

	<i>Office Use Only</i>
Name:	Motion: /40
Teacher:	Fields & electricity: /40
	TOTAL: /80

Melbourne High School



VCE Physics Unit 3 Motion, Fields & Electricity Practice SAC

Reading: 10 minutes
Writing: 80 minutes
Total Possible Score: 80 marks

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one approved scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper, CAS/graphics calculator, mobile phones, iPads and/or any other unauthorised electronic devices.

Materials Supplied

This Question and Answer booklet, with detachable formula sheet at the end of the booklet.

Instructions

- Detach the formula sheet at the end of the booklet during reading time.
- Write **your name and that of your teacher** in the spaces provided.
- Answer all questions in this book where indicated.
- **Always** show your working where spaces are provided and always place your answer(s) in the boxes provided.
- All written answers must be in comprehensible English.

Instructions for Section

Answer all questions for Area of Study in this section of the paper.

Area of Study -Motion :

Figure 1 shows Joe traveling on an up escalator that is moving with a speed of 1.5 m s^{-1} . Mary is on a parallel escalator that is moving down with a speed of 1.5 m s^{-1} .

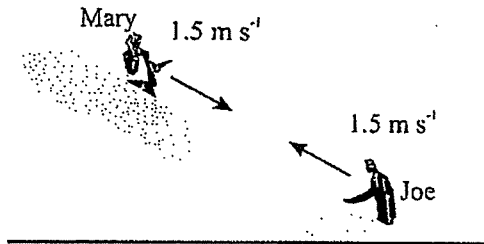


Figure 1

Question 1

Calculate the speed of Mary relative to Joe.

m s^{-1}

2 marks

When standing on the moving escalator Joe is carried to the top in a time of 60 s. The next day, the escalator has stalled. Joe walks up the stalled escalator and reaches the top in a time of 90 s.

Question 2

Calculate the time it would take Joe to walk up the moving escalator to the top.

s

3 marks

Eric stands motionless on a set of bathroom scales and notes the reading as 300 N. He then crouches down and suddenly jumps up. Jason, who is watching, notes that the reading on the bathroom scales momentarily increases to 400 N when Eric jumps up.

Question 3

Calculate the magnitude of Eric's maximum acceleration as he jumps up.

m s^{-2}

3 marks

Ashleigh drove her car of mass 900 kg along a straight horizontal road with a speed of 20 m s^{-1} . She applied the brakes and slowed down to a speed of 5.0 m s^{-1} in 10 s. Ignore effects due to friction.



Figure 2

Question 4

Calculate the magnitude of the braking force that acted on the car.

N

2 marks

Figure 3 shows a mass of 0.10 kg that is attached to a hanging mass of 0.90 kg by a cord. The table is frictionless and the small mass rotates in a circular path.

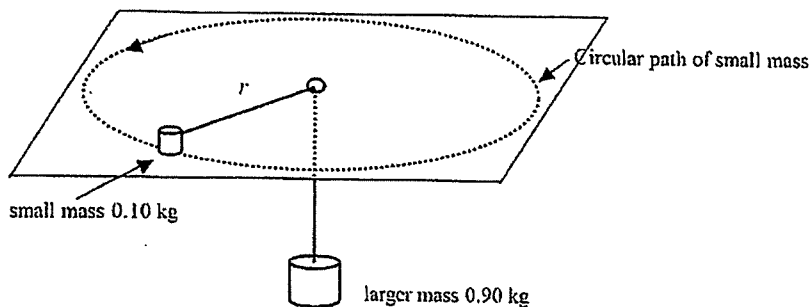


Figure 3

Question 5

Calculate the speed of rotation, in m s^{-1} , of the 0.10 kg mass which will keep the 0.90 kg mass at rest, if the radius of rotation, r , is 0.80 m.

m s^{-1}

2 marks

Questions 6 - 7 refer to the following information.

During a game of rugby, a football is kicked off with an initial speed of 18 m s^{-1} at an angle of 45° to the horizontal playing field. A receiver on the goal line 50 m away in the direction of the kick begins running to meet the ball at the instant it is kicked as shown in Figure 4.

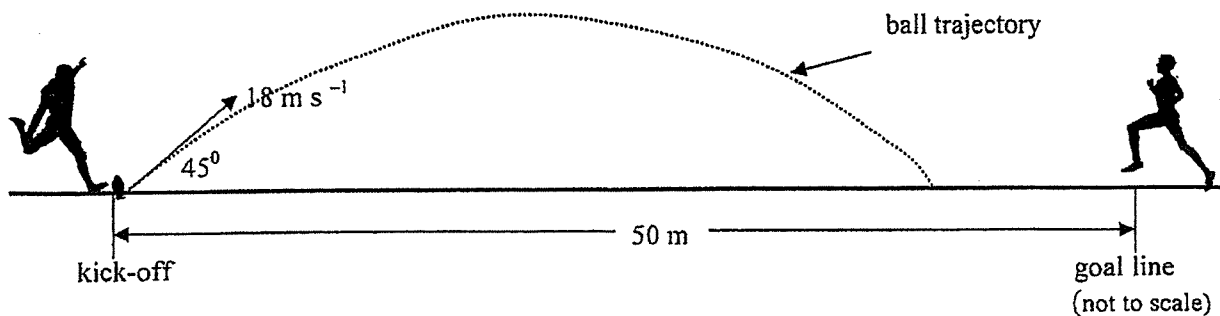


Figure 4

Question 6

Calculate the time the ball is in the air if it isn't caught.

s

2 marks

Question 7

Calculate the ^{minimum} average speed of the receiver if he is to catch the ball before it hits the ground.

m s^{-1}

3 marks

Questions 8 - 9 refer to the following information.

An elevator filled with passengers has a total mass of 2500 kg as shown in Figure 5. The cable snaps when the elevator is at rest at the first floor of a building. At this instant the bottom of the elevator is 3.0 m above the top of a cushioning spring. The spring is compressed by 0.50 m in bringing the elevator to rest initially. Ignore the mass of the spring in this question.

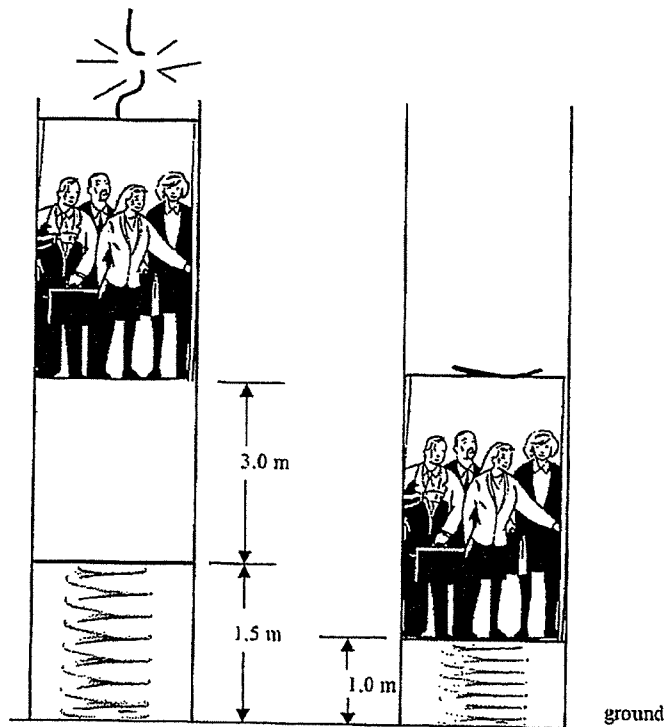


Figure 5

Question 8

Calculate the speed of the elevator as it first makes contact.

2 marks

Question 9

Calculate the spring constant of the spring.

3 marks

Questions 10 - 12 refer to the following information.

Figure 6 shows a train with an engine, a coal truck and carriage travelling at constant velocity along a straight, horizontal section of track. The mass of the engine is 20.0 tonnes and the mass of each of the other two parts is 10.0 tonnes.

At this constant velocity the resistance force (due to frictional forces and air resistance) on the engine is 2000 N and the carriage and coal truck experience a resistance force of 1500 N each.

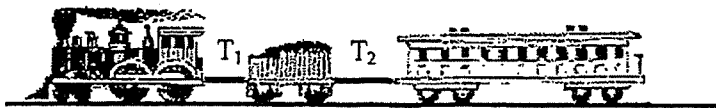


Figure 6

Question 10

Calculate the magnitude of the driving force provided by the engine.

2 marks

While still on the same section of track, the train is required to speed up and so the engine driving force is increased to 2.5×10^4 N.

Question 11

Calculate the acceleration of the train during this process. Assume that the resistance forces have not changed.

2 marks

During another part of the journey the train is accelerating at 0.20 m s^{-2} along a straight, level section of track.

Question 12

Calculate the magnitude of the tension (T_1) in the coupling between the engine and the coal truck during this acceleration. (Assume that the resistance forces remain the same as before).

3 marks

Questions 13 - 14 refer to the following information.

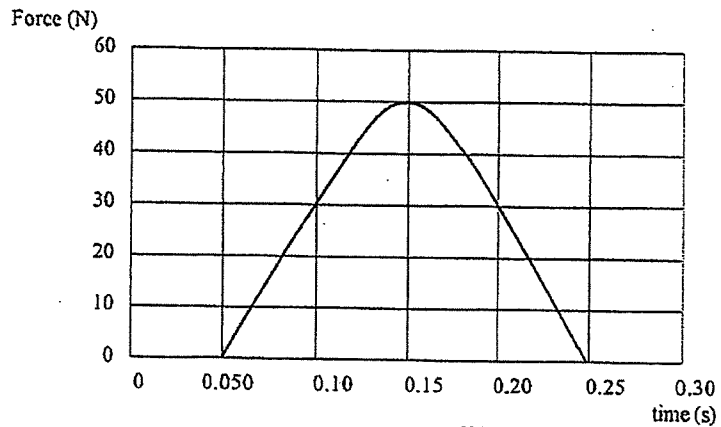


Figure 7

Anne throws a volleyball of mass 0.20 kg vertically into the air to serve. She strikes the ball with her hand at the instant the ball is motionless in the air. The force exerted by her hand on the ball varies with time as shown in Figure 7.

Question 13

Estimate the impulse of the force exerted by Anne's hand on the ball.

N s

2 marks

Question 14

Calculate the speed of the ball immediately after impact with Anne's hand.

m s^{-1}

2 marks

Questions 15 - 18 refer to the following information.



One of the more than 200 extra-solar planets discovered recently revolves in a circular path around a star, (HR 7291, found in the constellation Sagittarius), at a distance of 7.7×10^9 m (between centres). The period of the planet is 3.09 days.

Question 15

Calculate the orbital velocity, in m s^{-1} , of the planet.

m s^{-1}

2 marks

Question 16

Calculate the mass, in kg, of the parent star.

kg

2 marks

The mass of the planet revolving around star HR 7291 is 1.6×10^{26} kg.

Question 17

Calculate the magnitude of the gravitational force of attraction between the planet and star HR 7291.

N

2 marks

Question 18

How would the surface temperature of this planet compare with that of the Earth's surface temperature, *assuming the star is like the Sun?*

.....
1 mark

END OF AREA OF STUDY

Instructions for Section .
 Answer all questions for Area of study in this section of the paper.

Area of study – Electricity and Fields

Questions 1 and 2 refer to the following information.

Figure 1 shows a wire of length 0.12 m carrying an electric current of 2.0 A in a uniform magnetic field of strength 0.90 T and perpendicular to the field. A magnetic force causes the wire to move.

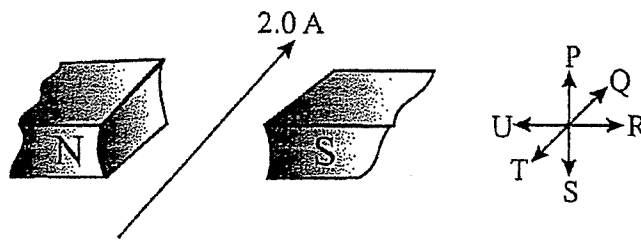


Figure 1

Question 1

Calculate the magnitude of the force on the wire. *Assume all of the wire is in the magnetic field.*

N

2 marks

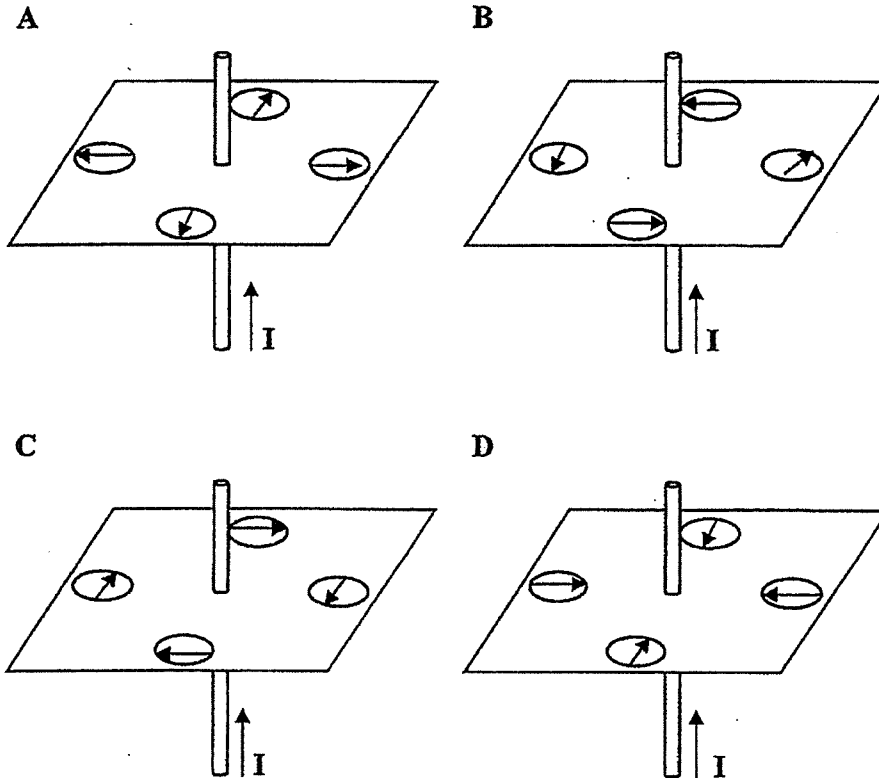
Question 2

Which one of the directions, P – U, shown in **Figure 2** indicates the direction of the force on the wire when the current flows.

1 mark

Question 3

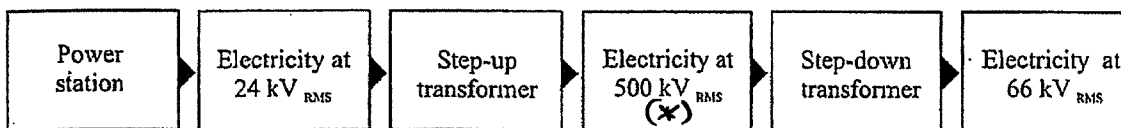
Which one of the following diagrams, A - D shown below, best shows the orientation for a set of four compasses placed around a current-carrying wire? The arrows indicate the north pole of the compass needle.



2 marks

Questions 4 - 7 refer to the following information.

The diagram shows part of the system used in Victoria for generating electric power and transmitting this power from the generating station to a terminal station.



Question 4

(* At beginning of transmission lines.)

Which statement below correctly describes the operation of a transformer?

- A. A current flows from one coil through the core to the other coil.
- B. An AC voltage across one coil induces an AC voltage across the other coil.
- C. A DC voltage across one coil causes a DC voltage in the other coil.
- D. An AC voltage in the primary coil is transformed to a DC voltage in the secondary coil.

2 marks

The primary coil of the step-up transformer has 1000 turns.

Question 5

Calculate the number of turns in the secondary coil.

2 marks

One generator at the power station produces of 530 MW of power.

Question 6

Calculate the magnitude of the RMS current in the secondary coil of the step-up transformer. The transformer is considered to be ideal.

2 marks

The electric power is transmitted over a considerable distance to a step-down transformer. There is a power loss of 5.0 % due to heating of the transmission cables.

Question 7

Calculate the RMS voltage of the primary coil of the step-down transformer. Answer in kilovolts.

2 marks

Questions 8 and 9 refer to the following information.

Figure 3 shows a transformer used in the home which converts mains 240 V_{RMS} electricity to 12 V_{RMS} to power a set of 100 identical Christmas lights wired in parallel. Assume zero power loss in this system.

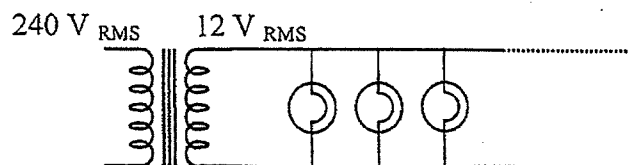


Figure 3

Question 8

Calculate the peak voltage across the secondary coil of the transformer.

2 marks

The primary circuit draws $120 W_{RMS}$ of power.

Question 9

Calculate the resistance, in ohms, of one of the Christmas lights.

2 marks

Two solenoids are positioned as shown in **Figure 4** and the switch, S, is closed,

Question 10

Determine the direction of the current that flows through resistor R as the switch closes.

Justify your answer.

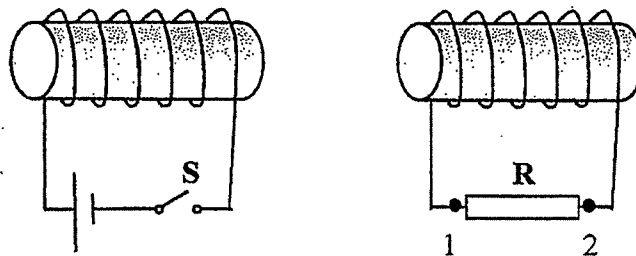


Figure 4

3 marks

Figure 5 shows a coil of area $1.13 \times 10^{-2} \text{ m}^2$ consisting of 200 loops placed in a 0.35 T magnetic field. The magnetic field is uniformly changed to 0.25 T in the **opposite** direction in 0.80 s. (Dots and crosses indicate opposite sense of the magnetic field).

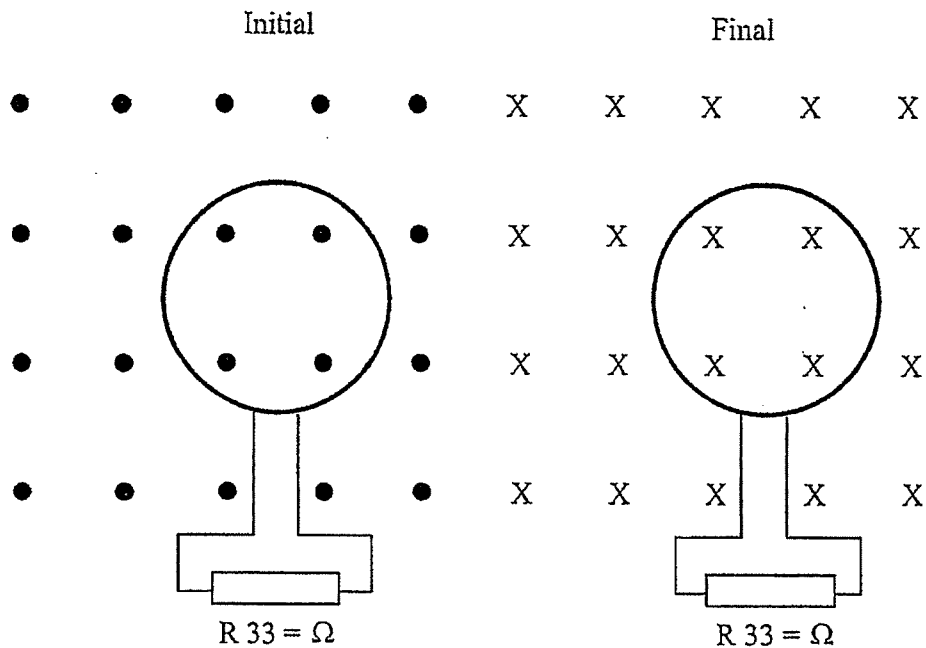


Figure 5

Question 11

Calculate the magnitude of the current in mA, that flows through the 33Ω resistor connected to the coil during this period. (Ignore the resistance of the coil.)

mA

3 marks

Questions 12 – 14 refer to the following information.

Figure 6 shows a model motor which Eric used during an experiment. A coil of wire was connected to a split-ring commutator and placed as shown in the uniform magnetic field. Eric then connected the terminals, T_1 and T_2 , to a battery. He observed that the coil began to rotate in a clockwise direction around axis XY .

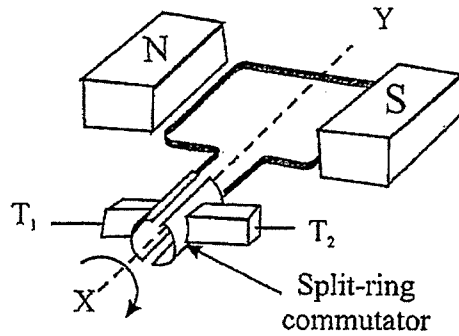


Figure 6

Question 12

Determine which of the terminals, T_1 or T_2 , is connected to the *positive* terminal of the battery.

2 marks

In order to observe the electromagnetic induction in the coil, Eric removed the battery connections and connected a cathode ray oscilloscope as shown in **Figure 7**. He then slowly rotated the coil around the axis XY in a clockwise direction (as shown).

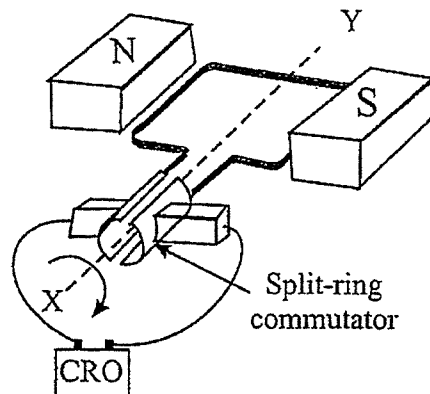
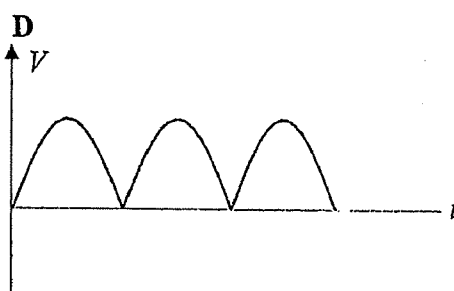
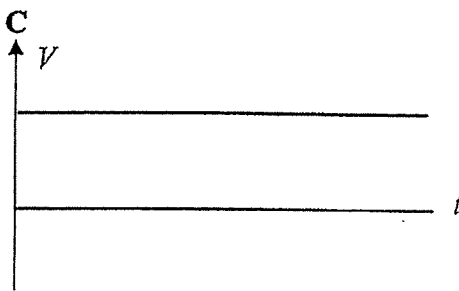
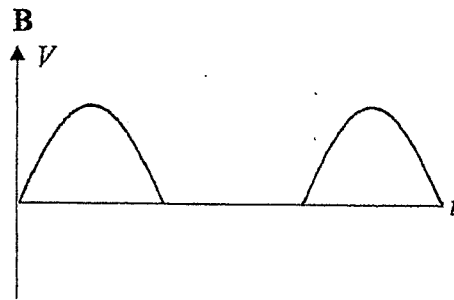
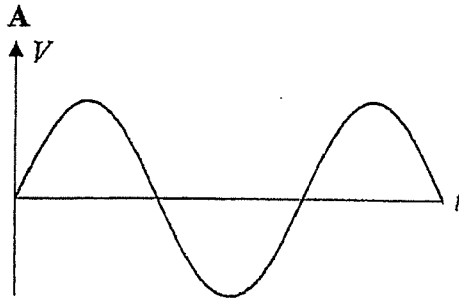


Figure 7

Question 13

Which one of the waveforms below best shows what Eric observed on the C.R.O when the coil was rotated in a clockwise direction as shown in **Figure 7**.



2 marks

Question 14

Describe the action of the split-ring commutator in **Figure 6**.

2 marks

Question 15 to 18 refer to the following information.

Figure 8 shows a simplified electrical generator consisting of a single square coil of wire PQRS placed in a uniform magnetic field of strength 0.60 T. The side length of the square coil is 10 cm.

The coil can be rotated about the axis XY. Louise, a physics student, experiments with this coil.

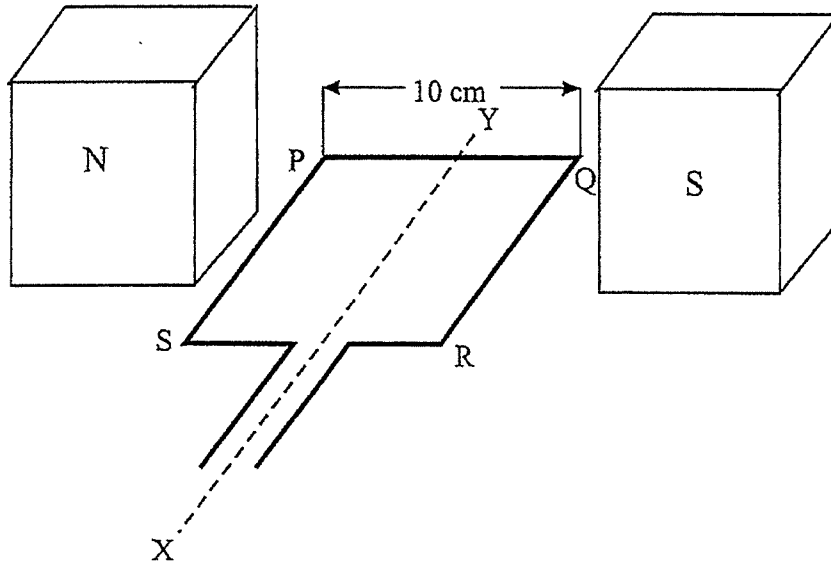


Figure 8

Question 15

Calculate the maximum magnetic flux that can pass through the coil.

Wb

2 marks

Figure 9 shows the variation of magnetic flux with time for one complete cycle, of the coil.

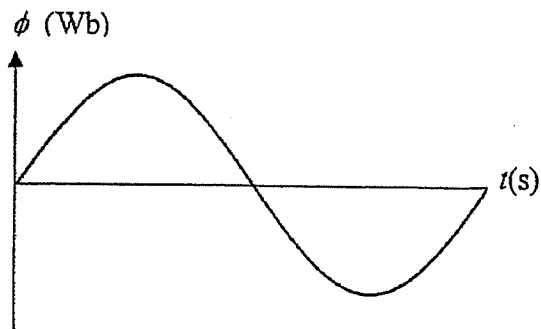
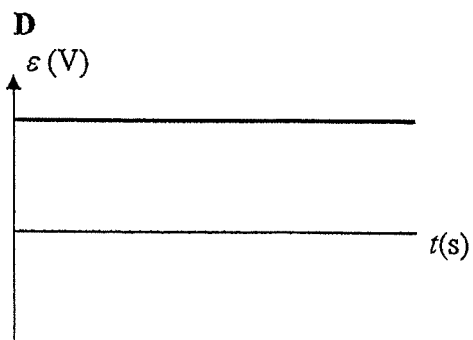
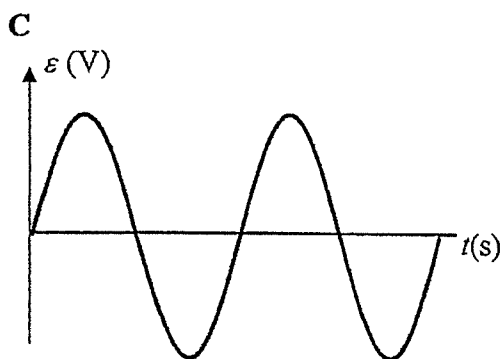
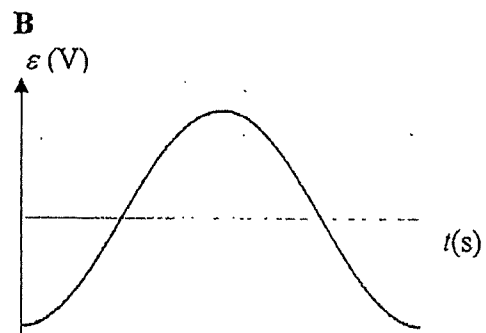
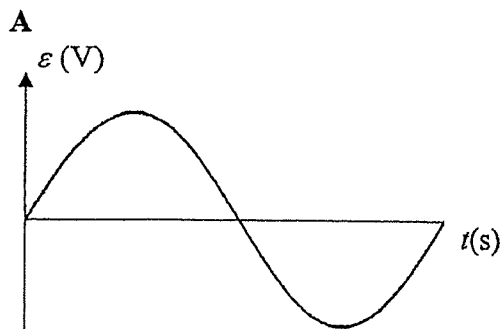


Figure 9

Question 16

From the graphs A – D shown below, choose the alternative that best shows the emf induced in the coil during this cycle.



2 marks

Figure 10 shows the emf, ε , produced by a coil when it is rotated with a frequency of 20 Hz in a magnetic field.

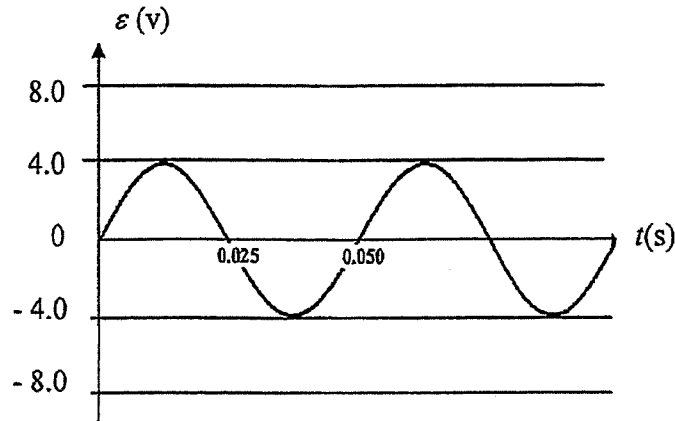


Figure 10

Question 17

On **Figure 10** above, draw the corresponding curve for emf induced in the same coil when it is rotated with a frequency of 40 Hz. Justify the shape of the curve that you draw.

3 marks

Louise wrote the following in her physics notebook.

“When a coil of wire is turned in a magnetic field, a potential difference is induced between the ends of the coil. The size of this potential difference is greater when

- the area of the wire coil is greater.
- the number of turns on the coil is greater.
- the strength of the magnetic field is greater.
- the speed of rotation of the coil is increased.

Question 18

How many of Louise’s dot points are correct?

- A. None of them.
- B. All of them.
- C. Only three of them.
- D. Only two of them.

2 marks

Looking along the axis of rotation from end X, in **Figure 8**, the coil rotated in a clockwise direction.

Question 19

Circle the correct alternative from those listed below.

The induced current will flow in the direction:

- from R to Q
- from Q to R

2 marks

END OF SAC

Physics formulas

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t}; a = \frac{\Delta v}{\Delta t}$
equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(v + u)t$
Newton's second law	$\Sigma F = ma$
circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
Hooke's law	$F = -k\Delta x$
elastic potential energy	$\frac{1}{2}k(\Delta x)^2$
gravitational potential energy near the surface of Earth	$mg\Delta h$
kinetic energy	$\frac{1}{2}mv^2$
Newton's law of universal gravitation	$F = G \frac{M_1 M_2}{r^2}$
gravitational field	$g = G \frac{M}{r^2}$
impulse	$F\Delta t$
momentum	mv
Lorentz factor	$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
time dilation	$t = t_0 \gamma$
length contraction	$L = \frac{L_0}{\gamma}$
rest energy	$E_{\text{rest}} = mc^2$
relativistic total energy	$E_{\text{total}} = \gamma mc^2$
relativistic kinetic energy	$E_K = (\gamma - 1)mc^2$

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformation of charges in an electric field	$\frac{1}{2}mv^2 = qV$
field of a point charge	$E = \frac{kq}{r^2}$
force on an electric charge	$F = qE$
Coulomb's law	$F = \frac{kq_1q_2}{r^2}$
magnetic force on a moving charge	$F = qvB$
magnetic force on a current	$F = IlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

Generation and transmission of electricity

voltage; power	$V = RI; \quad P = VI = I^2R$
resistors in series	$R_T = R_1 + R_2$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
ideal transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$
AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak} \quad I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
electromagnetic induction	EMF : $\varepsilon = -N \frac{\Delta\Phi}{\Delta t}$ flux : $\Phi = BA$
transmission losses	$V_{drop} = I_{line} R_{line} \quad P_{loss} = I_{line}^2 R_{line}$

Wave concepts

wave equation	$v = f\lambda$
constructive interference	path difference = $n\lambda$
destructive interference	path difference = $\left(n - \frac{1}{2}\right)\lambda$
fringe spacing	$\Delta x = \frac{\lambda L}{d}$
Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
refractive index and wave speed	$n_1 v_1 = n_2 v_2$

The nature of light and matter

photoelectric effect	$E_{K \max} = hf - W$
photon energy	$E = hf$
photon momentum	$p = \frac{h}{\lambda}$
de Broglie wavelength	$\lambda = \frac{h}{p}$
Heisenberg's uncertainty principle	$\Delta p_x \Delta x \geq \frac{h}{4\pi}$

Data

acceleration due to gravity at Earth's surface	$g = 9.8 \text{ m s}^{-2}$
mass of the electron	$m_e = 9.1 \times 10^{-31} \text{ kg}$
magnitude of the charge of the electron	$e = 1.6 \times 10^{-19} \text{ C}$
Planck's constant	$h = 6.63 \times 10^{-34} \text{ J s}$ $h = 4.14 \times 10^{-15} \text{ eV s}$
speed of light in a vacuum	$c = 3.0 \times 10^8 \text{ m s}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
mass of Earth	$M_E = 5.98 \times 10^{24} \text{ kg}$
radius of Earth	$R_E = 6.37 \times 10^6 \text{ m}$
Coulomb constant (in air)	$k = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$

Prefixes/Units

p = pico = 10^{-12}	n = nano = 10^{-9}	μ = micro = 10^{-6}	m = milli = 10^{-3}
k = kilo = 10^3	M = mega = 10^6	G = giga = 10^9	t = tonne = 10^3 kg

END OF FORMULA SHEET

