Nanyang Technological University
Division of Physics and Applied Physics

Academic Year	2023-24	**Semester**	1
Course Coordinator	Asst Prof. Chang Guoqing		
Course Code	PH2102		
Course Title	Electromagnetism		
Pre-requisites	(MH1801 and MH2800 and PH1106) OR (MH1802 and MH1803 and MH2802 and PH1106) OR (CY1601 and CY1602 and CY1308) OR (MH1101 and MH1200 and PH1106)		
No of AUs	4 AU		
Contact Hours	PH2102 **Face to Face: 2 hr – lecture; 1.5 hr – tutorial** **Online: 0.5 hr (pace depends on student)** (Note: face-to-face lecture time increased from 1.5 to 2 hr; online component reduced from 1 hr to 0.5 hr. Justification: After experimenting with the new format (increased tutorial time, reduced lecture time, online component), I found that it didn't work very well; students preferred more face-to-face time to understand the material better.)		
Proposal Date	8 August 2023		

Course Aims

By the end of the course, the students will be able to understand the fundamental principles of electromagnetism. Through tutorials, students will learn the relevant analytical, computational and mathematical skills such as partial differential equations and the physical concepts behind the equations/solutions. These skills and concepts are the essential for the advanced courses such as electrodynamics and fluid mechanics.

Intended Learning Outcomes (ILO)

Upon the successful completion of this course, you (as a student) would be **able to**:

Basics (BAS)

1. use the mathematical forms of gradient, divergence, and curl in different coordinate systems to solve problems and interpret the physics meaning behind it.
2. apply vector calculus (such as divergence theorem and Stoke's theorem) to solve electromagnetism problems.

Electrostatics (ES)

3. determine the electrostatic field produced by static charges in a variety of simple configurations.
4. identify and apply appropriate theoretical techniques (such as method of images, separation of variables, and multipole expansion) to determine the electric potential due to a system of charges.
5. determine the electric fields in a dielectric with Gauss's law of electric displacement.
6. identify boundary conditions for solving electrostatic problems.
7. determine various physical quantities (such as electric field, electric displacement, polarization, force, and electric potential energy) and discuss their physical origins in dielectric materials.

Magnetostatics (MS)

8. apply Lorentz force to solve problems involving moving charged particles.

9. determine magnetic fields using (such as Biot-Savart's law and Ampere's law) whenever appropriate.
10. discuss the significance and origins of the magnetic vector potential.
11. distinguish between paramagnetism, diamagnetism, and ferromagnetism.
12. determine various physical quantities (such as magnetic field, auxiliary magnetic field, magnetization, bound surface current and bound volume current) in magnetic materials.

Electrodynamics (ED)

13. apply concepts of electrodynamics to electric circuits.
14. apply Faraday's law and Lenz's law to solve electromagnetic induction problems.
15. discuss the derivation of Maxwell's equations and their physical origins.
16. construct wave equations from Maxwell's equations and identify that electromagnetic waves are transverse waves with polarizations.
17. determine physical quantities (such as electric field, magnetic field, and Poynting vector) of an electromagnetic wave.

Course Content

This course introduces key concepts in electromagnetism;

Basics (BAS)

Multivariable & Vector Calculus
Taylor Expansion (for Cartesian coordinates)
Spherical Harmonics (for spherical coordinates)
Solving Ordinary Differential Equations using Separation of Variables

Electrostatics (ES)

Coulomb's Law
Gauss's Law
Electric Dipole Moment
Polarization and Electric Displacement
Multipole Expansion
Laplace's and Poisson's Equations
Uniqueness theorem
Method of Images
Electrostatic energy

Magnetostatics (MS)

Lorentz Force
Faraday's law and Lenz's law
Magnetic Dipole Moment
Magnetic Field and Flux
Magnetic Scalar and Vector Potentials
Magnetization and Magnetic Media
Permeability and Susceptibility
Properties of B and H Fields

Electrodynamics (ED)

Boundary Conditions
Equation of Continuity
Maxwell Equations
Electromagnetic Wave Equation
Magnetic and Electric Energy Densities

Poynting Flux
Momentum Flux
Radiation Pressure
Polarization

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Weighting	Team / Individual	Assessment Rubrics
1. Final Examination	All	55%	Individual	Point-based marking, (not rubric based)
2. Homework 1	**BAS** 1-2 **ES** 3-4	10%	Individual	Point-based marking, (not rubric based)
3. Midterm Test	**BAS** 1-2 **ES** 3-5,7	25%	Individual	Point-based marking, (not rubric based)
4. Homework 2	**ES 6** **MS** 8-12	10%	Individual	Point-based marking, (not rubric based)
Total		100%		

Formative feedback

Formative feedback is given weekly through assignments marking and tutorial lessons. A weekly TA meeting discusses the progress, pace, and difficulty level of lectures.

Formative feedback is given during clicker sessions every lecture.

Formative feedback on the midterm test is given as a midterm check of students' understanding of learned contents. Feedback is also given after the midterm test on the common mistakes and level of difficulty of the problems. Past exam questions and examiner's report are made available for students.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lectures	Lectures provide the necessary content and practice of problem solving and discussion of conceptual understanding.
Tutorial	The students review and discuss main concepts learned in lectures with

	TAs by working through problems. TAs monitor and provide timely feedback.
Homework	The homework comprises standard textbook practice questions that are covered during tutorial allowing for formative assessment and feedback.

Reading and References

1. David J. Griffiths, Introduction to Electrodynamics, Pearson 4th ed. (2012). ISBN-13: 978-1108420419

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons

If you are sick and unable to attend your class / Mid-terms, you have to:

1. Send an email to the instructor regarding the absence and request for a replacement class and make-up mid-terms.
2. Submit the Medical Certificate* or official letter of excuse to administrator.
3. Attend the assigned replacement class (*subject to availability*) and make-up mid-terms.

* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Guoqing Chang	PAP-04-08	81325877	guoqing.chang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Recap and Diagnostics Vector Analysis	**BAS** 1-2	Textbook and lecture notes, videos
2	Electrostatics	**ES** 3-4	
3	Electrostatics	**ES** 4	
4	Electrostatics	**ES** 4	
5	Electric Fields in Matter	**ES** 5, 7	
6	Electric Fields in Matter	**ES** 6-7	
7	Electric Fields in Matter	**ES** 6-7	Midterm Test
8	Magnetostatics	**MS** 8-10	Textbook and lecture notes, videos
9	Magnetic Fields in Matter	**MS** 11-12	
10	Electrodynamics	**ED** 13	
11	Electrodynamics	**ED** 14	
12	Electrodynamics	**ED** 14-15	
13	Electromagnetic Waves	**ED** 16-17	