Sydney Boys High School

# Year 12 Physics Half Yearly Cohort Task 2022

# Multiple Choice Answer Sheet

Please complete the answer sheet AND your Student ID below using a 2B pencil or mechanical pacer.
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.
If you change your mind, use a clean eraser to make corrections.
Do **not** make any other markings on this page

Student ID

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | B | C | D | | 18 | A | B | C | D |
| 2 | A | B | C | D | | 19 | A | B | C | D |
| 3 | A | B | C | D | | 20 | 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 | | | | | | |
| 11 | A | B | C | D | | | | | | |
| 12 | A | B | C | D | | | | | | |
| 13 | A | B | C | D | | | | | | |
| 14 | A | B | C | D | | | | | | |
| 15 | A | B | C | D | | | | | | |
| 16 | A | B | C | D | | | | | | |
| 17 | A | B | C | D | | | | | | |

Student ID

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| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

Sydney Boys High School

Student Number:

# Physics

March 2022
Half Yearly Cohort Task
Advanced Mechanics, Electromagnetics, Special Relativity

**General Instructions**

- Reading time: 5 minutes
- Working time: 90 minutes
- Write using black or blue pen
- Draw diagrams using pencil
- SHOW ALL WORKING
- Board approved calculators may be used
- A data sheet, formula sheets and Periodic Table are provided at the back of this paper
- Write your student number in ALL of the boxes provided

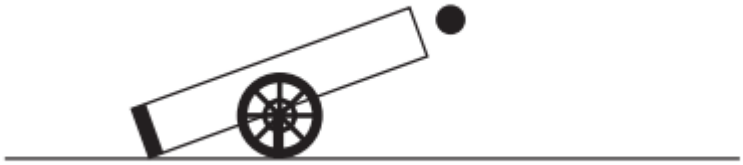
**Total marks – 60**

Part A – Multiple Choice
- 20 marks

Part B – Free Response
- 40 marks

**PART A – Multiple Choice (20 Marks)**

**1.** A projectile is launched by a cannon as shown.



Which arrow represents the velocity of the projectile at its maximum height?

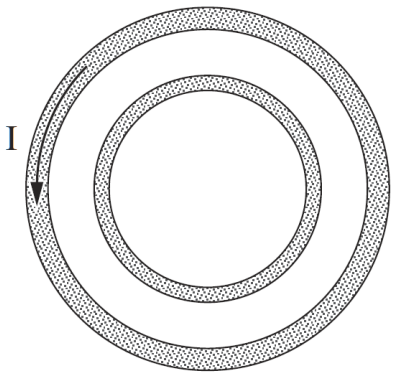
(A) ↑

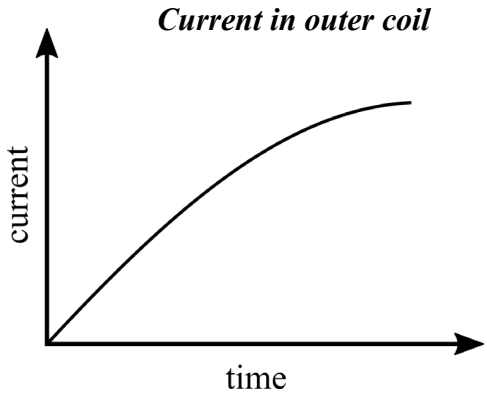
(B) ↓

(C) →

(D) ↘

**2.** Two copper rings lie in the same plane as shown.




A changing current, which follows the graph above, flows anticlockwise around the outer ring. What happens in the inner ring?

(A) A decreasing clockwise current flows in the inner ring.

(B) A decreasing anticlockwise current flows in the inner ring.

(C) An increasing clockwise current flows in the inner ring.

(D) An increasing anticlockwise current flows in the inner ring.

**3.** The table shows the value of the acceleration due to gravity on the surface of Earth and on the surface of Mercury.

| | *Acceleration due to gravity ($ms^{-2}$)* |
|---|---|
| Earth | 9.8 |
| Mercury | 3.7 |

A person has a weight of 550 N on the surface of Mercury.

What would be the person's weight on the surface of Earth?

(A) 56.1 N

(B) 208 N

(C) 550 N

(D) 1457 N

**4.** The rest length of a train is 200 m and the rest length of a railway platform is 160 m. The train rushes past the platform so fast that, when observed in the platform's frame of reference, the train and the platform are the same length.

How fast is the train moving?

(A) 0.60c

(B) 0.75c

(C) 0.80c

(D) 1.25c

**5.** A student throws a ball that follows a parabolic trajectory. What change to the initial velocity would make the ball's time of flight shorter?

(A) Increasing only the vertical component

(B) Decreasing only the vertical component

(C) Increasing only the horizontal component

(D) Decreasing only the horizontal component

**6.** A satellite is moved from a geostationary orbit to a higher orbit. Which statement about the orbit change is correct?

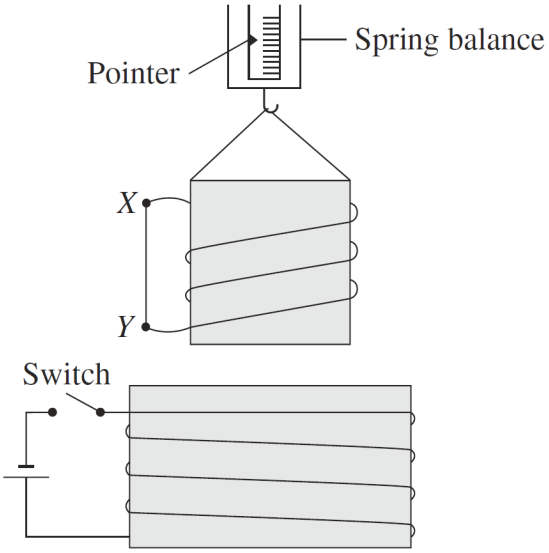
(A) During the move the gravitational potential energy decreases.

(B) The change in gravitational potential energy is independent of the mass of the satellite.

(C) The work done is the difference between the gravitational potential energy of the higher orbit and that of the geostationary orbit.

(D) The work done is the energy required to move the satellite, which is in the gravitational field, from a very large distance away, to the higher orbit.

**7.** An experiment is set up as shown.




When the switch is closed, the reading on the spring balance changes immediately, then returns to the initial reading.

Which row of the table correctly shows the direction of the current through the straight conductor XY and the direction in which the pointer relative to the spring balance initially moves?

| | *Direction of current through the straight conductor* | *Direction in which the pointer initially moves* |
|---|---|---|
| A. | From *X* to *Y* | Down |
| B. | From *X* to *Y* | Up |
| C. | From *Y* to *X* | Down |
| D. | From *Y* to *X* | Up |

**8.** A spaceship moves close to the speed of light, relative to a planet.

The rest-frame length of the spaceship can be determined by an observer who is

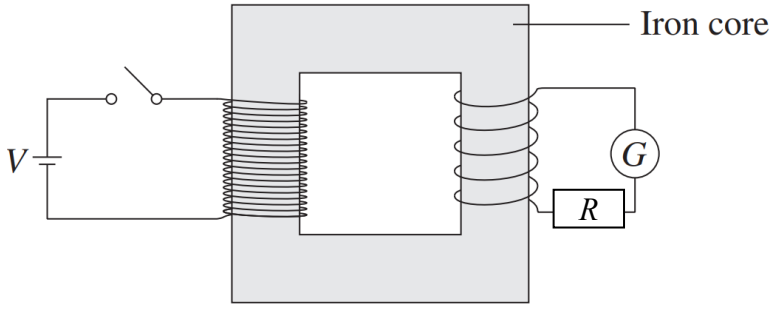
(A) on the spaceship measuring the time taken for light to travel between two points on the planet.

(B) on the planet measuring the time taken for light to travel from the front to the back of the spaceship.

(C) on the spaceship measuring the time taken for light to travel from the front to the back of the spaceship.

(D) on the planet measuring the difference in the arrival time of light from the front and the back of the spaceship.

**9.** The diagram shows an ideal transformer.




When the switch is closed, the pointer on the galvanometer deflects.

With consideration to Ohm's Law, how could the size of the deflection be increased?

(A) Decrease the number of primary coils

(B) Decrease the number of secondary coils

(C) Increase the number of both coils

(D) Increase the value of the resistor

*Use the data below to answer the next two questions.*

| | |
|---|---|
| Orbital period of the Moon around Earth | $2.36 \times 10^6$ s |
| Mean orbital radius of the Moon | $3.83 \times 10^8$ m |
| Mass of Earth | $6.00 \times 10^{24}$ kg |
| Mass of the Moon | $7.35 \times 10^{22}$ kg |

**10.** What is the orbital period of an Earth satellite having an orbital radius double that of the Moon?

(A) $5.9 \times 10^5$ s

(B) $8.3 \times 10^5$ s

(C) $1.2 \times 10^6$ s

(D) $6.7 \times 10^6$ s

**11.** What is the gravitational force experienced by the Moon due to Earth's influence?

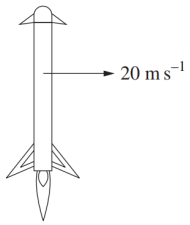
(A) $2.0 \times 10^{20}$ N

(B) $1.6 \times 10^{22}$ N

(C) $4.7 \times 10^{26}$ N

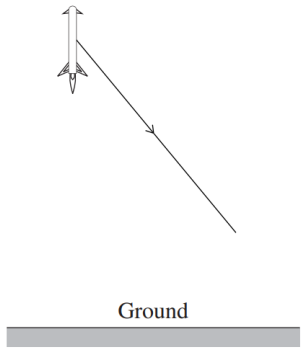
(D) $7.6 \times 10^{28}$ N

**12.** A rocket returns to Earth for reuse after launching satellites, using its engines to make a controlled landing. The rocket having a mass of 9800 kg is on approach to the ground, travelling horizontally at 20 $ms^{-1}$ as shown in the diagram, when the engine thrust is changed to 90 000 newtons.

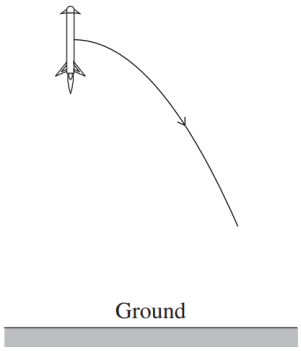



Which diagram shows the trajectory of the rocket following this change of thrust?

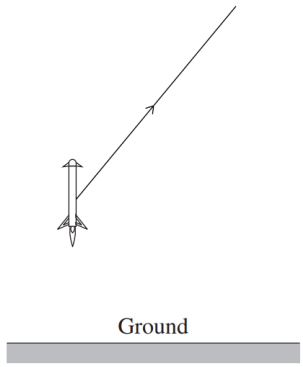
A.



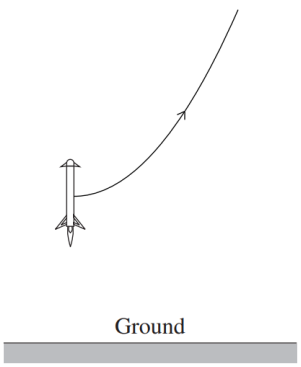

B.




C.




D.




**13.** An ideal electric motor connected to a DC voltage source rotates at a constant rate of 200 revolutions per minute. There is no load on the motor.
Which of the following is a correct statement about the operation of the motor?

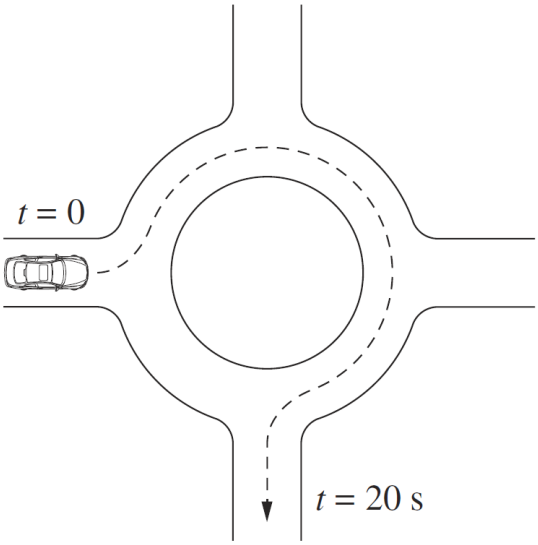
(A) The torque of the motor is directly related to the back emf of the motor

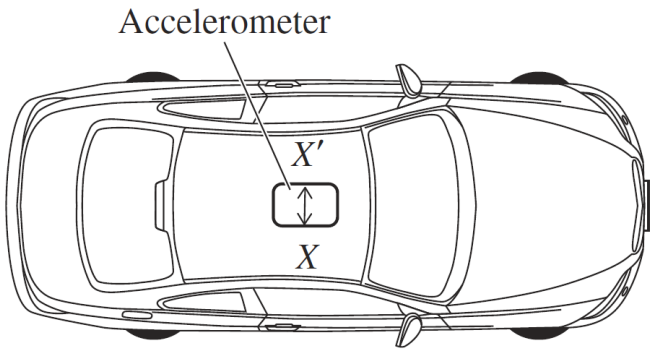
(B) There is no back emf because it is only produced in AC motors due to the changing flux.

(C) The back emf is equal to the applied voltage because no work is being done by the motor.

(D) The back emf must exceed the applied voltage to prevent the motor's speed from increasing.

**14.** A car travelling at a constant speed follows the path shown.

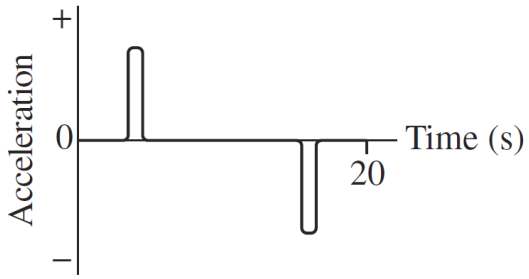


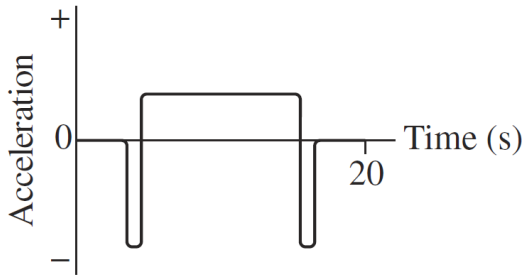

An accelerometer that measures acceleration along the $X$–$X'$ direction is fixed in the car.

Which graph shows the measurements recorded by the accelerometer over the 20-second interval?

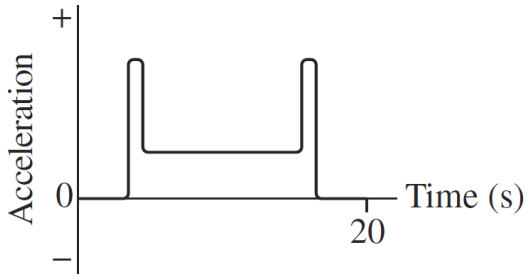
A.



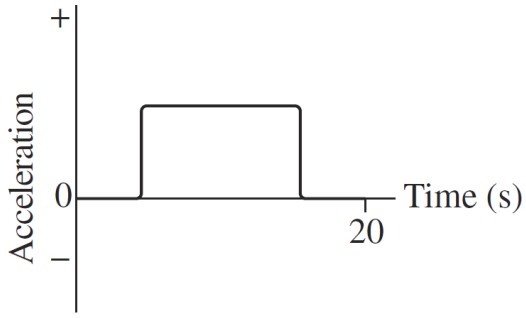

B.



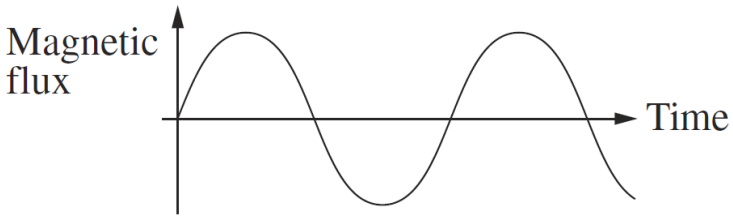

C.



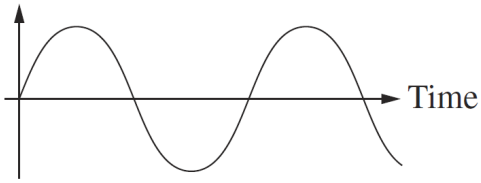

D.

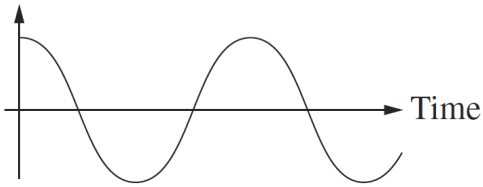


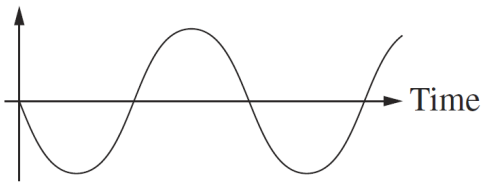
**15.** The graph shows variation in magnetic flux through a coil with time.

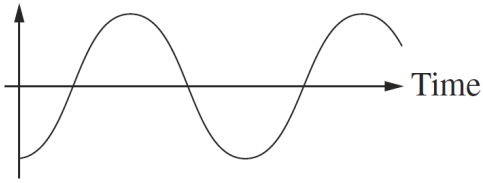



Which graph best represents the corresponding induced emf in the coil?

(A)



(B)


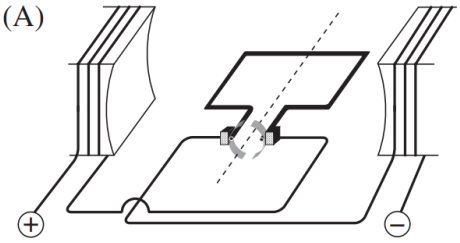

(C)



(D)


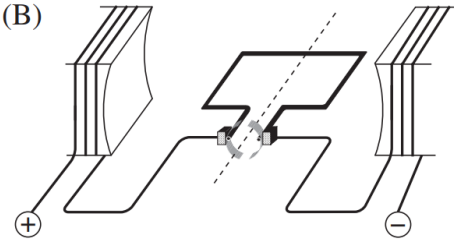
**16.** The diagrams show possible ways to connect the coils and rotor of a DC motor to a DC power supply.

In which circuit will the rotor turn in a clockwise direction?

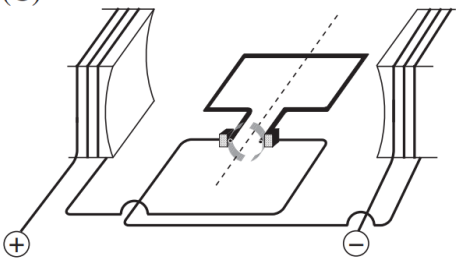
(A)



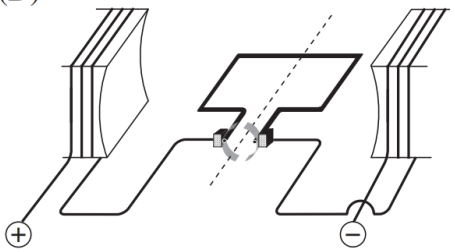
(B)



(C)



(D)



**17.** Eddy currents are a major source of energy loss in an iron core transformer.

What is one way to minimise this energy loss?

(A) Laminate the iron core with an insulator

(B) Put fewer turns of wire in the secondary coil

(C) Operate the transformer with a higher current

(D) Decrease the amount of primary and secondary coils

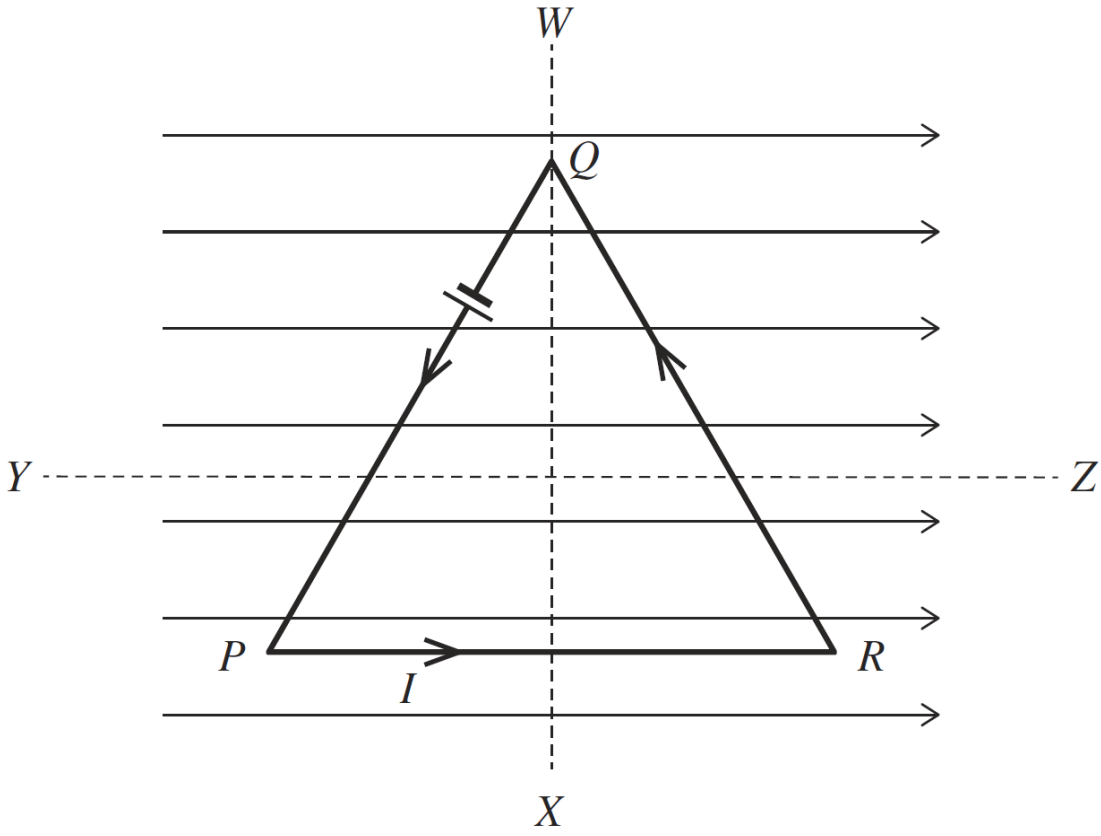
**18.** Two satellites have the same mass. One (LEO) is in low-Earth orbit and the other (GEO) is in a geostationary orbit.

The total energy of a satellite is half its gravitational potential energy.

Which row of the table correctly identifies the satellite with the greater orbital period and the satellite with the greater total magnitude of energy?

| | *Greater orbital period* | *Greater total magnitude of energy* |
|---|---|---|
| (A) | LEO | LEO |
| (B) | LEO | GEO |
| (C) | GEO | LEO |
| (D) | GEO | GEO |

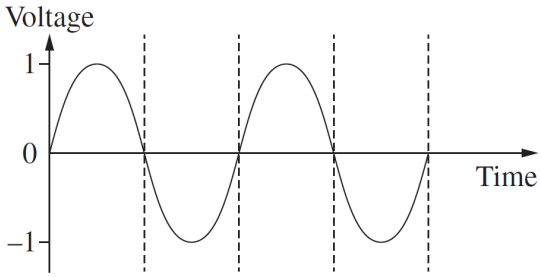
**19.** A triangular piece of wire is placed in a magnetic field as shown.




When current *I* is supplied as shown, how does the wire move?

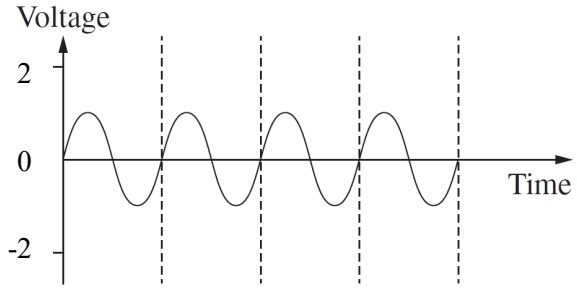
| | *Axis of rotation* | *Direction of movement* |
|---|---|---|
| (A) | YZ | Q into page |
| (B) | YZ | Q out of page |
| (C) | WX | R out of page |
| (D) | WX | R into page |

**20.** A simple AC generator was connected to a cathode ray oscilloscope and the coil was rotated at a constant rate. The output is shown on this graph.

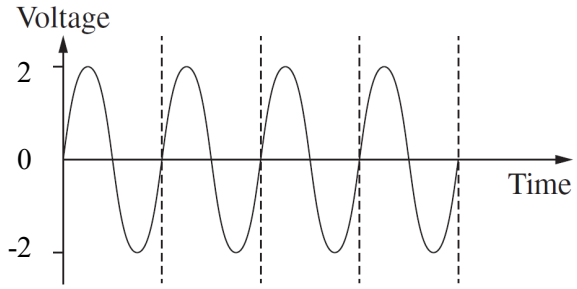



Which of the following graphs best represents the output if the rate of rotation is increased to double of the original value?

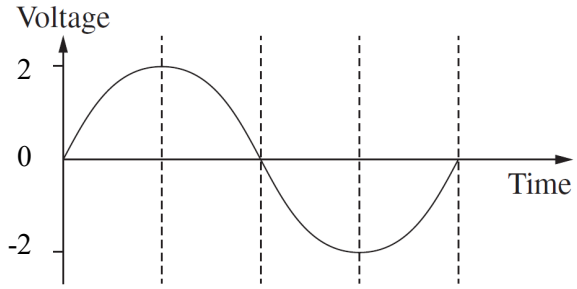
(A)



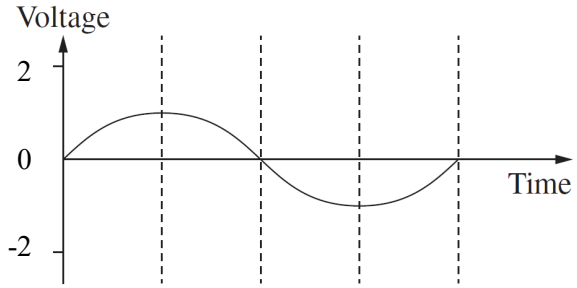

(B)




(C)



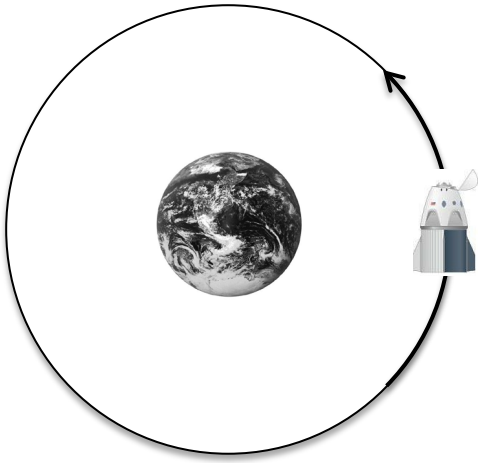

(D)



## PART B – Short Answer (40 Marks)

**Question 21** **(6 marks)**

A spacecraft of mass 2.50 tonnes is placed into a circular orbit which is 20274km above the surface of the earth.



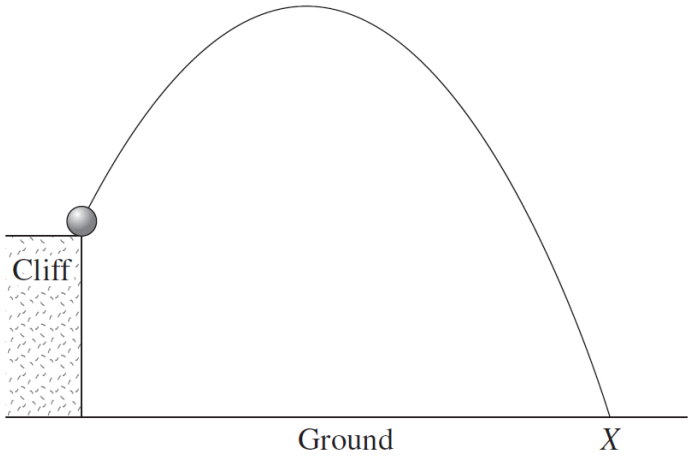
NOT TO SCALE

**a** Calculate the period of this orbit to the closest hour. **2**

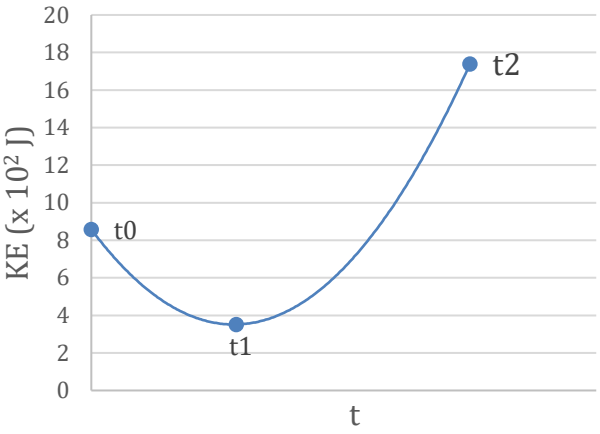
**b** The spacecraft fires its engines, and is measured to have increased its kinetic energy by $2.00 \times 10^7$ kJ in the original direction of motion. Describe the effect this will have on the spacecraft's motion around the earth. Show all working. **4**

**Question 22 (6 marks)**

A 4.50 kg mass is launched from the edge of a cliff.




The kinetic energy of the mass is graphed from the moment it is launched until it hits the ground at $X$. The kinetic energy of the mass is provided for times $t_0$, $t_1$ and $t_2$.




| *Time (t)* | *KE (J)* |
|---|---|
| $t_0$ | 858 |
| $t_1$ | 352 |
| $t_2$ | 1740 |

**a** From the information provided, calculate the horizontal and vertical components ($u_x$ and $u_y$) of the initial velocity of the ball at launch. **2**

**b** Using the information provided, calculate the time of flight of the ball. **2**

**c** With consideration to the law of conservation of energy and the information provided, calculate the height of the cliff. **2**

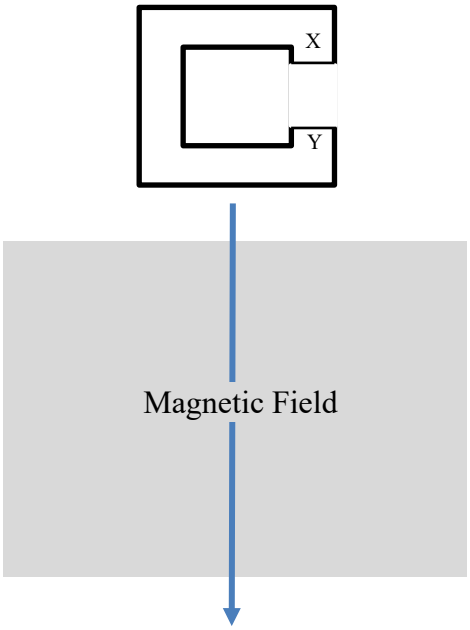
**Question 23 (2 marks)**

A spaceship travels to a distant star at a constant speed, $v$. When it arrives, 15 years have passed on Earth but 9.4 years have passed for an astronaut on the spaceship. Calculate $v$ in terms of $c$. **2**

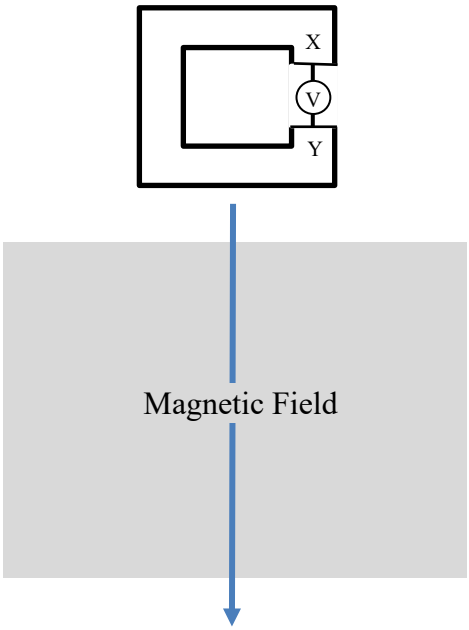
**Question 24 (4 marks)**

In experiment 1, a "C" shaped sheet of copper is dropped through an area with a magnetic field, entering and exiting the field. The motion of the sheet is recorded.

*Experiment 1*




*Experiment 2*



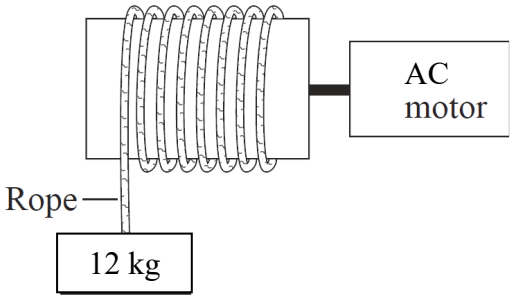

In experiment 2, the experiment is repeated with a voltmeter placed between points X and Y.

With reference to the physics involved, describe the motion of the copper sheet in both experiments, and the readings on voltmeter in experiment 2. **4**

**Question 25 (9 marks)**

The following makeshift device was made to provide lighting for a stranded astronaut on Mars.

The mass of Mars is $6.39 \times 10^{23}$ kg and a radius of 3390km.




The 12.00 kg mass on Mars is lowered using a 24V AC motor as a generator. The mass is lowered through a distance of 5m.

**a** From the information provided, calculate the acceleration of gravity on the surface of mars. **2**

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**b** If it takes 7.42s to drop the mass through 5 m, calculate the makeshift generator's output current. **3**

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**c** The salvaged lighting system the astronaut plans to use needs 120V. The astronaut has access to steel plating and wiring from the spacecraft. Calculate the ratio of the primary coils to the secondary coils required for a transformer to power the lights. **2**

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**d** The lighting system requires 200mA to operate. Justify whether the system can work **2**

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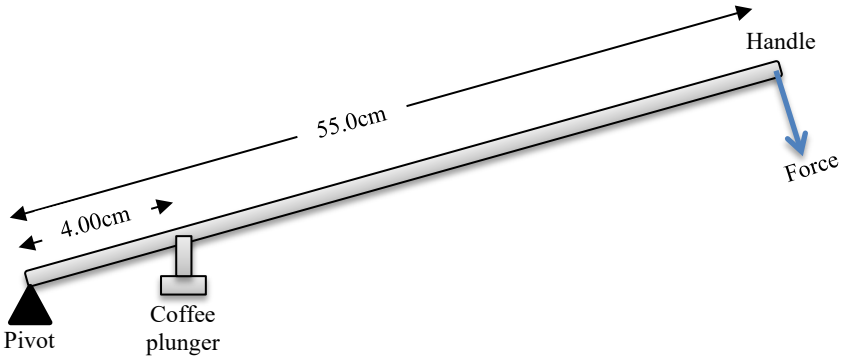
**Question 26 (6 marks)**

Dr Carman makes his coffee using a special coffee press. His coffee press works by using a lever to press hot water through the coffee grounds as shown in the diagram.




**a** A good extraction requires 1500N of force at the coffee plunger. Calculate the force is required at the end of the handle to make a coffee. **2**

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**b** Dr Carman injures his arm and cannot manually use the press. He finds an electric motor with a coil that is 7.00cm wide, 25.0cm long. The field magnets have a strength of 380mT, and there are 300 turns of the coil. Calculate the minimum current required to make a coffee if this motor is attached at the pivot of this press (indicated by the black triangle) to rotate the arm of the press and lower the coffee plunger. **2**

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**c** Identify TWO modifications that can be made to the motor that can reduce the amount of current and operate the coffee press as calculated in the last question. **2**

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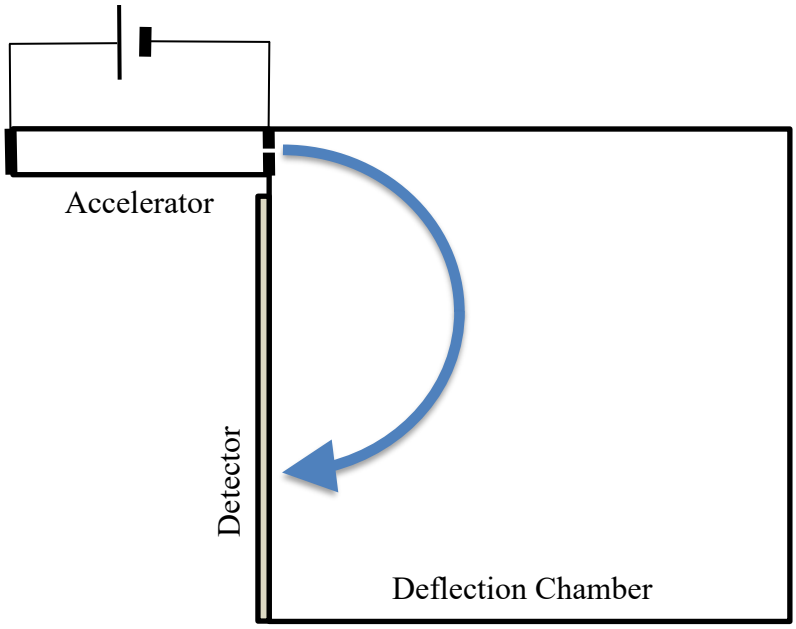
**Question 27** **(7 marks)**

A mass spectrometer is an analytical device which utilises the motor effect to determine the composition of an unknown sample. The machine uses and electric field **E,** of strength 4750 $NC^{-1}$, to accelerate stationary ions of the sample into a chamber with a magnetic field. The magnetic field **B**, of strength 150mT, deflects the sample onto the detector.




**a** Indicate the direction of the magnetic field in the deflection chamber with reference to the diagram above. **1**

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**b** Given that the length of the accelerator is 20.0cm, calculate the voltage applied. **2**

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**c** The accelerator uses an electric field to do work on the charged particles to accelerate them to a velocity *v*. Derive an expression for velocity. **1**

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**d** The detector picks up a signal at 20.6cm, as measured from the opening of the accelerator. **3**

Sample X was ionised to produce particles of charge $3.2 \times 10^{-19}$C.

By considering the balance of forces, calculate the mass of particles in sample X.

## END OF EXAM

Sydney Boys High School

# Year 12 Physics Half Yearly Cohort Task 2022

# Multiple Choice Answer Sheet

Please complete the answer sheet AND your Student ID below using a 2B pencil or mechanical pacer.
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.
If you change your mind, use a clean eraser to make corrections.
Do **not** make any other markings on this page

Student ID

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | B | C | D | | 18 | A | B | C | D |
| 2 | A | B | C | D | | 19 | A | B | C | D |
| 3 | A | B | C | D | | 20 | 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 | | | | | | |
| 11 | A | B | C | D | | | | | | |
| 12 | A | B | C | D | | | | | | |
| 13 | A | B | C | D | | | | | | |
| 14 | A | B | C | D | | | | | | |
| 15 | A | B | C | D | | | | | | |
| 16 | A | B | C | D | | | | | | |
| 17 | A | B | C | D | | | | | | |

Student ID

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

Sydney Boys High School

Student Number:

# Physics

March 2022
Half Yearly Cohort Task
Advanced Mechanics, Electromagnetics, Special Relativity

**General Instructions**

- Reading time: 5 minutes
- Working time: 90 minutes
- Write using black or blue pen
- Draw diagrams using pencil
- SHOW ALL WORKING
- Board approved calculators may be used
- A data sheet, formula sheets and Periodic Table are provided at the back of this paper
- Write your student number in ALL of the boxes provided

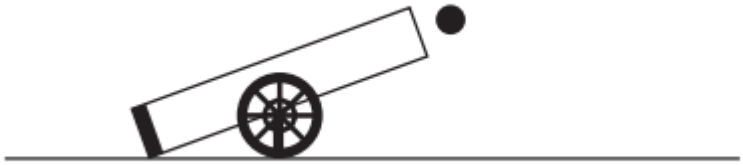
**Total marks – 60**

Part A – Multiple Choice
- 20 marks

Part B – Free Response
- 40 marks

**PART A – Multiple Choice (20 Marks)**

**1.** A projectile is launched by a cannon as shown.



Which arrow represents the velocity of the projectile at its maximum height?

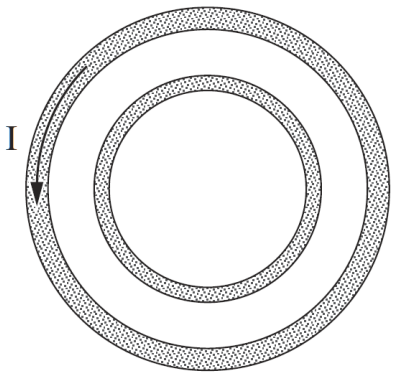
(A) ↑

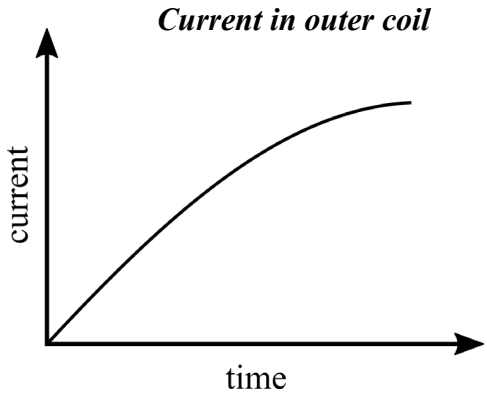
(B) ↓

(C) →

(D) ↘

**2.** Two copper rings lie in the same plane as shown.




A changing current, which follows the graph above, flows anticlockwise around the outer ring. What happens in the inner ring?

(A) A decreasing clockwise current flows in the inner ring.

(B) A decreasing anticlockwise current flows in the inner ring.

(C) An increasing clockwise current flows in the inner ring.

(D) An increasing anticlockwise current flows in the inner ring.

**3.** The table shows the value of the acceleration due to gravity on the surface of Earth and on the surface of Mercury.

| | *Acceleration due to gravity ($ms^{-2}$)* |
|---|---|
| Earth | 9.8 |
| Mercury | 3.7 |

A person has a weight of 550 N on the surface of Mercury.

What would be the person's weight on the surface of Earth?

(A) 56.1 N

(B) 208 N

(C) 550 N

(D) 1457 N

**4.** The rest length of a train is 200 m and the rest length of a railway platform is 160 m. The train rushes past the platform so fast that, when observed in the platform's frame of reference, the train and the platform are the same length.

How fast is the train moving?

(A) 0.60c

(B) 0.75c

(C) 0.80c

(D) 1.25c

**5.** A student throws a ball that follows a parabolic trajectory. What change to the initial velocity would make the ball's time of flight shorter?

(A) Increasing only the vertical component

(B) Decreasing only the vertical component

(C) Increasing only the horizontal component

(D) Decreasing only the horizontal component

**6.** A satellite is moved from a geostationary orbit to a higher orbit. Which statement about the orbit change is correct?

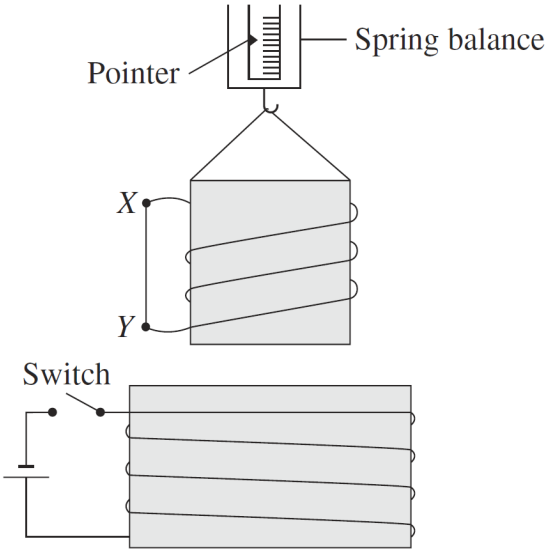
(A) During the move the gravitational potential energy decreases.

(B) The change in gravitational potential energy is independent of the mass of the satellite.

(C) The work done is the difference between the gravitational potential energy of the higher orbit and that of the geostationary orbit.

(D) The work done is the energy required to move the satellite, which is in the gravitational field, from a very large distance away, to the higher orbit.

**7.** An experiment is set up as shown.




When the switch is closed, the reading on the spring balance changes immediately, then returns to the initial reading.

Which row of the table correctly shows the direction of the current through the straight conductor XY and the direction in which the pointer relative to the spring balance initially moves?

| | *Direction of current through the straight conductor* | *Direction in which the pointer initially moves* |
|---|---|---|
| A. | From *X* to *Y* | Down |
| B | From *X* to *Y* | Up |
| C. | From *Y* to *X* | Down |
| D. | From *Y* to *X* | Up |

**8.** A spaceship moves close to the speed of light, relative to a planet.

The rest-frame length of the spaceship can be determined by an observer who is

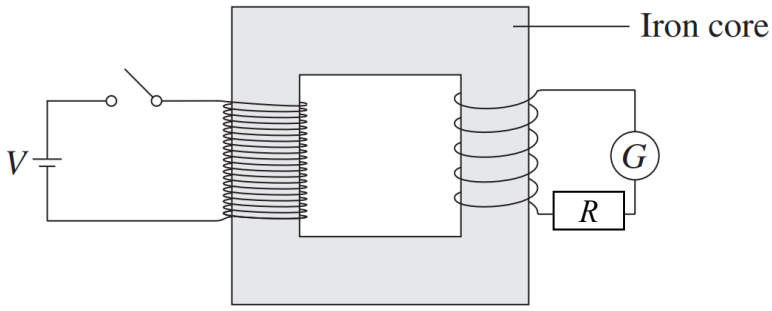
(A) on the spaceship measuring the time taken for light to travel between two points on the planet.

(B) on the planet measuring the time taken for light to travel from the front to the back of the spaceship.

(C) on the spaceship measuring the time taken for light to travel from the front to the back of the spaceship.

(D) on the planet measuring the difference in the arrival time of light from the front and the back of the spaceship.

**9.** The diagram shows an ideal transformer.




When the switch is closed, the pointer on the galvanometer deflects.

With consideration to Ohm's Law, how could the size of the deflection be increased?

(A) Decrease the number of primary coils

(B) Decrease the number of secondary coils

(C) Increase the number of both coils

(D) Increase the value of the resistor

*Use the data below to answer the next two questions.*

| | |
|---|---|
| Orbital period of the Moon around Earth | $2.36 \times 10^6$ s |
| Mean orbital radius of the Moon | $3.83 \times 10^8$ m |
| Mass of Earth | $6.00 \times 10^{24}$ kg |
| Mass of the Moon | $7.35 \times 10^{22}$ kg |

**10.** What is the orbital period of an Earth satellite having an orbital radius double that of the Moon?

(A) $5.9 \times 10^5$ s

(B) $8.3 \times 10^5$ s

(C) $1.2 \times 10^6$ s

(D) $6.7 \times 10^6$ s

**11.** What is the gravitational force experienced by the Moon due to Earth's influence?

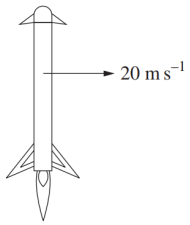
(A) $2.0 \times 10^{20}$ N

(B) $1.6 \times 10^{22}$ N

(C) $4.7 \times 10^{26}$ N

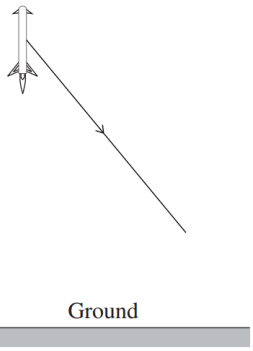
(D) $7.6 \times 10^{28}$ N

**12.** A rocket returns to Earth for reuse after launching satellites, using its engines to make a controlled landing. The rocket having a mass of 9800 kg is on approach to the ground, travelling horizontally at 20 $ms^{-1}$ as shown in the diagram, when the engine thrust is changed to 90 000 newtons.

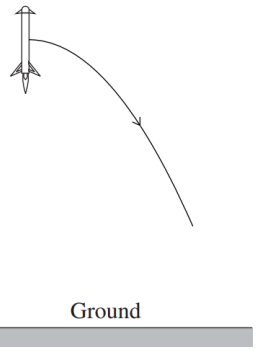



Which diagram shows the trajectory of the rocket following this change of thrust?

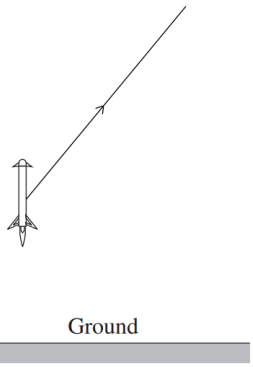
A.



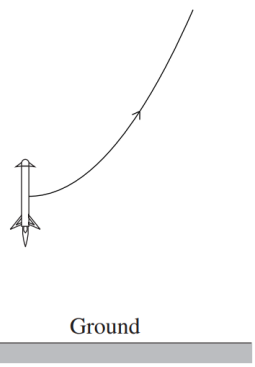

B.




C.




D.




**13.** An ideal electric motor connected to a DC voltage source rotates at a constant rate of 200 revolutions per minute. There is no load on the motor.
Which of the following is a correct statement about the operation of the motor?

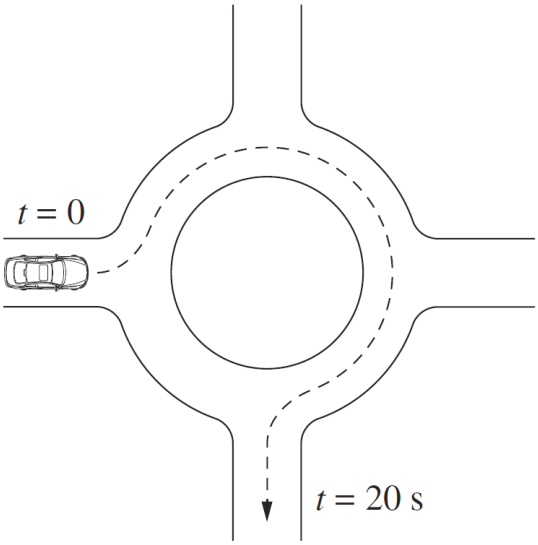
(A) The torque of the motor is directly related to the back emf of the motor.

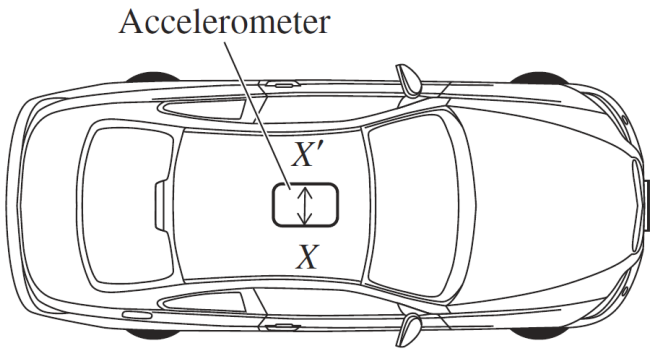
(B) There is no back emf because it is only produced in AC motors due to the changing flux.

(C) The back emf is equal to the applied voltage because no work is being done by the motor.

(D) The back emf must exceed the applied voltage to prevent the motor's speed from increasing.

**14.** A car travelling at a constant speed follows the path shown.

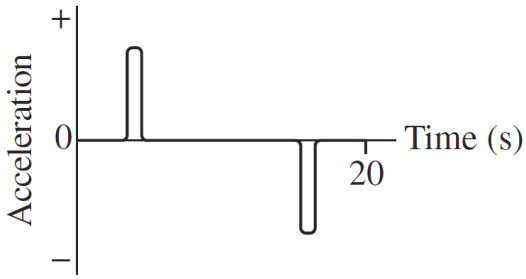


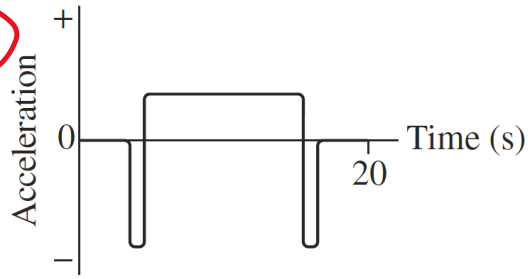

An accelerometer that measures acceleration along the $X$–$X'$ direction is fixed in the car.

Which graph shows the measurements recorded by the accelerometer over the 20-second interval?

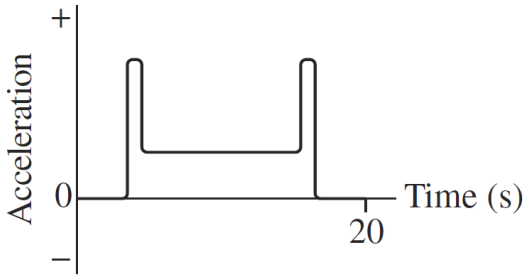
A.



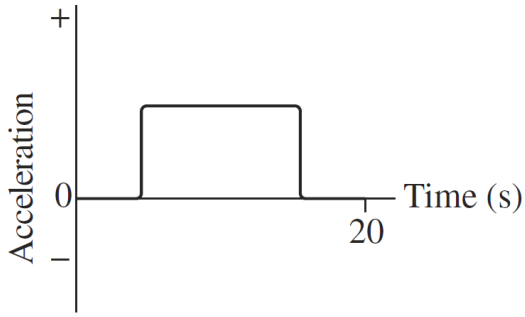

B.



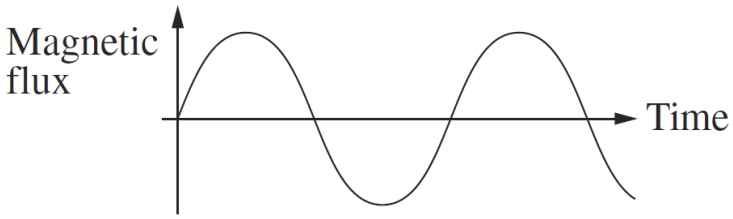

C.



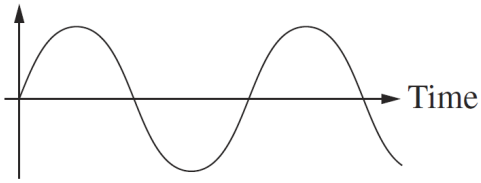

D.

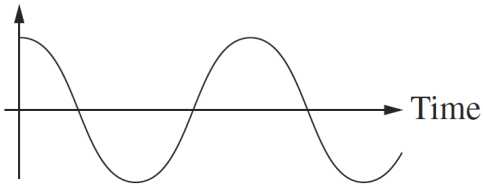


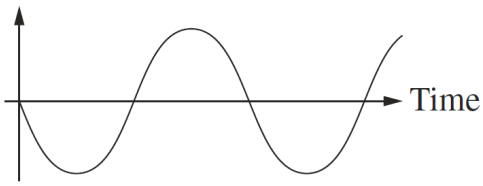
**15.** The graph shows variation in magnetic flux through a coil with time.

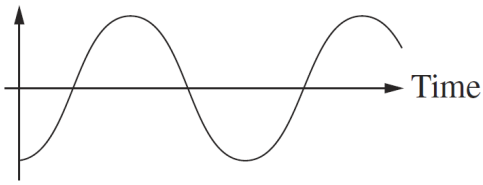



Which graph best represents the corresponding induced emf in the coil?

(A) 


(B) 

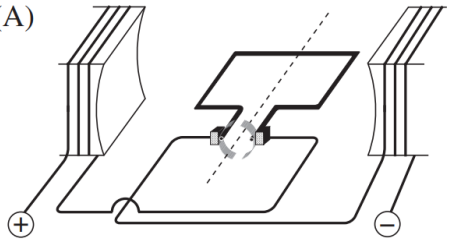

(C) 


(D) 

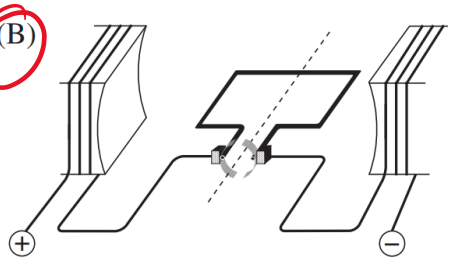
**16.** The diagrams show possible ways to connect the coils and rotor of a DC motor to a DC power supply.

In which circuit will the rotor turn in a clockwise direction?

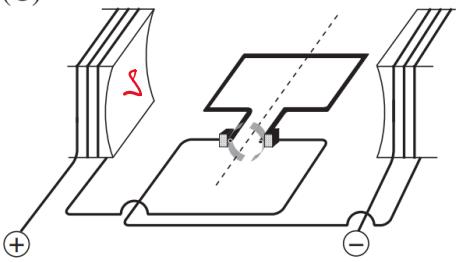
(A)



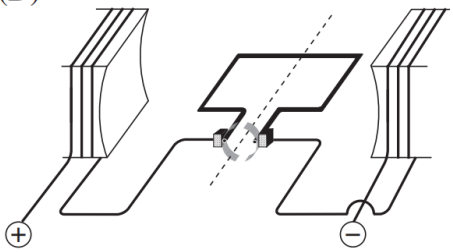
(B)



(C)



(D)



**17.** Eddy currents are a major source of energy loss in an iron core transformer.

What is one way to minimise this energy loss?

(A) Laminate the iron core with an insulator

(B) Put fewer turns of wire in the secondary coil

(C) Operate the transformer with a higher current

(D) Decrease the amount of primary and secondary coils

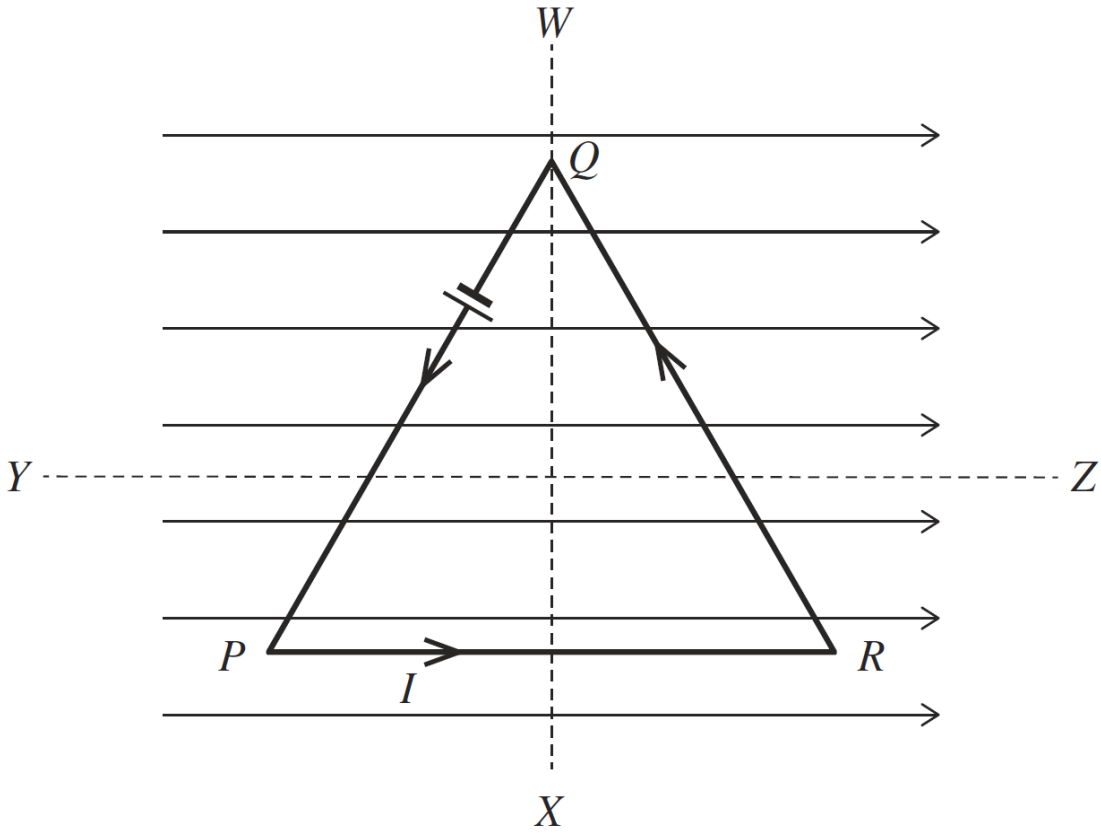
**18.** Two satellites have the same mass. One (LEO) is in low-Earth orbit and the other (GEO) is in a geostationary orbit.

The total energy of a satellite is half its gravitational potential energy.

Which row of the table correctly identifies the satellite with the greater orbital period and the satellite with the greater total magnitude of energy?

| | *Greater orbital period* | *Greater total magnitude of energy* |
|---|---|---|
| (A) | LEO | LEO |
| (B) | LEO | GEO |
| (C) | GEO | LEO |
| (D) | GEO | GEO |

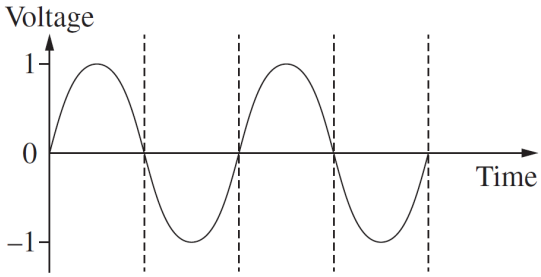
**19.** A triangular piece of wire is placed in a magnetic field as shown.




When current *I* is supplied as shown, how does the wire move?

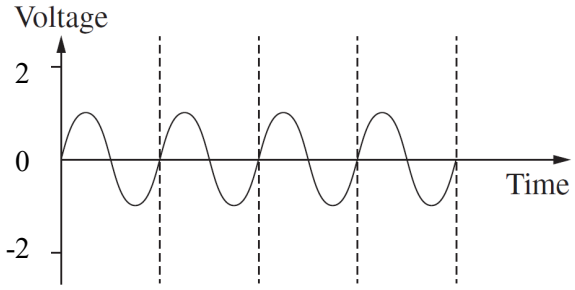
| | *Axis of rotation* | *Direction of movement* |
|---|---|---|
| (A) | YZ | Q into page |
| (B) | YZ | Q out of page |
| (C) | WX | R out of page |
| (D) | WX | R into page |

**20.** A simple AC generator was connected to a cathode ray oscilloscope and the coil was rotated at a constant rate. The output is shown on this graph.

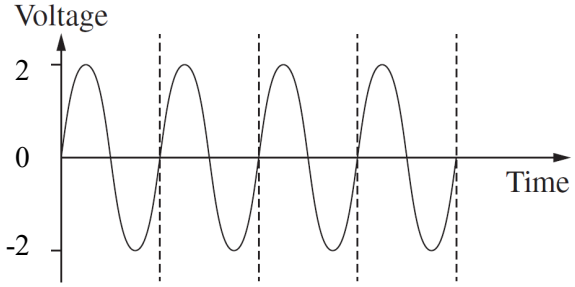



Which of the following graphs best represents the output if the rate of rotation is increased to double of the original value?

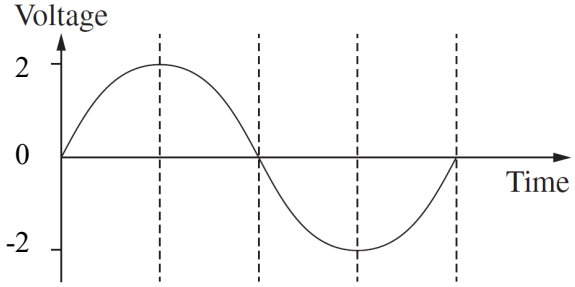
(A)



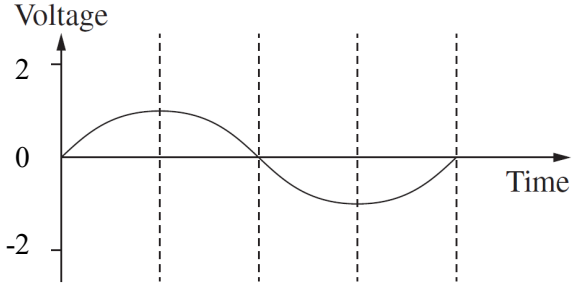

(B)




(C)



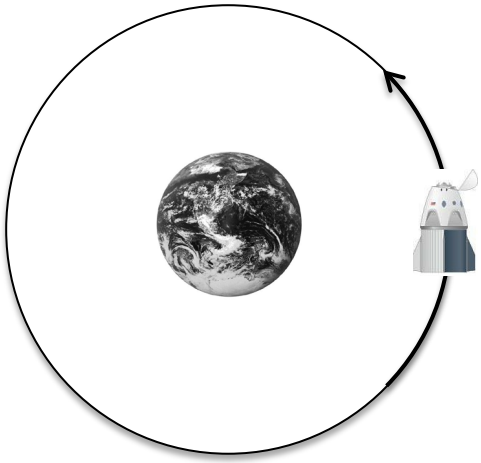

(D)



## PART B – Short Answer (40 Marks)

**Question 21 (6 marks)**

A spacecraft of mass 2.50 tonnes is placed into a circular orbit which is 20274km above the surface of the earth.



NOT TO SCALE

**a** Calculate the period of this orbit to the closest hour. **2**

$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$ (1)

$T = \sqrt{\frac{r^3 4\pi^2}{GM}}$

$T = \sqrt{\frac{(20274\times10^3+6.371\times10^6)^3\times4\pi^2}{6.67\times10^{-11}\times6\times10^{24}}}$

$= 43198s$

$= 720min$

$= 12hrs$ (1)

**b** The spacecraft fires its engines, and is measured to have increased its kinetic energy by 2.00 x$10^7$ kJ. Describe the effect this will have on the spacecraft's motion around the earth. Show all working. **4**

spacecraft's motion around the earth. Show all working.

$E_K = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2}m(v^2-u^2)$

$2\times10^{10} = \frac{1}{2}\times2500(v^2-3875.5^2)$

$v = \sqrt{\frac{2\times2\times10^{10}}{2500} + 3875.5^2}$

$= 5569.5\ ms^{-1}$ (1)

$F_c = F_G$

$\frac{v_o^2}{r} = \frac{GM_E}{r^2}$

$v_o = \sqrt{\frac{GM_E}{r}}$

$= \sqrt{\frac{6.67\times10^{-11}\times6\times10^{24}}{(6.371\times10^6+2027+\times10^3)}}$

$= 3875.5\ ms^{-1}$ (1)

incorrect answers but effect correct for your answers = 2

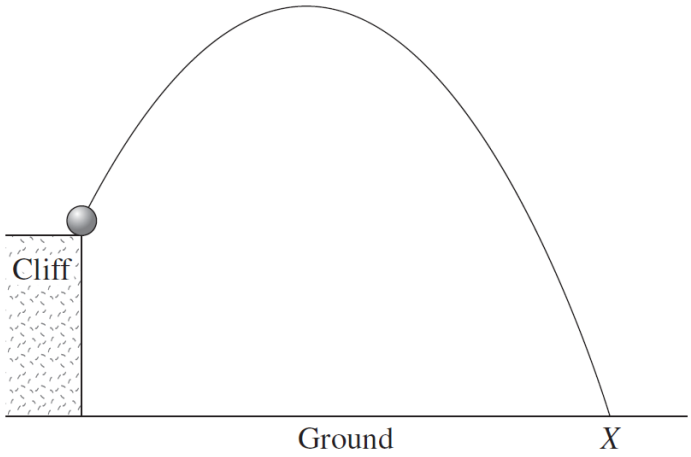
$v_{esc} = \sqrt{2}v_o$ or $\sqrt{\frac{2GM_E}{r}}$ $= 5480.8\ ms^{-1}$ (1)

$v_{total} > v_{esc}$ ∴ spacecraft escapes. based on your answer (1)

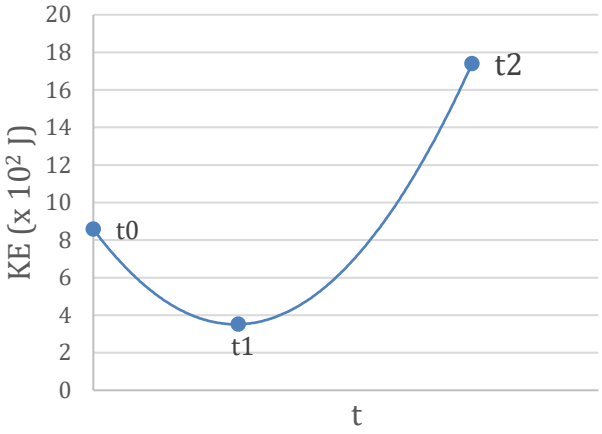
– 13 –

**Question 22** **(6 marks)**

A 4.50 kg mass is launched from the edge of a cliff.




The kinetic energy of the mass is graphed from the moment it is launched until it hits the ground at *X*. The kinetic energy of the mass is provided for times $t_0$, $t_1$ and $t_2$.




| *Time (t)* | *KE (J)* |
|---|---|
| $t_0$ | 858 |
| $t_1$ | 352 |
| $t_2$ | 1740 |

**a** From the information provided, calculate the horizontal and vertical components ($u_x$ and $u_y$) of the initial velocity of the ball at launch. **2**

@ $t_1$, $E_K = \frac{1}{2}mu_x^2$

$u_x = \sqrt{\frac{2E_K}{m}}$

$= \sqrt{\frac{2 \times 352}{4.5}}$

$= 12.5\ ms^{-1}$ (1)

$\Delta E_K$ from $t_0$ & $t_1$ = $E_K$ in y

$|E_{K_1} - E_{K_0}| = 858 - 352$

$= 506\ J$

$\Delta E_K = \frac{1}{2}mu_y^2$

$u_y = \sqrt{\frac{2 \times 506}{4.5}}$

$= 15.0\ ms^{-1}$ (1)

some attempt (1)

b Using the information provided, calculate the time of flight of the ball.

$\Delta E_K$ @ $t_1$ & $t_2$ = 1740 − 352 = 1388 J = $E_K$

$E_{Ky} = \frac{1}{2} m v_y^2$

$v_y = \sqrt{\frac{2 \times 1388}{4.5}}$

$= 24.8\ ms^{-1}$ down

$(= -24.8\ ms^{-1}$ up)

$v_y = u_y + a_y t$

$t = \frac{v_y - u_y}{a_y}$

$= \frac{-24.8 - 15}{-9.8}$

$= 4.1$ secs

correct answer (2)

some correct working (1)

c With consideration to the law of conservation of energy and the information provided, calcula the height of the cliff.

$\Delta U = |E_{Ky} @ t_0 - E_{Ky} @ t_2|$

$= |506 - 1388|$

$= 882$ J (1)

$\Delta U = mg \Delta h$

$\Delta h = \frac{\Delta U}{mg} = \frac{882\ J}{4.5 \times 9.8}$

$= 20$ m

Note: If used SUVAT eqns must get correct answer to get marks.

**Question 23 (2 marks)**

A spaceship travels to a distant star at a constant speed, $v$. When it arrives, 15 years have passed on Earth but 9.4 years have passed for an astronaut on the spaceship. Calculate $v$ in terms of $c$. **2**

$t_0 = \frac{t_v}{\sqrt{1 - \frac{v^2}{c^2}}}$ (1)

$\sqrt{1 - \frac{t_0^2}{t_v^2}} = \frac{v}{c} = 0.78c$ (1)

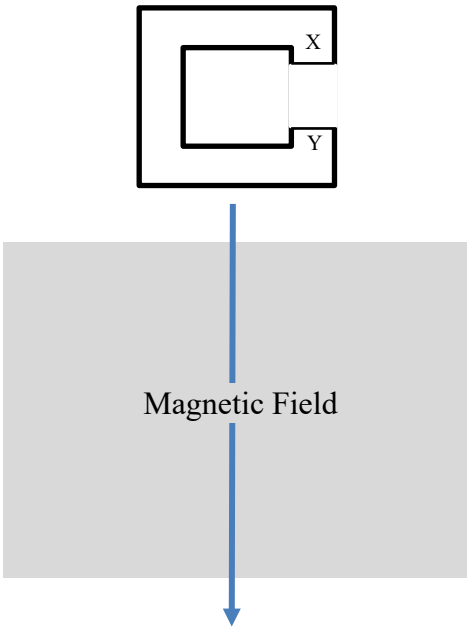
$\frac{t_v}{t_0} = \sqrt{1 - \frac{v^2}{c^2}}$

$\frac{t_v^2}{t_0^2} = 1 - \frac{v^2}{c^2}$

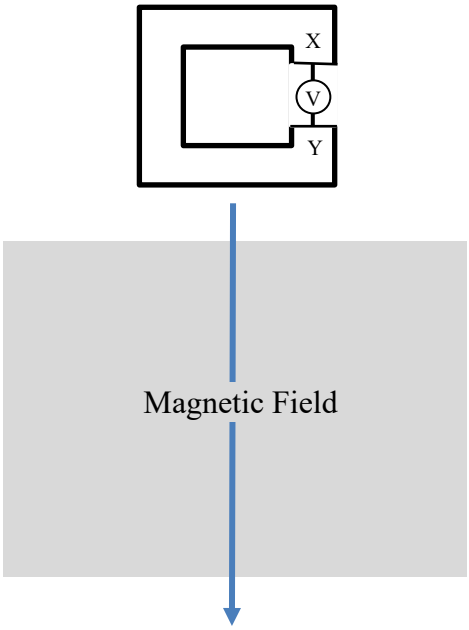
**Question 24 (4 marks)**

In experiment 1, a "C" shaped sheet of copper is dropped through an area with a magnetic field, entering and exiting the field. The motion of the sheet is recorded.

*Experiment 1*




*Experiment 2*




In experiment 2, the experiment is repeated with a voltmeter placed between points X and Y.

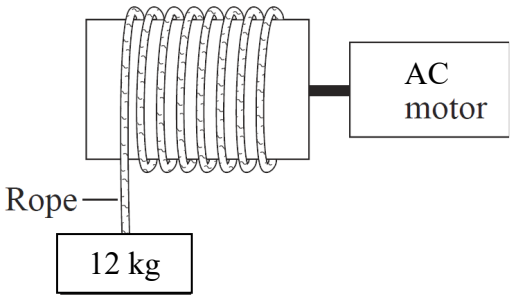
With reference to the physics involved, describe the motion of the copper sheet in both experiments, and the readings on voltmeter in experiment 2. **4**

| First mark | Second mark | Third mark | Fourth mark |
|---|---|---|---|
| Expt 1 is an **open circuit.**<br>Only **eddy currents** will form in the copper.<br>The copper may be slowed a little but will fall at **close to 9.8 m/s$^2$** | Expt 2 is also an open circuit since voltmeters are assumed to have extremely high resistance.<br>Only eddy currents will form in the copper surfaces.<br>The copper may be slowed a little but will fall at close to 9.8 m/s$^2$ – Same as Expt 1. | Both sheets will experience a changing magnetic flux as they enter the magnetic fields but as both C shaped copper sheets are open circuits the emf induced (according the Faraday's Law) will only induce eddy currents in the flat conducting surfaces. | The Voltmeter will flick one way as the sheet enters the B field and then the other way with greater amplitude as it leaves, due to the increased rate of change of magnetic flux $\left(\varepsilon = -N\frac{\Delta\Phi}{\Delta t}\right)$. |

**Question 25 (9 marks)**

The following makeshift device was made to provide lighting for a stranded astronaut on Mars.

The mass of Mars is $6.39 \times 10^{23}$ kg and a radius of 3390km.




The 12.00 kg mass on Mars is lowered using a 24V AC motor as a generator. The mass is lowered through a distance of 5m.

**a** From the information provided, calculate the acceleration of gravity on the surface of mars. **2**

$g = \frac{GM}{r^2} = 3.71\ ms^{-2}$ (1) (1)

2 Marks:
- Correct answer ($3.71 ms^{-2}$)
- Use of gravitational acceleration equation

1 Mark
- Use of gravitational acceleration equation

**b** If it takes 7.42s to drop the mass through 5 m, calculate the makeshift generator's output current. **3**

$E = mg\Delta h = 222.6\ J$ (1)

$P = \frac{E}{t} = \frac{222.6}{7.42} = 30\ W = IV$ (1)

$V = 24$, $I = \frac{P}{V} = \frac{30}{24}$ $1.25\ A$ (1)

1 Mark each for:
- Correct answer (1.25A)
- Correct use of work/power equation
- Correct use of conservation laws

**c** The salvaged lighting system the astronaut plans to use needs 120V. The astronaut has access to steel plating and wiring from the spacecraft. Calculate the ratio of the primary coils to the secondary coils required for a transformer to power the lights. **2**

$\frac{V_p}{V_s} = \frac{n_p}{n_s}$ (1) $\frac{24}{120} = \frac{1}{5}$ ratio of $n_p : n_s$ is $1:5$ (1)

2 Marks:
- Correct ratio (1:5) n.b. ratio is **not** a fraction
- Correct use of the transformer equation

1 Mark:
- Use of the transformer equation

**d** The lighting system requires 200mA to operate. Justify whether the system can work **2**

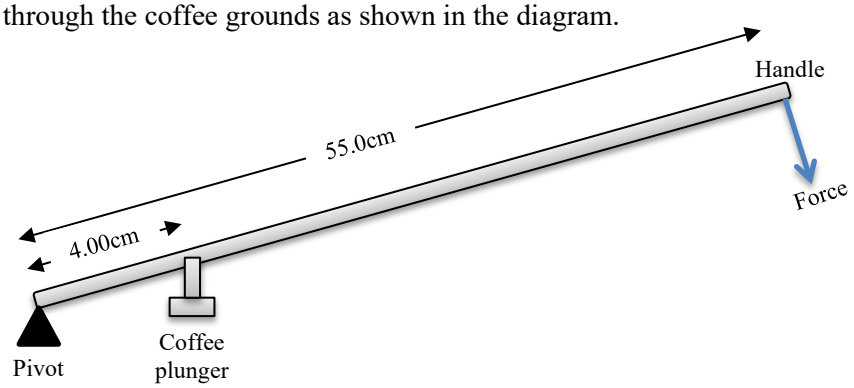
$P = IV = 0.2 \times 120 = 24W$. $24W < 30W$. yes

2 Marks:
- Correct answer (yes)
- Correct justification using conservation laws

1 Mark:
- Some justification using conservation laws

**Question 26 (6 marks)**

Dr Carman makes his coffee using a special coffee press. His coffee press works by using a lever to press hot water through the coffee grounds as shown in the diagram.




**a** A good extraction requires 1500N of force at the coffee plunger. Calculate the force is required at the end of the handle to make a coffee. **2**

When applying force on the plunger:

$\tau_{plunger} = F_{plunger} r_{plunger} = 1500 \times 0.0400 = 60 \text{ N m}$

$\tau_{plunger} = \tau_{handle} = F_{handle} r_{handle}$

$F_{handle} = \dfrac{\tau_{plunger} =}{r_{handle}} = \dfrac{60}{0.550} = 109.1 = 110\ N$

✓ uses correct equation
✓ correct answer & units

**note:** please make sure you know the difference between force and torque!

**b** Dr Carman injures his arm and cannot manually use the press. He finds an electric motor with a coil that is 7.00cm wide, 25.0cm long. The field magnets have a strength of 380mT, and there are 300 turns of the coil. Calculate the minimum current required to make a coffee if this motor is attached at the pivot of this press (indicated by the black triangle) to rotate the arm of the press and lower the coffee plunger. **2**

In order for a motor to drive the coffee machine, the torque needs to be provided by the motor is $\tau_{motor} = nIAB \sin\theta$

For minimum current, $\theta = 90°$ and $\tau_{motor} = nIAB$

$\Rightarrow I = \dfrac{\tau_{motor}}{nAB} = \dfrac{1500 \times 0.0400}{300 \times 0.0700 \times 0.2500 \times 0.380} = 30.08 = 30\ A$

✓ uses correct equation
✓ correct answer & units
(carry-over from (a) allowed)

**c** Identify TWO modifications that can be made to the motor that can reduce the amount of current and operate the coffee press as calculated in the last question. **2**

From (b), $I \propto \frac{1}{nAB}$ (keeping $\tau_{motor}$ constant):

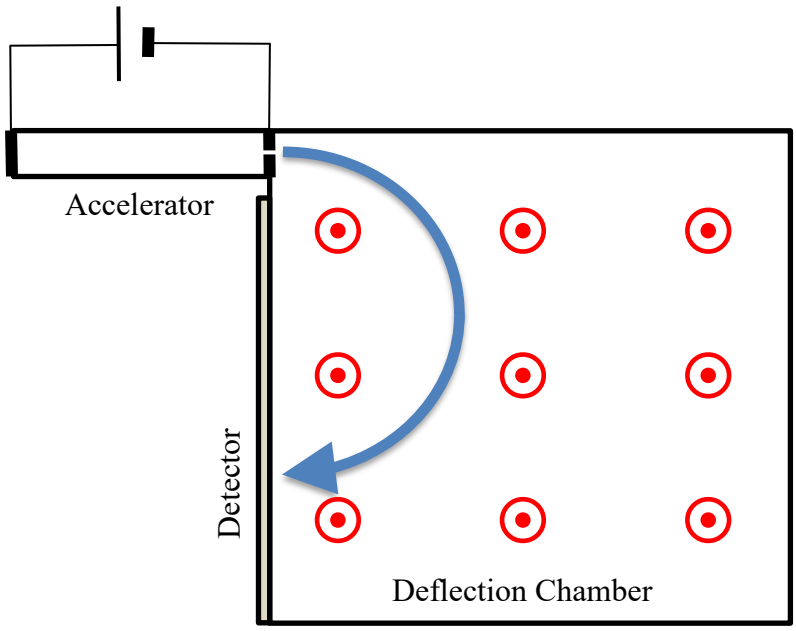
* more turns (↑n)
* larger coil (↑A)
* stronger magnets (↑B)

✓ 1 mark each for 2 valid improvements
(only first two considered)

**note:** there is no indication in question that motor uses uniform field, so radial magnets are not a valid modification

**Question 27** **(7 marks)**

A mass spectrometer is an analytical device which utilises the motor effect to determine the composition of an unknown sample. The machine uses and electric field **E,** of strength 4750 $NC^{-1}$, to accelerate stationary ions of the sample into a chamber with a magnetic field. The magnetic field **B**, of strength 150mT, deflects the sample onto the detector.




**a** Indicate the direction of the magnetic field in the deflection chamber with reference to the diagram above. **1**

Field lines out of page ✓ correct direction

**b** Given that the length of the accelerator is 20.0cm, calculate the voltage applied. **2**

$E = \frac{V}{d} \quad \Rightarrow \quad V = Ed = 4750 \times 0.200 = 950\ V$

✓ uses correct equation
✓ correct answer & units

**c** The accelerator uses an electric field to do work on the charged particles to accelerate them to a velocity *v*. Derive an expression for velocity. **1**

$W = \Delta K$

$qV = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2qV}{m}}$

✓ correct formula

**note:** the equation must include variables available from the question

**d** The detector picks up a signal at 20.6cm, as measured from the opening of the accelerator. **3**

Sample X was ionised to produce particles of charge 3.2 x$10^{-19}$C.

By considering the balance of forces, calculate the mass of particles in sample X.

$F_c = F_B$

Since magnetic field is perpendicular to the velocity of the ions:

$$\frac{mv^2}{r} = qvB$$

$$v = \frac{qBr}{m}$$

From (c):

$$\sqrt{\frac{2qV}{m}} = \frac{qBr}{m}$$

$$\frac{2qV}{m} = \frac{q^2B^2r^2}{m^2}$$

$$m = \frac{qB^2r^2}{2V} = \frac{3.2 \times 10^{-19} \times 0.150^2 \times 0.103^2}{2 \times 950} = 4.02 \times 10^{-26}\ kg$$

✓ uses appropriate equation(s)
✓ demonstrates $F_c = F_B$
✓ correct answer & units

**END OF EXAM**