

# *A Guide to Electrodynamics*

## **Teaching Approach**

In this series of videos we study the link between electricity and magnetism. The series progresses from the magnetic field that surrounds current carrying conductors and the motor effect right through to electromagnetic induction and the use of this effect in the real world.

Learners should ideally watch the videos in the correct order, followed by the task video. The order has been chosen to make the most sense and introduce the concepts slowly.

Electrodynamics relies heavily on models and hand rules and learners should practice and demonstrate their usage of the various hand rules throughout the series. Practice and demonstration will allow learners to better understand the visual aspect of this section of physics.

This section is traditionally seen as a difficult section for learners to grasp and where possible, real demonstrations can really help learners visualise this abstract concept. Use ideas from the lessons such as:

- Drawings;
- Physical apparatus where possible;
- Real electrical motors, magnets and wires.

A common mistake that is encountered by learners is one that is difficult to foresee: the difference between left and right hands and when to use them. First, establish that learners know the difference, and then make connection to when to use the various rules.

Lenz's law can also be linked successfully to Newton's Third Law of motion to provide learners with a handle on an otherwise abstract concept.

In summary, make sure that the learners are practicing, drawing and explaining as many examples as possible. Where possible, use pauses effectively in the videos to see if the learners can predict the outcome of a particular demonstration or animation.

## Video Summaries

Some videos have a 'PAUSE' moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson. Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next day's lesson; if desired, learners can be given specific questions to answer in preparation for the next day's lesson

### 1. The Magnetic Field around Conductors

In this video, we establish that a magnetic field is the result of current flowing in a conductor. The right hand rule is applied for a conductor and for a solenoid.

### 2. The Motor Effect

In this lesson, we look at the interaction between a current carrying conductor and another magnetic field. Fleming's Left-hand Motor rule is introduced and used to predict the direction of force experienced.

### 3. Electromagnetic Induction

In this lesson, the concept of induction of current in a conductor is introduced. The idea of a changing magnetic field producing a current at right angles is shown using Fleming's right-hand rule. Also included are Lenz's and Faraday's Laws, governing the direction of current and the emf induced respectively.

### 4. Generators

In this lesson, the AC and DC generators and their parts are discussed. Issues such as improvements in design are discussed and linked with Faraday's Law. Also, issues such as power generation and the national power grid are discussed.

### 5. Alternating Current

In this lesson, RMS voltage and current are expressed using graphs. Calculations involving RMS power and resistance are also measured and examples of the calculations covered using real values from appliances.

## Resource Material

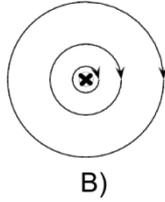
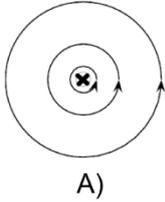
The preceding lessons Electricity and Magnetism, as well as Current Electricity will be of use during the teaching of this section and should be covered first.

<b>1. The Magnetic Field around Conductors</b>	<a href="http://www.magnet.fsu.edu/education/tutorials/java/handrules/">http://www.magnet.fsu.edu/education/tutorials/java/handrules/</a>	A good summary and pictures of most of the hand rules.
<b>2. The Motor Effect</b>	<a href="http://en.wikipedia.org/wiki/Left-hand_rule">http://en.wikipedia.org/wiki/Left-hand_rule</a> :	The left hand rule for motors is explained well here with a good picture and description.
	<a href="http://www.waowen.screaming.net/Maghandrules.htm">http://www.waowen.screaming.net/Maghandrules.htm</a>	A good summary of all the rules governing motors and dynamos.
	<a href="http://electronics.howstuffworks.com/motor.htm">http://electronics.howstuffworks.com/motor.htm</a>	This page has a good description of the parts and functions of a DC motor.
<b>3. Electromagnetic Induction</b>	<a href="http://www.pcbheaven.com/wikipages/How_DC_Motors_Work/">http://www.pcbheaven.com/wikipages/How_DC_Motors_Work/</a>	This site links electromagnetism to how motors work effectively, along with excellent animations.
<b>4. Generators</b>	<a href="http://www.youtube.com/watch?v=kqpXoppzg14">http://www.youtube.com/watch?v=kqpXoppzg14</a>	A more comprehensive video that covers the usage and mechanisms in AC generators.
	<a href="http://science.howstuffworks.com/electricity3.htm">http://science.howstuffworks.com/electricity3.htm</a>	This is also a good site that outlines the basics of AC generators with an animation at.
<b>5. Alternating Current</b>	<a href="http://en.wikipedia.org/wiki/Single-phase_generator">http://en.wikipedia.org/wiki/Single-phase_generator</a>	This page has an excellent set of pictures linking to alternating current and graphs of RMS voltage and positions of the generator.

## Task

### Question 1

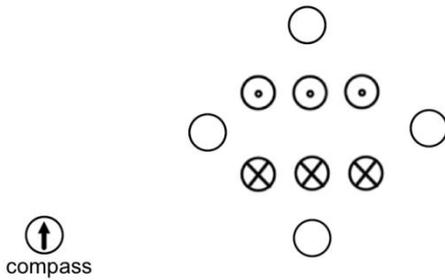
1.1 Which of these diagrams correctly shows the magnetic field around the conductor in the picture?



1.2 Draw the magnetic field around the coil shown in the picture.



1.3 Use arrows to show the direction of the field in these four compasses around the solenoid.

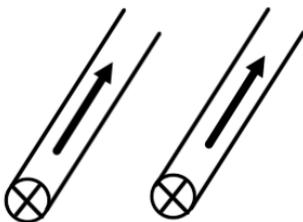


### Question 2

2.1 Which direction would this wire experience a force? Redraw the diagram and include an arrow to show the force.



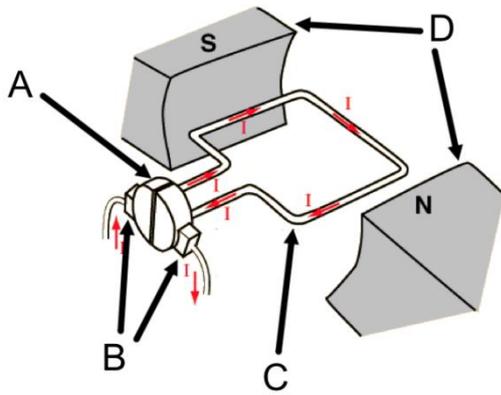
2.2 Draw field lines around these two wires that are carrying current.



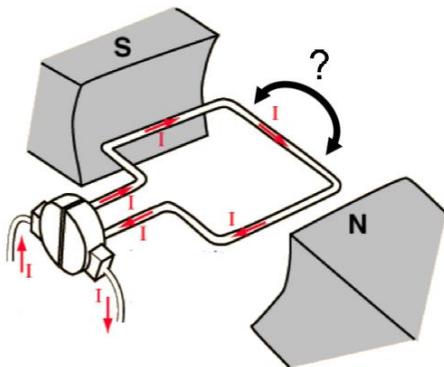
2.3 Now, use the field lines to predict whether the wires are going to be attracted or repelled.  
Give a reason for your answer.

**Question 3**

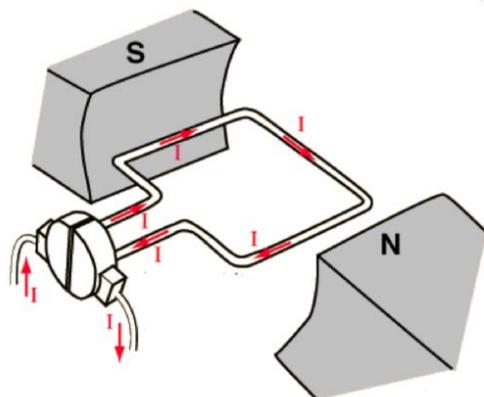
3.1 In the motor shown, provide labels and uses for the parts in the D in the picture.



3.2 Will the motor in the picture turn clockwise or anti-clockwise?



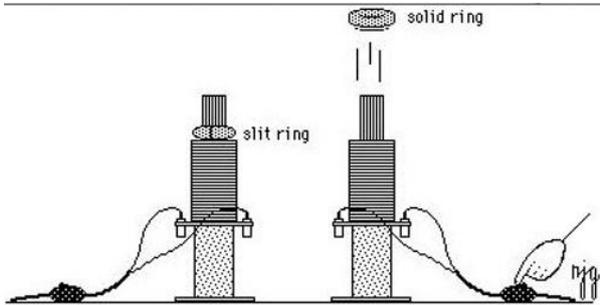
3.3 The motor experiences the most force at this position in its turning. Explain why.



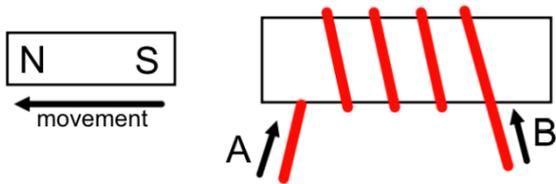
3.4 It is found that the motor turns with little force and does not turn very quickly. Suggest three ways that the motor design could be improved.

**Question 4**

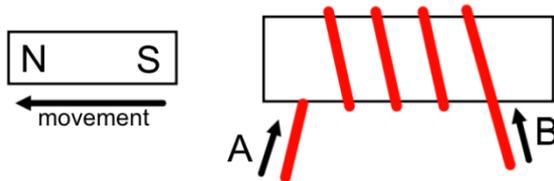
4.1 The ring in the picture is shot upwards from the solenoid. Explain the principle being applied.



4.2 Use the appropriate principle to predict the direction that current will flow in the picture. Choose option A or B.



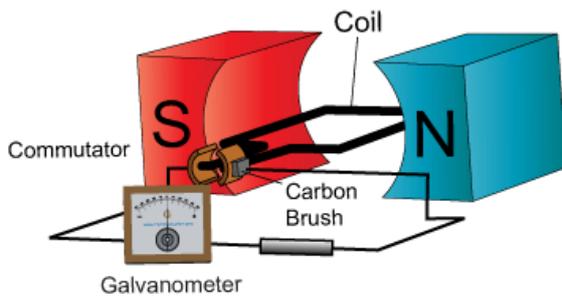
4.3 Describe another way that this magnet and solenoid could be used to make the same direction of current:

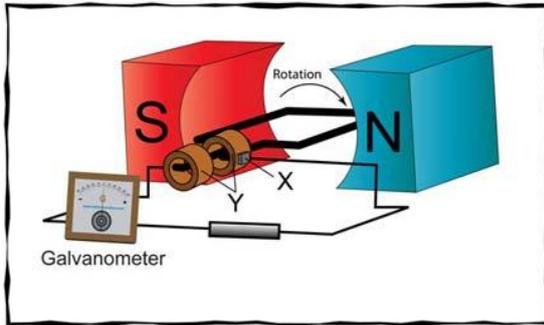


4.4 Describe three ways that the solenoid could be changed to induce a larger current.

**Question 5**

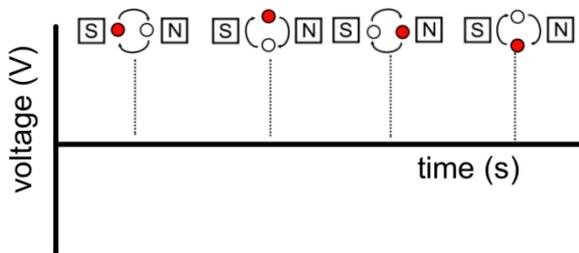
5.1 Identify which of these devices is D.C or direct current, and which is A.C, or alternating current.





5.2 Explain what the difference between the A.C. and the D.C. device is.

5.3 Draw a graph of voltage vs. time for the output of the A.C. generator. Match the voltage to the positions that are shown.



5.4 On the same set of axes, draw a graph which is made by an A.C. generator turning at half the speed.

5.5 What would the effect be if the magnets were placed closer to the armature?

**Question 6**



6.1 What is the current that this appliance uses?

6.2 Calculate the amount of resistance that this appliance has when it works.

6.3 Plot the voltage vs. time graph for this appliance.

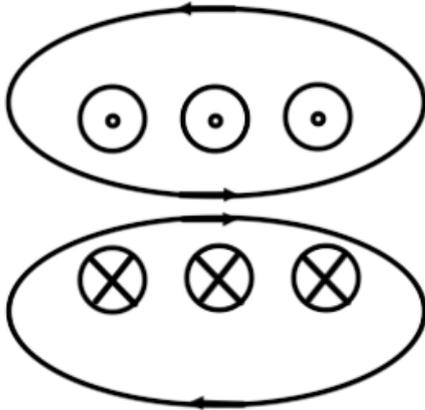
6.4 Now, calculate and show the peak and R.M.S voltages on the graph.

## Task Answers

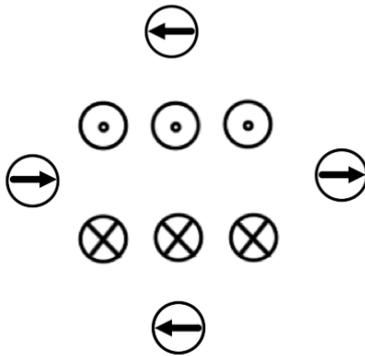
### Question 1

5.1 B (use right hand rule – cross is carrying current away)

5.2 .

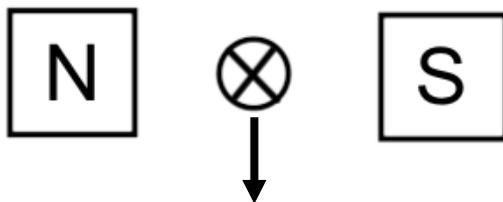


5.3

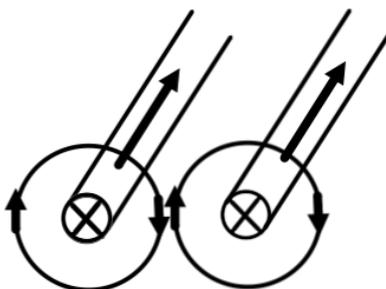


### Question 2

2.1



2.2



2.3 The wires would attract one another because of the opposite direction of the field lines.

**Question 3**

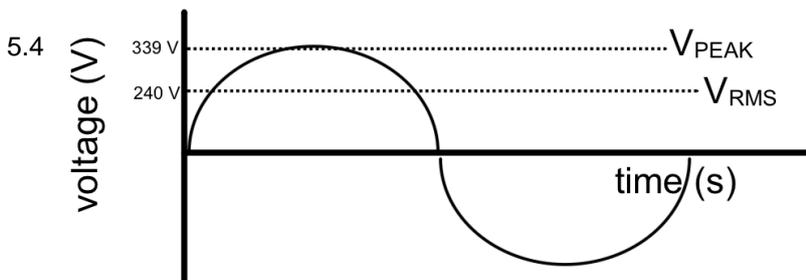
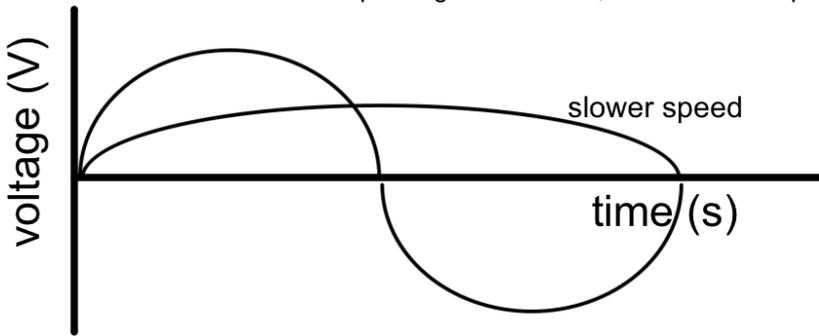
- 3.1 A= Split-ring commutator  
B= Brushes  
C= Armature  
D= Permanent Magnets
- 3.2 Clockwise.
- 3.3 The magnet field is strongest there and also, the wires are moving perpendicular to the field lines, a requirement for the force.
- 3.4 Stronger magnets, more turns in coil and stronger current.

**Question 4**

- 4.1 Lenz's law: When a changing magnetic field occurs when the switch is closed, an opposing change is induced in the ring, so repulsion occurs, pushing the ring upwards.
- 4.2 Option B
- 4.3 The north pole of the magnet could be pushed towards the solenoid.
- 4.4 The coil area can be made larger, more turns added and also a soft-iron core can be added.

**Question 5**

- 5.1 Top picture shows a DC generator, Bottom an AC generator.
- 5.2 The DC device is connected via a split-ring commutator; the AC uses slip-rings.
- 5.3



- 5.5 The voltage would be greater (greater magnetic flux)

**Question 6**

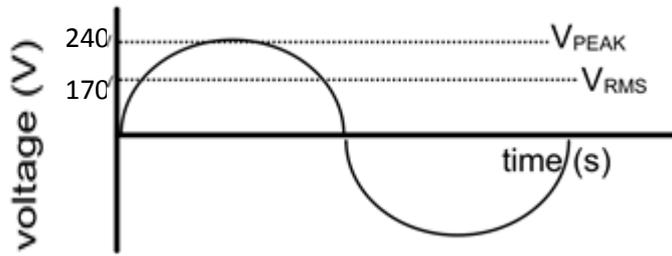
6.1  $P_{RMS} = V_{RMS} I_{RMS}$

$250 = (240) I_{RMS}$

$I_{RMS} = 1,04 \text{ A}$

6.2  $R = \frac{V_{RMS}}{I_{RMS}} = \frac{240}{1,04} = 230,77 \Omega$

$$6.3 V_{RMS} = \frac{V_{PEAK}}{\sqrt{2}} = \frac{240}{\sqrt{2}} = 170 \text{ V}$$



## Acknowledgements

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