2018 Physics ATAR

Electromagnetism III

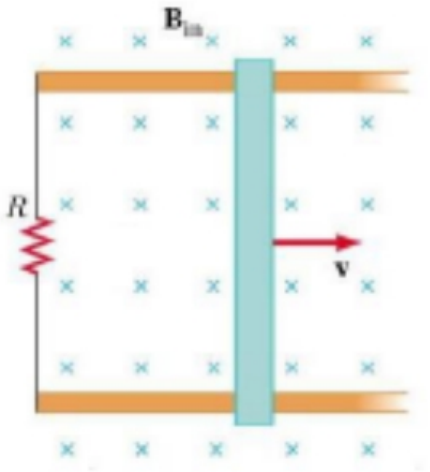
Miscellaneous questions

Challenge questions

Name:_____

jayantcheyyur@gmail.com

As shown in the diagram a length of copper wire is being pulled to the right through a magnetic field, along conductive rails. The length of the wire is 200 mm and it travels with a speed of 5.00 m s^{-1}. The strength of the magnetic field is 220 mT into the page and the resistance of the conductive rails is 200 mΩ.



(a) Calculate the emf induced in the length of copper wire. You must state its magnitude and direction.

(3)

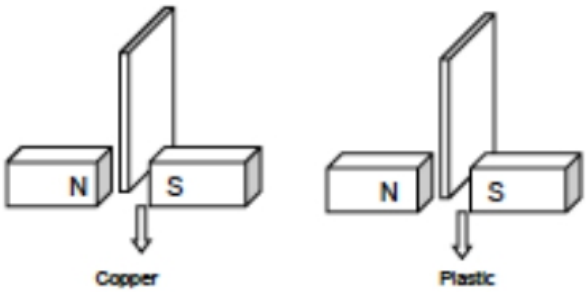
(b) Calculate the magnitude of the current running through the conductive rails.

(2)

(c) Calculate the force required to pull the wire through the field at a constant speed of 5.00 m s^{-1}.

(2)

Two square plates of identical mass and size are allowed to drop between the poles of two permanent magnets. The plates are released simultaneously from the same height above the ground however one is made of copper and one is made of plastic.

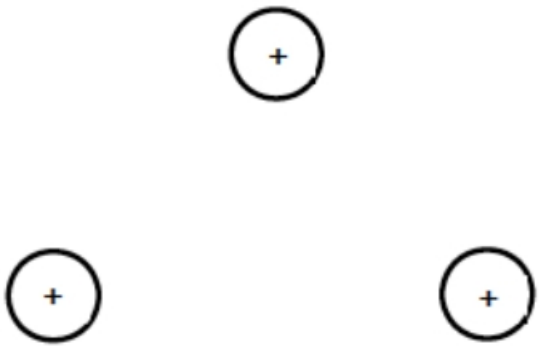


Which plate is the **last** to arrive at the ground below? Circle your answer and provide a detailed explanation.

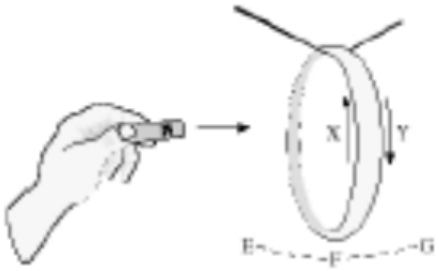
Copper Plastic

Explanation

Draw the electric field between the three positively charged spheres shown below. You must draw **at least 6** electric field lines.



A north pole of a magnet is moved towards a suspended conductive ring as shown in the diagram.



(a) In which direction will the induced current flow? Circle your answer and provide an explanation.

Direction X Direction Y

Explanation

(3)

(b) If the north pole of the magnet is moved towards the ring will a force be applied to the ring to the left, to the right or will it feel no force? Circle your answer and provide an explanation.

Left Right No force

Explanation

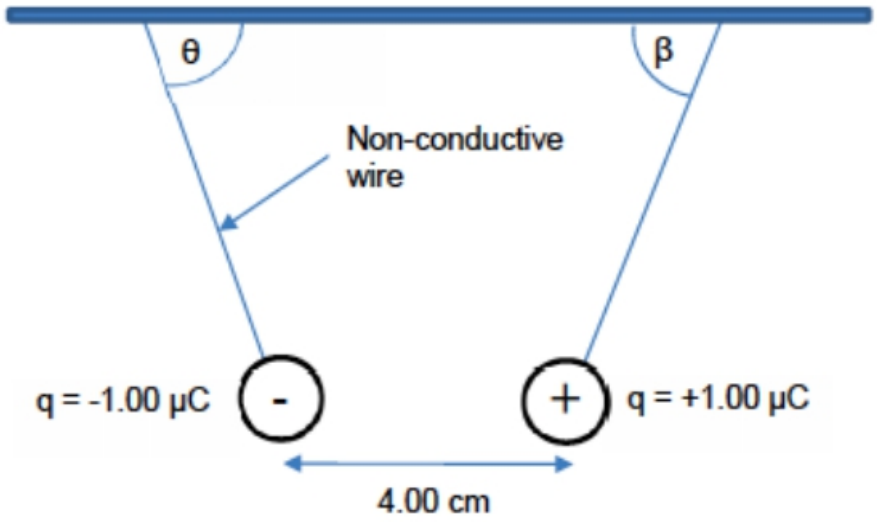
(3)

(c) The ring is now exposed to a magnetic field which decreases in strength from 500 mT to 100 mT in a time of 0.100 s. The magnetic field is directed towards the right.

Calculate the magnitude of the emf induced in the ring if its radius is 3.00 cm.

(3)

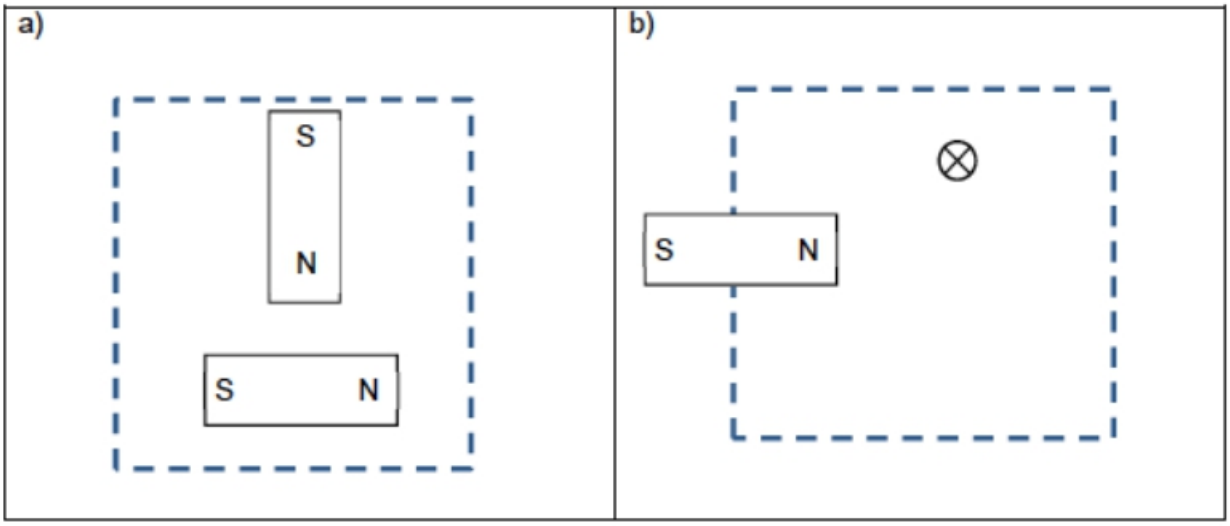
As shown in the diagram below, two small, electrically charged spheres, hang from a roof by non-conductive wires. Each sphere has a mass of 5.00 kg and the distance between the centre of each sphere is 4.00 cm. The charge of the left sphere is -1.00 μC and the charge of the right sphere is +1.00 μC.



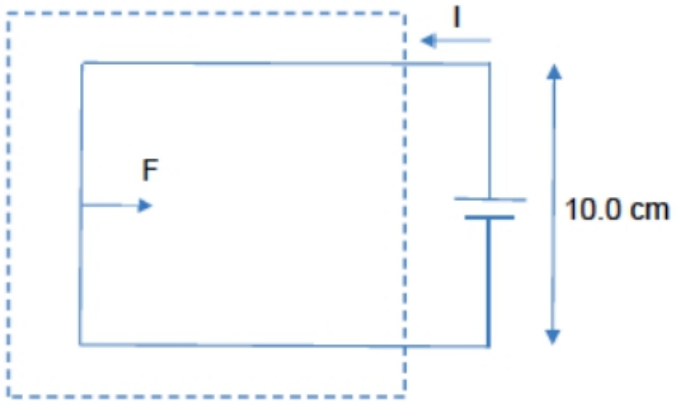
(a) Calculate the number of electrons required to produce a charge of -1.00 μC. (2 marks)

(b) Calculate the angle θ that the negative sphere makes with the horizontal. (4 marks)

Consider the areas identified by the hatched boxes in the diagrams below. Within each box sketch the **overall** magnetic field with **at least 6** magnetic field lines. You can assume that the magnets and wires are fixed in position and the Earth's magnetic field is negligible.



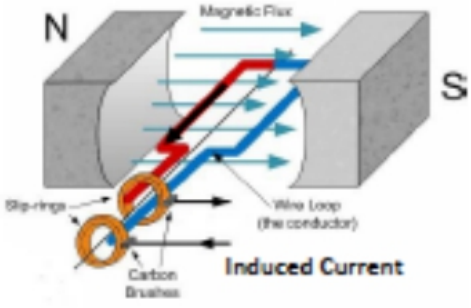
A rectangular wire loop is placed into a uniform magnetic field which acts within the boundary of the broken line shown in the diagram. The plane of the loop is perpendicular to the magnetic field. The wire carries a current I of 2.50 A which produces a force of 3.20 N to the right on the loop.



(a) Indicate the direction of the magnetic field on the diagram. (1 mark)

(b) Calculate the magnitude of the magnetic field strength. (2 marks)

A 20.0 cm x 20.0 cm square conducting coil with 60 turns is situated in a uniform magnetic field of flux density 40.5 mT. The coil is provided with a driving torque which rotates the coil and produces a current. The direction of the current is shown by the arrows on the coil. (Out of the page on the length next to the North Pole)



(a) Indicate, on the diagram, the direction of rotation of the coil and explain how you arrived at your answer.

(2)

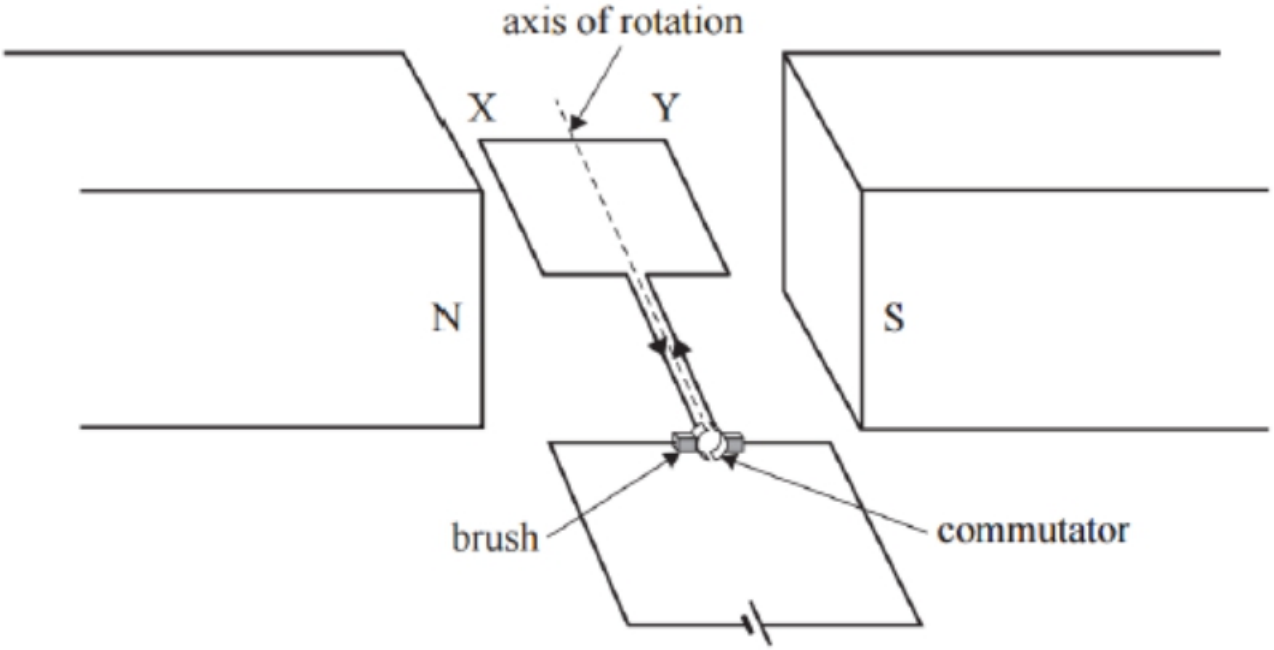
(b) If the rotation rate of the coil is 3000 rpm, calculate the maximum emf produced by the coil.

(3)

(c) On the diagram below draw the emf induced in the coil as it completes one rotation from the position shown. You must numerically indicate an appropriate emf value and the time value for one period.

(3)

The diagram shows a small DC motor connected to a battery. A uniform magnetic field of strength 0.500 T exists between the magnetic poles. The coil has a length (*l*) of 8.00 cm, a width (w) of 5.00 cm and 80 turns of wire. The coil draws a current of 3.85 A from the battery.



(a) Indicate the direction of rotation of the coil on the diagram. (1 mark)

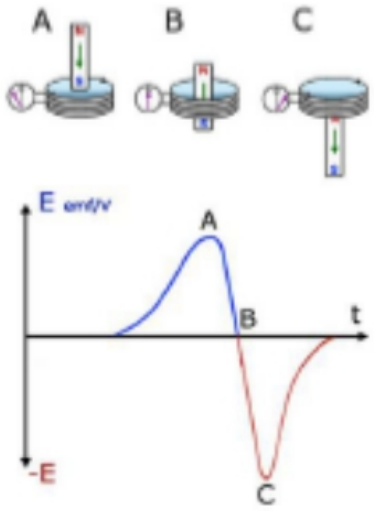
(b) Explain the function of the commutator in a DC motor. (2 marks)

(c) Calculate the maximum torque produced by the motor. (2 marks)

(d) Calculate the rotation angle of the coil from the horizontal if the torque produced by the motor is 40.0 % of the maximum torque. (3 marks)

(e) Explain why the torque produced by the motor varies as the coil rotates. (3 marks)

In the diagram above, a bar magnet is dropped vertically under the influence of gravity through a coil connected to a voltmeter. The output of the voltmeter is shown in the graph.



(a) Explain why the emf induced in the coil is zero at position B.

(1)

(b) Explain how the emf generated produced by the coil would have changed if a coil with lower resistance was used.

(2)

(c) Explain why the absolute magnitude of the emf at C is larger than the absolute magnitude of the emf at A.

(2)

A wind turbine generates electricity at a rate of 200 kW and an emf voltage of 660 V_{RMS}. The turbine is connected to a transformer which increases the voltage to 33.0 kV_{RMS} before connecting it to the electricity grid.

(a) Calculate the current in the primary side of the transformer.

(2)

(b) If there are 25 turns on the primary side of the coil calculate the number of turns on the secondary side.

(2)

(c) Explain why transformers can only be used with AC power.

(2)

(d) Explain why a soft iron core is used in transformers.

(2)

jayantcheyyur@gmail.com