Sydney Boys High School

Student Number:

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

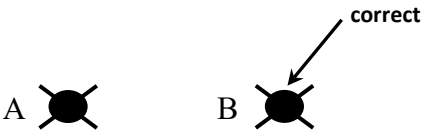
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



Start Here ➔

1.	A○	B○	C○	D○		**11.**	A○	B○	C○	D○
2.	A○	B○	C○	D○		**12.**	A○	B○	C○	D○
3.	A○	B○	C○	D○		**13.**	A○	B○	C○	D○
4.	A○	B○	C○	D○		**14.**	A○	B○	C○	D○
5.	A○	B○	C○	D○		**15.**	A○	B○	C○	D○
6.	A○	B○	C○	D○		**16.**	A○	B○	C○	D○
7.	A○	B○	C○	D○		**17.**	A○	B○	C○	D○
8.	A○	B○	C○	D○		**18.**	A○	B○	C○	D○
9.	A○	B○	C○	D○		**19.**	A○	B○	C○	D○
10.	A○	B○	C○	D○		**20.**	A○	B○	C○	D○

Sydney Boys High School

Student Number:

Physics

April 2019
Half Yearly Cohort Task
Advanced Mechanics, Electromagnetics

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

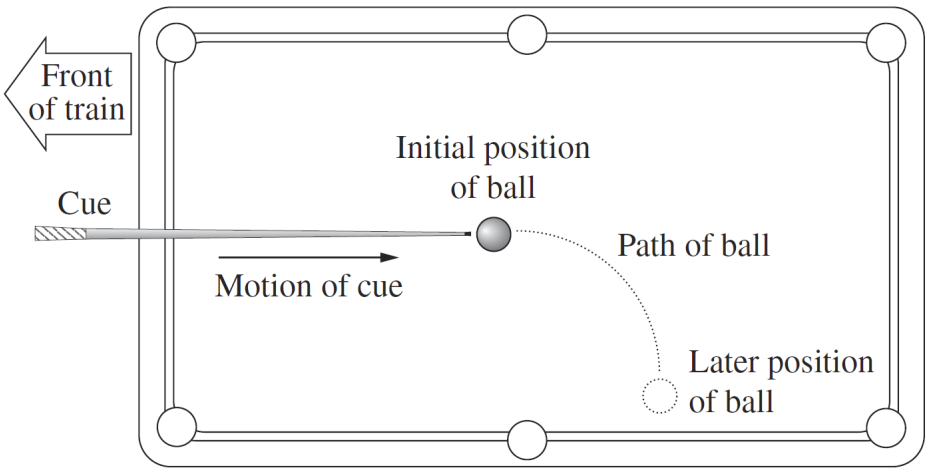
Total marks – 60

Part A – Multiple Choice
- 20 marks

Part B – Free Response
- 40 marks

PART A – Multiple Choice (20 Marks)

1. A passenger is playing billiards on a train that is travelling forwards on a level track. The ball takes the path shown when hit by the cue.



What can be inferred about the motion of the train?

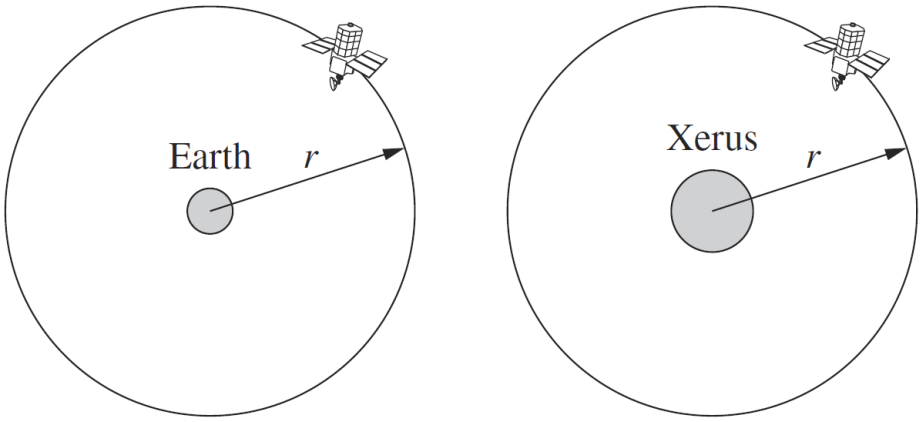
(A) It is turning left.

(B) It is speeding up.

(C) It is turning right.

(D) It is slowing down.

2. A satellite orbits Earth with period T. An identical satellite orbits the planet Xerus which has a mass four times that of Earth. Both satellites have the same orbital radius r.



What is the period of the satellite orbiting Xerus?

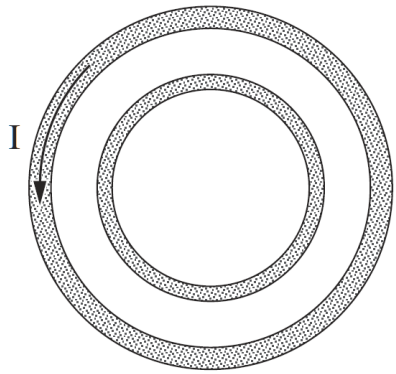
(A) $T/4$

(B) $T/2$

(C) $2T$

(D) $4T$

3. Two copper rings lie in the same plane as shown.



An increasing current flows clockwise around the outer ring.
What happens in the inner ring?

(A) A decreasing clockwise current flows.

(B) A decreasing anticlockwise current flows.

(C) An increasing clockwise current flows.

(D) An increasing anticlockwise current flows.

4. Two masses have a gravitational force of 12 N between them.

If the distance between the masses is doubled, what would be the new gravitational force between them?

(A) 3 N

(B) 6 N

(C) 12 N

(D) 24 N

5. A ball is launched horizontally from a cliff with an initial velocity of u m s^{-1}. After two seconds, the ball's velocity is in the direction 45° from the horizontal. What is the magnitude of the velocity in m s^{-1} at two seconds?

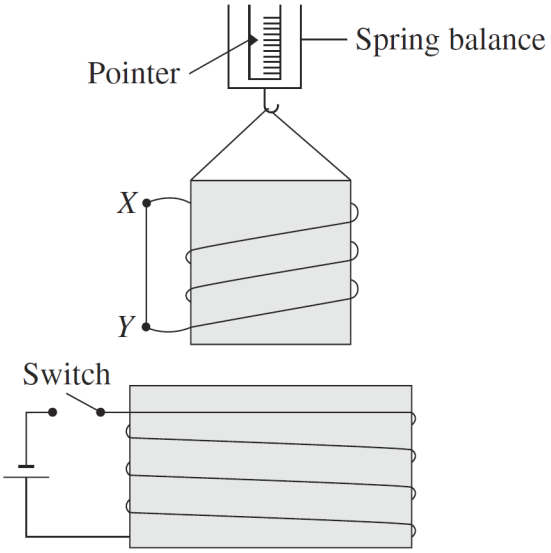
(A) u

(B) $1.5u$

(C) 19.6

(D) 27.7

6. 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

7. A satellite, initially in a low Earth orbit, is moved to a new orbit where its gravitational potential energy is half its initial value.

What is the gravitational force experienced by the satellite in its new orbit?

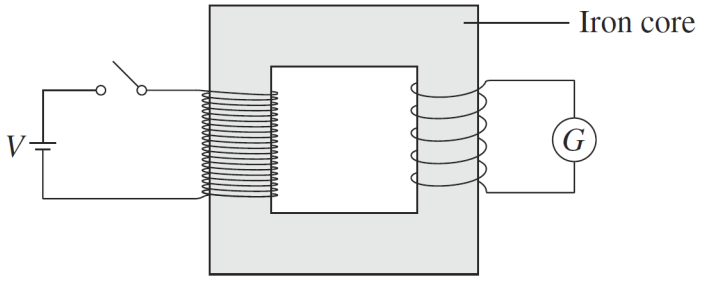
(A) Half the initial force

(B) Twice the initial force

(C) Four times the initial force

(D) One quarter the initial force

8. The diagram shows an ideal transformer.



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

How could the size of the deflection be increased?

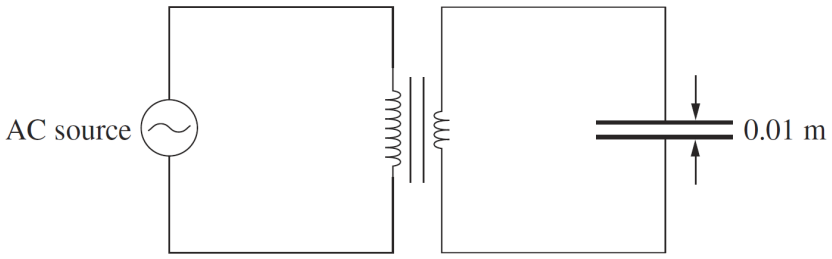
(A) Decrease the number of primary coils

(B) Decrease the number of secondary coils

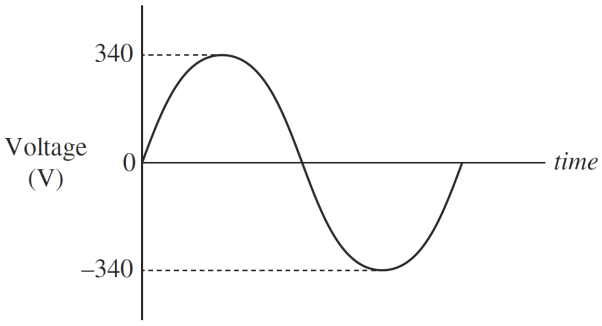
(C) Replace the iron core with a copper core

(D) Place a resistor in series with the galvanometer

9. An AC source is connected to a transformer having a primary winding of 900 turns. Connected to the secondary winding of 450 turns is a pair of parallel plates 0.01 m apart.



The AC input is shown in the graph.



What is the maximum field strength (in V m^{-1}) produced between the plates? (2017 20)

(A) 1.7

(B) 6.8

(C) 1.7×10^4

(D) 6.8×10^4

Use the data below to answer the next two questions.

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

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

(A) 5.9×10^5 s

(B) 8.3×10^5 s

(C) 1.2×10^6 s

(D) 7.5×10^6 s

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

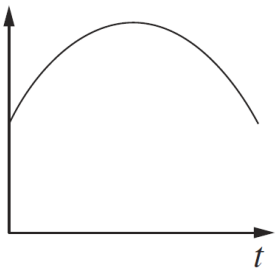
(A) 2.0×10^{20} N

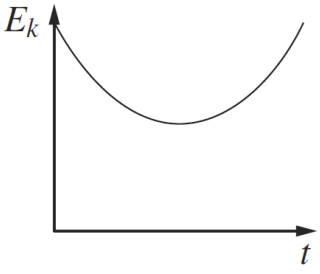
(B) 1.6×10^{22} N

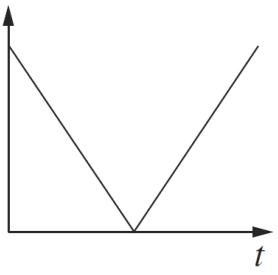
(C) 4.7×10^{26} N

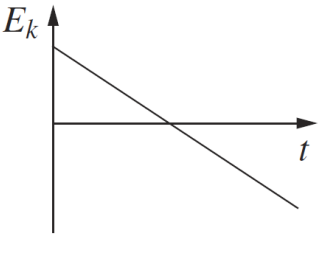
(D) 7.6×10^{28} N

12. A ball was thrown upward at an angle of 45°. It landed at the same height as thrown. Which graph best represents the kinetic energy of the ball during its time of flight?

(A)


(B)


(C)


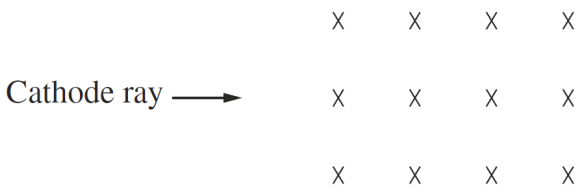
(D)


13. The acceleration due to gravity on the surface of Mercury is 3.6 m s^{-2}.
How much does a 2.0 kg brick weigh on Earth and on Mercury?

	Weight of brick on Earth	*Weight of brick on Mercury*
A.	2.0 kg	2.0 kg
B.	19.6 kg	7.2 kg
C.	19.6 N	19.6 N
D.	19.6 N	7.2 N

14. The diagram shows a cathode ray (a beam of electrons) entering a magnetic field.

An electric field is applied to cancel the effect of the magnetic field on the cathode ray.



Which row of the table correctly describes the direction of the applied electric field, and the direction of the force acting on the cathode ray as a result of the magnetic field?

	Direction of the electric field applied	*Direction of force as result of the magnetic field*
A.	↑	↑
B.	↓	↑
C.	↑	↓
D.	↓	↓

15. 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?

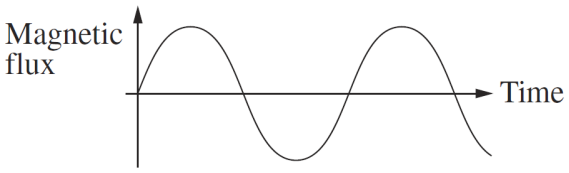
(A) The applied voltage must exceed the back emf in order to keep the motor running.

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

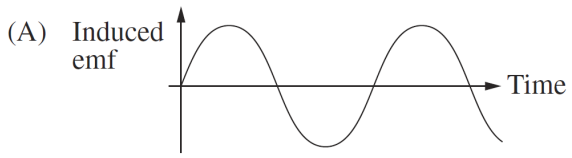
(C) The back emf is equal to the applied voltage because no work is being done by the motor.

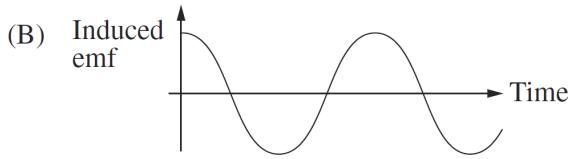
(D) The back emf must exceed the applied voltage to prevent the motor's speed from increasing.

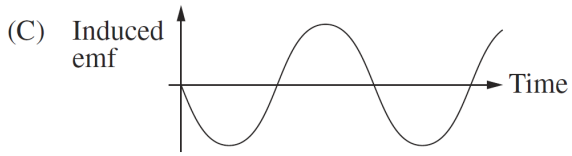
16. The graph shows variation in magnetic flux through a coil with time.

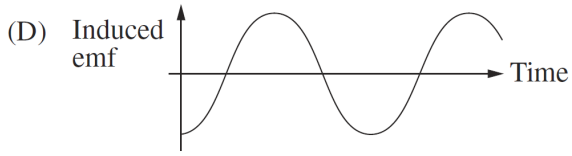


Which graph best represents the corresponding induced emf in the coil?

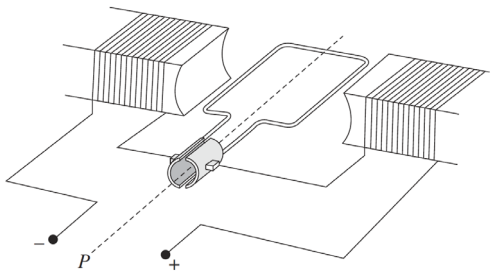
(A)


(B)


(C)


(D)


17. In the motor shown, the rotor spins clockwise, as viewed from point *P*, when connected to a DC supply

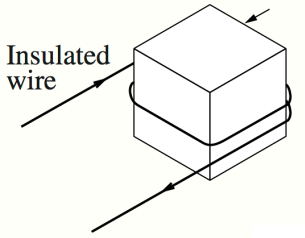


What happens when the motor is connected to an AC supply?
(A) There is no movement of the rotor.
(B) The rotor produces clockwise movement only.
(C) The rotor vibrates at the frequency of the AC supply.
(D) The rotor continuously turns half a rotation clockwise, then half a rotation anticlockwise.

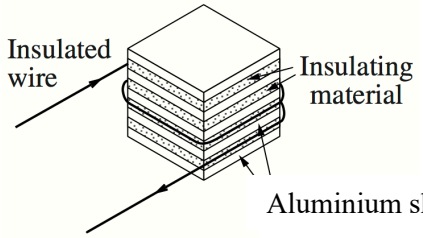
18. A transformer is to be designed so that it is efficient, with heating by eddy currents minimised. The designer has some metal and insulating material available to build the transformer core. The windings are to be made with insulated copper wire.

Which of the following designs transfers the most energy to the secondary coil?

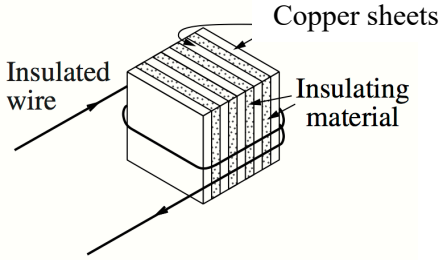
(A)



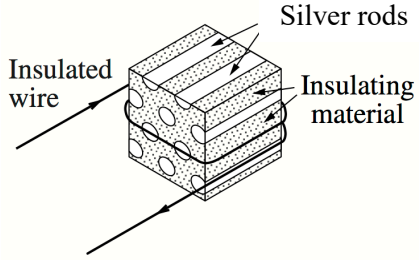
(B)



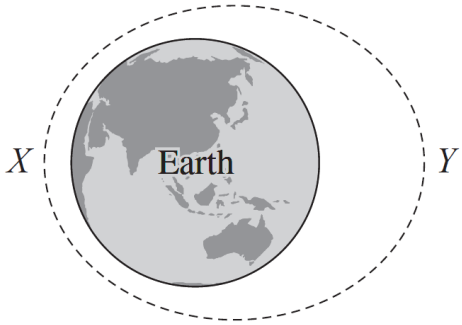
(C)



(D)



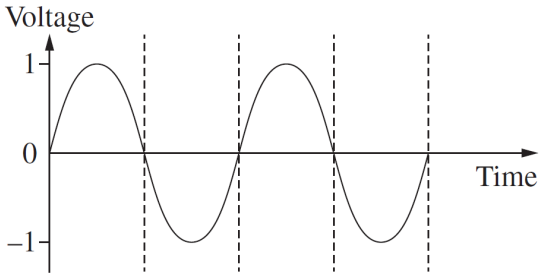
19. A satellite orbits Earth with an elliptical orbit that passes through positions X and Y.



In terms of absolute value only, which orbital positions would have least orbital speed V_{orb} and least gravitational potential E_P?

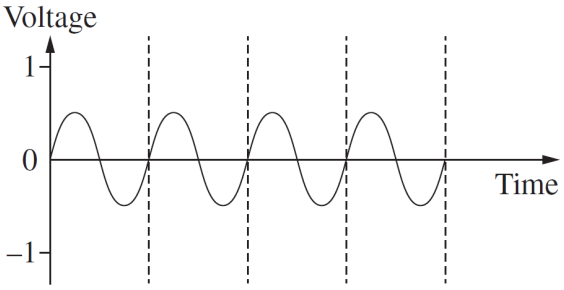
	Least V_{orb} (absolute value)	*Least E_P (absolute value)*
(A)	*X*	*X*
(B)	*X*	*Y*
(C)	*Y*	*X*
(D)	*Y*	*Y*

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.

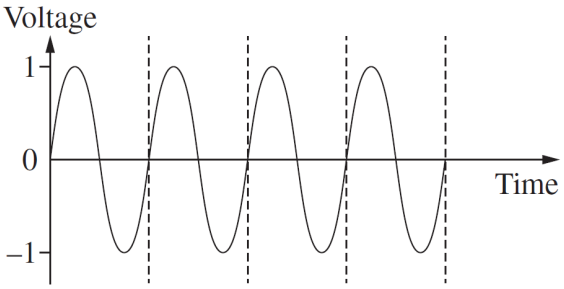


Which of the following graphs best represents the output if the rate of rotation is decreased to half of the original value?

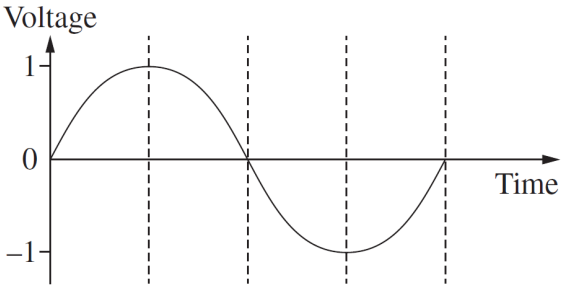
(A)



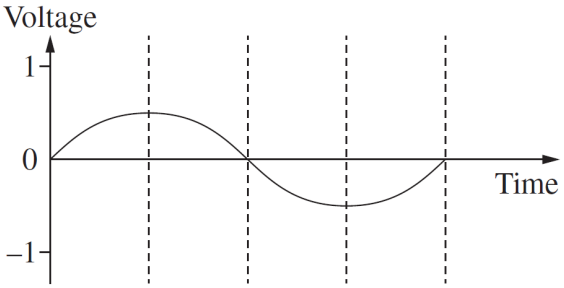
(B)



(C)



(D)



PART B – Short Answer (40 Marks)

Question 21 (6 marks)

The Earth has a mass of 5.97×10^{24} kg and a radius of 6370 km.

a Calculate the total energy that must be supplied to move a mass of 2000 kg from the Earth's surface at the equator to an altitude of 2.02×10^4 km. **2**

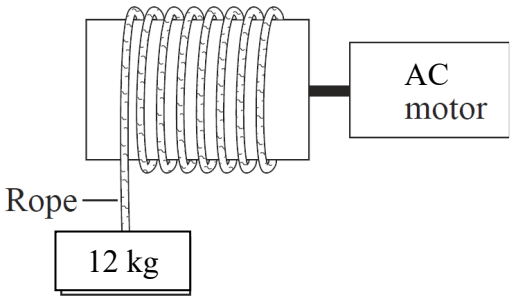
b Calculate the net force acting on the 2000 kg satellite in orbit around the Earth at an altitude of 2.02×10^4 km **1**

c For the satellite in part (b), calculate the period of this orbit to the nearest minute **3**

Question 22 (9 marks)

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

The mass of Mars is 6.39×10^{23} kg.



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 5 m from 3 376 203 m to 3 376 198 m from the centre of Mars.

a If it takes 8.97s to drop the mass through 5 m, calculate the makeshift generator's output current. **4**

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b The salvaged lighting system the astronaut plans to uses needs 120V. The astronaut has access to steel plating and wiring from the spacecraft. With the aid of a labeled diagram, outline an ideal device that the astronaut can build to use the light system **3**

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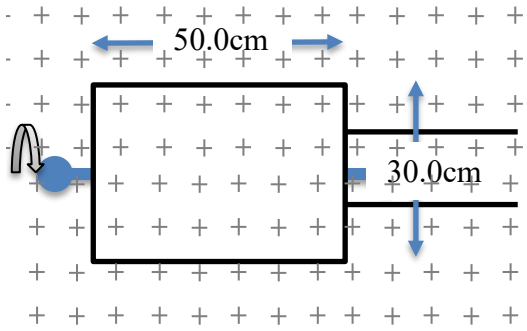
c The lighting system requires 600mA to operate. Justify whether the system can work **2**

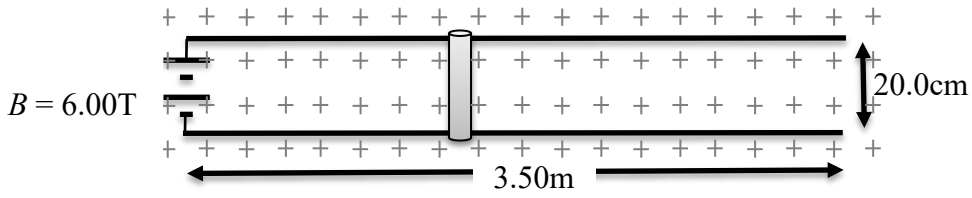
Question 23 (3 marks)

An electric generator consists of 100 turns of wire formed into a rectangular loop 50.0 cm by 30.0 cm placed entirely in a uniform magnetic field with magnitude B = 0.350 T. What is the maximum value of the emf produced when the loop is spun at 1000 RPM about an axis perpendicular to the magnetic field B **3**



Question 24 (8 marks)

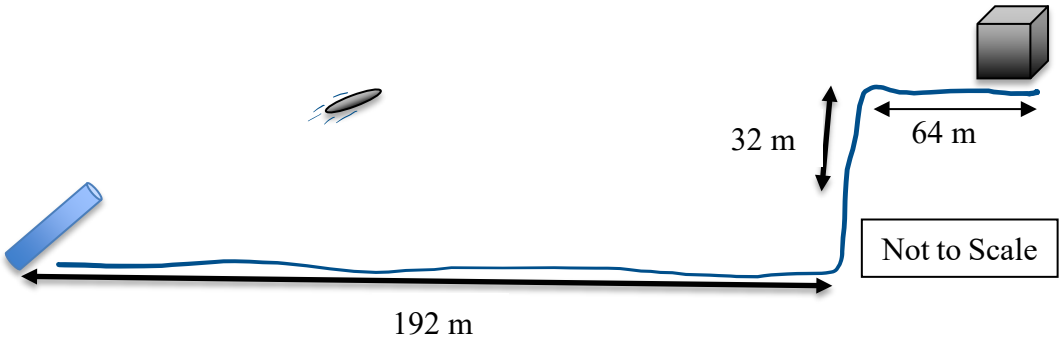
A rail gun is constructed out of two fixed parallel conductive rails 3.50 m long, firing a highly conductive projectile 20.0cm wide. The electromagnets produces a magnetic field of 6.00T.



a The rails are powered with 150.0A of current. Calculate the forces between the the conductors **2**

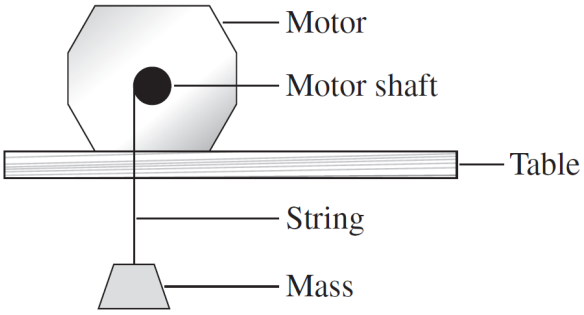
b A projectile of mass 0.500 kg is launched into the rails by a traditional propellant, with an initial velocity of u=20ms^{-1}. Calculate the final velocity of the projectile v leaving the rail gun **3**

c A projectile is launched from the rail gun at an angle of 40 degrees above the horizontal and 192 m from the cliff face as shown in the diagram. Calculate the speed of the projectile exiting the rail gun so that the projectile strikes the target, which is 64m from the cliff. (The target is 32 m above the launch point). **3**



Question 25 (5 marks)

A 0.065 kg mass is lifted at a constant speed by a DC motor. The motor has a coil of 120 turns in a 0.15 T radial magnetic field. The motor shaft has a diameter of 0.0040 m.

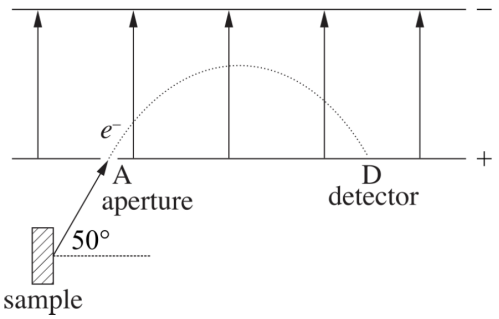


a Determine the minimum force needed to stop the mass from falling **2**

b The minimum current required to stop the mass falling is 0.065 A. Calculate the area of the motor coil. **3**

Question 26 (5 marks)

An electron is emitted from a mineral sample, and travels through aperture A between two charged parallel plates at an angle of 50° with a speed of 8.6×10^5 m s^{-1}. A voltage of 5.00kV is applied to the plates, which have a separation of 10.0cm



NOT TO SCALE

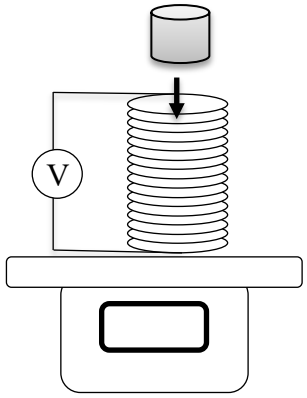
a Calculate the magnitude and direction of the force experienced by the electron inside the electric field. **2**

b The electron experiences a constant acceleration in the electric field and eventually strikes the detector, D. **3**

What is the time taken for the electron to travel from A to D?

Question 27 (4 marks)

A coil connected to an ideal voltmeter is set atop an electronic balance to measure its mass. A powerful rare earth magnet is rapidly lowered.



With reference to the variables involved, explain the readings on the balance and voltmeter **4**

Sydney Boys High School

Student Number:

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

correct

A ⊗ B ⊗ C ○ D ○

Start Here ➔ ○

1.	A○	B○	C○	D○		**11.**	A○	B○	C○	D○
2.	A○	B○	C○	D○		**12.**	A○	B○	C○	D○
3.	A○	B○	C○	D○		**13.**	A○	B○	C○	D○
4.	A○	B○	C○	D○		**14.**	A○	B○	C○	D○
5.	A○	B○	C○	D○		**15.**	A○	B○	C○	D○
6.	A○	B○	C○	D○		**16.**	A○	B○	C○	D○
7.	A○	B○	C○	D○		**17.**	A○	B○	C○	D○
8.	A○	B○	C○	D○		**18.**	A○	B○	C○	D○
9.	A○	B○	C○	D○		**19.**	A○	B○	C○	D○
10.	A○	B○	C○	D○		**20.**	A○	B○	C○	D○

Sydney Boys High School

Student Number:

Physics

April 2019
Half Yearly Cohort Task
Advanced Mechanics, Electromagnetics

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

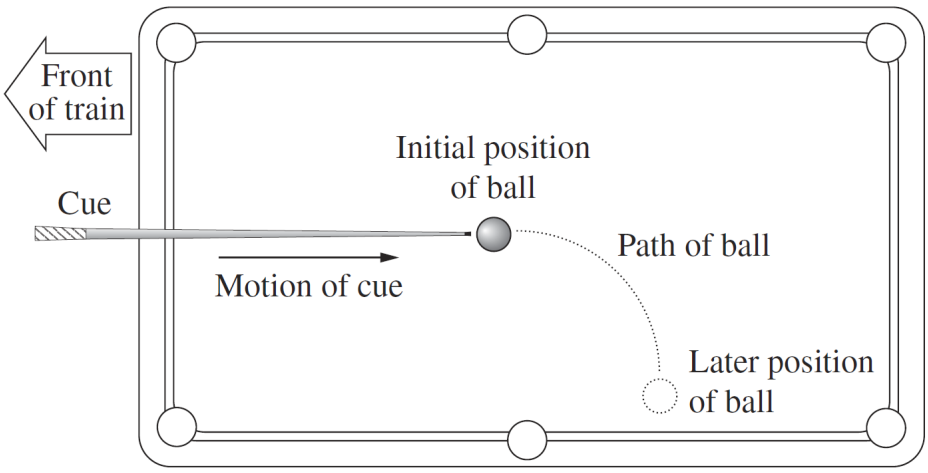
Total marks – 60

Part A – Multiple Choice
- 20 marks

Part B – Free Response
- 40 marks

PART A – Multiple Choice (20 Marks)

1. A passenger is playing billiards on a train that is travelling forwards on a level track. The ball takes the path shown when hit by the cue.



What can be inferred about the motion of the train?

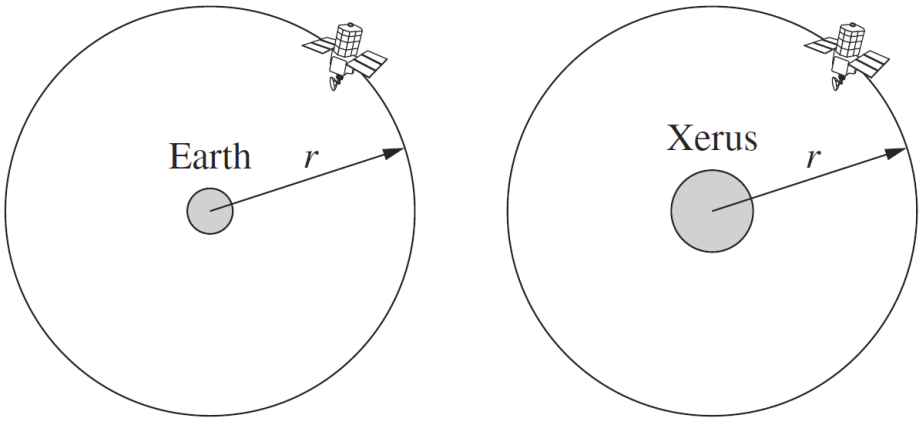
(A) It is turning left.

(B) It is speeding up.

(C) It is turning right.

(D) It is slowing down.

2. A satellite orbits Earth with period T. An identical satellite orbits the planet Xerus which has a mass four times that of Earth. Both satellites have the same orbital radius r.



What is the period of the satellite orbiting Xerus?

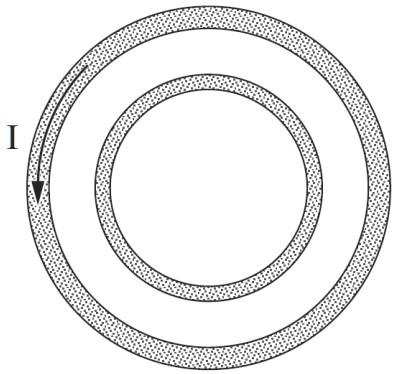
(A) $T/4$

(B) $T/2$ correct

(C) $2T$

(D) $4T$ wrong

3. Two copper rings lie in the same plane as shown.



An increasing current flows anticlockwise around the outer ring.
What happens in the inner ring?

(A) A decreasing clockwise current flows.

(B) A decreasing anticlockwise current flows.

(C) An increasing clockwise current flows.

(D) An increasing anticlockwise current flows.

4. Two masses have a gravitational force of 12 N between them.

If the distance between the masses is doubled, what would be the new gravitational force between them?

(A) 3 N

(B) 6 N

(C) 12 N

(D) 24 N

5. A ball is launched horizontally from a cliff with an initial velocity of u m s^{-1}. After two seconds, the ball's velocity is in the direction 45° from the horizontal. What is the magnitude of the velocity in m s^{-1} at two seconds?

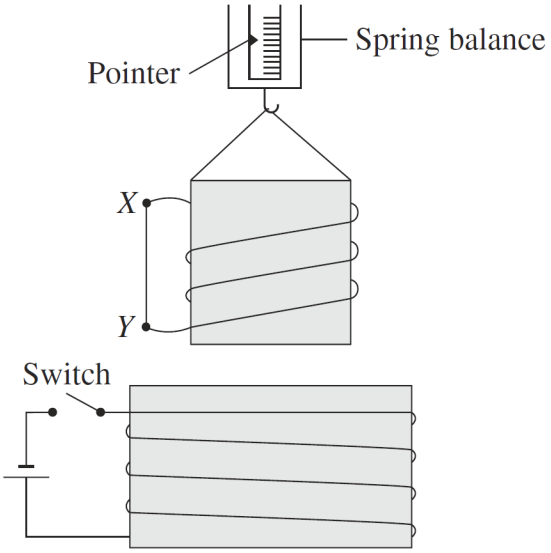
(A) u

(B) $1.5u$

(C) 19.6

(D) 27.7

6. 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

7. A satellite, initially in a low Earth orbit, is moved to a new orbit where its gravitational potential energy is half its initial value.

What is the gravitational force experienced by the satellite in its new orbit?

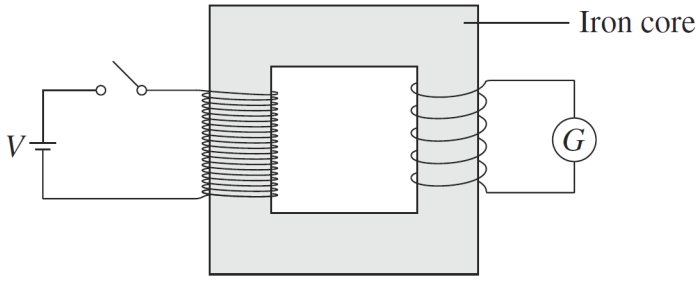
(A) Half the initial force

(B) Twice the initial force

(C) Four times the initial force

(D) One quarter the initial force

8. The diagram shows an ideal transformer.



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

How could the size of the deflection be increased?

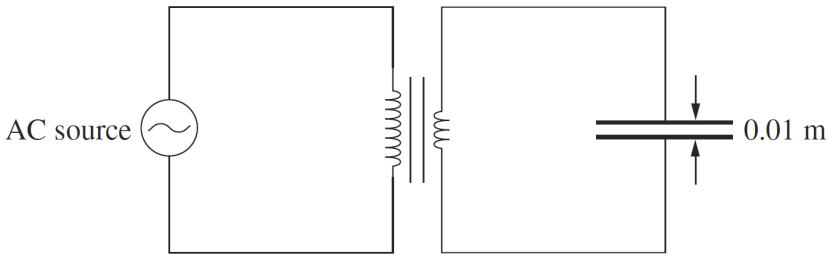
(A) Decrease the number of primary coils

(B) Decrease the number of secondary coils

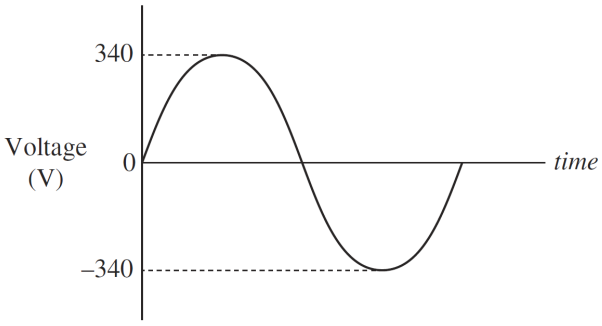
(C) Replace the iron core with a copper core

(D) Place a resistor in series with the galvanometer

9. An AC source is connected to a transformer having a primary winding of 900 turns. Connected to the secondary winding of 450 turns is a pair of parallel plates 0.01 m apart.



The AC input is shown in the graph.



What is the maximum field strength (in V m^{-1}) produced between the plates? (2017 20)

(A) 1.7

(B) 6.8

(C) 1.7×10^4

(D) 6.8×10^4

Use the data below to answer the next two questions.

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

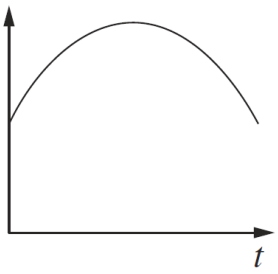
10. What is the orbital period of an Earth satellite having an orbital radius half that of the Moon?

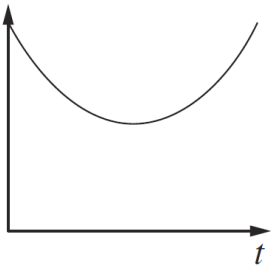
(A) 5.9×10^5 s
(B) 8.3×10^5 s
(C) 1.2×10^6 s
(D) 7.5×10^6 s

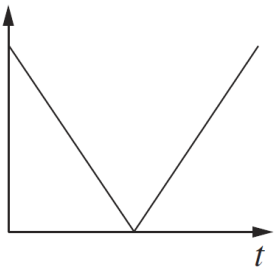
11. What is the centripetal force experienced by the Moon due to Earth's influence?

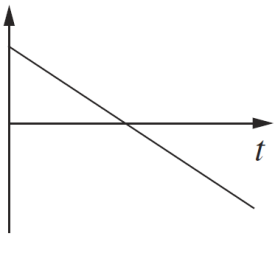
(A) 2.0×10^{20} N
(B) 1.6×10^{22} N
(C) 4.7×10^{26} N
(D) 7.6×10^{28} N

12. A ball was thrown upward at an angle of 45°. It landed at the same height as thrown. Which graph best represents the kinetic energy of the ball during its time of flight?

(A) 

(B) 

(C) 

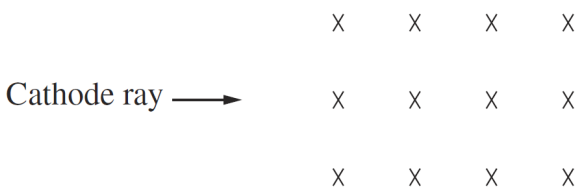
(D) 

13. The acceleration due to gravity on the surface of Mercury is 3.6 m s^{-2}.
How much does a 2.0 kg brick weigh on Earth and on Mercury?

	Weight of brick on Earth	*Weight of brick on Mercury*
A.	2.0 kg	2.0 kg
B.	19.6 kg	7.2 kg
C.	19.6 N	19.6 N
D.	19.6 N	7.2 N

14. The diagram shows a cathode ray (a beam of electrons) entering a magnetic field.

An electric field is applied to cancel the effect of the magnetic field on the cathode ray.



Which row of the table correctly describes the direction of the applied electric field, and the direction of the force acting on the cathode ray as a result of the magnetic field?

	Direction of the electric field applied	*Direction of force as result of the magnetic field*
A.	↑	↑
B.	↓	↑
C.	↑	↓
D.	↓	↓

15. 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?

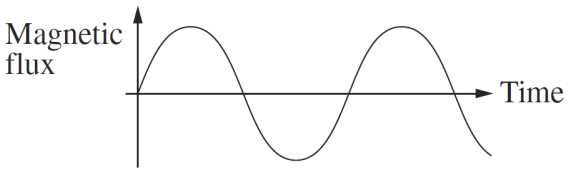
(A) The applied voltage must exceed the back emf in order to keep the motor running.

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

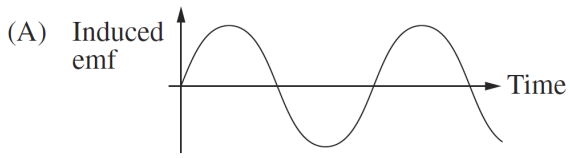
(C) The back emf is equal to the applied voltage because no work is being done by the motor.

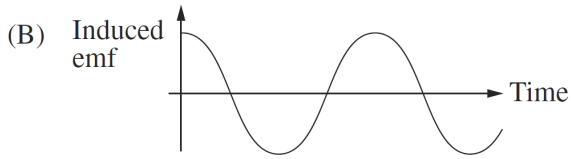
(D) The back emf must exceed the applied voltage to prevent the motor's speed from increasing.

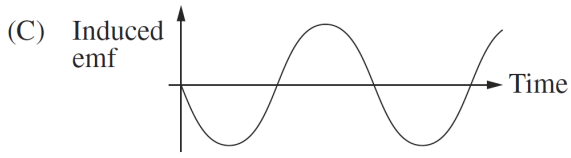
16. The graph shows variation in magnetic flux through a coil with time.

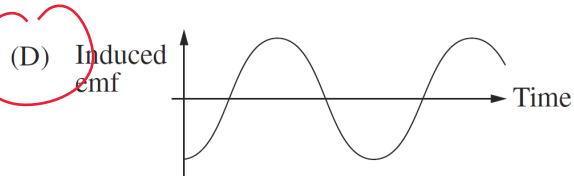


Which graph best represents the corresponding induced emf in the coil?

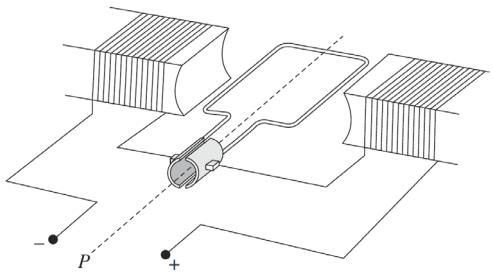
(A)


(B)


(C)


(D)


17. In the motor shown, the rotor spins clockwise, as viewed from point *P*, when connected to a DC supply

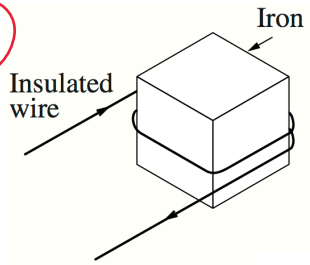


What happens when the motor is connected to an AC supply?
(A) There is no movement of the rotor.
(B) The rotor produces clockwise movement only.
(C) The rotor vibrates at the frequency of the AC supply.
(D) The rotor continuously turns half a rotation clockwise, then half a rotation anticlockwise.

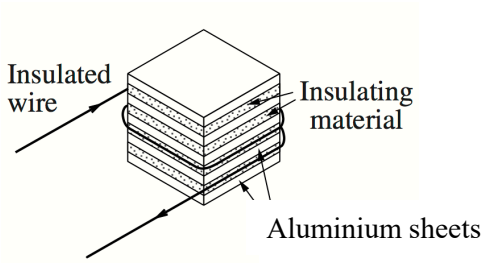
18. A transformer is to be designed so that it is efficient, with heating by eddy currents minimised. The designer has some metal and insulating material available to build the transformer core. The windings are to be made with insulated copper wire.

Which of the following designs transfers the most energy to the secondary coil?

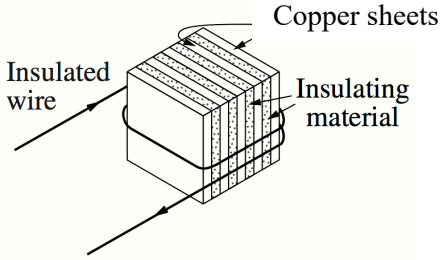
(A)



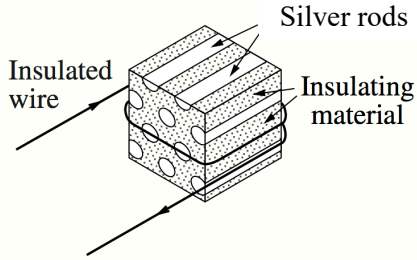
(B)



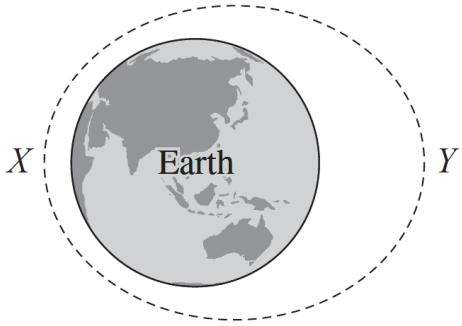
(C)



(D)



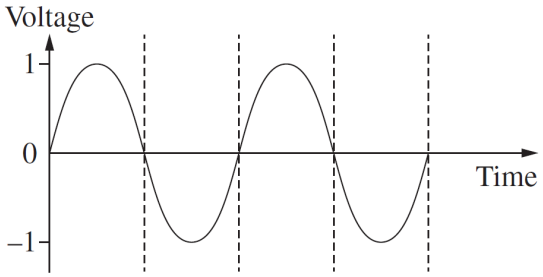
19. A satellite orbits Earth with an elliptical orbit that passes through positions X and Y.



In terms of absolute value only, which orbital positions would have least orbital speed V_{orb} and least gravitational potential E_P?

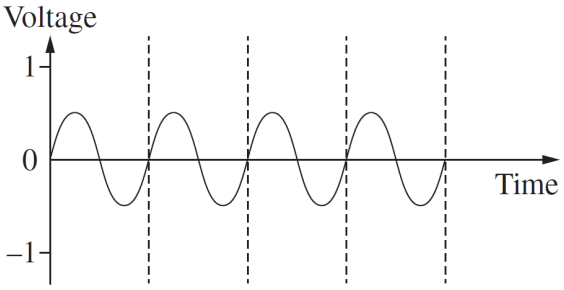
	Least V_{orb} (absolute value)	*Least E_P (absolute value)*
(A)	*X*	*X*
(B)	*X*	*Y*
(C)	*Y*	*X*
(D)	*Y*	*Y*

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.

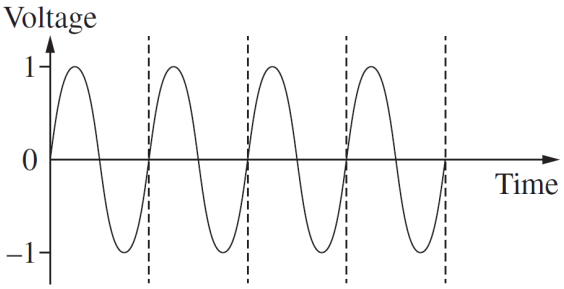


Which of the following graphs best represents the output if the rate of rotation is decreased to half of the original value?

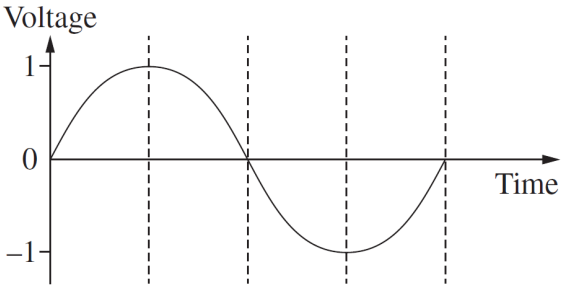
(A)



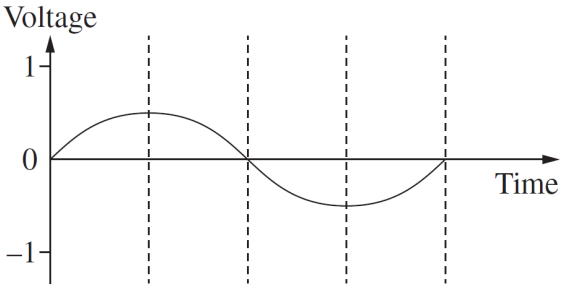
(B)



(C)



(D)



PART B – Short Answer (40 Marks)

Question 21 (6 marks)

The Earth has a mass of 5.97×10^{24} kg and a radius of 6370 km.

a Calculate the total energy that must be supplied to move a mass of 2000 kg from the Earth's surface at the equator to an altitude of 2.02×10^4 km. **2**

$$\Delta E = E_f - E_i$$

$$= (U+K)_f - (U+K)_i$$

$$= -\frac{GMm}{2r_f} - \left(-\frac{GMm}{r_i} + \frac{1}{2}mv^2\right)$$

$$= -\frac{6.67\times10^{-11}\times5.97\times10^{24}\times2000}{2\times\left(6370+2.02\times10^4\right)\times10^3} - \left(-\frac{6.67\times10^{-11}\times5.97\times10^{24}\times2000}{6370\times10^3} + \frac{1}{2}\times2000\times463.24^2\right)$$

$$= 1.10\times10^{11} \text{ J}$$

$$v_{surface} = \frac{s}{t} = \frac{2\pi r}{T} = \frac{2\times\pi\times6370\times10^3}{24\times60\times60} = 463.24 \text{ m s}^{-1}$$

	U (J)	K (J)	E (J)
intial	-1.250×10^{11}	2.146×10^{8}	-1.248×10^{11}
final	-2.997×10^{10}	1.499×10^{10}	-1.499×10^{10}
change	9.505×10^{10}	1.477×10^{10}	1.098×10^{11}

✓ correctly calculates at least 2 of U_i, K_i, U_f or K_f
✓ correctly calculates 4 of U_i, K_i, U_f or K_f

b Calculate the net force acting on the 2000 kg satellite in orbit around the Earth at an altitude of 2.02×10^4 km **1**

$$F = \frac{GMm}{r^2}$$

$$= \frac{6.67\times10^{-11}\times5.97\times10^{24}\times2000}{\left(\left(6370+2.02\times10^4\right)\times10^3\right)^2}$$

$$= 1128 \text{ N}$$

✓ correct answer with units

c For the satellite in part (b), calculate the period of this orbit to the nearest minute **3**

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

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

$$= \sqrt{\frac{4\times\pi^2\times\left(\left(6370+2.02\times10^4\right)\times10^3\right)^3}{6.67\times10^{-11}\times5.97\times10^{24}}}$$

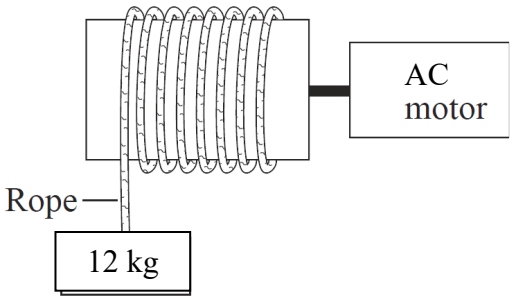
$$= 43124 \text{ s}$$

✓ use of correct equation(s)
✓ correct substitution
✓ answer with correct units

Question 22 (9 marks)

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

The mass of Mars is 6.39×10^{23} kg.



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 5 m from 3 376 203 m to 3 376 198 m from the centre of Mars.

a If it takes 8.97s to drop the mass through 5 m, calculate the makeshift generator's output current. **4**

Change in g over 5 m is negligible, so can use $\Delta U = mg\Delta h$.

$$F_g = mg = \frac{GMm}{r^2} \Rightarrow g = \frac{GM}{r^2} = \frac{6.67\times10^{-11}\times6.39\times10^{23}}{3376198^2} = 3.74$$

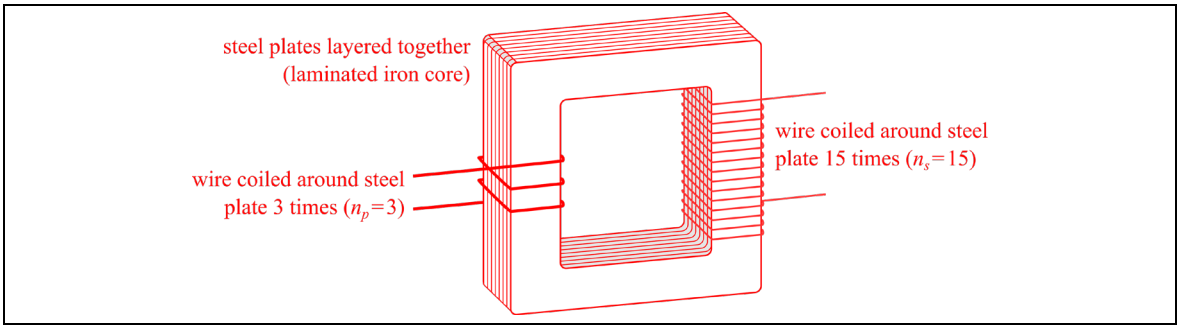
$$\Delta E = \Delta U = mg\Delta h = 12\times3.74\times5 = 224.3 \text{ J}$$

$$P_{fall} = \frac{\Delta E}{t} = \frac{224.3}{8.97} = 25.0 \text{ W}$$

$$P_{electrical} = VI \Rightarrow I = \frac{P}{V} = \frac{25}{24} = 1.04 \text{ A}$$

✓ correct use of equation(s)
✓ correct value for ΔU
✓ correct $\Delta U \rightarrow P$
✓ correct $P \rightarrow$ I

b The salvaged lighting system the astronaut plans to uses needs 120V. The astronaut has access to steel plating and wiring from the spacecraft. With the aid of a labeled diagram, outline an ideal device that the astronaut can build to use the light system **3**



1. Cut out holes from sheets of steel plating.
2. Layer sheets of steel plating to act as laminated core.
3. Wrap wiring three times around one side of steel sheets (acts as primary coil).
4. Wrap wiring fifteen times around other side of steel sheets (acts as secondarycoil)
5. Connect primary coil to 24V makeshift generator, thereby providing 120V output.

✓ labelled diagram includes a transformer
✓ outline of step-up transformer
✓ voltage ratio is 5

c The lighting system requires 600mA to operate. Justify whether the system can work **2**

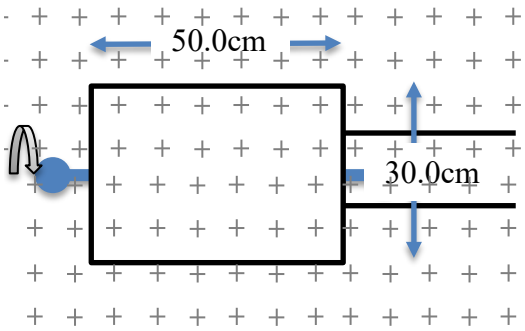
$P = VI = 120 \times 0.600 = 72$ W

Given that the makeshift generator only provides 25 W, the lighting system cannot use 72 W. Therefore, the system will not work.

✓ correct judgement, based on (a)
✓ correct mathematical support

Question 23 (3 marks)

An electric generator consists of 100 turns of wire formed into a rectangular loop 50.0 cm by 30.0 cm placed entirely in a uniform magnetic field with magnitude B = 0.350 T. What is the maximum value of the emf produced when the loop is spun at 1000 RPM about an axis perpendicular to the magnetic field B **3**



23) $\mathcal{E} = -n\frac{d\Phi}{dt}$

$= -n\frac{A(B_f - B_i)}{t}$

$= -100 \times 0.5\times10^{-3}(0-0.35)$ / 0.015

$= 350$ V or Wbs^{-1}

$f = 1000$ RPM
$= 16.7$ Hz
$T = 0.06$ s
$n = 100$
$A = 0.5 \times 10^{-3}$ m^2
$B = 0.35$ T
$\mathcal{E} = ?$

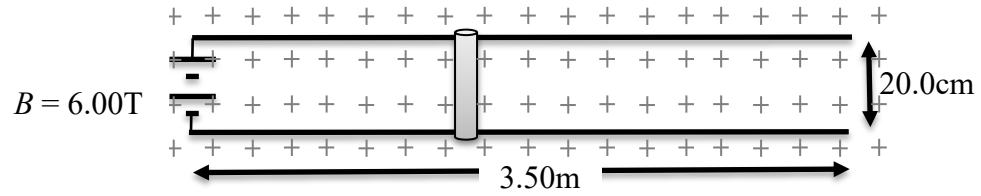
$t = \frac{1}{4} \cdot T = 0.015$ s

N.B
if used $t = 0.06$ (full turn)
$\mathcal{E} = 87.5$ V
or $t = 0.03$ (½ turn)
$\mathcal{E} = 175$ V
then max 2 marks

① correct eqn
① correct substitution including $t = 0.015$
① correct answer with units

Question 24 (8 marks)

A rail gun is constructed out of two fixed parallel conductive rails 3.50 m long, firing a highly conductive projectile 20.0cm wide. The electromagnets produces a magnetic field of 6.00T.



a The rails are powered with 150.0A of current. Calculate the forces between the the conductors **2**

24/
a)

$\frac{F}{l} = \frac{\mu_0}{2\pi} \cdot \frac{I_1 I_2}{d}$

$F = 2.0\times10^{-7} \times \frac{150 \times 150}{0.2} \times 3.5$

$= 7.88\times10^{-2}$ N repulsive

$\mu_0 = 4\pi \times 10^{-7}$

$\frac{\mu_0}{2\pi} = 2.0\times10^{-7}$

$I_1 = 150$ A

$I_2 = 150$ A

$d = 0.2$ m

$l = 3.5$ m

(1) answer with units

(1) repulsive

b A projectile of mass 0.500 kg is launched into the rails by a traditional propellant, with an initial velocity of u=20ms^{-1}. Calculate the final velocity of the projectile v leaving the rail gun **3**

24/
b)

$W = Fs = BIls$

$= 6\times150\times0.2\times3.5$

$= 630$ J

$KE_f = W + KE_i$

$= 630 + \frac{0.5\times20^2}{2}$

$= 730$ J

$v_f = \sqrt{\frac{2\times KE_f}{m}}$

$= \sqrt{\frac{2\times730}{0.5}}$

$= 54.0$ ms^{-1}

or

$F = BIl$

$a = \frac{F}{m} = \frac{BIl}{m}$

$= \frac{6\times150\times0.2}{0.5}$

$= 360$ ms^{-2}

$v^2 = u^2 + 2as$

$v = \sqrt{20^2 + 2\times360\times3.5}$

$= 54.0$ ms^{-1}

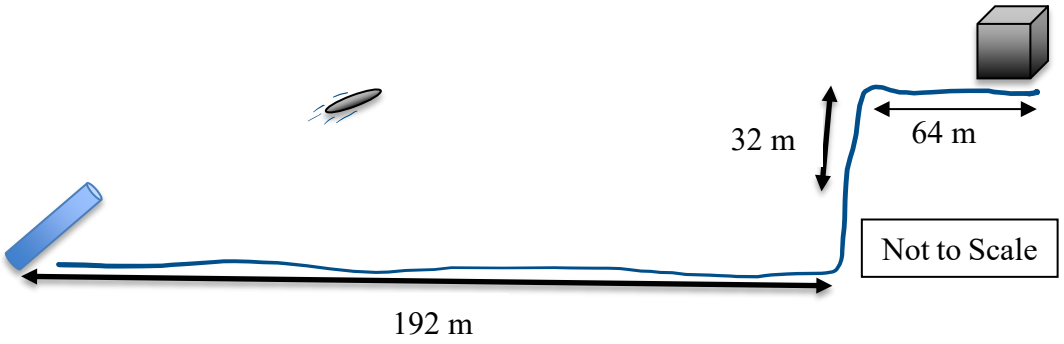
(1) mark a serious attempt showing some substitution

2 marks - serious attempt with correct equations but 1 error.

3marks - correct answer with units

24/

c A projectile is launched from the rail gun at an angle of 40 degrees above the horizontal and 192 m from the cliff face as shown in the diagram. Calculate the speed of the projectile exiting the rail gun so that the projectile strikes the target, which is 64m from the cliff. (The target is 32 m above the launch point). **3**



24

c) $u_x = u\cos\theta$ $\quad u_y = u\sin\theta$ $\quad \Delta x = 256\text{ m}$

$\Delta y = 32\text{ m}$

$a_y = -9.8\text{ ms}^{-2}$

$\theta = 40^\circ$

$\Delta x = u_x \cdot t$

$256 = u\cos 40^\circ t$

$u.t = \frac{256}{\cos 40^\circ}$

$\Delta y = u_y \cdot t + \frac{1}{2}a_y t^2$

$32 = \sin 40 \times \frac{256}{\cos 40^\circ} + \frac{1}{2}a_y t^2$

$= 256\tan 40 + \frac{1}{2}a_y t^2$

$t = \sqrt{\frac{2(32 - 256\tan 40)}{-9.8}}$

$= 6.108\text{ s}$

$\Delta x = u_x \cdot t$

$= u\cdot\cos\theta \; t$

$u = \frac{\Delta x}{\cos\theta . t} = \frac{256}{\cos 40 . \times 6.108} = 54.78\text{ ms}^{-1} = 55\text{ ms}^{-1}$

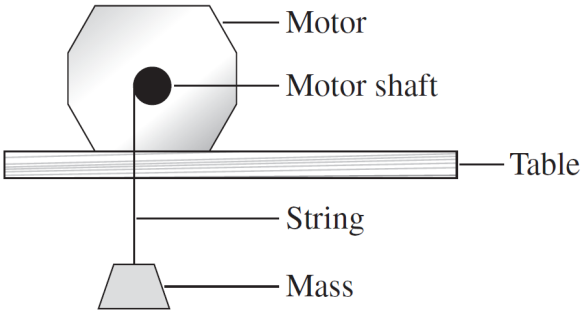
1 mark - some attempt at working

2 marks - correct process but incorrect answer & correct units. (must get an answe

3 marks - correct answer with units.

Question 25 (5 marks)

A 0.065 kg mass is lifted at a constant speed by a DC motor. The motor has a coil of 120 turns in a 0.15 T radial magnetic field. The motor shaft has a diameter of 0.0040 m.



a Determine the minimum force needed to stop the mass from falling **2**

$F=ma=mg$

$F = 0.065 \times 9.8 = 0.637N\ up$

- ✓ Correct value for F
- ✓ Correct direction (force is a vector quantity, direction is needed!!!)

b The minimum current required to stop the mass falling is 0.065 A. Calculate the area of the motor coil. **3**

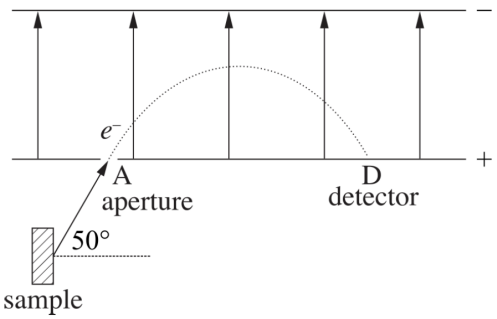
$\tau = nBIA = Fd$

$A = \frac{Fd}{nBI} = \frac{0.637 \times 0.002}{120 \times 0.15 \times 0.065} = 1.1 \times 10^{-3} m^2$

- ✓ Use of correct torque equation
- ✓ Correct value calculated (nb radius of motor, not diameter needed
- ✓ And correct Sig figs and units

Question 26 (5 marks)

An electron is emitted from a mineral sample, and travels through aperture A between two charged parallel plates at an angle of 50° with a speed of 8.6×10^5 m s^{-1}. A voltage of 5.00kV is applied to the plates, which have a separation of 10.0cm



NOT TO SCALE

a Calculate the magnitude and direction of the force experienced by the electron inside the electric field. **2**

$F = qE = 1.602 \times 10^{-19} \times \left(\frac{5 \times 10^3}{0.1}\right) = 8.01 \times 10^{-15} N \text{ DOWN or to the positive place}$

✓ Correct force calculated
✓ Correct direction (down or to the +ve plate)

b The electron experiences a constant acceleration in the electric field and eventually strikes the detector, D. **3**

What is the time taken for the electron to travel from A to D?

$F = ma, \quad a = \frac{F}{m} = \frac{8.01\times10^{-15}}{9.109\times10^{-31}} = 8.8\times10^{15}\ m s^{-2}$ (1)

$0 = u_y t + \frac{1}{2}at^2$

$= u\sin\theta t + \frac{1}{2}at^2$ (1)

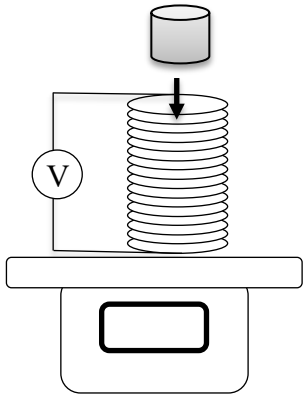
$= 8.6\times10^5 \sin 50\, t + 4.4\times10^{15} t^2$

$t = \frac{8.6\times10^5 \sin 50}{4.4\times10^{15}} = 1.5\times10^{-10}\ s$ (1)

✓ Correct force calculated
✓ Correct use of kinematic equations to calculate time
✓ Correct value of time

Question 27 (4 marks)

A coil connected to an ideal voltmeter is set atop an electronic balance to measure its mass. A powerful rare earth magnet is rapidly lowered.



With reference to the variables involved, explain the readings on the balance and voltmeter **4**

- ✓ Reading on voltmeter
- ✓ Correct explanation of reading on voltmeter (Faraday's law, not Lenz's Law
- ✓ No change on electronic balance
- ✓ Correct explanation of reading on balance due to ideal voltmeter with ∞ resistance OR Correct explanation if the coil was a closed conductive loop (mass reading increased, not decreased)