Name: ____

Topic 2: Mechanics Part 1

Date:

Time:

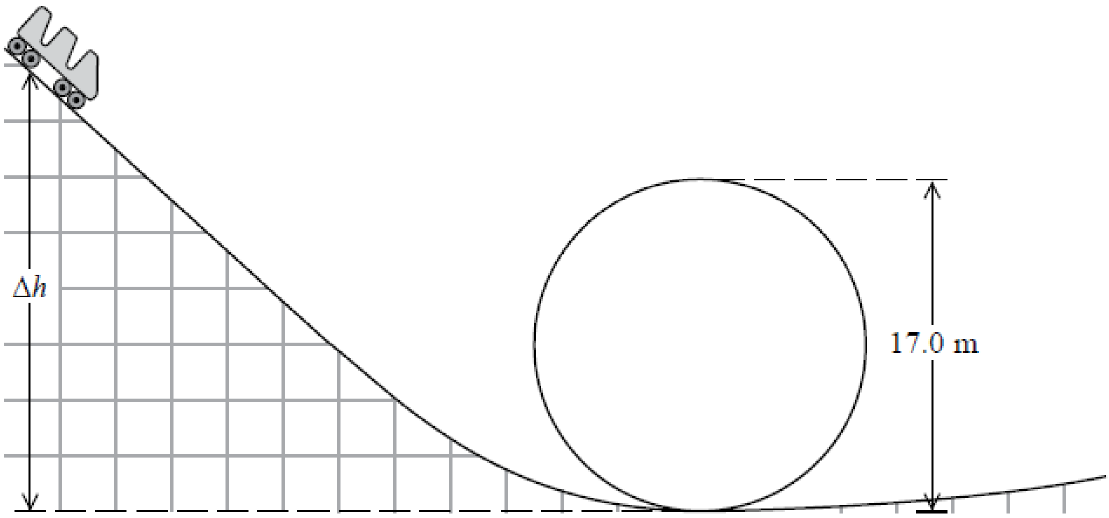
Total marks available:

Total marks achieved: ______

Questions

Q1.

The diagram shows the carriage of a rollercoaster about to enter a vertical loop of diameter 17.0 m. The carriage is initially at rest at a height Δh above the bottom of the loop.



(i) So that a passenger remains in contact with their seat at the top of the ride, show that the minimum speed of the car at the top of the loop is 9.1 m s^{-1}.

(3)

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(ii) Calculate the minimum value of Δh that will enable the passenger to remain in contact with their seat at the top of the loop.

(3)

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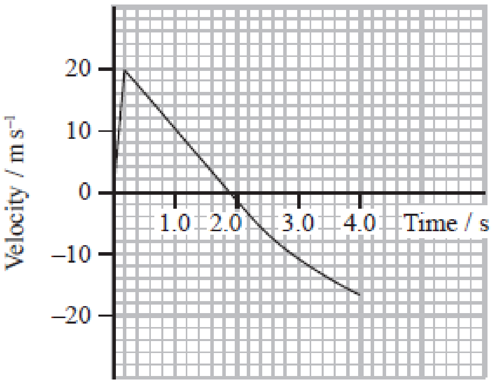
Δh = ...

(Total for question = 4 marks)

Q2.

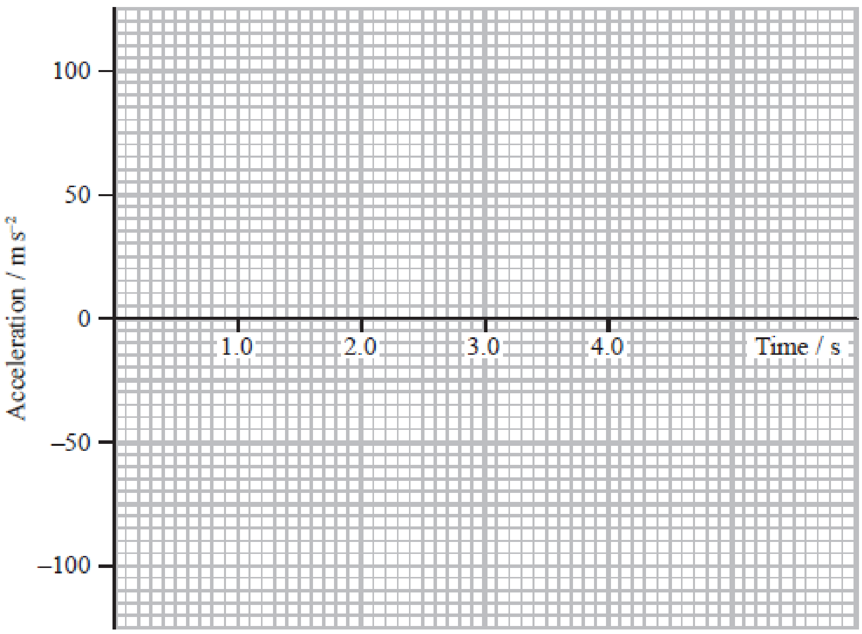
A physics class made a toy rocket. A drinks bottle was partially filled with water and inverted over a valve. An air pump delivered air to the bottle until the pressure forced the bottle from the valve and the water was ejected from the bottle at high speed.

A velocity-time graph for the bottle for the first 4 s after take-off is shown.



Sketch the corresponding acceleration-time graph on the axes below.

(5)



(Total for question = 5 marks)

Q3.

The photograph shows a vase made of uranium glass. Uranium glass is radioactive.

Uranium glass usually contains a maximum of 2% uranium. Uranium glass made in the early part of the 20th century can contain up to 25% uranium.

A uranium nucleus decays to thorium by emission of an alpha particle.

It can be assumed that all the energy of the decay is transferred to kinetic energy of the alpha particle.

Calculate the speed of the emitted alpha particle.

mass of uranium nucleus = 238.0003 u
mass of thorium nucleus = 233.9942 u
mass of alpha particle = 4.0015 u

(5)

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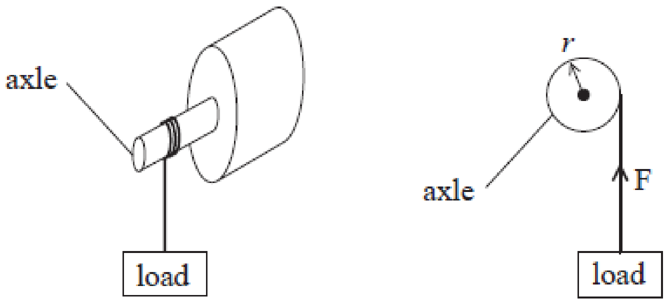
Speed of alpha particle = ...

(Total for question = 5 marks)

Q4.

Motors usually have a rotating component which can do work *W*.

(a) A motor lifts a load in a time *t*. The axle of the motor has a radius *r* and exerts a force *F*.



The power produced by a motor can be calculated by using the following word equation.

Power = moment of the force exerted by the rotating axle × angular velocity

Derive this equation, starting with power $P = \frac{W}{t}$.

(4)

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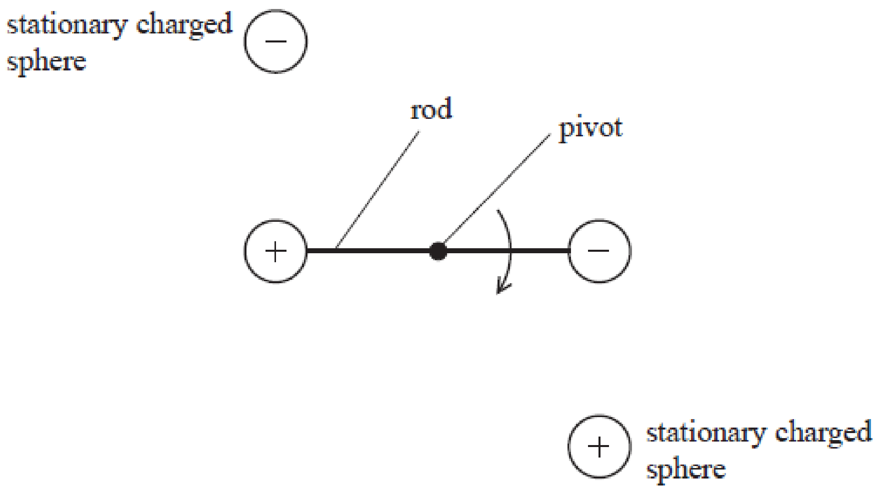
(b) An electrostatic motor was first demonstrated by Benjamin Franklin in 1750.

The diagram shows a simplified version of part of this motor.

This consists of a rod, with an oppositely charged sphere at either end, which rotates around a fixed pivot. Two stationary charged spheres apply a force on the spheres at either end of the rod.

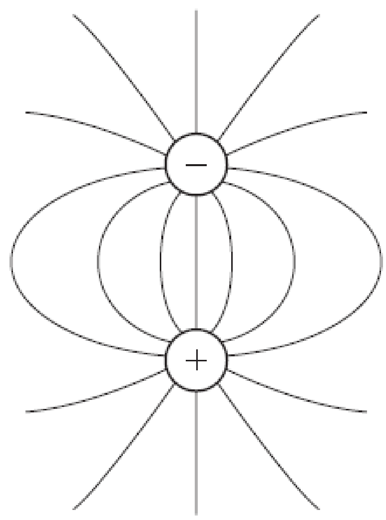


(i) In the diagram below, electric field lines have been drawn around one pair of these spheres.

Add to the diagram to show

- the directions of the field lines
- the lines of equipotential.

(3)



(ii) The distance between the centres of each charged sphere in this pair is 5.0 cm.

Show that the force between this pair of charged spheres is about 0.04 N.

charge on each sphere = 0.10 μC

(2)

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(c) The table shows the typical power and the corresponding angular velocity required for three different appliances.

	Power / W	Angular velocity / rad s^{-1}
Electric car	2.0×10^4	300
Vacuum cleaner	1.4×10^3	1000
Small pond pump	0.5	200

Deduce which of these appliances, in principle, could use the electrostatic motor in (b).

You should use the word equation in (a) and assume that the length of the rod in the electrostatic motor is 8.0 cm.

Assume that the electrostatic motor would deliver a constant force throughout one complete rotation.

(4)

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(Total for question = 13 marks)

Q5.

A student is investigating a 'Cartesian diver'.

The diver is made from a plastic pipette. When placed in a plastic bottle full of water the diver rises to the top and touches the lid.

(a) Show that the downward force of the lid on the diver is about 0.02 N.

volume of diver = 8.0×10^{-6} m^3

mass of diver = 0.0059 kg

density of water = 1.0×10^3 kg m^{-3}

(3)

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(b) When the pressure is increased by squeezing the bottle, water is forced into the diver increasing its weight. The diver sinks, then remains at rest in the position shown.

The volume of air in the empty pipette in part (a) was 8.0×10^{-6} m^3.

Show that the volume now occupied by the air is about 6×10^{-6} m^3.

(3)

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(c) The pressure of the air in the empty pipette in part (a) was 1.01×10^5 Pa.

Calculate the pressure of the air in part (b).

(2)

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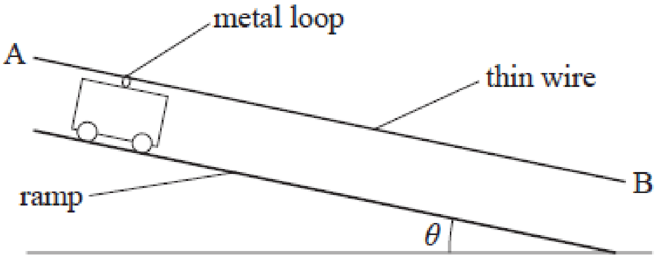
Pressure = ...

(Total for question = 8 marks)

Q6.

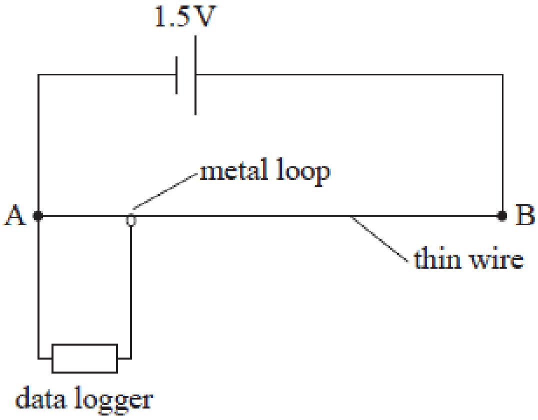
A student investigates the motion of a friction-free trolley down a ramp. On the top of the trolley there is a metal loop which makes contact with a length of thin resistance wire, AB, fixed above the ramp. The resistance wire has a uniform diameter.

The trolley accelerates down the ramp and the metal loop stays in contact with the wire along the full length of the ramp.



The student uses a protractor to measure the angle θ between the ramp and the horizontal and records a value of 4° with an uncertainty of ±1°.

(a) The two ends of the wire are connected to a 1.5 V cell. A data logger, set to measure potential difference, is connected to the metal loop and to the negative terminal of the cell.



Explain how the potential difference recorded by the data logger will vary as the loop moves along the length of the
wire AB.

(3)

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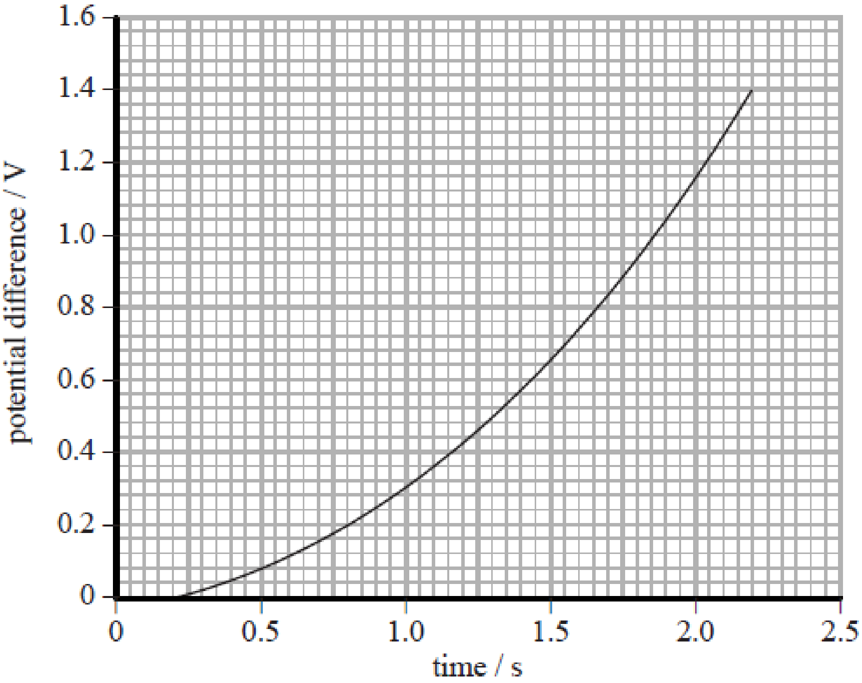
(b) The graph shows the data obtained from the data logger.



Determine the velocity of the trolley at 1.5 s.

1.5 V represents a distance of 2.00 m.

(4)

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Velocity = ...

(c) The student calculated the velocity of the trolley at 2.0 s to be 1.5 m s^{-1}.

By considering the acceleration of the trolley, determine whether the student's measurement of θ was within the uncertainty quoted.

(4)

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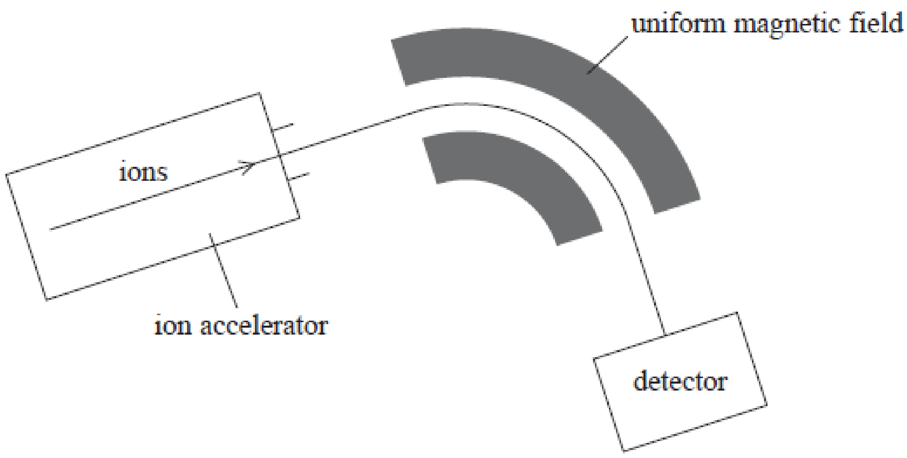
(Total for question = 11 marks)

Q7.

Mass spectrometry is a technique used to separate ions based on their charge to mass ratio.

The atoms in a sample are ionised and then accelerated and formed into a fine beam.
This beam is passed into a region of uniform magnetic field and the ions are deflected by different amounts according to their mass.



Analysis of mass spectrometer data shows that chlorine exists in nature as two isotopes, chlorine-35 and chlorine-37.

In a mass spectrometer, chlorine-35 ions are accelerated through a potential difference of 8.50 kV to produce an ion beam.

Show that the speed of singly ionised chlorine-35 atoms is about 2.2×10^5 m s^{-1}.

mass of an ion of chlorine-35 = 34.97 u

(4)

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(Total for question = 4 marks)

Q8.

The Starflyer is a fairground ride which operates 60 m above the ground. As it begins to spin, the chairs in which the riders sit move outwards.

Consider the chair and rider as a single object. By drawing a free-body force diagram and considering the forces acting, explain the following observations.

The angle to the vertical of the supporting ropes depends on the speed of rotation, but does not depend on the mass of the rider.

(5)

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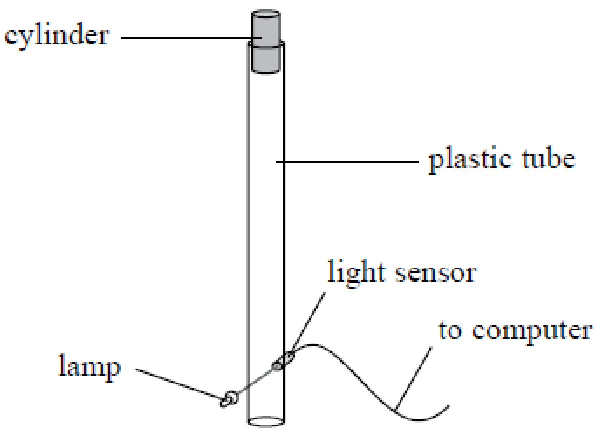
(Total for question = 5 marks)

Q9.

A student uses a lamp and a light sensor as a light gate connected to a data logger and computer to determine the speed of a falling object. He drops a small cylinder through a clear plastic tube. The light gate and data logger measure the time of fall of the cylinder and the speed is calculated.



The student repeats the experiment five times and records the results in a table.

Speed / m s^{-1}	Mean speed / m s^{-1}
4.52 4.59 4.43 4.63 4.58	4.55

The student incorrectly includes all the values when calculating the mean speed.
A second student thinks that the true value of the mean speed is different.

Explain whether the second student is correct.

(2)

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(Total for question = 2 marks)

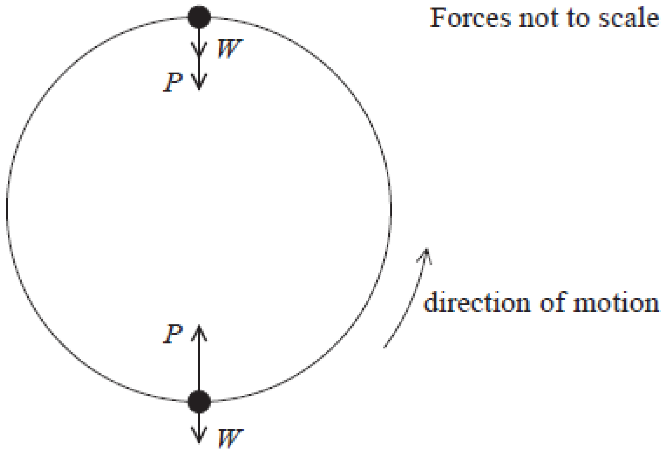
Q10.

The Enterprise is an amusement park ride. Riders sit in cars that are made to rotate in a vertical circle.

The ride starts by moving in a horizontal circle. The speed of rotation increases, and the frame tilts until the ride is rotating vertically as shown.

The photograph below shows riders at the top of the vertical circle. The riders are in contact with their seats at all times during the ride.

The diagram shows the weight *W* of a rider and the push *P* from the seat on the rider at the top and bottom of the circular path.



* The rider moves from the bottom to the top of the circular path.

Explain how the apparent weight experienced by the rider would change.

(6)

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(Total for question = 6 marks)

Q11.

* A stationary radium nucleus decays by emitting an alpha particle. The speed of the recoiling nucleus is small compared to the speed of the alpha particle.

Explain why the nucleus recoils and why its speed is small compared to that of the alpha particle.

(4)

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(Total for question = 4 marks)

Q12.

The Shanghai Maglev Train is the first commercially operated high-speed magnetic levitation train in the world, connecting the airport and central Shanghai.

The total distance travelled is 29.9 km and the total journey time is 440 s. The train starts from rest and reaches a speed of 97 m s^{-1} in 120 s.

(i) Calculate the average acceleration of the train during the first 120 s.

(2)

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Average acceleration of train = ...

(ii) Calculate the average speed of the train for the period following the 120 s acceleration.

(3)

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Average speed of train = ...

(Total for question = 5 marks)

Q13.

In the sport of curling, two teams of 'curlers' take turns sliding polished granite stones across an ice surface towards a circular target marked on the ice.

commons.wikimedia.org

A stone of mass 19.6 kg is accelerated uniformly for 1.25 s before being released by a curler.

The stone then decelerates uniformly to rest, travelling 32.5 m in a time of 17.5 s.

Calculate the average useful power developed by the curler in accelerating the stone.

(4)

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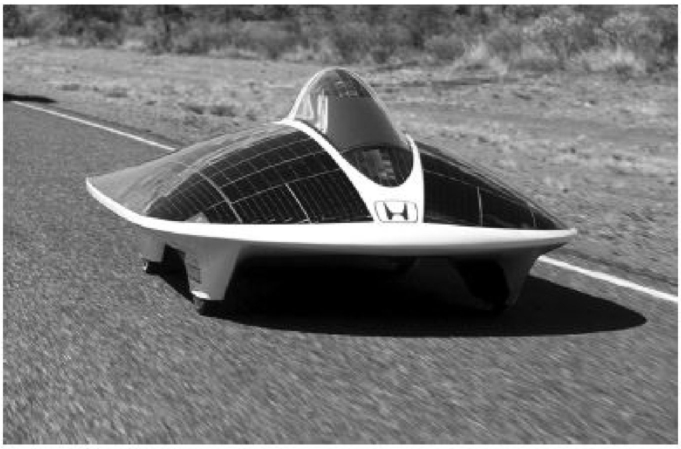
Average power = ...

(Total for question = 4 marks)

Q14.

The world solar challenge is set every two years, in Australia. The challenge is to complete a three thousand kilometre route with a vehicle powered only by the Sun.

Vehicles have their surfaces fitted with solar panels, as shown in the photograph.



(Source: © LAURENT DOUEK/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY)

The vehicle can reach a maximum speed of 34 m s^{-1} on flat ground. The electric motor used to move the vehicle has a power of 4.5 kW.

(i) Calculate the initial acceleration of the vehicle as it starts from rest.

mass of vehicle and driver = 420 kg

(3)

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Initial acceleration = ...

(ii) State one assumption made in this calculation.

(1)

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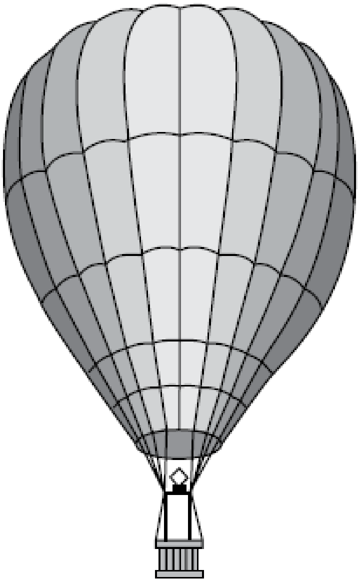
(Total for question = 4 marks)

Q15.

Newton's laws relate the changes in motion of an object to the forces acting on the object.

A hot-air balloon is made of an envelope, containing hot air, with a wicker basket suspended from it. The balloon rises upwards because the heated air in the envelope is less dense than the surrounding air.



The total volume of the hot-air balloon is 2880 m^3. The total mass of the hot-air balloon, including the envelope, is 3400 kg. The density of the surrounding air is 1.20 kg m^{-3}.

Calculate the initial upward acceleration of the balloon.

(4)

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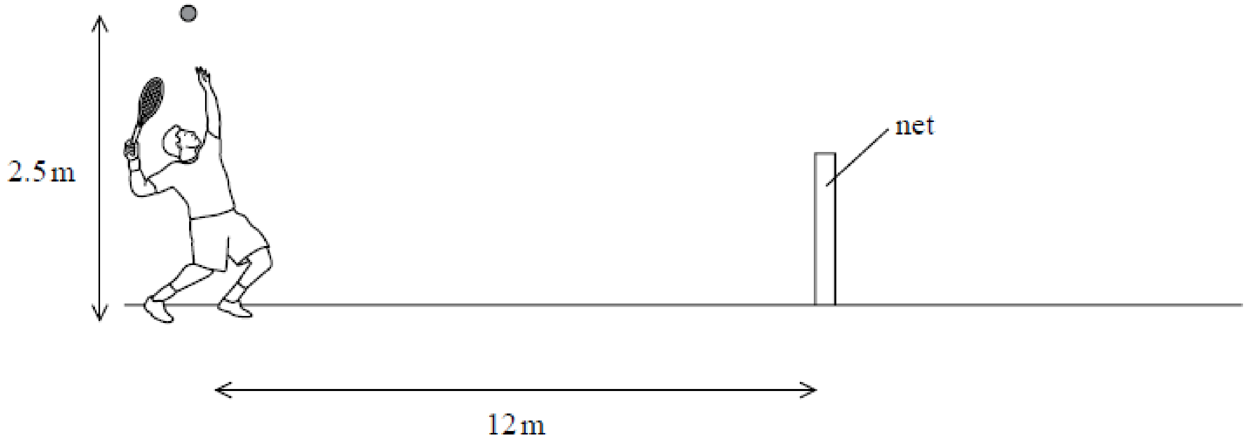
Initial acceleration = ...

(Total for question = 4 marks)

Q16.

A tennis player uses a racket to hit a ball over a net.



The player stands 12 m from the net. He throws the ball vertically upwards and hits the ball at a height of 2.5 m above the ground. The ball leaves the racket **horizontally** with a velocity of 25 m s^{-1}. The ball has a mass of 0.06 kg.

The ball is in contact with the racket for 0.04 s.

Calculate the average force on the ball.

(3)

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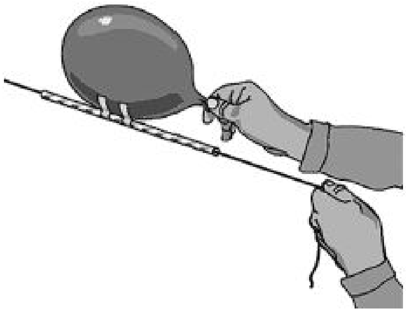
Average force = ...

(Total for question = 3 marks)

Q17.

A length of string is threaded through a drinking straw. The string is fixed at one end and held at the other so that it is at 30° to the horizontal. A balloon is inflated and attached to the straw. When the balloon is released, the air escapes from the balloon and the balloon and straw start to move up the string.



Calculate the minimum force on the balloon due to the escaping air if the balloon is to move in this way.

mass of straw and balloon = 11 g

(3)

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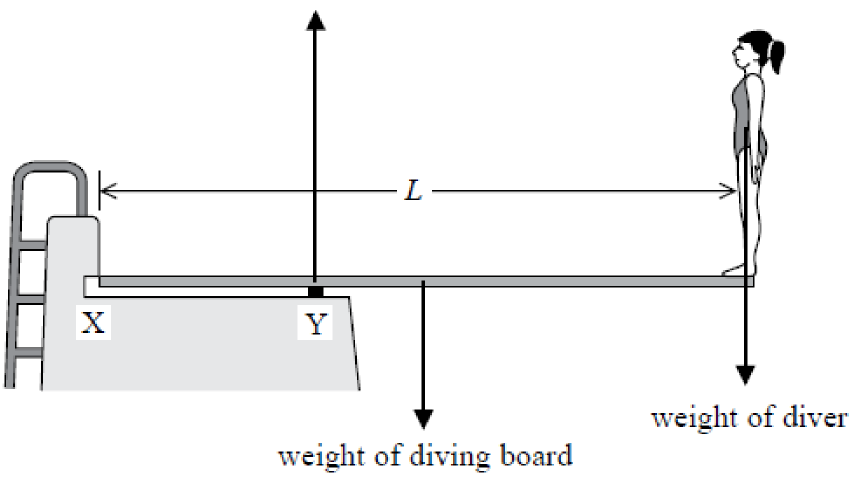
Minimum force = ...

Q18.

The diagram shows a diver of weight 680 N on a diving board.



The diving board has a length *L* of 3.6 m and is fixed at the end labelled X. It is supported at position Y which is 0.9 m from X. The diving board is uniform and has a weight of 390 N.

By taking moments about X, determine the upward force exerted by the support at Y on the diving board.

(5)

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Force = ...

(Total for question = 5 marks)

Q19.

In 1990, the Hubble Space Telescope (HST) was launched into a low Earth orbit above the Earth's atmosphere.

HST orbits the Earth in a circular orbit with a speed of 7.59 km s^{-1}.

mass of Earth = 5.97×10^{24} kg
radius of Earth = 6.37×10^{6} m

(i) Show that the height of HST above the surface of the Earth is about 6×10^{5} m.

(3)

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(ii) Calculate the increase in the gravitational potential energy as HST is raised, from its initial position at the Earth's surface, to its orbital height.

mass of HST = 11 600 kg

(2)

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Increase in gravitational potential energy = ...

(iii) A student suggests that giving HST more energy than that required in (ii) would result in the satellite orbiting at a greater height and with a greater speed.

Assess the validity of the student's suggestion.

(4)

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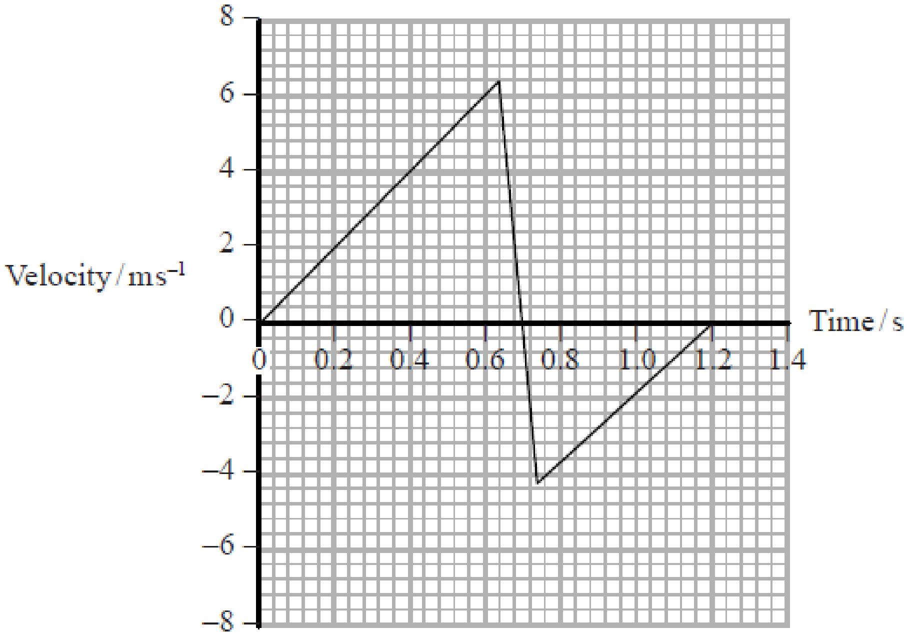
(Total for question = 9 marks)

Q20.

A stationary ball is released from a height of 2.0 m onto a hard surface.

The simplified velocity-time graph shows the motion of the ball as it falls and bounces back to its maximum height.



(a) Calculate the maximum height reached by the ball after bouncing.

(2)

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Maximum height = ...

(b) Calculate the decrease in kinetic energy of the ball as it bounces.

mass of ball = 60 g

(2)

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Decrease in kinetic energy = ...

(c) Calculate the resultant force on the ball when it is in contact with the ground.

(3)

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Resultant force = ...

(d) The ball is replaced with one that is softer. It is released from a height of 2.0 m onto the same surface as before. A velocity-time graph is drawn to show the motion of the new ball.

Describe the similarities and differences between the two graphs.

(3)

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(Total for question = 10 marks)

Q21.

A uniform paving slab is to be used as a garden step.

State what is meant by the centre of gravity of an extended body.

(1)

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(Total for question = 1 mark)

Q22.

The International Space Station (ISS) orbits the Earth with a constant speed *v*. The orbit is circular and of radius *r*.

(i) The ISS completes one orbit in 92 minutes.

Calculate the centripetal acceleration of the ISS.

r = 6800 km

(3)

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Centripetal acceleration = ...

(ii) Astronauts in the ISS are often described as being "weightless".

Discuss whether the astronauts are "weightless" when they are orbiting the Earth in the ISS.

(4)

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(Total for question = 7 marks)

Q23.

At the beginning of the 20th century, Rutherford carried out large-angle alpha particle scattering experiments using gold ($^{197}_{79}Au$) foil.

The vast majority of the alpha particles went straight through the foil whilst a few were deflected straight back.

Rutherford also carried out the experiment with aluminium ($^{27}_{13}Al$) foil.
The aluminium foil had the same thickness as the gold foil and the alpha particles had the same initial kinetic energy.

The following observations were made.

Observation 1:
The fraction of alpha particles scattered at any particular angle for aluminium foil was always much less than for gold foil.

Observation 2:
The alpha particles scattered from aluminium foil had less kinetic energy than the alpha particles scattered from gold foil.

Explain how these observations can be used to deduce how an aluminium nucleus compares to a gold nucleus.

(4)

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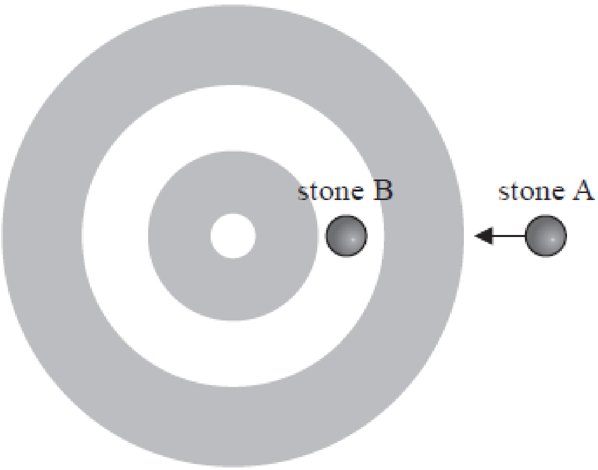
(Total for question = 4 marks)

Q24.

In the sport of curling, two teams of 'curlers' take turns sliding polished granite stones across an ice surface towards a circular target marked on the ice.

commons.wikimedia.org

* Stone B is stationary. Stone A travels towards the target and makes a direct hit on stone B as shown. Both stones have mass *m*.



The collision is elastic. Just before the collision stone A has a velocity *v*. After the collision stone B moves off with velocity *v*.

Discuss how the relevant conservation laws apply to this collision.

(6)

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(Total for question = 6 marks)

Q25.

* Particle accelerators accelerate particles to very high speeds before collisions occur.
New particles are created during the collisions.

Two particles of the same type can undergo two kinds of collision.

Fixed target: a high speed particle hits a stationary particle.

Colliding beams: two particles travelling at high speeds, in opposite directions, collide head-on.

By considering the conservation of energy and momentum, explain which type of collision is able to create a new particle with the largest mass.

(6)

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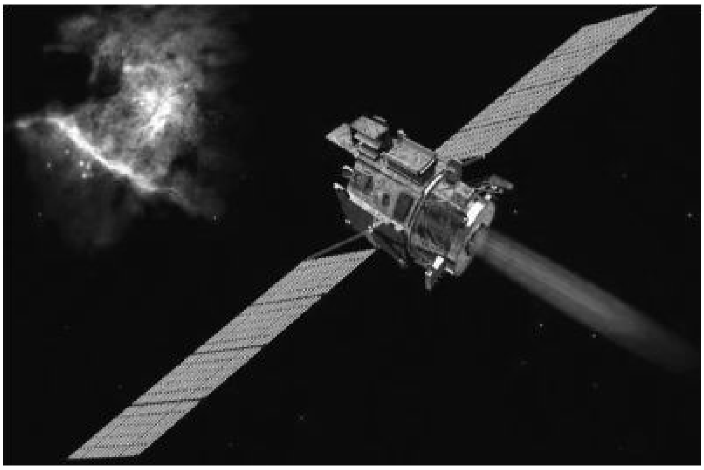
(Total for question = 6 marks)

Q26.

* The photograph shows a probe moving in space.



Whilst moving, empty fuel tanks can be ejected by means of an explosion. This has the effect of increasing the speed of the probe.

Discuss whether conservation of momentum and conservation of energy apply in this situation and why the speed of the probe increases.

(6)

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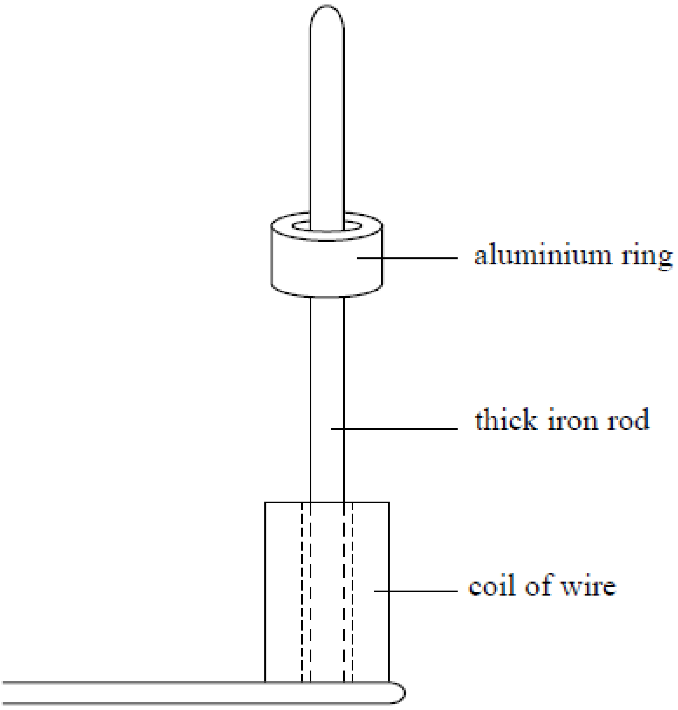
(Total for question = 6 marks)

Q27.

A coil of wire is placed around the lower end of an iron rod. The coil is supplied with an alternating current.

A thick aluminium ring is placed around the iron rod above the coil. The coil remains in the position shown.



The current is switched off and the aluminium ring comes to rest on top of the coil.
The supply to the coil is changed and a direct current (dc) is switched on. An upwards force *F* acts on the ring for 0.05 s accelerating it to a final speed, *v*. The ring then moves freely through a height of 30 cm.

Mean diameter of ring = 4.8 cm
Mass of ring = 0.019 kg
Magnetic field strength = 0.032 T

(i) Use conservation of energy to calculate the speed *v* of the ring after 0.05 s.

(2)

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v = ...

(ii) Use the idea of impulse to calculate the magnitude of the mean force F acting on the ring and hence the mean current I in the ring.

(6)

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F = ...

I = ...

(Total for question = 8 marks)

Q28.

A body, initially at rest, explodes into two masses M_1 and M_2. These masses move apart with speeds v_1 and v_2 respectively.

The ratio v_1/v_2 is equal to

$\frac{\sqrt{M_1}}{\sqrt{M_2}}$ **A** $\frac{M_1}{M_2}$

$\frac{\sqrt{M_1}}{\sqrt{M_2}}$ **B** $\frac{M_2}{M_1}$

$\frac{\sqrt{M_1}}{\sqrt{M_2}}$ **C** $\frac{\sqrt{M_1}}{\sqrt{M_2}}$

$\frac{\sqrt{M_1}}{\sqrt{M_2}}$ **D** $\frac{\sqrt{M_2}}{\sqrt{M_1}}$

(Total for question = 1 mark)

Q29. (a) Explain what is meant by the principle of conservation of momentum.

(2)

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(b) The picture shows a toy car initially at rest with a piece of modelling clay attached to it.

A student carries out an experiment to find the speed of a pellet fired from an air rifle. The pellet is fired horizontally into the modelling clay. The pellet remains in the modelling clay as the car moves forward. The motion of the car is filmed for analysis.

The car travels a distance of 69 cm before coming to rest after a time of 1.3 s.

(i) Show that the speed of the car immediately after being struck by the pellet was about 1 m s^{-1}.

(2)

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(ii) State an assumption you made in order to apply the equation you used.

(1)

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(iii) Show that the speed of the pellet just before it collides with the car is about 120 m s^{-1}

mass of car and modelling clay = 97.31g

mass of pellet = 0.84 g

(3)

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(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

(3)

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(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.

Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

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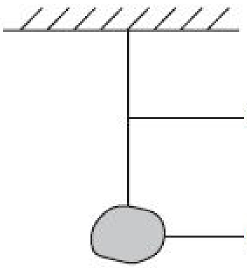
(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



The student's data and calculations are shown:

Data

mass of pellet = 0.84 g

mass of pendulum and pellet = 71.6 g

change in vertical height of pendulum = 22.6 cm

Calculations

change in gravitational potential energy of pendulum and pellet
$= 71.6 \times 10^{-3}$ kg $\times$ 9.81 N kg^{-1} $\times$ 0.226 m = 0.16 J

therefore kinetic energy of pendulum and pellet immediately after collision = 0.16 J

therefore kinetic energy of pellet immediately before collision = 0.16 J

therefore speed of pellet before collision = 19.5 m s^{-1}

There are no mathematical errors but her answer for the speed is too small.

State and explain which of the statements in the calculations are correct and which are not.

(4)

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(Total for Question = 16 marks)

Q30. * In 2012 Neil Armstrong, the first man to step on the moon during the Apollo 11 lunar mission, died at the age of 82.

During this mission, a planned explosion caused the separation of the module in which Armstrong was travelling and the final-stage rocket. This explosion resulted in an increase in the speed of the module.

Discuss how the conservation of momentum and the conservation of energy apply to this situation.

(5)

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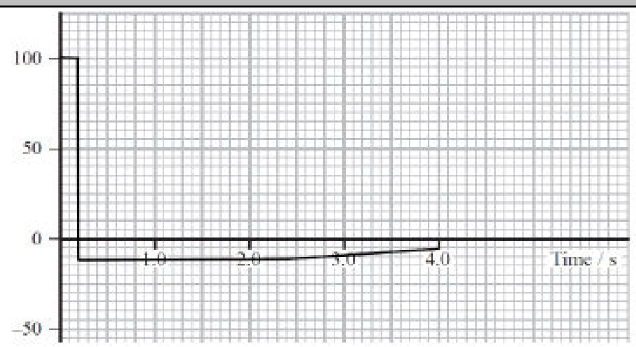
(Total for Question = 5 marks)

Mark Scheme

Q1.

Question number	Acceptable answers	Additional guidance	Mark
(i)	• Recognise that for passenger to remain in their seat normal reaction $R \geq 0$ **(1)** **or** centripetal force >= weight **(1)** • Equate centripetal force and weight (for R=0) **(1)** • $v = 9.1\ \text{m s}^{-1}$ **(1)**	Example of calculation: $\frac{mv^2}{r} = mg$ $v = \sqrt{rg} = \sqrt{8.5\text{m} \times 9.81\text{m s}^{-2}} = 9.13\text{m s}^{-1}$	**3**
(ii)	• Equate decrease in gravitational potential energy to increase in kinetic energy at top of loop **(1)** • Adds this to 17.0 **(1)** • $\Delta h = 21.3$ m **(1)**	Example of calculation: $mgh = \frac{1}{2}mv^2$ $h = \frac{v^2}{2g} = \frac{(9.13\text{m s}^{-1})^2}{2 \times 9.81\text{m s}^{-2}} = 4.25\text{m}$ $\Delta h = 17 + 4.3 = 21.3$ m	**3**

Q2.

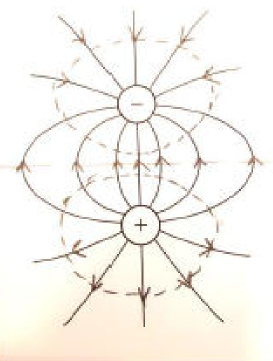
Question Number	Acceptable Answers	Additional Guidance	Mark
	• Positive value of acceleration for first 0.2 s (1) • Constant at 100 m s^{-2} (1) • Negative value of acceleration up to 4 s (1)		**5**
	• Initially at -12 m s^{-2} (value between -10 and -15 on graph) (1) • Negative value reducing in magnitude in last 1.0 s to 2.0 s (can be a step change) (1)		

Q3.

Question Number	Acceptable answers		Additional guidance	Mark
	• Calculates change in mass • Converts from u to kg • Use of $\Delta E = c^2 \Delta m$ • Use of $E_k = ½\, mv^2$ • $v = 1.4 \times 10^7$ m s^{-1}	(1) (1) (1) (1) (1)	<u>Example of calculation</u> $\Delta m = 238.0003u - (233.9942 + 4.0015)u$ $= 0.00463 \times 1.66 \times 10^{-27}$ kg $= 7.636 \times 10^{-30}$ kg $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 7.636 \times 10^{-30}$ kg $= 6.872 \times 10^{-13}$ J 6.872×10^{-13} J $= ½\, (4.0015\, u)\, v^2$ $v = 1.4 \times 10^7$ m s^{-1}	5

Q4.

Question Number	Acceptable answers		Additional guidance	Mark
(a)	• Replace Work W by force × distance • Replace distance ÷ time by velocity v • Use $v = r \times$ Angular velocity • Recognise $F \times r$ is the moment of F	(1) (1) (1) (1)	Alternative method: Consider one revolution of axle , Load rises $2\pi r$ Work done = $2\pi rF$ Time taken = $2\pi \div \omega$ Power = Work ÷ time= $2\pi rF \div 2\pi/\omega$ to give reqd eq	4

Question Number	Acceptable answers		Additional guidance	Mark
(b)(i)	• Arrow away from + charge **Or** arrow towards − charge • At least 3 Equipotential lines, perpendicular to field lines • Symmetrical about vertical/horizontal axis and not touching/crossing	(1) (1) (1)	MP3 dependent on lines being perpendicular in MP2 	3

Question Number	Acceptable answers		Additional guidance	Mark
(b)(ii)	• Use of $F = \frac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$	(1)	Example of calculation:	
	• $F = 0.036$ (N)	(1)	$F = 8.99 \times 10^9 \text{ Nm}^2\text{C}^{-2} \frac{(0.1 \times 10^{-6}\text{C})^2}{(0.05\text{m})^2}$ $F = 0.036\text{N}$	2

Question Number	Acceptable answers		Additional guidance	Mark
(c)	• Use of moment = $F x$	(1)	Show that value gives 3.2×10^{-3} Nm and 0.64 W	
	• Expression for correct moment	(1)	Example of calculation: Moment $= 0.036\text{N} \times 0.04\text{m} \times 2 = 2.89 \times 10^{-3} \text{Nm}$	4
	• Use of power = moment of force x angular velocity	(1)		
	• Only realistic possibility is pond pump and $P = 0.6$W (calculated answer could also be force and then comparison with b(i))	(1)	Power $= 2.89 \times 10^{-3} \text{N m} \times 200\text{s}^{-1} = 0.58\text{W}$	

Q5.

Question Number	Acceptable answers		Additional guidance	Mark
(a)	• use of $\rho = m/V$ and $W = mg$ to calculate upthrust	(1)	Example of calculation $m_{displaced} = 1.0 \times 10^3 \text{ kg m}^{-3} \times 8.0 \times 10^{-6} \text{ m}^{-3}$ $= 8.0 \times 10^{-3}$ kg $U = 8.0 \times 10^{-3} \text{ kg} \times 9.81 \text{ N kg}^{-1} = 0.0785$ N $W = 0.0059 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 0.0579$ N Lid force = 0.0785 N - 0.0579 N = 0.0206 N	
	• use of downward force of lid = upthrust – weight of diver	(1)		
	• downward force of lid = 0.021 (N)	(1)		3

Question Number	Acceptable answers	Additional guidance	Mark
(b)	**Either** • use of force of lid = $V\rho g$ **(1)** • volume of air = 8.0×10^{-6} m^{-3} - their value **(1)** • volume of air = 5.9×10^{-6} (m^3) **(1)** **Or** • use of upthrust on diver = weight of diver **(1)** • use of upthrust = $V\rho g$ **(1)** • volume of air = 5.9×10^{-6} (m^3) **(1)**	<u>Example of calculation</u> volume = 0.0206 N ÷ 9.81 N kg^{-1} ÷ 1.0 × 10^3 kg m^{-3} = 2.1×10^{-6} m^{-3} new volume of air = 8.0×10^{-6} m^{-3} - 2.1×10^{-6} m^{-3} = 5.9×10^{-6} m^3	**3**

Question Number	Acceptable answers	Additional guidance	Mark
(c)	• use of pV = constant **(1)** • $p = 1.4 \times 10^5$ Pa **(1)**	<u>Example of calculation</u> $p_1 \times V_1 = p_2 \times V_2$ $p_2 = 1.01 \times 10^5$ N m^{-2} × 8.0×10^{-6} m^{-3} / 5.9×10^{-6} m^3 $p = 1.37 \times 10^5$ Pa	**2**

Q6.

Question Number	Acceptable answers	Additional guidance	Mark
(a)	• V at top/start = 0V **Or** recognition "potential divider" **Or** V increases (by implication) **Or** V at bottom = 1.5V **(1)** • Two sections of wire act as series resistors **Or** $R=\rho l/A$ **Or** comment about R proportional to length **Or** $\frac{V}{1.5} = \frac{R}{R_T}$ **(1)** • potential difference proportional to length of wire **(1)**	**Alternative MS** Constant Current (I) in wire (1) p.d. across section of wire =Ir between A and loop (1) Increases from 0V to 1.5V linearly (1)	**3**

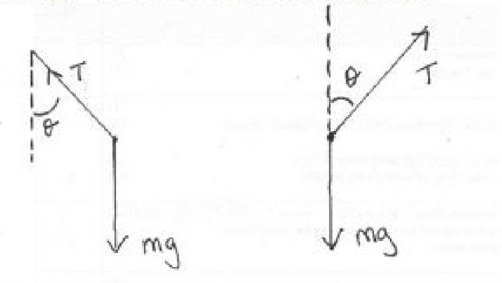
Question Number	Acceptable answers		Additional guidance	Mark
(b)	• Tangent drawn at 1.5 s • Scales p.d. to give distance • Gradient determined using a base of triangle of at least 1.0 s Or use of $s = \frac{(u+v)}{2}t$ and correct V read from graph • velocity = 1.0 m s^{-1} – 1.3 m s^{-1}	(1) (1) (1) (1)	Example of calculation Gradient = $\frac{1.1\text{V} - 0.2\text{V}}{1.0\text{s}} = 0.9\text{Vs}^{-1}$ As 1.5 V represents 2.00 m $v = 0.9\ \text{Vs}^{-1} \times \frac{2.00\text{m}}{1.5\text{V}} = 1.2\ \text{ms}^{-1}$	4

Question Number	Acceptable answers		Additional guidance	Mark
(c)	• Use of $v = u + at$ • Use of $a = g \sin\theta$ • Calculates a value for a, θ or v (using a SUVAT AND $a = g\sin\theta$) • Valid comparison of their calculated quantity and the stated quoted uncertainty.	(1) (1) (1) (1)	Example of calculation $1.5\ \text{ms}^{-1} = 1.2\ \text{m s}^{-1} + \text{a} \times 0.5\ \text{s}$ $a = \frac{0.3\ \text{m s}^{-1}}{0.5} = 0.6\ \text{m s}^{-2}$ $0.6\ \text{m s}^{-2} = 9.81\ \text{m s}^{-2} \sin\theta$ $\theta = 3.6°$	4

Q7.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• Use of $W = QV$ • Use of $KE = \frac{1}{2}mv^2$ • Use of 1u = 1.66×10^{-27} kg • v = 2.16×10^5 (m s^{-1})	(1) (1) (1) (1)	Example of calculation: $\frac{1}{2}mv^2 = eV$ $\therefore v = \sqrt{\frac{2 \times 1.6 \times 10^{-19}\text{C} \times 8.5 \times 10^3\text{V}}{(34.97 \times 1.66 \times 10^{-27})\text{kg}}} = 2.16 \times 10^5\ \text{ms}^{-1}$	4

Q8.

Question Number	Answer		Mark
	Free body force diagram showing 2 forces only Weight/*W/mg* Tension / *T* (Each additional forces e.g. horizontal component or resultant force, 1 mark penalty) **If θ is angle to the vertical then**: (Resolving vertically): $T\cos\theta = mg$ (Resolving horizontally): $T\sin\theta = mv^2/r$ **Or** $T\sin\theta = mr\omega^2$ Derives $\tan\theta = v^2/rg$ **and** links to observations **Or** Derives $\tan\theta = r\omega^2/g$ **and** links to observations If angle to horizontal is used candidates can score MP3 and 4.[then sin and cos swop over and tan of angle will be reciprocal of above] <u>Examples of free body force diagrams</u>  (full credit for the last 3 marks can be given to candidates who draw a vector triangle and derive $\tan\theta = T_{horzt}/mg$ and then $\tan\theta = r\omega^2/g$ **and** observation)	 **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question		**5**

Q9.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: • Comment on the data **(1)** • Correct consequent conclusion **(1)**	4.43 is an anomalous value So the mean value is too low Accept data is concordant so mean value is correct	**2**

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.	Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning	6

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The table shows how the marks should be awarded for indicative content and structure and lines of reasoning.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content:

IC1 The rider experiences a resultant force acting towards the centre (of the circular path)

IC2 This (resultant) force is constant, as the rider has a constant (angular) velocity
Or the weight W is constant

IC3 At the bottom of the circle P and W act in opposite directions, so P must be greater than W

IC4 At the top of the circle P and W act in the same direction, and so P must be less (than at the bottom of the circle)

IC5 P is the weight the rider appears to have

IC6 The rider would feel heavier at the bottom of the circle
Or the rider would feel lighter at the top of the circle

Additional Guidance:

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

Accept "the rider experiences a centripetal force"

Q11.

Question Number	Answer	Mark
*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Either** Initial momentum is zero Nucleus and alpha particle have equal momentum (1) (accept $m_n u_n = m_\alpha u_\alpha$ or $p_n = p_\alpha$) alpha particle and (1) nucleus move in opposite directions Mass of alpha (1) particle < mass of nucleus (therefore $v_n < v_\alpha$) (1) **Or** The nucleus and alpha particle exert an equal but opposite force on (1) each other. (1) Mass of alpha particle < mass of nucleus (1) Acceleration of nucleus < acceleration of alpha particle Force/acceleration acts for same time so Δv for nucleus is smaller for (1) nucleus	4
	Total for question	**4**

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Use of $v = u + at$ (1) • $a = 0.81 \text{ m s}^{-2}$ (1)	Example of calculation $a = \frac{v-u}{t} = \frac{97 \text{ m s}^{-1}}{120 \text{ s}} = 0.808 \text{ m s}^{-2}$	2
(ii)	• Use of $s = ut + \frac{1}{2}at^2$ **Or** $v^2 = u^2 + 2as$ **Or** $s = \left(\frac{(v+u)}{2}\right)t$ (1) • Use of $v_{av} = \frac{s}{t}$ with $t = 320 \text{ s}$ (1) • $v_{av} = 75 \text{ m s}^{-1}$ (1)	Ecf acceleration from (a)(i) Example of calculation $s = ut + \frac{1}{2}at^2 = 0.5 \times 0.808 \text{ m s}^{-2} (120 \text{ s})^2 = 5820 \text{ m}$ $s_2 = 29900 \text{ m} - 5820 \text{ m} = 24\,080 \text{ m}$ $t = 440 \text{s} - 120 \text{ s} = 320 \text{ s}$ $v_{av} = \frac{24\,080 \text{ m}}{320 \text{ s}} = 75.3 \text{ m s}^{-1}$	3

Q13.

Question Number	Acceptable Answer	Additional Guidance	
	• Use of $s = \frac{(u+v)}{2}.t$ (1) • Use of $E_k = \frac{1}{2}mv^2$ (1) • Use of $P = \frac{\Delta W}{\Delta t}$ (1) • $P = 110$ W (1)	Example of calculation: $32.5\text{ m} = \frac{(u+0)}{2} \times 17.5\text{ s}$ $\therefore u = \frac{32.5\text{ m} \times 2}{17.5\text{ s}} = 3.71\text{ m s}^{-1}$ $P = \frac{\Delta E_k}{\Delta t} = \frac{\frac{1}{2} \times 19.6\text{ kg} \times (3.7\text{ m s}^{-2})^2}{1.25\text{ s}} = 107\text{ W}$	4

Q14.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• Use of $\Delta W = F\Delta s$ and $P = W / t$ (1) • Use of $F = ma$ (1) • $a = 0.31\text{ m s}^{-2}$ (1)	Example of calculation: In 1 second $W = F\Delta s$ $4500\text{ W} = F \times 34\text{ m s}^{-1}$ Force applied by motor = 132 N $F = ma$ $132\text{ N} = 420\text{ kg} \times a$ $a = 0.31\text{ m s}^{-2}$	3
(ii)	• Neglect friction forces when it starts from rest (1) **Or** Motor/Driving force independent of speed	Do not accept “force” without a description	1

Q15.

Question number	Acceptable answers	Additional guidance	Mark
	• Uses weight of displaced air = ρVg **(1)** • Finds resultant force = upthrust – weight **(1)** • Uses F = ma to find acceleration **(1)** • Acceleration = 0.161 m s^{-2} **(1)**	Example of calculation: Weight of air displaced = ρVg = $1.20\text{ kg m}^{-3} \times 2880\text{ m}^3 \times 9.81\text{m s}^{-2} = 33\,903\text{N}$ Resultant upward force = 33 903 N – $(3400\text{ kg} \times 9.81\text{m s}^{-2}) = 549\text{ N}$ Acceleration = $549\text{ N}/3400\text{ kg} = 0.161\text{ m s}^{-2}$	4

Q16.

Question number	Acceptable answers	Additional guidance	Mark
	Either • Calculate acceleration **(1)** • Use of $F = ma$ **(1)** • $F = 38$ N **(1)** **OR** • Calculate change in momentum **(1)** • Use of $F = \frac{\Delta mv}{\Delta t}$ **(1)** • $F = 38$ N **(1)**	Example of calculation: $F = \frac{0.06 \times 25}{0.04} = 37.5\ \text{N}$	**3**

Q17.

Question Number	Acceptable Answer	Additional guidance	Mark
	• recognises minimum upward force is *mg* (1) • resolve force parallel to string (1) • minimum force = 0.22 N (1)	Example of calculation: $F = \frac{11 \times 10^{-3}\ \text{kg} \times 9.81\ \text{N kg}^{-1}}{\sin 30^\circ} = 0.22\ \text{N}$	**(3)**

Q18.

Question number	Acceptable answers	Additional guidance	Mark
	• Recognises that weight acts at midpoint of diving board 1.8 (m) from X **(1)** • Use of moment = perpendicular force x distance **(1)** • Total clockwise moment = 3150 Nm **(1)** • Recognises that clockwise moment = anticlockwise moment **(1)** • F=3500 N **(1)**	Example of calculation: Total clockwise moment = (680x3.6)+(390x1.8) = 3150 Nm F = 3150/0.9 = 3500 N	**5**

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$ (1) • Correct substitutions to calculate r (1) • $h = 5.4\times10^5$m (1) **OR** • Use of $g = \frac{GM}{r^2}$ to find value of g at orbit height (1) • Use of $a = \frac{v^2}{r}$ with value of g at orbit height (1) • $h = 5.4\times10^5$m (1)	Example of calculation: $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $r = \frac{GM}{v^2}$ $r = \frac{6.67\times10^{-11}\text{N m}^2\text{kg}^{-2}\times5.97\times10^{24}\text{ kg}}{(7.59\times10^3\text{ m s}^{-1})^2}$ r=6.91×10^{6}m $\therefore h$=(6.91×10^6-6.37×10^6) m=5.42×10^{5}m	**3**
(ii)	• Use of $GPE = \frac{GMm}{r}$ (1) • GPE = 5.7 × 10^{10} J (1) (ecf from (a)(i))	Example of calculation: $GPE = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $\therefore$GPE=6.67×10^{-11}Nm^{2}kg^{-2} × 5.97 ×10^{24} kg × 11600 kg $\left(\frac{1}{6.37\times10^6\text{m}} - \frac{1}{6.91\times10^6\text{m}}\right)$ $\therefore$GPE=5.67 ×10^{10}J	**2**

Question Number	Acceptable Answer		Additional Guidance	Mark
(iii)	• This would bring the gravitational potential energy closer to zero • This would mean that the satellite would orbit at a greater height as $GPE \propto \frac{1}{r}$ • To remain in orbit the centripetal acceleration must equal the gravitational field strength at the orbit height **Or** Since gravitational force smaller, $\frac{mv^2}{r}$ would be reduced • (Hence) r is greater so v must be smaller **Or** $v^2 = \frac{GM}{r}$ and satellite would orbit at lower speed **OR** • HST will have more kinetic energy at the original orbit height • The centripetal force will be too small to keep it in this orbit • The satellite would be travelling too fast, so it would move to a higher orbit • (Hence) r is greater so v must be smaller **Or** $v^2 = \frac{GM}{r}$ and satellite would orbit at lower speed	(1) (1) (1) (1) (1) (1) (1) (1)		4

Q20.

Question Number	Acceptable Answer		Additional guidance	Mark
(a)	• attempts to find area under second peak <u>OR</u> use of a suitable equation of motion <u>OR</u> equate $E = \frac{1}{2}mv^2$ and $\Delta E = mg\Delta h$ • height = 0.9 - 1.0 m	(1) (1)	<u>Example of calculation:</u> $h = \frac{1}{2} \times 4.2 \text{ m s}^{-1} \times (1.2 - 0.70) \text{ s} = 1.0 \text{ m}$	**(2)**

Question Number	Acceptable Answer		Additional guidance	Mark
(b)	• use of $\Delta E = mg\Delta h$ <u>OR</u> use of $E = \frac{1}{2}mv^2$ • ΔE = 0.59 J	(1) (1)	<u>Example of calculation:</u> $E = 0.060 \text{ kg} \times 9.81 \text{m s}^{-2} \times (2.0 - 1.0)\text{m}$ $E = 0.59 \text{ J}$	**(2)**

Question Number	Acceptable Answer		Additional guidance	Mark
(c)	EITHER • finds gradient of middle section • use of $F = ma$ • $F = 64$ N OR • reads two corresponding pairs of v and t from middle section of graph • use of $F = \frac{m(v-u)}{\Delta t}$ • $F = 64$ N	(1) (1) (1) (1) (1) (1)	Example of calculation: $F = \frac{(6.3+4.2)\text{ m s}^{-1}}{(0.74-0.64)\text{ s}} \times 0.060\text{ kg} = 64\text{ N}$	**(3)**

Question Number	Acceptable Answer		Additional guidance	Mark
(d)	Initial free-fall • gradient of both graphs is the same Bounce section • the gradient of the soft ball graph is less Second free-fall • gradient of the soft ball graph is the same as the first graph OR the gradient is the same as in the initial free-fall	 (1) (1) (1)	Accept the first line is the same Accept time for the bounce is longer	**(3)**

Q21.

Question Number	Acceptable answers	Additional guidance	Mark
	• the point through which the weight (of a body) acts (1) **Or** The point around which the mass is equally distributed **Or** if supported at/below this point the body would be in equilibrium	alt. the point at which the entire mass can be assumed to be located.	1

Q22.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• Use of $v = \frac{2\pi r}{T}$ or $\omega = \frac{2\pi}{T}$ (1) • Use of $a = \frac{v^2}{r}$ or $r\omega^2$ (1) • $a = 8.8 \text{ m s}^{-2}$ (1)	<u>Example of calculation</u> $v = \frac{2\pi 6800000\text{m}}{92\times60\text{s}} = 7740 \text{ m s}^{-1}$ $a = \frac{7740^2 (\text{m s}^{-1})^2}{6800000 \text{ m}} = 8.81 \text{ m s}^{-2}$ or $\omega = \frac{2\pi}{92\times60 \text{ s}} = 1.14 \times 10^{-3} \text{ rad s}^{-1}$ $a = 6800000 \text{ m} \times (1.14 \times 10^{-3} \text{ rad s}^{-1})^2$ $a = 8.81 \text{ m s}^{-2}$	3
(ii)	• The astronauts have weight or not weightless (1) **Or** Earth's gravitational field = 8.8 N kg^{-1} on ISS (ECF from (b)(i)) • Earth's gravitational field keeps astronauts/ISS in circular motion (1) **Or** Weight provides the centripetal force • Our notion of "weight" is reaction force acting on us from the ground/floor (1) • There are no reaction forces from the ISS on the astronauts so they "feel" weightless (1)		4

Q23.

Question Number	Acceptable answers		Additional guidance	Mark
	An explanation that makes reference to the following points: Observation 1 • (the fraction of alpha scattering is less for aluminium) so the force of repulsion is less (at a given distance) • therefore the charge on an aluminium nucleus is less than on gold nucleus Observation 2 • (the E_k is less for scattered alpha for aluminium) so recoiling nucleus must have some/more kinetic energy • The mass of an aluminium nucleus is less than mass of a gold nucleus	 **(1)** **(1)** **(1)** **(1)**		**4**

Q24.

Question Number	Acceptable Answer	Additional Guidance	
	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The table shows how the marks should be awarded for indicative content and lines of reasoning.	(see table below)	

IC points	IC mark	Max linkage mark available	Max final mark
6	4	2	**6**
5	3	2	**5**
4	3	1	**4**
3	2	1	**3**
2	2	0	**2**
1	1	0	**1**
0	0	0	**0**

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between its points and is unstructured	0

	Indicative content: • (Collision takes place on an ice surface so) there is minimal friction **Or** External forces are negligible • Momentum is conserved in the collision • The momentum of stone A before the collision equals the momentum of (A and) B after the collision • Stone A must be at rest after the collision • All of the kinetic energy of stone A must have been transferred to stone B • Kinetic energy is conserved in an elastic collision		6

Q25.

Question Number	Answer	Mark
*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 6** **Fixed target** There is momentum before the collision so there must be momentum after the collision. (1) So particle(s) created must have some kinetic energy (1) So not all KE converted to mass (1) **Colliding beams** (If particles have the same mass and speed), total initial momentum is zero (1) Momentum after collision will be zero (1) If one stationary particle is created (1) All of the kinetic energy of the particle is converted to mass (1)	6
	Total for question	**6**

Q26.

Question Number	Answer		Mark
*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)		
	statement that indicates that the conservation of momentum does apply	(1)	
	the idea that the probe and tank move in opposite directions [accept move apart] **Or** the idea that the probe and tank experience equal and opposite forces	(1)	
	Probe and tank experience equal **changes** in momentum (in opposite directions)	(1)	
	Statement that indicates that (total) energy is conserved	(1)	
	Kinetic energy of the system increases (so speed increases)	(1)	
	(Some) chemical energy converted to KE	(1)	**6**
	Total for question		**6**

Q27.

Question number	Acceptable answers	Additional guidance	Mark
(i)	• Use of $\frac{1}{2}mv^2 = mgh$ **(1)** • $v = 2.43\ \text{m s}^{-1}$ **(1)**	Example of calculation: $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.30} = 2.43\ \text{m s}^{-1}$	**2**
(ii)	• Use of impulse = change in momentum **(1)** • Recognises initial velocity is zero **(1)** • Hence $F = 0.923$ N **(1)** • Use of $l = \pi d$ **(1)** • Equates calculated value of F with BIl **(1)** • Hence I = 191 A **(1)**	Example of calculation: $Ft = mv - mu$ where $u = 0$ So $F = (0.019\ \text{kg} \times 2.43\ \text{m s}^{-1})/0.05\ \text{s} = 0.923\ \text{N}$ $l = \pi \times 0.048\ \text{m} = 0.151\ \text{m}$ $I = 0.923\ \text{N}/(0.032\ \text{T} \times 0.151\ \text{m}) = 191\ \text{A}$	**6**

Q28.

Question Number	Answer	Mark
	B	**1**

Q29.

Question Number	Answer		Mark
(a)	Sum of momenta before (collision) = sum of momenta after (collision) **Or** the total momentum before (a collision) = the total momentum after (a collision) **Or** total momentum remains constant **Or** the momentum of a system remains constant Providing no external/unbalanced/resultant force acts **Or** in a closed system	**(1)** **(1)**	**2**
(b)(i)	Use of equation(s) of motion sufficient to get answer Initial speed = 1.1 ($m\ s^{-1}$) <u>Example of calculation</u> $s = (u + v)t/2$ $0.69\ m = (u + 0) \times 1.3\ s/2$ $u = 1.06\ m\ s^{-1}$	**(1)** **(1)**	**2**
(b)(ii)	Constant acceleration/deceleration (accept constant force)	**(1)**	**1**
(b)(iii)	Use of momentum = mv ecf v from (b)(i) Calculates momentum after collision using correct mass Speed of pellet = 117 or 124 or 129 ($m\ s^{-1}$) <u>Example of calculation</u> Momentum after = $(97.31 + 0.84)\ g \times 1.06\ m\ s^{-1} = 104\ g\ m\ s^{-1}$ Momentum before = momentum after Speed of pellet = $104\ g\ m\ s^{-1} / 0.84\ g = 124\ m\ s^{-1}$	**(1)** **(1)** **(1)**	**3**
***(c)(i)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Mention of momentum Pellet (bounces back so) has negative momentum /velocity **Or** momentum after = momentum of car - momentum of pellet Pellet undergoes a bigger momentum/velocity change **Or** mass of car is less	 **(1)** **(1)** **(1)**	**3**
(c)(ii)	reference to greater horizontal momentum/force	**(1)**	**1**

(d)	[The question says that the calculations are correct, the question is about the assumptions made. Do not credit a statement that the GPE is correct. MP1 is for the assumption that the KE after firing is the same as the max GPE. Do not credit energy loss due to air resistance or sound] $E_k \rightarrow E_{grav}$ of pendulum correct **Or** KE after collision is correct E_k in collision not conserved **Or** not an elastic collision **Or** inelastic collision (do not credit just 'KE is lost') Some energy becomes heat E_k (of pellet before collision)is greater than 0.16J	 **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question		**16**

Q30.

Question Number	Answer		Mark
*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) No external/unbalanced/resultant force so momentum of system is conserved Rocket gains momentum in backward direction Module gains equal amount of momentum in forward direction <u>Kinetic</u> energy of the system increases (Some) chemical energy converted to KE **Alternative mark scheme** if candidate presumes that the initial total momentum is zero (Max 4) No external/unbalanced/resultant force so momentum of system is conserved Rocket and module have equal amount of momentum and move in opposite directions (after separation) <u>Kinetic</u> energy of the system increases (Some) chemical energy converted to KE	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question		**5**