Hong Kong Baptist University
Faculty of Science – Department of Physics

Title (Units): **PHYS 3027 INTERMEDIATE ELECTROMAGNETISM (3, 3, 1)**

Course Aims: This course studies electromagnetism up to Maxwell's equations at an intermediate level. It uses the tools of vector calculus for solving special problems in electrostatics and magnetostatics including the presence of dielectric and magnetic materials.

Pre-requisite: PHYS2006 Electricity and Magnetism or Consent of Instructor

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

Course Intended Learning Outcomes (CILOs):

No.	Upon successful completion of this course, students should be able to:
1	Apply vector calculus in the theory of electromagnetism;
2	Solve problems in electrostatics and magnetostatics including the presence of dielectric and magnetic materials;
3	Solve potential or field equations with appropriate boundary conditions for simple situations in boundary value problems;
4	Construct the unified picture of electric and magnetic phenomena described by Maxwell's equations.

Teaching and Learning Activities (TLAs):

CILOs	TLAs will include the following:
1-4	Lecture, homework and class discussion will address the desired learning outcomes by emphasizing the key concepts.
1-3	Students working in small groups solve problems involving one or more principles of electromagnetism such as determining the field or potential of a given charge distribution. They will learn how to analyse the given problem and evaluate the technique that should be used for solving it. Moreover, they will also learn to apply the theory in new physical contexts and obtain correct analytical and numerical results.
1-2	Graphics will be used to demonstrate some physical concepts, for example, the physical interpretation of bound charges and currents.

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Assessment Methods (AMs):

Type of Assessment Methods	Weighting	CILOs to be addressed	Description of Assessment Tasks
Assignments, quizzes and participation	40%	CILOs 1-4	Assignments and quizzes are designed to measure students' understanding of the basic electromagnetic theory and to enhance their analytical skills.
Mid-term Test	20%	CILOs 1-2	This test aims to measure students' ability to solve problems that relate to basic concepts in electromagnetism. It also serves to provide some feedback to the instructor and students.
Final Examination	40%	CILOs 1-4	Students will solve a set of problems to show how far they have achieved their intended learning outcomes.

Learning Outcomes and Weighting:

Content	LO No.	Teaching (in hours)
I. Vector Analysis	1	3
II. Electrostatics	1, 2	6
III. Boundary Value Problems in Electrostatics	3	6
IV. Electric Fields in Matter	2, 3	6
V. Magnetostatics	1, 2	4
VI. Magnetic Fields in Matter	2, 3	5
VII. Electrodynamics	4	6

Textbook: D.J. Griffiths, *Introduction to Electrodynamics*, 4th Ed., Addison-Wesley, 2012.

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References:

1. M. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Ed., Wiley, 2005.
2. R.P. Feynman, R.B. Leighton and M. Sands, *The Feynman Lectures on Physics, The Definitive Edition Volume 2*, 2nd Ed., Addison-Wesley, 2005.
3. P. Lorrain, D. Corson and F. Lorrain, *Electromagnetic Fields and Waves*, Freeman, 1988.
4. J.R. Reitz, F.J. Milford and R.W. Christy, *Foundations of Electromagnetic Theory*, 4th Ed., Addison Wesley, 2008.
5. J.D. Jackson, *Classical Electrodynamics*, 3rd Ed., Wiley, 1998.

Course Content in Outline:

	Topic	**Hours**
I.	Vector Analysis	3
	A. Gradient, Divergence and Curl	
	B. Line, Surface and Volume Integrals	
	C. Gradient Theorem, Divergence Theorem and Stokes' Theorem	
	D. Curvilinear Coordinates	
	E. The Dirac Delta Function	
	F. The Helmholtz Theorem	
II.	Electrostatics	6
	A. Coulomb's Law	
	B. Electric Field and Gauss's Law	
	C. The Curl of E	
	D. Electric Potential, Work and Energy	
	E. Conductors and Capacitors	
III.	Boundary Value Problems in Electrostatics	6
	A. Poisson's and Laplace's Equations	
	B. Boundary Conditions and Uniqueness Theorems	
	C. The Method of Images	
	D. Separation of Variables	
	E. The Multipole Expansion of the Scalar Potential	

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IV.	Electric Fields in Matter	6
	A. Polarization and Bound Charges	
	B. Fields due to a Dielectric Medium	
	C. The D Field	
	D. Gauss's Law for Dielectrics	
	E. Susceptibility, Permittivity and Dielectric Constant	
	F. Energy in Dielectric Systems	
	G. Boundary Value Problems with Linear Dielectrics	
V.	Magnetostatics	4
	A. Currents and the Continuity Equation	
	B. The Biot-Savart Law	
	C. The Divergence and Curl of B	
	D. Ampere's Law	
	E. Magnetic Vector Potential	
	F. The Multipole Expansion of the Vector Potential	
VI.	Magnetic Fields in Matter	5
	A. Diamagnets, Paramagnets and Ferromagnets	
	B. Magnetization and Bound Currents	
	C. The Field of a Magnetized Object	
	D. The H Field	
	E. Magnetic Susceptibility and Permeability	
	F. Ampere's Law for Magnetized Materials	
VII.	Electrodynamics	6
	A. Faraday's Law	
	B. Inductance and Magnetic Energy	
	C. The Displacement Current	
	D. Maxwell's Equations in Vacuum and in Matter	