Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	
Semester/Trimester/Others (specify approx. Start/End date)	
Course Author * Faculty proposing/revising the course	Zhang Baile
Course Author Email	blzhang@ntu.edu.sg
Course Title	Classical Electrodynamics
Course Code	PH7006
Academic Units	4
Contact Hours	52
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	For graduate students: No pre-requisites For undergraduates: PH2102 Electromagnetism or equivalent
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to equip you with a unified macroscopic theory of the dynamics of classical electromagnetic waves (hence called Classical Electrodynamics), in accordance with the form invariance of the Maxwell equations and the constitutive relations. Great emphasis is placed on the fundamental important of the k vector in electromagnetic wave theory.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Derive the wave equation of wave solution from Maxwell's equations.
ILO 2	Understand the importance of k vector.
ILO 3	Judge the polarization and construct different polarizations.
ILO 4	Understand the basics of radiation from Hertzian dipoles.
ILO 5	Master the application of boundary conditions.
ILO 6	Understand the complex notation of time-harmonic fields.
ILO 7	Master a general understanding of constitutive matrixes.
ILO 8	Solve electromagnetic waves in different media.
ILO 9	Apply KDB system for waves in anisotropic and bianistropic media.
ILO 10	Derive the reflection and refraction of electromagnetic waves at an interface between two media.
ILO 11	Understand the total internal reflection, negative refraction, and plasmonic waves.
ILO 12	Derive guidance condition for planar and rectangular waveguides.
ILO 13	Understand basics of cavity resonance.
ILO 14	Master the use of dyadic Green's functions.
ILO 15	Derive Cerenkov radiation.
ILO 16	Derive Hertizian dipole radiation.
ILO 17	Analyse and construct radiation patterns of dipole arrays.
ILO 18	Understand the uniqueness theorem.
ILO 19	Apply the equivalence principle and understand various equivalent sources.

ILO 20	Understand duality and complementarity.
ILO 21	Derive Fresnel and Fraunhofer diffraction based on Huygens' principle.
ILO 22	Understand reaction and reciprocity.
ILO 23	Derive Lorentz transformation of field vectors.
ILO 24	Classify electromagnetic fields based on Lorentz invariants.
ILO 25	Understand basics of electromagnetic waves in moving media.
ILO 26	Apply the tensor form of Maxwell's equations.

Course Content

Fundamentals: Wave equation from Maxwell’s equations. Spatial frequency k vector. Polarization Hertzian waves Poynting vector Constitutive relations Boundary conditions Media: Time-harmonic fields and their complex notation Time-averaged Poynting power Waves in plasma media Anisotropic media and bianisotropic media kDB system Reflection and Guidance: Reflection and refraction of TM waves Reflection and refraction of TE waves Phase matching Total internal reflection and Brewster angle Negative refraction Backward waves Guided waves in conducting parallel plates Guided waves in a rectangular waveguide Guided waves in a cylindrical waveguide Cavity resonance Radiation: Cerenkov radiation Dyadic Green’s functions Electric and magnetic Hertizian dipoles Linear dipole arrays Theorems: Equivalence principle Uniqueness theorem Duality and complementarity Huygens’ principle Fresnel and Fraunhofer diffraction Relativity: Lorentz transformation of space and time Lorentz transformation of field vectors Lorentz invariants Classification of electromagnetic fields Electromagnetic waves in moving media Tensor form of Maxwell’s equations

Reading and References (if applicable)

Electromagnetic Wave Theory, Jin Au Kong, EMW Publishing (2008) ISBN0-9668143-9-8

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Maxwell's equations; Constitutive relations; Poynting vector	Fundamentals: 1-5		In-person	Lecture, Tutorial
2	Plane wave solutions; Phase velocity and group velocity; kDB system	Media: 6-7		In-person	Lecture, Tutorial
3	Plane waves in uniaxial media	Media: 8-9		In-person	Lecture, Tutorial
4	Plane waves in gyrotropic and bianisotropic media	Media: 8-9		In-person	Lecture, Tutorial
5	Phase matching; Reflection and transmission at a plane boundary	Reflection and Guidance: 10-11		In-person	Lecture, Midterm Test 1
6	Reflection and transmission by a layered medium; Guidance by conducting parallel plates	Reflection and Guidance: 12		In-person	Lecture, Tutorial
7	Rectangular waveguide and cylindrical waveguide;	Reflection and Guidance: 12-13		In-person	Lecture, Tutorial
8	Cerenkov radiation; Dyadic Green's functions	Radiation: 14-15		In-person	Lecture, Tutorial
9	Hertzian electric dipole; Hertzian magnetic dipole; Antenna array	Radiation: 16-17		In-person	Lecture, Midterm Test 2

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	Equivalence principle; Extinction theory	Theorems: 18-19		In-person	Lecture, Tutorial
11	Duality and complementarity; Reaction and reciprocity	Theorems: 20-22		In-person	Lecture, Tutorial
12	Relativity and Lorentz transformation	Relativity: 23-25		In-person	Lecture, Tutorial
13	Lorentz covariant formulation	Relativity: 26		In-person	Lectures, Midterm Test 3

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Others([assignments (e.g. term paper, essay)] CA - Homework)	All		25		Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Others([quiz/test] Mid-term Test 1)	Fundamentals, Media		25		Individual	Analytic	Multistructural
3	Continuous Assessment (CA): Others([quiz/test] Mid-term Test 2)	Reflection and Guidance, Radiation		25		Individual	Analytic	Multistructural
4	Continuous Assessment (CA): Others([quiz/test] Mid-term Test 3)	Theorems, Relativity		25		Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

Formative Feedback

Homework problems provide timely feedback on your understanding of the course. Midterms allow formative assessment, and feedback to you.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Curiosity	Advanced
Critical Thinking	Advanced

Course Policy

Policy (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. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

Policy (Absenteeism)

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

Send an email to the instructor regarding the absence and request for a replacement class and make-up mid-terms.

Submit the original Medical Certificate* or official letter of excuse to administrator.

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.

Policy (Others, if applicable)

Last Updated Date: 22-01-2025 10:52:36