Hong Kong Baptist University
Faculty of Science – Department of Physics

Title (Units): **PHYS 4045 ELECTROMAGNETIC WAVES AND OPTICS (3, 3, 1)**

Course Aims: The first part of this course introduces the classical theory of electromagnetic waves and their interactions with matter. The second part treats interference and diffraction. The third part covers laser basics and Gaussian beams. Current topics will also be discussed.

Pre-requisite: PHYS 3027 Intermediate Electromagnetism or consent of instructor.

Course Reviewed by: Dr. Jack T.F Ng and Dr. Alex Mok

Course Intended Learning Outcomes (CILOs):

No.	Upon successful completion of this course student should be able to:
1.	Explain the propagation of electromagnetic waves in vacuum and in matter as well as their behavior at boundaries.
2.	Explain the optical properties of solids.
3.	Treat the interference and diffraction of light.
4.	Explain laser principles and Gaussian beam properties.
5.	Discuss some current developments in the field of EM waves and optics.

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Teaching & Learning Activities (TLAs):

CILOs	**TLAs will include the following:**
1-5	**Lectures.** The instructor will use the following teaching approaches, • *Orient and motivate* the students whenever a new idea is introduced, verbally explaining why it is needed, where it comes from and where it is leading to. • Move *from familiar to exotic*. For example, start with geometric optics and move onto Gaussian beam optics. • Relate new concepts to the overall logical structure, much like *mind maps*. • *Visualization*. Big sketches and tables will be used as frequently as possible to illustrate physical systems, concept comparisons, mind maps etc. • Do *worked examples* as much as possible. Will first describe and rationalize the approach before plugging in equations. Will show ways to check the consistency of answers. Will invite student participation throughout. • Crowning applications. One or two *real world problems* will be presented near the end of each chapter. The instructor will guide the students to understand the system, identify the essence, formulate the model, and analyze it qualitatively and quantitatively. • *End-of-chapter summary.* A summary will be given at the end of each chapter, typically within one A4 page. It serves as the skeleton of the logical structure as well as the breadth requirement of the course.
1,2,5	**Tutorials.** Given the smaller class size, students can learn interactively through, • Questions and answers. • Worked examples with student participation. • Small group discussions. Students are encouraged to adopt the instructor's strategies of (1) verbal explanation, (2) visualization, (3) mind maps, and the sort.

CILOs	TLAs will include the following:
2-4	**Homework assignments.** Students are assigned readings and problem sets. Solving homework problems is probably the most important learning activity. Students are encouraged to discuss with classmates and consult the instructor and TA though they have to write up their solution independently. In some cases, students are required to verbally explain their approach. Problems requiring numerical computation will also be assigned. Homework solutions may be posted on the web after the due date.
5	**Project assignments.** Students are to form small groups to work on a topic of current interest and relevance. They are to present their work near the end of the semester.

Assessment Methods (AMs):

No.	Assessment Methods	Weighting	CILOs to be addressed	Remarks
1	Problem and project Assignments	40%	1-3	Problem sets to measure how well the students have learned the subject, and to enhance their analytical skills. End of semester project assignments to measure how well the students have integrated the materials.
2	Mid Term Test	20%	1-2	This test aims to measure students' ability to solve problems that relate to the propagation of electromagnetic waves in vacuum and in different media. It also serves to provide some feedback to the instructor and students.
3	Final Examination	40%	1-5	Final Examination questions are designed to see how far students have achieved their intended learning outcomes.

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Learning Outcomes and Weighting:

Content	**LO No.**	**Teaching (in hours)**
I. Maxwell's Equations and Electromagnetic Waves	1	12
II. Optics of Solids	2	5
III. Interference and Diffraction	3	8
IV. Laser Light	4	5
V. Current Topics	5	6

Textbook: At the level of E. Hecht, Optics, Pearson International Edition, 2013.

References:
1. D.J. Griffiths, Introduction to Electrodynamics, 4th Ed., PHI Learning, 2012.
2. C.A. Bennett, Principles of Physical Optics, Wiley, 2008.
3. G.R. Fowles, Introduction to Modern Optics, 2nd Ed., Dover, 1989.
4. G. Brooker, Modern Classical Optics, Oxford U Press (2003).
5. W.J. Smith, Modern Optical Engineering, 4th Ed., McGraw-Hill, 2007.
6. O. Svelto, Principle of Lasers, 5th Ed., Springer, 2010.
7. Technical Information webpage of the optics company CVI-Melles Griot: http://www.cvimellesgriot.com/company/Documentation.aspx?SuperGroupid=27 .

Course Content in Outline:

	Topic	**Hours**
I.	Maxwell's Equations and Electromagnetic Waves	12
	A. Review of Maxwell's Equations	
	B. The Wave Equations for **E** and **B**	
	C. Monochromatic Plane Waves	
	D. Energy and Momentum in Electromagnetic Waves	
	E. Absorption, Dispersion and Scattering	
	F. Applications: For example, waveguides and optical fibers.	

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II.	Optics of Solids	5
	A. Dielectrics and Fresnel Equations	
	B. Conductors	
	C. Crystals	
	D. Applications: For example, glass reflectance, wave plates, and polarizing prisms.	
III.	Interference and Diffraction	8
	A. N-beam Interference	
	B. Coherence	
	C. Fraunhofer Diffraction of Slits and Apertures	
	D. Applications: For example, gratings, interferometers, Fourier transform spectroscopy, and diffraction-limited microscopy	
IV.	Laser Light	5
	A. Laser Principles	
	B. Gaussian Beams	
	C. Applications: For example, laser beam manipulation and control	
V.	Current Topics	6
	Current topics in electromagnetic waves relevant to energy science will be discussed, such as solar light collection and conversion, wireless energy transmission, the optics of laser inertial fusion, etc.	