UNIVERSITY OF KERALA

M.Phil Degree Course
PHOTONICS

Syllabus
w.e.f. 2015 Admission onwards
**Duration of the Course**

As per M.Phil regulations, M.Phil Degree Courses in Photonics shall be for one calendar year with two semesters of six months.

**Course Structure**

<table>
<thead>
<tr>
<th>Course</th>
<th>Subject</th>
<th>Lecture/week</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td><strong>SEMESTER I</strong></td>
<td></td>
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<tr>
<td>OPE 711  (Paper 1)</td>
<td>Photonics</td>
<td>5</td>
<td>100</td>
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<tr>
<td>OPE 712  (Paper 2)</td>
<td>Research methodology</td>
<td>5</td>
<td>100</td>
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<td>Paper 3</td>
<td>Elective</td>
<td>5</td>
<td>100</td>
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<tr>
<td>OPE 713</td>
<td>Dissertation Work</td>
<td>15 Evaluation only at the end of second semester</td>
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<td>Total</td>
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<td>30</td>
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<td><strong>SEMESTER II</strong></td>
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<tr>
<td>OPE 713</td>
<td>Dissertation Work</td>
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<td>300</td>
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<td>Viva-Voce Examination based on Dissertation work</td>
<td>100</td>
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<tr>
<td>Total</td>
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<td>30</td>
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<td>Grand Total</td>
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The final results shall be graded as follows:

- A grade 60% and above
- B grade 50% and above but below 60%
- Failure Below 50%
Detailed Syllabus

Core Papers

OPE 711 Photonics

Module I


Module I

Photo detectors and display devices, photodiodes, Photo transistor, APD, PMT, CCD, PIN photo diodes, liquid crystal display, Photo voltaic cells . Optical modulators- acousto-optics, electro-optics and magneto-optics. Physical origin of nonlinear optical coefficients, Second order optical nonlinearity, Propagation of EMW through NLO medium, optical second harmonic generation, phase matching conditions, Third order NLO, intensity dependent refractive index, Four wave mixing and optical phase conjugation.

Module III

Fibre Optics- classification of fibres- step index, graded index fibres, Numerical aperture, modes in optical fibre, single mode and multimode fibre, V- Parameter, evanescent modes, losses in fibres-bending and coupling losses, dispersion in fibres, Special fibres- polarization maintaining fibres, holey fibre, PC fibres, DC Flattened and dispersion shifted fibre.

Fibre optic sensors- advantages of FOS, intensity modulated sensors, interferometric sensors, rotation sensors, bio sensors. Optical communication – advantages, modulation, time division and wave length multiplexing

References

Text Books:


Reference

8. Emmanuel Rosencher and Borge Vinter, Optoelectronics, Cambridge University Press, 2002
11. S.C. Gupta, Optoelectronic Devices and Systems, PHI, 2005
12. R P Khare, Fiber Optics and Optoelectronics, Oxford University Press, 2004

Core Course Paper II

Research Methodology

Module I

Research-Definition, Characteristics, objectives, research and scientific methods, Evolution of scientific enquiry, philosophy of science, scientific investigation, The real practice of science, ideas in science, meaning and importance of research, importance of R&D activity in science and Technology, Current trends in research: mono disciplinary research, trans disciplinary research, inter-disciplinary research, A bird’s eye view of research and development activity in the field of photonics.

Research Methodology: An introduction, research process, basic overview, formulating the research problem, defining the research problem, research design-exploration, diagnosis, experimentation, Research methods: Different types of inductive logical methods, research methods versus research methodology.

Module II

Literature review: review concepts and theories, formulation of hypothesis, sources, characteristics, role and tests of hypothesis, sources of data, primary, secondary, tertiary, Types of data: categorical, nominal, ordinal, Methods of collecting data, observations, field investigations. Interview method, Questionnaires, correlation analysis, inferential analysis, correlation analysis, statistics in research, generalization and interpretation, modelling. MATLAB, OPTSIM, COMSOL applications.

Module III

Importance of effective communication, structure and components of scientific reports, layout, structure and language in scientific reports, illustration and tables, bibliography, referencing and footnotes, preparation of manuscripts for journals, seminars and conferences, application of research, research ethics, environmental impacts, ethical issues, ethical committees, commercialization, copyright, royalty, intellectual property right and patent law, reproduction of published material, plagiarism, reproducibility and accountability. Computer and internet: its role in research, threats and challenges to good research, criteria of good research, citation methods, citation rules-Blue Book, OSCOLA-MLA-APA, calculation of impact factor of journals, citation index, ISBN and ISSN

Module IV

Principles and working of scientific instruments: XRD, SEM, AFM, TEM, STM, UV-Visible, IR (FTIR and ATRFTIR), Raman and NMR spectroscopic techniques, particle size analysis, vapour deposition techniques, Optical spectrum analyzer-OTDR.
Text Books

11. Arlene Fink (2010), Conducting research literature reviews from internet to paper- Sage Publications

References:

1. Science (AAAS) Journal –(Selected articles from archives)
2. Nature (Nature publishing group) Journal- (Selected articles from archives)
4. Website : Web of Science - Science - Thomson Reuters, Website: Scopus (Elsevier Publications)
10. P.J. Wheatly (1968), The Determination of Molecular Structure, , Oxford Press
Elective Courses

OPE 701 Nanophotonics

Module I


Module II


Module III


Text Books:

1. Paras N. Prasad, Nanophotonics, Wiley Interscience ,2004
2. Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2006

Reference:


OPE 702 Image Processing

Module I

Introduction to digital image processing. image representation - gray scale and colour images introduction to two dimensional sequences , convolution correlation, separability etc. 2D-Fourier and Z- transform and its properties. 2D DFT and its properties. Convolution of two dimensional sequences,
convolutional filtering. Basics of 2D transform coding, 2D Discrete Cosine transform, Walsh transform. RGB color model, contrast, brightness, match-band effect etc., image formation model - perspective projection. Stereoscopic imaging - depth extraction and stereoscopic display.

Module II

Histogram of an image, computation of histogram, image enhancement operations, point operations - histogram equalization, histogram specification, contrast stretching, window slicing, bit extraction, change detection, gray scale reversal etc., median filtering, spatial low pass, high pass and band pass operations. Image Enhancement: spatial domain methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging. Spatial filteringsmoothing filters, sharpening filters, frequency domain methods - low pass filtering, high pass filtering, homomorphic filtering, generation of spatial masks from frequency domain specifications

Module III


Text books

3. J S Lim, Two Dimensional Signal and Image Processing, Prentice Hall

References:

2. Tamal Bose, Digital Signal and Image Processing, John Wiley publishers.

OPE 703 Holography and Speckle Interferometry

Module I

Optical Holography: basic principle, recording and reconstruction, types of holograms: transmission hologram, reflection hologram, phase holograms, rainbow hologram (qualitative analysis only), experimental techniques, detectors and recording materials, holographic optical elements, holographic scanners, application of holography: pattern recognition, information storage.

Module II

Holographic interferometry: theory of fringe formation and measurement of displacement vector, Holographic nondestructive testing, different techniques: double exposure, real time, time average, sandwich, acoustic, comparative and TV holography, loading methods, holographic contouring/shape measurement, dual wavelength method, dual refractive index method, digital holography, holographic photo-elasticity, optical coherence tomography.
Module III

Speckle metrology: speckle phenomena, statistics of speckle pattern, classification, objective speckle pattern, subjective speckle pattern, speckle techniques: speckle photography, speckle interferometry, speckle shear interferometry, electronic speckle pattern interferometry, theory of fringe formation and measurement of displacement vector, out of plane and in plane measurements, surface roughness measurement, vibration measurement, detection of defects.

Text Books:
3. Sirohi R.S., (Ed), Speckle Metrology, Mercel Dekker, 1993

Reference:
5. Graham Saxby, Practical Volume Holography, 3rdEdn, Marcal Dekker, 1994

OPE 704 Advanced Laser Technology

Module I

Black body radiation, Planck's law, spontaneous and induced transitions, Einstein's coefficients, gain coefficient, gain saturation and hole burning, homogenous and inhomogeneous broadened systems, laser oscillation conditions, population inversion, three and four level systems, rate equations, optimum output coupling. Optical resonators, rectangular cavity- open planar resonators- spherical resonators, modes and mode stability criteria, losses in optical resonators-quality factor, unstable optical resonators.

Module II

Q-switching, methods of Q-switching- methods, opto-mechanical methods of light- electro optic modulation- Pockels and Kerr modulators- magneto- optic modulators, acousto-optic modulators. Giant pulse lasers, mode locking in homogeneously and inhomogeneously broadened systems, passive and active mode locking beam diagnostics and characterization, thermal lensing effect. Descriptive and qualitative studies of laser applications in communication, remote sensing and interplanetary missions, laser gyro, laser Doppler aneometry (LDA). Applications of lasers in holography, material processing, pulsed laser ablation. Lasers in mechanical engineering and industry, metrology, defense and security, laser cooling, lasers for fusion, lasers for biology and medicine, satellite communications, LIDAR.
Module III


Text Books
5. A.Ghatak & K. Thyagarajan, Optical Electronics, Cambridge University Press, 2004

Reference

OPE705 Optical Sensor Technology

Module I

MM and SM fibers for sensing, lasers & LEDs suitable for sensing, PIN & APDs for fiber optic sensing. Principles of electro optic modulators bulk & integrated optic modulators. Optical sensor types, advantages and disadvantages of fiber optic sensors, sensor system performance: basic specifications, Intensity modulated sensors, reflective concept, micro-bend concept, evanescent fiber sensors,. In-fiber Bragg grating based sensors – sensing principles – temperature and strain sensing, integration techniques, cross sensitivity, FBG multiplexing techniques. Long period fiber grating sensors-temperature and strain sensing, refractive index sensing, optical load sensors and optical bend sensors, Signal processing techniques for fiber optic sensor.

Module II


Module III

Biomedical sensors, sensors for physical parameters, pressure, temperature, blood flow, humidity and radiation loss, sensors for chemical parameters. pH, oxygen, carbon dioxide, spectral sensors. Distributed fiber optic sensors - intrinsic distributed fiber optic sensor - optical time domain reflectometry
Text Books

1. Francis T.S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002

References

1. Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, John Wiley and Sons Ltd., 2001
2. Eric Udd (Ed), Fiber optic sensors: An introduction for engineers and scientists, John Wiley and Sons Ltd., 1991

OPE 706: Optical Instrumentation

Module I


Module II

Stops and photographic systems-theory of stops – aperture stop – entrance and exit pupils, telecentric stop and applications, requirements for photographic objectives – eye as an optical instrument, defects of eye and correction methods, space optics, adaptive optics, large space structures. Lens design optimization, opto-medical instruments, optical coherence tomography, infrared instrumentation; holographic camera; IR telescopes; Moire self- imaging and speckle metrology.

Module III


Text Books

References


OPE 707: Laser Remote Sensing

Module I

Earth’s atmosphere – basics of different regions of atmosphere, composition, structure and dynamics of atmosphere, important meteorological parameters and their influence in climate. Aerosols, optical properties and their role in Earth’s climate and radiation budget. Clouds: different types of clouds, clouds properties, high altitude cirrus clouds, influence of clouds on weather and climate modification. Atmospheric pollution, different types of pollutants and the sources conventional methods of measurements and limitations. Importance of air quality measurement and environmental monitoring.

Module II


Module III

Text Books:
1. E.D. Hinkley (Editor), Laser Monitoring of Atmosphere, Springer Verlag, 1976

References:
3. P. Caagani and S. S Sandroni( Editor)Optional Remote Sensing of the Air Pollution, Elsevier science Publisher B. V, pp. 123-142, 1984

OPE 708: Nonlinear Optics

Module I

Harmonic generation, nonlinear optical susceptibility tensor, on the physical origins of the nonlinear optical coefficients, electromagnetic formulation of nonlinear interactions, optical second harmonic generation, experimental set up, two photon absorption, parametric generation of light, basic equations of parametric amplification, parametric oscillation, frequency tuning, experimental arrangement, frequency up and down conversion.

Module II

Third order optical nonlinearities, stimulated Raman scattering, coherent anti-Stokes Raman scattering, stimulated Brillouin scattering, self -focusing of optical beams, degenerate four wave mixing, nonlinear optical materials, growth and characterization of nonlinear optical materials, optical bi-stability, absorptive and dispersive, simple model, optical bistability.

Module III

Propagation through a distorting medium, image transmission in fibers, theory of phase conjugation by four wave mixing, optical phase conjugation by four wave mixing, OPC by stimulated nonlinear scattering, beam coupling and phase conjugation by photorefractive effect, self- induced transparency, self- phase modulation.

Text Books:
3. Introduction to Photorefractive Nonlinear Optics, PochiYeh, John Wiley & Sons, New York, 1993
Module I


Module II

Characterization and analysis: ideal cell under illumination- solar cell parameters ,optical losses; electrical losses, surface recombination velocity, quantum efficiency - measurements of solar cell parameters; I-V curve & L-I-V characteristics, internal quantum yield measurements – effects of series and parallel resistance and temperature - loss analysis.

Module III

PV modules: solar PV modules from solar cells, series and parallel connections, design and structure of PV modules, power output, batteries for PV systems, DC-DC converters, DC-AC converters, PV system configurations, Hybrid PV systems

Text Books:


References:

Module I


Module II


Module III


Text books:
1. Introduction to Biophotonics-V N Prasad (Wiley-Interscience April 2003)

References:
1. A Handbook of Optical Biomedical diagnostics, SPIE press monograph vol pm 107
2. Biomedical Optics-Principles and Imaging -Lihong V and Hsin-IWU, Wiley Interscience 1st Ed, 2007)
OPE 711 Laser Material Processing

Module I

Models of laser heating - choice of laser for material processing - laser welding, drilling, machine and cutting - laser surface treatment - laser vapour deposition - thin film application, depth of penetration with respect to laser energy density - reflectivity of metals with respect to wavelength - rate of heating and cooling - maximum temperature rise and depth of hardened layer - different gases used using laser materials processing - operational parameters in laser materials processing - key hole effect.

Module II


Module III


Text books:

Reference:

OPE 712 Laser Spectroscopy

Module I

Module II


Module III


Text books:


References:

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