School of Physics

Course Outline 2022

PHYS2114

Electromagnetism

School of Physics

Faculty of Science

T2, 2022

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Rajib Rahman	rajib.rahman@unsw.edu.au	Please email lecturers only for urgent matters and arranging a consultation time. Questions about course related matters should be posted on the appropriate Moodle Discussion Forum	
Lecturer	Oleg Sushkov	sushkov@unsw.edu.au		
Laboratory Staff	Tamara Reztsova	t.reztsova@unsw.edu.au	Higher Year Lab 142 OMB	(02) 9385 4577
Teaching Support Officer	Zofia Krawczyk-Bernotas	z.krawczyk-bernotas@unsw.edu.au	School of Physics office G06, Old Main Building	(02) 9065 5719

2. Course information

Units of credit: 6
Pre-requisite(s): PHYS1221 or PHYS1231 or PHYS1241 and MATH2069 or MATH2011 or MATH2111

Teaching times and locations:
http://timetable.unsw.edu.au/2022/PHYS2114.html

2.1 Course summary

Electromagnetism is important from both fundamental and applied viewpoints. This course aims to provide students with an introduction to the principles and behaviours of electric and magnetic systems, and the unified subject of electromagnetism in terms of Maxwell's four equations. Building on electromagnetic theory, we will analyse a number of problems that are of importance in optical and radiofrequency engineering.

Topics to be covered include:

- Electric field and force due to a static electric charge distribution.
- Electric potential.
- Work and energy.
- Laplace's equation and solution methods.
- Electric polarisation.
- Linear dielectrics.
- Lorentz force.
- Magnetic fields due to a steady current distribution.
- Magnetic vector potential.
- Magnetization.
- Linear media.

- Ohm’s law and electromotive force
- Electromagnetic Induction
- Kirchhoff ’s laws, Complex impedance
- Maxwell’s equations. Poynting’s vector.
- Skin effect, Foucault’s currents (Eddy currents).
- Vector potential and gauge invariance.
- Electromagnetic waves.
- Polarization of electromagnetic wave.
- Fresnel Eqs. for reflection/refraction.
- Radiation of electromagnetic waves.
- Retarded potentials.
- Electric dipole radiation.

1. Course aims

Electromagnetism is important from both fundamental and applied viewpoints. This course aims to provide students with an introduction to the principles and behaviours of electric and magnetic systems, and the unified subject of electromagnetism in terms of Maxwell’s four equations. Building on electromagnetic theory, we will analyse a number of problems that are of importance in optical and radiofrequency engineering.

Graduate Attributes Developed in this Course

- Research, inquiry and analytical thinking abilities
- Capability and motivation for intellectual development
- Ethical, social and professional understanding
- Communication in a scientific/technical context
- Collaborative and management skills
- Information literacy

2.3 Course learning outcomes (CLO)

By the end of this course, you will be able to:
- Explain how electricity and magnetism are related and unified
- Use Maxwell’s equations to analyse static and simple time-dependent systems of charge and current distributions.
- Apply Maxwell’s equations to describe the behaviour of electromagnetic waves for a number of important geometric arrangements.
- Demonstrate the practical implications of electromagnetic theory in experiments

Graduate Attributes Developed in this Course

Research, inquiry and analytical thinking abilities
Capability and motivation for intellectual development
Ethical, social and professional understanding

Communication in a scientific/technical context
Collaborative and management skills Information literacy

2.4 Relationship between course and program learning outcomes and assessments

Course learning outcomes are assessed in the three assessment tasks. These assessments are largely of a critical-thinking nature designed to determine students' ability to deploy acquired knowledge to new situations, which is a key graduate attribute for successful university graduates.

3. Strategies and approaches to learning

3.1 Learning and teaching activities

Assumed Knowledge

Pre-requisite(s): PHYS1221 or PHYS1231 or PHYS1241, plus MATH2069 or MATH2011 or MATH2111

Timetable

Lectures: 1x 2hr plus 2x 1hr lectures per week (Weeks 1-5, 7-10)

Tutorial: 1hr per week (Weeks 1-5, 7-10)

Laboratory: 2 x 3hr per term

Lecture Timetable

Day	***Time***	***Location***	***Weeks***
Monday	10:00-12:00	OMB G31	1-2, 4-5, 7-10 (there will be no lecture on Monday Queen's Birthday)
Wednesday	9:00-10:00	OMB 230	1-5, 7-10
Thursday	11:00-12:00	OMB G31	1-5, 7-10

Lecture Information

Lecture: This course is taught by two lecturers teaching 18 hours each. Lectures will be recorded, so students are able to attend lectures online if they are unable to come to campus. Please see Moodle for more details.

Tutorial: Friday 9:00-10:00 in Keith Burrows Theatre, Weeks 1-5, 7-10. Tutorials will be run both face to face and online, so any students who cannot come to campus are still able to participate. Please see Moodle for more details.

Laboratory Information

Laboratory Information Two experiments need to be conducted during the term. The laboratory component of the course will be held in OMB142. For details about lab days, times and class codes, see http://timetable.unsw.edu.au/2022/PHYS2114.html or contact Laboratory Staff (Tamara Reztsova at t.reztsova@unsw.edu.au).

3.2 Expectations of students

We believe that effective learning is best supported by a climate of enquiry, in which students are actively engaged in the learning process. To ensure effective learning, students should participate in class. Effective learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes, in the case of lectures, and, in the case of tutorials or laboratories, have made a serious attempt at doing the problems or pre-work themselves prior to the class. Furthermore, lectures should be viewed by the student as an opportunity to learn, rather than just copy down lecture notes. Effective learning is achieved when students have a genuine interest in the subject and make a serious effort to master the basic material. Academic misconduct will not be tolerated in any form in this course. Substantiated instances of cheating, plagiarism or copying answers may result in a failure grade or significant deduction of marks. Please see https://student.unsw.edu.au/plagiarism if you are in any way unsure of what constitutes plagiarism. Assignments in this class are to be done independently.

4. Course schedule and structure

Detailed Syllabus

Weeks	Lecturer	Topics
1-4.5	A/Prof Rajib Rahman	Electrostatics and Magnetostatics (Unit 1)
4.5-10	Prof Oleg Sushkov	Electrodynamics and Electromagnetism (Unit 2)

Unit 1 – Electrostatics, Dielectrics and Magnetism (Rajib Rahman)

Topic 1: Vectors algebra (1.1), Differential Calculus (1.2), Divergence Theorem, Stokes' Theorem (1.3), Delta functions (1.5), Electric field, principle of superposition (2.1), divergences & curl of 5 electrostatic fields, electric potential (2.2, 2.3).

Topic 2: Work and energy in electrostatics (2.3, 2.4), conductors, capacitors (2.5), Laplace's equation, uniqueness theorems (3.1), method of images (3.2).

Topic 3: Separation of variable (3.3), numerical solutions of Laplace's equation, Multipole expansion (3.4).

Topic 4: Electric polarisation, bound charges (4.1, 4.2), Electric displacement, linear dielectrics (4.3, 4.4), boundary value problems with linear dielectrics (4.4), energy and forces in dielectrics (4.4).

Topic 5: Lorentz force, steady currents (5.1), Biot-Savart law (5.2), divergence and curl of B, Ampère's law (5.3), magnetic vector potential (5.4), multipole expansion, boundary conditions (5.4).

Topic 6: Magnetisation (6.1), bound currents, Ampere's law in magnetised materials (6.2, 6.3), magnetic susceptibility and permeability (6.4)

Unit 2 – Electrodynamics, Electromagnetism and Light (Oleg Shushkov)

Topic 7: Density of electric current. Ohm's law. Locality of Ohm's law. Drude formula. Electromotive force due to battery. Motional electromotive force.

Topic 8: Faraday's law. The right hand rule. Lenz's law. Electric generator. Differential form of Faraday's law. Inductance (=selfinductance) of a coil. Mutual inductance of two coils. Energy density in magnetic field

Topic 9: Kirchhoff 's laws for DC circuits. Kirchhoff 's laws for AC lumped circuits. Transient behaviours of simple circuits. AC circuits driven by sinusoidal voltage, complex impedance.

Topic 10: Electric charge conservation. Maxwell's equations. Energy conservation and Poynting's vector. Maxwell's equations in dielectric matter: the linear approximation. Skin effect in a metal. Foucault's currents (= Eddy currents). Scalar and vector potentials, gauge transformation and gauge invariance, Maxwell's Eqs. written in terms of potentials.

Topic 11: Electromagnetic waves. Plane wave. Partial and full polarization. Polarization density matrix and Stokes parameters. Fresnel Eqs. For reflection/transmission.

Topic 12: Radiation of electromagnetic waves. Retarded potentials in Lorentz gauge. Spectral decomposition of retarded potentials. Fields in the wave zone (Far field). Radiated power. Electric dipole radiation (E1-radiation).

(Note: Chapter references to Griffiths 4th edition)

5. Assessment

5.1 Assessment tasks

Course assessment comprises assignments, in-session test, laboratory and final examination.

Assessment task	Length	Weight	Mark	Due date
Assessment 1: Assignment		20%		Wednesday 13th July (Week 7)
Assessment 2: Laboratory		20%		See above note regarding lab classes
Assessment 3: Final Exam	2 hours	60%		See Exam Schedule - TBA

Information about Special Consideration is available from https://student.unsw.edu.au/special-consideration

Further information
UNSW grading system: student.unsw.edu.au/grades
UNSW assessment policy: student.unsw.edu.au/assessment

5.2 Assessment criteria and standards

Please see Moodle for a marking rubric for each assessment task.

5.3 Submission of assessment tasks

Assignment Submissions

Unless otherwise specified, assignments should be submitted online by 5pm on the due date.

A downloadable assignment cover sheet is available from https://www.physics.unsw.edu.au/current-students/cover-sheet

Marks will be deducted for late assignments, at a rate of 5% of the maximum possible mark for the assignment per day. A weekend will count as two days. An assignment submitted after the solutions have been posted will automatically receive 0%.

5.4. Feedback on assessment

Please see Moodle for details on how feedback will be provided for each assessment task

6. Academic integrity, referencing and plagiarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site student.unsw.edu.au/plagiarism**,** and
- The *ELISE* training site subjectguides.library.unsw.edu.au/elise

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: student.unsw.edu.au/conduct.

7. Readings and resources

Recommended Text:

Introduction to Electrodynamics, 4th Ed, David J Griffiths, ISBN-13 9780321856562, Pub. Pearson Education

Other reference textbooks on Electromagnetism used in this course:

"Foundations of Electromagnetic Theory" Reitz, Milford, & Christy, 4th Edition "Modern Electrodynamics", Andrew Zangwill.

Other Resources

The PHYS2114 lecture notes will be posted to Moodle. Additional resources such as articles, papers, websites, other published material will be referred to during lectures and listed at the Moodle site.

8. Administrative matters

Communications
Students should check their UNSW email account regularly as all official university communication will be sent to that address. Students should use their university email account when writing to UNSW staff and should always include their name and student number.

Health and Safety

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

The School of Physics is actively committed to the health, safety and welfare of its staff and students. Information on relevant UNSW Occupational Health and Safety policies and expectations is available at: www.ohs.unsw.edu.au and https://www.physics.unsw.edu.au/about/safety

Recommended Internet Sites
The School of Physics website is www.physics.unsw.edu.au. Under the "Current Students" link students will find information about degrees, courses, and assessment.
The University website my.unsw.edu.au provides links to the UNSW Handbook, Timetables, Calendars and other student information.

Student Complaint Procedures
UNSW has procedures for dealing with complaints. These aim to solve grievances as quickly and as close to the source as possible. Information is available here: student.unsw.edu.au/complaints. Staff who can assist include:

School Contacts:

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9. Additional support for students

- The *Current Students* Gateway: student.unsw.edu.au
- Academic Skills and Support: student.unsw.edu.au/skills
- Student Wellbeing, Health and Safety: student.unsw.edu.au/wellbeing
- Disability Support Services: student.unsw.edu.au/disability
- UNSW IT Service Centre: www.it.unsw.edu.au/students