CORPUS CHRISTI COLLEGE
SEQUERE DOMINUM

Year 12	***ATAR* Physics Unit 3**	**2017**
TEST 5	***Electromagnetism 2***	***5.0%***

NAME: ....Adams............

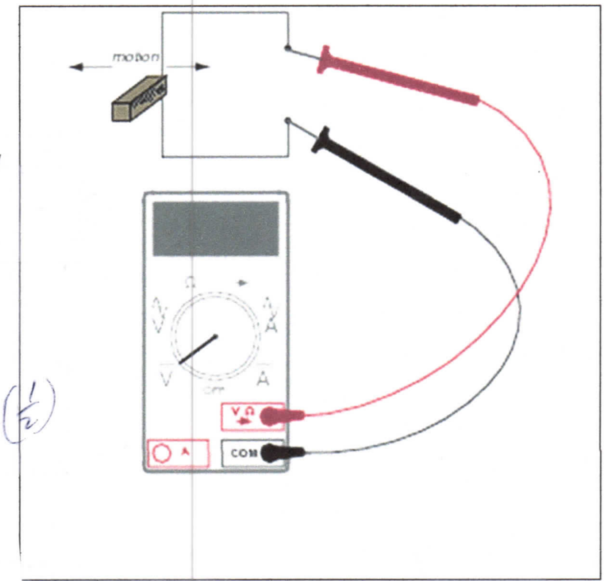
Data: See Data Sheet
Approx. marks shown.

(60 marks)

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

1. By moving a permanent magnet sideways perpendicularly past a wire, a voltage will be generated between the ends of that wire.



(a) Describe what factors determine the polarity and magnitude of this voltage. [4]

$EMF_{ind} = Bvl$

The factors are

magnitude

1. The greater the strength of the magnet, the greater V. $\left(\frac{1}{2}\right)$
2. The greater the speed v the greater V (or less time) $\frac{1}{2}$
3. The larger the cross-sectional area of the magnet the greater the length of wire in B field, greater V. ✓

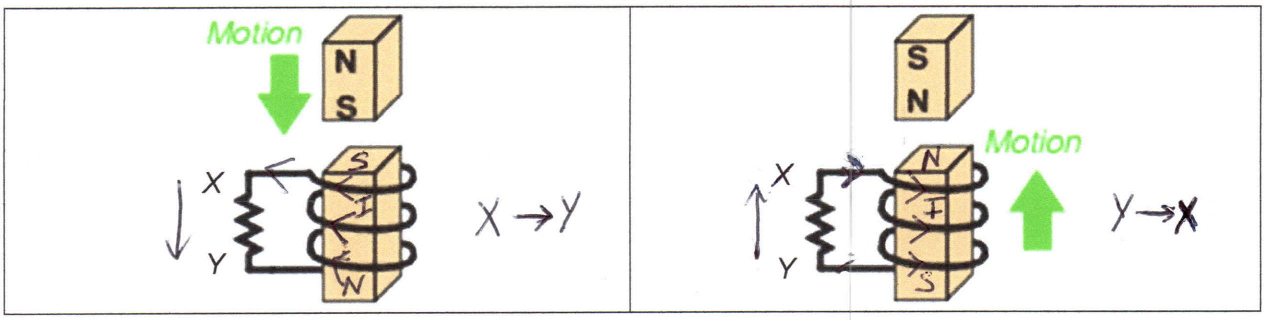
polarity

4. The polarity of the pole of the magnet closest to the wire determines the polarity of the V. ✓
5. The direction of the movement of the magnet determines the polarity of the V. ✓

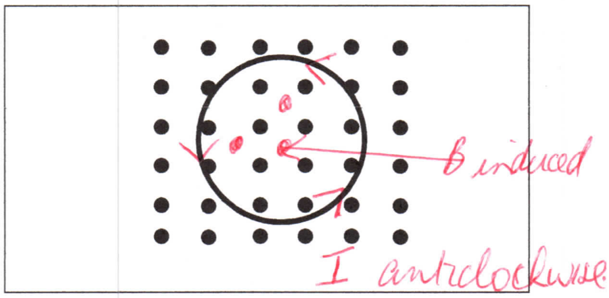
(b) In the diagram given, when moving the permanent magnet sideways to the ***left***, the red probe attached to the positive jack of the voltmeter produces a positive reading.
Which pole of the magnet is closest to the wire? [1]

South

2. In each of the diagrams below clearly show the direction of the induced current through the resistor *XY* when the magnet moves relative to the coil as shown. [2]



3. Consider the coil of wire located the magnetic field shown.



(a) How many turns of wire must the coil have in order to induce a voltage of 10.5 volts when exposed to a magnetic flux decreasing at a rate of 0.0075 Wb s^{-1}? [3]

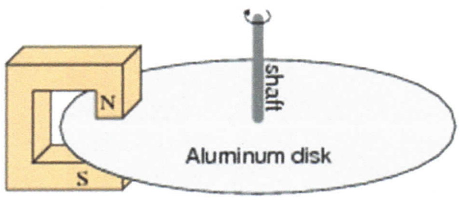
$EMF_{ind} = -n \frac{\Delta\phi}{t}$

$10.5 = n\,(0.0075)$

$n = 1400$ turns

(b) On the diagram above clearly show the direction of the induced current in the loop. [1]

4. Electromechanical watt-hour meters use an aluminium disk that is spun by an electric motor. To generate a constant "drag" on the disk necessary to limit its rotational speed, a strong magnet is placed in such a way that its lines of magnetic flux pass perpendicularly through the disk's thickness:



(a) Using the laws of induction explain the phenomenon behind this magnetic "drag" mechanism. [5]

By Faraday's Law $EMF_{ind} = -n \Delta\phi / t$, as the disk moves between the poles of the magnet the area between the poles experiences an increase in magnetic flux This induces an EMF and an eddy current in the disc.

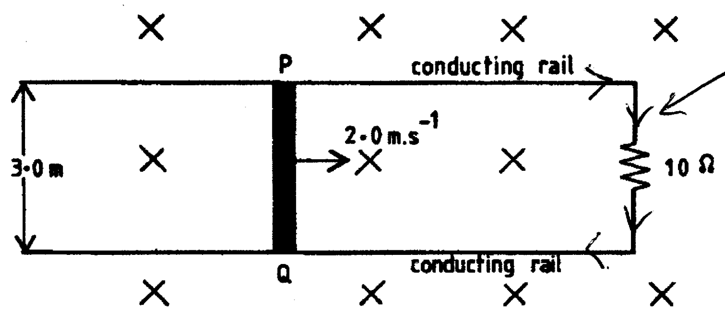
By Lenz's Law this eddy current produces a magnetic field so as to oppose the increase in magnetic flux. This results in a drag affect on the disc.

(b) Explain how the permanent magnet assembly should be re-positioned so that it provides *less* drag on the disk for the same rotational speed. The poles of the magnet remain completely over the disk. [2]

Move the magnet closer to the centre of the disc. The region near centre of the disc is moving slower than the region at the edge of the disc. Hence $\frac{\Delta\phi}{t}$ will be less, so induced current & EMF is less

5. The diagram below shows a conducting bar PQ moving with constant speed, 2.00 m s^{-1}, along two parallel conducting rails 3.00 m apart. The ends of the bar touch the rails. The rails are connected by a 10.0 Ω resistor, as shown. The resistance of the bar and rails is negligible.

There is a uniform magnetic field of magnitude 0.50 T perpendicular to the bar and the rails. This field is directed into the page.



Direction of induced current th-10 R (cancelled)

(a) What is the magnitude of the EMF induced in the bar? Show your working. [2]

$$EMF_{ind} = Bvl$$
$$= 0.50 \times 2 \times 3 = 3.00\ V \ (3sf)$$

(b) What is the magnitude of the force required to keep the bar moving? Show your working. [2]

$F = BIl$

$I = \frac{V}{R} = \frac{3}{10} = 0.3A.$

$\therefore F = 0.50 \times 0.3 \times 3$

$= 0.450\ N\ (3sf)$

(Left, so need to keep applying force to right)

OR

$P = Fv$ and $P = \frac{V^2}{R}$

$\therefore \frac{V^2}{R} = Fv$

$\frac{3^2}{10} = F(2)$

$F = 0.450\ N$

(c) The rails are frictionless and there is good electrical contact between the bar and the rails. Why is it necessary to apply a force to keep the bar moving at a constant speed? [2]

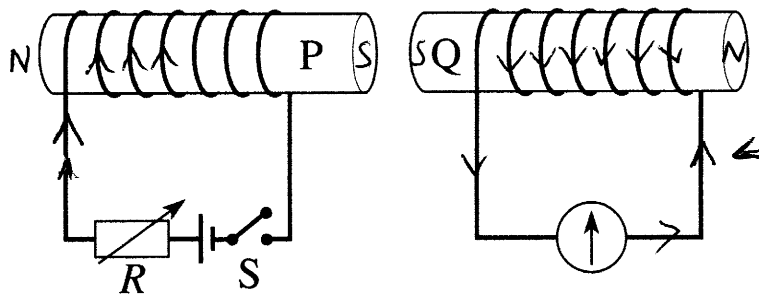
By Right Hand Induction Rule the current is induced in the bar from Q → P. ✓

By Right Hand Palm Rule the force on the bar due to this current in B field is to left. ✓

Hence to oppose this drag force, a force to right is necessary.

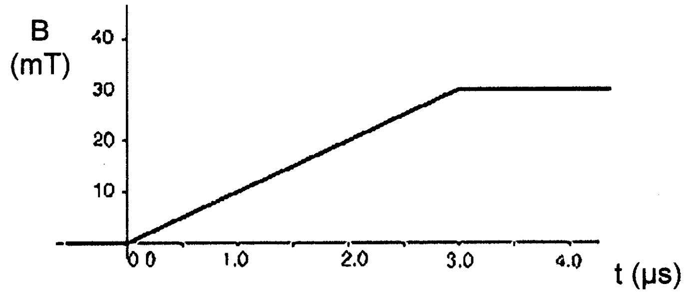
OR Explanation using Lenz's Law ($\Delta\phi = \Delta(BA) = B\Delta A$)

6. Two coils A and B are placed closed together, as shown below. P and Q are soft iron cores.



(a) Show the direction of the current induced in coil B when the switch in coil A is closed. [1]

(b) The graph below shows how the magnet field strength changes in coil A when the switch closes.



Assume that all of the magnetic flux from coil A passes through coil B which has an area of 5.0 cm^2.

(i) Calculate the emf induced in coil B. [5]

$$emf_{ind} = -n\frac{\Delta\phi}{t} \qquad \phi = BA$$

$n = 7$ loops ✓

$A = 5\,cm^2 = 5\times10^{-4}\,m^2$ ✓

$\Delta B = 30\times10^{-3}\,T$ ✓

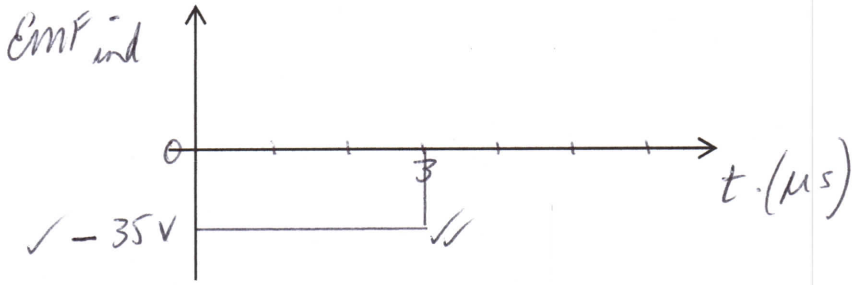
$t = 3\times10^{-6}\,s$ ✓

$$= \frac{nA\Delta B}{t}$$

$$= \frac{7\times5\times10^{-4}\times30\times10^{-3}}{3\times10^{-6}}$$

$$= \underline{35.0\,V\ (3sf)}$$ ✓

(ii) On the axes below draw the graph of the emf calculated in (i). [3]
[t = 0 s when the switch is closed.]



7. (a) A rectangular coil of side 15 cm by 12 cm lies perpendicular to a magnetic field of flux density 4.0 T. What is the magnetic flux passing though the coil? [2]

$$\phi = BA$$
$$= 4 \times (0.15 \times 0.12)$$
$$= \underline{0.0720\ Wb}\ (3sf)$$

Note: When coil is parallel to B field, $\phi = 0$ Wb.

(b) The coil, consisting of 20 turns of wire, is rotated and generates a peak emf of 63.5 V. Calculate the frequency with which it is being rotated. [2]

$$emf_{ind} = -2\pi BAnf$$
$$63.5 = 2\pi (0.0720) \times 20 \times f$$
$$f = 7.018 = \underline{7.02\ Hz}$$

(c) The coil is shown below. In Figure 7A the coil is connected to slip rings. In Figure 7B the coil is connected to a split commutator.

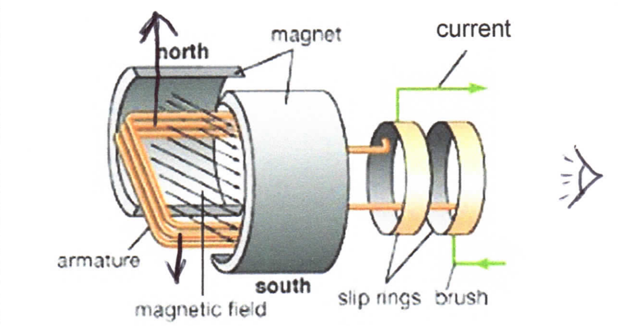


Fig 7A

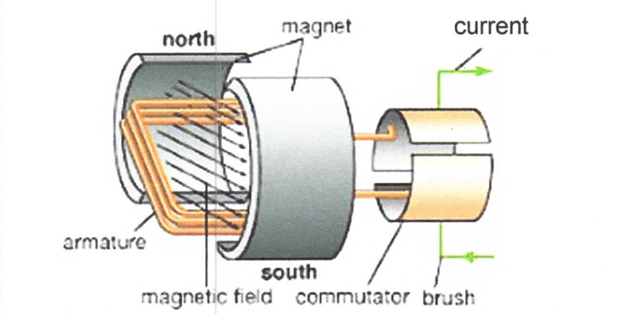


Fig 7B

(i) On Figure 7A clearly show the direction of rotation of the coil that induces the current shown on the diagram. [1]

Anticlockwise as viewed from slip-ring.

(ii) On the axes below draw the graph of the emf induced by during one rotation of each of the generators above. Assume that time t = 0 s when the coil is located in the position shown in Figure 7A and in Figure 7B.

Also indicate ***clearly*** on the graph the time when the plane of the coil is parallel with the magnetic field. [4]

$$t = \frac{1}{f} = \frac{1}{7.018} = 0.1425\text{ s.} \checkmark$$

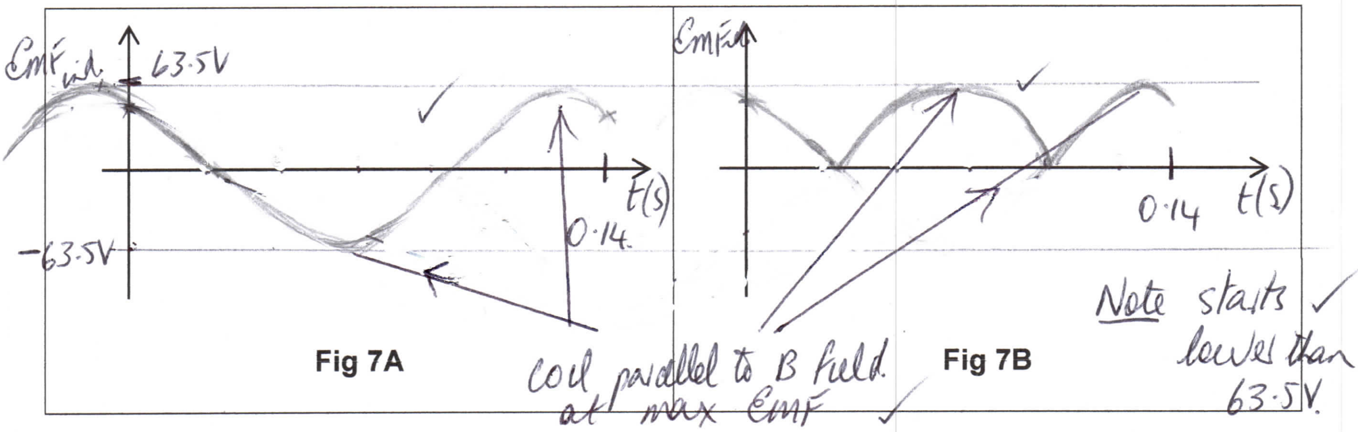
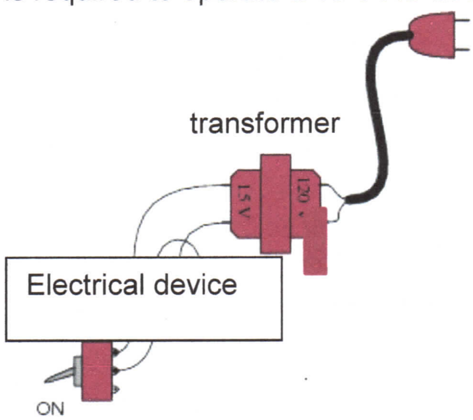


Fig 7A **Fig 7B**

8. The following transformer is required to operate a 15 V AC device, as shown, in WA.



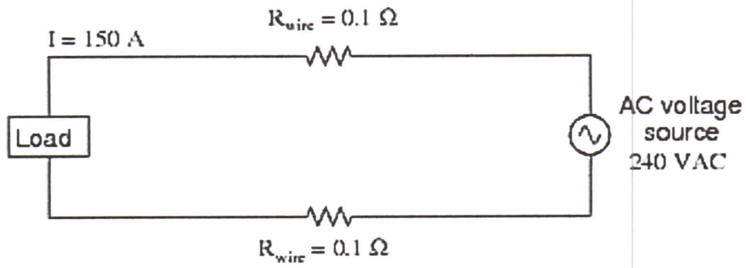
(a) Determine the turns ratio: $N_s : N_p$ for the transformer. [2]

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{15}{240} \checkmark = \frac{1}{16} \checkmark \text{ OR } \checkmark = 0.0625$$

(b) Some transformers can be up to 98% efficient. Describe 2 methods used in the construction of transformers to produce this efficiency. [2]

1. Laminations used in iron core to reduce heat losses by minimizing eddy current
2. Secondary coil placed over primary coil to ensure max flux transfer from primary to secondary coil
3. The coil having the greater current is made from thicker wire to reduce heat losses by $H = I^2Rt$ since R less.

9. Suppose a power system were delivering AC power to a resistive load drawing 150 amps:



(a) Calculate the load voltage and the load power dissipation. [3]

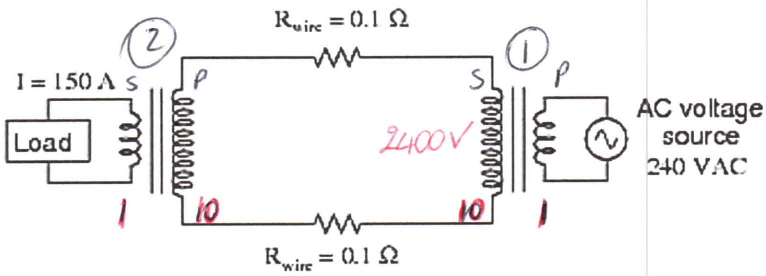
[OR Load power $= 240 \times 150 - P_{Loss\ on\ cable}$
$= 36000 - I^2R$
$= 36000 - 150^2(0.2)$
$= 36000 - 4500$
$= 31500W$]

$V_{lost\ on\ wires} = IR = 150 \times 0.2 = 30V$ ✓

$\therefore V_{load} = 240 - 30 = 210\,V = 2.10 \times 10^2\,V$ (3sf) ✓

$P = VI = 210 \times 150 = 3.15 \times 10^4\,W$ ✓

(b) Now, suppose we were to use a pair of perfectly efficient 10:1 transformers to step the voltage up for transmission, and back down again for use at the load.



Re-calculate the load voltage, ~~load power~~, wasted power, and overall efficiency of this system: [5]

Need I in wires

$\frac{N_s}{N_p} = \frac{I_p}{I_s} \quad \therefore \quad \frac{10}{1} = \frac{150}{I_s} \quad \therefore \quad I_s = 15A$ ✓ $= 15.0A$

$\therefore V_{lost\ on\ wires} = IR$
$= 15 \times 0.2 = 3\,V$ ✓ $= 3.00V$

$P_{loss} = I^2R = 15^2 \times 0.2 = 45W$ ✓ $= 45.0W$

T/F 1: $V_s = 2400\,V$

So V at 2 $= 2400 - 3 = 2397V$ ✓

Load voltage $= \frac{N_s}{N_p} = \frac{V_s}{V_p} \quad \frac{1}{10} = \frac{V_s}{2397} \quad \therefore V_s = 239.7V.$

Load power $= VI = 239.7 \times 150 =$ (35955 W) $3.60 \times 10^4\,W.$ ✓

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} \times 100\%$$

$$= \frac{3.60 \times 10^4}{(240 \times 150)} \times 100$$

Cancelled.

$$= 99.88\% = \underline{99.9\%}$$