Scheme of work – Cambridge IGCSE® Physics (0625)

Unit 5: Electromagnetism

Recommended prior knowledge
The linking of magnetic fields and electrical circuits is a part of the course that students find one of the most challenging. It is probable that students will have encountered magnets and magnetism at a fairly young age and the basic rules of like poles repelling and so on will have been known for many years when the Cambridge IGCSE Physics course is begun. It is surprising, however, that students are so commonly uncertain about which materials are ferromagnetic. Students at this stage very often believe that aluminium and copper – and sometimes all metals – are ferromagnetic. The plotting of magnetic fields with iron filings, plotting compasses and other devices will probably have been dealt with earlier although what is actually shown by the patterns is not always properly understood. That repulsion is the only true test for a magnet is also likely to have been met. Electromagnets will have been made and students will be familiar with many standard examples of temporary, permanent and electro-magnets. Students will need to have studied the electricity 1 unit before embarking on this unit; they need to be familiar with current and voltage (and the distinction between them) before dealing with electromagnetism. Surprisingly, students who might otherwise never confuse the terms *motor* and *generator* are sometimes tempted to do so when the *motor effect* and the *dynamo effect* are encountered within a short space of time. It is wise to separate them and to emphasise the distinction between what they do.

Context
Since students find electromagnetism so challenging, it is probably best left to the end of the course; this ensures that they have the maximum possible understanding of most other topics and the proximity of the examination is likely to concentrate their determination and enthusiasm. Many students are not especially clear about electromagnetic effects and wherever possible, they should be demonstrated by the teacher or – even better – performed by the students themselves. The progression from inserting a magnet into a solenoid, to repeating the experiment with an electromagnet, to switching the electromagnet off instead of removing it from the solenoid and then switching it back on, and finally to using the electromagnet with an a.c. supply is a clear and helpful way of introducing the transformer.

Outline
This unit contains ideas that relate directly to the way in which electricity is generated commercially, also to its transmission at high voltage and also to its use in motors. It can be used to tie the physics into the everyday lives of students and to help them see the relevance and importance of the subject as a whole. It needs to be handled carefully, however, as it is strangely inaccessible to many and frequently misunderstood.

(Please note: **(S)** in **bold** denotes material in the Supplement (Extended syllabus) only)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
4.1	State the properties of magnets Give an account of induced magnetism Distinguish between ferrous and non-ferrous materials Describe methods of magnetisation and of demagnetisation Describe an experiment to identify the pattern of field lines round a bar magnet Distinguish between the magnetic properties of iron and steel Distinguish between the design and use of permanent magnets and electromagnets	Simple experiments with magnets to show attraction and repulsion, leading to investigation of the field patterns round bar magnets (individually and between attracting poles and between repelling poles). Extend to show the direction of the field lines using a plotting compass. Make and use a simple electromagnet. Experiments to investigate the magnetisation and demagnetisation of samples of iron/steel by mechanical and electrical means. Iron is considered to be magnetically *soft* whilst steel is magnetically *hard*.	This website called 'Gallery of Electromagnetic Personalities' contains brief histories of 43 scientists who have made major contributions, from Ampere to Westinghouse: www.ee.umd.edu/~taylor/frame1.htm This site has a very full lesson plan including making an electromagnet: www.school.discovery.com/lessonplans/ IGCSE Physics Coursebook CD-ROM Activity Sheet 16.1, 16.2 Unit 5: Past Paper Question Core 1 Unit 5: Past Paper Question Alternative to Practical 1
4.5 (a)	Describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit	Experiment moving a permanent magnet in and out of a coil, connected to a very sensitive meter. This can be extended to show the same effect using an electromagnet moved in and out of the coil and then by simply switching the electromagnet on and off.	www.ndt-ed.org/EducationResources/HighSchool/Electricity/electroinduction.htm or www.regentsprep.org/regents/physics/phys03/dinduction/default.htm IGCSE Physics Coursebook CD-ROM Activity Sheet 21.1 Unit 5: Past Paper Question Core 2

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
4.5 (a) (S)	**State the factors affecting the magnitude of an induced e.m.f.** **Show understanding that the direction of an induced e.m.f. opposes the change causing it**	**Extend the experiments above to show the effects of the strength of the field (use a stronger permanent magnet or increase the current in the electromagnet), the speed of movement and the number of turns per metre in the coil.** **Induce a current in a solenoid by inserting a known pole at one end. Then pass a current through the solenoid in the same direction as the induced current; show that the field *opposes* the original insertion of the magnet.**	www.youtube.com/watch?v=KGTZPTnZBFE www.bbc.co.uk/schools/gcsebitesize/science/add_ocr/electric_circuits/mainsproducedrev1.shtml
4.5 (b)	Describe a rotating-coil generator and the use of slip rings Sketch a graph of voltage output against time for a simple a.c. generator	Make a working model generator – use a commercial science kit generator. Use a c.r.o. to show the voltage output. Make a large "generator" with cereal packets as magnets, a soup tin as the armature and mains wiring wrapped into a coil that connects to slip rings – it does not work but is much bigger and so easier for pupils to see.	This website describes the working of an a.c. generator: www.pbs.org/wgbh/amex/edison/sfeature/acdc_insideacgenerator.html
4.5 (c)	Describe the construction of a basic iron-cored transformer as used for voltage transformations Recall and use the equation $(V_p/V_s) = N_p/N_s$ Describe the use of the transformer in high-voltage transmission of electricity Give the advantages of high-voltage transmission	Make a working model transformer (two 'C-cores' with suitable wire windings) to introduce the ideas and follow with a demonstration (demountable) transformer. Use the experiment from 4.5(a) but use a.c. rather than switching on and off. Use a model transmission line and show that more energy gets through at a higher voltage; do not have high voltage wires uninsulated in the laboratory.	How transformers work: www.energyquest.ca.gov/how_it_works/transformer.html or www.youtube.com/watch?v=VucsoEhB0NA IGCSE Physics Coursebook CD-ROM Activity Sheet 21.2
4.5 (c) (S)	**Describe the principle of operation of a transformer** **Recall and use the equation $V_pI_p = V_sI_s$ (for 100% efficiency)** **Explain why energy losses in cables are lower when the voltage is high**	**A simple worked example using specific values is often a clear way of showing the significance of high voltage transmission.**	Unit 5: Past Paper Question Extension 1

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
4.5 (d)	Describe the pattern of the magnetic field due to currents in straight wires and in solenoids Describe applications of the magnetic effect of current, including the action of a relay	Use iron filings on a suitably placed card to show the field patterns round a straight wire and a solenoid. The direction of the field can be shown with a plotting compass. If a thin sheet of Perspex is used in place of the card the apparatus can be mounted on an overhead projector to give a class demonstration. Perspex sheets with dozens of built-in plotting compasses are also available. Fields in 3D can be shown with commercially available cylinders containing floating magnetic particles in a dense oil. Use a relay mounted in a Perspex box and it can be seen and heard switching a mains circuit on and off.	Plotting magnetic fields: www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/living_future/5_magnetic_field1.shtml or www.youtube.com/watch?v=JUZC679CwKs or www.bbc.co.uk/learningzone/clips/the-3d-magnetic-field-of-a-bar-magnet/287.html Unit 5: Past Paper Question Extension 2
4.5 (d) (S)	**State the qualitative variation of the strength of the magnetic field over salient parts of the pattern.** **Describe the effect on the magnetic field of changing the magnitude and direction of the current**	**Extend the experiments to show the effect of changing the magnitude and direction of the current (separation of lines of iron filings and direction of plotting compass).** **When drawing the field pattern around a straight wire pupils should be encouraged to draw circles whose separation increases outwards from the wire; this shows that the field gets weaker further from the wire.**	
4.5 (e)	Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing (i) the current (ii) the direction of the field	Use the 'catapult' experiment or similar. Use two parallel strips of aluminium foil mounted a few mm apart vertically. Pass a current through them in the same direction and in opposite directions and watch them attract or repel; like currents attract and unlike currents repel.	www.youtube.com/watch?v=14SmN_7EcGY IGCSE Physics Coursebook CD-ROM Activity Sheet 20.1, 20.2
4.5 (e) (S)	**Describe an experiment to show the corresponding force on beams of charged particles.** **State and use the relative directions of force, field and current**	**Use a cathode ray tube or a e/m tube to demonstrate these effects.**	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
4.5 (f)	State that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing the number of turns on the coil Relate this turning effect to the action of an electric motor	Make a model motor and investigate the effect of changing the number of turns. As with the generator, make a large and visible model with cereal packets and so on which does not work but is very clear to see. Make sure that pupils do not confuse *split-ring (commutator)* with *slip rings*.	www.youtube.com/watch?v=Xi7o8cMPI0E Explanation of how the motor works, with helpful illustrations: www.howstuffworks.com/motor.htm Model motor kits: www.practicalphysics.org/go/Experiment_334.html Unit 5: Past Paper Question Core 3
4.5 (f) (S)	**Describe the effect of increasing the current**	**Increase the current in the coil of an electric motor and see it speed up.**	