ATARNotes

HSC Physics Topics 1 & 2 Practice Exam

By blasonduo

- Working Time - **3 hours**
- Reading Time - **5 minutes** (not necessary, but may be needed)

- Total marks: **100**
- Section I - **20 marks**
- Section II - **80 marks**

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

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1 A satellite orbits Earth at an altitude of 250km. The astronaut was unable to sleep due to the bright lights and moved his spacecraft up an extra 50km, unknowingly changing his day and night cycle. What is the change in time the satellite experiences?

(A) 0.0169 hours

(B) -0.0169 hours

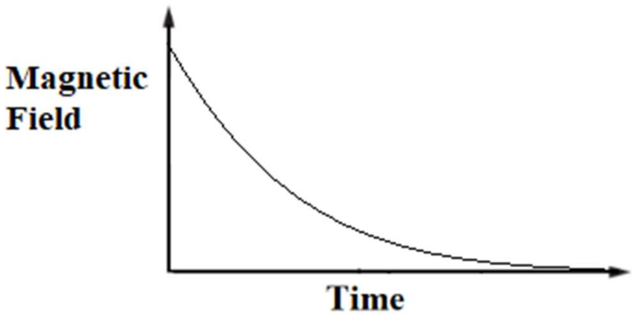
(C) 0.00343 hours

(D) -0.00343 hours

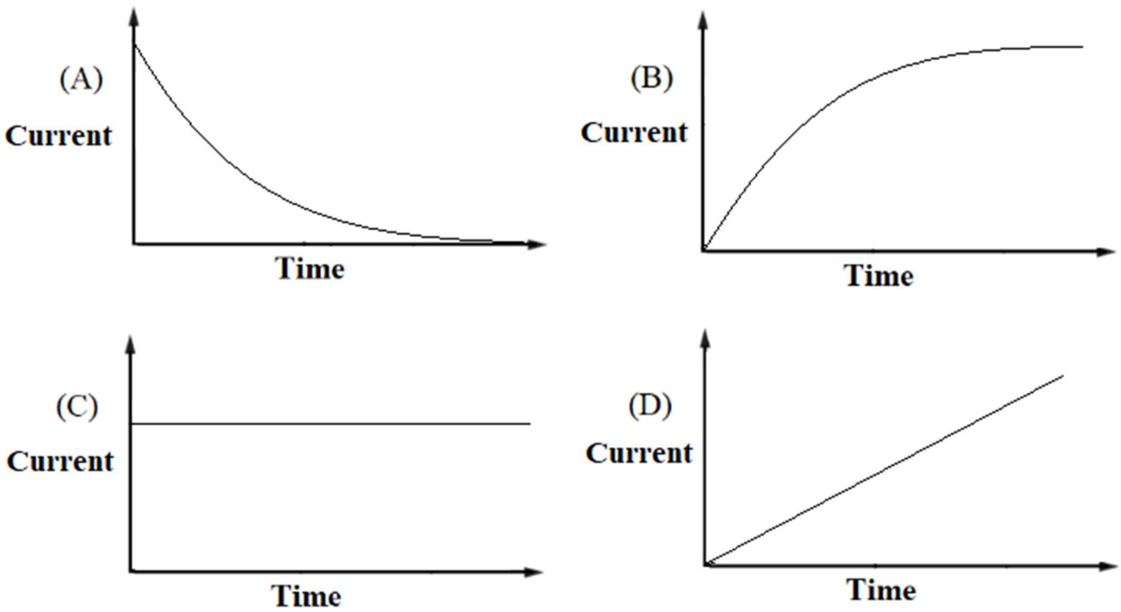
2 An electron is fired between two plates 5.00mm apart such that it experiences an acceleration that mimics Earth's (*9.80 ms^{-2} down*). What is the magnitude and direction of the electric field for this to occur?

(A) 2.79×10^{-13} $\frac{N}{C}$ Up
(B) 2.79×10^{-13} $\frac{N}{C}$ Down
(C) 5.57×10^{-11} $\frac{N}{C}$ Up
(D) 5.57×10^{-11} $\frac{N}{C}$ Down

3 A single loop wire is placed inside a variable magnetic field and is connected to a galvanometer. The magnetic field was changed and the following graph was recorded.



Which of the following graphs best portrays the induced current due to the change in magnetic flux?



4 A satellite is orbiting Earth. Which of the following would NOT change the orbital altitude of the satellite?

(A) The mass of the satellite increases

(B) The mass of Earth decreases

(C) The speed of the satellite increases

(D) The diameter of Earth decreases

5 Lucas is conducting an experiment to see if there is a relationship between how high a ball is dropped to how much energy is lost in the bounce.

In this experiment, which of the following could be the **dependent** variable?

(A) The type of material the ball is bounced off

(B) The type of ball being dropped

(C) The height the ball is released from

(D) The height the ball reaches after the bounce

6 A mass on a string is currently undergoing uniform circular motion. Which of the following is a correct statement about the system?

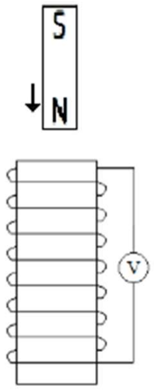
(A) The net force on the system is zero

(B) The net work done on the system is zero

(C) The net acceleration on the system is zero

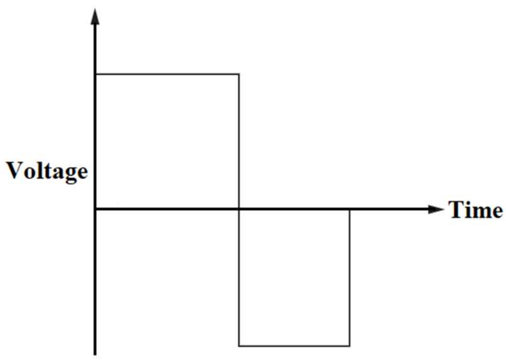
(D) The total energy on the system is zero

7 A magnet is dropped through a vertical solenoid, as shown in the diagram

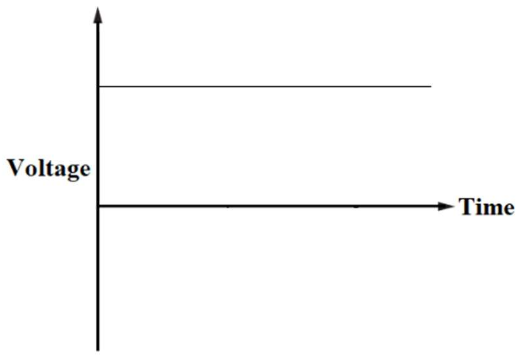


Which of the following graphs best represents the voltage output as the magnet falls through the solenoid?

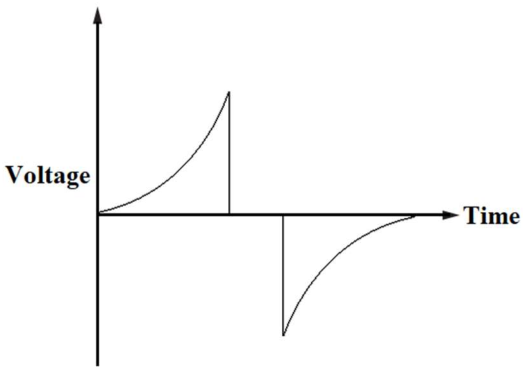
(A)



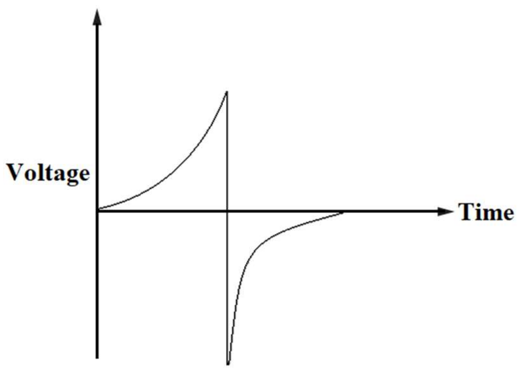
(B)



(C)



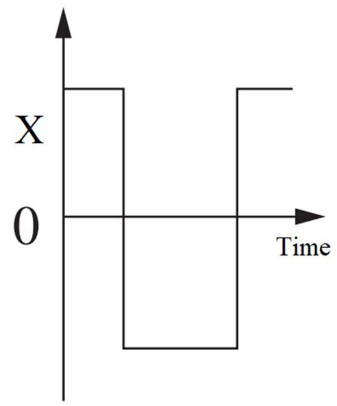
(D)



8 A distant planet has a mass M and diameter D. Spock stands on the surface of the planet inspecting rocks. Gru, in his ship orbiting the planet accidentally shoots the planet with his shrink ray such that the planet's diameter decreases by half, while the mass remained the same. Which row of the table correctly identifies the change in Gru's orbital velocity and Spock's gravitational acceleration?

	Orbital velocity	Gravitational acceleration
(A)	v	$4a^2$
(B)	$\frac{1}{\sqrt{2}}$ v	$2a^2$
(C)	$\sqrt{2}$ v	$4a^2$
(D)	$\sqrt{2}$ v	$2a^2$

9 The following graph shows an unknown quantity over time for a DC motor in a non-radial magnetic field.



Which of the following variables correctly identifies X in the graph?

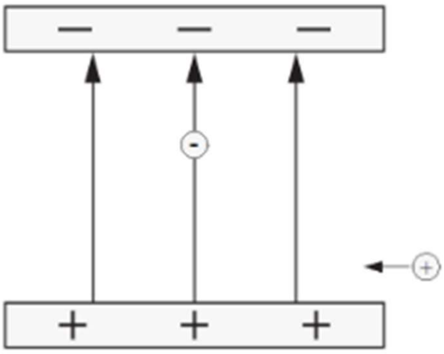
(A) Torque on one side of the coil

(B) Magnetic flux density

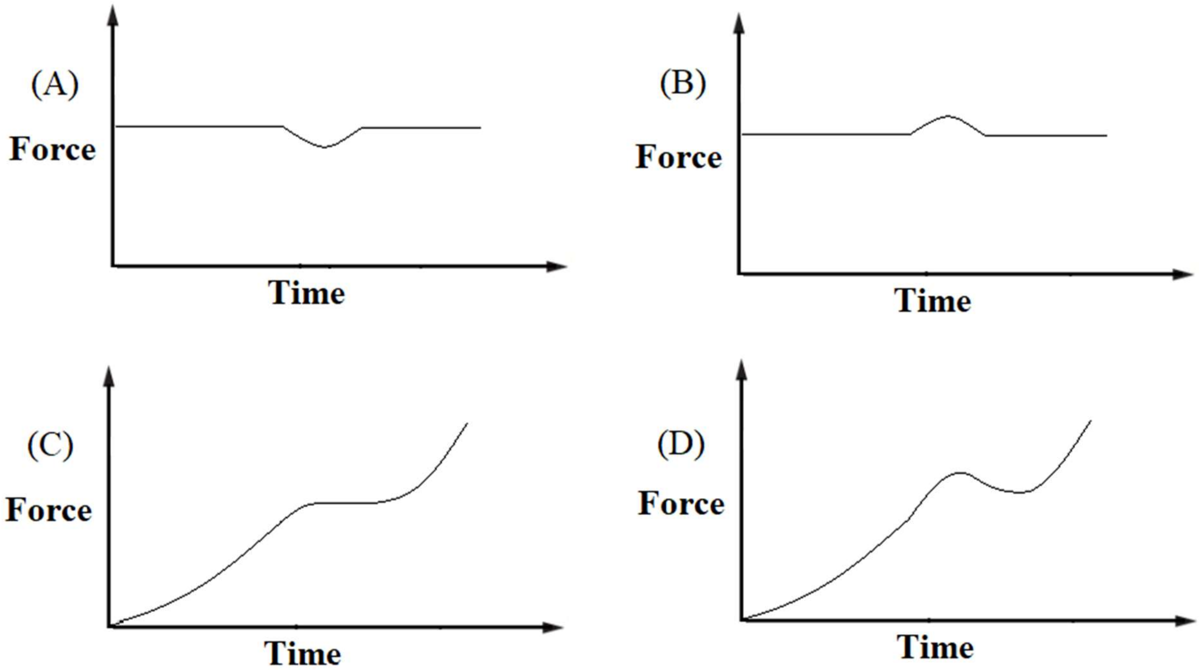
(C) Force on one side of the coil

(D) Net voltage

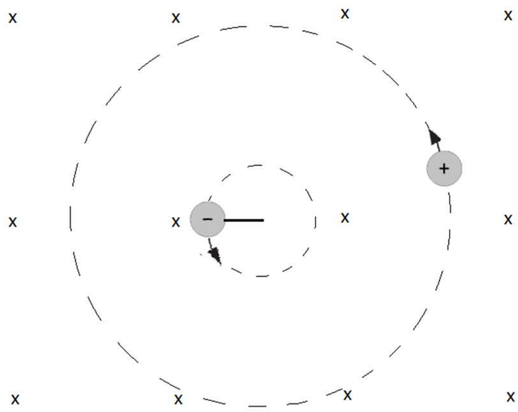
10 A proton is both simultaneously fired into an strong electric field with an electron permanently fixed in the middle as shown in the diagram below.



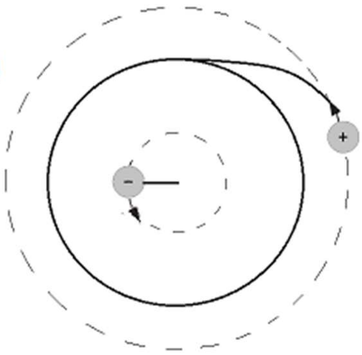
Which of the following graphs best represents the net force felt on the proton as it travels through the electric field?

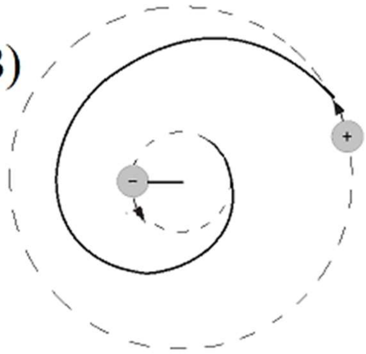


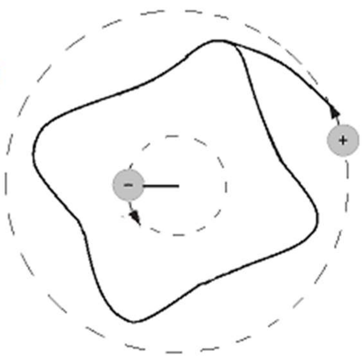
11 A proton is undergoing uniform circular motion due to an external magnetic field. An electron is then placed inside the circle, and attached to the center of both circles such that it can not move from it's circle. The diagram below shows the instantaneous moment the electron is placed into the field.

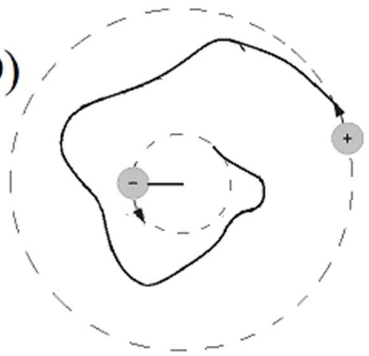


Which of the following options best describes the new motion of the proton?

(A) 

(B) 

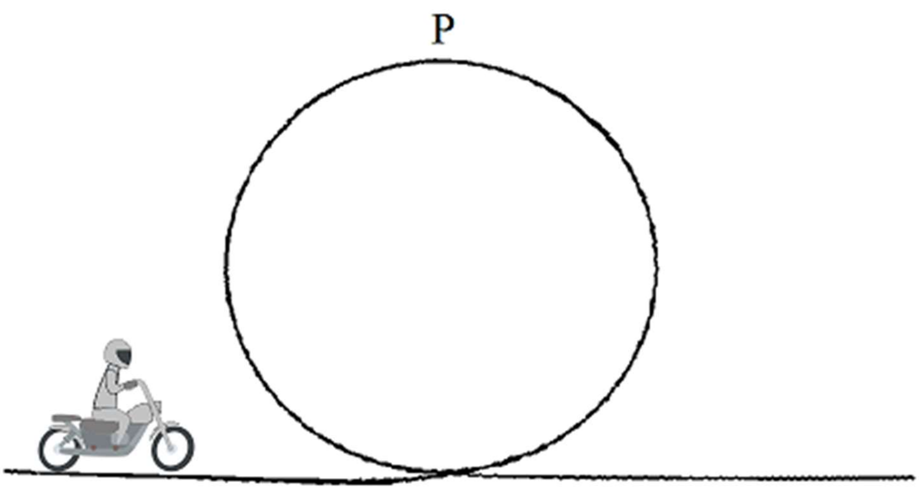
(C) 

(D) 

12 Earth has an orbital period of 365.256 years around the sun. What is the centripetal force Earth experiences during its orbit? Assume the orbit is circular and the mass of the sun is 1.99×10^{30} kg.

(A) 1.01×10^{28} N
(B) 1.96×10^{27} N
(C) 3.301×10^{27} N
(D) 3.56×10^{22} N

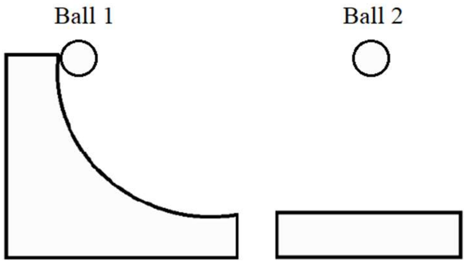
13 A motorcyclist with mass of 106.3 kg performs a stunt in which he rides his motorcycle around the inside of a vertical loop as shown in the diagram below. The loop has a radius of 4.59m and the motorcyclist travels at a constant speed of 8.76 m/s around the loop.



What is the force the motorcyclist acts onto the track at the top of the loop? (point P.)

(A) 2819 N
(B) 1042 N
(C) 735 N
(D) 122 N

Refer to the following diagram for questions **14** and **15**:



14 Both balls were dropped at the same time at the same height, assuming the blocks were fixed and friction is negligible, which of the following statements is correct?

(A) Ball 1 has more kinetic energy at the bottom of the blocks than ball 2

(B) Ball 2 has more kinetic energy at the bottom of the blocks than ball 1

(C) Both balls have the same kinetic energy at the bottom of the blocks

(D) It is impossible to determine with the data given

15 The blocks are now able to slide freely on a frictionless floor, and the balls were dropped a second time, again at the same time and same height. Which of the following statements is correct?

(A) Ball 1 has more kinetic energy at the bottom of the blocks than ball 2

(B) Ball 2 has more kinetic energy at the bottom of the blocks than ball 1

(C) Both balls have the same kinetic energy at the bottom of the blocks

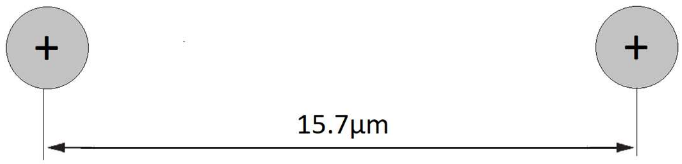
(D) It is impossible to determine with the data given

16 A charged particle with charge q and mass m travels between two parallel metal plates with surface area A and experiences an acceleration of 5m/s/s. A second particle has a charge 3q and mass 2m and travels through the SAME metal plates with surface area 4A.

What is the acceleration of the second particle?

(A) 0.3 ms^{-2}
(B) 7.5 ms^{-2}
(C) 13.3 ms^{-2}
(D) 30 ms^{-2}

17 Two protons are located a distance 15.7μm apart, as shown in the diagram below



One of the protons is then moved to a distance of 0.5mm away. By taking potential at an infinite distance to be 0, how much work was needed to move the particle?

(A) 0 J
(B) -1.42× 10^{-23}J
(C) 4.61× 10^{-25}J
(D) -4.61× 10^{-25}J

18 A car travels on a banked track with a very low coefficient of friction at an angle of θ with a velocity V such that the car does not move up or down the slope. It now rains such that the coefficient of friction between the tyre and the track decreases. Assuming the car still travels at a velocity V, which statement correctly identifies the new motion of the car?

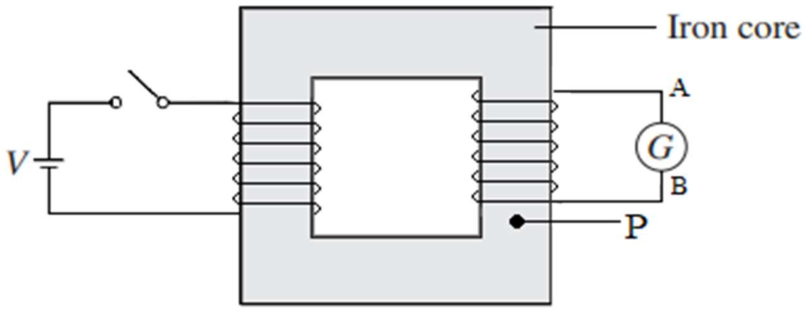
(A) The car begins to move up the track

(B) The car begins to slide down the track

(C) The car does not move up or down the track

(D) The car briefly starts to move up the ramp, but then slides down the track

19 The diagram shows an ideal transformer.



The switch is closed, and the secondary coil briefly carries a current.

Which option correctly identifies the secondary coil's brief current and magnetic field?

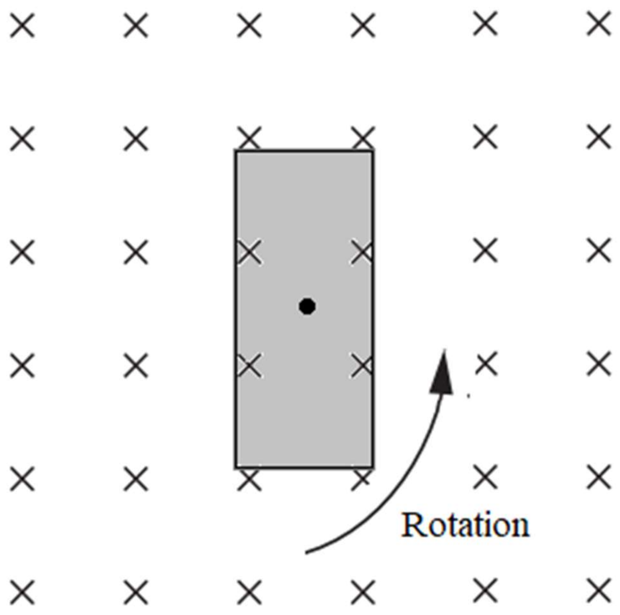
(A) Current flows from A to B. Point P sits at the solenoid's north pole

(B) Current flows from A to B. Point P sits at the solenoid's south pole

(C) Current flows from B to A. Point P sits at the solenoid's north pole

(D) Current flows from B to A. Point P sits at the solenoid's south pole

20 A conductive plate was placed inside a uniform magnetic field and rotated uniformly as shown in the below diagram.



Which of the following options correctly explains what occurs to the plate as it rotates?

(A) The constant rotation allows for a force on the electrons to move towards the center of the plate at different speeds, causing the induced emf

(B) As the outer edges of the plate spins faster than the middle of the plate, the difference in change of magnetic flux produces EMF to slow the plate down.

(C) The net induction is effectively 0 as any induced EMF produced on one side of the plate will be cancelled out by the eddy currents on the opposite side travelling in the opposite direction due to the law of conservation of energy

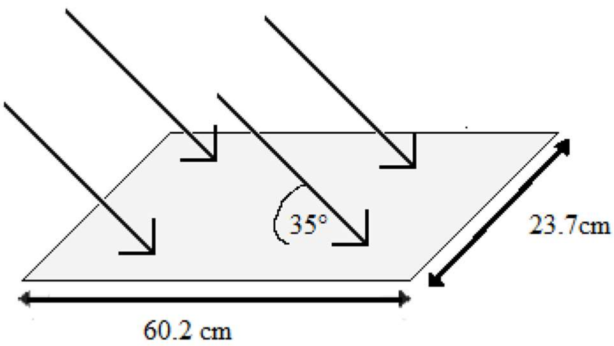
(D) There is no current flowing, as the change in flux at each infinitesimal point on the plate does not experience a change in magnetic flux

Section II

80 marks
Attempt Questions 21–33
Allow about 2 hours and 25 minutes for this section

Question 21 (4 marks)

a) The diagram shows a uniform magnetic field (B = 0.75T) interact with a metal plate. **2**



What is the magnetic flux through the plate?

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b) Referring to their definitions, Outline the differences between the terms magnetic field and magnetic flux **2**

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Question 22 (6 marks)

Jennifer conducted an investigation to measure Earth's gravitational acceleration through a pendulum with the equation:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

(a) Assuming gravity is 9.80 ms^{-2}, What length of string is needed to have a period of 4.00 seconds? **1**

(b) Jennifer made sure the mass always was released at the same height, and was always dropped, not pushed. She records her experimental results below:

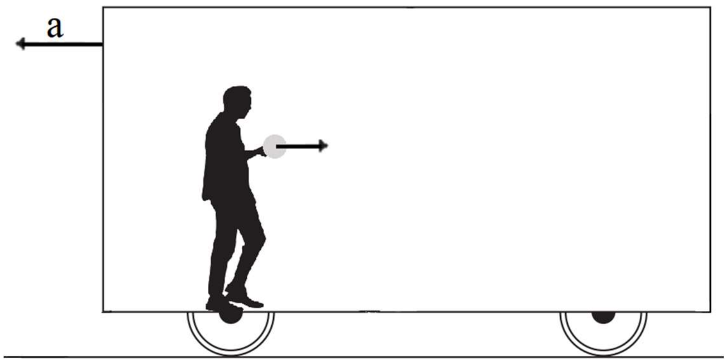
Trial	Length (cm)	Period (seconds)
1	39.6	1.28
2	39.6	1.33
3	39.6	0.44
4	39.6	1.37
5	39.6	1.31
6	39.6	1.42

What is Jennifer’s experimental gravitational acceleration? **2**

Identify TWO potential sources of error and alternatives to minimise them **3**

Question 23 (5 marks)

Blake throws a ball horizontally with a speed of 3.93 m/s to the right from a height of 1.60 m. At the same instant the ball is thrown, the train accelerates **from rest** away from the station at 4.74 m/s/s to the left.

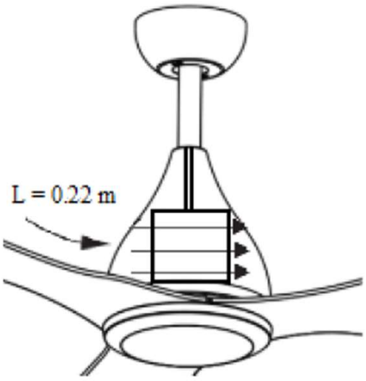


(a) How long does it take for the ball to hit the floor? **2**

(b) How far away does the ball land away **from Blake**? **3**

Question 24 (8 marks)

The following diagram shows a simplified (and frankly incorrect!) workings of a ceiling fan:



A fan manufacturer designs a fan that has a total mass of 5.5kg and carries a current of 10A in an anticlockwise direction seen in the diagram with lengths of wire of 0.22 m which have not been coiled. The fan has permanent magnets with strength of 0.21 T. They program it to reach a constant speed of $10ms^{-1}$ when turned on.

How long does it take for the base of the fan to reach $10ms^{-1}$ from rest? Ignore effects of rotational inertia and back EMF **3**

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A typical ceiling fan has blades that are 50cm long. Hence, or otherwise calculate the angular acceleration of the end of the blade **3**

A buyer wants to have their fan modified so it gets to $20ms^{-1}$ faster. Outline 2 modifications such that this can be accomplished. (Assume the fan design meant that supply current or mass can't be changed) **2**

Question 25 (6 marks)

Two students are undergoing a civilised discussion about Earth's interaction with the sun.

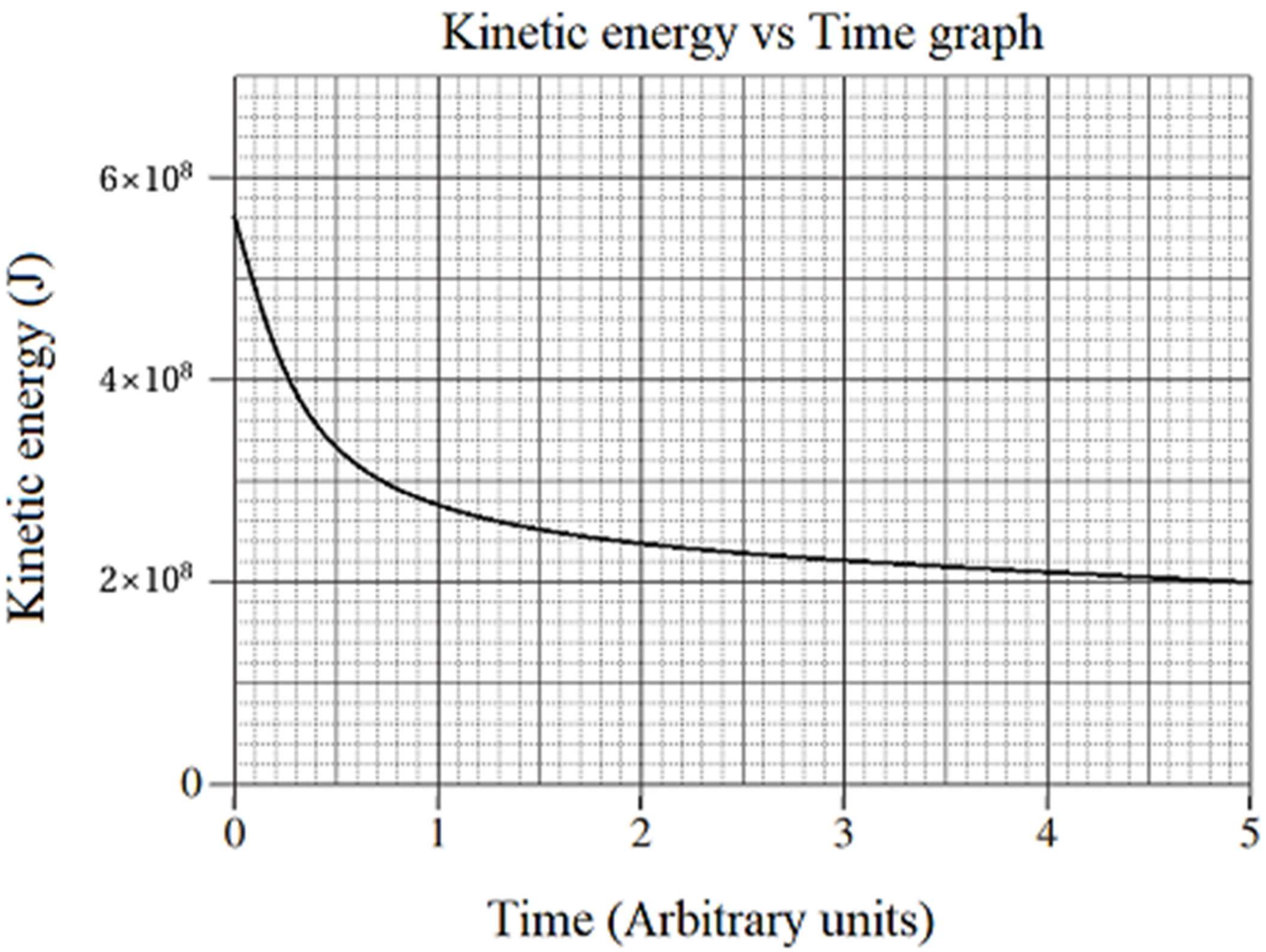
Student 1: By Newton's third law, the force the sun exerts on Earth must be equal to the force the Earth exerts on the Sun. As the sun is much heavier, we don't see it move.

Student 2: That is incorrect as it doesn't account for Earth's motion. Earth's net force is higher as we are undergoing circular motion while the sun does not.

Explain which student is correct. Use equations and related information to support your answer **6**

Question 26 (9 marks)

The following graph shows an object with mass of 10kg being thrown from the surface of a planet to an infinite point away. In the following questions, assume air resistance is negligible



(a) How much work was done to the object? **2**

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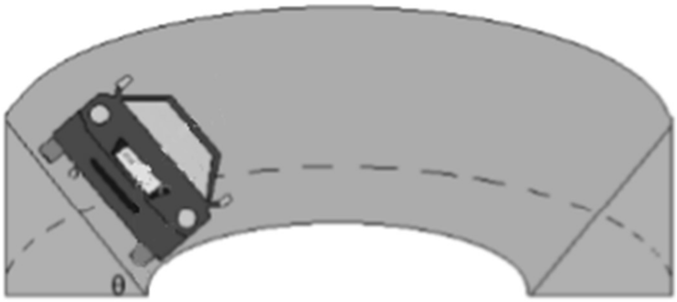
(b) What is the escape velocity of this planet? **2**

(c) The mass of the planet now suddenly doubles and an identical object is thrown. **3**
Will the object still make escape velocity? Show all working.

(d) Sketch a graph showing the total mechanical energy (kinetic + potential energy) of the object **investigated in question c)** **2**

Question 27 (5 marks)

A car travels around a circular track with a radius of 109 m . The race track is banked at a steep angle of 36.6°. The car and driver have a combined mass of m=1825 kg.



At what speed does the driver travel at to not move up or down the track? Assume friction is negligible **3**

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At the speed found in a), what is the normal force exerted by the track? **2**

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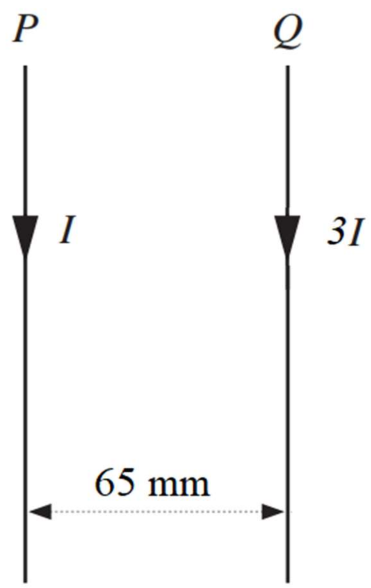
Question 28 (9 marks)

Two straight current-carrying conductors, P and Q carry currents *I* and *3I* respectively are fixed onto a table.



A third conductor, R, carries a current *I* in the opposite direction and is placed in between conductors P and Q. By assuming P = 0mm and Q = 65mm,

Where does R need to be placed such that the net force on it is 0? **4**

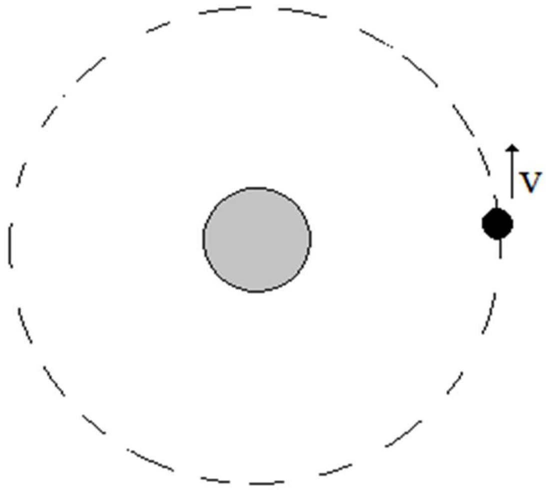
A student hypothesised that for the third wire to have a net force of 0, it must be placed between the two wires, no matter the current flowing through them.

Qualitatively justify whether the student's hypothesis is correct or not **2**

Explain the relationship between the definition of an ampere and Newton's third law of motion. **3**

Question 29 (4 marks)

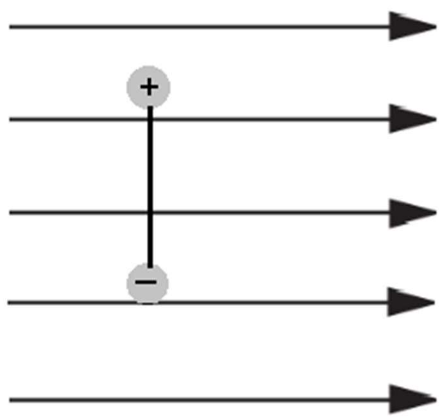
The ISS space station orbits Earth at a constant speed. Although both the astronaut and the space station have a force acting on them, the astronaut feels weightless and the space station moves perpendicularly to the force.



Explain why the weightlessness of the astronaut and the motion of the ISS do not contradict the laws of physics. **4**

Question 30 (6 marks)

An electric dipole is defined by the distance between a positive and negative charge. In the diagram below. An electric dipole, shown in the diagram has an electron and a proton separated at a distance of 0.00102 μm placed in an electric field of 731124 N/C. The particles are separated by a stiff massless wire so the particles cannot move closer to each other. In this question remember to mention direction.



What is the force acting on the proton? **3**

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Calculate the net torque on the dipole. **3**

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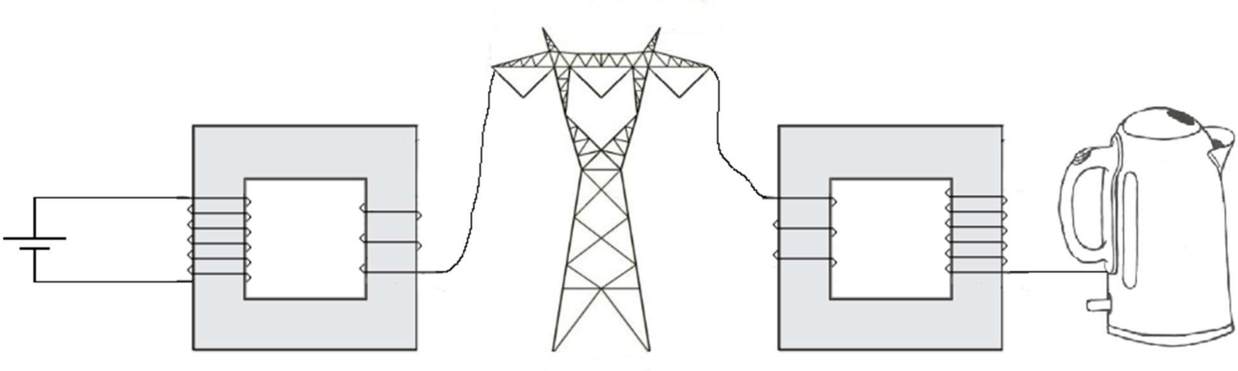
Question 31 (6 marks)

Danika designs a simplistic diagram to model the distribution of energy using transmission lines to household appliances



Identify THREE errors in Danika's diagram, explaining why it is an error, and how to fix it. **6**

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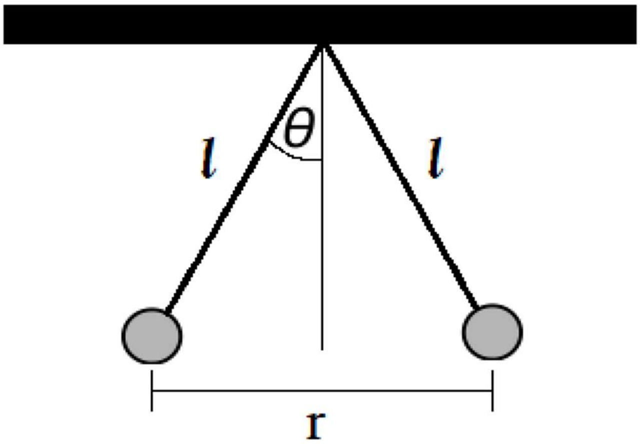
Question 32 (4 marks)

Compare the interaction of charged particles moving in magnetic fields and electric fields **4**

Question 33 (8 marks)

Two identical positively charged particles with charge q and mass m hang from the same point on the ceiling with equal lengths of string, l forming an angle, θ.



By using the small angle approximation: θ = sinθ = tanθ : **5**

Show that θ is given by the expression: $\theta = \sqrt[3]{\left(\frac{q^2}{16\pi\epsilon_0 l^2 mg}\right)}$

(b) Hence, or otherwise, in the case where $l = 31.8$ cm, $q = 1.72 \mu C$ and $m = 40.5$ g Calculate the separation, r **3**

END OF EXAM

ATAR NOTES

HSC Physics Half Yearly Exam

blasonduo

February 25, 2019

Multiple Choice Answers

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

10) **B** 11) **C** 12) **D** 13) **C** 14) **C** 15) **B** 16) **B** 17) **B**

18) **C** 19) **A** 20) **A**

Multiple Choice Detailed Answers

1) **A**

This question requires us to use the Kepler's 3rd law equation:

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

We need to remember here that this law assumes everything is a point mass, meaning we need to accommodate for the radius of Earth, otherwise it would assume the astronaut was very close to the centre of the earth (and giving us a period of 39 seconds, which by intuition is wrong). Using the formula sheet, we can get both our radius and mass of Earth:

$$T_{diff} = \sqrt{\frac{(300000+6371000)^3 4\pi^2}{6.67\times10^{-11}\times6\times10^{24}}} - \sqrt{\frac{(250000+6371000)^3 4\pi^2}{6.67\times10^{-11}\times6\times10^{24}}}$$

$$= 60.727 \text{ seconds}$$

converting this into hours...

$$hours = \frac{60.727}{60\times60}$$

$$= 0.0169 \text{ hours.}$$

As the astronaut went from a lower orbit to a height orbit, it makes sense how our answer is positive, as now it takes longer to make a full circle. The other multiple choice answers were based off if you did not account for the radius of Earth, or if you accidentally made the astronaut go to a lower orbit in the equation.

2) **C**

The electron needs a force downwards and electrons are attracted towards the positive plate, meaning the positive plate has to be down and negative plate to be up for this to work. By definition the electric field lines travel from the positive plate to the negative plate, meaning in this case, the electric field is going Up, eliminating B and D.

We need to find out the magnitude of the electric field, and from the formula sheet, we pull out the formula:

$$E = \frac{F}{q}$$

We know what the force on the electron will be, as we have both mass and acceleration, so our new formula will be:

$$E = \frac{ma}{q}$$

subbing in from the formula sheet and question...

$$E = \frac{9.109 \times 10^{-31} \times 9.80}{1.602 \times 10^{-19}}$$

$$E = 5.57 \times 10^{-11} NC^{-1}$$

3) **A**

From the graph given, we see that the rate of change of the magnetic field decreases dramatically. Induction is given by:

$$\epsilon = -N\frac{\Delta\phi}{\Delta t}$$

We see that as the change in magnetic flux tends towards 0, the EMF induced also tends towards 0. The only graph that does this is A.

4) **A**

Firstly, we'll look at this formula:

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

We can see from this, that radius will change if the mass of Earth changed, so this rules out B. Now we'll look at orbital velocity:

$$v = \sqrt{\frac{GM}{r}}$$

This also has radius in the formula, so changing the velocity of the satellite will change the orbital altitude, so C is wrong.

Finally, the key term in the question is altitude. If the Earth only shrinks, the orbital altitude will change, as altitude is measured from the surface of the planet, so D is wrong. This leaves us with A, in which no formula requires the mass of the satellite.

5) **D**

The dependent variable is the variable we are measuring. An experiment will always have an independent variable (the only variable we change) that will impact the results of the dependent variable. In this experimental case, both A and B are controlled variables, because changing these won't help in determining how much energy is being lost. It only shows a potential reason to why the energy is being lost, which is not the aim of Lucas's experiment. So A and B are incorrect.
C is our independent variable, it is what Lucas is changing, he is changing the height to see if that changes how much energy is lost, so it cant be C. Leaving D to be correct. For this experiment, Lucas will be measuring the change in height from the drop to the bounce height. The bounce height is what he is measuring, so is our dependent variable.

6) **B**

This one is a lot easier if you cross out the ones that are clearly wrong. In circular motion, there is a centripetal force acting towards the middle of the circle, meaning that there is a force (It's what keeps it in motion!) so A is wrong.

We know an object is accelerating if the velocity changes direction, which in circular motion, is always changing direction. Also, if there is a net force, there has to be a net acceleration.

Total energy relates to the sum of both kinetic energy and potential energy. The object is moving, so there's kinetic energy, meaning total energy has to be higher than 0, so D is wrong.

This leaves B to be the answer. The answer to this is because the formula for work is:

$$W = Fdcos(\theta)$$

In circular motion, the force and the direction the object is moving in is perpendicular, this makes the equation.

$$W = Fdcos(90)$$

$$= 0.$$

7) **D**

This is another application of the formula:

$$\epsilon = -N\frac{\Delta\phi}{\Delta t}$$

As the magnet falls, its speed gets faster and faster, making the change in magnetic flux get larger and larger. This means that the EMF induced gets larger and larger too, making A and B incorrect.

When the magnet falls through the tube, there will always be a change in magnetic flux, as it'll always continue to fall, having a long period of time where no EMF is induced can't be possible, so C is wrong.
This leaves D which has a steeper second spike. This makes sense has the magnet is still getting faster and faster, so it leaves the tube faster, having a higher second peak, which diminishes faster. This is what D shows, so it is correct.

8) **A**

This could be a very quick question if you realised that orbital velocity's formula is derived from the fact that the centripetal force is equal to the gravitational force due to its cicular motion:

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

Rearranging gives:

$$v = \sqrt{\frac{GM}{r}}$$

As mass of this planet does not change, as since orbital velocity is based off the centre of the planet, the radius at which Gru sits at does not change, so Gru's orbital velocity doesn't change. A is the only options that says that.
To test gravitational acceleration though, we use the formula:

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

then by using F = ma, we get

$$a = \frac{GM}{r^2}$$

Now, if the radius of the planet decreased by half:

$$a = \frac{1}{0.5^2}$$

$$a = 4$$

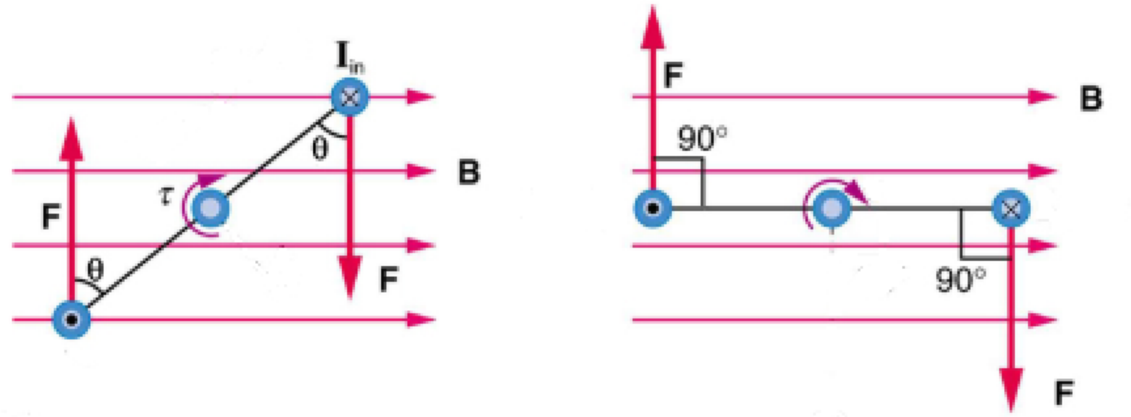
This is what we expected, so answer is A.

9) **C**

First, let's look at torque; torque is given by:

$$\tau = Fdsin(\theta)$$

Where F is force and d is distance away from axis and theta is the angle between the force and the armature. As the force will always be pointing in the same direction due to the right-hand palm rule, when the motor rotates, the angle decreases. By our formula, if theta changes, then our torque changes as a sine graph, meaning it can't be constant, so A is incorrect.



Magnetic flux density is constant, which is true for half the graph. If magnetic flux density were to be correct, the magnets would have to swap poles, which in a DC motor, is not what happens, so B is incorrect
For voltage, there is one main thing that tell us it's wrong, the question says the graph shows an output, for voltage, it is an input, its the electrical energy that gets converted to mechanical energy, so there should not be any voltage output.
So, now to why is force is the answer. The formula from the formula sheet for force here is given by:

$$F = BILsin(\theta)$$

Where the angle is between the magnetic field and current, as they are the only two vectors in the equation. For a DC motor, the current and magnetic field are always perpendicular, so the angle never changes. Every half rotation, the split commutators reverse the direction of current so the force flips every half rotation. From this, we can see the the force output would always be constant, and would flip to negative and back to positive as it spins, which is seen by the graph.

10) **B**

We are looking at net force for this question, and from the formula sheet, we are given the formula:

$$F = qE$$

Our charge on the proton definitely isn't changing, and nothing about the electric field is changing. This means that the force is constant assuming that the electron is not near the proton. So both C and D can't be right, as it suggests that force tends towards infinity

We know that a proton will act towards the negative plate, upwards. We also know that protons are attracted to electrons, and repelled by protons. In this case we have an electron, meaning there will be an attraction, an additional force upwards. Meaning on our graph, we should see an increase in net force, getting bigger as the electron gets closer. This follows B. (although in the graph, the bump probably shouldn't be symmetrical, but I tried my best, and it's the most correct :))

11) **C**

There are 2 main things that can help us in this scenario, firstly is how objects act in circular motion. This is due to the net force towards the centre of the circle. By placing an electron in the circle, the net force the proton experiences increases. A larger net force towards the centre in circular motion makes the object move inwards, to a smaller circle. This same thing happens with satellites if they move altitude, the closer to earth they are, the faster they are due to the increased gravitational force, but they do not fall to earth. The same thing happens in this question, the proton will move inwards to a new path, but it will never fall all the way to the electron. This means that B and D are incorrect.

Secondly, A would be correct if the electron was set stationary in the middle of the proton's circle, however, it undergoes circular motion of its own. This means that the electron will at times, be very close to the proton and very far away. Following our logic previously, this means that the protons motion would move between two circles, where the net force would be greatest and lowest. Although C does not that accurately portray what happens, as the electron would rotate much faster, meaning that the protons motion would definitely not be symmetric (It made it easier to draw, so that's why).

12) **D**

This question asks about centripetal force, which is a simple formula:

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

But first, we need to calculate both velocity and radius as we don't know them. Let's start with radius:

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

Subbing in the values, we get:

$$r = \sqrt[3]{\frac{(365.256 \times 24 \times 60 \times 60)^2 \times 6.67 \times 10^{-11} \times 1.99 \times 10^{30}}{4\pi^2}}$$

$$= 1.496 \times 10^{11} \text{meters}$$

Now we need to find velocity, using the formula:

$$v = \frac{2 \times \pi \times r}{T}$$

Subbing in values:

$$v = \frac{2 \times \pi \times 1.496 \times 10^{11}}{365.256 \times 24 \times 60 \times 60}$$
$$= 29786.254 \text{ m/s}$$

And now we can use the values in our centripetal force formula!

$$F = \frac{6 \times 10^{24} \times 29786.254^2}{1.496 \times 10^{11}}$$
$$= 3.56 \times 10^{22} \text{N}$$

13) **C**

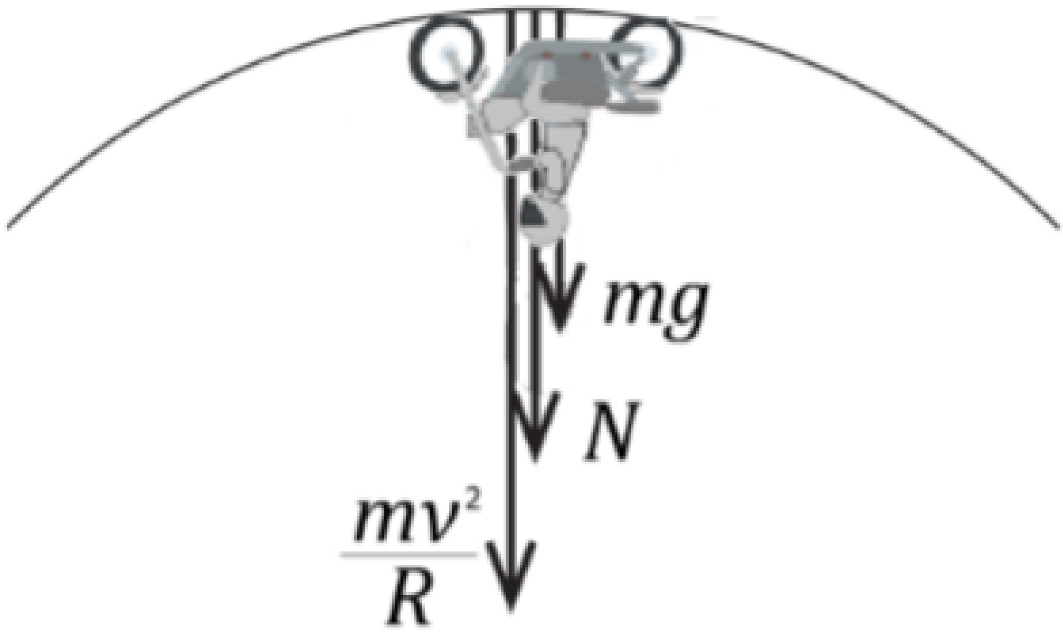
The resultant force, causes the circular motion and is given by:

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

According to Newton's third law, the force the motorcyclist acts on the track is equal to the normal force (N), so we can use that to answer this.

$$\Sigma F = ma$$
$$= \frac{-mv^2}{r} = N - mg$$

We can use this to solve for N, our normal force. We can use a diagram to make sure that our calculations are correct.



We see that the forces of gravity goes down (duh) and that the centripetal force at this instance is also down, to the center of the circle. This means that in our equation, both gravitational force and centripetal force should have the same sign, which they do which is correct!
As we know, the normal force is the force the floor acts on the person, in this case is also down, so when we do our calculation to find out the normal, we expect the answer to be negative.

$$N = \frac{-mv^2}{r} + mg$$

Now subbing in values:

$$N = \frac{-106.3 \times 8.76^2}{4.59} + 106.3 \times 9.8$$

$$N = -735N$$

This is negative, which is perfect, now we swap the sign as we want the upward force the motorcyclist acts on the track, and that's our answer.

14) **C**

As stated in the question, there are no non-conservative forces acting on the system, so all potential energy gets converted to kinetic energy, so both balls have the exact same kinetic energy at the bottom of the block.

15) **B**

This one is a little trickier, as the blocks are now able to move. Here we need to consider Newton's Law of motion. When ball 1 begins to fall and move to the right, it pushes onto the block. When it was fixed, the block just pushed back with an equal force to stop it from moving, but this time, it is able to move friction-less, so it is now unable to push back, making it move. This means that when it moves, a transfer of energy occurs between the ball and the block.
As the ball gave some of its kinetic energy away, it has now slowed down, meaning that ball 2 will reach the bottom of the block first.

16) **B**

This question uses the equation:

$$a = \frac{qE}{m}$$

The main thing to pick up here is that the surface area of the plates do not affect the acceleration of the particle, all it will do is affect for how long it accelerates, but the question doesn't want that. Also, E doesn't change between each particle, so we can just cancel it out to:

$$5 = \frac{q}{m}$$

Now, we consider our acceleration for the second particle:

$$a = \frac{3q}{2m}$$

Simplifying this to:

$$a = \frac{3}{2}(\frac{q}{m})$$

Since our first equation showed us that q/m was 5, we sub that in.

$$a = \frac{3}{2}(5)$$

$$a = 7.5ms^{-2}$$

17) **B**

This is a really tricky one, so well done if you got it right!

Firstly, we use our given work formula from the formula sheet:

$$W = qV$$

By definition, work done is equal to the change in potential (or kinetic!) energy. Which comes from the change in voltage (a potential difference) so our formula should look like:

$$W = q\Delta V$$

Now, all we have to do is figure out an expression for voltage, and this will be solvable. We know a formula for V is:

$$V = Er$$

It should be noted that the definition for the electric field is "a region around a charged particle or object within which a force would be exerted on other charged particles or objects." This is the exact same thing that electric plates are, basically a "row" of excess electrons. So this is why we are allowed to use this.
In this question, the values for r and d will be the same, and hence why the r is in the equation now; to make it simpler. We are also given the formula for E, so let's sub that in:

$$V = \frac{F \times r}{q}$$

Sadly, force doesn't get us anywhere either, but luckily we have an equation for that too, so let's sub that in:

$$V = \frac{q}{4 \times \pi \times \epsilon_0 \times r}$$

This works well! So let's sub it but into our work formula.

$$W = \frac{q^2}{4 \times \pi \times \epsilon_0 \times r}$$

We need to remember that we need it to be the change in voltage, so let's account for that:

$$W = q(\frac{q}{4 \times \pi \times \epsilon_0 \times r_f} - \frac{q}{4 \times \pi \times \epsilon_0 \times r_i})$$

Where ri is initial radius and rf final radius. We now have everything we need, so let's sub it all in!

$$W = 1.602 \times 10^{-19}\left(\frac{1.602 \times 10^{-19}}{4 \times \pi \times 8.854 \times 10^{-12} \times 0.0005} - \frac{1.602 \times 10^{-19}}{4 \times \pi \times 8.854 \times 10^{-12} \times 1.57 \times 10^{-5}}\right)$$

$$W = -1.423 \times 10^{-23} J$$

Yes, this equation could have been much easier to simplify, but to make it easier understand, I have left it as is. And luckily enough, the only answer that fits this is B, meaning we don't have to worry about the magnitude and if we did it right (although it has to be negative as there is less potential). Overall, this question is annoying to have in a multiple choice since it means only 1 mark, and it takes probably 2 minutes to do if you know what you're doing, but sometimes that's what it is, and leaving this type of question till the end might be a good alternative.

18) **C**

This question is relatively straight forward if you know the reasons of banked tracks. An object on a banked track does not use friction, but the velocity of the object to maintain its circular motion. If the velocity is too slow or too fast,the car will either slip and fall into the centre of the banked track or go over the top of the banked track.

In this case, velocity isn't changing, it's the friction. Since the car at that velocity did not move up or down the track, when it travels again, it again will not move regardless of friction.
The argument could arise that originally friction was what was stopping the car from sliding, but since the question states that the friction was already very low, its crude to assume that this is the case, making C most correct.

19) **A**

Again, a very tricky one. To figure out where the poles are in the primary coil, we use the right-hand rule, where you wrap your fingers around the direction of flow of current, and your thumb will point to the north pole. In this question, the north pole is upwards.

The iron-core than transmits this direction to the secondary coil, but due to the law of conservation and energy and induction, the secondary coil will produce a pole to oppose the change, ie a south pole. This makes the pole at point P for the secondary coil to be a north pole.

Again, by using our right-hand rule, this time in the other direction, we can figure out the direction of current, and from that we get from A to B, which is A.

20) **A**

This one is best solved by ruling out the incorrect statements.

B is wrong as it states that a difference of change in magnetic is what causes the EMF to be produced. This is wrong. All you need is a change in magnetic flux for it to work, the difference means nothing. Also, the equation:

$$\epsilon = -N\frac{\Delta\phi}{\Delta t}$$

Shows us that a constant change in magnetic flux allows for EMF to be produced, not a difference. The rest of the statement is there to trick you to pick it as it sounds about right with it slowing down.

C is wrong as Eddy currents would be needing to be going in the same direction to slow down the relative movement. If one of the eddy currents were going in the other direction, that would break the law of conservation of energy as it wouldn't be slowing it down, but speeding it up. Also, eddy currents are only generated by a change in magnetic flux, in this question, there is no change in magnetic flux.

D is similar to C, it claims that the change in magnetic flux and every point experiences no change in magnetic flux, which is true, however is also claims that because of this, no current flows. This is wrong due, as this question isn't referring to induction, but more just the force applied to the electrons due to their movement in the metal, shown by the formula:

$$F = q \times v \times B \times sin(\theta)$$

When we consider each infinitesimal point, that point is moving in a circular path, this movement can be considered using the formula on the formula sheet:

$$\omega = \frac{\Delta\theta}{\Delta t}$$

We can determine how fast the electron is moving based on it's radius. We know that the circumference of a circle is given by:

$$s = 2 \times \pi \times r$$

(Where the angle in radians is 2 π) We then use this as a fraction, to find a formula. (as we want the angle 2pi to be equal to one, making our circumference, and anything lower than that to be less than the circumference.

$$\Delta s = (\frac{\theta}{2 \times \pi}) \times 2 \times \pi \times r = r\Delta\theta$$

We have an expression for $\Delta\theta$, so let's put it in.

$$\Delta s = r \times \omega \times \Delta t$$

We know that velocity is the change of distance over the change in time, which we have if we divide both sides by Δt

$$v = r \times \omega$$

When we plug this into our force formula we get:

$$F = q \times \omega \times r \times B \times sin(\theta)$$

This shows that the radius away from the center of rotation affects the force on the electrons, this also shows why they would be travelling at different speeds. where they tend towards r = 0. This is what answer A suggests.
Now, I can hear you saying, "There is no way that is assessable" and I agree, There was no way I was expecting you to go through that type of working, and why you needed to cross out the ones that were definitely incorrect to come to the conclusion that only A could be correct. The main concept for this question is understanding that induction doesn't occur here because there is not change in magnetic flux, if you recognised that, it was a pretty straight forward.

SHORT RESPONSE ANSWERS

Question 21 (a)

Criteria	Marks
• Provides correct calculation of magnitude with correct units	2
• Provides correct calculation of magnitude OR • Provides correct units	1

We need to use the formula:

$$\Phi = B \times A \times cos(\theta)$$

The magnetic flux would be highest when it is directly hitting the plate (from above). So we need to know the angle from there, so we need to calculate that, (it's 55). Now we plug it into the formula:

$$\Phi = 0.75 \times 0.602 \times 0.237 \times cos(55)$$

$$\Phi = 0.061 \text{ Webers}$$

Question 21 (b)

Criteria	Marks
• Contrasts both magnetic flux and magnetic field with use of definitions	2
• Defines magnetic flux OR • Defines and magnetic field	1

Sample answer:
Magnetic field is defined by the area of space around a magnet in which a particle experiences a charge, denoted by the formula:

$$B = \frac{F}{qv}$$

Magnetic field is measured in Teslas.

Magnetic flux is defined by the amount of magnetic field lines passing through an imaginary area, denoted by:

$$\Phi = BA$$

Magnetic flux is measured in Webers.

Question 22 (a)

Criteria	Marks
• Provides correct solution	1

All we need to do is rearrange the formula and subsitute the values.

$$L = (\frac{4^2 \times 9.80}{4 \times \pi^2})$$

L = 3.97 meters

Question 22 (b)

Criteria	Marks
• Calculates average acceleration excluding outlier	2
• Calculates average acceleration including outlier or slight error in calculation	1

Average is given by:

$$avg = \frac{1.28 + 1.33 + 1.37 + 1.31 + 1.42}{5} = 1.342s$$

Note that the period "0.44" was excluded from the average, as it is a clear outlier, it would skew our final results, so it needs to be excluded. We now rearrange and sub in:

$$g = (\frac{4 \times \pi^2 \times 0.396}{1.342^2})$$

$$\text{g} = 8.68\ ms^2$$

Question 22 (c)

Criteria	Marks
• Outlines TWO sources of error with suitable alternatives	3
• Outlines ONE source of error with a suitable alternative	2
• States a potential error	1

Answers could include:

- Earth's gravity is not constant 9.80 but varies at location - use a reference
- The angle the mass was released from was too high, involving an extra force - make sure dropped at lower angles (This one wasn't expected as an answer, but it can be, so if you said it, you're correct)
- Human reaction - involve instruments that don't require it (eg laser times, cameras.. etc). Find time for 10 oscillations and divide by ten.
- Air resistance/wind - make object more aerodynamic and in a vacuum

Sample Answer: One source is Jennifer's reaction time, explaining the variance in period. To improve this, Jennifer could record the experiment and use this to record the period. Another source could be air resistance, explaining why the acceleration was lower. Undergoing the experiment inside a non draft room or a vacuum chamber and making the mass spherical if possible could improve results.

Question 23 (a)

Criteria	Marks
• Calculates correct answer with units	2
• Shows relevant steps towards the answer OR • Calculates correct answer with incorrect/no units	1

We have to use projectile motion formulae here, this one has variables we can find:

$$S = ut + \frac{1}{2}at^2$$

Since we are only considering the vertical motion right now, our initial velocity is 0, and S is our height off the ground. Now we rearrange to get the formula:

$$t = \sqrt{\frac{2S}{a}}$$

Subbing in:

$$t = \sqrt{\frac{2 \times 1.60}{9.80}}$$

t = 0.571 seconds

Question 23 (b)

Criteria	Marks
• Calculates correct answer with units	3
• Identifies that the distance Blake moved is needed, but included a minor mistake OR • Calculates correct answer with incorrect/no units	2
• Calculates distance travelled without including the distance Blake moved	1

As the ball is in the air, it is not affected by the acceleration of the train, so we can just use the formula:

$$S_x = ut$$

As Blake is affected by the acceleration, we need to find out how far he travels when the ball lands, as we want the distance from Blake to the ball. So we again use the formula:

$$S_x = \frac{1}{2}at^2$$

Again, it was from rest, so no initial velocity, also note that the formula formally should be negative as Blake is travelling in the opposite direction, but in the end, we are looking at a distance.
Now, we just add the two equations to find the total distance apart.

$$S_x = \frac{1}{2}at^2 + u_x t$$

Using t found in a), subbing in:

$$S_x = \frac{1}{2} \times 4.74 \times 0.5714285^2 + 3.93 \times 0.5714285$$

$$\text{distance} = 3.02 \text{ meters}$$

Question 24 (a)

Criteria	Marks
• Calculates correct answer with units	3
• Calculates answer without including the second wire OR • Calculates answer with a minor mistake	2
• Provides relevant steps/equations to answer question	1

This question asks about acceleration, which means force needs to play a part in our answer:

$$F = ma$$

The force is coming from the wires, so let's plug that formula and rearrange:

$$a = \frac{2BIL}{m}$$

It's important to note here that there are 2 wires undergoing a force, both helping in the acceleration of the object, hence why there is a 2 in our equation.

$$a = \frac{2 \times 0.21 \times 10 \times 0.22}{5.5}$$

$$a = 0.168 \text{ ms}^{-2}$$

Now we need to find time taken, which formally is given by:

$$v = u + at$$

Since initial velocity is 0, we rearrange and sub in:

$$t = \frac{v}{a}$$

$$t = 59.5 \text{ seconds}$$

Question 24 (b)

Criteria	Marks
• Gives a correct answer with direction	3
• Gives a correct answer or minor error	2
• Shows relevant formula / steps to solution	1

Angular acceleration is almost exactly like linear acceleration, where it is the derivative of velocity.

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

Luckily the change isn't too hard as the fan started from rest. We also know the formula for angular velocity:

$$\omega = \frac{v}{r}$$

$$\omega = \frac{20}{0.5}$$

$$\omega = 40\frac{\theta}{s}$$

We found time in a) so we substitute that in too.

$$\alpha = \frac{40}{59.5}$$

$$\alpha = 0.672\frac{\theta}{s^2}$$

Angular acceleration is a vector, so we need a direction. From our question, we are told that current flows in an anticlockwise direction, meaning we can use our right hand palm rule to find the direction of movement. This tells us the fan rotates anticlockwise.

Question 24 (c)

Criteria	Marks
• Gives 2 correct modifications	2
• Gives 1 correct modification	1

Restrictions in this question were made to make it slightly harder.

Answers could include:

- Increasing the strength of the magnets
- Coiling the wires - increase the amount of turns
- Make the lengths of wire longer

Question 25

Criteria	Marks
• Correctly identifies the correct statement by explaining both why each statement is correct/incorrect supported by equations	6
• Correctly identifies the correct statement by outlining both why each statement is correct/incorrect supported by equations	5 5
• Outlines main concepts of forces and relates them to the statements	3-4
• Shows some understanding about forces and motion	2
• Provides limited but relevant information	1

Answers also could include:

- Uses a smaller scale like a mass on a string to explain how centripetal motion works
- Relates to how it is impossible to have unequal forces in a closed system.
- Defining Newton's Law of gravitation
- Deriving different equations to show the relationship between centripetal and gravitational force
- Conservation of energy and how it relates

Sample Answer:
Student 1 is correct. As they state, the forces are equal. This can be seen by the formula:

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

This formula shows that no matter where we measure from (the sun or Earth) the magnitude will always be the same, just either in a positive or negative direction. This follows Newton's third law that states that every reaction has an equal and opposite reaction, that one body cannot exert a force on another without experiencing a force itself. This second part of student 1's statement is also correct as shown by:

$$F = ma$$

The sun's acceleration due to earth is much lower because of how much heavier it is.

Student 2's claim that the net force is higher because Earth is undergoing circular motion. This is untrue as the gravitational force the sun exerts on Earth is what causes the circular motion.

In fact, the formula for gravitational force is derived from both Kepler's law and centripetal force:

$$T = \frac{2 \times \pi \times r}{v}$$

Now we use our new period and sub it into Kepler's law

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

Now We flip our equations and add m and rearrange:

$$\frac{mv^2}{r} = \frac{GM \times 4 \times \pi^2 m}{4 \times \pi^2 \times r^2}$$

Now, we know the formula centripetal force, and we'll cancel some things to get:

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

This shows us that the gravitational force IS the centripetal force and not an additional force as student 2 suggests.

NOTE: The derivation above is quite tricky and is NOT needed. Just describing how centripetal force is the gravitational force and giving evidence for that is sufficient.

Question 26 (a)

Criteria	Marks
• Calculates correct answer with units	2
• Calculates answer with incorrect sign/units	1

By definition, work is defined by the change in kinetic energy, ie:

$$W = K_f - K_i$$

By looking at our graph, we can see our initial and final kinetic energies:

$$W = 2.0 \times 10^8 - 5.6 \times 10^8$$

$$W = \text{-}3.60 \times 10^8 \text{J}$$

The work is negative (note here that although a scalar, can have a negative value, as it depends on the direction of force. Scalars can be negative) as the force is acting against the displacement, also by the definition of change (final - initial)

Question 26 (b)

Criteria	Marks
• Calculates correct answer with units	2
• Calculates answer with a minor error	1

Kinetic energy is given by:

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

Remembering we want escape velocity, which means we want the change in kinetic energy, as the escape velocity is defined as the **minimum** velocity to completely leave a planets gravitational field so the difference in kinetic energy is what counts. So rearranging:

$$v = \sqrt{\frac{2\Delta K}{m}}$$

Subbing in:

$$v = \sqrt{\frac{2 \times 3.60 \times 10^8}{10}}$$

$$v = 8485\ ms^{-1}$$

Note here that our kinetic energy here is positive, and that's because it is based on motion, which can't be negative. (also not a vector).

Question 26 (c)

Criteria	Marks
• Correctly calculates and evaluates if object reaches escape velocity	3
• Showed steps to answer, including escape velocity and kinetic energy formula	2
• Provides relevant information	1

For this we need to have a reference to our escape velocity formula:

$$v = \sqrt{\frac{2GM}{r}}$$

As only mass is increasing, it means that our escape velocity will increase by $\sqrt{2}$

$$v = \sqrt{2} \times 8485$$

$$v = 12000\ ms^{-1}$$

Now all we have to do is compare the kinetic energy needed to make the object originally move 12000 ms^{-1} with the kinetic energy it receives on the graph. So let's see how much energy is needed for the object to originally have 12000 ms^{-1}:

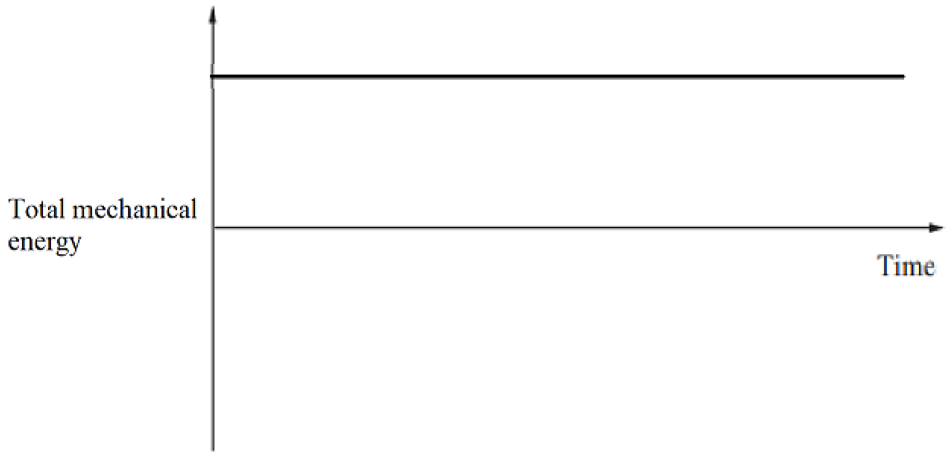
$$K = \frac{1}{2} \times 10 \times 12000^2$$

$$K = 7.2\times10^8\text{J}$$

We see from our graph that the maximum kinetic energy the object ever gets is 5.6×10^8J
Which is not enough, so NO, the object will not make escape velocity

Question 26 (d)

Criteria	Marks
• Draws a graph with both correct features	2
• Draws a graph that is strictly positive OR • Draws a graph that is a straight horizontal line	1

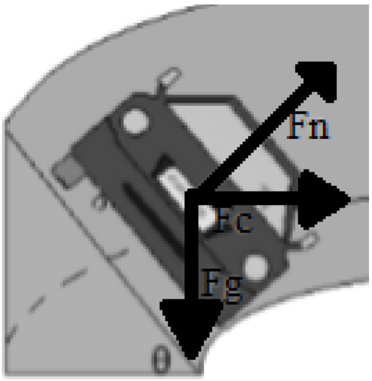


Remember that total mechanical energy is defined as to sum of the objects potential and kinetic energy. As kinetic energy decreases, potential energy increases by the same amount.

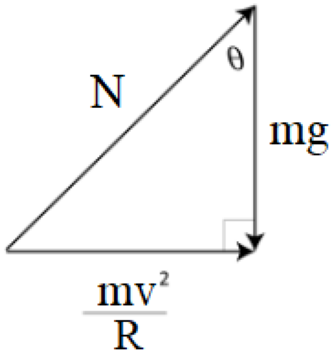
Question 27 (a)

Criteria	Marks
• Correctly calculates answer with units	3
• Calculates answer with a minor error showing understanding of the relationship between centripetal force and gravitational force	2
• Shows relevant steps/formulae	1

We know that with any object moving in a circle uniformly, the object travels in a circle at a constant speed due to a force accelerating it inwards, which is called centripetal force. We also know that the force of gravity acts on this car;



Let's make this a bit more neater to look at.



From trig, we know that:

$$\tan\theta = \frac{opposite}{adjacent}$$

so let's sub that in:

$$\tan\theta = \frac{mv^2}{rmg}$$

Make v the subject:

$$v = \sqrt{rg\tan\theta}$$

$$v = \sqrt{109 \times 9.8\tan(36.6)}$$

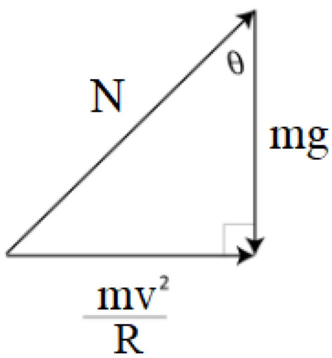
$$v = 28.2 \text{ ms}^{-1}$$

There are other ways to do it, similar to this, all valid!

Question 27 (b)

Criteria	Marks
• Correctly calculates answer with units	2
• Calculates answer with a minor error showing understanding of the Normal's relationship between centripetal force and gravitational force	1

This equation becomes pretty easy once we know the velocity, by using our triangle again:



Again, using Pythagoras's theorem:

$$N^2 = (mg)^2 + (\frac{mv^2}{r})^2$$

$$N = \sqrt{(mg)^2 + (\frac{mv^2}{r})^2}$$

$$N = \sqrt{(1825 \times 9.80)^2 + (\frac{1825 \times 28.2^2}{109})^2}$$

$$N = 22297 \text{ Newtons}$$

Question 28 (a)

Criteria	Marks
• Correctly calculates answer with units	4
• Incorrect answer but Identifies one force is positive and other is negative AND • Identifies that the distance from R to Q is 65-r (or equivalent) AND • Identifies that net force has to be 0	3
• Identifies 2 factors stated above	2
• Identifies 1 factor stated above	1

We want the conductor R to experience a net force of 0. Ie,

$$F_{PR} + F_{QR} = 0$$

Let's put in our equations!

$$\frac{\mu_0 \times l}{2\pi r} - \frac{3\mu_0 \times l}{2\pi(65 - r)} = 0$$

Note that one side has 65-r because it'll be the distance from Q to R. Also note that the second term is negative, as the force is in the other direction.

$$\frac{\mu_0 \times l}{2\pi r} - \frac{3\mu_0 \times l}{2\pi(65 - r)} = 0$$

$$\frac{\mu_0 \times l}{2\pi}\left(\frac{1}{r} - \frac{3}{(65 - r)}\right) = 0$$

Now let's get rid of the factors we just pulled out so we just end up with the terms in the brackets:

$$\frac{1}{r} + \frac{-3}{-r + 65} = 0$$

Multiply all terms by r(-r+65) and cancel:

$$1(-r + 65) - 3r = 0$$

65 = 4r

r = 16.3mm to the right of P

This question can also be tackled in the exact same fashion with the formula:

$$F = BILsin(\theta)$$

This method does also make it slightly easier, and is probably the "normal" way to do this, but both methods still work.

Question 28 (b)

Criteria	Marks
• Justifies their argument logically and provides a correct answer	2
• Shows some understanding about forces on wire	1

Sample answer:
Yes, the student is correct, When we consider placing the 3rd wire slightly to the left from wire P. Both wires will act a force to the left, which makes it impossible to have a net force of 0. When the 3rd wire is between both wires, one will always have a force to the left, while the other has a force to the right, allowing there to be a point where the net force is 0.

Question 28 (c)

Criteria	Marks
• Explains the relationship logically by defining the terms	3
• Defines both terms correctly without explaining their relationship	2
• Defines one term correctly	1

Sample answer:
One ampere is the constant current which, if maintained in two straight parallel conductors of infinite length, and placed one metre apart in vacuum, would produce between those conductors a force equal to 2×10^{-7} newtons per metre of length.
Newton's third law states that every reaction has an equal and opposite direction.
An ampere falls into Newton's third law as the force wire P acts on wire Q will be equal to the force wire Q exerts on wire P, but in the opposite direction. Seen by the formula used in a)

Answers could include:

There is a new definition of the Ampere: Taking the fixed numerical value of the elementary charge to be 1.602×10^{-19} C where one Coulomb is one ampere per second. Including this definition is also accepted.

Question 29

Criteria	Marks
• Explains that the astronaut has a weight force but no reaction force (normal) AND • Explains the physics of circular motion.	4
• Identifies the effects of gravitational force on both the astronaut and spaceship	2-3
• Provides some relevant information	1

Sample Answer:
We know that both the astronaut and the spaceship have a force acting on them as they are not travelling in a straight line. This force comes from Earth's gravitational field.

Since there is confirmed to be a force, they must obey all of Newton's laws and accelerate in the direction of the force, given by:

$$a = \frac{v^2}{r}$$

This means that velocity will always be changing, which explains the circular motion. Note here that the speed is constant, as acceleration is constant.

Similarly with the astronaut, the astronaut has a weight because there is a force from Earth. However, the astronaut feels weightless because they are "falling" at the same rate as the spaceship as there is not normal force able to act on them.

Question 30 (a)

Criteria	Marks
• Correctly calculates force with units and direction	3
• Calculates force with incorrect units or direction OR minor error	2
• Identifies direction or identifies equation for answer	1

We know electric field strength and we know charge, so let's use:

$$F = qE$$

$$F = 1.602 \times 10^{-}19 \times 727251$$

$$F = 1.17 \times 10^{-13} \text{ Newtons}$$

We know protons are attracted to the negative plate and electric field lines go from the positive plate to the negative plate, so the proton feels a force to the right

$$F = 1.17 \times 10^{-13} \text{ Newtons to the right.}$$

Question 30 (b)

Criteria	Marks
• Correctly calculates net torque with units and direction	3
• Calculates net torque with incorrect units or direction OR minor error	2
• Identifies direction or identifies equation for answer	1

Torque is given by:

$$\tau = Fd$$

Before we go any further, it is important to note that the point this dipole rotates around is half the distance. Also, the electron also experiences an equal force, in the opposite direction, which is the same direction in torque, so we need to times by 2.

$$\tau = 2 \times 1.17 \times 10^{-13} \times 0.00051 \times 10^{-}12$$

$$\tau = 1.17 \times 10^{-28} Nm^{-1}$$

Now we need to know the direction of torque, as it is a vector. In my case I use the right-hand palm rule: thumb is force, fingers is distance and palm is force. In our case when we use this for the electron (fingers point up, thumb points right) We get force into the page. We can do the test for the electron and again, it will be into the page. However this is advanced for highschool physics, so claiming it is clockwise is sufficient.

$\tau = 8.51 \times 10^{-8} Nm^{-1}$ into the page / clockwise

Question 31

Criteria	Marks
• Identifies 3 errors with reason, and suitable fixes to them	5-6
• Identifies 2 errors with reason, and suitable fixes to them	3-4
• Identifies 1 error with reason, and a suitable fix to it	1-2

Answers could include:

- The system is attached to a DC power supply, transformers only work with AC, where there's a change in magnetic flux - Change it to AC
- The secondary coil is not closed, no current will be induced if the solenoid is not connect at either points - Connect them (so 2 wires go up to the transmission)
- The first transformer is a step-down - This leads to a higher power loss in the transmission (P = I^2R) - replace with a step-up
- The second transformer is a step-up - A kettle does not require that much power - change it to a step-down

Question 32

Criteria	Marks
• Provides 2 similarities and 2 differences	3-4
• Provides 1 similarity and 1 difference	2
• Identifies a feature between particles in magnetic and electric fields	1

Sample answer:

Both particles, when entering their respective fields will always experience a force, assuming they are charged, However, the force on the particle in the magnetic field is proportional to its speed, but in an electric field it is not. Both particles experience a larger force when the strengths of their respective fields increase. A particle in a magnetic field will always undergo circular motion whereas the particle in an electric field will never complete a full circle.

Answers could also include:

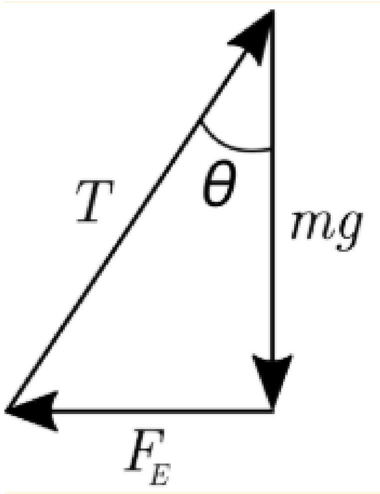
- The mass of the particle affects force.
- The angle in which the particle enters in the magnetic field matters, but not the electric field.

- Stationary charged particles will not experience a force when in a magnetic field.

Question 33 (a)

Criteria	Marks
• Marks for this question will be awarded as shown in the answer	5

A huge hint here is when it says for you to use to small angle approximation, right angle triangles will be used.
The balls will move to a place where the forces are in equilibrium, so let's draw up a vector diagram:



The forces on the mass are the weight force directly downwards, the electrostatic force to the left and tension in the thread towards the point it is hanging from. **(1 MARK for recognising this)**
The Coulomb force is given by:

$$F_e = \frac{q^2}{4\pi\epsilon_0 r^2}$$

q^2 as both particles have the same charge.
When we look at the equation we need to achieve, we see the part of it is the Coulomb force over the weight force, which is tanθ, so let's do that:

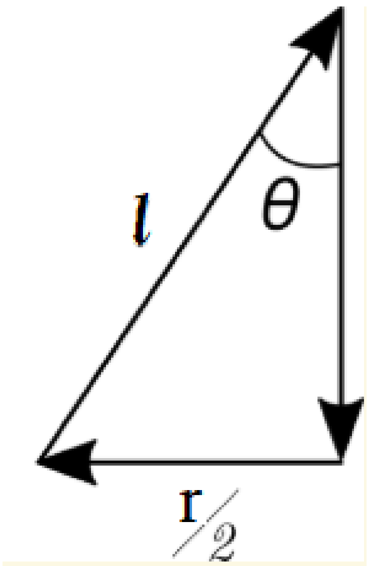
$$\tan\theta = \frac{q^2}{4\pi\epsilon_0 r^2 mg}$$

Using our small angle approximation $\tan\theta = \theta$

$$\theta = \frac{q^2}{4\pi\epsilon_0 r^2 mg}$$

(1 MARK for getting to this point)

However, we have r^2 in our equation, we need it to be l^2, these are both lengths found in diagram, meaning we can make a second triangle:



1 MARK for recognising this

Now we get an expression for the angle with the only way possible:

$$\sin\theta = \frac{r}{2l}$$

Using our small angle approximation $\sin\theta = \theta$ and rearranging we get:

$$r = 2l\theta$$

1 MARK for getting this expression

Now we sub this into our other equation:

$$\theta = \left(\frac{q^2}{4\pi\epsilon_0(2l\theta)^2 mg}\right)$$

now let's do some rearranging....

$$\theta = \left(\frac{q^2}{4\pi\epsilon_0 4l^2\theta^2 mg}\right)$$

$$\theta = \sqrt[3]{\left(\frac{q^2}{16\pi\epsilon_0 l^2 mg}\right)}$$

Final Mark awarded when complete

Question 33 (b)

Criteria	Marks
• Correct answer with units	3
• Attempts to use the equation derived in a) but includes minor error	2
• Identifies the equation derived in a) is meant to be used	1

For this equation, we need to use:

$$r = 2l\theta$$

Subbing in our θ equation:

$$r = 2l\sqrt[3]{\left(\frac{q^2}{16\pi\epsilon_0 l^2 mg}\right)}$$

Subbing in numbers...

$$r = 2 \times 0.318 \times \sqrt[3]{\left(\frac{(1.72 \times 10^{-6})^2}{16\pi\epsilon_0(0.318)^2 \times 0.0405 \times 9.8}\right)}$$

r = 0.349 meters

That's all! Thanks for reading, I hope it was helpful!