A Proposal for a Sandwiched Three year M. Tech. course in Photonics

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ABSTRACT

A sandwiched M tech program is proposed for Photonics. The course structure is designed care fully so as to provide a thorough base in the subject simultaneously students are trained well to meet the present and the future market challenges at par with any conventional technology based program.

1. INTRODUCTION

The rapid advancement as well the enormous applications in the field of optics and photonics has felt the need of specialized curriculum to trained the men power at various level. The educational program required for this purpose should be designed care fully to meet the multidisciplinary nature of the subject as well as to attract the good students before being screened out at other existing professional avenues and should place them at par with any other professional courses in terms of employment. Keeping the present day demand of specialized trained men power in the areas of optical sciences a proposal is presented for the sandwiched program for M Tech in Photonics. The course is designed for three years to have the intake at the level of graduation (B.Sc being the minimum qualification with physics and maths as the measure subjects). Scope can also be extended for engineering graduate and M.Sc Physics student by cutting few of the engineering based courses or the basic physics courses respectively. Accordingly the duration of the course can be reduced.

2. COURSE SCHEDULE

The weakly schedule is projected in Table I. Systematic development of the understanding of the base subjects requires the regimented and tedious class room and laboratory teaching in coherence with each other. This is exactly projected in the course work. First two semesters are classroom and laboratory teaching both. Unlike any normal course, in this program a good amount of laboratory hours are planed so as theoretical and experimental skills go side by side. After going through the rigorous course work for the first two semester student acquire sufficient skill to collect the study material for the related topics and can discuss or even they can discuss the latest development in the field. Therefore in the third semester two hours are reserved for the group discussion and the seminar. Weakly seminar can also be around the laboratory experiments conducted by the student. As the advanced level training requires some dilution in terms of standard class room teaching to allow the skills for innovation therefore fourth and fifth semester teaching hours are slightly reduced to motivate and encourage the students for self reading and discussion. Final semester is kept free from the classroom regimentation so that student can take up some research problem for the project and can devote full time on to it. It is strongly recommended to have the allowance for some innovation in the laboratory work along with the frozen set of experiment. The laboratory should be designed to give a free hand to the students for conducting experiment in totality starting from the setting up, data recording along with the computer interfacing and detailed analyses of data. Strong interaction of the instructor students is must unlike the conventional laboratory courses where the student will come to the laboratory, follow a certain sequence of steps for conducting the experiment and will submit the report.

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Tuan-Kay Lim, Arthur H. Guenther, Editors, Proceedings of SPIE Vol. 4588 (2002)

Table I

Semester	Lecture (L) (Hours Per Weak)	Tutorial	Practical (lab)	Group discussions and seminars (hrs per weak)	Total Hours per weak
I	17	04	15	00	36
II	12	02	20	00	34
III	18	00	16	02	36
IV	12	03	16	02	33
V	18	00	06	03	27
VI	00	00	24	03	27

3. COURSE STRUCTURE

The details of the course structure in terms of course title and the number of hours associated with each course are illustrated in table II below. The first three semester students will be undergoing the basic courses on optics, electrodynamics, mathematical physics, computational skills, quantum mechanics, solid state physics, Laser physics, Instrumentation and basic electronics (power electronics) and few experimental courses based on optics, measurements techniques in the relevant areas, optical workshop, electronics and other relevant physics experiment. All these courses are the back ground courses for the advanced level courses to be taken in next three semester as well as these are must in order to have the deep understanding of the subject as the field of Photonics is multidisciplinary in nature. Moreover a good experimental and computational skill is also required to meet the present and future demand for the photonics devices. A rigorous skill in mechanical and optical workshop is also must particularly in designing and fabrication of the hardware for components involved at any stage of the photonics based equipment. The next three semester the theory courses will be of advanced level viz; Non linear optics, quantum optics, Laser spectroscopy, Fibre optics, Semiconductor lasers, integrated optics, Material science Image processing and industrial management. A rigorous training will also be given on the experimental labs in the last three semester based on the development and characterization of advanced materials for general and specific applications. The emphasis in the program will be learning through the experiment rather than the conventional classroom teaching. In the V semester students are allowed to take two elective courses of appropriate level offered by the institute. The purpose of the elective laboratory course is that students themselves should able to conduct few of the advanced level laboratory experiment available in the area of science or engineering in the host institute.

Table II.

Course name	**L-T-P**
Semester I	
Mathematical Physics	3-1-0
Electrodynamics	3-1-0
Quantum mechanics I	3-1-0
Computer Programming	3-0-3
Electronics	3-0-6
Engineering Drawing	2-1-3
Mechanical Workshop	0-0-3
Semester II	
Quantum Mechanics II	3-1-0
Modern Optics	3-1-0
Solid state Physics	3-0-0
Instrumentation and measurement Techniques	3-0-4
Optical workshop	0-0-4
Optics lab I	0-0-6

General Physics Lab I	0-0-6
Semester III	
Atomic and Molecular Spectroscopy	3-0-3
Laser Physics	3-0-3
Optical engineering	3-0-0
HSS Course	3-0-0
Statistical optics	3-0-0
Material engineering	3-0-4
Optics Lab II	0-0-6
Seminar and discussion	0-0-2
Semester IV	
Non Linear Optics	3-1-0
Fibre Optics	3-1-0
Laser Spectroscopy	3-1-3
Fourier optics and image processing	3-0-3
Non Linear Optics Lab	0-0-6
Fibre Optics lab	0-0-6
Library and Discussions	0-0-2
Semester V	
Semiconductor Lasers	3-0-0
Optical Computing and neural net work	3-0-0
Quantum Optics	3-0-0
Industrial Management	3-0-0
Elective I	3-0-0
Elective II	3-0-0
Elective Lab	0-0-6
Seminar	0-0-1
Group discussion	0-0-2
Semester VI	
Project	0-0-24
Group discussion	0-0-3

4. COURSE CONTENT

First semester course work is very basic offered by any institute awarding degree in the area of engineering and physics. Therefore there is no need to give any details of all the courses for the first semester.

Two of the second semester courses; Modern Optics and Instrumentation and measurement techniques are relatively not very common among many institutions. Other courses are again the regular courses and the details may not be new to academicians in the related areas. Third, fourth and fifth semester courses are highly specialized and advanced level courses and are less known even in well established organization. Laboratory courses can be designed under the general headings of the course based on the funds and the infrastructure available with the parent organization offering this program. The interaction of the student with research labs available with in the institute or in the neighboring institute should also be encouraged in the laboratory courses. Some of the experimental set-up should be based on designing and should give the free hand rather than a conventaional regimented approach. The HSS and the industrial management courses can be taken from the respective departments of the organization and therefore details are not given here.

4.1 Modern Optics
Scattering of electromagnetic radiation, diffraction theory (Kirchhoff integral), fourier optics, image formation, polarisation Optics, statistical optics, fibre optics, non linear optics, electrooptic, acoustooptic and electromagnetic effects and optical modulators.

4.2 Instrumentation and Measurement Techniques
Signal and their representation, noise and method of its minimization, high voltage high current systems (dc and pulsed) and measurement, power switches, over current over voltage protection, sensitive measurement of voltage, current, and resistances, time domain measurements, lockin amplifier, Boxcar averager, active and passive transducers, temperature controller, optical detectors, spectroscopic instruments, Vacuum technology, high pressure system, cryotechnology measurement of electrical, thermal and magnetic and optical properties of materials, Non -destructive measurement techniques.

4.3 Atomic and Molecular Physics
Hydrogen and hydrogen like ions Einstein coefficient of stimulated and sponanious emission, spectral line widths many electron system, electron coupling scheme, Zeeman, Paschen and strak effect, hyperfine structure, diatomic and polyatomic molecule, roational vibration and electronic spectra, ESR, NMR, EPR, NQR.

4.4 Laser Physics
Black body radiation, Einstein coefficient, emission and absorption of radiation, lifetime of excited states, spectral line profiles, amplification of radiation, threshold conditions for oscillations, conditions on population inversion, gain saturation, effect of line profile, pumping mechanism, dynamics laser processes, density matrix approach (semiclassical), effect of gain saturation on modes, Q factor of an optical resonator, photon life time, mode stability, losses in optical resonator, Q switching, mode locking, pulse compression, pulse amplifications, limitation on laser output, specific laser systems

4.5 Optical engineering
Diffraction of gaussian beam, interferometry, metallic and interfernce coating, optical microscopy, interference microscopy and confocal microscopy, phase shifting and hetrodyne interferometry techniques, holography, spatial frequency filtering, optics, optical metrology, Optical shoptesting, fabrication techniques for some of the optical elements, two dimensional imaging.

4.6 Statistical Optics
Random variables - Definitions. Distribution function, statistical averages, transformation of random variables, Real and complex valued random variables, Random processes, Stationarity and ergodicity, Spectral analysis of random process, Auto-correlation and cross-correlation functions, Gaussian and Poisson random processes, Random process from analytic signals. Some first order properties of light waves a) mono and broad band sources, b) polarized and unpolarized light c) laser light. Coherence of optical waves.

4.7 Material Engineering
Crystal growth techniques, Thin film techniques, production of nano and periodic structure, alloys, intermetallic compounds, ceramics and composite materials, Phase diagram, application of phase diagram in purification of materials, heat treatment, mechanical treatment, characteristaion of material.

4.8 Non Linear Optics
Electromagnetic waves in non linear media, nonlinear susceptibilities and symmetry properties, physical mechanism of non linearities in materials, density matrix and perturbative approach to non linearties, Feynman diagram, three waves and four waves mixing, harmonic generation, parametric processes, optical phase conjugation, optical bistability, stimulated Raman and brillouin processes, self focussing, quantum size effects, optical non linearities in low dimensional semiconductors, photorefractive crystals, linear and non linear intereference filters, electrooptics, magnetooptics and acoustoptics effects and devices, optical rectification, modulatores, Materials for photonics

4.9 Fibre Optics
Propagation of radiation in dielectric wave guides, modes in a planar wave guides, propagation chracteristics and modal analyses instep index and graded index fibre, dispersion in multimode & monomode fibres, dispersion compensation, attenuation mechanisms in fibres, leaky modes, mode coupling, fibre parameters specifications and measurements, fabrication techniques, optical solitons, Fibre optic sensors, optical communications, coherent optical fibre communications, optical fibre amplifiers, Optocouplers, Pulse compression, wavelength division multiplexers/demultiplexeres. optical switches, optical logic gates, circuits and interconnects, integrated optics, optical memories, optical amplifiers.

4.10 Laser Spectroscopy
Laser matter interaction, widths and profiles of spectral lamb shift, line profiles in liquid, solids and gases, doppler limited spectroscopy, laser induced absorption and fluorescence spectroscopy, optogalvanic spectroscopy, high resolution spectroscopy, double resonance techniques, Laser Raman spectroscopy, non linear raman spectroscopy, non linear spectroscopy, time resolved laser spectroscopy, measurement of ultrashort pulses, pump and probe techniques, quantum beat spectroscopy, photon echo, correlation spectroscopy, single ion spectroscopy, atom interferometry, polarization spectroscopy, applications of spectroscopy. multiphoton transistions, Transient coherent non linear optical effects,

4.11 Fourier Optics and Image processing
Two dimensional linear, shift invariant systems, Scalar diffraction theory, Fresnel and Fraunhofer diffraction, Fourier transform, Lens as F.T element, Frequency analysis of imaging systems, Spatial filtering, Fabrication of Amplitude, phase and complex filters and their uses in Image processing, Convolution and correlation, Joint transform correlator, Edge detection, differentiation of images, Pattern recognition and image processing and applications, Synthetic aperture radar, Hologram and its uses in image processing, Quantum noise in optical processing.

4.12 Semiconductor Lasers
Opticallly induced band to band transitions in semiconductors, parameters for controlling optical band gap, diode laser, cavity design, modulation for semiconductor laser, quantum well laser, high speed laser, tunable laser, surface emitting laser, fabrication techniques of surface emitting laser, quantum optics effects in semiconductor laser, principle and fabrication of optical integrated devices.

4.13 Optical computing and neural net work
Optical Associative processing, fixed hologram neural network, multi grating process, system hardware and applications, computing architecture

4.14 Quantum Optics
Interaction of light and atom, Atomic motion in laser light, laser cooling, chaos in atomic systems, quantum fluctuations and quantum noise in optical systems, interefernce in phase space, Quantum statistics, quantum electrodynamics, squeezed states, quantum theory of photoelectric detection of light, collective atomic interaction (free induction decay, photon echo,ect.), Quantum effects in non linear optics atom-atom and elctron atom scattering in laser field.

5. CONCLUSION

A carefully designed course for three years duration for M Tech degree in Photonics is proposed.