EECS 434: Principles of Photonics
Fall 2017

Instructor: Professor Stephen C. Rand
University of Michigan
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Class: M,W 15:30 - 17:00; Discussion 17:00-17:30
Prerequisites: EECS 330 or 334 or permission of instructor or graduate standing
Office Hours: Wednesday 12:00 – 13:30

Course Description
EECS 434 provides an introduction to photonics, optoelectronics, lasers and fiber-optics. The course begins by analyzing optical propagation, reflection/refraction at interfaces and optics in anisotropic media. Polarization is discussed, with application to liquid crystal displays and waveplates. Anti-reflection coatings, dielectric mirrors, and interferometers are studied. Dielectric waveguides and fiber optics are discussed, together with methods of modulating radiation for communications and metrology. Optical spectral analysis, filtering, resonators, lasers and coherence are covered. The course concludes with semiconductor optics: laser diodes, LEDs, photo-detectors and communication systems.

Textbooks: A. Yariv, P. Yeh, "Photonics: Optical Electronics in Modern Communication", 6th edition, Oxford University Press, 2007.
Alternate References:
B.E.A. Saleh and M.C. Teich, "Fundamentals of Photonics", 2nd edition, Wiley-Interscience, 2007.
G.R. Fowles, "Introduction to Modern Optics", Dover, 2nd edition, 1989.
M. Born and E. Wolf, "Principles of Optics", Cambridge, 7th edition, 1999.

Homework: HW is due in class on Monday, not accepted late without a medical waiver. Complete all assignments on your own. You may discuss approaches to solving problems but not compare written solutions in draft or final form with those of other students.

Grading:	**Percentage**	
Midterm1 (Oct. 11, 2017, Chrysler 151, 15:30 -17:00)	15	(20)*
Midterm2 (Nov. 22, 2017, Chrysler 151, 15:30 -17:00)	20	(25)*
Homework (~12 weekly problem sets)	25	(25)*
Project	10	-----
Final Exam (Dec.18, 2017, Chrysler 151, 4:00-6:00 pm)	30	(30)*
	100	(100)*

As a rough guide, letter grades are usually assigned from the aggregate numerical scores for all work as follows: A>85, A->80, B+>75, B>70, B->65, C+>60, C>55, C->50.

* Online students only – the licence for solver program Lumerical is unavailable off-campus

Course Outline:		**No. (1.5 hour) Lectures**
1.	Introduction: Optics in modern technology. Propagation in free space, phase velocity, Poynting's vector, complex representations, plane waves, dielectric materials, boundary conditions, classical SHO model, chromatic dispersion, group velocity, absorption, reflection, properties of metals.	3
2.	Scattering, polarization, Jones matrices, polarizers, Stokes analysis, Poincare sphere, reflection and refraction at interfaces, total internal reflection, phase shifts, evanescent waves, Goos-Hanchen shift, Brewster's angle, dielectric tensor, optic axes, linear and circular birefringence, propagation in crystals, optical activity, Faraday rotation, polarization-based devices (waveplates), non-reciprocity, microscopes, liquid crystal displays	3
3.	ABCD matrices for lenses & dielectric waveguides, TE/TM modes, effective index, modal dispersion, symmetric & asymmetric slabs, 2-D mode patterns, losses, Mach-Zehnder interferometers, integrated optics, optical fibers, LP modes, cutoff, fiber materials, splices, couplers, graded index & polarization-maintaining fibers	5
4.	Multiple interference, thin films, anti-reflection and maximum reflection coatings, Fabry-Perot interferometers, spectrum analysis, resonant cavities, quality factor & losses, intracavity field, ring & micro-resonators	4
5.	Periodic structures: diffraction gratings, Bragg reflectors, filters, periodic waveguides, chirped Bragg gratings, Fresnel zones, Fresnel lenses, dispersion management, photonic crystals, Brillouin zones for light, defects, photonic crystal fibers, super-continuum & comb generation, photonic crystal micro-cavities & circuits, slow light	4
6.	Photons and atoms: quantized energy levels, luminescence, detailed balance, blackbody radiation, stimulated emission, population inversion, optical gain, 4-level lasers, single-mode operation, coherence, types of laser, ultrashort pulse generation, frequency comb metrology	4
7.	Semiconductor optics: solar cells, light-emitting diodes, laser diodes, quantum wells, quantum cascade lasers, photo-detectors, quantum efficiency, speed, responsivity, noise, optical communication systems	3
	TOTAL:	26