Scheme and syllabus effective from session 2014-15

Name of the M.Tech. Programme		**Optical Engineering**	
Distribution of Total Credits			
Program Core (PC)	Program Elective (PE)	Open Elective (OE)	**Total Credits**
74	14	0	**88**

Scheduling of Courses

Semester I

S.No.	Course No.	Title	Type	L-T-P	Credits	Internal	External
1.	PHL-701	Digital Image Processing	PC	3-1-0	3	30	70
2.	PHL702	Optical Materials and Thin Films	PC	3-0-0	3	30	70
3.	PHL703	Laser Engineering	PC	3-0-0	3	30	70
4.	PHL704	Optical Instrumentation	PC	3-0-0	3	30	70
5.	PHL705	Integrated Optics and Information Technology	PC	3-0-0	3	30	70
6.	PHL-706	Optical Fibers, Components and Devices	PC	3-0-0	3	30	70
7.	PHP707	Optics Laboratory-I	PC	0-0-6	3	30	70
8.	PHP708	Optical Workshop	PC	0-0-6	3	30	70
		Total Credits			24		
Semester II							
1.	PHL711	Multispectral and Infrared Imaging	PC	3-0-0	3	30	70
2.	PHL712	Nonlinear Optics	PC	3-0-0	3	30	70
3.	PHL713	Optical and Optomechanical System Design	PC	3-0-0	3	30	70
4.	PHL714	Optical Fiber Communication and Network	PC	3-0-0	3	30	70
5.	PHL***	Programme Elective-1*	PE	3-0-0	3	30	70
6.	PHL***	Programme Elective-2*	PE	3-0-0	3	30	70
7.	PHP717	Optics Laboratory-II	PC	0-0-6	3	30	70
8.	PHP718	Laser Engineering and Photonics Laboratory	PC	0-0-6	3	30	70
		Total Credits			24		
Semester III							
1.	PHL***	Programme Elective- 3*	PE	4-0-0	4	30	70
2.	PHL***	Programme Elective-4*	PE	4-0-0	4	30	70
3.	PHD723	Project-I	PC	0-0-24	12	30	70
		Total Credits			20		
Semester IV							
1.	PHD731	Project –II	PC	0-0-40	20	00	100
		Total Credits			20		

*List of Program Electives

S.No	Course No.	Title	L-T-P	Credits		
I.	PHL715	Quantum Optics and Quantum Computation	3-0-0	3	30	70
II.	PHL716	Guided Wave Optical Components and Devices	3-0-0	3	30	70
III.	PHP721	Nano Photonics	3-0-0	3	30	70
III.	PHL722	Ocean and Atmospheric Optics	3-0-0	3	30	70
IV	PHL723	Photolithography and Diffractive Optics	3-0-0	3	30	70
V.	PHP724	Advanced Optical Workshop	0-0-6	3	30	70
V	PHL725	Semiconductor Optics	3-0-0	3	30	70
VI	PHL726	Biomedical Optics and Biophotonics	3-0-0	3	30	70
VII	PHL727	Space Science and Astro Optics	4-0-0	3	30	70
VIII	PHP 728	Photonics Laboratory	0-0-8	4	30	70
Ix	PHL 729	Ultra Fast Photonics Networks	4-0-0	4	30	70
X	PHL 730	Ultra Fast Lasers	4-0-0	4	30	70
XI	PHL 731	Laser Spectroscopic Techniques	3-0-0	4	30	70
XII	PHL 732	Machine Vision	3-0-2	4	30	70
XIII	PHL-733	Advanced Optical Communication system	4-0-0	4	30	70
XIV	PHL-734	Information Optics	4-0-0	4	30	70
XV	PHL-735	MEMS Technology	4-0-0	4	30	70

Programme Electives are offered as per availability of specialist faculty members (PHL715-727 in IISem & Rest in III Sem)

Detail Syllabus of Courses of Studies

PHL 701 – Digital Image Processing Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

2-D Signals and Systems -Discrete-space signals, Sampling and quantization, Linear shift-invariant systems, Fourier transform;2-D z-Transform –Definition ,Difference equations;. Discrete Fourier Transform- Derivation of DFT, Discrete cosine transform, Fast Fourier transform.
Digital Images and basic image processing-Arithmatic Image Processing.
Filter Design-Window method,Frequency sampling method, Frequency tansformation method, Fourier techniques, Maximum likelihood method, Autoregressive modeling.Image Perception Luminance, hue, and saturation.Color representation,
Image Enhancement- Linear Mapping, Clipping, Thesholding, Negation, Histogram modification, Linear filtering, Nonlinear filtering, adaptive filtering ,Pseudocolor.
Image Restoration- Degradation models. Wiener filtering, Inverse filtering, Blind deconvolution.
Image Compression- Scalar quantization, Vector quantization, Spatial coding, Transform coding

References:

Digital Image Processing, 2nd Ed, R. C. Gonzalez and R. E. Woods, Addison-Wesley, 2002
Fundamentals of Digital Image Processing, Anil K. Jain, Prentice-Hall, 1989
Digital Image Processing, by Sarp Ertürk , National Instruments Corporation,2003

PHL-702 – Optical Materials and Thin Films Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Microscopic properties of optical materials: optical constants, Dispersion equation, optical constants n and k, Fresnel equations, Scattering, polishing, surface roughness, Ge, Si Glasses, multicomponent glasses, properties of fluoride and chalcogenide Glass , Experimental methods to measure of Refractive Index, Dispersion and spectral Transmittance of optical materials:

Reflectance, transmittance, and absorption in thin films. Anti-reflection coatings, Mirror and beam splitter coating, Edge and Band pass Filters, thin film materials

Production methods: Operational principles of various mechanical pumps as well as limitations, Various Deposition Techniques for Optical Thin Film Dispositions. Optical Structure in Thin Films, Spectrophotometers and ellipsometers

Reference:

1) Thin-Film Optical Filters by HA Macleod (Adam Hilger Ltd.)
2) Hand Book of Physical Vapor Deposition ,

PHL: 703 LASER ENGINEERING **Max.Marks:70(Major Exam.)**

(7 questions are to be set out of entire syllabus in uniform manner. The students are required to attempt any 5)

Basics of lasers principles like stimulated Emission, Einstein Coefficients, Concept of resonant cavity, Rate equations and conditions for population inversion, Laser Threshold, Schawlow and Townes treatment for cavity modes, Different resonator geometries, Optical pumping schemes, Cavity modes, Transverse and longitudinal modes , Gaussian Beam characteristics, , Beam waist, Q switching, CW and Pulsed lasers , Mode Locking , Line width and broadening mechanisms, M^2 value, Common laser systems (He-Ne-, Nitrogen laser, Nd: YAG, Erbium doped fibre laser, Argon ion laser, Copper vapor laser, color centre lasers)

Tunable Dye lasers , Standing wave and Ring Dye lasers. Advanced laser systems like Excimer (with different wave lengths), X-ray laser, Free Electron Lasers, Ti_Sapphire (Femto second). Optical parametric Oscillators (OPO) Autocorrelation and Cross correlation, Disc lasers, Semiconductor lasers, double heterostructure and quantum well lasers and quantum Dots, VCSEL, DBR and DFB lasers.

References:

1. Principles of lasers by O Svelto and David C Hanna

2. Laser fundamentals by William T Silfvast

PHL:704 -Optical Instruments

Max.Marks:70(Major Exam.)

(7 questions are to be set out of entire syllabus in uniform manner. The students are required to attempt any 5)

Eye , Introduction to microscopy – Fundamentals, Objectives, Reflective objectives Illumination, Tube lens Stereo microscopes Phase contrast microscope Eyepieces Differential interference contrast microscope, Polarization microscope, Fluorescence imaging systems Telescopes- Fundamentals Refracting telescopes Reflecting telescopes Tilted-component telescopes, Large telescopes

Photographic systems- History Film and image sensor Photographic lenses Zoom lenses Digital camera , Displays – Projection displays Pico projector Digital cinema,3D display

Spectral imaging systems Optical configurations Raster scanning Line scanning Applications

Optical Coherence Tomography (OCT),Fourier-domain OCT (FD-OCT) , Confocal system - ,Confocal scanning systems ,Scanning systems , Relay optics , Fiber-optic confocal imaging systems , Endoscope, Wireless endoscopes Lithographic systems, Performance of lithographic lenses, Evolution of lithographic lens systems

References:

1. Optics and Optical Instruments: By B.K.Johnson(Dover)
2. Basic Optics and Optical Instruments: Bureau of Neval Publications(Dover)
3. Handbook of Optics: McGraw Hill Publications
4. Optical Shop Testing: By D. Malacara

PLL 705: Integrated Optics and Information Technology, Max.Marks:70 (Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner. The students are required to attempt any 5)

Introduction to Integrated optics and photonics, Theory of optical devices: Diode laser sources, waveguides, photo detectors. Modulations of these devices. Review: Maxwell equations and boundary conditions, Different type of optical waveguides, effective index method, gain and index guidance in semiconductor laser, loss and gain in wave guides, coupled mode theory, directional semiconductor quantum well lasers in Integrated optics,

LED structure, different Electro-optical phase and amplitude modulators, electro absorption modulators, Mach-Zehnder ,integrated laser modulator, DBR devices, Various types of diode lasers, DFB, DBR, VCSEL, tunable lasers

Optical components of Integrated optics , rectangular wave guides , channel waveguides , Y-junction , Bi-Directional coupler , Ring resonators ,Waveguide grating , Wavelength filters and switches , scramblers, Input –output couplers, direct, butt, prism, grating and tapered couplers Fibre in waveguide couplers, branching waveguide couplers
Active semiconductor components: Diode Lasers, Detectors

Reference:
Photonics, by Iizuka,
Integrated Optics, Hansperger, Spinger Verlag
Semiconductor Opto-Electronics, B Bhattacharya

PHL-706: Optical Fibers, Components and Devices , Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Optical fibres: Geometry of Fiber Structure, Propagation in Fiber – Geometrical optics approach, Wave theory approach;; Fiber loss mechanisms and bandwidth; Fibre dispersion mechanisms. Manufacturing issues: Fiber Fabrication, component design, integrated automation and packaging; Measurement of fiber characteristics: Measuring Dispersion and polarization properties, Optical Time Domain Reflectometry

Application of optical fiber in communication and illuminations, optical networking, optical fiber based TV networking and other fields. Components for Fiber Technology: Cable structure, Preparation of Fiber Ends, Connections, Spectral Manipulation, Polarization manipulation, Isolator, Circulators, Power launching and coupling-Couplers/Direction Coupler, Light Sources and Receivers. Light Guides and illumination devices. WDM components: Fabry Perot and Bragg gratings, Multilayer dielectric thin film filters, Mach-Zehnder interferometers, multiplexers, Optical amplifiers: Semiconductor amplifiers, Erbium-doped fiber amplifiers, Raman amplifiers. Fiber optic sensors-Chemical, Structural strain and temperature measurements.

References:

1. Fiber Optics: Physics and Technology, by Feder Mitschke, Springer(2009)
2. Optical Fiber Communication , by Gerd Keiser (Mc Graw Hill)
3. Optical Networking &WDM by Walter Goralski, Tata McGraw Hill (2001)

PHP-707 – Optics Laboratory-I **Max.Marks:70(Major Exam.)**

(Any 7 experiments are to be minimum done)

Lab 1- Cleaning Optics and Data Analysis
- Basic Mechanical Measurement Techniques, Proper Cleaning of Optical Elements.

Lab 2- Refractive Index and Snell's Law:
- Total Internal Reflection, Pfund's Method, Microscope Method, Deviation by a Plane Parallel Plate

Lab 3- Reflection, Polarization by reflection, Brewsters angle

Lab 4- Prisms:
Deviation (Right Angle Prism, Porro Prism, Porro-Prism Combination, Amici Prism, Penta Prism, Dove Prism, Cube Corner)

Lab 5- Determination of numerical aperture of objectives

Lab 6- Ideal Imaging
- Pinhole Imaging, Lens Imaging, Image Quality, F-number, Depth of Focus

Lab 7- Thin Lenses
- Object-image Relationships, Method of Conjugates, The Spherometer, Double Pinhole Method, Autocollimation, Determination of focal length

Lab 8- The Eye
- Anatomy and Geometrical Optics of the Human Eye, Refractive Error, Light Response, Accommodation, Blind Spot, Dissection of Animal Eyes

Lab 9- Thick Lenses I
- The Nodal Slide, Measurement of Cardinal Points

Lab 10- Gaussian Reduction—The Telephoto Lens
- Gaussian Reduction of Multiple-lens Systems, Cardinal Points using the Nodal Slide

Lab 11- Thick Lenses II
- Newtonian Distance, The Focometer

Lab 12- The Camera Lens
- Cardinal Points using the Nodal Slide, Relation to the Camera Body and Film Plane

Lab 13- Radiometry—Throughput of the Camera Lens
- Throughput vs. F-number

Lab 14 –Polarization studies: Production and analysis of different polarizations

Lab: 15:- Experiments with Grating and Lloyd's mirror

PHP-708 – Optical Workshop **Max.Marks:70(Major Exam.)**

Study on optical material's homogeneity and other bulk properties ,Working of Machines in Optical Workshop: Slitting Machine, Trepanning Machine, Curve Generator, Centering and Edging machine. Making of optical flats, prisms, mirrors and lenses, Techniques and precautions in roughing, grinding and polishing of specialized optical materials. Experiments on Deposition of Thin Films .

Reference: Optical Production Technology by Horne

PHL-711: Multispectral and Infrared Imaging Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Image based remote sensing, Photogrammetric methods, Reflection spectroscopy of remote objects spectral properties of materials, hyper spectral imaging,Atmospheric interference in remote sensing, target–background Interactions, IR transmission, Atmospheric MTF, LOWTRAN codes, Sun glints, navy model, Contrast transmittance, turbulence and aerosols.

Imagers like track scanners, Scanner Imagery, push broom scanners and Line scanners, Modern systems like Common module system, SPRITE detector, MTF (Modulation Transfer Function) defenitions.

IR Imaging, Quatitative measurements like NEE, NEDT, MRTD and MDTD. Optical designs for scanning, IR sources and detectors,IR scanners like FLIR, Video trackers, Radiation sources (for illumination and thermal emission) for IR and Imaging,Target signatures and target identifications in defense applications, BLIP detectors
References

1. Electro-optical Imaging system performance by G C Holst
2. Thermal Imaging systems by J.M Lloyd
3. Infrared Technology Fundamentals by I J Spiro and M Schlessinger
4. Remote sensing by George Joseph

PHL-712 - Nonlinear Optics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Introduction to NLO : Change in optical properties or generation of new frequencies , classical expansion in powers of the field, induced polarization ,linear susceptibility, on-parabolic potential well ,nonlinear driving equation and perturbative solution ,Coupled Mode Equations, nonlinear polarizations, Maxwell's equations in Susceptibility Tensor, d-tensor terms of total polarization, simplifications, slowly varying amplitude approximation, coupled mode equations for SHG and for three wave interactions

Phase-matching, Type I and Type II phase-matching, uniaxial crystals and phase-matching directions, non-collinear phase-matching SHG & Three Wave Mixing conversion efficiency ,phase mismatch & coherence length, large conversion on phase match ,SHG , Optical phase conjugation, Phase conjugated mirror, Upconversion process. Introduction to Density matrix formulation

Optical Parametric Amplifiers and Oscillators, parametric gain length, OPO lasers NLO Materials, nonlinear refraction and absorption, Laser intensity induced refractive index changes and dynamic grating formation, two photon process, pump-probe, intensity-dependent refractive index, self-focusing and defocusing, bistability, Solitons, self-trapping, Four-Wave Mixing, and Mechanisms for NLR.

Reference:

- Nonlinear Optics 3rd edition, Robert Boyd (Academic Press)
- Principles of Nonlinear Optics , Ron Shen (Wiley)

PHL 713 Optical & Opto-Mechanical System Design Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Optical System Design: Gaussian theory of optical system, Ray Tracing: paraxial, finite and oblique/skew rays, Methods of evaluating image quality Image evaluation, Spot Diagram, OPD plot, OTF/MTF and Strehl ratio, Aberrations: Transverse ray and wave aberrations, chromatic aberration, wave aberration function and variance of wave aberration function. Optimization techniques in lens design: Definition of merit function commonly used optimization methods, orthonormalization and global search method. Design Tolerances and Budgeting
Case Studies: Design of Singlet, doublet, triplet, symmetrical lens system and their tolerances, eye piece, wide angle lens, high NA optics.
Opto-Mechanical System Design: Opto mechanical design process, Environmental influence, Opto-Mechanical characteristics of materials; mounting individual lenses, mounting multiple lenses, mounting small mirrors and prisms, mounting windows, filters, light weight, non-metallic mirror mount design, Mounting Large Mirrors.
References:

1.Modern Optical Engineering: By W.J.Smith
2.The Art and Science of Optical Design: R.R.Shannon
3.Modern Lens Design: W.J.Smith
4.Opto-Mechanical System Design: P.Yoder

PHL 714: Optical Fiber Communication and Network Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Basic concepts and components of optical fiber systems:- Optical fiber-Geometrical optics description of SI&GI fibers: Maxwell's equation, wave equation of propagation; Fiber loss: Attenuation and dispersion induced Limitations, Nonlinear optical effects and its use in compensation of other losses: stimulated scattering, nonlinear refraction and four wave mixing.
Transmitters and Receivers: Light Sources and Detectors, Modulation/Demodulation, Transmitter design, optical receiver design, receiver noise, receiver sensitivity, sensitivity degradation; High speed EO devices and detection mechanism optical transmitter for high speed long distance communication, modulation response and laser noise.
Optical Link Design: System Considerations, Link Power Budget, Rise-Time Budget, Line Coding. Optical Networking and Switching: General Network Concepts, SONET/SDH, Optical Ethernet, Network Management, WDM light wave systems. WDM components, system performance Issues, Optical Amplifiers, Er-doped Fiber Systems,
References:

1) Optical Fiber Communication System by G.P.Agrawal, (Wiley International)
2) Nonlinear Fiber Optics, by G.P.Agrawal (Acad. Press)
3) Optical Communication Essentials by Gerd Keiser ,Tata McGraw Hill(2008)
4) Optical Fiber Comminication , by Gerd Keiser (Mc Graw Hill)

PHL 715: Quantum Optics and Quantum Computation

Max.Marks:70(Major Exam.)

(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Quantum mechanical understanding of light: Interaction of radiation with matter, Quantization of electromagnetic energy, Fluctuations of the electromagnetic field, Coherent states of the radiation field, Light Detectors, Spontaneous emission, Beam splitting ,Self Interference of Photon. Interference of independent photons, Photon statistics, squeezed sate of light, Measurement of Distribution Function.
Qubits and Quantum States, Quantum measurement theory, Entanglement, Quantum Gates and Circuits, Quantum Algorithms, Applications of Entanglement, Teleportation and Superdense Coding, Quantum Cryptography, Quantum Noise and Error Correction

References:

1) Introduction to Quantum Optics by Harry Paul (Cambridge)
2) Quantum Computation Explained by David McMahon (Wiley)

PHL 716 – GUIDED WAVE OPTICAL COMPONENTS AND DEVICES

Max.Marks:70(Major Exam.)

(7 questions are to be set out of entire syllabus in uniform manner. The students are required to attempt any 5)

Single-mode fiber designs , Recent development of polymer optical fiber and its applications: Microstructured optical fibers: Photonic Bandgap Bragg fibers: Radial effective index method for the analysis of microstructured fibers: Some important nonlinear effects in optical fibers
Fiber-optic parametric amplifiers for lightwave systems ; Erbium doped fiber amplifiers: Fiber-optic Raman amplifiers: Application of numerical analysis techniques for the optimization of wideband amplifier performances: Analog and digital transmission using high-power Fiber amplifiers: Optical amplifiers for dynamic optical networks: Fused fiber couplers: Fabrication, Modeling, and Applications: Side-polished evanescently coupled optical fiber overlay devices: Fiber gratings : Enhancing photosensitivity of optical fibers
Solitons in fiber Bragg gratings: Advances in DWDM multiplexing/demultiplexing Technologies,Dispersion tailored higher order mode fibers for in-line fiber photonic devices ,Principles of fiber optic sensors, Structural strain and temperature measurements using FBG sensors

References :

1) Guided Wave Optical Components and Devices- Ed.by **Bishnu Pal,(**Elsevier)
2) Foundations for guided-wave optics / by Chin-Lin Chen , John Wiley & Sons

PHP-717 – Optics Laboratory-II **Max.Marks 70**

Lab 1- Multiple Lens Systems—The Zoom Lens

· Paraxial design of a simple two-lens zoom system. SLR camera zoom lens.

Lab 2- Aberrations

· Chromatic Aberration, Spherical Aberration, Coma, Distortion

Lab 3- The Simple Magnifier, Eyepieces

· Magnification of a Simple Magnifier, Optical Properties of Various Eyepieces

Lab 4- Refracting Telescopes Afocal Systems, Galilean and Keplerian Designs, Angular Magnification, FOV, Vignetting, Field and Relay Lenses.

Lab 5- Optical Comparator—Reverse-engineering of a Keplerian telescope with a reticle. Complete Prescription Entered into CODE V or ZEMAX.

Lab 6- Reflecting Telescopes

· Optical Properties of a Maksutov Telescope (individual mirrors and as a system), Angular Magnification, Focal Length, FOV, Entrance and Exit Pupils

Lab 7- The Reverse Galilean Telescope—Door Peephole Viewer

· Reverse-engineering of a Reverse Galilean telescope. Complete Prescription Entered into OSLO or ZEMAX.

Lab 8- The Compound Microscope

· Magnification of the objective, the eyepiece and the overall system. Telecentricity, Commercial Microscopes.

Lab 9- Optical Materials and Dispersion I

· The Prism Spectrometer (optical layout and alignment), Dispersion Curves (comparison to theoretical data).

Lab 10- Optical Materials and Dispersion II

· The Abbe Refractometer (optical layout of the instrument), Total Internal Reflection, Measuring Unknown Samples.

Lab 11-Binoculars

· Reverse Engineering of Commercial Binoculars, Complete Prescription Entered into OSLO or ZEMAX

Lab 12-Feazeau Interferometers

Lab-13- Michelson Interferometer in Testing of Optical Components

Lab-14 Spatial Filtering Experiments

PHP-718 – Laser Engineering and Photonics Laboratory Max.Marks: 70

List of topics

Lab1: Characterization on laser diode , diode characteristics

Lab2. Gaussian beam stiudeus bewam waist

Lab3: Michelson interferometer

Lab4. Freshnal diffaction at circular

Lab5. Fraunhoffer diffaction at circular

Lab 6: Cornus Spiral

Lab7: Speckle Interferometery

Lab 8: Techniques in Holography

Lab 9: MTF and its demo

Lab10: Fresnel Zone plates

Lab.11 : Kerr effect

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PHL721 – Nano Photonics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Introduction and overview (zoo of nanostructures, what is nanophotonics), Preparation and Review (Maxwell Equations, Quantum Mechanics, Optics) ,Light generation by nanostructures (semiconductor quantum wells, wires, dots, nanocrystals, nanowires), Light propagation in nanostructures (nanowires, nano-waveguides)
Combining emission and propagation: Nanolasers (laser basics, nanowire lasers),Photonic crystals (Maxwell equations and dielectric periodic structures),Surface plasmas (propagation at metal-dielectric interfaces, transmission through sub wavelength hole, sub wavelength waveguides),Near-field optics

Reference :

- Principles of Nano-Optics, by Lukas Novotny and Bert Hecht
- Nanophotonics, by Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson
- Surface Plasmon Nanophotonics, by Mark L. Brongersma, Pieter G. Kik
- Nanophotonics, by P.N. Prasad
- Photonic Crystals, by John D. Joannopoulos, Robert D. Meade, Joshua N. Winn

PHL722 – Ocean and Atmospheric Optics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Light and Radiometry, Overview of IOPs, AOPs, and the RTE (CR), Absorption physics; overview of absorption spectra for water, CDOM, NAP, phytoplankton, etc (CR), Physics of elastic and inelastic scattering, volume scattering and phase functions; scattering by water constituents (CM), Beam attenuation and its spectra, Intro to ocean color satellite remote sensing and basic atmospheric corrections for remote sensing, Calibration and validation of satellite data, Calibration and validation of satellite data, Deployment strategies for different optical sampling platforms, Primary production, optical and remote sensing models.

Optical effects caused by the interaction of sunlight with atmospheric gases, clouds or aerosols ,Solar and terrestrial radiation , Scattering and absorption of solar radiation in the atmosphere, Atmospheric instrumentation ,Measurement of the direct component, Measurement of diffuse and global radiation, Measurement of ultraviolet radiation, Measurement of polarization ,Measurement of sunshine duration, Measurement of terrestrial radiation, Other optical instruments used in atmospheric studies.

References

1. Atmospheric and Ocean Optics – by G.A. Zubcov, Institute of Atmospheric Optics (2005)
2. Ocean Optics by Martin A. Blizzard, SPIE(1988)

PHL723 – Photolithography and Diffractive Optics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Basics of lithography, Optical Systems used in Lithography, Advantages and limitations of photolithography, Case study of a photolithographic lens system

Diffractive Optics: Two-dimensional Fourier analysis, Diffraction theory, Fresnel and Fraunhofer approximations, Fourier transforming properties of lenses, Transfer functions, Image formation with coherent and incoherent light, Transform functions of imaging systems

Diffractive Optical Elements (DOE): Design and fabrication of DOE, Comparison of holographic optical element and diffractive optical elements. DOE with Sinusoidal, binary, or other grating profiles. Photoresist on silica, etched silica as substrate materials for DOE, High diffraction efficiency DOE, Application of DOE in Beam splitting, Machine vision systems, Multiple imaging, Spectrometry, Beam sampling, Metrology

References:

1. Diffractive Optics for maskless lithography and imaging by Rajesh Menon, MIT Press
2. Principles of Optical Lithography by Herry J . Levinson, SPIE Press

PHP 724-Advanced Optical Workshop Max.Marks:70

Making of Large Dimension Optics: Study of Specific Material requirements for large optics. Roughing, Grinding and Polishing of Large Optical Surfaces. Testing of large optical surfaces Generation of Aspheric surfaces. Single Point Diamond Machining. Charcterisation of aspheric surfaces.
Optical Thin Film Coatings : Deposition of Metals by Physical Vapor Deposition , Sputtering and Spin Coaters. Deposition of Metals and Dielectric single and Multilayer by Physical Vapor Deposition , Sputtering and Spin Coaters.
Use of Optical and other profilers for chacterization of optical surfaces. Measurement of various optical parameters. Fabrication and Testing of IR and UV Optics

Refrerences

1. Advanced optics using aspherical elements / B. Braunecker, R. Hentschel, H. Tiziani, SPIE
2. Field Guide to Optical fabrication by Ray Williamson, SPIE

PHL725 –Semiconductor Optics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Materials for Optoelectronics: Structural Properties, Light propagation in dielectric media ,Light propagation in waveguide, Characterization of semiconductor optical properties, Light detection and imaging, Optical Properties of Phonons, Optical Properties of Plasmons, Plasmon-Phonon Mixed States and of Magnons.

Optical Properties of Intrinsic Excitons in Bulk Semiconductors, Optical Properties of Bound and Localized Excitons and of Defect States, Optical Properties of Excitons in Structures of Reduced Dimensionality, Excitons Under the Influence of External Fields, From Cavity Polaritons to Photonic Crystals

Review of the Linear Optical Properties, High Excitation Effects and Nonlinear Optics, The Intermediate Density Regime, The Electron–Hole Plasma, Stimulated Emission and Laser Processes, Time Resolved Spectroscopy, photo luminescence in semiconductors

References:

1. “Optoelectronics: An introduction to materials and devices”, J. Singh, McGraw-Hill
2. “Semiconductor Optics”, Claus Klingshirn (Springer).

PHL726 - Biomedical Optics and Biophotonics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Basic principles of optical imaging and spectroscopy systems, Light-Tissue interactions, index of refraction, reflection, absorption, scattering, fluorescence.Optical properties of tissues, Fiberoptics, optical endoscopes and clinical applications.

Compound microscopes: bright field, darkfield, Zernicke phase contrast, differential interference contrast, polarization, fluorescence. Advanced microscopes: confocal, multiphoton and non linear interactions, Fluorescence techniques in biology and medicine: reporters, lifetime, FRET. Dynamic light scattering and its uses. Flow cytometry

Super resolution and Near-field imaging systems. Optical coherence tomography. Diagnostic spectroscopy and optical coherence tomography of tissue: absorption, scattering, diffusion, fluorescence, Raman. Optical biosensors and optical tweezers

Ref: 1. Biomedical Optics -by L.V. Wang & H. Wu , John Wiley and Sons

2. Laser Light Scattering –by Bengamin Chu, Dover Publications

PHL 727: Space Science and Astro Optics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Telescopes:Types of telescopes. Design and construction of a simple Optical telescopes. Schmidt telescopes. Sky charts and their importance. Solar telescopes.

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

Photometry and Spectroscopy:Astronomical photometry. Simple design of an astronomical photometer. Observing technique with a photometer Correction for atmospheric extinction. Tansformation to a standard photometric system. Astronomical spectroscopy. Spectral classification. Simple design of astronomical spectrograph. Radial velocity measurements.

REFERENCES

1. C.R.Kitchin: Astrophysical Techniques.
2. Gordon Walker: Astronomical Observations - an Optical Perspective (Cambridge University press).
3. Henden and Kaitchuck: Astronomical Photometry.
4. Astrophysics-Stars and galaxies by K.D.Abhyankar.
5. C.R.Miczaika and W.M.Sinton: Tools of the Astronomers
6. W.A.Hiltner (Ed): Astronomical Techniques.
7. Carleton: Methods of Experimental Physics. Vol.XIIA.

PHP 728 - Photonics Laboratory Max.Marks.70

The goal of this course is help the students relate what they have learnt in classroom to what they can see in the lab of a variety topics related to photonics. In addition, it will take away the "fear factor" by providing experience of operating various equipment. The students will learn to establish good practices in experimentation including keeping a lab notebook, keeping the experiment station clean and to write lab reports of journal-manuscript quality/style.

List of topics

- LabView,
- Beam Propagation,
- Waveguides,
- Acousto-Optics,
- Electro-Optics,
- Liquid Crystal Display,
- Fiber Sensor,
- Fibre based Interferrometers
- Laser Diode,
- Fiber-Optic Link,
- Wavelength-Division Multiplexed System,

Simulation of Photonic Systems

References:

1. Fundamentals of Photonics by B. E. A. Saleh and M. C. Teich, Wiley, 1991.
2. Optical Electronics in Modern Communications by A. Yariv, Oxford, 5th Edition, 1997

PHL 729 – Ultrafast Photonics Networks Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Introduction to ultra high speed optical Transmission Technology, OTDM, Compensation of chromatic dispersion and PMD, Photonic crystal devices, PCF and novel devices of PC, semiconductor mode locked devices (lasers), ultra fast mode locked fibber lasers, ultrahigh speed LiNbO3 modulators, SOA and nonlinear fiber in optical signal processing, ultra fast photo detectors, electro absorption modulators, Fiber Bragg grating, Ultrafast optical technologies for large capacity TDM/WDM photonic , optical sampling Mach Zehnder Type All optical switches using interbband transition in QWs, optical fiber non linearities : an introduction,

References:

1. H.G Weber & M Nakazawa, Ultrahigh speed optical Transmission, Springer
2. Fiber optical communication systems, G P Agrawal, John wiley
3. Optical Fiber Communication, Keiser
4. Optical fiber telecommunications , Kaminov and Li, Vol IV –B, Academic Press

PHL 730 – Ultrafast Lasers **Max.Marks:70(Major Exam.)**
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Ultra fast lasers, ultra fast pulse characteristics, Pulse models, Pulse width measurements, Autocorrelation, cross correlation and FROG techniques to characterize pulses. Femto second laser systems, Ti-sapphire lasers, Pumping for femtosecond lasers, white light continuum generation
Pulsed semi conducting lasers, mode locking of ultrafast lasers, Different methods to produce ultrfast pulses, pulse compression, pulse stretching, regenerate Amplifier, Soliton laser, pulse generation without mode locking- DFDL as an example, colliding pulse mode locked Quantum well lasers, wave length tunability,
Erbium doped fiber lasers, Free space and fibre based femtosecond lasers, Optical parametric amplifiers, MOPO systems, Spectroscopic methods, Pump-Probe (Monocolor and two colour schemes) and Time resolved absorption.Uses of femtosecond lasers in Biomedical imaging and Quantum computing
Reference:
Femtosecond Laser pulse, C Rulliere (ed) Springer

PHL 731 – Laser Spectroscopic Techniques **Max.Marks:70(Major Exam.)**
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Laser spectroscopy Instrumentation, spectroscopy of gases, molecules, atom, Laser raman spectroscopy, Fluorescence, Absorption, Coherent Antistokes spectroscopy,
Spectroscopy of molecules, symmetry considerations and elements
Fluorescence spectroscopy, Absorption spectroscopy, Photoaccoustic spectroscopy, Optogalvanic spectroscopy, Doppler free spectroscopy, High resolution techniques, Optical pumping, Hanle effect, Hole burning, saturation spectroscopy, Ultra high resolution , Non linear techniques to produce high resolution.
Laser spectroscopy to study plasma state, scattering techniques for determining plasma temperatures, Laser light scattering, Static and dynamic light scattering, photon correlation techniques to study biological motion
Fluorescence life time measurements, Line broadening effects, Splitting of energy levels,
Two photon and multi photon spectroscopy, Laser Induced ionization spectroscopy.
IR spectroscopy of transient species
References

1. An Introduction to laser spectroscopy, David L Andrews and A A Demidov, Springer,
2. Laser Spectroscopy, W .Demtroder, Springer

PHL732 – Machine Vision **Max.Marks:70(Major Exam.)**
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

The nature of vision, Images and imaging operations, Object illumination basics, sequential and parallel operations, Basic image filtering operations, Thresholding techniques, Edge detection, Binary Shape analysis, Boundary pattern analysis; Line, circle, ellipse, hole and polygon detection; Abstract pattern matching techniques.

3-D Vision and Motion: Tracking the perspective n-point pattern, Image transformation and camera calibration. Automated visual inspection, Staistical pattern recognition, Texture, Image acquisition.

Practical on image acquisition and vision problems (LabVIEW, Matlab and other Platforms).

Reference:

1) "Machine Vision: Theory, Algorithms, Practicalities" 3rd Ed. by E.R.Davies (Elsevier)
2) Image Processing, Analysis and machine Vision by Sonka, Hlavac and Boyle 3rd Ed. (Thomson Press)

PHL733 – Advanced Optical Communication Systems **Max.Marks:70(Major Exam.)**
(7 questions are to be set out of entire syllabus in uniform manner . The students are required to attempt any 5)

Noise sources, channel impairments, and optical transmission system design principles. Advanced modulation formats, OFDM, polarization multiplexing, constrained coding, and coherent detection-Multilevel modulation schemes, Orthogonal frequency-division multiplexing (OFDM), Polarization multiplexing, Constrained (line or modulation) coding, Coherent optical communication systems..
Forward error correction (FEC), Self-coherent optical transport systems, High-bit-rate ETDM transmission systems:- Ultra-high-speed OTDM transmission technology.
Coded modulation schemes: Multilevel coding, Bit-interleaved coded modulation, and Coded OFDM.
Advanced chromatic dispersion compensation, Compensation of chromatic dispersion by OFDM, Advanced PMD compensation: Optical compensation techniques, Electrical compensation techniques ,Nonlinearity management-Compensation of intrachannel and interchannel nonlinearities ,Capacity of Optical OFDM Systems , Channel Capacity of Optical MIMO MMF Systems
Parametric processes and applications, Optical performance monitoring, Optical Ethernet: Protocols and management,Fiber-based broadband access technology and deployment, Optical and electronic technologies for packet, Switching, Microwave-over-fiber systems, Optical interconnection networks in advanced computing systems, Simulation tools for devices, systems, and networks

Reference:

1. *Advanced Optical Communication Systems and Networks*.M. Cvijetic, I. B. Djordjevic, Artech House, Jan. 2013.
2. Optical Fiber Telecommunications V B: Systems and Networks, Ed.Ivan P. Kaminow,Tingye Li, Alan E. Willner, Academic Press (2008)

PHL734 – Information Optics Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner. The students are required to attempt any 5)

Entropy Information and Optics-Information Transmission-Entropy Information, Communication Channel, Memoryless Discrete Channel, Continuous Channel
Signal Analysis, Signal Detection, Statistical Signal Detection , Signal Recovering, Signal Ambiguity , Wigner Distribution , Trading Information with Entropy, Quantum Mechanical Channel, Capacity of a Photon Channel
Signal Processing with Optics -Processing under Coherent and Incoherent Illumination, Broadband Signal processing, Processing with Photorefractive Optics, Signal Processing with White Light, Processing with Neural Networks , Optical Neural Networks, Toward Photonic Integrated Circuit All-Optical Signal
Processing Base on Kerr Nonlinearities, Ultrafast Photonic Processing Applied to Photonic Networks
Communication with Optics, Switching with Optics, Transformation with Optics, Interconnection with Optics, Pattern Recognition with Optics,. Information Storage with Optics, Holography and its use in information processing/storage, Computing with Optics, Sensing with Optics, Information Display with Optics, Networking with Optics, The Intimate Integration of Photonics and Electronics
Reference.
Introduction to Information Optics by Francis T.S. Yu, Suganda Jutamalia, Shizhuo Yin , Academic Press,2001
Advances in information optics and photonics / Ari T. Friberg and René Dändliker,,SPIE Press monograph ; PM183,2008

PHL-735 MEMS Technology Max.Marks:70(Major Exam.)
(7 questions are to be set out of entire syllabus in uniform manner. The students are required to attempt any 5)

Micro electro mechanical systems (MEMS) surface micromachining, bulk mirror machining and micro mirrors. Integration techniques, bumb bonding, epitaxial lift off (ELO), optical interconnects, high speed optical memory and optical coupling design, photon integrated circuits.
- Epitaxial growth,
- Lithography(EUV and Laser based),
- Etching,
- Metallization,
- Passivation and packaging

Bulk Micromaching, Surface Micromaching, Electromagnetics and Its Application for MEMS and NEMS, Mems for photonics components manufacturing
References
1. MEMS Introduction and Fundamentals 2nd Ed., Ed. Mohamed Gad-el-Hak, Taylor & Francis (2006)
2. MEMS and NEMS: Systems, Devices, and Structures by:Sergey Edward Lyshevski, CRC Press(2002)