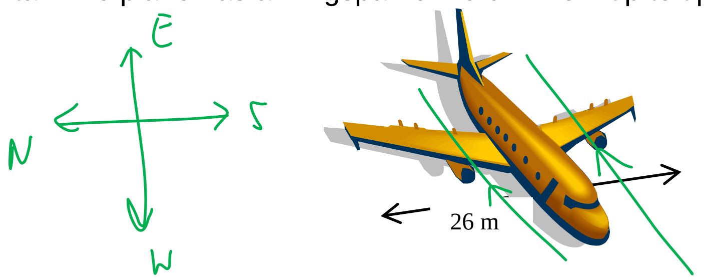
	ALL SAINTS' COLLEGE **Ewing Avenue, Bull Creek, Western Australia**
	Year 12 Physics 3A 3B Electric Power Test 2 May 2013

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

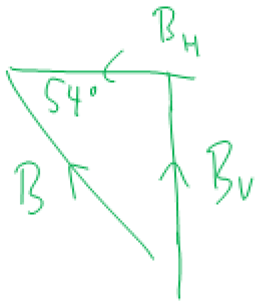
Student Name:________________________

1. An aluminium plane maintains a constant altitude and is flying due West near Darwin where the Earth's magnetic field has a flux density of 5.50×10^{-5} T at an angle of dip of 54.0° to the horizontal. The plane has a wingspan of 26.0 m from tip to tip.



a) Calculate the magnitude of the flux density component that is being cut by the horizontal wings of the plane.

(2)



$B_V = B \times \sin 54°$

$B_V = 5.50 \times 10^{-5} \times \sin 54°$

$B_V = 4.45 \times 10^{-5}$ T

b) The jet's safety equipment detects a potential difference of 75.2 mV between each wing tip. Determine the speed of the plane.

(2)

$emf = v.B.l$

$v = \frac{emf}{B.l} = \frac{0.0752}{4.45 \times 10^{-5} \times 26} = 65.0$ m/s

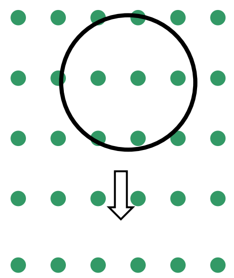
c) On which wing tip (North or South) would there be a positive charge? Explain briefly.

(2)

By RH palm rule. Finger up, +ve current out of page. Conventional current → North

2. For the following situations *briefly* explain what happens in terms of Lenz's Law and show on the diagrams the direction of the induced current when the changes indicated are made.

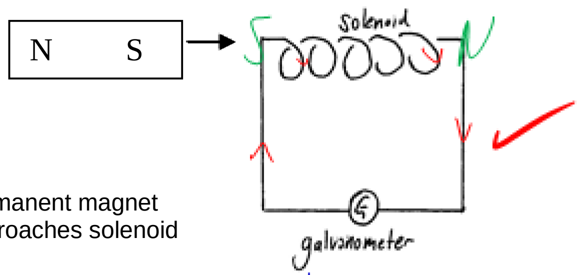
(4)



½ each ✓

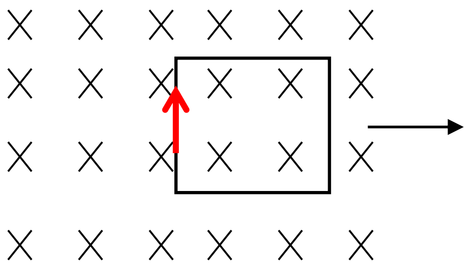
a) Conducting loop moved down within a uniform magnetic field.

No change in flux within the coil ∴ no emf / current ✓



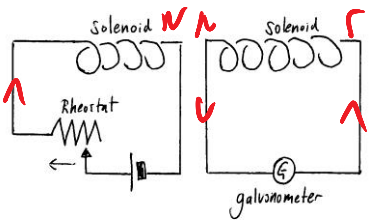
b) Permanent magnet approaches solenoid

Current flows in a direction such that it establishes a magnetic field to oppose the change ✓



c) Square conducting coil is removed from a uniform magnetic field

Current flows to establish magnetic field to replace the loss (change)



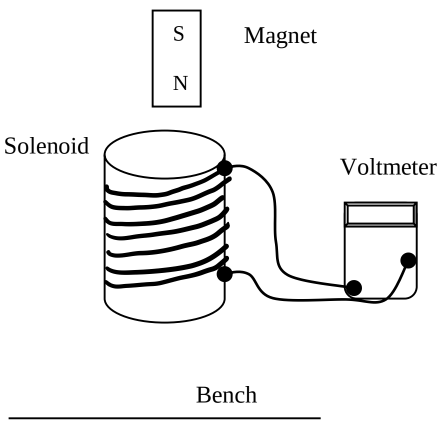
d) The resistance of the rheostat in the powered solenoid circuit is reduced.

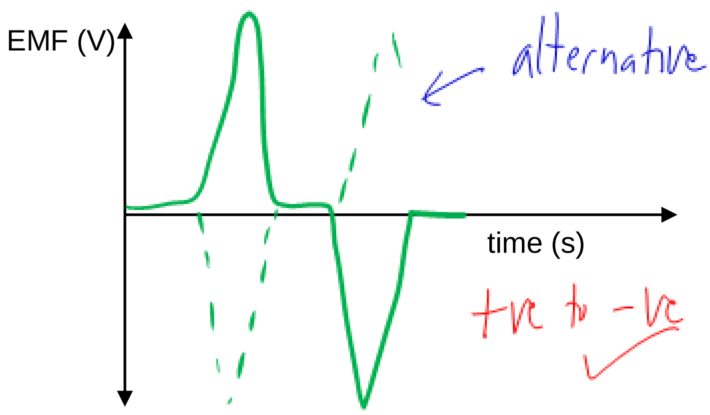
R↓ I↑ ∴ B↑ ✓

RH coil generates I with its own field to oppose build up from LH coil

3. A permanent magnet is dropped through a hollow core solenoid which is connected to a voltmeter. Sketch the shape of an emf graph for this situation.

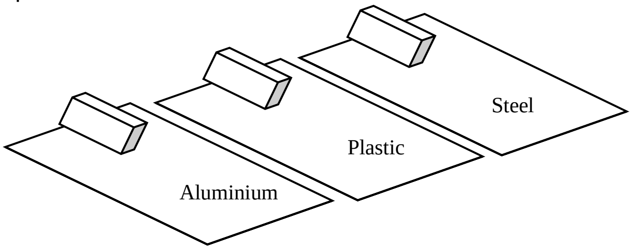
(2)





4. Three identical magnets are allowed to slide down inclined planes of aluminium sheet, plastic sheet and steel sheet (The sheets have negligible friction and are inclined at the same angle). The magnets are released simultaneously.

Identical magnets on inclined planes



a) State the order of arrival at the bottom of the inclined planes (1)

#1 plastic
#2 aluminium
#3 Steel (will not arrive)

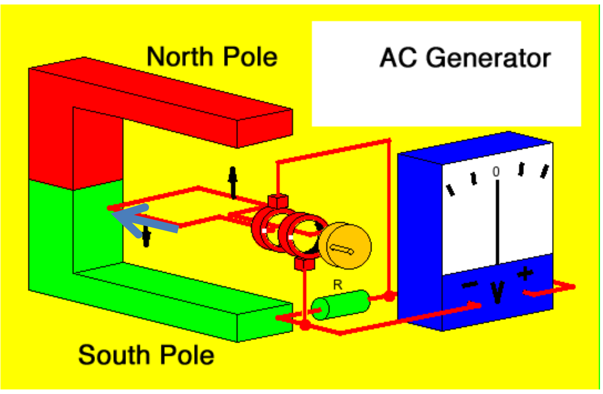
b) Clearly explain your response to part a) (3)

plastic - no induced eddy currents ∴ only accelerated by gravity

aluminium - eddy currents induced in sheet they establish magnetic field to oppose change and repel the magnet ∴ slowing descent along slope

Steel - magnetic attraction between steel and magnet causes it to attract to sheet. (ferromagnetic domains align to magnetic field)

5. A 22.0 cm × 22.0 cm square conducting coil of 350 turns is situated in a vertical uniform magnetic field of flux density 74.9 mT. The coil is provided with a driving torque and rotated anti-clockwise at a constant rate of 1500 revolutions per minute around a central axle, as indicated by the arrows on the coil in the diagram below.



a) Calculate the magnitude of **magnetic flux** within the area of the coil at this position when the plane of the coil is horizontal? (2)

$\Phi = BA = 0.0749 \times 0.22^2$ ✓ $= 3.62516 \times 10^{-3}$ Wb

$\Phi = 3.63 \times 10^{-3}$ Wb ✓

b) Indicate, on diagram, the direction of current flow, as the coil rotates 90° from this position. (1)

c) Briefly describe how you arrived at your answer for part b) (1)

By Lenz's law – flux is decreasing. Current established in a direction that replaces the loss with its own magnetic field ✓

d) Calculate the magnitude of **average induced EMF** in the coil using the **¼ turn** method (3)

f = 1500 / 60 = 25 Hz T = 1/25 = 0.04 $T_{1/4} = 0.01$ ✓

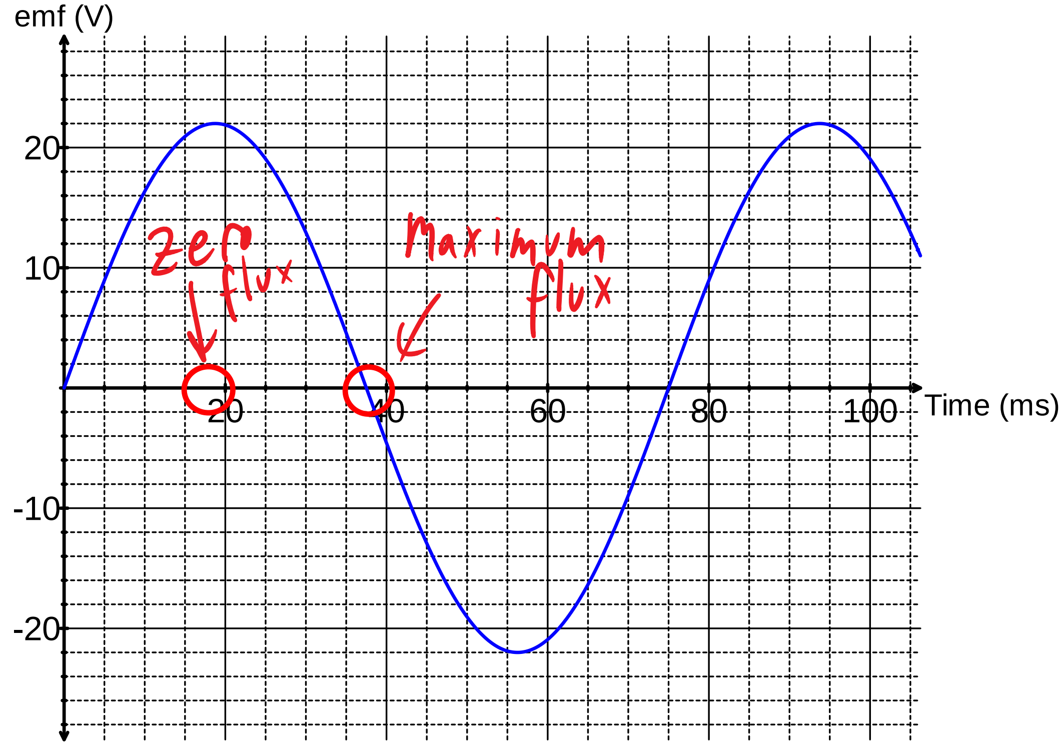
$$\text{emf} = -N\frac{\phi_2 - \phi_1}{t\ (quarter\ turn)}$$

$\text{emf} = -350\dfrac{0 - 3.62516 \times 10^{-3}}{0.01}$ ✓ emf = 127 V ✓

e) The Root Mean Square (RMS) voltage output is actually 141 V. Explain why your solution using the ¼ turn method gives a slightly different answer. (2)

¼ turn method assumes linear rate of change of flux ✓ but is actually part of a sine shape ✓

The emf output of a **different** AC generator is shown on the graph below.



f) The RMS voltage of an AC generator is given by the expression: $V_{RMS} = \frac{V_{max}}{\sqrt{2}}$

Determine the RMS voltage of this AC generator. (2)

$V_{RMS} = \frac{22}{\sqrt{2}}$ ✓ $V_{RMS} = 15.6$ V ✓

g) Why is the RMS voltage used in calculations for 3AB Physics? (e.g. with transformers) (1)

It is the equivalent DC/DV rating that will give same power characteristics. ✓

h) Determine the frequency of rotation of the coil in r.p.m (revolutions per minute) from this graph. (3)

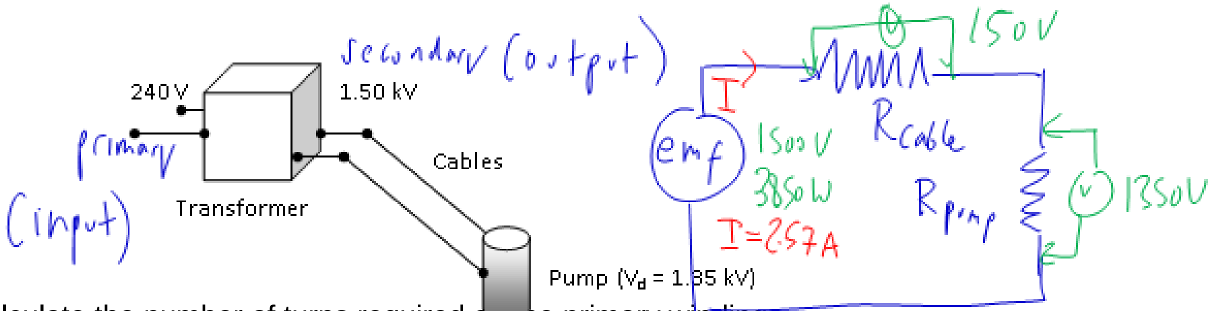
T from graph = 0.075 s ✓
f = 1/T = 1/0.075 = 13.333 Hz ✓

f = 13.333 × 60 = 800 rpm ✓

i) Circle a time on the graph when maximum flux is enclosed by the coil and label it 'maximum flux'. (1)

j) Circle a time on the graph when zero flux is enclosed by the coil and label it 'zero flux'. (1)

6. A mining company has a water pump with an operating voltage in the range 1.2 kV-1.5 kV. There is only a 240 V_{RMS} domestic supply available. They use a transformer to step up the output emf to 1.50 kV_{RMS}. The secondary winding has 1,250 turns of wire.



a) Calculate the number of turns required on the primary winding.

(2)

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \qquad \frac{1500}{240} = \frac{1,250}{N_p} \qquad N_p = 200 \text{ turns}$$

The transformer has an electrical power output of 3.85 kW. The underground pump is connected by 1.20 km of cables to the surface. The potential difference across the pump is 1.35 kV.

b) Calculate the total resistance of the cables. (5)

$$P_{out} = V_{emf} \times I_{out}$$

$$I_{out} = \frac{P_{out}}{V_{emf}} = \frac{3,850}{1500} = 2.57 \text{ A}$$

$$V_d \text{ (cables)} = V_{emf} - V_{pump} = 1500 - 1350 = 150 \text{ V}$$

$$R_{cable} = \frac{V_d \text{ (cable)}}{I_{cable}} = \frac{150}{2.57} = 58.4 \, \Omega$$

c) Calculate how much electrical power is available to the pump.

(2)

$$P_{pump} = V_d \times I = 1350 \times 2.57 = 3469.5 \text{ W}$$

$$= 3.47 \text{ kW}$$

d) The transformer is 92.1% efficient. Calculate the current on the primary side of the transformer. (3)

$$P_{in} = \frac{P_{out}}{0.921} = \frac{3{,}850}{0.921} = 4180.239\ W$$

$$P_{in} = V_{RMS} \times I_{RMS}$$

$$I_{RMS} = \frac{P_{in}}{V_{RMS}} = \frac{4180.239}{240} = 17.4\ A$$

e) Explain why a soft iron core is used in a transformer and explain why the core is made from laminations. (3)

must be soft iron ferro magnetic
in order to concentrate magnetic field between primary and secondary coils
laminated to reduce Eddy Currents

f) Describe another feature of transformer design that aids efficiency. (2)

large diameter cable on winding
⇒ lower resistance (Ω)
∴ less heating effects $P_{HEAT} = I^2 R_{Cable}$

End of test