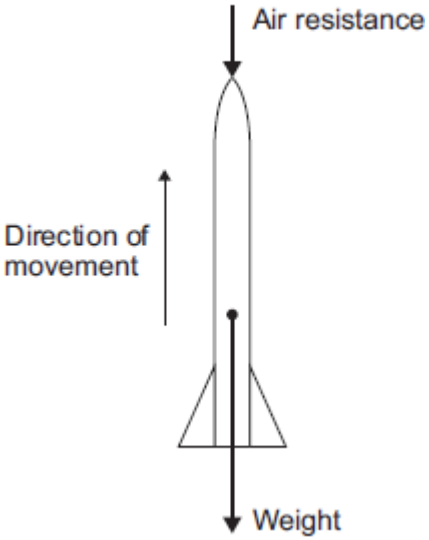
Q1.

(a) **Figure 1** shows the forces acting on a model air-powered rocket just after it has been launched vertically upwards.

Figure 1



(i) How does the velocity of the rocket change as the rocket moves **upwards**?

_____

Give a reason for your answer.

_____

_____

(2)

(ii) The velocity of the rocket is not the same as the speed of the rocket.

What is the difference between the velocity of an object and the speed of an object?

_____

_____

_____

(1)

(b) The speed of the rocket just after being launched is 12 m / s.
The mass of the rocket is 0.05 kg.

(i) Calculate the kinetic energy of the rocket just after being launched.

_____

_____

Kinetic energy = _____ J

(2)

(ii) As the rocket moves upwards, it gains gravitational potential energy.

State the maximum gravitational potential energy gained by the rocket.

Ignore the effect of air resistance.

Maximum gravitational potential energy = _____ J

(1)

(iii) Calculate the maximum height the rocket will reach.

Ignore the effect of air resistance.

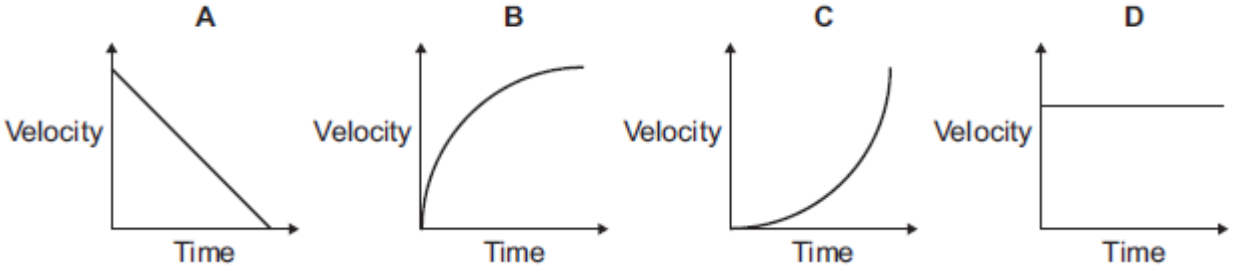
Gravitational field strength = 10 N/kg.

Maximum height = _____ m

(2)

(iv) **Figure 2** shows four velocity–time graphs.

Figure 2



Taking air resistance into account, which graph, **A**, **B**, **C** or **D**, shows how the velocity of the rocket changes as it **falls** from the maximum height it reached until it just hits the ground?

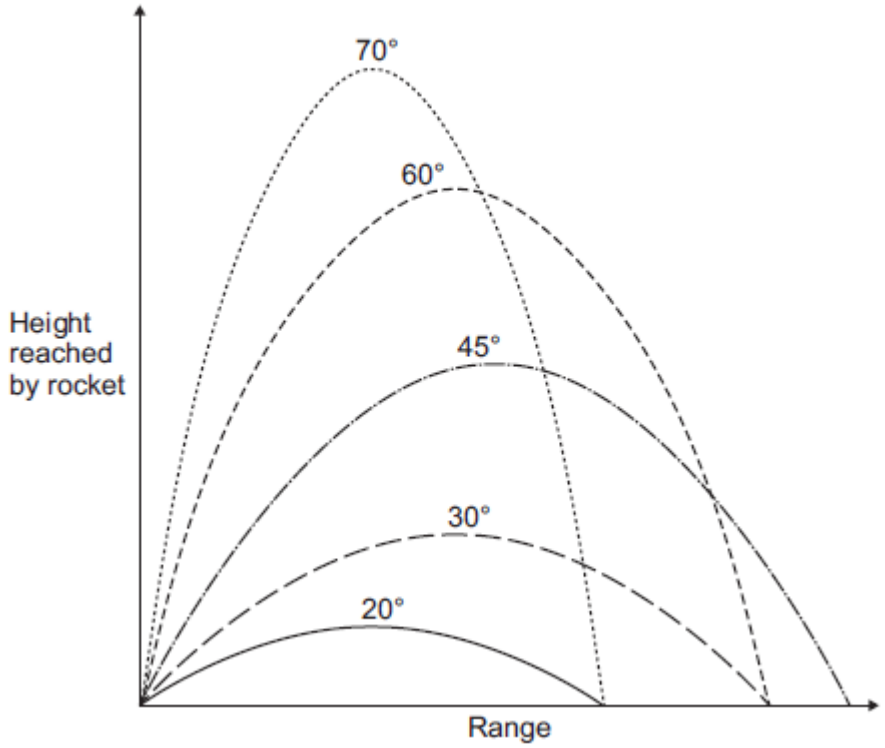
Write the correct answer in the box. ☐

(1)

(c) The rocket can be launched at different angles to the horizontal.
The horizontal distance the rocket travels is called the range.

Figure 3 shows the paths taken by the rocket when launched at different angles.
Air resistance has been ignored.

Figure 3



What pattern links the angle at which the rocket is launched and the range of the rocket?

_____

_____

_____

_____

(2)

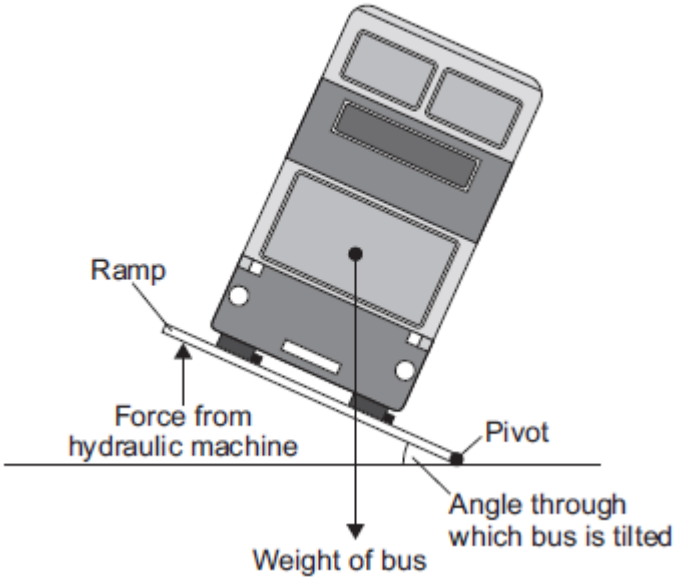
(Total 11 marks)

Q2.

Before a new bus can be used on the roads, it must pass a stability test.
Figure 1 shows how the bus is tested.

Figure 1

Front view



(a) (i) The bus will topple over if the ramp is tilted at too great an angle.

Explain why.

_____

_____

_____

_____

(2)

(ii) The bus is tested to angles of tilt far greater than it would experience in normal use.

Suggest **two** reasons why.

1. _____

_____

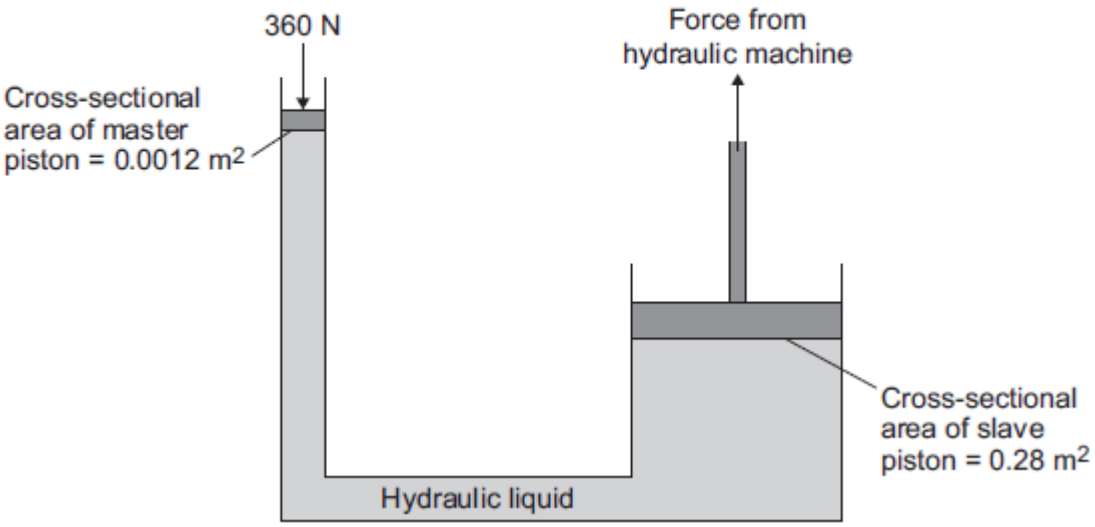
2. _____

_____

(2)

(b) **Figure 2** shows the hydraulic machine that is used to make the ramp tilt.

Figure 2



The pressure applied to the hydraulic liquid at the master piston is the same as the pressure applied by the hydraulic liquid to the slave piston.

(i) State the property of the liquid that keeps the pressure at both pistons the same.

_____

(1)

(ii) A 360 N force acts on the master piston.

Use information from **Figure 2** to calculate the force applied by the hydraulic liquid to the slave piston.

_____

_____

_____

_____

Force = _____ N

(3)

(Total 8 marks)

Q3.

Some students fill an empty plastic bottle with water.
The weight of the water in the bottle is 24 N and the cross-sectional area of the bottom of the bottle is 0.008 m^2.

(a) Calculate the pressure of the water on the bottom of the bottle and give the unit.

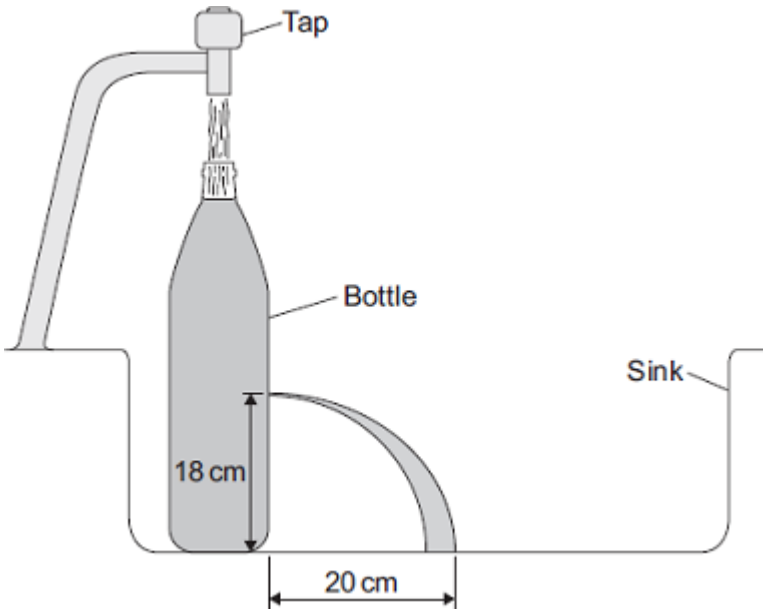
_____

_____

Pressure = _____

(3)

(b) The students made four holes in the bottle along a vertical line.
They put the bottle in a sink. They used water from a tap to keep the bottle filled to the top.



The students measured and recorded the vertical heights of the holes above the sink.
They also measured the horizontal distances the water landed away from the bottle.
A pair of measurements for one of the holes is shown in the diagram.

The complete data from the experiment is shown in the table.

Hole	Vertical height in cm	Horizontal distance in cm
J	24	15
K	18	20
L	12	30
M	6	40

(i) Which hole is shown in the diagram?

Draw a ring around the correct answer.

J **K** **L**

(1)

(ii) On the diagram, draw the path of the water coming out of hole **M**.

Use the information in the table to help you.

(2)

(c) Suggest **one** problem that might arise from trying to collect data from a fifth hole with a vertical height of 1 cm above the sink.

_____

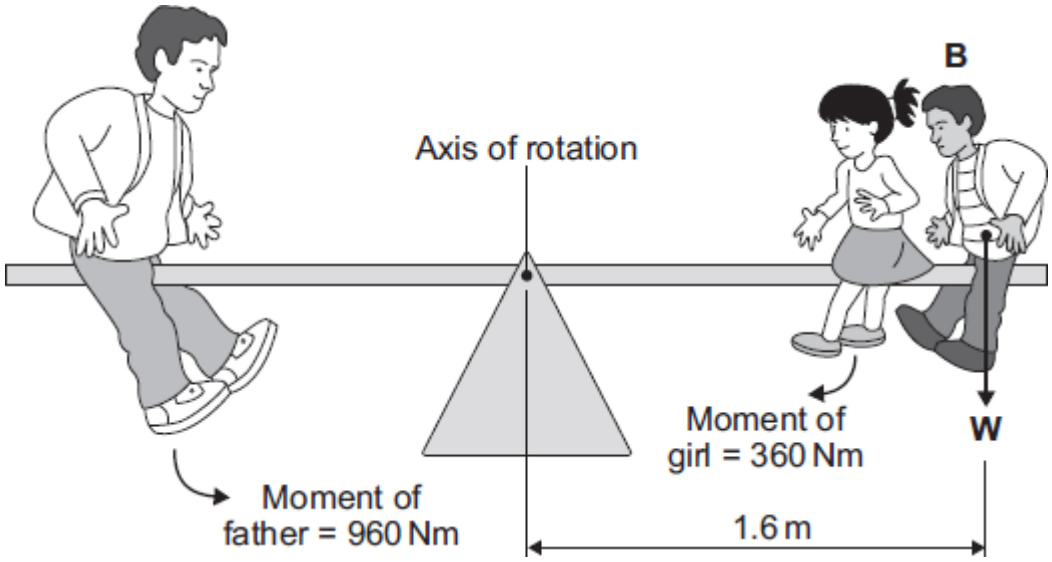
_____

(1)

(Total 7 marks)

Q4.

The diagram shows a father and his two children sitting on a playground see-saw. The see-saw is not moving.



(a) What is the total clockwise moment of the two children about the axis of rotation?

_____

Explain the reason for your answer.

_____

_____

_____

_____

_____

_____

(3)

(b) (i) What is the clockwise moment of the boy, **B**, about the axis of rotation?

_____

Moment = _____ Nm

(1)

(ii) Use the information in the diagram to calculate the weight, **W**, of the boy, **B**.

Show clearly how you work out your answer.

_____

_____

_____

_____

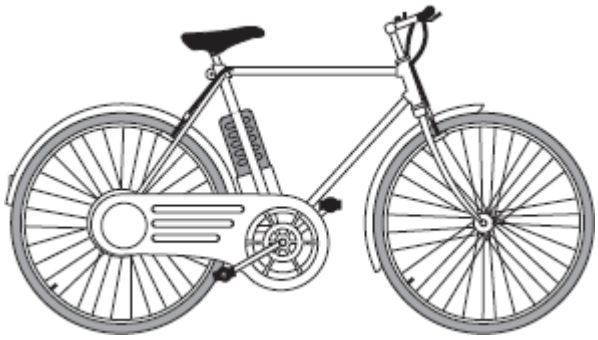
Weight of boy **B** = _____ N

(2)

(Total 6 marks)

Q5.

The picture shows an electric bicycle. The bicycle is usually powered using a combination of the rider pedalling and an electric motor.



(a) A 36 volt battery powers the electric motor. The battery is made using individual 1.2 volt cells.

(i) Explain how a 36 volt battery can be produced using individual 1.2 volt cells.

To gain full marks, you must include a calculation in your answer.

_____

_____

_____

_____

(2)

(ii) The battery supplies a direct current (d.c.).

What is a *direct current (d.c.)*?

_____

_____

(1)

(iii) When fully charged, the battery can deliver a current of 5 A for 2 hours. The battery is then fully discharged.

Calculate the maximum charge that the battery stores.

Show clearly how you work out your answer and give the unit.

_____

_____

Charge stored = _____

(3)

(b) When powered only by the electric motor, the bicycle can carry a 90 kg rider at a maximum speed of 6 m/s. Under these conditions, the maximum distance that the bicycle can cover before the battery needs recharging is 32 km.

The bicycle has a mass of 30 kg.

(i) Calculate the maximum kinetic energy of the bicycle **and** rider when the rider is not pedalling.

Show clearly how you work out your answer.

_____

_____

Kinetic energy = _____ J

(2)

(ii) The bicycle can be fitted with panniers (bags) to carry a small amount of luggage.

What effect would fitting panniers and carrying luggage have on the distance the bicycle can cover before the battery needs recharging?

_____

Give a reason for your answer.

_____

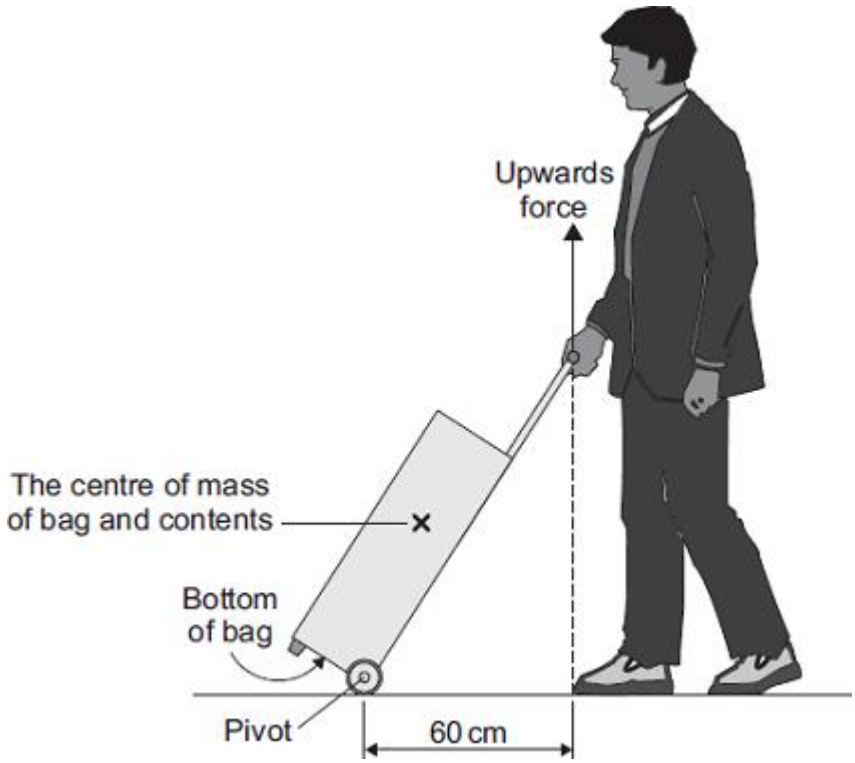
_____

(2)

(Total 10 marks)

Q6.

The diagram shows a man standing in an airport queue with his wheeled bag.



(a) The man applies an upward force to the handle of his bag to stop the bag from falling.
The moment of this force about the pivot is 36 Nm.

Calculate the upward force the man applies to the handle of his bag.

Force = _____ N

(2)

(b) When the man lets go of the bag handle, the bag falls and hits the floor.

Explain why.

(2)

(Total 4 marks)

Q7.

(a) In any collision, the total momentum of the colliding objects is usually conserved.

(i) What is meant by the term 'momentum is conserved'?

_____

_____

(1)

(ii) In a collision, momentum is **not always** conserved.

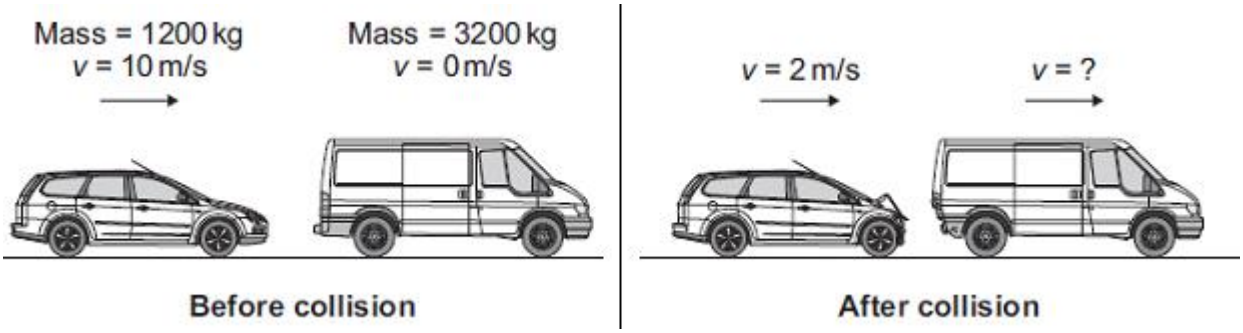
Why?

_____

_____

(1)

(b) The diagram shows a car and a van, just before and just after the car collided with the van.



(i) Use the information in the diagram to calculate the **change** in the momentum of the car.

Show clearly how you work out your answer and give the unit.

_____

_____

_____

_____

Change in momentum = _____

(3)

(ii) Use the idea of conservation of momentum to calculate the velocity of the van when it is pushed forward by the collision.

Show clearly how you work out your answer.

_____

_____

Velocity = _____ m/s forward

(2)

(Total 7 marks)

Q1.

(a) (i) decreases (to zero)

1

resultant force acts in opposite direction to motion

accept air resistance and weight for resultant force

accept resultant force acts downwards

*do **not** accept air resistance increases*

1

(ii) velocity includes direction

or

velocity is a vector (quantity)

1

(b) (i) 3.6

allow 1 mark for correct substitution i.e.

½ × 0.05 × 12^2 provided no subsequent step

2

(ii) 3.6 **or** their (i)

1

(iii) 7.2

or

their (ii) ÷ 0.5 correctly calculated

*allow **1** mark for correct substitution i.e.*

3.6 or their (ii) = 0.05 × 10 × h

2

(iv) **B**

1

(c) range increases up to 45°

1

range decreases from 45°

the range is a maximum at 45° gains both marks

for any two angles that add up

to 90° the range is the same gains both marks

*the range increases then decreases gains **1** mark*

1

[11]

Q2.

(a) (i) the line of action of the weight (of the bus) lies / acts outside of the base (of the bus)

allow line of action through the centre of mass lies / acts outside the base

1

there is a resultant moment (acting on the bus)

1

(ii) in normal use the centre of mass may be in a different position

1

or

passengers on the bus may affect the position of the centre of mass

for safety, buses should always be tested beyond the normal operating conditions / parameters

for safety is insufficient

accept in case something unexpected happens

1

(b) (i) a liquid is (virtually) incompressible

accept a liquid cannot be squashed

a liquid is difficult to compress is insufficient

1

(ii) 84000

*award **2** marks for*

$$\frac{F}{0.28} = \frac{360}{0.0012}$$

or

$$\frac{F}{0.28} = 300\ 000$$

***or** award **1** mark for*

$$P = \frac{360}{0.0012}$$

or

300 000 (Pa)

seen anywhere

3

[8]

Q3.

(a) 3000

*correct substitution of 24 / 0.008 gains **1** mark provided no subsequent steps are shown*

2

N / m^2 or Pa

1

(b) (i) K

accept ringed K in table

1

(ii) water exiting bottle one-third of vertical height of K

allow less than half vertical height of spout shown, judged by eye

1

water landing twice the distance of the spout shown in the diagram

accept at least one and a half times further out than spout shown, judged by eye

*do **not** accept water hitting the side of the sink*

ignore trajectory

1

(c) water will land on the (vertical) side of the sink

*accept sink **not** long / wide / big enough*

or

water will dribble down very close to the bottle

or

that part of the bottle is curved

*do **not** accept goes out of the sink*

1

[7]

Q4.

(a) 960 (Nm)

1

see-saw is in equilibrium

accept see-saw is balanced

see-saw is stationary is insufficient

1

(total) clockwise moments = anticlockwise moment

accept no resultant moment

forces are balanced is insufficient

*an answer clockwise moments balance the anticlockwise moments gains **2** marks*

1

(b) (i) 600 (Nm)

1

(ii) 375 (N) **or** their (b)(i) ÷ 1.6 correctly calculated

*do **not** credit if (b)(i) is larger than 960*

*allow **1** mark for correct substitution **and** transformation ie*

$\frac{600}{1.6}$ *or* $\frac{\text{their (b)(i)}}{1.6}$

2

[6]

Q5.

(a) (i) (connect) 30 (cells)

1

in series

1

(ii) current always flows in the same direction
or
current only flows one way

1

(iii) 36 000

*allow **1** mark for correctly converting 2 hours to 7200 seconds*

*answers 10 or 600 score **1** mark*

2

coulombs / C

*do **not** accept c*

1

(b) (i) 2160

*allow **1** mark for correct substitution, ie ½ × 120 × 6^2*

*answers of 1620 or 540 score **1** mark*

2

(ii) reduce it

1

any **one** from:

- draws a larger current (from battery)
- motor draws greater power (from battery)
  accept energy per second for power
  accept more energy needed to move the bicycle
- greater resistance force (to motion) / air resistance / drag / friction
  accept less streamlined
  more mass to carry is insufficient

1

[10]

Q6.

(a) 60

*allow **1** mark for correct substitution (with d in metres), ie 36 = F × 0.6*

*an answer of 0.6 **or** 6 gains **1** mark*

2

(b) the line of action of the weight lies outside the base / bottom (of the bag)

accept line of action of the weight acts through the side

accept the weight (of the bag) acts outside the base / bottom (of the bag)

1

a resultant / overall / unbalanced moment acts (on the bag)

accept the bag is not in equilibrium

*do **not** accept the bag is unbalanced*

1

[4]

Q7.

(a) (i) momentum before = momentum after

accept no momentum is lost

accept no momentum is gained

or

(total) momentum stays the same

1

(ii) an external force acts (on the colliding objects)

accept colliding objects are not isolated

1

(b) (i) 9600

allow 1 mark for correct calculation of momentum before or after ie 12000 or 2400

or

correct substitution using change in velocity = 8 m/s ie 1200 × 8

2

kg m/s

or

Ns

this may be given in words rather than symbols

*do **not** accept nS*

1

(ii) 3 or their (b)(i) 3200 correctly calculated

allow 1 mark for stating momentum before = momentum after

or

clear attempt to use conservation of momentum

2

[7]

Examiner reports

Q1.

(a) (i) Nearly two thirds of the students scoring zero. Some students had the idea of the weight and air resistance combined being greater than the upward force, but then failed to mention the direction of the forces so missed out on the second mark. Very few students used the term ‘resultant force’ but when it was used it was more often used to explain an increasing speed, suggesting that the students couldn’t believe the rocket was getting slower as it went up. Unfortunately, many students stated that air resistance would increase and hence would start to push down on the rocket and reduce its velocity.

(ii) Nearly three quarters of the students scored this mark, most giving a clear explanation of the directional difference between speed and velocity.

(b) (i) Just over three quarters of the students scored both marks, a great improvement on similar calculations in previous years.

(ii) Many answers seemed to be spontaneous, incorrect and obscure numbers. Many of the students clearly did not understand that the command word ‘state’ in an exam question means that no calculation was required. Many students wrote 36 for this answer, omitting the decimal place, and then correctly used 36 in the final part of the question, getting an answer of 72 m instead of 7.2 m.

(iii) This was poorly done with half of the students scoring zero. A small number of students made a fresh start with this part question and scored both marks for correctly calculating 7.2 m, despite having gained no marks for the first two parts of the question.

(iv) Surprisingly, only half of the students scored this mark.

(c) About one third of the students scored both marks. Many students who stated a pattern wrote that “the greater the angle the greater the range” but did not comment on what happened after 45 degrees and so scored zero. Those who did not state a pattern just picked out a couple of angles and commented on the range for those angles specific angles i.e. ‘big’ or ‘small’. A significant number of students wrote about the relationship between height and range or angle and height, instead of angle and range.

Q2.

(a) (i) Just over two thirds of the students failed to score on this question. Few referred to a 'line of action' and many of those who did fail to identify where the line acted from or through. It was very unusual to see a reference to a moment, and the idea that there was a resultant / unbalanced moment was extremely rare.

(ii) Few students recognised that passengers could affect the position of the centre of mass. It was, however, more common to see answers that made reference to unexpected events. Consequently, just over half of the students failed to score a mark, with the majority of the rest gaining just one mark.

(b) (i) Nearly two thirds of the students were successful in stating that a liquid is virtually incompressible. Others tried to describe the effects of a liquid, such as taking the shape of the container, rather than giving the correct property.

(ii) Over half the students were able to complete the calculation in this part successfully hence gaining all three marks. Students who failed to obtain the correct answer usually found it challenging to manipulate the equation, or to realise that the pressure on the master piston equated to that on the slave piston. A significant number of students, just over one third scored zero.

Q3.

(a) About two-thirds of the students scored full marks for the calculation of pressure when given values for force and cross-sectional area. The remainder lost a mark for giving an incorrect unit for pressure.

(b) (i) Nearly all students were able to match the dimensions given on a diagram with those in a table of results.

(ii) Nearly all students were able to draw the trajectory of water from a bottle giving both the vertical and horizontal distances of the trajectory.

(c) About half of the students were able to suggest a problem that might arise from trying to collect data from a hole close to the bottom of the bottle.

Q4.

(a) Most candidates correctly identified 960 Nm but fewer followed this with correct reasoning. Some candidates failed to score a second or third mark because the moments were not directional i.e. ‘clockwise moments’.

(b) (i) This question was well answered with 80% of candidates scoring this mark.

(ii) This part question proved to be a good end to the paper for the majority of candidates. Just over 71% of candidates gained both marks, few candidates scored just one mark.

Q5.

(a) (i) Only a few students scored both marks. The first mark for calculating 30 cells was most frequently scored however the mark for series circuit was rarely given. Appearances of ‘parallel circuit’ were fortunately rare. Those students who did attempt to describe the connection needed for the cells to make a battery said ‘positive to negative’ without realising that this could be achieved both in series and parallel.

(ii) About three fifths of students could describe a direct current however there were a lot of common misconceptions: a current which goes straight to where it is needed, it flows through all of the circuit, a current which travels in a straight line. A few students tried to describe d.c. only in terms of a CRO display which was insufficient for this question.

(iii) About a quarter of students scored all three marks. The most common mistake was the failure to convert the time of two hours to seconds. Of the third of students who gained two marks, the majority gave the ‘fall back answer’ of 10 or 600 with the correct unit, those who gained one mark achieved this mostly with answers of 10 or 600 with very few gaining 1 mark from a correct unit without a correct calculation. A number of students had been well trained to put a really large C but unfortunately a number of small c’s and q’s were also in evidence. A few students scored no mark.

(b) (i) This question was well done compared to recent years, with nearly three quarters of students scoring bothmarks. Common mistakes were the failure to square ‘6’, and erroneously changing 120 kg to 120000 g.

(ii) Most students correctly stated that the distance was reduced (in their own words) but some mistakenly gave an answer of ‘time being less between recharge’ thus not answering the question. A common misconception is that more KE is needed to move the bicycle with a greater load rather than more energy from the battery being transferred as more KE for a bicycle of greater mass moving at the same speed. Very few students who mentioned KE in their answer managed to do so in an appropriate way to score the mark. The two fifths of students who scored the reason mark generally did so by simply stating that ‘more energy is needed’.

Q6.

(a) Less than half of answers gained 2 marks. The most common mistake was failing to convert 60 cm into 0.6 metres.

(b) The majority of candidates failed to gain any marks. Most failed to mention line of action, and simply restated what they were seeing in the diagram.

Q7.

(a) (i) A small number of students could come up with a simple phrase to explain ‘momentum is conserved’. Incorrect responses indicated that students were confused with momentum as being a type of energy.

(ii) This was even less well known with a very small number of the students gaining this mark. Again the responses were varied and indicated a lack of understanding of momentum.

(b) (i) More students were able to use the equation for momentum with the majority scoring some marks on this question. A small number of the students gained all 3 marks.

(ii) A small number of the students scored both marks for this question, and a tiny minority picked up the compensation mark for using the conservation of momentum but not achieving the correct final numerical answer.