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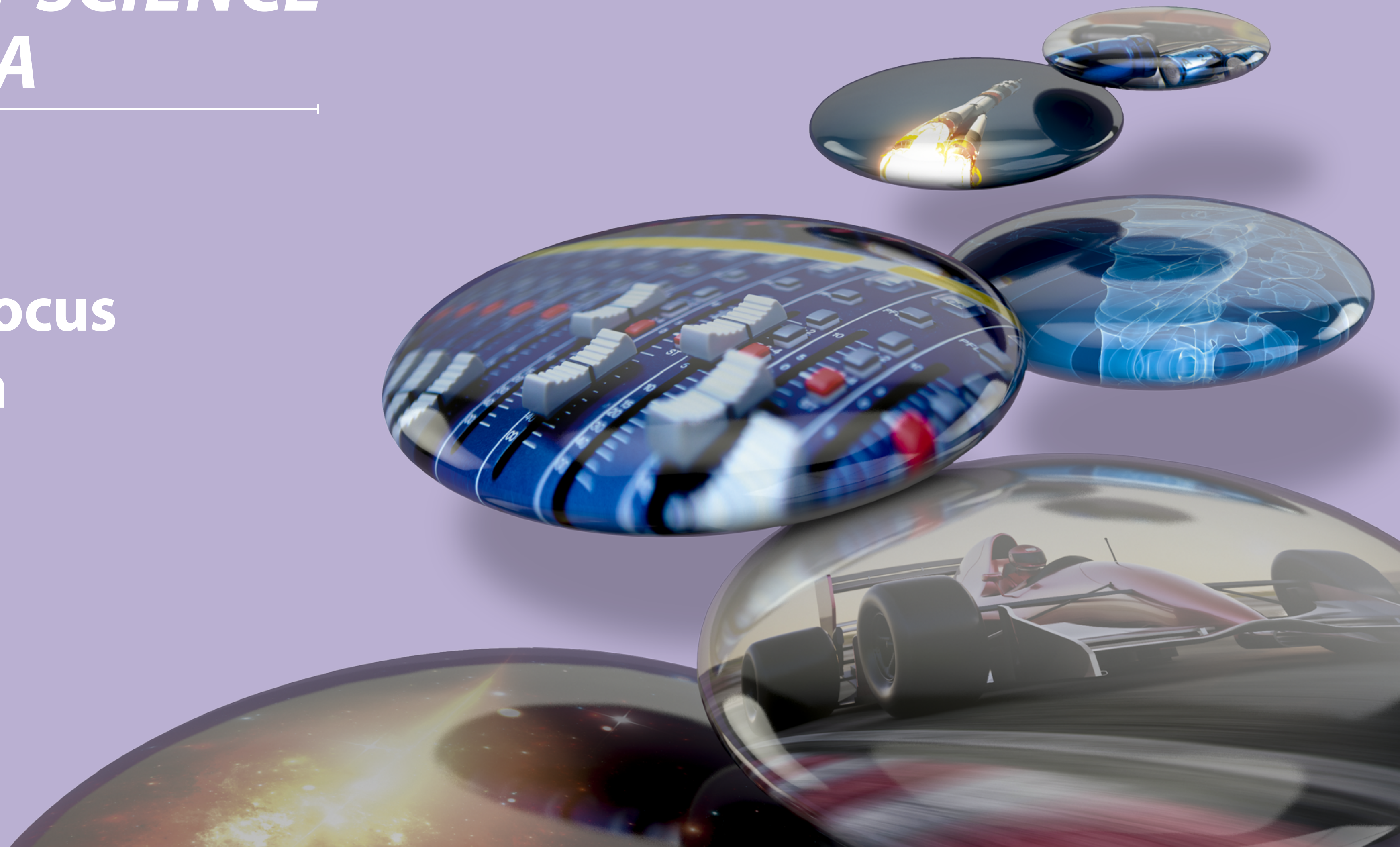
GCSE (9–1)
Transition Guide

GATEWAY SCIENCE PHYSICS A

J249
For first teaching in 2016

KS3–KS4 Focus
Magnetism

Version 1



www.ocr.org.uk/physics

Introduction

GCSE (9–1)

GATEWAY SCIENCE PHYSICS A

Key Stage 3 to 4 Transition guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 3 which will help prepare students for progression to Key Stage 4;
- Common student misconceptions in this topic.

Transition guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 3 and 4 and are designed to be of use to teachers of both key stages. Central to the transition guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 3 and assess their 'readiness for progression' to Key Stage 4 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 3 teaching of the topic or by Key Stage 4 teachers to establish their students' conceptual starting point.

Key Stage 3 to 4 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 3 Content

From study at Key Stages 1 to 3 learners should:

- be familiar with the basic properties of magnets, and use these to explain and predict observations
- know that there is a magnetic field close to any wire carrying an electric current.

Key Stage 4 Content

- describe the attraction and repulsion between unlike and like poles for permanent magnets
- describe the difference between permanent and induced magnets
- describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another
- explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic
- describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire
- recall that the strength of the field depends on the current and the distance from the conductor
- explain how solenoid arrangements can enhance the magnetic effect

- describe how a magnet and a current-carrying conductor exert a force on one another
- show that Fleming's left hand rule represents the relative orientations of the force, the current and the magnetic field
- apply the equation that links the force on a conductor to the magnetic flux density, the current and the length of conductor to calculate the forces involved
- explain how the force exerted from a magnet and a current-carrying conductor is used to cause rotation in electric motors
- recall that a change in the magnetic field around a conductor can give rise to an induced potential difference across its ends, which could drive a current, generating a magnetic field that would oppose the original change
- explain how this effect is used in an alternator to generate a.c., and in a dynamo to generate d.c.
- explain how the effect of an alternating current in one circuit, in inducing a current in another, is used in transformers
- explain how the ratio of the potential differences across the two depends on the ratio of the numbers of turns in each
- apply the equations linking the potential differences and numbers of turns in the two coils of a transformer
- explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits, and the reverse effect as used in loudspeakers and headphones

Comment

Learners' experiences with this topic so far have been qualitative; the progression to KS4 represents a considerable increase in the depth, complexity and specificity of the phenomena concerned. While the arithmetic/algebraic aspect of the quantitative element of the topic should not be noticeably more difficult than those in other areas of the subject, learners can have trouble intuitively dealing with the spatial relationships between electrical and magnetic phenomena. While learners should have some understanding of the different patterns of magnetic field lines around bar magnets, current-carrying wires and so on, the translation between these phenomena and the essential idea that they are all aspects of the same phenomenon can be difficult to understand. In part, this is because it is in no way intuitively obvious that attractive and repulsive forces towards and away from charged particles should result in attractive and repulsive forces perpendicular to the direction of motion of these particles. In fact, it is a result of special relativity, and thus the deeper explanations, as so often, are beyond GCSE level. However, as always, it can be useful for more engaged learners to have some idea of the way that electricity and magnetism are two aspects of the same phenomenon, not merely connected topics.

When using diagrams to show the shape of magnetic fields and the distribution of field strength, care should be taken to explain what field lines really represent. Some learners can easily become confused by the representational convention, and indeed by the behaviour of iron filings in related experiments, into thinking that the lines they see are in some way the form that the magnetic field actually takes. Of course, the point about the lines is that they represent the direction of force, and that the density of them represents the strength of the field; the exact individual placement of each line is arbitrary; as long as the relationship between density and field strength is maintained. The behaviour of the iron filings is of course caused by the individual filings becoming magnetised and lining up with each other. Again, exactly where each line forms is largely arbitrary.

Another problem some learners have is with the idea that electrical energy can be transferred with very high efficiency using transformers when there is no physical contact between the current-carrying wires on either side. Indeed, this connects to the wider problems many people have with the conceptual stretch involved in accepting that forces act over a distance without contact.

Of course, from the point of view of physics, these forces acting at a distance are the norm, and it is the idea of contact itself that requires explaining. Many learners enjoy thinking about the fact that, when they touch an object and feel that there is contact between them and it, what they are actually feeling is a form of electrostatic repulsion acting on very small scales, and that the particles inside the atoms both of them and the object do not 'touch' each other in a conventional sense. Indeed, if electrons are considered at point charges, as they are in classical physics, the probability of any two ever 'touching' each other is infinitesimal anyway, regardless of repulsion.

For less theoretically-minded learners, this area can be somewhat intimidatingly complicated, but in some cases motivation can be provided by the fact that electromagnetism in particular is an area with an enormous amount of practical applications, and the phenomenon itself can be great fun to explore experimentally. This is an areas of physics which combines some very familiar and obvious phenomena with others that are more mysterious and counterintuitive. The ease of building such devices as simple electric motors, loudspeakers and so on can also be a source of considerable fulfilment to those who prefer the more hands-on aspects of the subject.

It is, of course, always worth reminding learners as a precautionary measure that, since magnetism is an integral part of much of the technology they use, exposing electronic devices (and indeed cards with magnetic strips) to strong magnetic fields can have a rather deleterious effect on technology.

The checkpoint tasks are designed to reinforce the conceptual aspects of this topic. When more detailed quantitative work arrives later in KS4, learners have some intuitive understanding of the sorts of results they should be expecting and the relationships they are describing. In answering the questions given, learners should be encouraged to use initiative and attempt to come up with original ideas wherever possible.

Activities

Electricity and Magnetism
NDE-ed
https://www.nde-ed.org/EducationResources/HighSchool/Magnetism/electricitymagnet.htm

A helpful resource that takes what is known about magnetism at KS3 and extrapolates from it to approach higher level ideas.

KS3 Physics - Electromagnetism and magnetism - Revision 1
BBC
http://www.bbc.co.uk/education/guides/z3g8d2p/revision

Another helpful revision resource with relevant diagrams and brief explanations

Magnetic Concepts
Hyperphysics
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magcon.html#c1

The main page of a set of interlinked pages which go into considerable higher level detail about the principles of magnetism.

Right-Hand Rule
Sixty Symbols
https://www.youtube.com/watch?v=6oPNjQDOqkU

A demonstration of the right-hand rule, with a great deal of extra detail and historical information, plus an experiment in which the action of forces can be seen to a greater extent than learners will usually see.

Magnetic Field
Sixty Symbols
https://www.youtube.com/watch?v=VB55RwvoPi4

A more in-depth look at some magnets, including an extremely high-powered superconducting magnet at Nottingham University.

Overview

Each of the three tasks features a question which relates to a concept within magnetism/electromagnetism that will become an important underlying principle upon which many details are built at KS4, but with the emphasis on provoking learners to anticipate some of the ideas themselves; discovering something before they are told it can be a good way for learners both to feel invested in and to remember the information they will need to understand at GCSE level.

In each case, there are some obvious answers to the questions, but it is the explanations and reasoning that are most important; learners should be encouraged to think these questions through for themselves as much as possible before seeking assistance, perhaps including group work. The important thing, even if the answers are already known, is to demonstrate a good grasp of the idea and the paths of reasoning that can lead from the most basic information to the higher level emergent properties. There will be times later in the course where this connection between the basic principles and the more complicated higher level ideas can be hard to maintain. It is important that learners develop the habit of occasionally 'retracing their steps' and making sure that things still check out against basic principles.

Checkpoint task:

www.ocr.org.uk/Images/382337-magnetism-checkpoint-task.doc

Activities

Fleming's left hand rule (using the Earth's magnetic field)

Practicalphysics.org

http://practicalphysics.org/flemings-left-hand-rule-using-earths-magnetic-field.html

An ingenious experiment to use the catapult effect to show the orientation of Earth's magnetic field.

Simple Speaker Experiment!

Mist8k

https://www.youtube.com/watch?v=kXw2hFyTMTA

A short video showing a very simple way of making a simple loudspeaker that can be attached to a normal electronic sound source.

The Electric Cannon

Sixty Symbols

https://www.youtube.com/watch?v=eA3SDiyMiWU

An experiment showing how conductivity is increased by cooling metals, in the context of an experiment in which projectiles are launched with electromagnetism.

Spinning Magnet

Sixty Symbols

https://www.youtube.com/watch?v=hri1IsxKw3E&index=7&list=PLcUY9vudNKBNwSaBpVEWXk774OzczwW-v

A short video featuring a levitating magnetic spinning top.

World's First Electric Generator

Veritasium

https://www.youtube.com/watch?annotation_id=annotation_296038&feature=iv&src_vid=Nu3Y_jyeTyY&v=NqdOyxJZj0U

A short video about induction in which members of the public are entertained by a magnet falling through a copper pipe , featuring a look at Faraday's original electric generator.

Generator - Generator, Magnetism, Magnetic Field

PhET simulations, University of Colorado, Boulder

https://phet.colorado.edu/en/simulation/legacy/generator

A comprehensive interactive app in which users can interact with virtual components and observe the mechanisms of magnets, electromagnets, dynamos, motors and generators.

Activities

Feynman: Magnets FUN TO IMAGINE 4

BBC

https://www.youtube.com/watch?v=wMFPe-DwULM&t=38s

Richard Feynman spends a few minutes talking about magnets and reminding us that common sense and reality don't always go together in science.

How Special Relativity Makes Magnets Work

Veritasium

https://www.youtube.com/watch?v=1TKSfAkWWN0

A more detailed explanation of the reason why moving electric charges create magnetic forces.

MAGNETS: How Do They Work?

Minute physics

https://www.youtube.com/watch?annotation_id=annotation_4257245699&feature=iv&src_vid=1TKSfAkWWN0&v=hFAOXdXZ5TM

A companion to the video above which explains permanent magnets in terms of moving charges.

Do Atoms Ever Touch?

Sixty Symbols

https://www.youtube.com/watch?v=P0TNJrTlbBQ

An amusing video in which a physics professor and a Youtuber argue about the scientific definition of contact.

Momentum, Magnets & Metal Balls

Sixty Symbols

https://www.youtube.com/watch?v=xoUNyGUCzqs&list=PLcUY9vudNKBNwSaBpVEWXk774OzczwW-v&index=2

An experiment with magnets and momentum with a counterintuitive result.

Resources, links and support

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