Neap

Trial Examination 2022

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 28 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 2022 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.

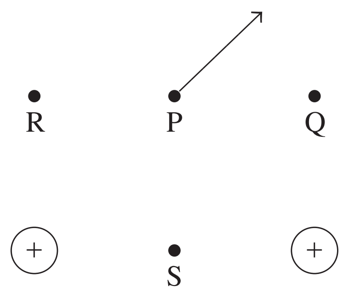
No marks will be given if more than one answer is completed for any question.

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}.

Question 1

The diagram below shows two positive point charges of equal magnitude. Points R and Q and the two positive point charges are placed at the vertices of a square, as shown in the diagram below. Point S is equidistant between the two point charges and point P is equidistant between points R and Q. The vector at point P indicates the direction of the net electric field when a third point charge of equal magnitude is placed at point Q, R or S.

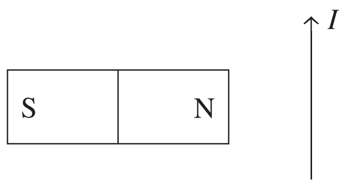


Which one of the following correctly identifies the location and charge of the third point charge?

	Location	Charge
A.	Q	negative
B.	R	negative
C.	S	negative
D.	Q	positive

Question 2

A permanent magnet is brought near a 10 cm long wire that has a current of 2 A flowing through it, as shown in the diagram below. The magnet generates a magnetic field of strength 0.01 T.



What is the magnitude and direction of the force on the wire?

A. 0.002 N into the page

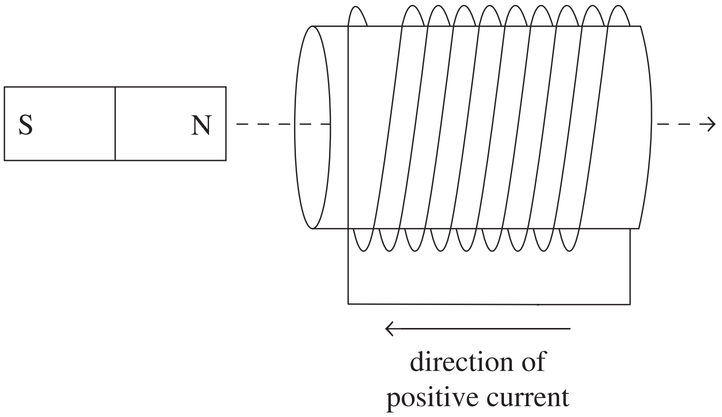
B. 0.002 N out of the page

C. 0.002 N left

D. 0 N, no direction

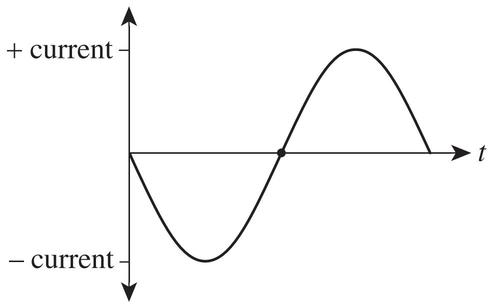
Question 3

The following diagram shows a bar magnet moving at a constant speed towards a hollow, metal tube. The metal tube has a uniformly wound copper wire coil wrapped around it, which forms a closed circuit.
The magnet passes through the metal tube and out the other side. Assume that a positive current travels from right to left on the straight section of the wire, as indicated on the diagram below.

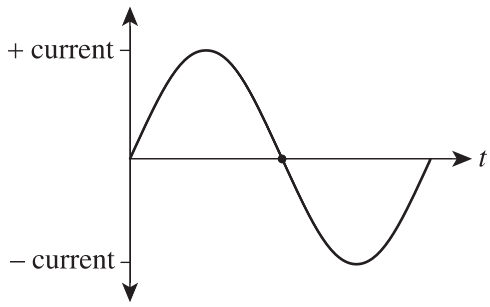


Which one of the following graphs best represents the induced current variation in the coil over time?

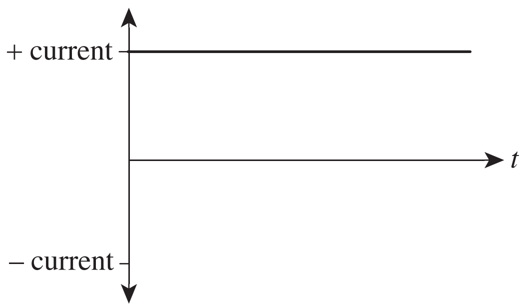
A.



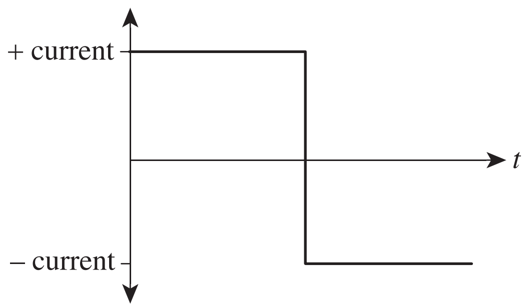
B.



C.

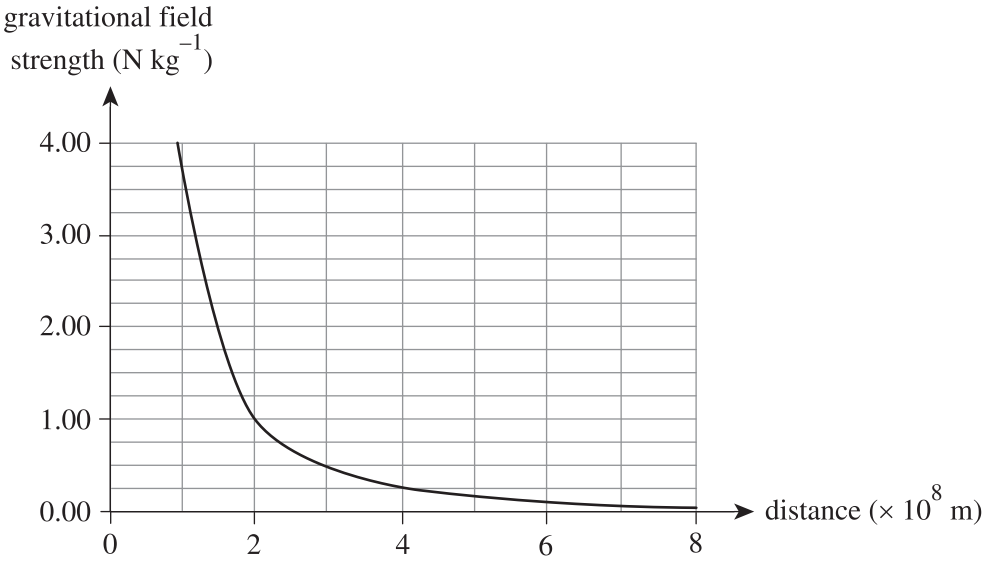


D.



Use the following information to answer Questions 4 and 5.

A space probe that is orbiting a planet periodically needs its orbit adjusted. Assume that there are two possible adjustments that could be made to the space probe's orbital radius. Adjustment A alters the orbital radius of the space probe from 2×10^8 m to 3×10^8 m. Adjustment B alters the orbital radius of the space probe from 2×10^8 m to 4×10^8 m. The graph below shows the gravitational field strength as a function of distance from the centre of the planet.



Question 4

The difference in energy due to adjustment A is closest to

A. 3.75×10^{-4} kJ

B. 3.75×10^{4} kJ

C. 7.50×10^{4} kJ

D. 1.00×10^{5} kJ

Question 5

Which one of the following statements correctly compares adjustments A and B?

A. The speed of the space probe after adjustment A is greater than the speed of the space probe after adjustment B.

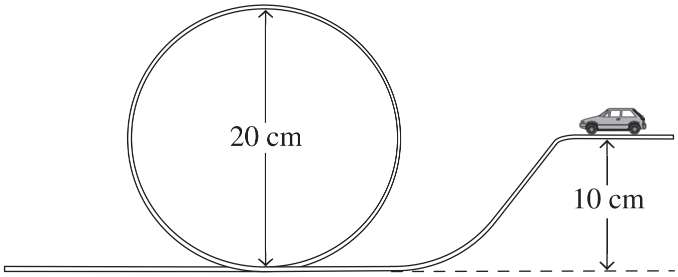
B. The difference in energy due to adjustment A is the same as the difference in energy due to adjustment B.

C. The gravitational field strength after adjustment A is the same as the gravitational field strength after adjustment B.

D. The centripetal acceleration of the space probe after adjustment A is less than the centripetal acceleration of the space probe after adjustment B.

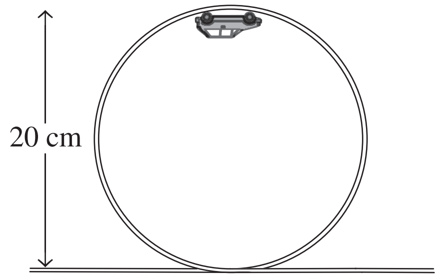
Use the following information to answer Questions 6 and 7.

A toy car of mass 50 g is launched down a track from a height of 10 cm. The track contains a loop of height 20 cm, as shown in the diagram below.



Question 6

The following diagram shows the position of the toy car while performing the loop.



At the position shown in the diagram above, the toy car experiences apparent weightlessness because

A. the magnitude of the net force acting on the car is zero.

B. the direction of the net force acting on the car is to the left.

C. the magnitude of the normal force acting on the car is zero.

D. the direction of the net force acting on the car is down.

Question 7

The minimum initial speed required for the toy car to remain on the track at the top of the loop is closest to

A. 0.99 m s^{-1}

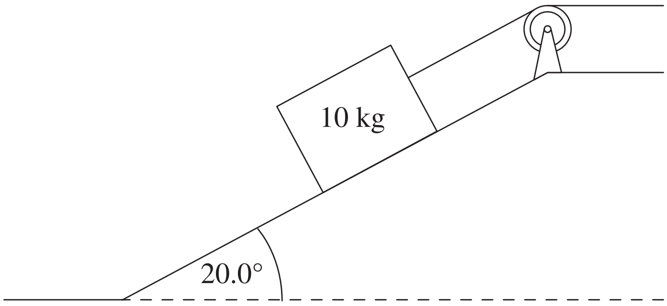
B. 1.71 m s^{-1}

C. 1.94 m s^{-1}

D. 2.94 m s^{-1}

Question 8

A block of mass 10 kg is pulled at a constant speed up an inclined plane by a rope attached to a pulley, as shown in the diagram below. There is a constant frictional force of 5.0 N applied when the block is being pulled.



The magnitude of the tension in the rope is closest to

A. 30.7 N

B. 38.5 N

C. 40.7 N

D. 98.0 N

Question 9

It has been estimated that the Sun loses a mass of approximately 4×10^{12} g every second due to nuclear fusion.

The amount of energy that the Sun emits per day is closest to

A. 3.60×10^{26} J

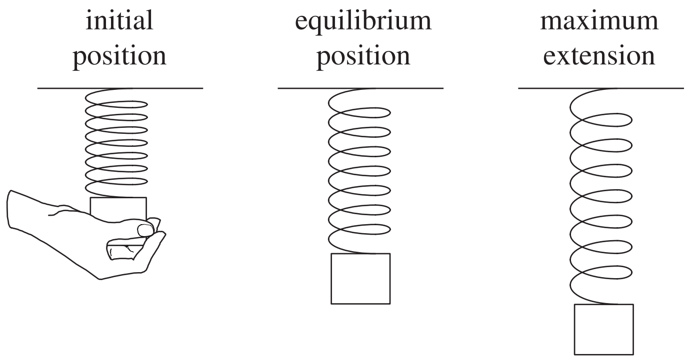
B. 2.16×10^{28} J

C. 1.30×10^{30} J

D. 3.11×10^{31} J

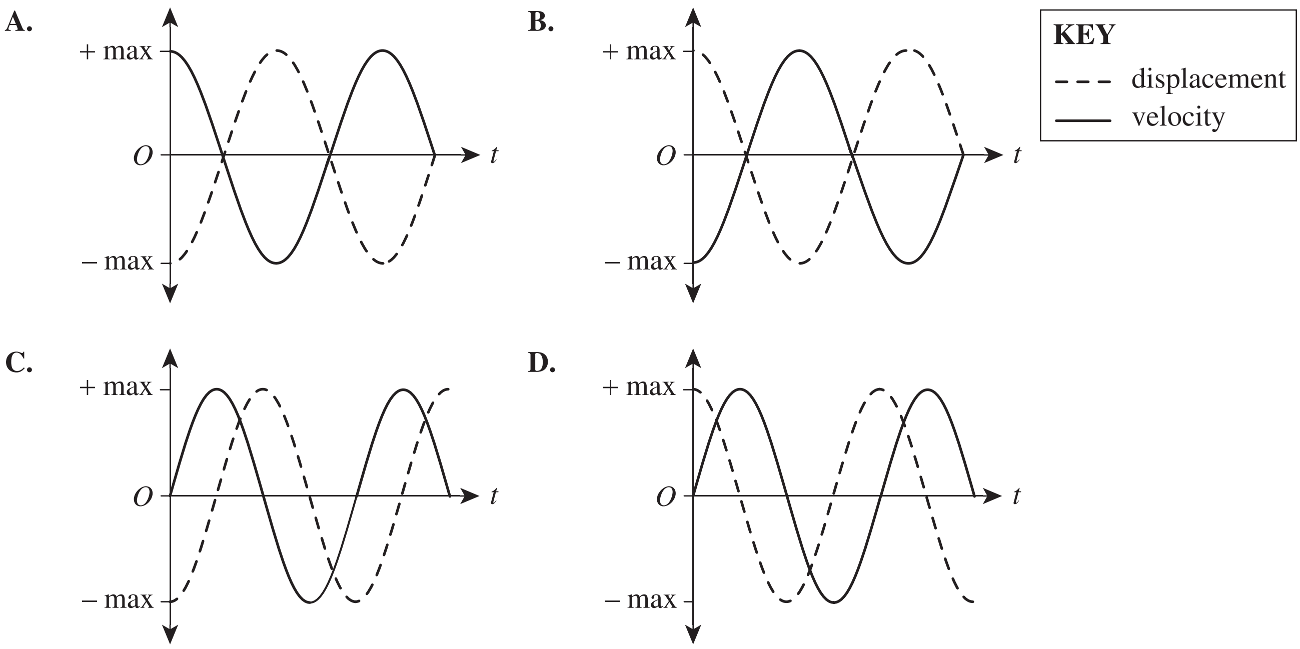
Question 10

A mass is connected to a spring attached to the ceiling and is held stationary by a hand such that the spring is unextended. When the mass is released, it oscillates about its equilibrium position, as shown in the diagram below.



Displacement is measured from the equilibrium position. Take down as the positive direction.

Which one of the following graphs best represents the velocity and displacement of the mass over time, starting at its initial position?



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)

Two devices are constructed. In each device, a coil of wire is placed around an iron rod and the coil is connected to a DC battery. The devices are arranged as shown in Figure 1.

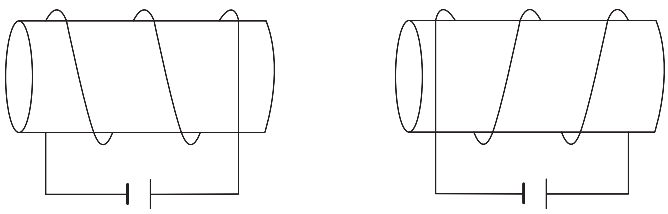


Figure 1

Sketch the shape and direction of **at least four** magnetic field lines in the region around the devices shown in Figure 1. Include labels for north and south where appropriate.

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Question 2 (8 marks)

A mass spectrometer is an instrument used to measure the mass of particles in a sample. Samples are subjected to an electron beam to create positively charged particles. These particles are accelerated through a velocity selector consisting of two charged plates perpendicular to a magnetic field that enables particles of a particular velocity to pass through. They then pass through a magnetic field generated by an electromagnet. The particles are deflected by the field and eventually reach a detector. The set-up of a mass spectrometer is shown in Figure 2.

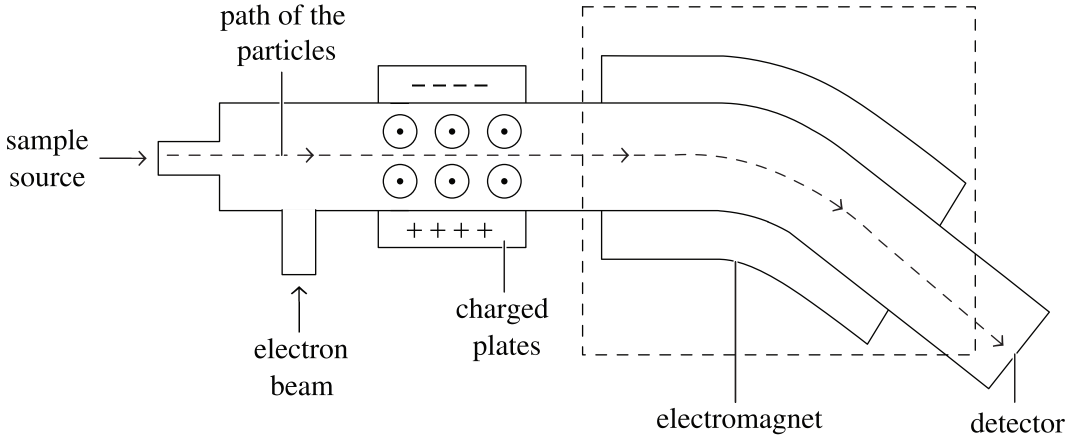

Figure 2

The mass spectrometer has the following specifications.

Data

plate voltage	2.7 kV
magnetic field strength	0.25 T
plate separation	15 cm

Assume that the particles gain a single positive charge and the magnetic field strength is the same throughout all sections of the mass spectrometer.

a. Within the dashed border in Figure 2, draw the magnetic field that would deflect the particles along the path shown by the dashed arrows. 1 mark

b. Calculate the magnitude of the velocity of the particles when they are accelerated by the charged plates. Show your working. 3 marks

____

____

____

____

____

____

m s^{-1}

c. The radius of the path of one particle was measured to be 44.82 m.

i. Determine the mass of the particle. Show your working. 2 marks

kg

ii. Circle the correct word to complete the following statement. 1 mark

A heavier particle would have a *(smaller / equal / larger)* radius than a smaller particle.

iii. How can a mass spectrometer be used to determine the mass of different particles in a single sample? 1 mark

Question 3 (11 marks)

On 23 April 2021, SpaceX launched a Falcon 9 rocket. The rocket carried a crew of four astronauts inside a Dragon capsule that was designed to dock with the International Space Station (ISS). The ISS orbits the Earth at an average altitude of 4.00×10^2 km. You may use data from the table below in your calculations.

Data

mass of the ISS	4.2×10^5 kg
mass of the Dragon capsule	4.2×10^3 kg
mass of the Earth	5.98×10^{24} kg
radius of the Earth	6.37×10^6 m
gravitational constant	6.67×10^{-11} N m^2 kg^{-2}

a. Calculate the orbital speed needed to achieve an orbital radius that would allow the Dragon capsule to dock with the ISS. Show your working. 3 marks

km s^{-1}

b. The Dragon capsule docks with the ISS. They remain at the same position that the ISS occupied prior to the docking.

i. Explain why the velocity of the combined mass of the ISS and the Dragon capsule did not change after the docking occurred. 2 marks

ii. Determine whether the collision is elastic or inelastic. Show your working. 3 marks

c. Calculate the orbital period of the ISS when its orbital radius is 400 km. Show your working. 3 marks

min

Question 4 (12 marks)

Figure 3 shows a power station that generates power using steam turbine generators and is connected to a transformer and transmission lines. It is located 145 km from Melbourne CBD. The electricity generated must be transported across this distance via 275 kV RMS transmission lines. However, due to resistance in the lines, power loss occurs during the transport.

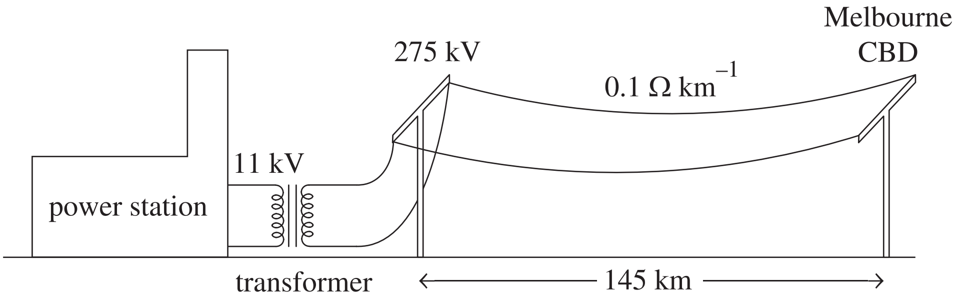

Figure 3

The steam turbine generators generate a voltage of 11 kV RMS, which is stepped up to 275 kV via a transformer. The resistance of the power lines is $0.1\ \Omega\ km^{-1}$.

a. Typically, the 275 kV transmission lines carry a current of 700 A.

i. What is the current in the primary windings of the transformer? Show your working. 2 marks

A

ii. Calculate how much power is lost in the transmission lines. Show your working. 2 marks

W

iii. What percentage of the power generated by the station is lost in the transmission lines? Show your working. 3 marks

%

iv. Suggest one reason why voltages higher than 275 kV are not used. 1 mark

b. The transformer has 500 turns in the primary coil.

What is the number of turns in the secondary coil? Show your working. 2 marks

turns

c. After the power is transmitted to substations, the voltage is stepped down to 11 kV. Distribution lines carry electricity from substations to houses and businesses, as shown in Figure 4. These wires typically carry electricity at 475 V.

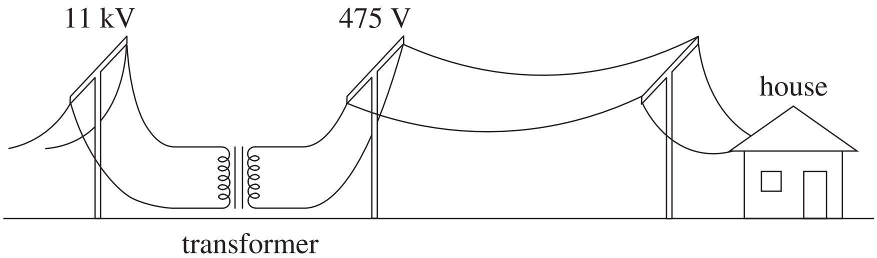

Figure 4

Determine the peak voltage in the secondary windings of the transformer in Figure 4. Show your working. 2 marks

kV

Question 5 (10 marks)

A single metal wire is shaped into a square coil with a side length of 10 cm and placed in a magnetic field with a strength of 0.50 T, as shown in Figure 5.

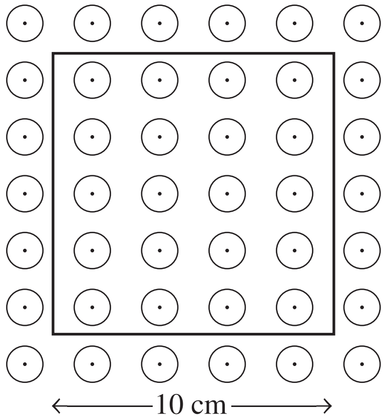

Figure 5

a. Calculate the magnetic flux through the square coil. 1 mark

____

____

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| Wb |

b. The coil is rotated to a different position, as shown in Figure 6.

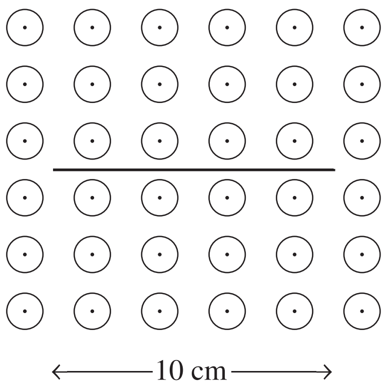

Figure 6

i. Determine if the magnetic flux is greater than, equal to or less than the initial magnetic flux present in Figure 5. Circle your response below and explain your answer. 2 marks

less than initial magnetic flux   equal to initial magnetic flux   greater than initial magnetic flux

____

____

ii. The coil takes 5.0 seconds to rotate from the position shown in Figure 5 to the position shown in Figure 6.

What is the induced EMF in the coil as it rotates? Show your working. 2 marks

V

c. Figure 7 shows the induced EMF in the coil as the coil rotates 360 degrees over 10 seconds.

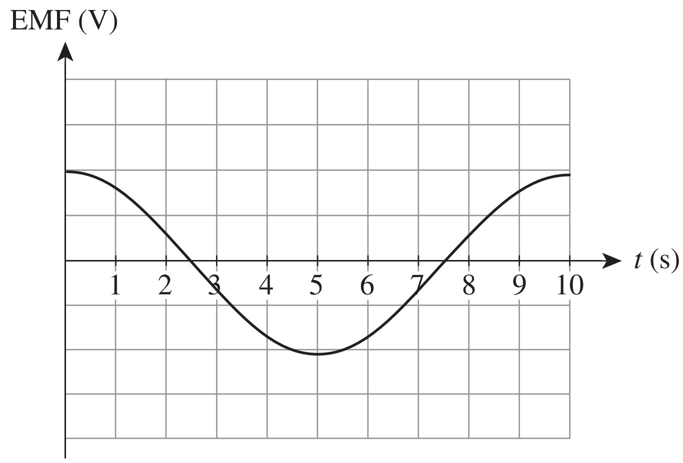

Figure 7

Did the plane of the coil start perpendicular or parallel to the magnetic field? Justify your answer. 1 mark

d. On Figure 7, sketch a graph of the induced EMF between 0 and 10 seconds if the speed of the coil's rotation is doubled. 2 marks

e. Explain your answer to **part d.** 2 marks

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Question 6 (6 marks)

A universal motor is a type of motor that can be operated using both direct current (DC) and alternating current (AC) power supplies. Figure 8 shows the side and top view of a universal motor.

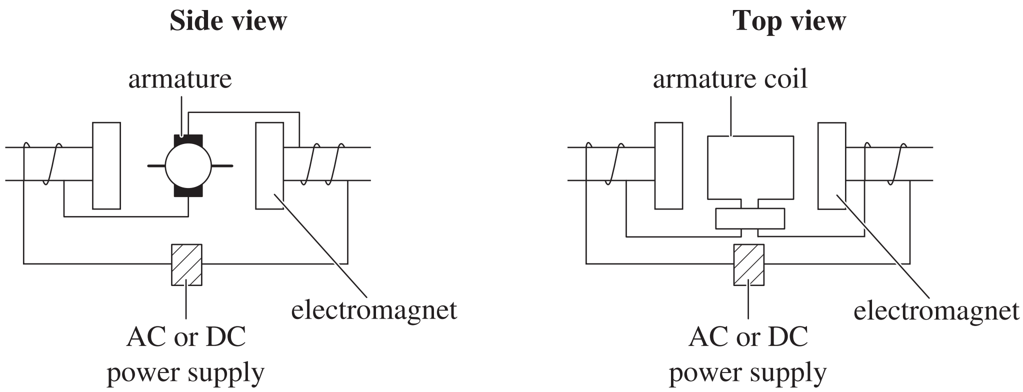


Figure 8

a. A split-ring commutator is vital when operating the universal motor in DC mode.

Explain the role of the split-ring commutator in the operation of a DC motor. 2 marks

b. The electromagnet on either side of the armature coils generates a magnetic field that changes direction when operating the universal motor in AC mode.

Explain why this needs to occur for the motor to operate. 2 marks

c. The top view diagram of the electromagnet is reproduced in Figure 9. In AC mode, the armature coil and the electromagnet coils are connected in series.

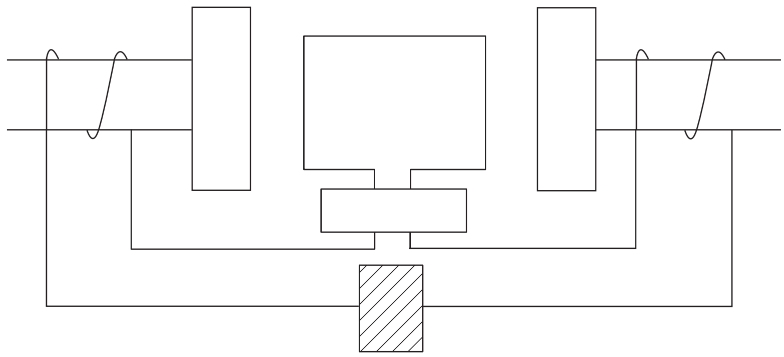


Figure 9

On Figure 9, indicate the direction of the current through the armature coil and electromagnet coils that will allow the coil to rotate clockwise from the position shown in the side view of Figure 8. 2 marks

Question 7 (8 marks)

A student has set up a 15 cm long spring-loaded cannon to shoot a 10 g marble. The cannon is positioned at an angle of 40°, and the 15 cm long spring is initially compressed to 10 cm, as shown in Figure 10. When the spring is released, the spring fully extends and a pin connected to the spring strikes the marble.

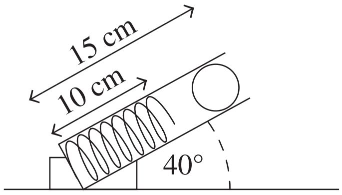


Figure 10

Figure 11 shows the force versus distance graph for the spring.

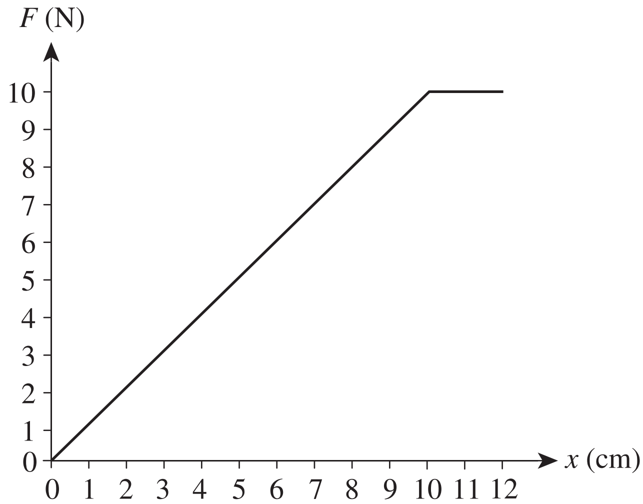


Figure 11

a. Calculate the spring constant. 1 mark

N m^{-1}

b. The spring is compressed by 5 cm and then released.

Calculate the initial speed of the marble as it leaves the cannon when the spring is released. Show your working. 2 marks

m s^{-1}

c. What is the maximum height above the ground reached by the marble? Show your working. 2 marks

m

d. A target is placed at the same height as the cannon. The target is placed at the maximum horizontal distance from the cannon so that the marble strikes the centre of the target, as shown in Figure 12.

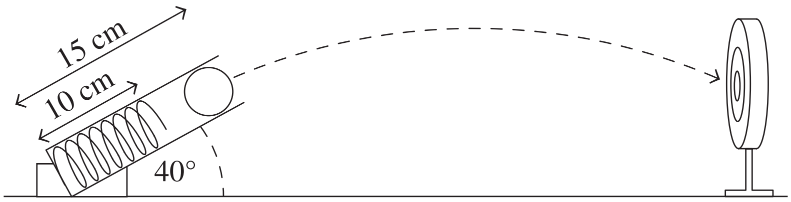
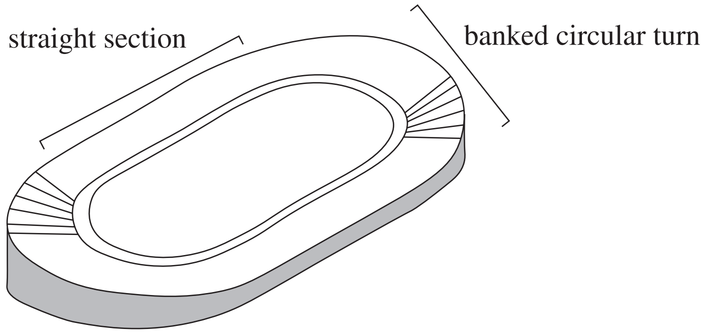


Figure 12

Show that the maximum horizontal distance the marble is capable of reaching is 10.05 m. 3 marks

Question 8 (5 marks)

A velodrome track consists of two straight sections and two banked circular turns, as shown in Figure 13. The circular turns are banked at an angle, θ. The banking helps to ensure that cyclists do not come off the track when cycling at speeds of up to 70 km h^{-1}.



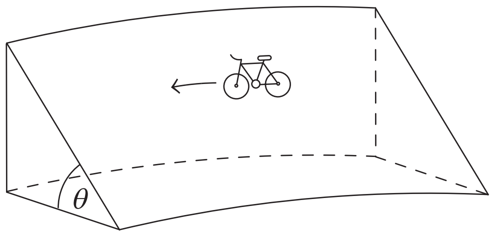


Figure 13

a. Figure 14 shows a cross-section of the track with the cyclist facing the front. Assume that the cyclist is travelling at a constant speed and that any sideways friction does not act on the bicycle's wheels.

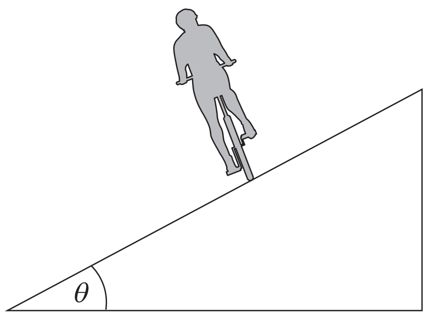


Figure 14

On Figure 14, draw and label **two** forces acting on the cyclist. 1 mark

b. A cyclist is racing at a speed of 70 km h^{-1} at a radius of 10 m on the curved section. The combined mass of the cyclist and the bicyle is 60 kg. The banking angle of the circular turns is 45°.

i. Show that this banking angle is **not** sufficient on its own to prevent the cyclist from coming off the track. Show your working. 3 marks

ii. Suggest **one** way that the cyclist could prevent themselves coming off the curved section of the track at this speed. 1 mark

Question 9 (8 marks)

A train weighing 3.2×10^5 kg is travelling along a frictionless railway track, as shown in Figure 15.
The train is pulling two identical carriages, A and B, each of which weighs 3.0×10^5 kg.

Figure 15

Between times $t = 0$ and $t = 5.0$, the train and carriages are moving at a constant speed of 5.0 m s^{-1}.

a. What is the tension in the coupling between the train and carriage A during this time? Give your reasoning. 2 marks

N

At time $t = 5$, the train accelerates uniformly to a speed of 25.0 m s^{-1} over 10 seconds, then moves at a constant speed.

b. What is the tension in the coupling between carriage A and carriage B as the train is accelerating? Show your working. 2 marks

N

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Figure 16 shows the velocity versus time graph for the train.

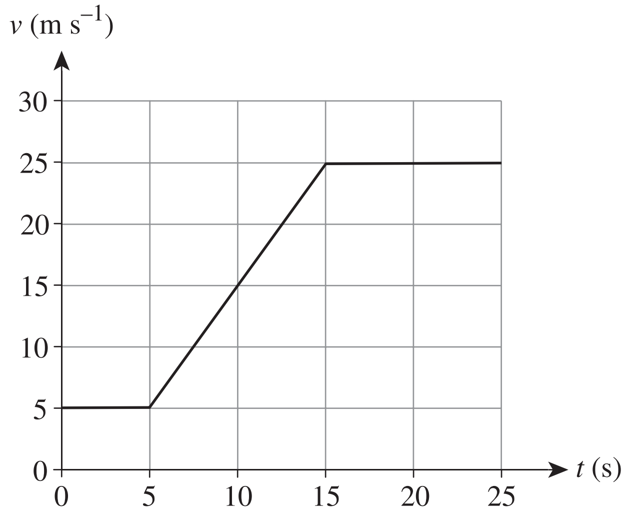

Figure 16

c. Using the graph, or otherwise, calculate the displacement of the train and the carriages from $t = 0$ to $t = 15$. Show your working. 2 marks

m

d. Four students are asked to draw a graph that represents the acceleration of the train over time. The students draw the four graphs shown in Figure 17.

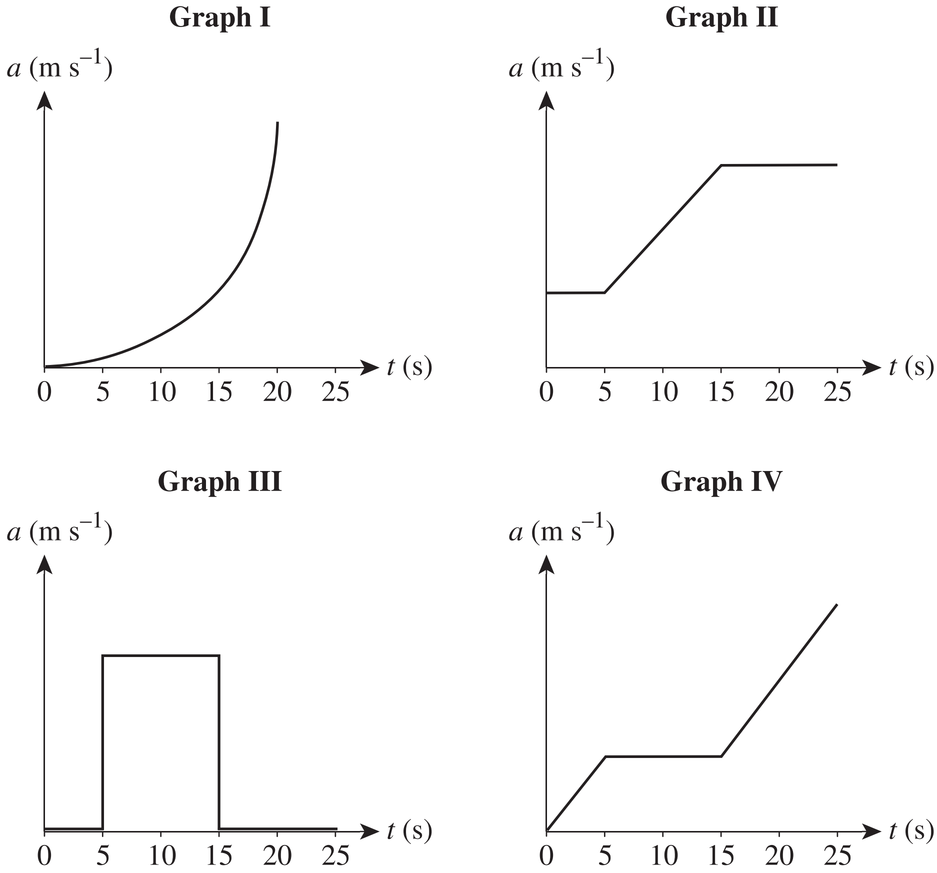

Figure 17

Which graph (I–IV) is correct? Explain your answer. 2 marks

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Question 10 (6 marks)

A child who has a mass of 35 kg is bouncing up and down on a pogo stick, as shown in Figure 18. The pogo stick has a mass of 5 kg. Assume that any resistance and any friction forces are negligible.

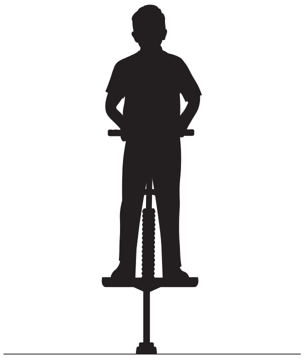

Figure 18

a. The child and pogo stick travel through a maximum vertical height of 0.46 m.

What is the initial velocity of the child and pogo stick? Show your working. 2 marks

m

b. When the child and pogo stick return to the ground, the spring takes 25 ms to compress.

i. Calculate the magnitude and indicate the direction (up or down) of the change in momentum when the child and pogo stick return to rest on the ground. 2 marks

kg m s^{-1}	direction =

ii. What is the magnitude of the average force applied to the Earth by the child and pogo stick? 2 marks

N

Question 11 (4 marks)

Two scientists decide to conduct an experiment to investigate special relativity. Scientist A boards a spaceship of length 100 m and travels away from the Earth at near the speed of light, c. Scientist B remains on Earth.

a. At a specific instant while the spaceship is moving, scientist B records the spaceship's length as 50.0 m.

Show that the speed of the spaceship at this instant is $0.866c$ m s^{-1}. 2 marks

b. As measured by scientist B, the spaceship travels 4.37 light years to one of the closest star systems to Earth, Alpha Centauri. Assume that the spaceship maintains a constant speed of $0.866c$ m s^{-1} throughout its trip.

From the frame of reference of scientist A, how long did it take the spaceship to make the trip from Earth to Alpha Centauri and back again? Show your working. 2 marks

years

END OF QUESTION AND ANSWER BOOKLET

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Trial Examination 2022

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	$g = 9.8$ 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 $h = 4.14 \times 10^{-15}$ eV s
speed of light in a vacuum	$c = 3.0 \times 10^{8}$ m s^{-1}
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
radius of Earth	$R_E = 6.37 \times 10^{6}$ m

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

Neap

Trial Examination 2022

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