جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

Course Syllabus: Principles of Optics - EE 231

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	EE 231
Course Title	Principles of Optics
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	02:30 PM - 04:00 PM | Sun Thu

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Andrea Fratalocchi	Andrea.Fratalocchi@kaust.edu.sa	+966128080348		Building 1, Room 4305. I give 100% time availability to my students. If for some reason I am out of my office, please send me an email and we will arrange a meeting.

Teaching Assistant(s)

Name	Email
TBA	TBA

Course Information

Comprehensive Course Description	The course offers a general introduction to optics, covering classical topics such as diffraction, waveguides and resonators, taught in a modern style. Examples and selected lab lessons complement theoretical arguments and concepts introduced during lessons. At the end of the course, the student will be able to understand basic optical systems, and master general concepts of wave propagation that can be applied in a variety of different contexts, from acoustics to microwaves. The topics covered during the lessons are listed below. Maxwell's equations in isotropic media. Poynting theorem. Definition and physical meaning of the Poynting vector and the energy density of the electromagnetic wave. Complex formalism. Time average of products of sinusoidal functions. Definition of optical intensity. Plane wave solutions of Maxwell's equations. The scalar theory of diffraction. Sommerfield definition of diffraction. Helmholtz equation for the disturbance field. Intensity observable in the scalar approximation. Classical approach to the diffraction problem: definition of propagation and interaction problems. A first example of propagation problem: interference of two non collinear plane waves. Analysis of intensity distribution. Definition of interference fringes and discussion on possible applications. Spherical waves. Paraxial approximation. Interference between a spherical wave and a plane wave. Bessel beam solution of the Helmholtz equations. Field distribution and dispersionless propagation. Discussion and experimental generation of Bessel beams. Elements of linear system theory and Fourier analysis. The propagation problem. General solution through Fourier modal decomposition. Plane-wave propagator. Linear system representation. Evanescent waves and their physical implications. The propagation problem. First formula of Rayleigh-Sommerfield. Huygens principle. Fresnel diffraction integral. Far-Field diffraction formula. Optical resolution limits in the far-field. Double-Slit experiment: analysis with the far-field diffraction integral. Derivation of the paraxial wave equation from Helmholtz equation. Spherical waves and Gaussian beam solutions. Curvature, waist and general properties of Gaussian beams. Direct and Inverse problem of Gaussian beams. Physical explanation of the diffraction of Gaussian beam in terms of dispersion relation. ABCD Law of Gaussian beams. Free space propagation ABCD matrix. The interaction problem: general approach through the transfer function. Exact solution of the interaction with a semi-infinite metallic plane; comparison with the transfer function method; discussion. The thin lens. Transfer function of the thin lens. Application of a thin lens to visualize the far field. Action of a thin lens on a Gaussian Beam. Collimation and Focusing problem. Beam Expander. ABCD matrix of a thin lens. Fresnel diffraction from circular apertures. Fresnel diffraction for opaque discs. Poisson spot. Gratings. General definition. Diffracting orders. Discussion on some possible applications of gratings. Moving gratings. Doppler shift of the input frequency. Application to laser instabilities. Introduction to geometrical optics. Rays and optical paths. Derivation of Snell's law from Fermat principle. Slab waveguides. Definition of guided modes. Geometrical optics analysis of guided modes. Dispersion relation. Symmetric waveguide. Analysis of dispersion relation of symmetric waveguide. TE and TM modes. Number of modes for a given geometry. Asymetric waveguides: study of the general case. Modal profile of guided modes. The Fabry-Perot interferometer. Reflection and Transmission from multiple rays. Airy's Formulae. Finesse. Interferometer resolving power. Optical cavities. ABCD transfer matrix approach. Stability analysis. Gaussian mode solution of cavities made by spherical mirrors. Phase and amplitude self-consistent equations.
Course Description from Program Guide	Basic principles of optics. Topics include classical theory of diffraction, interference of waves, study of simple dielectric elements such as gratings and lenses, analysis of Gaussian beams, elements of geometrical optics, Waveguides, interferometers and optical resonators. The course aims at equipping the student with a set of general tools to understand basic optical phenomena and model simple optical devices.
Goals and Objectives	At the end of the course, the student will be able to understand basic optical systems, and master general concepts of wave propagation that can be applied in a variety of different contexts, from acoustics to microwaves.
Required Knowledge	**Calculus, Funademntal EM theory, Linear algebra**
Reference Texts	1. Yariv, Photonics: Optical Electronics in Modern Communications (Oxford University Press, USA, 2006). 2. J. D. Jackson, Classical Electrodynamics (Wiley, 1998). 3. M. Born, E. Wolf, Principle of optics: electromagnetic theory of propagation, interference and diffraction of light (Cambridge University Press, Cambridge, 1999). 4. J. T. Verdeyen, Laser Electronics (Prentice Hall, 1995). 5. Updated slides are found at my group website www.primalight.org->teaching; The slides are not reference texts, the texts are listed above.
Method of evaluation	**100.00**% - Others - Please specify
Nature of the assignments	**GRADING POLICY:** The exam is graded from two written exams (midterm and final) and an oral discussion, with modality described as follows. Each written exam is composed by oral questions and exercises. A student that gets A in both written exams does not need to perform an oral and the final grade is A. A student that gets A- at the written exams has an optional oral discussion, which if taken will form 25% of the final grade. If the oral option is not taken, the final grade is A-. Students with average grade below A- at the written have a compulsory oral discussion, which will form 50% of the final grade. Students that get a failing grade both at the midterm and final will not be admitted at the oral and get a failing grade calculated from the average grade of the written exams.
Course Policies	**ATTENDANCE POLICY required.** Students that miss more than 10% of the course with no justification will not be admitted at the exam. **HOMEWORK ASSIGNMENTS**: after every lesson (not graded). The Homeworks are compulsory. Students that do not complete homework assignments will not admitted at the exam.

Additional Information	COMMUNICATION INSTRUCTIONS Website www.primalight.org and email **CLASS SCHEDULE at www.primalight.org -> teaching** **HONOR CODE** In accordance with the University policy and professional standards, the highest levels of academic integrity are expected in this class. The code of student conduct is strictly enforced. Academic dishonesty will result in reductions in grades and/or expulsions from this class and/or the University.

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 08/25/2019 Thu 08/29/2019	Semester starts
2	Sun 09/01/2019 Thu 09/05/2019	The scalar theory of diffraction. Sommerfield definition of diffraction. Discussion and theoretical justification of the scalar approximation. Helmholtz equation for the disturbance field. Intensity observable in the scalar approximation. Classical approach to the diffraction problem: definition of propagation and interaction problems.
3	Sun 09/08/2019 Thu 09/12/2019	A first example of propagation problem: interference of two non collinear plane waves. Analysis of intensity distribution. Definition of interference fringes and discussion on possible applications. Spherical waves.
4	Sun 09/15/2019 Thu 09/19/2019	Brief introduction to coherence and interference effects in coherent fields. Discussion of applications of Newtons rings. Interference between spherical waves and plane waves.
5	Sun 09/22/2019 Thu 09/26/2019	University holiday
6	Sun 09/29/2019 Thu 10/03/2019	Experimental generation of Bessel beam; discussion on possible applications of Bessel beams; Elements of linear system theory and Fourier analysis. Exercises set before the midterm evaluation.
7	Sun 10/06/2019 Thu 10/10/2019	The propagation problem. General solution through Fourier modal decomposition. Plane-wave propagator. Linear system representation. Evanescent waves and their physical implications.
8	Sun 10/13/2019 Thu 10/17/2019	First formula of Rayleigh-Sommerfield. Huygens principle. Fresnel diffraction integral. Far-Field diffraction formula. Optical resolution limits from wave propagation. Exercise set on far-field diffraction from slit and simple optical apertures.
9	Sun 10/20/2019 Thu 10/24/2019	Modeling of laser light beams. General considerations on laser light properties. Derivation of Paraxial wave equation.
10	Sun 10/27/2019 Thu 10/31/2019	Mid-semester break
11	Sun 11/03/2019 Thu 11/07/2019	Mid-semester break
12	Sun 11/10/2019 Thu 11/14/2019	Mid-semester break
13	Sun 11/17/2019 Thu 11/21/2019	Mid-semester break
14	Sun 11/24/2019 Thu 11/28/2019	Mid-semester break
15	Sun 12/01/2019 Thu 12/05/2019	Mid-semester break
16	Sun 12/08/2019	Exams

Note

The instructor reserves the right to make changes to this syllabus as necessary.