Neap

Trial Examination 2023

VCE Physics Unit 3

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	10	10	10
B	11	11	80
			Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 22 pages

Formula sheet

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in the booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

You may keep the formula sheet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2023 VCE Physics Units 3&4 Written Examination.

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

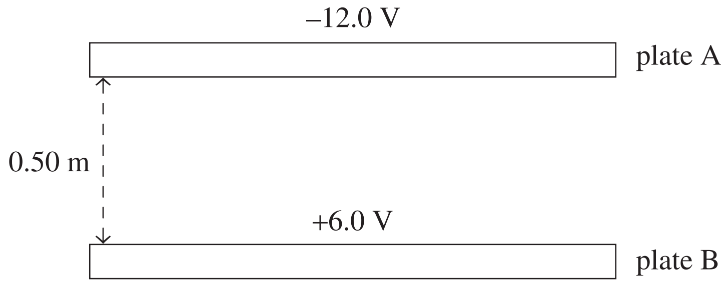
No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Use the following information to answer Questions 1 and 2.

Two plates, A and B, have potentials of –12.0 V and +6.0 V respectively. The plates have a separation of 0.50 m, as shown in the diagram below.



Question 1

What is the magnitude of the electric potential midway between the two plates?

A. –6.0 V

B. –3.0 V

C. 0 V

D. 3.0 V

Question 2

An electron at rest is released from plate A and strikes plate B.

How much kinetic energy does the electron gain?

A. 9.60×10^{-19} J

B. 1.44×10^{-18} J

C. 1.92×10^{-18} J

D. 2.88×10^{-18} J

Question 3

An electron is fired at right angles into a magnetic field and follows a circular path with a radius of 0.18 mm. The electron's speed is doubled and the magnetic field value is halved, then the electron is again directed at right angles into the magnetic field.

The radius of the electron's new path is

A. 0.045 mm

B. 0.090 mm

C. 0.36 mm

D. 0.72 mm

Question 4

A simple, ideal, step-down transformer has an input current to output current ratio of 1 : 100. The transformer is in operation so that voltages exist in the primary and secondary side of the transformer.

Which of the following shows the correct ratios for the transformer?

	Primary turns : secondary turns	Input power : output power
A.	100 : 1	100 : 1
B.	100 : 1	1 : 1
C.	1 : 100	1 : 1
D.	1 : 100	1 : 100

Question 5

Determine the Lorentz factor for a speed of 2.0×10^8 m s^{-1}.

A. 1.34

B. 1.73

C. 1.80

D. 3.00

Question 6

An electron has a rest mass-energy of 0.512 MeV.

What is the mass-energy of the electron if it travels with a Lorentz factor of 3.00?

A. 0.171 MeV

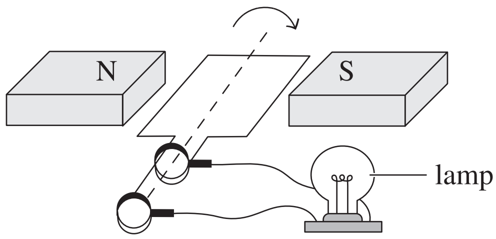
B. 0.256 MeV

C. 1.02 MeV

D. 1.53 MeV

Question 7

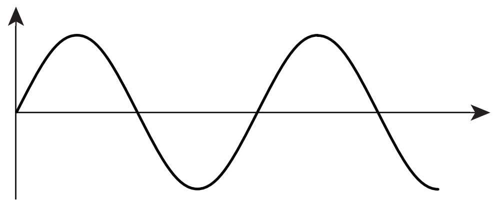
A group of Physics students assembled the following apparatus as part of an investigation. When the coil turns, the lamp remains switched on. The coil is turned at a constant rate.



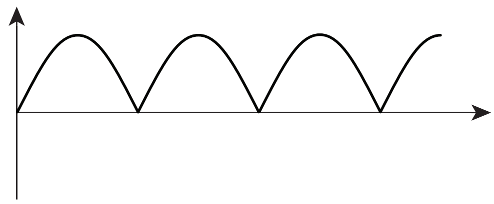
The students are asked to construct a voltage versus time graph to represent the output of the apparatus, including a relevant title that identifies the apparatus.

Which one of the following graphs is correct?

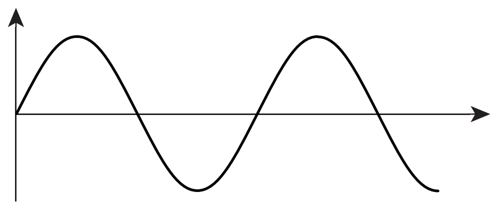
A. **Voltage versus time for the motor**



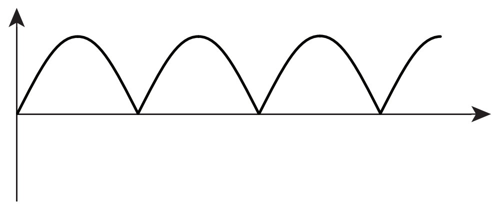
B. **Voltage versus time for the motor**



C. **Voltage versus time for the generator**

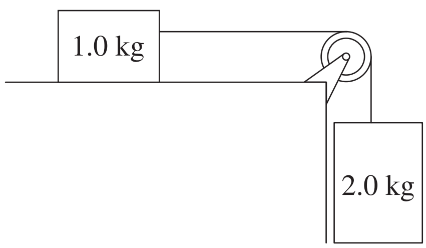


D. **Voltage versus time for the generator**



Question 8

The diagram below shows a 2.0 kg mass falling and pulling a 1.0 kg mass along a frictionless surface via a frictionless pulley.



The net force acting on the 2 kg mass is closest to

A. 6.5 N

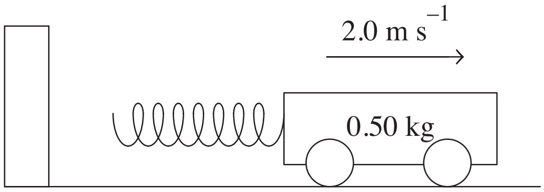
B. 9.8 N

C. 13.1 N

D. 19.6 N

Use the following information to answer Questions 9 and 10.

A spring-loaded laboratory cart of mass 0.50 kg is pressed up against a wall such that its spring is compressed by 2.0 cm. When released, the spring unloads and returns to its original length, and the cart reaches a speed of 2.0 m s^{-1} from rest. The spring is considered ideal. This set-up is shown in the diagram below.



Question 9

The stiffness constant of the spring is

A. 0.5 N m^{-1}

B. 2.45 N m^{-1}

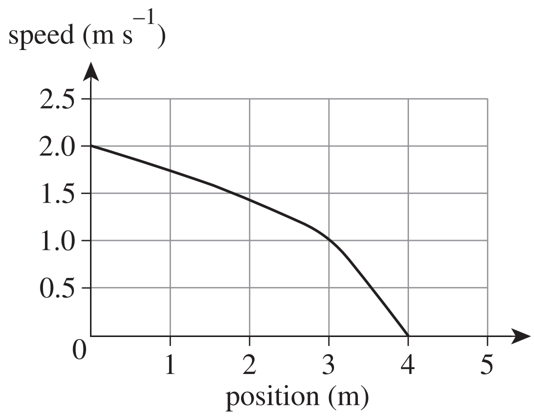
C. 2450 N m^{-1}

D. 5000 N m^{-1}

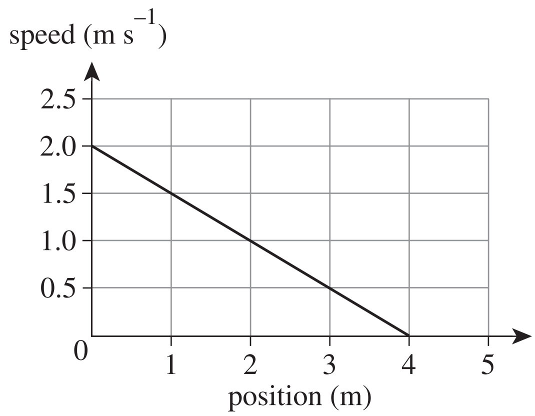
Question 10

Once the cart reaches 2.0 m s^{-1}, it decelerates at a constant rate and eventually comes to rest after 4 m. Which one of the following speed versus position graphs represents the cart's deceleration?

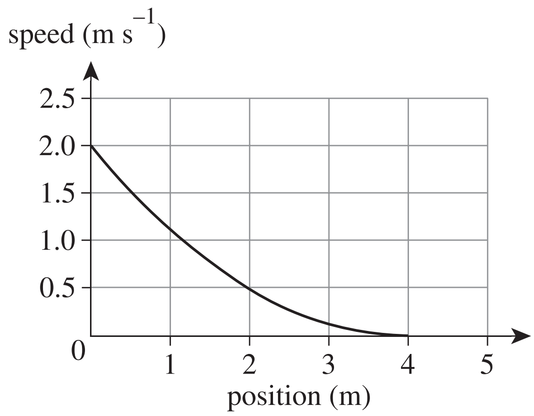
A.



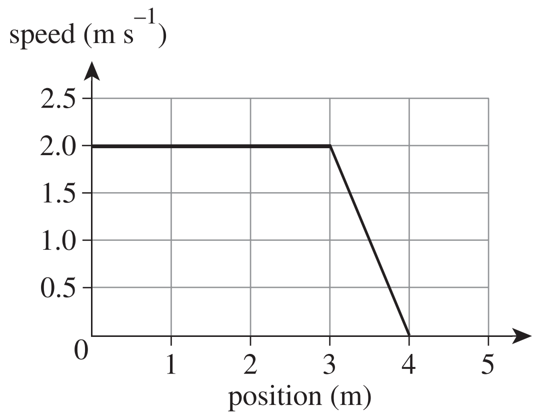
B.



C.



D.



END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.
Take the value of *g* to be 9.8 m s^{-2}.

Question 1 (2 marks)

Figure 1 shows two magnets, X and Y, with their north pole ends very close to each other.

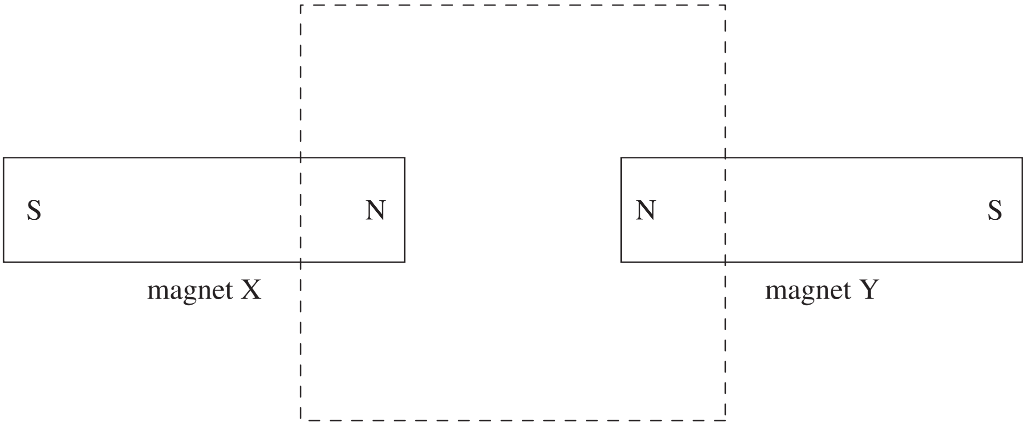


Figure 1

Magnet X has a greater magnetic field strength than magnet Y for the same position from each pole end.

Sketch the shape and direction of **six** magnetic field lines from **each** north pole within the dashed border shown in Figure 1.

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Question 2 (6 marks)

Two charges, Q_1 and Q_2, are 2.0 m apart, and a third charge, Q_3, is exactly midway between both charges, as shown in Figure 2.

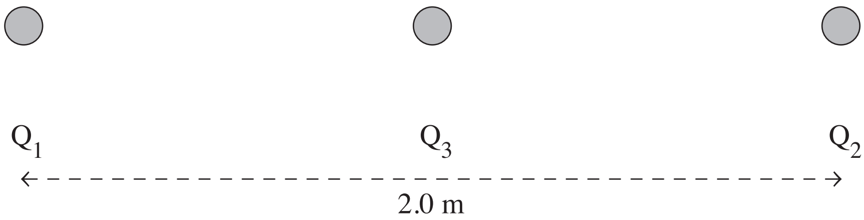

Figure 2

Q_1 and Q_3 have a charge of $+1.0\ \mu C$.

The force of Q_1 on Q_3 is 9.0×10^{-3} N to the right.

The net force acting on Q_3 is 4.5×10^{-3} N to the left.

a. Calculate the magnitude of the force of Q_2 on Q_3. Show your working. 2 marks

N	direction:

b. Show the magnitude and direction of the force calculated in **part a.** by drawing a labelled arrow at the position of charge Q_3 in Figure 2. 1 mark

c. Determine the value and sign (+ or –) of the charge Q_2. Show your working. 3 marks

C	sign:

Question 3 (10 marks)

An electrical device is shown in Figure 3. The direction of electron flow from the battery through the coil JKLM is shown.

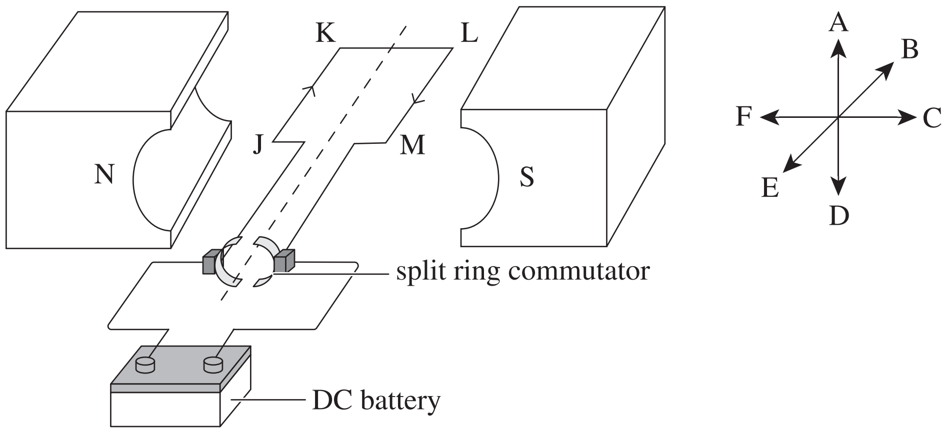

Figure 3

Data

battery voltage	12.0 V
number of loops in coil	50
resistance of coil	2.0 Ω
magnetic field strength	0.50 T
length of sides JK and ML	15 cm

a. Determine the magnitude and direction (A–F) of the force acting on side ML. 3 marks

N	direction:

b. Describe the net magnetic force acting on the coil as it is rotating and determine whether this accounts for the motion of the coil. 2 marks

c. The magnets are slowly pulled away from one another.

Explain how this affects the motion of the coil. 2 marks

d. The device is modified as shown in Figure 4.

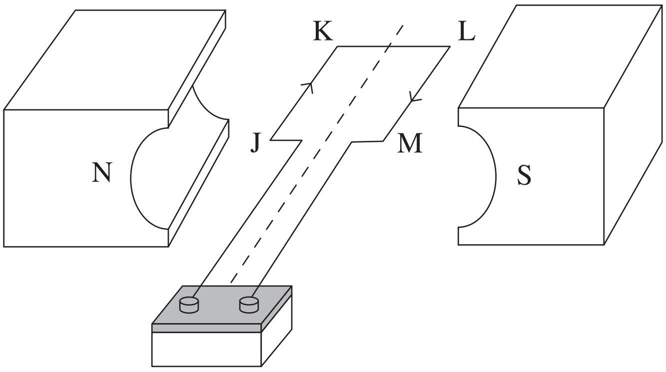

Figure 4

Explain the effect of this modification on the rotation of the coil. 3 marks

Question 4 (13 marks)

An experiment is conducted in which a magnet is dropped from rest through a single square loop, as shown in Figure 5.

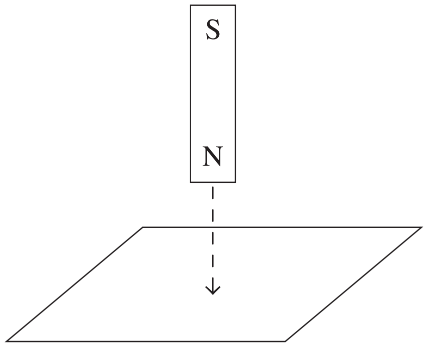

Figure 5

The side length of the square loop is 5.0 cm and it consists of 10 turns of wire. The magnet is dropped such that the north pole end travels vertically downward. It takes 0.20 seconds to reach the position of maximum flux.

The magnetic field strength of the magnet is 0.20 T at the point where the end of the magnet has just entered the plane of the loop.

a. Calculate the maximum magnetic flux experienced by the loop due to the magnet. Show your working. 2 marks

Wb

b. Calculate the average EMF generated in the loop as the magnet falls from rest to the point where the north pole reaches the position of maximum flux. Show your working. 2 marks

V

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The magnet falls through the loop. Figure 6 shows the instant in which the south pole of the magnet is at the plane of the loop.

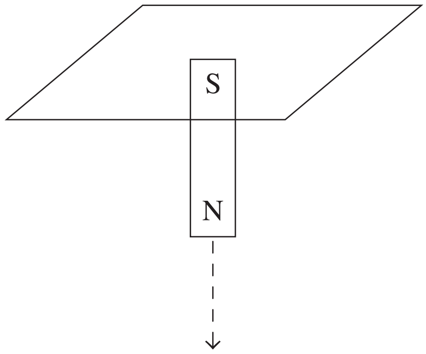

Figure 6

After the instant shown in Figure 6, the magnet continues to fall and moves away from the loop.

c. Explain why a current is developed in the loop as the magnet falls and moves away from the loop. 3 marks

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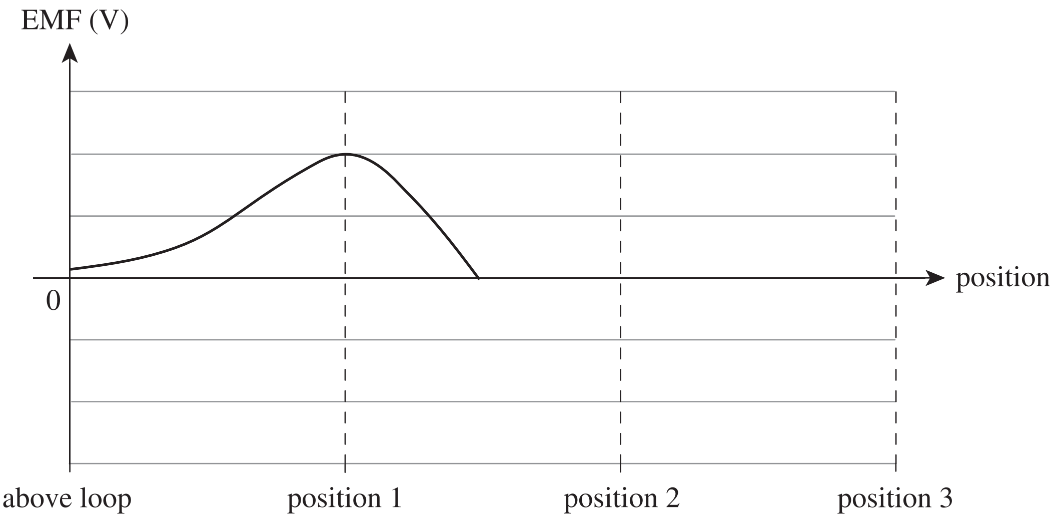
d. Sketch the direction of the current in the loop on Figure 6. 1 mark

e. The incomplete EMF versus position graph below shows the magnet moving from its initial at rest position to the point of entry of the north pole in the plane of the loop. Position 1 represents the north pole of the magnet becoming level with the plane of the loop. Position 2 represents the south pole of the magnet becoming level with the plane of the loop. Position 3 represents the south pole of the magnet falling away from the loop.

Complete the graph by sketching the EMF that is developed at positions 2 and 3. 3 marks



f. Explain **one** modification that could be made to the system to increase the maximum EMF. 2 marks

Question 5 (11 marks)

Figure 7 shows an electricity generating station that generates 400 MW of power at an input of 20.0 kV_{RMS} to the step-up transformer. The electricity flows along the long-distance line to reach the step-down transformer. The step-up transformer operates at a factor of 15 and the step-down transformer operates at a factor of $\frac{1}{15}$.

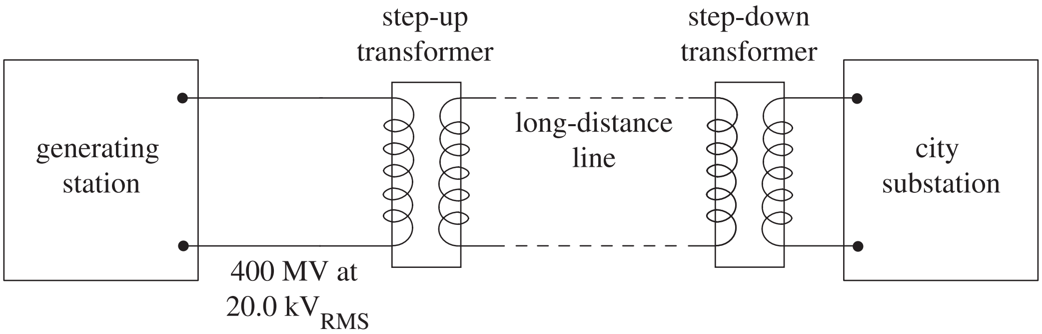


Figure 7

a. Show that the peak current produced by the generating station is 2.83×10^4 A. 3 marks

b. Determine the RMS line current. Show your working. 2 marks

A

Engineers test the power loss in the long-distance line and find it to be 12.8 MW.

c. Determine the resistance of the long-distance line. Show your working. 3 marks

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| Ω |

d. The engineers want to increase the voltage at the city substation, but the long-distance line structure and the outputs from the generating station cannot be altered.

Suggest **one** way that the voltage at the city substation can be increased. Explain the physics of your suggestion. 3 marks

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Question 6 (4 marks)

As part of a class experiment, students set up a netball ring and a tennis ball launcher. The height of the netball ring above the plane of the tennis balls at launch is 3.00 m. The position from which the tennis balls are launched is 6.75 m horizontally from the centre of the netball ring. The tennis balls are launched at an angle of 45.0° above the horizontal. The students' set-up is shown in Figure 8.

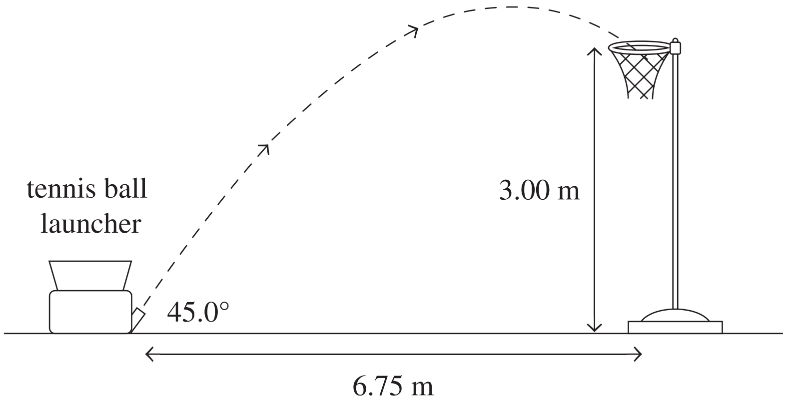

Figure 8

The students launch a tennis ball several times. They vary the launch speed in each trial and find that a launch speed of 10.91 m s^{-1} enables the tennis ball to pass through the netball ring.

a. Determine the time it takes the tennis ball to enter the plane of the netball ring, correct to three significant figures. Show your working. 2 marks

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b. Show that the ball enters the plane of the ring when fired at 10.91 m s^{-1}. 2 marks

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Question 7 (5 marks)

A person on a motorcycle travels around a corner on a horizontal road and leans into the turn to ensure she is stable. Two forces act on the motorcycle system as she turns the corner: the road reaction force and the weight of the motorcycle and rider, as shown in Figure 9.

The angle of lean, θ, is the angle between the axis of the rider's body and the vertical as she makes the turn.

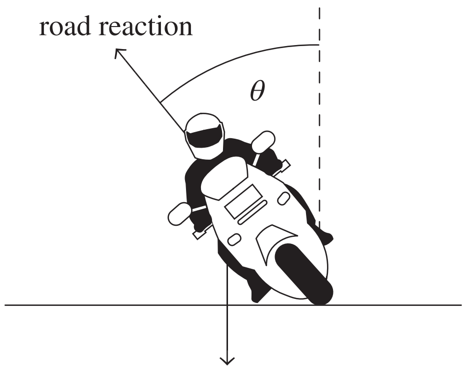

Figure 9

The radius of the turn is 40.0 m and the angle of lean, θ, is 35°.

The combined mass of the rider and motorcycle is 300 kg.

a. Identify and explain the type of force that enables the rider to maintain a stable path for her motorcycle as she takes the turn. 2 marks

b. Can the rider successfully ride around the corner at a speed of 20 m s^{-1}? Provide calculations to support your answer. 3 marks

Question 8 (8 marks)

A car is undertaking a loop-the-loop in a vertical, circular track, as shown in Figure 10.

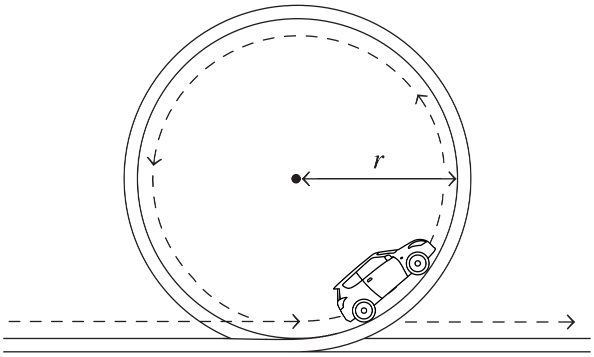

Figure 10

The combined mass of the car and driver is 2000 kg. The radius from the centre of the circle to the centre of mass of the car, *r*, has a value of 10.0 m. The track is deemed to be frictionless and air resistance is negligible.

a. Calculate the speed of the car when it is at the top of the loop such that the driver feels a normal reaction equal to twice their weight. Show your working. 3 marks

m s^{-1}

b. Show that the car's minimum speed at the top of the loop must be 9.9 m s^{-1} in order for the car to remain on the track. 2 marks

c. Determine the minimum speed required when the car enters the loop so that it reaches a speed of 9.9 m s^{-1} at the top of the loop. Assume that the car's engine is not used as it moves around the loop. Show your working. 3 marks

m s^{-1}

Question 9 (7 marks)

Astronauts in two identical spacecrafts, X and Y, want to conduct tests to determine if the considerations of special relativity are correct. They organise for a 1000 m distance to be set up between two markers, A and B, in space. The markers remain at this distance the entire time of the tests. Spacecraft X remains stationary relative to the markers. Spacecraft Y travels at a constant speed of $0.75c$ ($\gamma = 1.51$) relative to the markers. This scenario is shown in Figure 11.

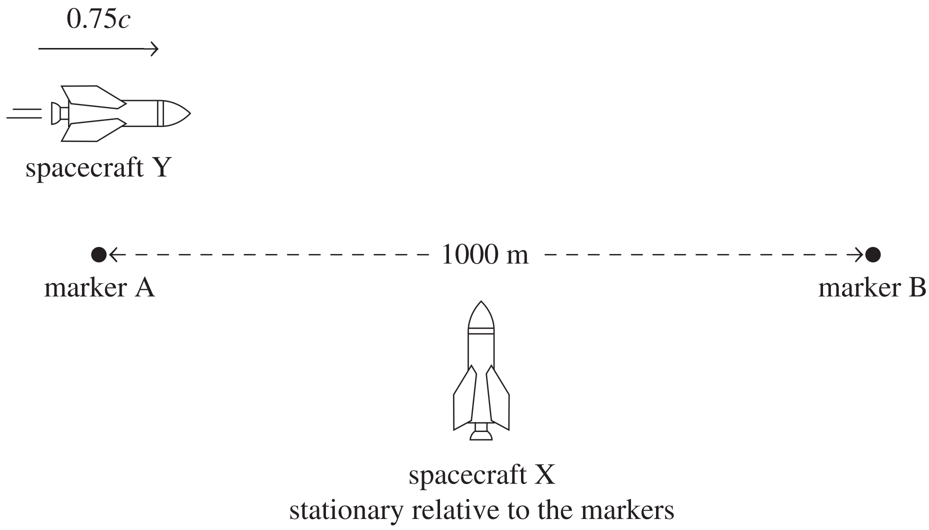

Figure 11

The astronauts in spacecraft Y start their timing device as soon they see themselves go past marker A and stop their timing device as soon as they see themselves go past marker B. Simultaneously, the astronauts in spacecraft X start their timing device as soon as they see spacecraft Y reach marker A and stop their timing device as soon as they see spacecraft Y reach marker B.

a. Determine the distance between markers A and B according to the astronauts of spacecraft Y. Show your working. 2 marks

m

b. The astronauts of spacecraft X measure the time taken for spacecraft Y to travel the distance between the two markers as 4.444 μs.

Determine the time taken for this movement as measured by spacecraft Y, correct to three significant figures. Show your working. 2 marks

μs

c. The two sets of astronauts are discussing the different measurements found in **part a.** and **part b.** Both sets of astronauts believe that their measurements are correct and the measurements of the astronauts in the other spacecraft are incorrect.

Explain which astronauts have the correct set of measurements. In your response, refer to the principles of relativity. 3 marks

Question 10 (9 marks)

A system of internet satellites orbits Earth at approximately 540 km above Earth's surface.

a. Calculate the gravitational field of Earth at the position of the satellites. 3 marks

$\boxed{\qquad\qquad\qquad \text{N kg}^{-1}}$

b. Calculate the period of the orbit of the satellites. Show your working. 3 marks

$\boxed{\qquad\qquad\qquad \text{s}}$

c. Two students, Jen and Bilal, are discussing the placement of new satellites in the same orbit.

Jen claims that it would be more useful if a satellite could travel faster in the same orbit so that it could connect more places on Earth with Wi-Fi.

Bilal thinks that Jen's claim would be correct only if the new satellite has a lower mass, enabling it to travel faster while keeping the same kinetic energy and momentum as the existing satellites.

Evaluate the students' claims using physics principles. 3 marks

Question 11 (5 marks)

A truck of mass 5000 kg travels at 5.0 m s^{-1} to the right. A small car of mass 800 kg travels at 2.0 m s^{-1} to the right. The truck approaches and collides with the car. The truck slows to a speed of 4.2 m s^{-1} to the right. This scenario is shown in Figure 12.

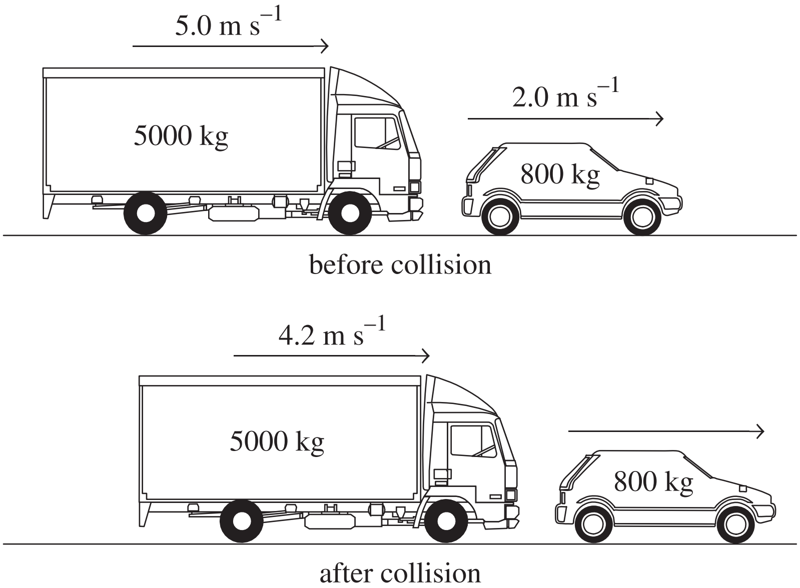

Figure 12

a. Show that the speed of the car immediately after the collision is 7.0 m s^{-1}. 2 marks

b. Determine whether the collision was elastic or inelastic. Support your answer with calculations. 3 marks

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2023

VCE Physics Unit 3

Written Examination

Multiple-choice Answer Sheet

Student's Name: ______________________________

Teacher's Name: ______________________________

Instructions

Use a **pencil** for **all** entries. If you make a mistake, **erase** the incorrect answer – **do not** cross it out.
Marks will **not** be deducted for incorrect answers.
No mark will be given if more than **one** answer is completed for any question.

All answers must be completed like this example: A B C D

Use pencil only

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D

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Trial Examination 2023

VCE Physics Unit 3

Written Examination

Formula Sheet

Instructions

This formula sheet is provided for your reference. A question and answer booklet is provided with this formula sheet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

PHYSICS FORMULAS

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t}; \quad a = \frac{\Delta v}{\Delta t}$
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	$t = t_o\gamma$
length contraction	$L = \frac{L_o}{\gamma}$
rest energy	$E_{rest} = mc^2$

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformations 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 carrying conductor	$F = nIlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

Generation and transmission of electricity

voltage; power	$V = RI$; $P = VI = I^2R$
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	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak}$ $I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
electromagnetic induction	EMF: $\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$ flux: $\Phi_B = B_{\perp}A$
transmission losses	$V_{drop} = I_{line}R_{line}$ $P_{loss} = I^2_{line}R_{line}$

Data

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

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