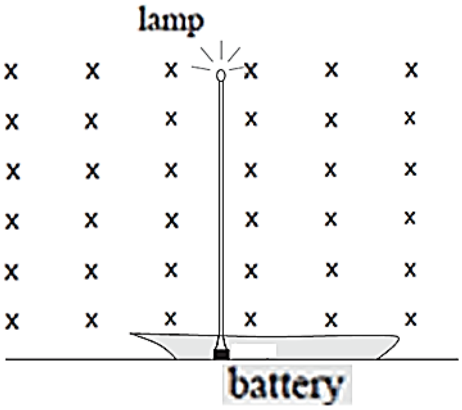
ELECTRICITY: ELECTROMAGNETISM QUESTIONS

MAGNETIC FIELDS (2009;3)

Sean's yacht has an 8.0 m high mast with a light on top. Two wires connect the 12 V battery to the lamp (nothing else is connected to the battery). The total resistance of the wires and lamp is 18.0 Ω. The horizontal component of the earth's magnetic field is 4.0×10^{-4} T. The charge on an electron is 1.6×10^{-19} C.



The yacht is stationary.

(a) State the direction of the magnetic force acting on the wire that is connected to the negative terminal of the battery.

(b) Calculate the size of the magnetic force acting on ONE wire.

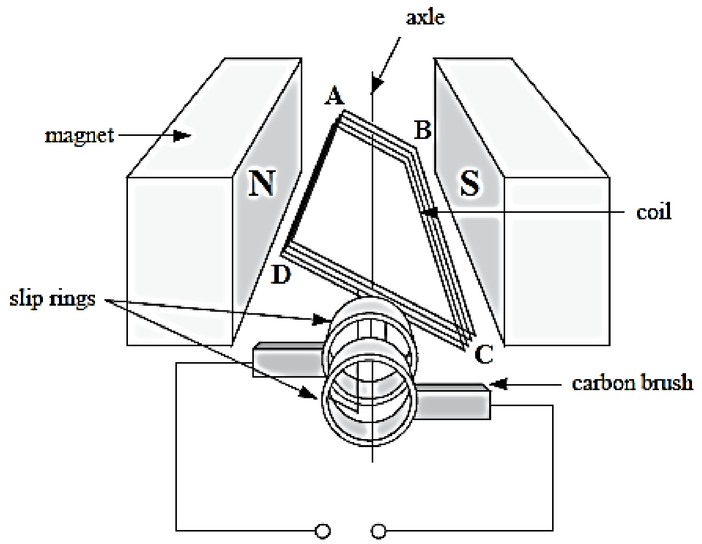
(c) Will the magnetic force on the two connecting wires produce a net force on the yacht? Explain your answer.

The yacht now moves forward.

(d) Sean switches the light off. Is there a voltage induced in the wire as the yacht moves forward? Explain your answer.

(e) Calculate the size of the magnetic force acting on a single electron if the yacht moves at 3.0 ms^{-1} perpendicular to the magnetic field.

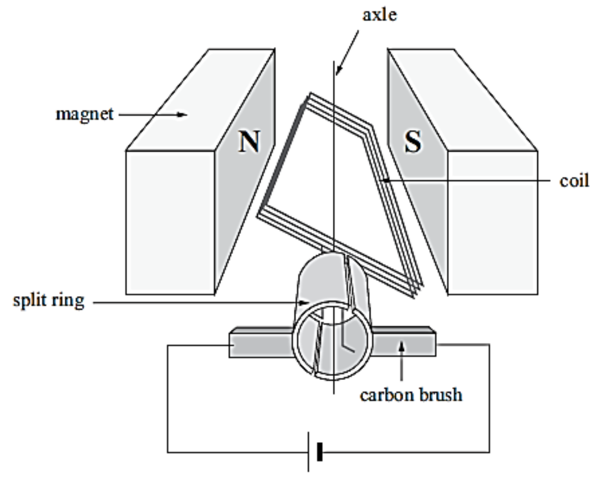
ELECTROMAGNETISM (2008;3)



The diagram above shows a wind-powered generator in a yacht. It comprises a rectangular coil of wire that is rotated in a magnetic field.

The width (AB) of the coil = 6.4 cm
The length (AD) of the coil = 14.6 cm
The strength of the magnetic field = 0.75 T
Speed of the long side of the coil = 20.0 cms^{-1}
Number of turns of coil =100 turns

(a) Calculate the maximum induced voltage across one loop.
(b) Describe three ways in which the size of the induced voltage across the length of the coil can be increased.
(c) State the position of the coil that produces the maximum voltage and explain why the size of the voltage changes as the coil rotates.



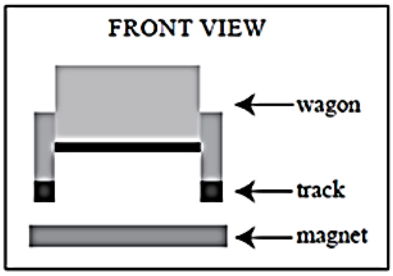
The generator can be modified to act as a DC motor by changing the slip rings to a split ring, as shown in the diagram above.
The motor is connected to a 12 V battery.
The coil has a resistance of 4.5 Ω
The coil has 100 turns.

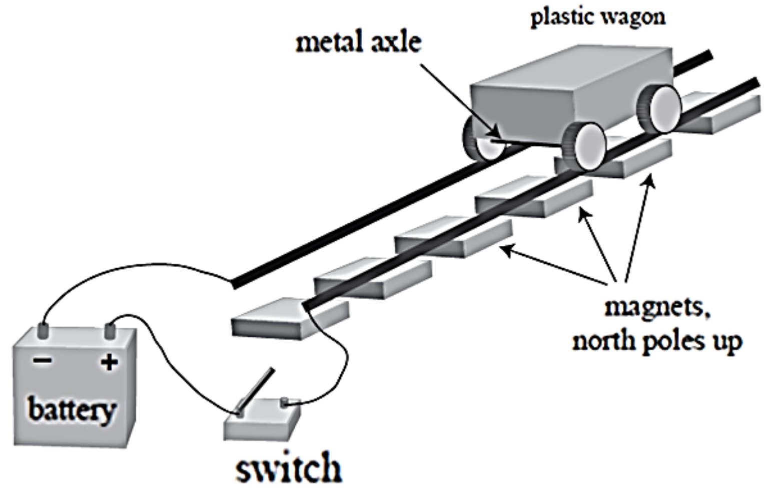
Calculate the maximum force acting on one side of the coil.

THE MODEL RAILWAY (2007;3)

Tana is playing with a model railway. He wants to make one of the plastic wagons move without an electric motor. He places a row of magnets under (but not touching) the horizontal tracks, with the north poles pointing up. He then connects the tracks to a battery and puts a wagon on the tracks. The wheels, axles and track conduct electricity.

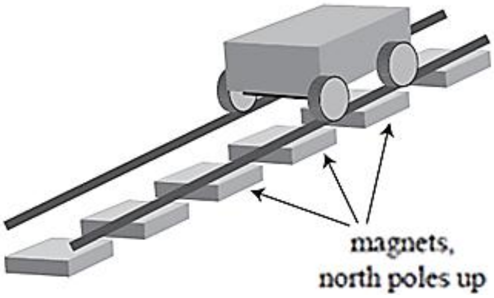
The magnets produce a uniform magnetic field of 0.25 T.
The tracks are 35 mm apart.
The resistance of the circuit is 0.55 Ω.



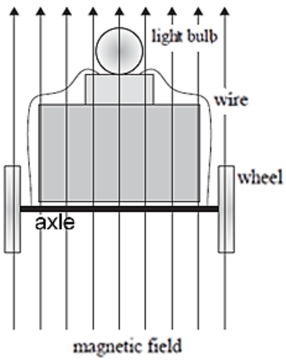


(a) Explain what causes the wagon to move when the switch is closed.
(b) Draw an arrow on the diagram above to show the direction of the electromagnetic force on the wagon.
(c) When the switch is closed, the size of the electromagnetic force on the wagon due to the two axles is 0.052 N. Calculate the battery voltage.

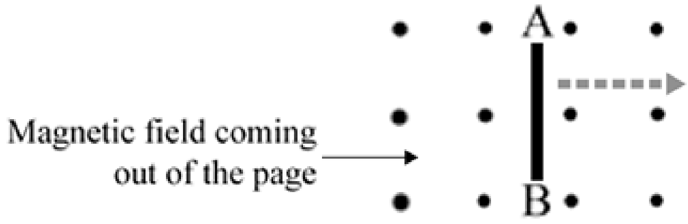
Tana disconnects the battery, then gives the carriage a horizontal push.



(d) Calculate the induced voltage across each axle when the carriage is travelling at 0.29 ms^{-1}. Write your answer in mV.
(e) Explain clearly why one end of the axle becomes negatively charged.
(f) Tana wants to use the induced voltage to light a lamp. With the battery still disconnected, he puts a low-power lamp on the carriage and connects it to the axles as shown below. Explain what will happen in the circuit of the lamp and axle, as the wagon cuts across the magnetic field.

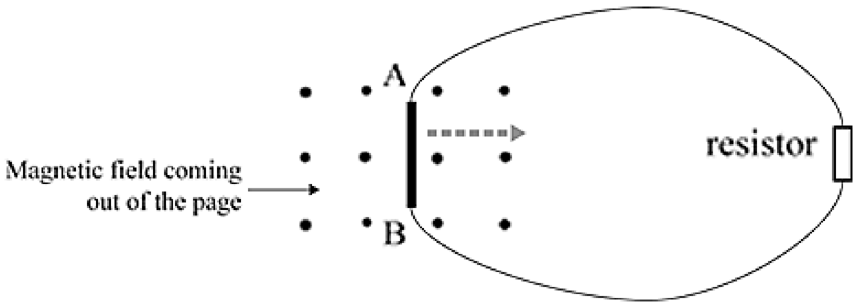


ELECTROMAGNETISM (2006;3)



A metal rod AB is pushed from left to right so that it cuts across the magnetic field, as shown in the diagram above.

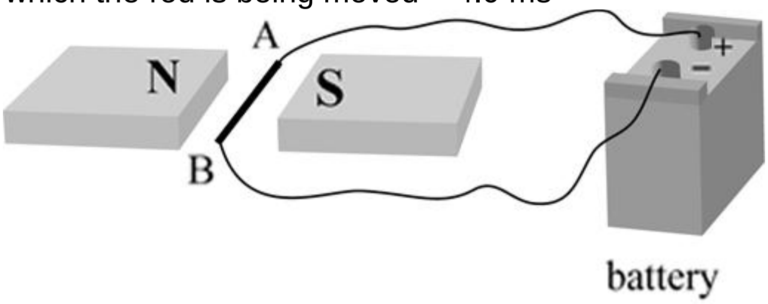
(a) Explain clearly in terms of movement of electric charge, what would happen as the rod starts moving in the direction shown.



The rod is then connected by two wires to a resistor to a make a complete circuit.

(b) Explain what would now happen as the rod is moved through the magnetic field while the resistor remains stationary. In your explanation, include the direction of any charge flow.

(c) Calculate the current that would flow through the resistor, using the following information:
- Resistance of resistor = 2.0 Ω
- Strength of magnetic field = 0.80 T
- Length of rod in the magnetic field = 10.0 cm
- Speed with which the rod is being moved = 4.0 ms^{-1}



The metal rod, AB, is now connected to a battery, and placed between the poles of two magnets, as shown in the diagram above.

(d) Draw an arrow on the diagram above to show the direction of the magnetic field produced by the magnets.

(e) Using one of the terms: "left, right, up, down, into the page, out of the page", identify the direction of the magnetic force on the rod.

(f) Explain clearly why the rod experiences a magnetic force in the direction you have stated.

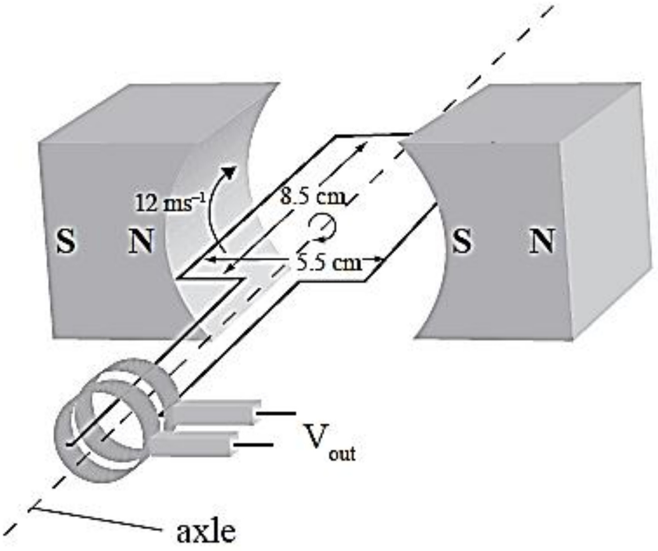
(g) Calculate the size of the magnetic force experienced by the rod, using the information given below (Write your answer to the correct number of significant figures):
- Strength of the magnetic field = 0.90 T
- Current = 3.20 A
- Length of rod in the field = 10.0 cm

(h) When generator handle is turned, the coil spins. Explain clearly why the lamp glows when the handle is turned rapidly.

MIKE'S MOTORBIKE GENERATOR (2005;3)

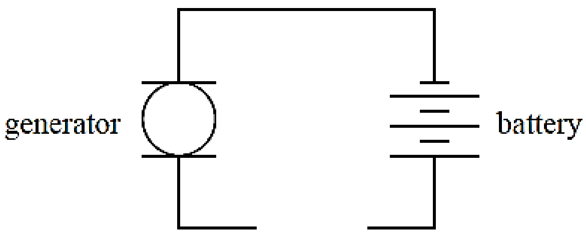
Mike's motorbike has a battery that provides electric current for various components. It also has a generator to provide electric current to charge the battery. The generator is turned by the motorbike's engine.

The generator is essentially a coil of wire that spins between a pair of magnets as shown in the diagram.



The coil is 8.5 cm long and 5.5 cm wide. The magnetic field strength is 0.070 T. The speed of the coil is 12 ms^{-1}. The coil has 45 turns of wire.

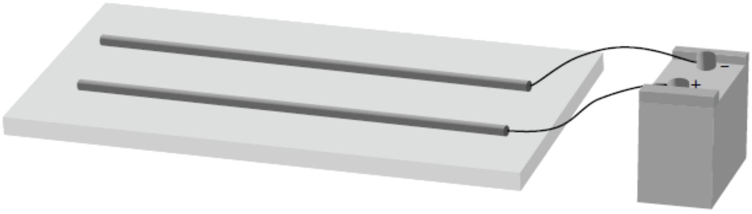
(a) Calculate the output voltage of the coil when it is in the position shown.
(b) Determine the size of the voltage a quarter of a cycle later. Explain your answer.
(c) Moana told Mike to put a diode in the circuit so the generator could charge the battery. Draw the correct symbol for a diode in the space in the circuit.



(d) Explain clearly why a diode is required in the circuit to charge the battery.
(e) On the axes below, draw a graph of the output voltage of the generator for one cycle, starting at the position shown in the top diagram.

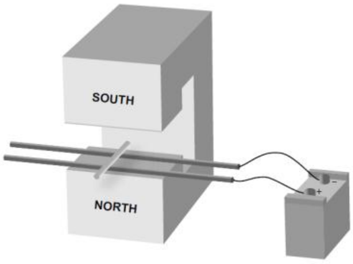
INDUCTION (2004;3)

David's teacher Mr Manu asked him to set up an experiment to show the force acting on a conductor in a magnetic field. David put two horizontal, parallel metal rails on a wooden table and connected them to a battery as shown.



(a) State why the battery did not produce a current.

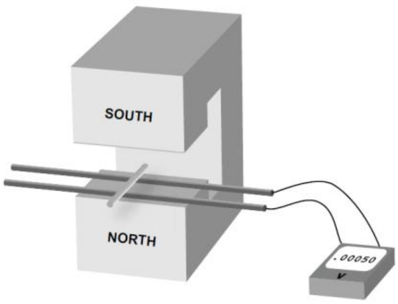
David then put an aluminium rod across the rails and placed the rod and rails between the poles of a magnet as shown below.



(b) On the above diagram:
(i) Draw an arrow to show the direction of the magnetic field between the rails. Label this arrow ‘field'.
(ii) Draw an arrow to show the direction of the electromagnetic force on the aluminium rod. Label this arrow 'force'.
(c) Explain what caused the aluminium rod to experience an electromagnetic force.
(d) Use the data below to calculate the size of the electromagnetic force on the aluminium rod.

Battery voltage = 12 V
Total resistance of circuit = 2.5 Ω
Distance between rails = 6.0 cm
Length of aluminium rod = 8.0 cm
Magnetic Field strength = 0.15 T

David then removed the battery and replaced it with a sensitive voltmeter. He pushed the aluminium rod so it rolled along the rails while maintaining electrical contact. At one time the voltmeter reads 5.0×10^{-4} V.



(e) Calculate the speed of the aluminium rod as it rolled along the rails.
(f) David observed that as the aluminium rod approached the magnet, it slowed down when the current was produced. Explain clearly why it slowed down.