Perth College
Anglican School for Girls

Year 12 Physics ATAR

Electromagnetism 2 Practice Test

Student Name: Solutions

Teacher: ____________________

Total: _______ /62

Time allowed for this paper: 55 minutes

This test contains three parts:

Section A: Short Answer	**20 marks**
Section B: Problem-Solving	**32 marks**
Section C: Comprehension	**10 marks**

Note: Some extra practice questions have been added to Sections A and B.

Answers are to be written in the space below or next to each question.

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.

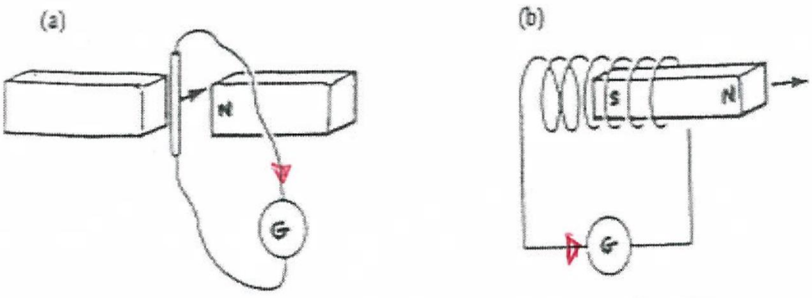
You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

Section One: Short Response (20 marks)

This section has **six (6)** questions. Answer **all** questions. Write your answers in the spaces provided.

Question 1 (2 marks)

In each case below, an external force is applied in the direction of the arrow inducing an emf in the external circuit, and current flow is detected by the galvanometer. Indicate the direction of induced current in each of these cases. Draw an arrow on the wire next to the galvanometer.



Question 2 (2 marks)

Calculate the magnetic flux threading a single loop of wire shaped into a rectangle of length 5.00 cm and width 4.00 cm and held perpendicular to a uniform field of 0.300 T.

$\Phi = B \times A$

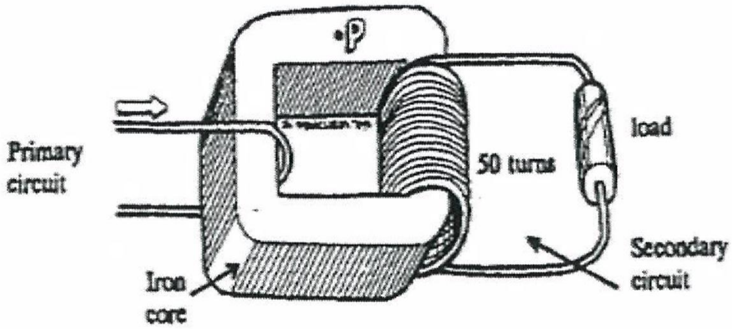
$\Phi = 0.05 \times 0.04 \times 0.3$

$\Phi =$

Question 3 **(4 marks)**

A single loop of wire is passed through the iron core of a transformer as shown in the diagram below. This loop forms the primary circuit. The secondary winding has 50 turns.

A steady current of 10.0 mA DC is flowing in the primary circuit in the direction shown by the arrow.



(a) Draw, on the diagram, an arrow to indicate the direction of the magnetic field at P, created by the current in the primary circuit. (1 mark)

(b) The current in the primary circuit is steadily increased over 0.0500 seconds, causing the magnetic flux threading the loops to increase by 0.00500 Wb.

Calculate the emf induced in the **secondary** circuit. (3 marks)

$N = 50$
$I = 10 \times 10^{-3}$ A
$t = 0.05$ s
$\Phi = 0.005$ Wb

$V_{emf} = -N \frac{\Delta \Phi}{t}$ ①

$V_{emf} = \frac{50 \times 0.005}{0.05} = 5.00$ V ①

①

Question 4 **(4 marks)**

A set of door chimes is activated from the 6.00 V output of a step-down transformer. The transformer primary input is at 240 V and has a current of 1.00×10^{-1} A. The primary coil has 120 turns. Calculate the current flowing through the door chimes from the transformer if the transformer is 90% efficient.

$V_s = 6V$

$V_p = 240V$

$I_p = 0.1A$

$I_s = ?$

$N = 120$

$Eff = 90\%$

$Eff = 0.9 = \frac{output}{input} = \frac{V_s I_s}{V_p I_p}$ (1)

$0.9 = \frac{6 I_s}{240 \times 0.1}$ (2)

$I_s = 3.60A$ (1)

Question 5 **(4 marks)**

The 'black box' on the power lead that connects a standard school laptop computer to the domestic power supply for recharging batteries is marked

TOSHIBA AC ADAPTOR
INPUT: 240V, 0.550 A, 50 Hz
OUTPUT: 15.0V, 3.00 A

(a) What type of device is this adaptor? Be specific. (1 mark)

Stepdown Transformer. (No ½ marks)

(b) Calculate the efficiency of the power lead. (3 marks)

$Eff = \frac{output}{input} \times 100 = \frac{V_s I_s}{V_p I_p} \times 100$

$= \frac{15 \times 3}{240 \times 0.55} \times 100 = 34.1\%$

Question 6 **(4 marks)**

(a) Explain the difference between an AC and a DC generator. (2 marks)

AC generator has slip rings resulting in an alternating emf ①

DC generator has split rings / commutator resulting in a

direct emf ①

(b) Name **two** physical quantities that determine the magnitude of the induced emf from a generator and explain the effect on the induced emf if these quantities are increased. (2 marks)

↑ windings / length of coil ↑ emf

↑ field strength ↑ emf

↑ frequency ↑ emf

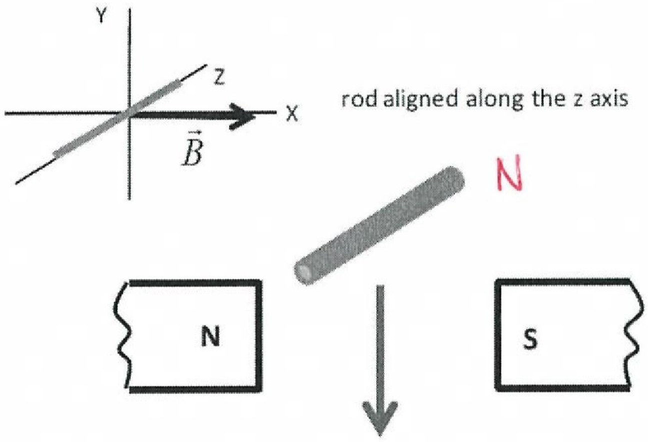
End of Section A

Section Two: Problem-Solving (32 marks)

This section has **two (2)** questions. Answer **all** questions. Write your answers in the spaces provided.

Question 7 (7 marks)

A copper rod is held in a horizontal position just above the poles of a permanent magnet. It then is released and falls through the magnetic field of the magnet.



(a) Describe how an induced emf is created in the rod. (2 marks)

As rod approaches magnets it experiences and increases in magnetic flux ①

This induces an emf in the rod according to

emf = $\Delta\Phi / t$ ①

(b) State and explain how the motion of the rod differ from its free fall motion. (3 marks)

Induced emf is in a direction to oppose the change that caused it ①

results in a force up on the rod ①

force ↑ opposes F of gravitation ↓ so rod slower than in free fall ① (back emf)

(c) Indicate with the letter N on the diagram end of the rod that becomes negatively charged. (1 mark)

(d) Explain why is no induced current in the rod. (1 mark)

There is no closed (½) circuit for current (½) to flow

Question 8 **(6 marks)**

An aeroplane with a wingspan of 10.0 m is flying horizontally at a velocity of 200 m s^{-1}. In the region the plane is flying, the Earth's magnetic field is 2.0 x 10^{-4} T, at an angle of 60.0° to the horizontal.

(a) Calculate the vertical component of the Earth's magnetic field. (2 marks)

$B_v = B \sin 60^{\circ}$

$= 2 \times 10^{-4} \sin 60$ (1)

$= 1.73 \times 10^{-4}$ T (1)

(b) Calculate the emf induced across the wingtips of the plane. (2 marks)

$V_{emf} = Blv$

$V_{emf} = 1.73 \times 10^{-4} \times 10 \times 200$ (1)

$V_{emf} = 0.346$ V

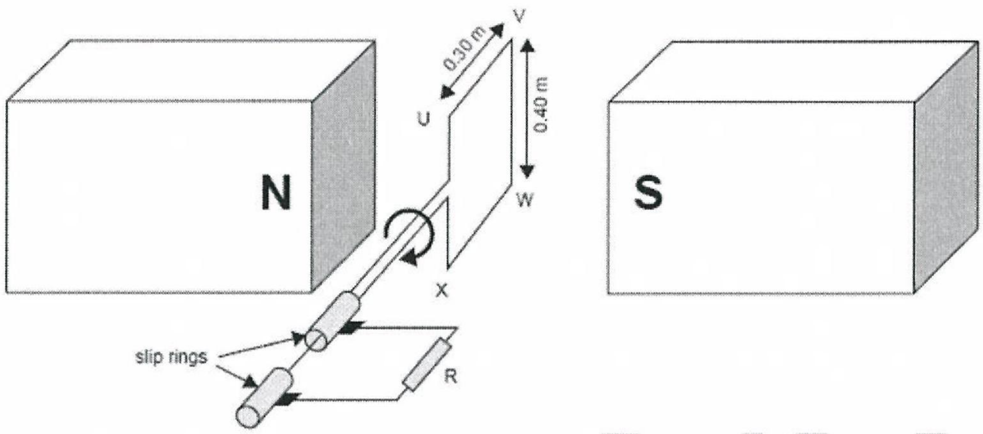
(c) Could this emf be used to power the cabin lights? Explain. (2 marks)

No. (1)

There is no circuit for the current to flow through (1)

Question 9 **(12 marks)**

The figure below is a diagram of a simple alternator. A coil (UVWX) 0.300 m by 0.400 m, **consists of 20 turns of wire**. It is in a uniform magnetic field of strength 0.250 T, and can rotate as shown.



(a) Calculate the magnitude of the magnetic flux through each turn of the coil when the coil oriented as above. (3 marks)

$l = 0.3 m$
$W = 0.4 m$
$n = 20$
$B = 0.25 T$

$\Phi = B \times A$ (1)
$\Phi = 0.25 \times 0.3 \times 0.4$ (1)
$\Phi = 0.0300 Wb$ (1)

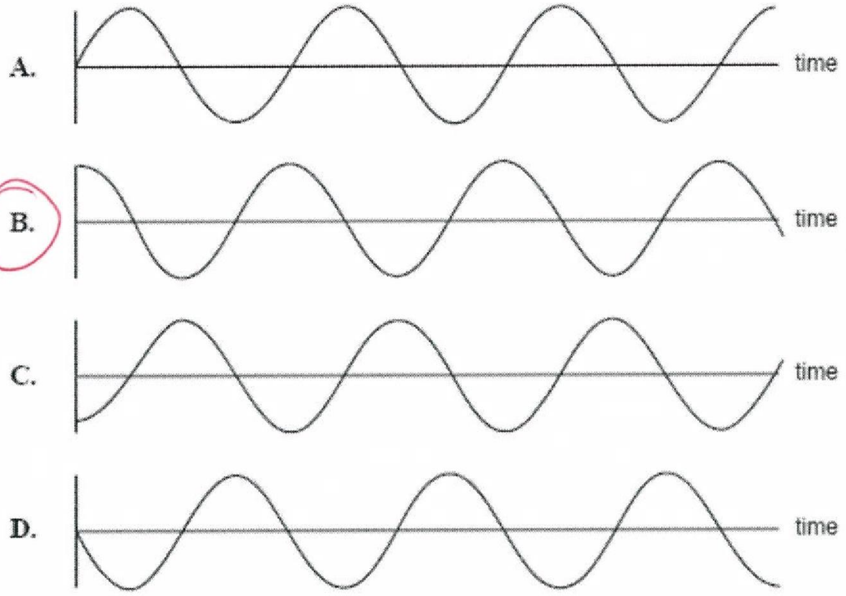
(b) The coil is rotated at **a constant rate of 50 revolutions per second** in the direction shown. Calculate the **average voltage** developed across the resistor R when the coil rotates through 90 degrees from the orientation shown in the figure above. (3 marks)

$f = 50 Hz$
$T = \frac{1}{50}$
only on $\frac{1}{4}$ turn

$emf_{average} = \frac{N \Delta \Phi}{t}$
$= \frac{20 \times 0.03}{1/50}$
$= 30.0 V$

(c) The graphs below show possible variations of **the magnetic flux** through the coil as a function of time as it rotates. They all begin at time t = 0, when the coil is oriented as in the diagram above.

(i) Indicate which of these graphs (**A – D**) best shows the variation of **the magnetic flux** through the coil as a function of time. Take the direction from N to S in the figure as positive. (1 mark)

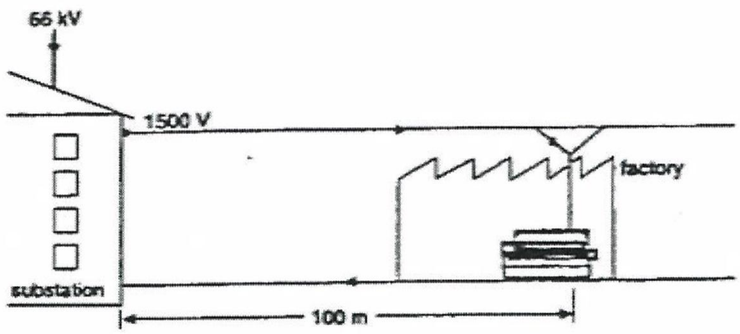


(ii) Assuming the same conditions, indicate which of the graphs (**A – D**) best shows the variation of the current flowing **from U to V in the coil**, as a function of time? Explain. (5 marks)

- A. (1)
- Current starts at minimum as the gradient of graph B = $\frac{\Delta\Phi}{T}$ and is minimum at position shown (1)
- As coil rotates to parallel to field flux reduces to minimum & gradient of graph B increases to max^{m} to current increased to maximum (1)
- This reverses for next $\frac{1}{4}$ turn (1)
- Then repeats with opposite sign for the next 180° of rotation (1)

Question 10 **(7 marks)**

An electrical power grid supplies 66.0 kV to a substation which uses a transformer to provide power at 1500 V to a line to operate a machine in a factory as shown below. The power output from the substation is 120 kW.



The machine is located 100 m from the substation and the average resistance of the circuit wires are 4.00 x 10^{-3} Ωm^{-1} (a circuit return wire is also used).

(a) Calculate the current that flows in the factory circuit when the machine is operating. (3 marks)

$I = P/V = \frac{120000}{1500}$ ①

$I = 80.0$ A ①

(b) What is the total power lost in the circuit wires when the machine is operating? (2 marks)

$P_{loss} = I^2 \times R$

$P_{loss} = 80^2 \times 0.8$

$P_{loss} = 5120$ W

$R = 4 \times 10^{-3} \times 100 \times 2$ ← to machine & back.

$= 0.8\ \Omega$.

(c) What is the actual operating voltage of the machine? (2 marks)

$V_{drop} = IR = 80 \times 0.8 = 64$ V ①

$V_{at\ machine} = 1500 - 64 = 1436$ V ①

End of Section B

Section Three: Comprehension **(10 marks)**

This section has **one (1)** question. Answer **all** questions. Write your answers in the spaces provided.

Read the article below and answer the questions that follow.

Power stations burn coal to heat water to produce steam. This steam turns the turbine which spins a massive magnet inside a very large coil of wire. As the magnet spins, electricity is induced in the coil of wire.

Inside the generator

A generator turns mechanical energy into electrical energy. The turbine turns a *rotor* which consists of coils of wire wound on a steel core (see Figure 3 below). An electric current supplied to the rotor produces a magnetic field so that it behaves like a magnet. This is an electromagnet. The rotor turns inside another set of windings called the *stator.* As the rotor turns its magnetic field induces an electric current in the coils of the stator. Because first the north pole and then the south pole cuts the stator windings, the current that flows continually reverses its direction. This is an alternating current (AC) generator, sometimes called an alternator. In Australia, there is a complete cycle of flow and reversal 50 times a second, making the supply frequency 50 Hertz.

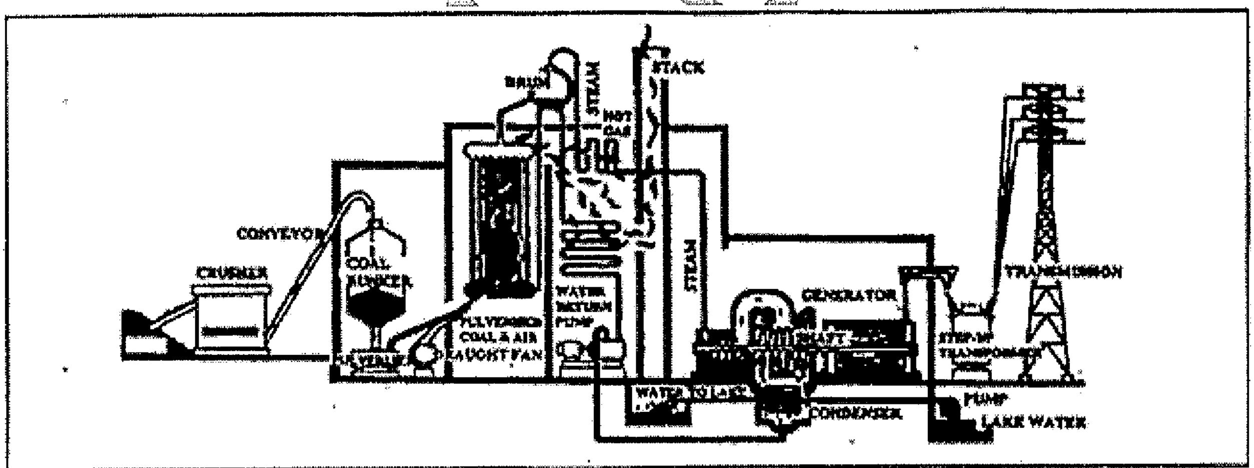


Figure 2: Inside a coal-fired power station

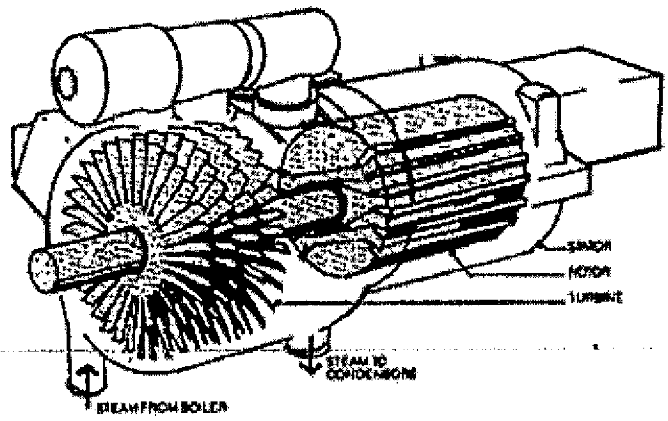


Figure 3: Inside the generator

(a) Calculate the period of the AC cycle due to the rotational speed of the turbine. (2 marks)

$f = 50\ Hz$

$T = \frac{1}{f} = \frac{1}{50} = 2.00 \times 10^{-2}\ s$ (1) (1)

b) Figure 2 shows a Step-up Transformer between the generator and transmission lines.

(i) State the purpose of this device? (2 marks)

Converts voltage to high voltage (1) for power

This reduces energy (power) loss (1) as current ↓

according to $P = I^2R$.

(ii) Describe the relationship between the number of windings in the primary and secondary coils that would exist in this device. (1 mark)

More windings in secondary coil

than primary coil

(iii) These devices require some sort of heat dissipation (i.e. cooling) design. Explain why they get hot? (2 marks)

As the current flows in the coil some electrical

energy is converted to energy due to resistance

in wires (1) Alternating magnetic field induces eddy

currents which also results in dissipation of heat (1)

e) Explain why the coils of the *rotor* are wound on a steel core. (2 marks)

Steel is an alloy of iron which is ferromagnetic (1)

the domains line up with the magnetic field

↑ing the magnetic field strength (1)

f) The induced emf is produced in the coils of the *stator.* Western Australia power grid generators have three *stators* placed around the *rotor.* Each produces an emf as the *rotor* spins but the resulting electrical cycles are out of phase. A basic law would suggest you could not continually add more *stators* to induce a greater number of separate emf supplies from the same *rotor* without affecting its rotation.

Name this law.

(1 mark)

Lenz's Law

End of Test