ALL SAINTS' COLLEGE

Ewing Avenue, Bull Creek, Western Australia

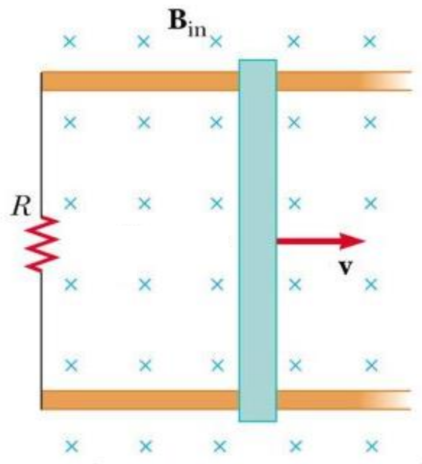
Year 12 Physics ATAR	Electromagnetism Test 2	2016

Time allowed: 50 minutes
Total marks available: 50
Show calculation answers to 3 significant figures

Student Name:________________________

Question 1 **(7 marks)**

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.

Description	Marks
$emf = lvB$ $= 0.200 \times 5.00 \times 0.220$	1
$= 0.220\ V$	1
direction = anticlockwise	1
Total	**3**

(3)

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

(2)

Description	Marks
$I = V/R$ $= 0.220/0.200$	1
$I = 1.10\ A$	1
Total	**2**

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

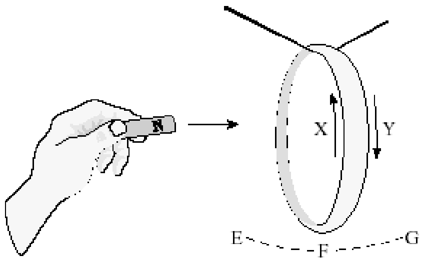
(2)

Description	Marks
$F = IlB$ $= 1.10 \times 0.200 \times 0.220$	1
$F = 4.84 \times 10^{-2}\ N$	1
Total	**2**

Question 2

(9 marks)

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

Description	Marks
Direction X	1
Moving north pole towards the ring will increase flux through the ring.	1
The ring will act to oppose the increase in flux (Lenz's Law) which using the right hand grip rule requires a current in direction X.	1
Total	**3**

(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)

Description	Marks
Right	1
To oppose the increase in flux the ring will produced a north pole on its left hand side (Lenz's Law).	1
The north pole induced in the ring will be repelled by the north pole of the magnet which applies a force to the ring to the right.	1
Total	**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.

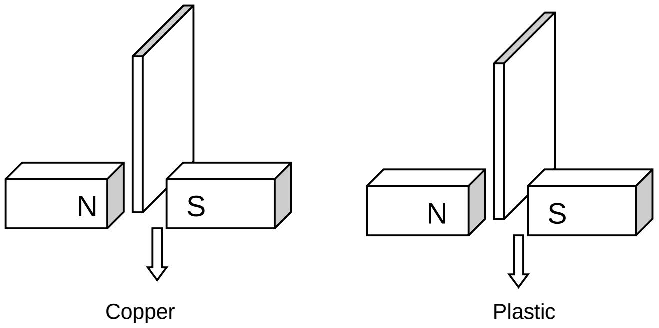
Calculate the magnitude of the emf induced in the ring if its radius is 3.00 cm.

(3)

Description	Marks
$A = \pi \times 0.03^2 = 2.87 \times 10^{-3}\ m^2$	1
$emf = -\frac{\Delta\Phi}{\Delta t} = -\frac{\Phi_2 - \Phi_1}{\Delta t} = -\frac{0.1 \times 2.87 \times 10^{-3} - 0.5 \times 2.87 \times 10^{-3}}{0.100}$	1
$= 1.13 \times 10^{-2}\ V$	1
Total	**3**

Question 3 **(4 marks)**

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.



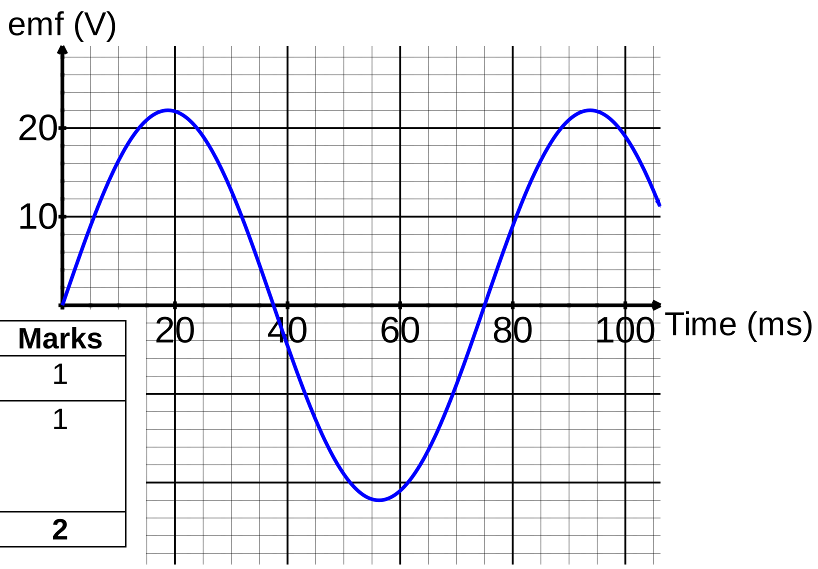
Which plate is the **last** to arrive at the ground below? Circle your answer and provide a detailed explanation.

Description	Marks
Copper plate	1
As the plates enter the magnetic field produced by the magnets, the flux through the plates begins to increase. As copper is a conductor the change in flux induces an eddy current in the plate which produces a flux that opposes the increase in flux through the plate.	1
The flux induced in the copper plate interacts with the flux produced by the magnets and acts to oppose its motion. This applies an upwards force to the plate.	1
The plastic plate does not produce a current and opposing flux as it is not a conductor. It is therefore not slowed by the magnetic field.	1
Total	**4**

Question 4

The graph at right shows the emf output from a simple AC generator.

Determine the RMS Voltage of this generator showing how you obtained data from the graph

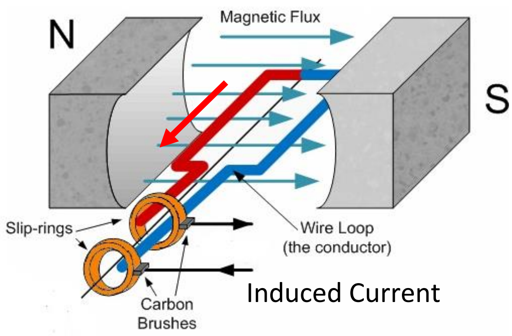


Description	Marks
$EMF_{max} = 22.0\ V$	1
$EMF_{rms} = \frac{EMF_{max}}{\sqrt{2}} = \frac{22.0}{\sqrt{2}} = 15.6\ V$	1
Total	**2**

(2)

Question 5 **(7 marks)**

A 20.0 cm × 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)



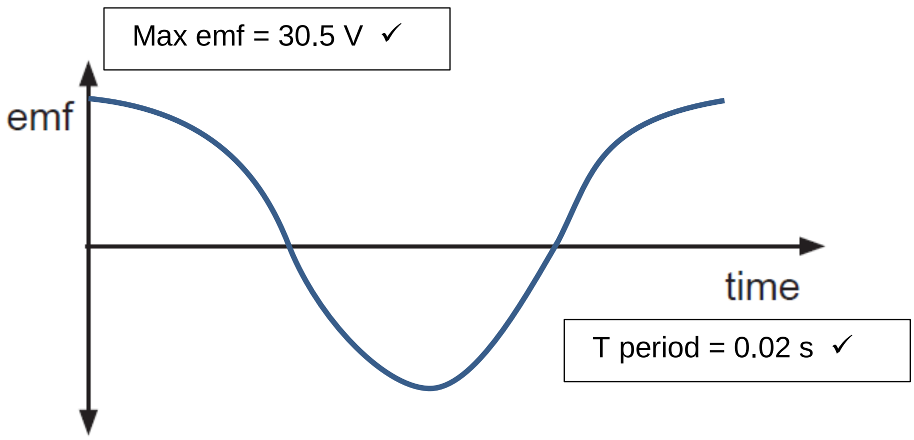
(a) Indicate, on the diagram, the direction of rotation of the coil and explain how you arrived at your answer. (2)

Description	
Looking at the side of the coil under the north pole, the current is out of the page which means that the induced emf is in the same direction. The magnetic flux is to the right.	1
Using the right hand rule for induced emf the length of the coil under the north pole must be moving downwards to produce an emf into the page. This means that the coil rotates in a anticlockwise direction as viewed from the slip rings.	1
Total	**2**

(b) If the rotation rate of the coil is 3000 rpm, calculate the maximum emf produced by the coil. (3)

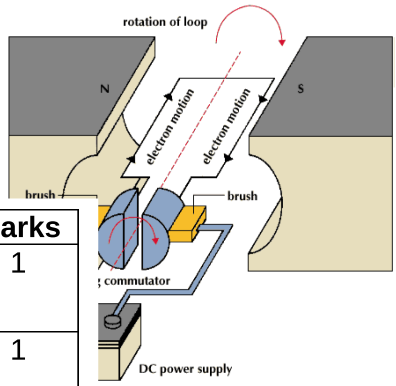
Description	Marks
$rpm(Hz) = \frac{3000}{60} = 50\ Hz$	1
$EMF_{max} = NBA \times 2\pi f$ $= 60 \times 0.0405 \times 0.2^2 \times 2 \times \pi \times 50$	1
$EMF_{max} = 30.5\ V$	1
Total	**3**

(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. (2)



Question 6 **(8 marks)**

The diagram shows the coil of a simple DC electric motor. It turns in the direction shown and the emf supplied by the power source is constant.



(a) Explain why the torque produced by the coil decreases as the speed of rotation of the coil increases. (3)

Description	Marks
As the speed of the coil increases the back emf induced in the coil increases (emf = lvb).	1
As the back emf increases it opposes the applied emf and reduces the emf available to produce current.	1
As the current decreases the torque produced by the coil decreases.	1
Total	**3**

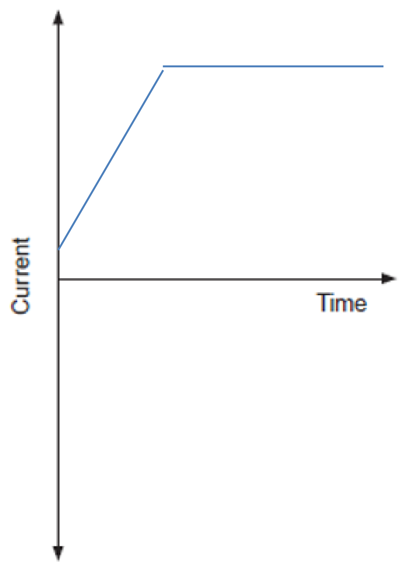
(b) While the motor was turning an external torque was applied to it and the motor stopped spinning. Did the current running through the coil increase, decrease or remain the same. Circle you answer and provide an explanation. (3)

Increase   Decrease   Remain the same

Explanation

Description	Marks
Increase	1
The external torque stops the motor which reduces the back emf.	1
As the back emf decreases the net voltage increases which increases the current running through the coil.	1
Total	**3**

(c) On the axes below sketch the current in the coil as the external torque is applied. (2)



Question 7 **(8 marks)**

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 before connecting it to the electricity grid.

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

(2)

Description	Marks
$I = \frac{P}{V}$ $I = \frac{2.00\times10^6}{660}$	1
$I = 3.03 \times 10^2\ A$	1
Total	**2**

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

(2)

Description	Marks
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{690}{33\times10^3} = \frac{25}{N_s}$ $N_s = \frac{25\times33\times10^3}{660}$	1
$N = 1250\ turns$	1
Total	**2**

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

(2)

Description	**Marks**
AC power causes the current on the primary side to vary which causes the flux produced by the primary side to vary.	1
The varying flux produced by the primary coil changes the flux in the secondary coil which induces a current in the secondary coil.	1
Total	**2**

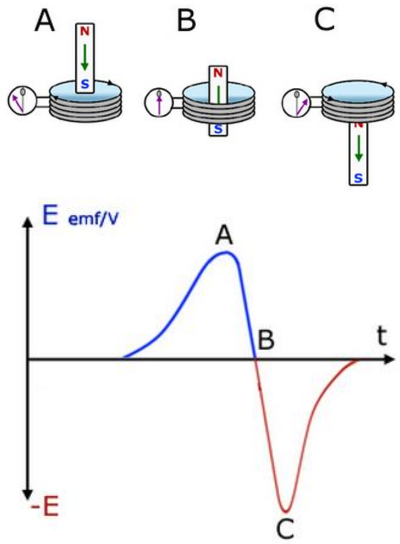
(d) Explain why a soft iron core is used in transformers.

(2)

Description	Marks
Iron is a ferromagnetic material and will align with dominant field as it fluctuates. This concentrates the magnetic field and improves the flux linkage between the primary and secondary coils.	1-2
Total	**2**

Question 8 **(5 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.

Description	Marks
The emf is zero because the change in flux is zero because the magnet is in the centre of the coil. (The point between increasing flux and decreasing flux is no change)	1
Total	**1**

(1)

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

(2)

Description	Marks
The emf would not have changed.	1
emf is equal to the rate of change of flux which is unaffected by the resistance of the coil.	
Total	**2**

(c) Explain why the absolute magnitude of the emf at C is larger than the absolute magnitude of the emf at A. (2)

Description	Marks
The absolute magnitude of the emf at C is larger than the emf at A because the speed of the magnet is greater at C as the magnet has been accelerated by gravity.	1
The greater speed increases the rate of change of flux which increases the induced emf.	1
Total	**2**

End of test