Photonics for mechanical engineering in tertiary education

Gopalkrishna M. Hegde* and Andrew T. Sabaratnam
Photonics Centre, School of Engineering
Ngee Ann Polytechnic
535, Clementi Road, Singapore-599 489

ABSTRACT

Photonics has emerged as multidisciplinary technology of the future. Hence photonics has become an important course to be reckoned with in all disciplines of technology. We have developed a new basic and advanced lecture and laboratory course on optics, lasers, interferometry and fiber optics for mechanical engineers. This course is the primary senior level experimental physics course with emphasis on practical experience with necessary theoretical knowledge. The course is structured to cover the relevant topics in photonics, from wave nature of light to ultra short pulse generation, types of lasers and various applications.

Keywords: education, photonics, photonics course, lasers, optics.

1. INTRODUCTION

The era of modern photonics began with the discovery of lasers in 1960. Until its impact in telecommunications was enabled by the perfection of low signal loss optical fibers for long distance communications in the late 1970's, this was a subject of interest for physicists only. After the invention of YAG, CO2 and Dye lasers photonics has spread its wings into chemistry, biology and emerged as potential device for solving many engineering problems. One of the engineering disciplines which has a very high potential for varieties of photonics applications is mechanical engineering. Use of lasers in materials processing such as welding, cutting, drilling, perforating, scribing, engraving, heat treating, cladding, vapor deposition, scribing, trimming, annealing, and shock hardening and fusion are well known. In line with the application of lasers/photonics devices in various disciplines of science and engineering it is necessary to tailor-make the photonics courses to suit the requirements of different disciplines. The present paper describes a course specifically designed for mechanical engineers at tertiary level. The course aims to train and enable mechanical engineers to teach and use laser technology.

2.COURSE TOPICS

The introductory photonics course is structured and taught in the following way;
1. The nature of light: This chapter covers a brief history of light starting from Huygen's principle, Newton's corpuscular theory, Einstein's photoelectric effect, to Plank's hypothesis.

2.Wave nature of light: This chapter explains light waves in greater detail, phase difference, optical path difference between two travelling waves, principle of superposition and visibility, interference, diffraction and polarization of light waves.

3. Geometric optics: This chapter covers reflection, refraction, Snell's law, curved mirrors, prisms, dispersion, total internal reflection, focusing, thin and thick lenses, lens equation and chromatic aberration.

* contact: email: hgm@np.edu.sg ; phone (65) 460 8581; fax (65) 467 1730 ; http://www.np.edu.sg

Seventh International Conference on Education and Training in Optics and Photonics,
Tuan-Kay Lim, Arthur H. Guenther, Editors, Proceedings of SPIE Vol. 4588 (2002)

4. Basic laser operation: This section comprises energy levels, radiative transitions, absorption spontaneous emission, stimulated emission, population inversion, basic laser components, description of laser operation and characteristics of laser output, Gaussian beam, Ruby laser and He- Ne laser.

5. Laser safety: Human eye, laser hazards, laser classifications, hazard evaluation, personal protective equipment, control measures and design of a laser room/laboratory

6. General Properties of Waves: Interference, division of wavefront, division of amplitude, Young's double slit principle, parallel-block, and optical wedge interference, Michelson interferometer and Mach-Zehnder interferometer are covered in this chapter

7. Types of lasers: This section talks about gas lasers, solidstate lasers, dye lasers and semiconductor lasers. Also covers cw and pulsed lasers. Nd:YAG and CO2 lasers are taken as specific examples in the course as they are commonly used in mechanical engineering applications.

8. Laser beam handling: This chapter comprises the use of optical components such as lenses, mirrors, prisms, polarizers, dichroics, density filters, beam splitters, beam expanders, power meters. Also includes laser beam steering, focusing, power density estimation, peak power, average power and repetition rate.

9. Fiber optics: Fundamentals, single mode, multimode, step-index and graded-index fibers, numerical aperture, fiber loss and dispersion, and detection and measurements.

10. Laser applications: This section covers application of lasers in various fields such as science, technology, communication medicine and defence.

Most of these course materials are uploaded onto our websites[1]. Each chapter is provided with links to websites with java applets for further reading. The advanced course deals with more theoretical approach with tutorials as well as advanced experiments on the above topics in addition to chapters on advanced lasers and pulse generation techniques, nonlinear optics and electro- and acousto-optics, and fiber optic-communication. Online tutorials are also uploaded onto our website.

3. EXPERIMENTS

The experiments cover the basic characteristics of lasers, interferometry, geometric optics and wave optics. Since each experiment is specifically designed, which involves lasers, optics and necessary electronics, there are also strong connections between experiments and theory, which demonstrates important concepts. The participants are expected to do the following experiments as part of the completion of the course.

-- Laser beam characteristics
-- Malu's law verification
-- Brewster angle measurement
-- Coherence length measurement using Michelson interferometer
-- Yong's double slit experiment
-- Wavelength measurement using a diffraction grating
-- Beam waist and power density measurements of focused laser beam

Since each experiment involves lasers, the course offers an enough hands-on experience in handling of laser beams, optics, detection and measurements. The experiments in advanced course involve fiber optics, non-linear optics and optical design and simulation. The same course has been offered to industries with modification of or additional topics as demanded by the industry.

4.CONCLUSION

The Photonics Centre has been providing training in optics and photonics at different levels of education since 1997. Short courses have also been conducted for industries. The feedback from a group of mechanical engineers who have completed this course is very positive, hence encourages regular revision of the course in line with changing scenario in technology.

REFERENCES

1. http://www.np.edu.sg/ece/oelt