New Course Proposal

Course Title: **Introduction to Photonics**

Course Number: **PSE 601**

Department: **Photonics Science and Engineering Program (PSEP)**

Units: **3-0-0-0-9**

Pre-requisite: None

Level: **PG**

**Course Description:**
Photonics deals with light generation, amplification, guiding, manipulation, and detection for harvesting information. This course introduces some of the fundamental aspects of photonics excluding generation and detection.

**Course Topics:**
- Maxwell Equations, Wave Equations, Dielectric Media, Constitutive Relations
- Electromagnetic Waves- Gaussian Beams, Absorption and Dispersion
- Spatial and Temporal Coherence
- Boundary conditions, Fresnel’s equations and coefficients, Brewster and critical angles, Total internal reflection, Evanescent waves, ATR
- Polarization, Crystal optics and Optics of Anisotropic Media
- Interference and Interferometers: Fabry Perot
- Electro-optics, Acousto-optics and modulators
- Fourier transform, optical Fourier transform and introduction to Diffraction
- Dielectric Waveguides – conditions for propagation, modes, dispersion, field distribution

Suggested topics for photonics applications, if time permits, will include: Photonic devices in brief: Beam splitter, Waveplates, Optical Isolator, Wavelength Switches, Fabry Perot Filters, Bragg Mirrors, Micro-ring Resonators
References:
Course Title: **Principles of Lasers and Detectors**

Course Number: **PSE 602**

Department: **Photonics Science and Engineering Program (PSEP)**

Units: **3-0-0-9**

Pre-requisite: None

Level: **PG**

**Course Description:**

This course provides an introduction to the fundamental principles governing the operation and design of coherent light sources and detection tools.

**Course Topics:**

- Introduction to light sources, Lasers, principle of lasing
- Optical cavities, longitudinal, transverse modes, Stability
- Interaction of radiation with matter, Spontaneous emission
- Absorption and stimulated emission, line broadening mechanisms
- Population inversion, absorption and gain coefficients
- Pumping schemes (Rate equation based Lasing model)

- Three- and four- level lasers
- CW and pulsed lasers, Q-switching and mode-locking

Detection of optical radiation:
- Photomultiplier tubes, semiconductor photodiodes, avalanche photodiodes, Single photon detectors, dark current, thermal noise, shot noise

Measurement systems: Spectroscopy (Spectral and Temporal measurement systems),
- CCD, monochromater, pulse width measurement
References:
Course Title: **Numerical Methods in optics**

Course Number: **PSE 603**

Department: **Photonics Science and Engineering Program (PSEP)**

Units: **3-0-0-9**

Pre-requisite: None

Level: **PG**

**Course Description:**
To train a student to be able to numerically model problems related to optical phenomena. Each of the topics listed below will be accompanied by case studies related to optics. Some suggested case studies are: Ray Tracing using Matrix methods, Design of optical systems, Vectorial Wave propagation, Beam propagation, Anisotropic media, Modal description.

**Course Topics:**

Introduction to MATLAB/MATHMATICA type platform

Linear algebra: matrices, matrix inversion; QR, Singular value decomposition, systems of equations, eigenvalues, eigenvectors, orthonormalization, condition number

Laplace and Fourier transforms

Vector calculus, Cartesian tensors

Ordinary differential equations, series solution, Fourier series, Special functions

Iterative and direct methods for linear algebraic equations; generalized inverses, least squares

Numerical differentiation and integration; Numerical solution of 1st and second order ODEs, Runge-Kutta method, stability, stiff systems

Partial differential equations, second order equations, classification, separation of variables, Sturm-Liouville theory

Numerical solution of linear PDEs by the method of finite differences, stability

Interpolation; Regression analysis

Laplace equation, Poisson equation, Heat equation, Wave equation, Telegraph equation

Complex variable theory

Taylor series expansion, Taylor series approximation, applications such as linearization,
root finding
Signal processing fundamentals, time domain and frequency domain statistics, Convolution and Correlation, DFT applications

References:
Course Title: **Photonic Systems and Applications**

Course Number: **PSE 604**

Department: **Photonics Science and Engineering Program (PSEP)**

Units: **3-0-0-0-9**

Pre-requisite: None

Level: **PG**

**Course Description:**

Number of industrial and scientific applications related to photonics is growing rapidly across various disciplines. The basic courses in the first semester related to generation and transmission of photons deal with fundamental principles. The present course focuses on design issues for various applications/devices of photonics. Design of lasers, its tuning system and design of beam transmission components are discussed specific to different practical applications.

**Course Topics:**

**Principles and Applications of Solid State Laser Systems**


**Principles and Applications of Liquid and Gas Laser Systems**


**Nonlinear optics**

Parametric processes, Phase matching, Nonlinear optical processes, SHG, Chirped pulse amplifier, parametric amplifier.

**Photonics Applications in Medicine and Surgery**

Laser Tissue Interaction, Turbid media, Depth of penetration, Thermal and optical properties of tissue, Heat dissipation by blood flow, Diagnostic application of lasers, Dosimetry Photon Transport theory, Measurement of tissue properties, Double
integrating sphere.

**Laser Applications in Material Processing**
Laser matter interaction, Non-Fourier thermal transport, Ablation, Laser induced plasma, Laser micromachining, Microfabrication, Direct-write patterning, Laser CVD, Texturing, Joining, Annealing, Scribing

**Optical measurements**
Thin film measurements, Temperature and concentration measurements, Stresses, Flow imaging, Biomedical diagnostics, Optical Tomography

**Entertainment: CD Rom, Video Projection, Laser shows**

**Special Topics**
Plasmonics, Photonic crystals, Optical antennas, Photonic metamaterials, anophotonics.

**References:**
4. M. H. Niemz, Laser Tissue Interaction Fundamentals and Applications,
5. K. Sugioka, M. Meunier, Laser Precision Microfabrication
Course Title: **Photonics Lab Techniques**

Course Number: **PSE 605**

Department: **Photonics Science and Engineering Program (PSEP)**

Units: **1-0-6-0-9**

Pre-requisite: **PSE 601, PSE 602**

Level: **PG**

**Course Description:**

This course will help develop experimental skill of the students in the areas of optics and photonics. An eclectic mix of about ten experiments would be undertaken by the students in the semester from the given list, apart from demonstration experiments and laboratory visits.

**Course Topics:**

1. Electro-optic effect using LiNbO3 crystal
2. Acousto-optic modulator
3. Study of effects of loss, dispersion, amplifier noise on 10Gbps links
4. 40Gbps QAM modulation and coherent demodulation
5. Nonlinearities in fiber: Four-wave mixing, Raman scattering etc.
6. SHG generation and OPO using Nd:Yag laser
7. OPO using BBO crystal
8. Fresnel and Fraunhofer Diffraction
9. He-Ne laser beam parameters
10. Laser diode characteristics: L-I characteristic, beam profile measurement, modes and spectrum using FP cavity
11. Michelson interferometer: setup, refractive index measurement
12. Nd:YAG laser characteristics
13. Fiber Mach-Zehnder interferometer

14. Holography

15. Loss and dispersion characterization of WDM optical components – Coupler, Circulator, EDFA, Filter, and single-mode fibers.

Demonstration experiments and Research Lab visits are meant to familiarize students with CELP facilities and various research activities of the faculty.
Course Number: **PSE 606**

Department: **Photonics Science and Engineering Program (PSEP)**

Units: **0-0-9-9**

Pre-requisite: None

Level: **PG**

**Course Description:**

This course will serve as a precursor to the full Master’s thesis that a student in the program will undertake in the second year. The purpose of the course is two fold. It will reveal emerging trends in photonics and laser applications to the concerned student and bring out the topicality and importance of the program. The second goal is to train the student in various aspects of research methodology. These are literature survey, problem definition, preliminary analysis, defining a research program, conducting experiments/simulation, data analysis and interpretation, and report preparation. The student will identify and complete a short project during the semester. This project may be similar to his Master’s dissertation and may be guided by the thesis advisor, though it is not a requirement. The student grade will be based on a mid-term presentation and a final presentation combined with a report. A department level committee will evaluate all research projects and the committee chair will award the final grade.

**This will be a S/X grade course.**

Research areas that can be pursued will evolve with time and reflect faculty interest. Possible topics include the following:

- Biophotonics, nanobiophotonics,
- Optical communication, Quantum cryptography
- Nonlinear optics
- Tomography
- Quantum dots, photonic crystals
- Laser manufacturing and materials processing
- Laser instrumentation, PIV, thermography, micro scale imaging
- Satellite imaging, Clouds, aerosols, Lidar spectroscopy
Multiphoton imaging.

Texts and references will be project specific. A few lectures will be given to assist students in data representation, thesis and manuscript preparation. It is proposed to allocate five lectures for these, and will be conducted in the second half of the semester. The following reference will be appropriate in this context.