PHYS106

Electric and Magnetic Interactions

S2 Day 2015

Dept of Physics and Astronomy

Contents

General Information

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Credit points 3
Prerequisites PHYS107
Corequisites MATH132 or MATH133 or MATH135 or MATH136
Co-badged status

Unit description
This unit, together with PHYS107, provides an overview of physics both for students primarily intending to study physics, astronomy or photonics beyond first year, and for engineering students who wish to explore physics at a greater depth. As well as broadening their experience in basic classical Newtonian physics of matter and waves, and Maxwell's theory of electromagnetism, in this pair of units students are introduced to the main theories underlying modern physics: quantum mechanics, thermodynamics and statistical mechanics, and Einstein's theory of relativity, with an emphasis on understanding the interrelationship between these fundamental ideas. Fundamentals of experimental method and data analysis are taught in well-equipped laboratories using examples which support and complement the lecture course.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
- Demonstrate the understanding and use of key vector concepts including dot products, vector products, surface integrals over simple surfaces and electric and magnetic flux.
- Demonstrate the application of the laws of electromagnetism to solve a variety of quantitative problems in electrostatics, magnetostatics, circuit theory, induction and electromagnetic waves.
- Demonstrate familiarity with the use of, and the relations between, different electromagnetic SI units, and be able to correctly substitute physical quantities into formulae to obtain numerical answers.
- Understand and be able to mathematically interpret the basic properties of waves and show an understanding of the concept of wave-particle duality.
- Demonstrate the ability to manipulate laboratory equipment and perform physical measurements with an understanding of the statistical nature of measurement uncertainties involved. Be able to record experimental results, analyses and conclusions in a clear, logical, concise and systematic manner with only moderate guidance.

General Assessment Information

Satisfactory performance in all of the assessment types is required to pass the unit.

Assessment Tasks

Name	Weighting	Due
Assignments	15%	Spread through the session
Lab work	20%	Throughout the session
Midsession Exam	15%	Monday 8th Week
Final exam	40%	Exam period
In-tutorial tests	10%	Week 3 - Week 13

Assignments

Due: **Spread through the session**
Weighting: **15%**

We will set four assignments spread through the session (due approximately at the end of weeks 3, 6, 9, and 12)

On successful completion you will be able to:

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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- Understand and be able to mathematically interpret the basic properties of waves and show an understanding of the concept of wave-particle duality.

Lab work

Due: **Throughout the session**
Weighting: **20%**

Labs will take place throughout the term. You will learn practical experimental skills, and discover how to design, carry out, and analyse practical investigations.

On successful completion you will be able to:

- Demonstrate familiarity with the use of, and the relations between, different electromagnetic SI units, and be able to correctly substitute physical quantities into formulae to obtain numerical answers.
- Demonstrate the ability to manipulate laboratory equipment and perform physical measurements with an understanding of the statistical nature of measurement uncertainties involved. Be able to record experimental results, analyses and conclusions in a clear, logical, concise and systematic manner with only moderate guidance.

Midsession Exam

Due: **Monday 8th Week**
Weighting: **15%**

There will be a mid-session exam. This 50-minute exam will be at 9 am, Monday, Week 8, 28th September the normal lecture room E6A 102. The exam will include content from lectures in weeks 1 to 6 only.

On successful completion you will be able to:

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Demonstrate the understanding and use of key vector concepts including dot products, vector products, surface integrals over simple surfaces and electric and magnetic flux.
- Demonstrate the application of the laws of electromagnetism to solve a variety of quantitative problems in electrostatics, magnetostatics, circuit theory, induction and electromagnetic waves.
- Demonstrate familiarity with the use of, and the relations between, different electromagnetic SI units, and be able to correctly substitute physical quantities into formulae to obtain numerical answers.

Final exam

Due: **Exam period**
Weighting: **40%**

The final exam will be in the normal exam period, and will cover material from the entire course, with a slight emphasis on material from weeks 7 - 13. If your performance in the final exam is better than in the midsession exam, your midsession mark will be replaced by the final exam mark.

On successful completion you will be able to:

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
- Demonstrate the understanding and use of key vector concepts including dot products, vector products, surface integrals over simple surfaces and electric and magnetic flux.
- Demonstrate the application of the laws of electromagnetism to solve a variety of quantitative problems in electrostatics, magnetostatics, circuit theory, induction and electromagnetic waves.
- Demonstrate familiarity with the use of, and the relations between, different electromagnetic SI units, and be able to correctly substitute physical quantities into formulae to obtain numerical answers.
- Understand and be able to mathematically interpret the basic properties of waves and show an understanding of the concept of wave-particle duality.

In-tutorial tests

Due: **Week 3 - Week 13**
Weighting: **10%**

There will be a test of 5-10 minutes duration in each tutorial from week 3 to week 13. The tests will comprise a single question, based on those questions covered in the tutorial of the previous week. The results of your best nine tests from the total of eleven will contribute 10% of your final mark.

On successful completion you will be able to:

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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vector products, surface integrals over simple surfaces and electric and magnetic flux.

- Demonstrate the application of the laws of electromagnetism to solve a variety of quantitative problems in electrostatics, magnetostatics, circuit theory, induction and electromagnetic waves.
- Demonstrate familiarity with the use of, and the relations between, different electromagnetic SI units, and be able to correctly substitute physical quantities into formulae to obtain numerical answers.
- Understand and be able to mathematically interpret the basic properties of waves and show an understanding of the concept of wave-particle duality.

Delivery and Resources

Required and Recommended Texts and/or Materials

Required Text

Matter and Interactions by Ruth Chabay and Bruce Sherwood.

Either Volume 2 (Paperback) or the combined Volume (hardbound). Note that Volume 1 is the required text for PHYS107 in semester 1.

Required Resources

A copy of the PHYS106 Laboratory Manual should be purchased from the Coop bookshop before the laboratory sessions begin in the second week of the semester.

Web Resources

More information on the required text as well as additional ressource material can be found at http://www.matterandinteractions.org/

There are also other high quality learning resources on the web which we would recommend to you to use in your studies. The HyperPhysics site hosted by the Department of Physics and Astronomy at Georgia State University is widely acclaimed and used. The site also has mathematics learning resources on the maths used in physics.

http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html (Mechanics, and, Electricity & Magnetism).

Increasingly there are excellent web-based interactive simulations available – some are in the on-line resources that support the textbook. We encourage you to conduct your own web searches for others, and to develop your own critical judgment of which sites provide high quality resources that assist your learning. Two that we recommend to you are:

• http://www.explorelearning.com/ The Explorelearning Gizmos: follow links to Grade 9-12, Physics, Motion and Force; and Electricity & Magnetism. You will have to register to use this site.

• http://phet.colorado.edu/simulations/index.php?cat=Featured_Sims The University of Colorado, Boulder, Physics Education Technology (PhET) Simulations: follow the links to Motion; Energy, Work & Power; and Electricity, Magnets and Circuits. This site also contains maths resources, for example vector addition.

Technology Used and Required

Lecture notes, tutorial questions and answers, assignments, and other resources will be posted on the PHYS106 iLearn site.

Learning and Teaching Strategy

This unit is taught through lectures and tutorials and through undertaking laboratory experiments. We strongly encourage students to attend lectures because they provide a much more interactive and effective learning experience than studying a text book. The lecturer is able to interpret the physics that you will be learning, showing you the relationships between different components/concepts and emphasising the key physics principles involved. Questions during and outside lectures are strongly encouraged in this unit - please do not be afraid to ask, as it is likely that your classmates will also want to know the answer. You should aim to read the relevant sections of the textbook before and after lectures and discuss the content with classmates and lecturers.

This unit includes a compulsory experimental component. The experiments are stand-alone investigations and may include topics not covered by the lecture content of this course - they are an important part of the learning for this unit and the skills learned are essential for a well-rounded physics graduate.

You should aim to spend an average of 3 hours per week understanding the material and working on the tutorial problems and the assignments. You may wish to discuss your tutorial and assignment problems with other students, the tutors and the lecturers, but you are required to be able to show your own work (see the note on plagiarism). Tutorials and assignments are provided as one of the key learning activities for this unit. It is by applying knowledge learned from lectures and textbooks to solve problems that you are best able to test and develop your skills and understanding of the material.

As mentioned, there are many useful web resources on this material and we encourage you to seek out youtube videos on electromagnetism and other resources. However, while reading over the lecture notes and reading the textbook are very important, reading notes and watching physics videos are *passive* learning activities. It is critical that a substantial portion of your study time in physics is devoted to *active* learning strategies by attempting numerous problems from the text, tutorials, assignments and past exams. It is simply impossible to become adept in this subject by *watching* physics problems, you must *do* physics problems.

Unit Schedule

Lectures:

There are three lectures per week, as timetabled. Lectures follow the chapters from Volume II of the textbook Matter and Interactions.

Week 1: The electric field

Week 2: Electric fields in matter

Week 3: Electric fields of distributed charges

Week 4: Electric potential

Week 5: Electric field and circuits

Week 6: Circuit elements

(The midsemester exam will cover content up to this point)

Week 7: Magnetic field

Week 8: Magnetic force

Week 9: Patterns of field in space

Week 10: Faraday's law

Week 11: Electromagnetic radiation

Week 12: Waves and particles

Week 13: Revision

Tutorials

You should attend one tutorial per week.

Laboratory work

Lab experiments start in week 2, and take place each subsequent week apart from week 9 and 11. See the section on Laboratory Practicals.

Learning and Teaching Activities

Lectures

There will be three one hour lectures per week. During these the content of the unit will be explained, example problems will be solved and physics principles demonstrated.

Tutorials

There will be one tutorial per week. During this time students will work through problems related to the previous week's lecture content. Questions will be released in advance, and it is strongly recommended that you attempt the questions yourself before each tutorial.

Laboratory practicals

Three hour laboratory classes will be held in 11 weeks during the semester. During these students will engage in practical exercises to further their understanding of the physics concepts discussed in lectures and to develop their skills at measurement, analysis and verification of physical models.

In-tutorial quizes

There will be a test of 5-10 minutes duration in each tutorial. from week 3 onwards. These short quizzes are designed to test a key concept from the work from two weeks earlier ; e.g. week 1 lecture material will be the topic in week 2 tutorial problems and will be tested in the week 3 quiz. Quiz answers from each of the tutorials will be released, forming a set of basic revision questions.

Suggested book questions

We will each week publish a list of problems from the textbook. We recommend that you attempt these key problems to help you master the basic concepts covered in that week.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Disruption to Studies Policy http://www.mq.edu.au/policy/docs/disruption_studies/policy.html *The Disruption to Studies Policy is effective from March 3 2014 and replaces the Special Consideration Policy.*

In addition, a number of other policies can be found in the Learning and Teaching Category of Policy Central.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/support/student_conduct/

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://informatics.mq.edu.au/help/.

When using the University's IT, you must adhere to the Acceptable Use Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
- Demonstrate the understanding and use of key vector concepts including dot products, vector products, surface integrals over simple surfaces and electric and magnetic flux.
- Demonstrate the application of the laws of electromagnetism to solve a variety of quantitative problems in electrostatics, magnetostatics, circuit theory, induction and electromagnetic waves.
- Demonstrate the ability to manipulate laboratory equipment and perform physical measurements with an understanding of the statistical nature of measurement

uncertainties involved. Be able to record experimental results, analyses and conclusions in a clear, logical, concise and systematic manner with only moderate guidance.

Assessment tasks

- Assignments
- Lab work
- Midsession Exam
- Final exam
- In-tutorial tests

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcomes

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcome

- Demonstrate the ability to manipulate laboratory equipment and perform physical measurements with an understanding of the statistical nature of measurement uncertainties involved. Be able to record experimental results, analyses and conclusions in a clear, logical, concise and systematic manner with only moderate guidance.

Assessment task

- Lab work

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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electromagnetic waves.

- Demonstrate familiarity with the use of, and the relations between, different electromagnetic SI units, and be able to correctly substitute physical quantities into formulae to obtain numerical answers.
- Demonstrate the ability to manipulate laboratory equipment and perform physical measurements with an understanding of the statistical nature of measurement uncertainties involved. Be able to record experimental results, analyses and conclusions in a clear, logical, concise and systematic manner with only moderate guidance.

Assessment tasks

- Assignments
- Lab work
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Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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- Demonstrate the ability to manipulate laboratory equipment and perform physical measurements with an understanding of the statistical nature of measurement uncertainties involved. Be able to record experimental results, analyses and conclusions in a clear, logical, concise and systematic manner with only moderate guidance.

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Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcomes

- Demonstrate familiarity with the concepts of electricity and magnetism including charge, current, Coulomb's law, the Lorentz force law and Maxwell's equations.
- Understand and be able to describe the distinction between electric and magnetic fields, electric potential, electric and magnetic flux, electromotive force and electrical circuit properties such as voltage and current.
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Changes from Previous Offering

We have changed the operation of the exams in the unit. This session, if your final exam mark is better than your midsession exam mark, then only your final exam mark will count towards your final grade. This should not encourage students to place less emphasis on the midsession exam, but does allow for students whose performance improves through the session to get a final grade commensurate with their final performance.

We will publish recommended problems from the textbook each week. These questions are a suggestion for what work you can do to help you master the key concepts from the course.

Your quiz answers will be returned to you each week, so that you can compare your answer with the model solutions provided.

Laboratory Practicals

Laboratory Requirements

The laboratory component is considered an essential component of your studies and so counts for an appreciable fraction of your final assessment.

The laboratory work is designed to introduce you to some of the basic skills and techniques that are used in experimental physical science. Some of the activities in the laboratory may not relate directly to the material in the lecture course. This is because the laboratory activities are intended not only to illustrate physical concepts but also to introduce you to some techniques of measurement.

There is not a close correspondence between topics covered in the labs and those covered in lectures. By providing you with instructional material in the form of the Laboratory Notes manual, together with help from the laboratory demonstrators, the laboratory work has been designed to be tackled independently of the lecture material. There is some advantage in becoming familiar with a topic in an experimental situation before you meet it in lectures - that is often the case in real life! All the information you need for each experiment is contained in the Laboratory Manual. There is no need to spend a long time outside the laboratory hours in preparation, however a quick read through the lab notes beforehand will allow you to make better use of your time in the laboratory

Location of the 100-level Physics Laboratory

The laboratory is located on the ground floor of building E7B, at the NE corner (room 114). Entry is from the courtyard at the opposite end to the main staircase.

Laboratory Attendance Requirements

You are required to attend all rostered laboratory sessions. If you miss more than one session without a written explanation then **you will not be considered to have satisfactorily completed the laboratory component of the unit and you will fail the course**. Each time you attend the laboratory you must sign in and out (legibly) in the attendance book.

If you miss a laboratory session you should contact the Unit Convenor, David Spence, with written explanation and/or a medical certificate. If you miss a session without a valid reason, you must make up that session at an alternate time arranged with the Lab Manager Danny.

Lab manual

There is a PHYS106 lab manual, which guides you through each of the experiments. The laboratory manual is available on the iLearn website, and will also be available on the computers in the laboratory itself. If you wish, you can also buy a printed copy of the manual from the printery using this link.

Lab Notebook

You will be provided with a notebook to record your experimental results. Your notebook should show your collected data and the calculations and graphs resulting from the data. At the end of each section summarise your findings and answer any questions posed in the guiding notes.

At the completion of each laboratory session you must show your book to the laboratory supervisor who will check it and collect for marking. The marker (one of the laboratory demonstrators) will be checking your book to see whether you have kept a satisfactory record of what you have done and what you have concluded. Your marked notebook will be available at the start of your next scheduled laboratory. Be sure to check you book for comments from the marker as this will help you refine you laboratory technique (and increase your laboratory mark). Your notebook will be kept in the laboratory, and must not be removed from the laboratory at any time; this includes any previously filled notebook.

Laboratory Assessment

Details of the laboratory assessment will be outlined in the first session.

Laboratory Safety

You are required to follow all safety guidelines given in the lab manual, and as outlined by your lab supervisor. Food and drink cannot be taken into the laboratory and students without suitable covered footwear will be refused admission.

Laboratory Schedule

The schedule of labs is posted in the lab. Labs start in week 2, and are on each week apart from weeks 9 and 11. Please attend your nominated laboratory session. If you cannot attend your nominated session due to illness etc then you need to bring a doctor certificate to David Spence.

Changes since First Published

Date	Description
24/07/2015	Amended to reflect that the Laboratory manual is now available online.