo instrumentation, Transmission and Resonance techniques.

Radiographic NDT methods: Principles of radiography: X-rays and Gamma rays, properties of X-rays relevant to NDE - Absorption of rays - scattering. Types and use of Filters: screens, Geometric factors, Film type and Processing. Characteristics of films graininess, Density,

Speed, Contrast. Characteristic curves. Characteristics of Gamma rays: fluoroscopy, X-ray Radiography. Safety with X-rays and Gamma rays.

Learning Resources:

Text Books:

1. Cartz L. - 'Non-Destructive testing' - ASM International, Metals Park Ohio, US - 1995
2. Baldev Raj, T.Jayakumar, M.Thavasimuthu, Practical Non-Destructive Testing, Narosa Publishing House, 2014.

Reference Books:

1. ASM Metals Hand Book, 'Non-Destructive Evaluation and Quality Control' - American Society of Metals, Metals Park Ohio, USA - 1989
2. Charles, J. Hellier, Handbook of Nondestructive Evaluation, McGraw Hill, New York 2001.
3. Paul E Mix, Introduction to Non-destructive testing: a training guide, Wiley, 2nd Edition New Jersey, 2005

Online Resources:

1. https://www.nde-ed.org/
2. https://www.macndt.com/?gclid=CjwKCAjwt8uGBhBAEiwAayu_9Qbf34oEsBt930_P4BjJtUzM6H-drBLIapWUvXPjX-NneVOcWPvznhoCb44QAvD_B\.

Course Code: PH5266	THIN FILMS AND VACUUM TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand generation and monitoring of high vacuum using pumps and gauges
CO2	Explain the influence of growth process on the properties of thin films
CO3	Identify vacuum related flaws in standard physical vapour deposition units
CO4	Select appropriate PVD/CVD technique for the deposition of thin films
CO5	Determine grain size, texture coefficient, sheet resistance, thickness and band-gap of thin films

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH5454	MICROCONTROLLERS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Obtains the skills of ALP, C programming writing for 8051 microcontrollers.
CO2	Obtains programming skills to solve scientific problems using 8051 programming.
CO3	Understands the interfacing concepts of different devices with 8051 microcontrollers.
CO4	Obtains the knowledge of simulations for different applications.
CO5	Develops testing and experimental procedures on microcontrollers and analyses their operation in real time applications.

Course Articulation Matrix:

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

Learning Resources:

Text Books:

1. 8051 Microcontroller an application-based Introduction, David Calcutt, Frederick Cowan, Elsevier Imprint, 1st edition, 2004.
2. The 8051 Microcontroller and Embedded System, Muhammad Ali Mazidi, Pearson Education, 3rd edition, 2014.

Reference books:

1. 8051 microcontroller interrupts, instructions, programming and interfacing, Subrata Ghoshal, 2nd edition, 2014.
2. The 8051 Microcontroller based Embedded Systems, Manish K Patel, TMH, 3rd edition, 2014.

Online Resources:

1. www2.keil.com
2. https://www.iitk.ac.in/new/microprocessor-and-microcontroller-laboratory.

Course Code: PH5455	TRANSDUCERS TECHNOLOGY LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Obtain the skill in designing different measurement devices
CO2	Obtain knowledge on the principle of different transducers.
CO3	Design advanced measurement circuits using simulation
CO4	Obtain the knowledge of simulations for different applications.
CO5	Develops testing equipment for operation in real time applications.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

1. Temperature measurement using Thermistor Characteristics Trainer
2. Study and calibration of LVDT transducer for displacement measurement.
3. Study of resistance temperature detectors for temperature measurement.
4. Calibration of thermocouple for temperature measurement
5. Measurement of strain using strain gauge
6. Measurement of liquid level using capacitive transducer.
7. Study of distance measurement using ultrasonic transducer
8. Speed measurement using magnetic pickup and photoelectric pickup.
9. Characteristics of Hall-effect Transducer.
10. Characteristics of Load cell
11. Study of distance measurement using inductive proximity transducer

Learning Resources:

Text Books:

1. Analytical Instrumentation Hardcover, Bela G. Liptak, CRC Press, 1st edition, 1994.

2. Instrumentation and Process Control, Prasad, M.N. Jayaswal, Dreamtech Press, 1st edition, 2019.

Reference Books:

1. Transducers and Their Elements: Design and Application, Alexander D. Khazan, Prentice Hall, Illustrated edition, 1993.
2. Micro and Nano-Scale Sensors and Transducers, Ezzat G. Bakhoum, CRC Press, 1st edition, 2015.

Online Resources:

1. https://slcoep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineering
2. https://online.stanford.edu/courses/me220-introduction-sensors.

Course Code: PH5456	CONTROL SYSTEMS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Analyse Mechanical and Electrical systems using mathematical modelling
CO2	Determine Transient and Steady State response of systems using standard test signals
CO3	Analyse Step Response of systems for addition of Pole/Zero at the Origin
CO4	Plot the Root Locus and analyse the system by adding Pole/Zero
CO5	Apply Frequency Domain methods for the design of compensators

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

List of Experiments:

1) Obtain Phase Plane Plot of Mechanical and Electrical Systems
2)Plot the Dynamic Response of Electrical and Mechanical Systems for Step Input
3) Find the Time Response of First and Second Order Systems
4) Study the effects of adding a pole and adding a Zero at the origin in the Step and Impulse Response of a feedback system.
5) Find the effects of Derivative and Integral Controllers in feedback Control Systems
6) Plot the Root Locus of Unity feedback control System for a given open loop transfer function.
7) Study the effect of adding a pole and adding a zero at specific locations in S-Plane on the Root Locus Plot.
8) Obtain a Polar Plot and hence find the Phase margin and Gain margin.
9) Obtain Bode Plot and hence find the Phase margin and Gain margin.
10) Obtain Nichols Plot and hence find the Phase margin and Gain margin.
11) Design Lead, Lag and Lead-Lag Compensators to meet given specifications.

Learning Resources:

Text Books:

1. Control Systems Theory and Applications, S. K. Bhattacharya, Pearson. 3rd edition, 2013.
2. Automatic Control Systems, B.C. Kuo, Prentice Hall of India, 7th edition, 2009.

Reference Books:

1. Control Systems Engineering, I.J. Nagarath and M. Gopal, New Age Pub. Co., 2nd edition 2008.
2. Control Systems, A. Anand Kumar, PHI publishers, 2nd edition, 2019.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ee90/preview
2. https://nptel.ac.in/courses/107/106/107106081/

V Semester Electronics

Course Code: PH6201	DIGITAL SIGNAL PROCESSING	Credit 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Find DFT of a given signal through Fast Fourier Transform Techniques
CO2	Designs FIR and IIR type digital filters using transformation techniques
CO3	Identifies various structures and their realisations for Digital Filters
CO4	Understand the concepts of Finite Word Length Effects and Errors in Digital Filters
CO5	Apply Z-Transform for the analysis of Discrete-Time signals and Systems

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH6202	MICROCONTROLLERS AND EMBEDDED SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: MPI (PH5252)

Course Outcomes:

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

CO1	Understands the architecture of 8051 microcontroller and finds the difference.
CO2	Imparts the knowledge of instruction set of 8051
CO3	Develops the skill in simple program writing for 8051
CO4	Gets the knowledge of interfacing different real time devices.
CO5	Imparts the knowledge of advanced microcontrollers for real time applications

Course Articulation Matrix:

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

Online resources:

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

Course Code: PH6211	ADVANCED COMMUNICATION SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: EDC (PH4154), CS (PH5253)

Course Outcomes:

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

CO1	Understand the concepts of measure of information, Shannon's theorem and entropy
CO2	Understand PCM and its variants, Eye Patterns
CO3	Analyze Line and Error control coding
CO4	Understand and apply the digital modulation and demodulation techniques
CO5	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:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit-1: 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

Unit-2: 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

Unit-3: 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

Unit-4: 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.

Unit-5: 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

Course Code: PH6212	DESIGNING WITH FPGA AND CPLDS	Credits 3-0-0: 3

Pre-Requisites: SDSD (PH5251)

Course Outcomes:

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

CO1	Identifies different types of programmable logic devices
CO2	Compares the Performance of Different Types of FPGA and their Programming Technologies
CO3	Compares the Performance of Different Types of CPLD and their Programming Technologies
CO4	Able to apply knowledge gained in software-hardware integration
CO5	Able to design, test and implement FPGA/CPLD based projects

Course Articulation Matrix:

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

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

Web Sources:

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

Course Code: PH6213	SOLAR ENERGY SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes**:**

After studying this course, the student will be able to:

CO1	Outline the technologies that are used to harness the power of solar energy.
CO2	Understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO3	Comprehend the challenges in sustainable energy processes, perform cost analysis, design photovoltaic systems for different applications meeting residential and industrial needs, predict and test performance.
CO4	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials.
CO5	Illustrate the concepts of direct energy conversion systems & their applications.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Solar Energy: Fundamentals of Solar Energy**-**Spectral Irradiance, Terrestrial Solar Radiation, Atmospheric effects, Air Mass, The Sun's Position, Solar Radiation on a Tilted Surface, Solar Insolation, Measurement and Analysis of Solar Irradiance.

Solar Photovoltaics: Solar Cell and its operation, Solar technologies, Silicon solar structure and parameters, efficiency of solar and spectral response; Solar cell design principles-light trapping, optical losses, anti-reflection coatings, Top contact design, Metal Grid Pattern. Environmental and safety issues, Cell passivation.

Solar PV Modules and PV Systems: PV Module Circuit Design-Module Structure, Packing Density, Interconnections, Mismatch and temperature effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module; Solar PV systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

Storage in PV Systems: Battery Operation**,** Types of Batteries, Battery parameters, Application and selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV system.

Solar Thermal Systems: Design of Solar Thermal Systems-Solar concentrators, Storage of solar generated heat; Hybrid systems-combinations of solar thermal and solar cell systems.

Learning Resources:

Text Books:

1. Solar Cells: Operating Principles, Technology and system Applications, Martin A. Green, Published by the University of New South Wales, 1st edition,1998.
2. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 1st edition, 2000.

Reference Books:

1. Photovoltaic Engineering Handbook, F. Lasnier and T. G. Ang, IOP Publishing UK, 1st edition, 1990.
2. Semiconductor Devices, Physics, and Technology, S. M., Sze, New York, NY: Wiley, Second Edition, 2001.

Online Resources:

1. https://energyeducation.ca/encyclopedia/Photovoltaic_system
2. https://www.open.edu/openlearn/nature-environment/environmental-studies/energy-resources-solar-energy/content-section-1

Course Code: PH6214	COMPUTER ORGANIZATION AND OPERATING SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the functional units and their interconnection
CO2	Identify the hardware and software techniques for improving the performance of the computer.
CO3	Estimate the average waiting time in CPU scheduling for improving the efficiency.
CO4	Examine the multithreading issues.
CO5	Predict the process scheduling issues and give the remedies.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Computer hardware and software: Fundamental units, bus structures, addressing methods, main memory operations, instructions, addressing modes, assembly language, basic input and output operations, stack and queues, subroutines.

Micro programmed control Input-Output organization: Accessing I/O devices, interrupts, DMA, I/C hardware, standard I/O interfaces.

Pipelining: Basic concepts, instruction queue, branching, data dependency, influence 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.

Online Resources:

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

Course Code: PH6215	VLSI DESIGN	Credits 3-0-0: 3

Pre-Requisites: TFVT (PH5263)

Course Outcomes:

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

CO1	Realize the concepts of digital building blocks using MOS transistor.
CO2	Design combinational MOS circuits and power strategies.
CO3	Design and construct Sequential Circuits and Timing systems.
CO4	Design arithmetic building blocks and memory subsystems.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

INTRODUCTION TO MOS TRANSISTOR: MOS Transistor, CMOS logic, Inverter, Pass Transistor, Transmission gate, Layout Design Rules, Gate Layouts, Stick Diagrams, Long-Channel I-V Charters tics, C-V Charters tics, non ideal I-V Effects, DC Transfer characteristics, RC Delay Model, Elmore Delay, Linear Delay Model, Logical effort, Parasitic Delay, Delay in Logic Gate, Scaling.

COMBINATIONAL MOS LOGIC CIRCUITS: Circuit Families: Static CMOS, Ratioed Circuits, Cascade Voltage Switch Logic, Dynamic Circuits, Pass Transistor Logic, Transmission Gates, Domino, Dual Rail Domino, CPL, DCVSPG, DPL, Circuit Pitfalls.
Power: Dynamic Power, Static Power, Low Power Architecture.

SEQUENTIAL CIRCUIT DESIGN: Static latches and Registers, Dynamic latches and Registers, Pulse Registers, Sense Amplifier Based Register, Pipelining, Schmitt Trigger, Monostable Sequential Circuits, Astable Sequential Circuits. Timing Issues: Timing Classification of Digital System, Synchronous Design.

DESIGN OF ARITHMETIC BUILDING BLOCKS AND SUBSYSTEM: Arithmetic Building Blocks: Data Paths, Adders, Multipliers, Shifters, ALUs, power and speed trade-offs, Case Study: Design as a trade-off.

Designing Memory and Array structures: Memory Architectures and Building Blocks, Memory Core, Memory Peripheral Circuitry.

Learning Resources:

Text Books:

1. CMOS VLSI Design: A Circuits and Systems Perspective, Neil H.E. Weste, David 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.

Online Resources:

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

Course Code: PH6216	SATELLITE COMMUNICATION	Credits 3-0-0: 3

Pre-Requisite: CS (PH5253)

Course Outcomes:

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

CO1	Understands working principle and operation of various sub systems of a satellite
CO2	Applies various communication techniques for various satellite applications
CO3	Analyses and designs satellite communication link.
CO4	Learn advanced techniques and regulatory aspects of satellite communications.
CO5	Understand the role of satellite in various applications.

Course Articulation Matrix:

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

Online resources:

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

Course Code: PH6217	SMART MATERIALS AND DEVICES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the significance and pre-requisites of smart materials.
CO2	Understand the necessity for new and novel materials in our day-to-day scenario.
CO3	Understand the need for the development of self-healing technologies and biomaterials for healthcare.
CO4	Understand about the smart gels and textiles for many exotic applications.
CO5	Understand the urge for self-expanding implants and basics of personalized smart devices

Course Articulation Matrix**:**

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Pre-requisites of Smart Materials: Smart materials, properties and requirement for smart system, Classification of smart materials, Production of smart materials, Merits and demerits of smart materials, Applications of smart materials.

New Materials – Why do we need them? Need for new materials, Piezoelectric materials, Electro strictive materials, Magneto strictive materials, Rheological materials, Thermo responsive materials, Electrochromic materials, Fullerenes, Biomimetic materials, Quantum tunnelling composite etc., Requirements in Industry, Engineering, Medicine, Sports, Cosmetics, Food, Agriculture, Textiles, Energy conservation and Construction.

Smart Materials for Self-Healing Technologies: Introduction, Self-healing process, Materials for self-healing, Biomaterials, Need for biomaterials, Examples of uses of biomaterials, Material attributes for biomedical applications, Biocompatibility, Biomaterials science, Classes of Biomaterials.

Smart Gels and Textiles for Exotic Applications: Smart gels, Aerogels, Super hydrophobicity, Measurement of hydrophobicity, Self-cleaning technologies, Smart textiles, Applications in sports, Healthcare, Firefighting, Military/Security, etc.

Smart Self-Expanding Implants and Devices: Shape Memory Alloys (SMA), One-way and two-way memory effect, Pseudo elasticity, Preparation and properties of SMA, Practical

limitations, Magnetic putty, Applications of SMA, Components of a smart device, Characteristics, Examples of smart devices, Personalization of smart devices.

Learning Resources:

Text Books:

1. Materials that Move: Smart Materials, Intelligent Design, Bengisu, Murat; Ferrara, Marinella, Springer International Publishing, 1st edition, 2018.
2. Encyclopedia of Smart Materials, Schwartz, Mel, Ed., John Wiley and Sons, 1st edition, 2002.

Reference Books:

1. Intelligent Materials, Shahinpoor, Mohsen; Schneider, Hans-Jorg, Eds., RSC Publishing, , 1st edition, 2007.
2. Smart Structures: Physical Behaviour, Mathematical Modelling and Applications, Gaudenzi, Paolo, John Wiley & Sons, 1st edition, 2009
3. A Review of Shape Memory Alloy Research, Applications and Opportunities, Mohd Jani, Jaronie; Leary, Martin; Subic, Aleksandar; Gibson, Mark A, Materials & Design. 56: 10781113 (2014)

Online Resources:

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

Course Code: PH6218	DATA COMMUNICATIONS	Credits 3-0-0: 3

Pre-Requisites: CS (PH5253)

Course Outcomes:

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

CO1	Understands the underlying structure of networks and how they operate in relation to OSI model
CO2	Describe layered communication, the process of encapsulation, and message routing in network equipped devices using appropriate protocols
CO3	Compares different types of data communication networks
CO4	Analyses the different issues related to internetworking
CO5	Understands the different concepts involved in satellite communications

Course Articulation Matrix:

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

Online Sources:

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

Course Code: PH6219	EMBEDDED SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: SDSD (PH5251)

Course Outcomes

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

CO1	Understands the concepts of embedded systems
CO2	Able to write programs for embedded systems
CO3	Understands interfacing of IO and other devices.
CO4	Able to apply knowledge gained in software-hardware integration
CO5	Able to design, test and implement embedded systems in team-based projects

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH6221	LUMINESCENT MATERIALS AND DEVICES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the luminescence phenomenon in bulk and nanoforms.
CO2	Understand the synthesis processes of phosphors at lower dimensions.
CO3	Understand the importance of photometry and colorimetry in day-to-day scenario.
CO4	Understand the structures of typical inorganic pc-LEDs and their characteristics
CO5	Understand the basics of device physics and different strategies of making white-LEDs

Course Articulation Matrix**:**

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

Online Resources:

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

Course Code: PH6222	FIBER OPTIC COMMUNICATION	Credits 3-0-0: 3

Pre-Requisite: OP (PH4103), CS (PH5253)

Course Outcomes:

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

CO1	Understands the importance and significance of fiber optic communication practical applications.
CO2	Understand the fundamentals of optical fiber sources, detector and other passive device.
CO3	Able to design optical link with different system components.
CO4	Understands various optical components and measuring equipment.
CO5	Design, test and operates, instruments for measuring fiber and optical system properties.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to optical fiber communication: Introduction-Overview of fiber communication - Evolution of optical fiber systems. Elements of an optical fiber transmission link- - simulation and modelling tools -Comparison of optical fiber communications and electronic communication.

Optical Receivers and Transmission Systems: Power launching and coupling- Source to fiber power launching –Lensing schemes for coupling– Digital Transmission systems – Point-to-Point links –Power and rise time budget- Analog Systems –common type photo-detectors-Fundamental Receiver operation – Digital Receiver performance – Analog Receivers - Coherent optical fiber communication techniques.

Optical Amplifiers: Passive components – Couplers – Multiplexers-fiber to fiber joints-splicing-connectors- Principle of WDM- types of optical amplifiers –Semiconductor optical amplifiers- Erbium Doped fiber amplifiers – Raman Amplifiers– Wavelength converters.

Optical Networks: Basic networks – SONET/SDH – Broadcast-and-select WDM networks – Wavelength Routed Networks – Nonlinear effects on network performance – Performance of WDM + EDFA system-Solitons – Time division multiplexing-optical code division multiplexing-optical switching networks.

Measurement: Test Equipment- Fiber attenuation, dispersion, numerical aperture, measurements- Reflection and optical return loss-OTDR and OSA applications.

Learning Resources:

Textbooks:

1. Optical fiber Communications, Gerd Keiser, TMH-fifth edition, 2017.
2. Fiber Optic Communications, V edition, Joseph C. Palais-Pearson Education, fifth edition, 2011.

Reference Books:

1. Optical Fiber Communications, John M. Senior, Pearson Education, Third Edition, 2010.
2. Optical Fiber Communications, fundamentals and applications, Shiva Kumar and Jamal Deen, Wiley Publications, first edition, 2014.
3. Fiber Optic Communications Systems, Govind P. Agarwal, Wiley, Third Edition, 2010.

Online Resources:

1. www.otelco.com
2. www.online library wiley.com

Course Code: PH6223	DIGITAL IMAGE PROCESSING	Credits 3-0-0: 3

Pre-Requisites: STLD (PH5101)

Course Outcomes:

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

CO1	Understand the basic image enhancement techniques in spatial & frequency domains
CO2	Identifies various kinds of noise present in the image and how to restore the noisy image.
CO3	Understand the basic multi-resolution techniques and segmentation methods.
CO4	Compare the image compression techniques in spatial and frequency domains.
CO5	Select feature extraction techniques for image analysis and recognition.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Image Processing Systems: Image Sampling, Quantisation, Resolution-Classification of Digital Images-Elements of Image Processing Systems-Applications of Digital Image Processing.

2D Signals and Systems and Image Transforms: Classification of 2D-Signals and Systems-2D Convolution using Matrix Method and Z-Transforms-Circular Convolution and Correlation- Image Transforms-2D-DFT-Walsh Transform-Hadamard Transform-Haar-Transform-Slant Transform-Discrete Cosine Transform-KL Transform-Comparison of Image Transforms.

Image Enhancement, Restoration and Denoising: Image Enhancement in Spatial Domain-Enhancement through Point Operation-Histogram Manipulation-Linear Grey Level Transform-Spatial Domain Filtering-Image Enhancement in Frequency Domain-Image Degradation-Types of Blur-Linear Image Restoration Techniques-Blind Deconvolution-Image Denoising-Median Filtering-Trimmed Average Filter.

Image Segmentation and Image Compression: Region Approach-Clustering Techniques-Thresholding-Edge based Techniques-Edge Detection-Shape representation Techniques-Object Recognition Techniques-Perception-Structural Pattern Recognition-Image Compression and its need-Image Compression Schemes and their Classification.

Binary and Wavelet-based Image Processing: Binarization-Mathematical Morphology and Morphological Image Processing-Wavelet Transforms-2D-Continuous Wavelet Transform-Wavelet based Image Compression-Wavelet based Denoising-Wavelet based Thresholding-Watermarking-Applications.

Learning Resources:

Text Books:

1. Digital Image Processing, Rafel. C. Gonzalez, Richard.E, Woods-Pearson, 4th Edition, 2018.
2. Digital Image Processing, S. Jayaraman, E. Esakkiranjan, T. Veerakumar, TMH, 2nd edition, 2020.
3. Introductory Digital Image Processing - A Remote Sensing Perspective, John R. Jensen, Pearson, 4th Edition, 2017.
4. Digital Image Processing: A Signal Processing and Algorithmic Approach, D. Sundararajan, Spinger, 1st edition, 2017.
5. Digital Image Processing Using MATLAB- Ralph Gonzalez, Richard Woods, MHI, 2nd edition, 2017

Online Resources:

1. https://nptel.ac.in/courses/117/105/117105135/

Course Code: PH6224	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: 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: Alex net

AI for Physicists: AI for: optical communications, quantum communications, Quantum Computing, Particle Physics and Cosmology. Outlook and challenges.

Learning Resources:

Text Books:

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

Reference Books:

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

Online Resources:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-034-artificial-intelligence-fall-2010/
2. MIT 6. S191 Introduction to Deep Learning, http://introtodeeplearning.com/

Course Code: PH6225	ARM 7 ARCHITECTURE AND PROGRAMMING	Credits 3-0-0: 3

Pre-Requisites: MC (PH5453)

Course Outcomes:

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

CO1	Understand the features of embedded systems, architecture of ARM7 and applications
CO2	Analyse and understand the instruction set and development tools of ARM
CO3	Analyse and understand the THUMB state and achieving competency in assembly programming of ARM
CO4	Understand the exception, interrupts and interrupt handling schemes
CO5	Understand the architectural features of LPC2148 microcontrollers
CO6	Understand and analyse the hardware and interfacing peripheral devices to LPC2148

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

ARM Introduction and Pipeline structures: Types of computer Architectures, ISA's and ARM History, Embedded System Software and Hardware, stack implementation in ARM, Endianness, condition codes. Processor core VS CPU core, ARM7TDMI Interface signals, Memory Interface, Bus Cycle types, Register set, Operational Modes, Instruction Format, ARM family attribute comparison.

ARM7TDMI assembly instructions and modes: ARM ISA and Processor Variants, Different Types of Instructions, Addressing Modes, Instruction Timing, Loading Constants. Program Control Flow, Control Flow Instructions, B & BL instructions, BX instruction. Interrupts and Exceptions, Exception Handlers, Reset Handling. Aborts, software Interrupt Instruction, undefined instruction exception. Interrupt Latency, Multiply Instructions.

ARM Coprocessor Interface and VFP: ARM coprocessor interface and Instructions, Coprocessor Instructions, data Processing Instruction, data transfers, register transfers.

Number representations, Flynn's Taxonomy, SIMD and Vector Processors, Vector Floating Point Processor (VFP), VFP and ARM interactions.

Cache and Memory Management and Protection: Memory Technologies, Virtual Memory. Cache Memory, Mapping Functions. Cache Design, Unified or split cache, multiple level of caches, ARM cache features, Memory Map, Protected Systems, ARM systems with MPU, memory Protection Unit (MPU). Physical Vs Virtual Memory, MMU Advantage, Multitasking with MMU, MMU organization, tightly coupled Memory (TCM).

C Programming for ARM: Overview of C compiler and optimization, Basic C data types, C Looping structures, Register allocations, function calls, pointer aliasing, structure arrangement, bit- fields, unaligned data and Endianness, C programs for General purpose I/O, general purpose timer, PWM Modulator, UART, I2C Interface, SPI Interface.

Learning Resources:

Text Books:

1. ARM System Developers Guide, Designing and Optimizing System Software, by Andrew N. SLOSS, Dominic SYMES and Chris WRIGHT, ELSEVIER, 1st edition, 2004
2. Arm Assembly Language, Fundamentals and Techniques, , William Hohl, Christppher Hinds, CRC Press, 2nd edition, 2014.

Reference Books:

1. Operating Systems, William Stallings, Pearson, 5th Edition, 2014.
2. Manuals and Technical Documents from the ARM Inc, web site.

Online Resources:

1. www.Arm.com

Course Code: PH6204	MICROCONTROLLERS AND APPLICATIONS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Obtains the skills of ALP, C programming writing for 8051 microcontrollers.
CO2	Obtains programming skills to solve scientific problems using 8051 programming.
CO3	Understands the interfacing concepts of different devices with 8051 microcontrollers.
CO4	Obtains the knowledge of simulations for different applications.
CO5	Develops testing and experimental procedure on microcontroller and analyse their operation in real time applications.

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH6203	DIGITAL SIGNAL PROCESSING LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Finds Linear and Circular Convolution and Correlation of two sequences using MATLAB
CO2	Find DFT of a given signal through Fast Fourier Transform Techniques
CO3	Designs FIR and IIR type digital filters using transformation techniques
CO4	Designs various structures and their realisations for Digital Filters
CO5	Apply Z-Transform for the analysis of Discrete-Time signals and Systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Subst

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.

Online Resources:

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

V Semester Photonics

Course Code: PH6301	OPTOELECTRONIC SENSORS AND MOEMS	Credits 3-0-0: 3

Pre-Requisites: OE (PH5103)

Course Outcomes:

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

CO1	Understand the fundamental concepts of Optoelectronic Sensors
CO2	Apply the optical fibers for optoelectronic sensor design
CO3	Analyse the FBG and LPG based sensor architecture
CO4	Understand the LED based sensor and Image sensor
CO5	Understand the features and application of MOEMs

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH6302	OPTICAL ELEMENTS PRODUCTION AND TESTING	Credits 3-0-0: 3

Pre-Requisites: MS (PH5120)

Course Outcomes:

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

CO1	Understand types of IR materials, optical crystals, optical plastics, metals, their properties and applications
CO2	Select production methods for Optical glass, optical crystals, IR materials and Optical plastics
CO3	Identify the shop supplies for making optical components
CO4	Analyse/ Validate the optical components by Interferometry, spherometry, autocollimator and surface analyser
CO5	Design optical systems

Course Articulation Matrix:

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

Online resources:

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

Course Code: PH6311	INTEGRATED OPTICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), OE (PH5103)

Course Outcomes:

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

CO1	Understand the fundamental concepts of integrated optics
CO2	Gain the knowledge about various optical components for Integrated Optics
CO3	Analyse the design and working of photonic integrated circuits
CO4	Illustrate the fabrication methods of integrated optics

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Guided TE and TM Modes of Symmetric and anti-symmetric, Planar waveguides: Step-index and graded-index waveguides, Strip and channel waveguides, anisotropic waveguides, Marcatili's Method, Effective-Index method and perturbation method of analysis.

Integrated Optical Devices: Passive and active devices, Directional couplers, delta-beta couplers. Applications as power splitters, Yjunction, optical switch; phase and amplitude modulators, filters A/D converters; Y-splitters, mode splitters and polarization splitters, Arrayed waveguide devices, Photonic integrated circuits

Coupling methods, Horizontal incoupling: inverted tapers, Vertical incoupling: grating couplers operating principles the base line improving efficiency, bandwidth, polarization fiber arrays and packaging, Grating couplers, basic measurements with fibers wafer-scale testing for free-space communication

Fabrication of integrated optical waveguides and devices. Waveguide characterization, end-fire and prism coupling; grating and tapered couplers, Fiber pigtailing

Learning Resources:

Text Books:

1. *Optical Electronics*, A Ghatak and K Thyagarajan, Cambridge University Press, 1989.
2. *Integrated Optics*, ED. T. Tamir, Springer Verlag, New York, 1982.

Reference books:

1. *Optical Integrated Circuits;* H Nishihara, M Haruna and T Suhara, McGraw-Hill Book Company, New York, 1989.
2. *Fundamentals of Optical waveguides, K Okamota, Academic Press, 2006 .*

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ee35/preview

Course Code: PH6312	NEW LASING MATERIALS	Credits 3-0-0: 3

Pre-Requisites: LA (PH5259)

Course Outcomes:

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

CO1	Select the solid-state laser for different applications based on material design, mechanical design, host material, doping ions and other properties
CO2	Understand different types of Garnet lasers and applications
CO3	Comprehend fluorides laser crystals and applications
CO4	Understand the mechanism of energy transfer in lasers
CO5	Understand different types of two micron lasers and applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Solid State Laser Materials: Properties, Optics, Material design, Mechanical design, Doping Ions, Laser host materials, General Properties of Hosts, Optical properties, Chemical properties, Mechanical properties, Thermal properties, Photo physics of Solid-State Laser Materials: Nonradiative Transition, Energy gap and temperature dependence of multi phonon relaxation, Temperature dependence of nonradiative relaxation

Garnet Crystals as Laser Hosts: Physical Characteristics of Garnets and Mixed Garnets, Chromium- and Neodymium-Doped Garnets, Disordered (Mixed) Garnets, Glass and Crystalline Ceramics, Yb-YAG Laser

Fluoride Laser Crystals: YLiF4 (YLF), Thermal and Mechanical Properties of YLF, Estimate of thermal load at fracture, Nonradiative Losses in YLF, Neodymium-Doped YLF, Holmium Doped YLF, Thulium-Doped YLF, Other Fluorides Crystals, Cascade Emission, Up conversion, Applications to up conversion

Energy Transfer: Introduction, Radiative Energy Transfer, Nonradiative Energy Transfer, Basic mechanisms of energy transfer, Resonant energy transfer, Exchange interaction,

Phonon assisted energy transfer, Pathways of excited state relaxation, Statistical model (Inokuti Hirayama model)

Two-Micron Lasers: Holmium- and Thulium-Doped Crystals: Introduction, Advantages of the Holmium Laser, Utilizing energy transfer, Conventional Pumping CW laser operation, Pulsed operation of holmium lasers, Diode Pumping, End-pumped 2 um lasers, Side-pumped 2 um lasers.

Learning Resources:

Text book:

1. Yehoshua Y. Kalisky, The Physics and Engineering of Solid-State Lasers, PIE, 2005

Reference Books:

1. Fuxi Gan, Laser Materials, 1995

Course Code: PH6313	QUANTUM OPTICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103)

Course Outcomes:

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

CO1	Understand quantum optics and its applications
CO2	Classify the properties of light based on photon statistics
CO3	Distinguish the physical phenomena behind the weak and strong filed atom-photon interactions
CO4	Apply the principles of quantum optics to quantum cryptography
CO5	Adopt the concept of quantum bits to quantum computing

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

Quantum cryptography, Basic principles, Quantum key distribution, Single photon source and detectors.

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.

Online Resources:

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

Course Code: PH6213	SOLAR ENERGY SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

After studying this course, the student will be able to:

CO1	Outline the technologies that are used to harness the power of solar energy.
CO2	Understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO3	Comprehend the challenges in sustainable energy processes, perform cost analysis, design photovoltaic systems for different applications meeting residential and industrial needs, predict and test performance.
CO4	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials.
CO5	Illustrate the concepts of direct energy conversion systems & their applications.

Course Articulation Matrix:

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

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, 1998.
2. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 3rd edition, 2000.

Reference Books:

1. Photovoltaic Engineering Handbook, F. Lasnier and T. G. Ang, IOP Publishing UK (Adam Hilger USA) 1990.
2. Semiconductor Devices, Physics, and Technology, S. M., Sze, New York, NY: Wiley, 2nd edition, 2001.

Online Resources:

1. https://energyeducation.ca/encyclopedia/Photovoltaic_system
2. https://www.open.edu/openlearn/nature-environment/environmental-studies/energy-resources-solar-energy/content-section-1

Course Code: PH6314	ADVANCED OPTICAL SYSTEM DESIGN	Credits 3-0-0: 3

Pre-Requisites: OSD (PH5351)

Course Outcomes:

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

CO1	Design various application specific lens
CO2	Understand the fundamental of non-imaging optics and freeform optics
CO3	Gain the knowledge of illumination systems
CO4	Design various reflectors for solar collectors
CO5	Understand the automotive lighting and vision

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Lens designs for Eyepice, Microscopes and Camera; Telescope Systems and Eyepieces, Microscopic objectives, Photographic objectives, Condenser systems

Introduction to Nonimaging optics; Thermodynamic origin of nonimaging Optics, Phase representation, Construction of nonimaging optical systems, Solar reflectors

Introduction to Illumination design, radiometry and photometry, LEDs, incandescent, high-intensity discharge, daylight, Fluorescent, source measurement, source modeling, luminaires, lighting. Freeform design

Automotive light design, Head lamp and interior lighting, Human vision, visual construction, visual structures

Learning Resources:

Text Books:

1. Modern Lens Design, W. J. Smith, 2nd Edition, McGraw-Hill, 2004.
2. Nonimaging optics: a tutorial," Roland Winston, Lun Jiang, and Melissa Ricketts, Adv. Opt. Photon. 10, 484-511 (2018).
3. Illumination Engineering: Design with Nonimaging Optics, R. J. Koshel, Ed., Wiley (2013).
4. Automotive Lighting and Human Vision, Burkard Wördenweber; Jörg Wallaschek; Peter Boyce; Donald D. Hoffman, Springer, 2007.

Reference books:

1. Nonimaging Optics, R. Winston, J. C. Miñano, P. Benitez, Elsevier Academic Press (2004).
2. Field Guide to Illumination Optics, V. Arecchi, T. Messadi, and R. J. Koshel, SPIE Press (2007).

Online Resources:

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

Course Code: PH6315	SILICON PHOTONICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), SSP (PH4153)

Course Outcomes:

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

CO1	Explain the operating principles of silicon photonic devices
CO2	Comprehend fundamentals of silicon waveguides for photonic applications.
CO3	Choose couplers and interconnects for silicon photonic applications
CO4	Comprehend working of integrated silicon light sources and photo-detectors
CO5	Illustrate silicon photonic device fabrication techniques

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH6316	NANOPHOTONICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103)

Course Outcomes:

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

CO1	Understand the physics of nanotechnology, optical behaviour of nanomaterials and their synthesis methods.
CO2	Explain the importance of lower-dimension materials for the realization of novel photonic devices, and systems.
CO3	Understand the intuitive concepts of nanophotonics using the concept of near-field optics.
CO4	Understand the present status of research and development in nanophotonics and related technologies
CO5	Familiarize with nanophotonic fabrications, novel nanophotonic devices and their applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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.

Online Resources:

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

Course Code: PH6217	SMART MATERIALS AND DEVICES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the necessity for new and novel materials in our day to day scenario.
CO2	Explain the basic principles of smart materials.
CO3	Gain insight into self-healing technologies and biomaterials for healthcare.
CO4	Comprehend the smart gels and textiles for many exotic applications.
CO5	Enlighten the urge for self-expanding implants and basics of personalized smart devices

Course Articulation Matrix**:**

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

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, Thermoresponsive materials, Electrochromic materials, Fullerenes, Biomimetric materials, Quantum tunneling 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, Fire fighting, Military/Security, etc.

Smart Self-Expanding Implants and Devices: Shape Memory Alloys (SMA), One-way and two-way memory effect, Pseudoelasticity, 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, 2018.
2. Encyclopedia of Smart Materials, Schwartz, Mel, Ed., John Wiley and Sons, 2002.

Reference Books:

1. Intelligent Materials, Shahinpoor, Mohsen; Schneider, Hans-Jorg, Eds., RSC Publishing, 2007.
2. Smart Structures: Physical Behaviour, Mathematical Modelling and Applications, Gaudenzi, Paolo, John Wiley & Sons, 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: 1078–1113 (2014).

Online Resources:

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

Course Code: PH6317	BIOPHOTONICS	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103)

Course Outcomes:

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

CO1	Understand basics of biology, the interaction of light with cells and tissues.
CO2	Demonstrate the characteristics and properties of various bioimaging techniques used in biomedicine.
CO3	Analyze optical properties of tissues.
CO4	Apply light to illness diagnosis and therapy.
CO5	Identify antibodies and apply them in various bio sensing techniques.

Course Articulation Matrix:

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

Online Resources:

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/

Course Code: PH6318	OPTICAL MICROSCOPY	Credits 3-0-0: 3

Pre-Requisites: OSD (PH5351), FOH (PH5353)

Course Outcomes:

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

CO1	Illustrate the basic principles of optical microscopy
CO2	Analyse the optical microscopic images
CO3	Understand the concepts of interferometric, widefiled, Confocal and Fluorescence microscopy
CO4	Compare Widefield, Confocal and Fluorescence Microscopy

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Monochromatic Field Propagation Through a Lens, Lens Transmission, Fourier Transform with a Lens, Intensity Propagation, Field Correlations, Free Space Propagation, Propagation Through a 2f System, Propagation Through a 4f System: Imaging

Widefield Microscopy, Transmission Microscopy, Thin Samples, Brightfield Microscopy, Phase Imaging, Volume Samples, Reflection Microscopy, Brightfield Microscopy, Darkfield Microscopy

Interference Microscopy, Coherent Illumination, Lensless Fourier Holography, Fourier Holography with a Lens, Imaging Holography, Incoherent Illumination, Extraction of Complex Interference, Resolution and Sampling, Fluorescence Lifetime Imaging Microscopy (FLIM); Time Domain, Frequency Domain, Fluorescence Correlation Spectroscopy (FCS)

Confocal Microscopy, Scanning Configurations, Non-Fluorescence Confocal Microscopy, Transmission Confocal, Reflection Confocal, Comparison with Widefield Microscopy, Confocal Fluorescence Microscopy

Learning Resources:

Text Books:

1. Introduction to Optical Microscopy, Mertz Jerome, Cambridge University Press, 2019.
2. Optical Microscopy: Emerging Methods and Applications, Brian Herman, John J. Lemasters, Academia Press, 1993.

Reference books:

1. A Practical Guide to Optical Microscopy, John Girkin, CRC Press, 2019

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc18_mm03/preview

Course Code: PH6319	DISPLAY TECHNOLOGIES	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), EDC (PH4154)

Course Outcomes:

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

CO1	Understand optics for use in displays.
CO2	Understand the principles of addressing passive, active and the importance of the TFTs.
CO3	Imbibe the knowledge of early display devices to modern display technologies.
CO4	Comprehend the display technologies such as LCD, inorganic/organic devices
CO5	Gain knowledge on designing the new display devices for cost effective, environmentally friendly future display applications.

Course Articulation Matrix:

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

Course Code: PH6321	NANOFIBERS SYNTHESIS, PROPERTIES AND APPLICATIONS	Credits 3-0-0: 3

Pre-Requisites: MS (PH5102)

Course Outcomes:

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

CO1	Understand the concepts of nanofibers and its production
CO2	Understand the basics of different electrospinning machine instrumentation
CO3	Understand the effect process parameters effect on nanofibers synthesis
CO4	To simulate the process of the nanofibers
CO5	Apply the nanofibers in different applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to electrospinning, understanding the Nanofiber, Preparation methods for nanofibers, Basics of relevant of electrospinning, Materials classes, Polymers, Composites, Ceramics, solution property, polymer solubility, viscosity, volatility, conductivity of solution, Electrostatics.

Electro spinning process, polymer solution parameters, processing conditions, ambient parameters, Melt electrospinning, creation of different nanofibers, Modelling of the electrospinning process.

Characterization of nanofibers, morphology, molecular structure, Mechanical property, Electrical properties, Optical properties.

Electrospun nanofibers for energy applications: Nanogenerators, Fuel cells, Lithium-ion batteries, Solar cells. Electrospun nanofibers in medical filed: Regenerative medicine, Drug delivery, Tissue engineering, Industrial application of nanofibers.

Learning Resources:

Text Books:

1. An Introduction to Electrospinning and Nanofibers, Seeram Ramakrishna, World Scientific Publishing Company, 2005.
2. Electrospinning: principles, practice and possibilities, Mitchell, Geoffrey, Royal Society of Chemistry, 2015.

Reference Books:

1. Electrospinning for High Performance Sensors, Antonella Macagnano, Emiliano Zampetti, Erich Kny, Springer International Publishing, 2015.
2. Electrospinning of Nanofibers for Battery Applications, Shengjie Peng, P. Robert Ilango, Springer, 2020.

Online Resources:

1. Electrospinning and Electrospun Nanofibers: Methods, Materials, and Applications, Chem. Rev. 2019, 119, 5298−5415.
2. https://www.inovenso.com/ (for instrumentation)
3. https://www.pdfdrive.com/electrospinning-materials-processing-and-applications-e185284905.html

Course Code: PH6221	LUMINESCENCE MATERIALS AND DEVICES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the luminescence phenomenon in bulk and nanoforms.
CO2	Explain the basic principles of phosphors at lower dimensions.
CO3	Gain insight into the fundamentals of photometry and colorimetry.
CO4	Analyse the structures of typical inorganic pc-LEDs and their characteristics
CO5	Comprehend the device physics and strategies of making white-LEDs

Course Articulation Matrix:

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

Online Resources:

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

Course Code: PH6222	FIBRE OPTIC COMMUNICATION	Credits 3-0-0: 3

Pre-Requisite: EMT (PH4151), CS (PH5253)

Course Outcomes:

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

CO1	Understands the importance and significance of fiber optic communication practical applications.
CO2	Understand the fundamentals of optical fiber sources, detector and other passive device.
CO3	Able to design optical link with different system components.
CO4	Understands various optical components and measuring equipment.
CO5	Design, test and operates, instruments for measuring fiber and optical system properties.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to optical fiber communication: Introduction-Overview of fiber communication - Evolution of optical fiber systems. Elements of an optical fiber transmission link- - simulation and modelling tools -Comparison of optical fiber communications and electronic communication.

Optical Receivers and Transmission Systems: Power launching and coupling- Source to fiber power launching –Lensing schemes for coupling– Digital Transmission systems – Point-to-Point links –Power and rise time budget- Analog Systems –common type photo-detectors- Fundamental Receiver operation – Digital Receiver performance – Analog Receivers - Coherent optical fiber communication techniques.

Optical Amplifiers: Passive components – Couplers – Multiplexers-fiber to fiber joints-splicing-connectors- Principle of WDM- types of optical amplifiers –Semiconductor optical amplifiers- Erbium Doped fiber amplifiers – Raman Amplifiers– Wavelength converters.

Optical Networks: Basic networks – SONET/SDH – Broadcast-and-select WDM networks – Wavelength Routed Networks – Nonlinear effects on network performance – Performance of WDM + EDFA system-Solitons – Time division multiplexing-optical code division multiplexing-optical switching networks.

Measurement: Test Equipment- Fiber attenuation, dispersion, numerical aperture, measurements-Reflection and optical return loss-OTDR and OSA applications

Learning Resources:

Text books:

1.Optical fiber Communications, Gerd Keiser, TMH, 5th edition, 2017.
2.Fiber Optic Communications, Joseph C. Palais, Pearson Education, 5th edition, 2011.

Reference Books:

1. Optical Fiber Communications, John M. Senior, Pearson Education, 3rd edition, 2010.
2. Optical Fiber Communications, fundamentals and applications, Shiva Kumar and Jamal Deen, Wiley Publications, 1st edition, 2014.
3. Fiber Optic Communications Systems, Govind P. Agarwal, Wiley, 4th edition, 2010.

Online Resources:

1. www.otelco.com
2. www.online library wiley.com

Course Code: PH6322	INFRARED OPTICS AND THERMAL IMAGING	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), MS (PH5102)

Course Outcomes:

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

CO1	Understand the unique features of IR region
CO2	comprehend zoom lens, refractive and reflective zoom lenses
CO3	Comprehend IR imaging systems and applications
CO4	Identify Infrared detectors for different applications
CO5	Understand the fundamentals of infrared thermal imaging

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unique Features of the Infrared Region, Optical Materials, Materials for the infrared, Calculation of index of refraction, Thermal Compensation, Focus shift with temperature, effect of temp on optical properties Athermalization, Athermalization methods

Optical Design Techniques, Optical Materials Selection, Zoom Lenses, Types of Zoom Lenses, Optically , Mechanically compensated zoom lens, Infrared Zoom Lens Specifications, Optical system performance, Refractive Infrared Zoom Lenses, Reflective Infrared Zoom Systems

Basic Properties of IR Imaging Systems: Introduction, Basic Measurement Process, Complete Camera Systems, Camera Performance Characterization, Night vision equipment. Applications in industry and defense.

Detection Processes: Basics of Infrared Detection, Noise in Infrared Detection, Figures of Merit for Infrared Detectors, Types of Infrared Detectors : Photovoltaic Detectors, Photoconductive Detectors, Band-engineered detectors

Fundamentals of Infrared Thermal Imaging, Introduction, Infrared Radiation, Radiometry and Thermal Radiation, Emissivity, Optical Material Properties in the IR, Thermal imaging instruments,

Learning Resources:

Text books

1. Mann Allen, Infrared Optics and Zoom Lenses, SPIE, 2002.

Reference books

1. R. Kingslake, Applied Optics and Optical Engineering, Vol. 4 and 5, Academic, 2002.
2. Michael Vollmer, Infrared Thermal Imaging: Fundamentals, Research and Applications, Wiley, 2010.

Course Code: PH6224	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: 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 Physicists: AI for: optical communications, quantum communications, Quantum Computing, Particle Physics and Cosmology. Outlook and challenges.

Learning Resources:

Text Books:

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

Reference Books:

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

Online Resources:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-034-artificial-intelligence-fall-2010/
2. MIT 6. S191 Introduction to Deep Learning, http://introtodeeplearning.com/

Course Code: PH6323	PHOTONIC DEVICES	Credits 3-0-0: 3

Pre-Requisites: OP (PH4103), OE (PH5103)

Course Outcomes:

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

CO1	Understand various aspect and applications of photonic devices
CO2	Gain the knowledge of active and passive photonic devices
CO3	Gain the knowledge of micro optic component for photonic technology
CO4	Gain the knowledge of fiber optic component for photonic technology
CO5	Gain the knowledge of plasmonic, slow light and photonic crystal based devices.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction Active and Passive Photonic devices, Applications, Micro optic devices, Waveguide Mechanism, Waveguides, Multilayer Structures, Couple mode theory and couplers, Leaky Structures, Optical channels and routers, Optical switches, Optical buffers

Fiber optic devices, Device applications of Optical fibers, Special Fiber, Photonic Crystal Fiber, Photonic Bandgap fiber, Bragg Fiber, Fiber Bragg Grating, Long period grating, Optical fiber tapering, Erbium doped fiber amplifier, Fiber laser

Novel Photonic devices, Photonic band gap and Periodic photonic crystals, Theory of Plasmonic and Plasmonic devices, Slow light photonic device

Quantum Optical Devices, Single-photon emitters, Photon pair sources, Low noise photo detectors, Photon counter, Optical Traps, Systems for quantum Cryptography including quantum key distribution

Learning Resources:

Text Books:

1. Introduction to Fiber Optics, Ajoy Ghatak and K Thyagarajan, Cambridge University Press, 1998.
2. Fundamentals of Photonics, BMA Saleh and MC Teich, John Wiley, NY, 2007.
3. “Optical Electronics”, A Ghatak and K Thyagarajan, Cambridge University Press, 1989.
4. Applied optics fundamentals and device applications, Mark A.Mentzer, , CRC Press, 2011.

Reference books:

1. Photonics essentials, Thomas P.Pearsall, 2nd Ed, Mc-Graw Hill, 2010.
2. Fundamentals of Optical waveguides, K Okamota, Academic Press, 2006.

Online Resources:

1. https://www.edx.org/course/optical-materials-and-devices

Course Code: PH6303	OPTOELECTRONIC SENSING LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Set optical and mechanical housing and associated arrangements for an experiment
CO2	Develop fiber optic based optoelectronic sensors
CO3	Analyse different parameters of sensing components regarding photonics.
CO4	Design the basic optics experiments to verify various laws and principles

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

Online Resources:

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

Course Code: PH6304	FOURIER OPTICS AND OEPT LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Learns the methods of preparation of optical glass, optical crystals and IR materials
CO2	Learns cutting, grinding and polishing different optical elements
CO3	Learns to test the optical elements
CO4	Design different types of optical elements
CO5	Application of optical elements

Course Articulation Matrix:

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

Online Resources:

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

V Semester Instrumentation

Course Code: PH6401	ANALYTICAL INSTRUMENTATION	Credits 3-0-0: 3

Pre-Requisites: MS (PH5102)

Course Outcomes:

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

CO1	Compare the strengths and limitations of analytical technique used for material characterization.
CO2	Distinguish between qualitative and quantitative measurements.
CO3	Comprehend working principles and instrumentation involved in characterization of materials.
CO4	Analyze microstructural properties of materials using electron microscopy.
CO5	Understand the applications of spectroscopic and thermal techniques to evaluate the material properties

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

SPECTROPHOTOMETERS: Electromagnetic spectrum- Spectral methods of analysis-Absorption spectroscopy -Emission Spectroscopy -Beer Lamberts Law; Ultraviolet-visible Spectrophotometer: Electronic absorption and transitions- Sources and detectors; IR Spectrophotometer: Sources and detectors -FTIR spectrometer; Fluorescence Spectroscopy-Emission of Radiation, Photoluminescence- Phosphorescence; Raman Spectroscopy: Principle and instrumentation.

SURFACE MORPHOLOGICAL TECHNIQUES: Optical Microscope- Resolution Limit; Electron Microscopes-Scanning Electron Microscope (SEM)- Energy Dispersive X-Ray Spectroscopy (EDX); Transmission Electron Microscope (TEM); Scanning Probe Microscopes: Scanning Tunneling Microscope (STM)-Atomic Force Microscope (AFM).

THERMAL & OTHER TECHNIQUES: Thermogravimetric Analysis (TGA)-Weight/mass loss of materials as a function of temperature; Differential Scanning Calorimetry (DSC)-detection of phase transition, concept of glass transition temperature and melting point; Mass spectrometry-Sources and detectors, operation and applications.

Learning Resources:

Text Books:

1. Instrumental methods and analysis, Willard. Merrit, Dean, D. Van. Nostrand CBS Publication, New Delhi, 7th Edition,2012.
2. Analytical Instrumentation, R.S. Khandpur, McGraw-Hill Education Private Limited, 2nd Edition.2006,

Reference Books:

1. Principles of Instrumental Analysis, Douglas. A Skoog , F. James Holler , Stanley R. Crouch, Cengage Learning, 7th edition, 2017.
2. Process Measurement and Analysis, B.G. Liptak, CRC Press, 4th edition, 2003.
3. Instrument Technology, E.B. Jones, Butterworth Scientific Publications, 3rd edition, 1974.

Online Resources:

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

Course Code: PH6402	PROCESS INSTRUMENTATION	Credits 3-0-0: 3

Pre-Requisites**:** CS (PH5451)

Course Outcomes**:**

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

CO1	Identify and monitor process parameters of various processes
CO2	Apply fundamental knowledge of mathematics to modelling and analysis of fluid flow, level, pressure, temperature problems.
CO3	Conduct experiments in pipe flows and open-channel flows and interpreting data from model studies to proto type cases.
CO4	Understand the possible disasters caused by an incorrect Design/Analysis in hydraulic, pneumatic engineering system.
CO5	Apply multi loop control systems in various process industries.

Course Articulation Matrix**:**

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Process Dynamics Process variables: Load variables – Dynamics of simple pressure, flow, level and temperature process – interacting and non-interacting systems – continuous and batch process – self-regulation – Servo and Regulator operation - problems.

Control Actions and Controllers and Types of Controllers Basic control actions: characteristics of two position, three position, Proportional, Single speed floating, Integral and Derivative control modes – PI, PD, PID control modes – 153 Problems -types of controllers - Pneumatic, Hydraulic and Electronic Controllers to realize various control actions.

Controller Settings and Tuning of Controllers: Evaluation criteria – 1/4th decay ratio, I AE, ISE, ITSE, ITAE - determination of optimum settings for mathematically described process using time response and frequency response-tuning of controllers- process curve reaction method – continuous oscillation method – damped oscillation method – problems.

Final Control Elements and Control Valves: I/P Converter, P/I converter - pneumatic, electric and hydraulic actuators

Multi loop Control System: Feed forward control – Feed Forward Feedback Controller (FFFBC) – Ratio control – Cascade control – Split range – Multivariable control and examples from distillation column, Boiler system and heat exchanger.

Learning Resources:

Text Books:

1. Automatic Process Control, Donald P. Eckman, Wiley India Pvt Ltd, 1st edition, 2009.
2. Process Control Instrumentation technology, Curtis. D. Johnson, PHI Publishers,8th edition, 2008.

Reference Books:

1. Chemical Process Control: An introduction to Theory and Practice, Stephanopoulos, Prentice Hall, 1st edition, 1999.
2. Process Control, Liptak B.G., Chilton Book Company, Pennsylvania, 3rd edition,1995.

Online Recourses:

1. https://www.udemy.com/course/introduction-to-process-control-and-instrumentation/
2. https://nptel.ac.in/courses/103/103/103103037/

Course Code: PH6411	ELECTRONIC INSTRUMENTATION	Credits 3-0-0: 3

Pre-Requisites**:** None

Course Outcomes**:**

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

CO1	Understand the principle of Oscilloscopes and Wave analysers
CO2	Identify the suitable signal source for various applications
CO3	Make use of the spectrum and network analysers
CO4	Combine software and modular measurement hardware to create user-defined measurement systems, called virtual instruments
CO5	Design to calibrate various practical instruments

Course Articulation Matrix**:**

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

Virtual instrumentation: Personal computer for data acquisition and instrument control, instrument drivers and driver software, GPIB – VXI, PCI and PXI bus standards, application software lab view.

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

Learning Resources:

Text Books:

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

Reference Books:

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

Online Resources:

1. https://drive.google.com/file/d/1w7LSIAx3B-lI06YjHr0f7WgI8_-TyyiI/view

Course Code: PH6412	PC BASED INSTRUMENTATION	Credits 3-0-0: 3

Pre-Requisites: MC (PH5453)

Course Outcomes:

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

CO1	Understand measurement and analyze techniques of digital computer power and performance
CO2	Understand the various types of interfacing systems and components
CO3	Develop the knowledge of real-time systems and case studies in instrumentation
CO4	Capability to analyze PC based data
CO5	Capable to develop instrumentation systems on various processes of industrial measurements

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

INTRODUCTION: Review of microprocessors, microcomputers, micro processing systems - Input-output structures -Measurement of digital computer power and performance.

INTERFACING: Analogue signal conversion –Interface components and techniques -Signal processing -Interface systems and standards –Communications.

SOFTWARE: Real time languages –Programming real time systems -Discrete PID algorithms -Real time operating systems -Case studies in instrumentation.

MEASUREMENT AND CONTROL: PC based data -Acquisition systems –Data Acquisition-Data Gathering

APPLICATION EXAMPLES: Industrial process measurements, like flow temperature, pressure, and level PC based instruments development system.

Learning Resources:

Text Books:

1. Computer based industrial control, Krishna Khan, Prentice Hall, 1997.
2. Programmable Logic Controllers: Principles and Applications, John. W. Webb and Ronald A Reis, Prentice Hall Inc., New Jersey, 5th edition, 2002.

Reference Books:

1. Microprocessors with applications in process control, Ahson, S.I, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1st edition, 1984.
2. Intelligent Instrumentation, George Barney C., Prentice Hall of India Pvt. Ltd., New Delhi, 1st edition, 1998.
3. PC Based Instrumentation and Control, Mike Tooley, Elsevier, 3rd Edition, 2005.

Online Resources:

1. https://nptel.ac.in/courses/112102011/11

Course Code: PH6213	SOLAR ENERGY SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

After studying this course, the student will be able to:

CO1	Outline the technologies to harness the power of solar energy.
CO2	Understand solar energy conversion and utilization processes currently used.
CO3	Comprehend solar photovoltaic systems for residential and industrial purposes.
CO4	Understand solar energy manufacturing, environmental challenges, economic aspects, and future developments.
CO5	Design solar thermal and hybrid systems.

Course Articulation Matrix:

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

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 (Adam Hilger USA), 1st edition, 1990.
2. Semiconductor Devices, Physics, and Technology, Second Edition, S. M., Sze, New York, NY:Wiley, 1st edition, 2001.

Online Resources:

1. https://energyeducation.ca/encyclopaedia/Photovoltaic system
2. https://www.open.edu/openlearn/nature-environment/environmental-studies/energy-resources-solar-energy/content-section-1

Course Code: PH6413	MEDICAL INSTRUMENTATION	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes**:**

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

CO1	Describe and characterize the sources of biomedical signals and needs of using biomedical instruments & their limitations.
CO2	Understand pc based medical instrumentation & regulation of medical devices.
CO3	Characterize medical instruments as per their specifications, static & dynamic characteristics and understand data acquisition system.
CO4	Analyse, characterize and design Bio-amplifiers
CO5	Design various medical recording systems & their components.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

BIO POTENTIAL ELECTRODES: Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode– skin interface, half-cell potential, impedance, polarization effects of electrode – nonpolarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes

ELECTRODE CONFIGURATIONS: Bio signals characteristics – frequency and amplitude ranges. ECG – Einthoven's triangle, standard 12 lead system. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG, ERG and EOG – unipolar and bipolar mode

BIO AMPLIFIER: Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier – right leg driven ECG amplifier. Band pass filtering, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier. Chopper amplifier. Power line interference.

MEASUREMENT OF NON-ELECTRICAL PARAMETER: Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods - auscultatory method, oscillometric method, direct methods: electronic manometer, Pressure amplifiers - systolic, diastolic, mean detector circuit. Blood flow and cardiac output measurement: Indicator dilution, thermal dilution and dye dilution method, Electromagnetic and ultrasound blood flow measurement.

BIO-CHEMICAL MEASUREMENT: Biochemical sensors - pH, pO2 and pCo2, Ion selective Field effect Transistor (ISFET), Immunologically sensitive FET (IMFET), Blood glucose sensors - Blood gas analyzers, colorimeter, flame photometer, spectrophotometer, blood cell counter, auto analyzer (simplified schematic description).

Learning Resources:

Text Books:

1. Medical Instrumentation - Application and Design, John G Webster, John Wiley and Sons, 4th edition, 2009.
2. Handbook of Biomedical Instrumentation, R S Khandpur, Tata McGraw Hill Publishing Company Limited, 1st edition, 2004.

Reference Books:

1. Biomedical Instrumentation & Measurements, Leslie Cromwell, Fred. J. Weibell, Erich. A. Pfeiffer, Pearson Education, 2nd edition, 2001.
2. Introduction to Biomedical Equipment Technology, Carr & Brown, Pearson, 4th edition, 2002.

Online Recourses:

1. https://nptel.ac.in/courses/108/105/108105101/

Course Code: PH6414	TELEMETRY AND TELECOMMAND	Credits 3-0-0: 3

Pre-Requisites**:** CS (PH5253)

Course Outcomes**:**

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

CO1	Understand Basic System, Classification, Non-electrical telemetry systems, Voltage and current Telemetry systems
CO2	Design Phase Locked Local Loop, Mixers. Time Division Multiplexed System – TDM/PAM system
CO3	Realize Modems & modem protocol.
CO4	Formulate Transmission Techniques, Inter stage Coupling, Receiver Antennas: The Ideal structure, dipoles.
CO5	Design Active RC Filters, Universal Filter Circuits, Switched Capacitor Filters, Digital Filters Basics of Satellite and Fiber Optic.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Telemetry System Definition Learning Objectives: Telemetry System Overview -Data Collection System -Multiplex System- FDM System- Pulse Code Modulation TDM Combination of FDM and TDM -Modulator, Transmitter, and Antenna-Transmission or Waveform Channel Antennas, Receivers with RF and IF-Amplifiers, and Carrier Demodulators -Demultiplex System Frequency Division Demultiplexing- Time Division Demultiplexing-Hybrid Systems

Design of FM/FM Systems: System Parameters -Design Procedure -Design Examples-Threshold- Changing the Preemphasis Schedule to Utilize Specified IF or Transmission Bandwidth -Designing to a Specified Transmission Bandwidth-Designing the Preemphasis Schedule for Different Values for the *Dsi* 's - Designing the Preemphasis Schedule for the Minimum Transmission Bandwidth with Equal *Dsi* 's (Concurrent All-Channel Dropout) -- Designing the Preemphasis Schedule for All-Channel Dropout and Unequal *Dsi* 's - Designing the Preemphasis Schedule for Different Specified Signal-to-Noise Ratios in the Channels

Reliability and availability: Introduction-Reliability -Availability -SCADA system reliability (or failure) rates -Complete system testing -Improving reliability -Reliability calculation Qualification of the processes.

Integrating telemetry systems into existing radio systems: General-Appropriate radio systems -Traffic loading -Implementing a system -Trunking radio -Ocean data telemetry

application - Electromechanical cable -Acoustic modem -Inductive modem -Physiological telemetry application.

Learning Resources:

Text Books:

1. Telemetry Systems Engineering by Frank Carden, Russell Jedlicka, Robert Henry published by Artech House Boston · London, 1st edition,2002
2. Practical Radio Engineering and Telemetry for Industry by David Bailey-Newness publications, 1st edition, 2003

Reference Books:

1. Handbook of Telemetry and Remote Control – by Gruenberg L., McGraw Hill, New York, 1st edition, 1987.
2. Telemetry Engineering – by Young R.E., Little Books Ltd., London, 1st edition, 1988.

Online Recourses:

1. https://nationaltelemetryassociation.org/telemetry-course/

Course Code: PH6217	SMART MATERIALS AND DEVICES	Credits 3-0-0: 3

Pre-Requisites**:** None

Course Outcomes:

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

CO1	Understand the necessity for new and novel materials in our day to day scenario.
CO2	Explain the basic principles of smart materials.
CO3	Gain insight into self-healing technologies and biomaterials for healthcare.
CO4	Comprehend the smart gels and textiles for many exotic applications.
CO5	Enlighten the urge for self-expanding implants and basics of personalized smart devices

Course Articulation Matrix:

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

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: Need for new materials, Piezoelectric materials, Electrostrictive materials, Magnetostrictive materials, Rheological materials, Thermoresponsive materials, Electrochromic materials, Fullerenes, Biomimetric materials, Quantum tunneling 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, Superhydrophobicity, 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, Pseudoelasticity, 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: 1078–1113 (2014)

Online Resources:

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

Course Code: PH6415	DATA COMMUNICATION	Credits 3-0-0: 3

Pre-Requisites**:** CS (PH5253)

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

CO1	Understands the underlying structure of networks and how they operate in relation to OSI model
CO2	Describe layered communication, the process of encapsulation, and message routing in network equipped devices using appropriate protocols
CO3	Compares different types of data communication networks
CO4	Analyses the different issues related to internetworking
CO5	Understands the different concepts involved in satellite communications

Course Articulation Matrix**:**

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

Introduction to local area 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

Packet-switched and frame relay networks: Evolution of switched communications -X.25 packet-switched networks - Frame relay networks Frame relay traffic management

Internetworking: Internetworking requirements -Internetworking techniques-The Internet - Security Internet protocols The 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, 6th edition, 2013.
2. Data Communications for Computer Networks, Michael Duck & Richard Read, Pearson, 2nd Edition, 2003.

Reference Books

1. Data Communications and Networks, Achyut Godbole, McGraw Hill Education, 2nd edition, 2017.
2. Data Communications and Networking, Behrouz A. Forouzan, McGraw Hill Education, 4th edition, 2007.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105082/

Course Code: PH6416	DIGITAL AND DISTRIBUTED CONTROL SYSTEMS	Credits 3-0-0: 3

Pre-Requisites: CS (PH5451)

Course Outcomes:

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

CO1	To get an introductory knowledge on PLC and Programming Languages
CO2	To get Adequate knowledge about application of PLC
CO3	To get basic knowledge about computer-controlled systems
CO4	To get basic knowledge on the architecture and local control unit of Distributed Control

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

PROGRAMMABLE LOGIC CONTROLLER: Evolution of PLCs, Components of PLC, Architecture of PLC, Discrete and analog I/O modules, Programming languages, Ladder diagram, Function block diagram (FBD), Programming timers and counters

APPLICATIONS OF PLC: Instructions in PLC, Program control instructions, math instructions, data manipulation Instructions, sequencer and shift register instructions, Case studies in PLC

COMPUTER CONTROLLED SYSTEMS: Basic building blocks of computer-controlled systems, Data acquisition system, Supervisory control, Direct digital control, SCADA: Hardware and software, Remote terminal units, Master Station and Communication architectures.

DISTRIBUTED CONTROL SYSTEM: DCS, Various Architectures, Comparison, Local control unit, Process interfacing issues, Communication facilities

Learning Resources:

Text Books:

1. Programmable Logic Controllers, F.D. Petruzella, Tata Mc-Graw Hill, 3rd edition, 2010
2. Distributed Control Systems: Their Evaluation and Design, Michael P. Lukas, Van Nostrand Reinhold Co, 1st Edition, 2016.

Reference Books:

1. Programmable Controllers, T.A. Hughes, ISA press, 4th edition, 2005
2. Computer Based Industrial Control, Krishna Kant, Prentice Hall of India, New Delhi, 2nd edition, 2010.
3. Programmable Logic Controllers, John W. Webb and Ronald A. Reis, Prentice Hall of India, 5th edition, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105063/
2. http://glomacs.com/online-training/distributed-control-systems-

Course Code: PH6221	LUMINESCENCE MATREIALS AND DEVICES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the luminescence phenomenon in bulk and nanoforms.
CO2	Explain the basic principles of phosphors at lower dimensions.
CO3	Gain insight into the fundamentals of photometry and colorimetry.
CO4	Analyze the structures of typical inorganic pc-LEDs and their characteristics
CO5	Comprehend the device physics and strategies of making white-LEDs

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	1	1
CO2	3	1	2	3	1	1
CO3	2	3	3	2	2	3
CO4	3	1	2	2	2	2
CO5	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, 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, 1st Edition, 2003.

Online Resources:

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

Course Code: PH6417	SUPERVISORY CONTROL AND DATA ACQUISITION	Credits 3-0-0: 3

Pre-Requisites: DAS (PH5457)

Course Outcomes:

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

CO1	Introduction to industrial automation
CO2	Understand basic concepts of PLC and develop application programs.
CO3	Identify and interpret the functionality of DCS and various elements of SCADA
CO4	Understanding the SCADA software
CO5	Hands-on experience with SCADA hardware

Course Articulation Matrix:

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

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

Syllabus:

Introduction to SCADA: Definition of SCADA, Application area of SCADA, Major elements of SCADA, Advantages, and disadvantages of SCADA, Comparison of SCADA, DCS, PLC, and Smart Instrumentation

Real-time systems: Definition and Introduction of real-time control, Real-time control for Continuous process communication Access and Master-Slave concept, Determination of Scan Interval,

SCADA Software: SCADA software components, Concept of FBD technique, Comparison of centralized and distributed processing, HDLC Protocol

SCADA Hardware RTU: Remote Terminal Unit (RTU), Structure of RTU, CPU, Analog I/O, Pulse I/P, Digital I/Os, Communication Interface, Power supply, RTU Rack and Enclosure, Test and maintenance of RTU, Requirements for RTU system, ANSI/IEEE C37.1 Protocol

SCADA Hardware MTU: Master Terminal Unit, Hardware structure, Functions of MTU, Configuration of MTU, Redundant MTU system

Learning Resources:

Text Books:

1. Mini S. Thomas, John Douglas McDonald, Power System SCADA and Smart Grids, 3rd Edition, CRC Press, 2015
2. K S Manoj, Industrial Automation with SCADA: Concepts, Communications and Security, 1st Edition, Notion Press, 2019

Reference Books:

1. Rajesh Mehra, Vikrant Vij, PLCs & SCADA - Theory and Practice, Laxmi Publications Private Limited, First edition, 2017
2. R. G. Jamkar, Industrial Automation Using PLC SCADA & DCS, Global Education Limited, Second Edition, 2018

Online Resources:

1. https://nielit.gov.in/calicut/content/online-course-industrial-automation-plc-scada
2. https://www.computerworld.com/article/2587586/scada-resources.html
3. http://plcs.net/

Course Code: PH6201	DIGITAL SIGNAL PROCESSING	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Find DFT of a given signal through Fast Fourier Transform Techniques
CO2	Designs FIR and IIR type digital filters using transformation techniques
CO3	Identifies various structures and their realisations for Digital Filters
CO4	Understands the concepts of Finite Word Length Effects and Errors in Digital Filters
CO5	Apply Z-Transform for the analysis of Discrete-Time signals and Systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Fundamentals of Signals and Systems: Signals, Systems, Properties, Convolution, Time domain and Frequency domain analysis Signals, Continuous time Fourier Transform and Discrete Time Fourier Transform-Examples.

The Z Transform: Introduction-Definition of Z Transform, Z- Transform and ROC of Finite and Infinite duration sequences, ROC and properties, properties of Z- Transform, Inverse Z-Transform-Partial Fraction Expansion, Long Division and Residue methods-Exa mples.

Discrete Fourier Transform: Introduction, Properties of Discrete Time Fourier Series, Definition of DFT and its Inverse, Direct evaluation of DFT and IDFT, Matrix Relation for computing DFT and IDFT (DFT as a Linear Transformation), Properties of DFT, Useful DFT Pairs, Circular Convolution, Filtering Long Duration Sequences- Overlap and ADD- Overlap and Save Methods-Examples.

Fast Fourier Transform: Introduction-The Fast Fourier Transform, Decimation in Time Algorithm, Butterfly Diagrams, Summery Steps of Radix-2 DIT-FFT Algorithm, Decimation in Frequency Algorithm, Summery Steps of Radix-2 DIF- FFT Algorithm and Butterfly Diagrams, Differences between DIT and DIF Algorithms, IDFT using FFT algorithms, Frequency analysis of signals using DFT.

Design of IIR Filters: Introduction, Analog Filter Specifications, Classification of Analog Filters, Classification of Analog Filters, Butterworth Filters, Frequency Transformations and Special Transformations, Design of Low Pass Butterworth Filters, Chebyshev Filters, Digital

Filters-Backward Difference Method, Bilinear Transformation, Impulse Invariant Transformation and matches Z-Transform Design-Analog Design using Digital Filters, Advantages and Disadvantages of IIR Filters, Examples.

Design of FIR Filters: Introduction-Linear Phase FIR Filters, Frequency Response of Linear Phase FIR Filters, Location of Zeros of a Linear Phase FIR Filters,The Fourier Series Method of Designing FIR Filters, Desidn of FIR Filters using Windows, Frequency sampling Method of Designing FIR Filters, Equiripple Filters, Examples.

Learning Resources:

Text Books:

1. Digital Signal Processing-Principles, Algorithms and Applications, John G. Proakis, Dimitris G.Manolakis, PHI, 4th Edition, 2006.
2. Digital Signal Processing – A Computer Based Approach, Sanjit K. Mitra, Tata Mc Graw Hill, 3rd edition, 2007.

Reference Books:

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

Online Resources:

1. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/
2. https://nptel.ac.in/courses/108/106/108106151/

Course Code: PH6224	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: 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 Physicists: AI for optical communications, quantum communications, Quantum Computing, Particle Physics and Cosmology. Outlook and challenges.

Learning Resources:

Text Books:

1. Artificial Intelligence: A Modern Approach, S. J. Russell and P. Norvig, 3rd Edition, 2010.
2. MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, Phil Kim, Apress, 1st Edition, 2017.

Reference Books:

1. Deep Learning, I. Goodfellow, Y. Bengio & A. Courville, MIT Press, 1st Edition, 2016.
2. Data Science from Scratch, J. Grus, O'Reilly Media, 2nd Edition, 2019.

Online Resources:

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

Course Code: PH6403	ANALYTICAL INSTRUMENTATION LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Demonstrate an understanding of the analytical methods of characterization.
CO2	Differentiate and Identifies suitable instruments for analysis of different kind of chemical compounds, thin films, and nanostructures.
CO3	Design experiments, records observations and analysing data for estimating the desirable parameters and material property.
CO4	Comprehend the working principle, perform experiment and method calibration.
CO5	Distinguish the structural, optical, spectroscopic and thermal analytical techniques

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. X-Ray Diffraction
2. Electron Diffraction (ED)
3. Transmission Electron Microscope (TEM)
4. Scanning Electron Microscope (SEM & EDAX)
5. UV-Vis-Absorption and Transmittance Spectroscopy
6. Infrared (IR) Spectroscopy
7. Photoluminescence (PL) Spectroscopy
8. Thermo-analytical Techniques

Learning Resources:

Text Books:

1. Instrumental methods and analysis, Willard. Merrit, Dean, D. Van. Nostrand CBS Publication, New Delhi, 7th edition, 2012.
2. Analytical Instrumentation, R.S. Khandpur, McGraw-Hill Education Private Limited, 2nd Edition.2006

Reference Books:

1. Principles of Instrumental Analysis, Douglas. A Skoog , F. James Holler , Stanley R. Crouch, Cengage Learning, 7th edition, 2017.

2. Process Measurement and Analysis, B.G. Liptak, CRC Press, 4th edition, 2003.
Instrument Technology, E.B. Jones, Butterworth Scientific Publications, 3rd edition,1974.

Online Resources:

1. https://jordilabs.com/lab-testing/techniques/
2. https://tdx.cat/bitstream/handle/10803/8595/13.pdf?sequence=

Course Code: PH6404	PROCESS INSTRUMENTATION LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Apply the identification concepts for systems.
CO2	Design controllers for non-interacting systems.
CO3	Identify and control nonlinear processes.
CO4	Design controllers for time delay processes.
CO5	Design controllers for cascade processes.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Transfer function models
2. Second Order System (Non-Interacting Tanks)
3. Second Order System (Interacting Tanks)
4. Temperature level control unit.
5. Servo and regulator operation.
6. Process tuning – Process reaction curve method.
7. Process tuning – continuous and damped oscillation method.
8. Input convertor – Pneumatic actuator.
9. Input convertor – Hydraulic actuator.
10. Feed forward control systems
11. Multi loop control systems – Ratio Control.
12. Multi loop control systems – Cascade Control.

Learning Resources:

Text Books:

1. Process Dynamics and Control, Seborg, D. E., Edgar, T. F., Millechamp, D. A., Doyle III, F. J., Wiley, 3rd edition, 2014.
2. K. Ogata, Discrete Time Control Systems, Prentice Hall, 2nd Edition, 1995.

Reference Books:

1. Chemical Process Control: An introduction to Theory and Practice, Stephanopoulos, Prentice Hall, 1st Edition, 1999.
2. Process Control, Liptak B.G., Chilton Book Company, Pennsylvania, 3rd edition, 1995.
3. Process control, Pollard A., Heinemann Educational Books, London, 1st Edition, 1971.

Online Recourses:

1. https://www.udemy.com/course/introduction-to-process-control-and-instrumentation/
2. https://nptel.ac.in/courses/103/103/103103037/