Forces part 9 AQA Triple Physics

Name: _____

Class: _____

Date: _____

Time: **77 minutes**

Marks: **72 marks**

Comments:

1. The stopping distance of a car is the braking distance added to the thinking distance.

(a) Complete the sentences.

Choose answers from the box.

chemical	**electrostatic**	**kinetic**
nuclear	**thermal**	

A driver applies the brakes to a moving car.

As the car slows down, there is a decrease in the _____

energy of the car.

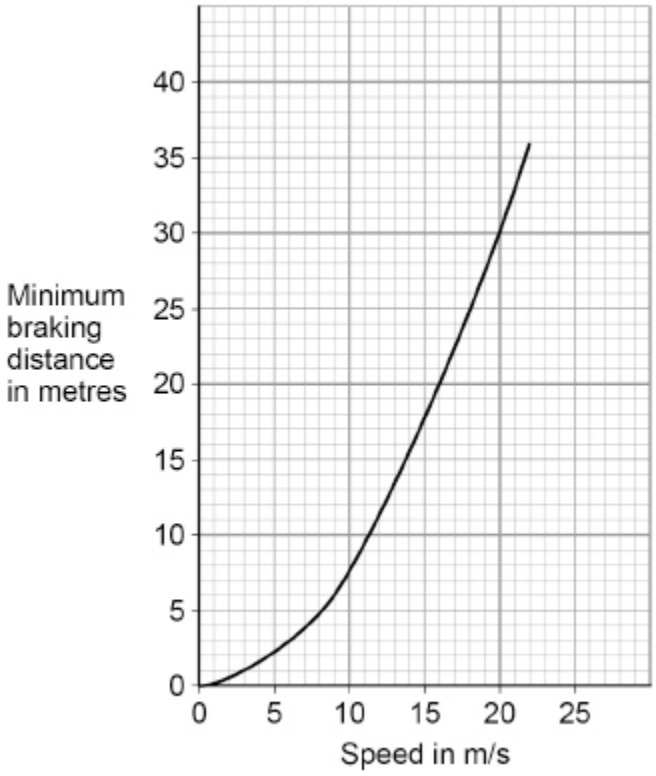
The work done by friction causes an increase in the _____

energy store of the brakes.

(2)

(b) **Figure 1** shows how the speed of the car affects the minimum braking distance of the car.

Figure 1



Describe the relationship between the speed of the car and the minimum braking distance of the car.

_____

_____

(1)

(c) Complete the sentence.

Choose the answer from the box.

decreases	**stays the same**	**increases**

When the road becomes icy, the braking distance _____.

(1)

A car driver applies the brakes to decelerate the car as it approaches a road junction.

The car decelerates at 0.25 m/s^2.

mass of the car = 1600 kg

(d) Calculate the time taken for the velocity of the car to decrease from 12.5 m/s to 5.0 m/s.

Use the equation:

$$\text{time taken} = \frac{\text{change in velocity}}{\text{deceleration}}$$

Time taken = _____ s

(3)

(e) Calculate the resultant force causing the car to decelerate.

Use the equation:

resultant force = mass × deceleration

Resultant force = _____ N

(2)

Thinking distance is affected by the reaction time of the driver.

Figure 2 shows how a student tested a person's reaction time.

Figure 2

The student held a ruler and then released it.

The person being tested closed his hand to catch the ruler as quickly as possible.

The further the ruler fell the greater the person's reaction time.

(f) The student wanted to test the reaction time of the people in her class.

Which of the following could have been a control variable in this investigation?

Tick (✓) **one** box.

Distance fallen by the ruler before being caught ☐

Initial height of the ruler above the person's hand ☐

Reaction time of the person being tested ☐

(1)

(g) The student tested three people in her class.

The mean distance that the ruler fell before being caught was 18.2 cm.

If all of the people in her class were tested, the mean distance may not be 18.2 cm.

Suggest why.

_____

_____

(1)

(h) Describe how this investigation could be changed to find out how listening to music affects reaction time.

_____

_____

_____

_____

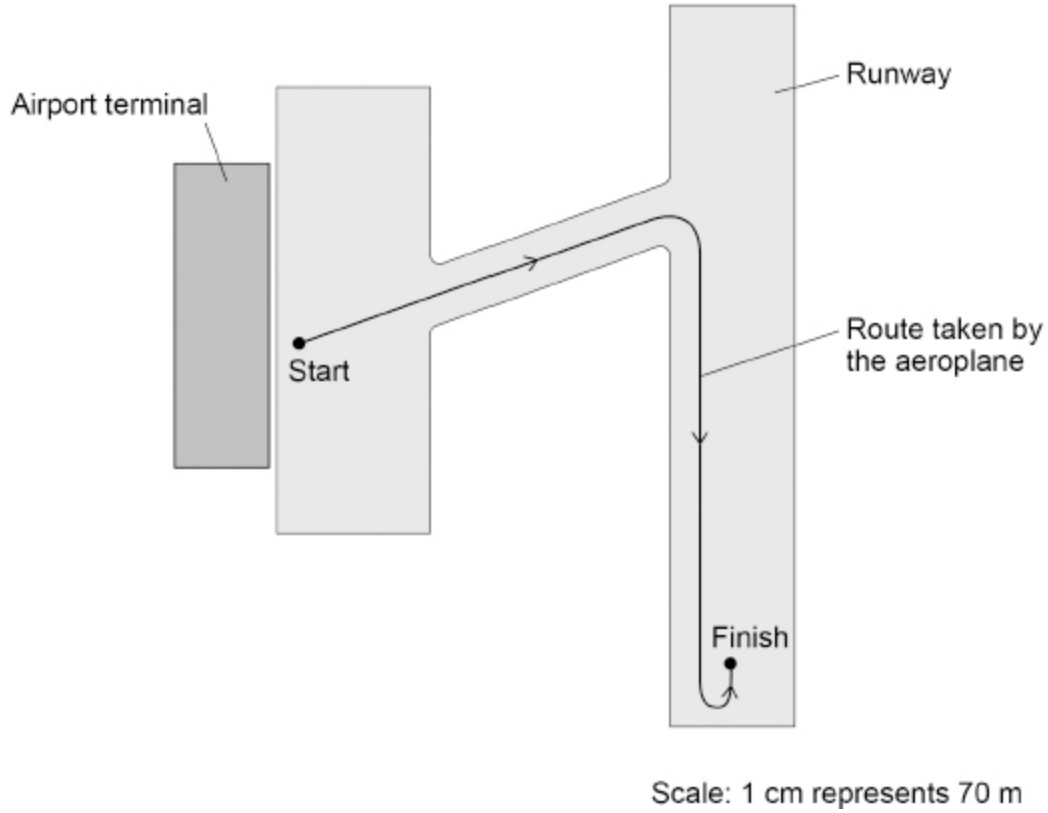
(2)

(Total 13 marks)

2. **Figure 1** shows the route an aeroplane takes as it travels from an airport terminal to the runway.

Figure 1 has been drawn to scale.

Figure 1



(a) Determine the magnitude of the aeroplane's displacement from the start point to the finish point on **Figure 1**.

_____

_____

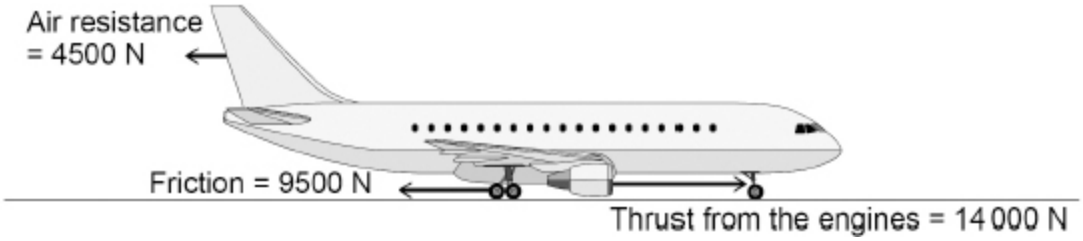
_____

Displacement = _____ m

(2)

Figure 2 shows the direction of the horizontal forces acting on the aeroplane as it moves in a straight line towards the runway.

Figure 2



(b) Determine the magnitude of the resultant horizontal force on the aeroplane.

_____

_____

Resultant horizontal force = _____ N

(1)

(c) Describe the motion of the aeroplane as it moves towards the runway.

_____

_____

(1)

(d) Air resistance and friction are contact forces.

Give **one** other example of a contact force.

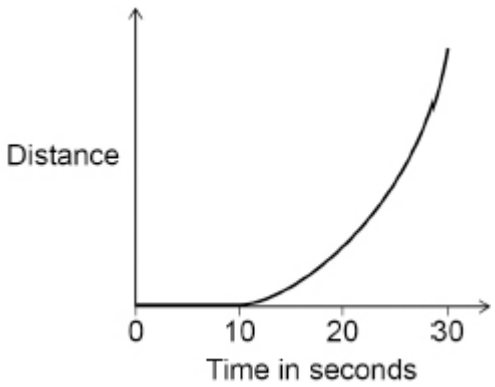
_____

(1)

(e) The aeroplane stops for a short time and then accelerates along the runway.

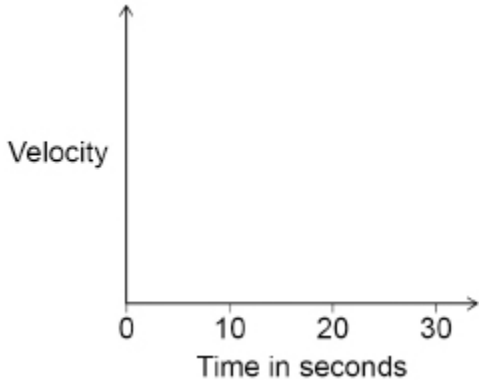
Figure 3 shows a distance–time sketch-graph for this stage of the journey.

Figure 3



Draw the velocity–time sketch-graph for this stage of the journey on **Figure 4**.

Figure 4

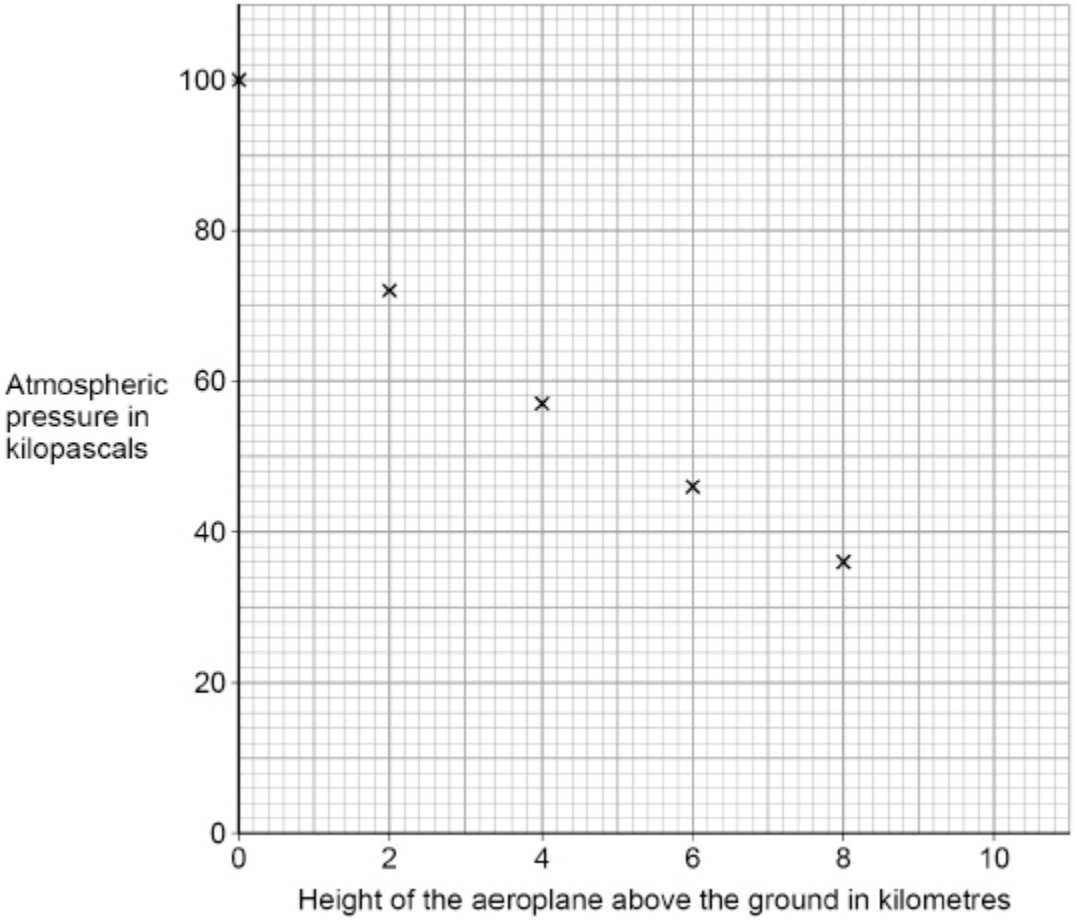


(2)

(f) The aeroplane takes off from the runway, so its height above the ground increases.

Figure 5 shows how atmospheric pressure varies with the height of the aeroplane above the ground.

Figure 5



Estimate the atmospheric pressure when the height of the aeroplane above the ground is 10 km.

Atmospheric pressure = _____ kPa

(2)

(g) What happens to the air surrounding the aeroplane as the height of the aeroplane above the ground increases?

Tick (✓) **one** box.

The average density of the air above the aeroplane decreases. ☐

The mass of air above the aeroplane increases. ☐

The temperature of the air increases. ☐

The volume of air below the aeroplane decreases. ☐

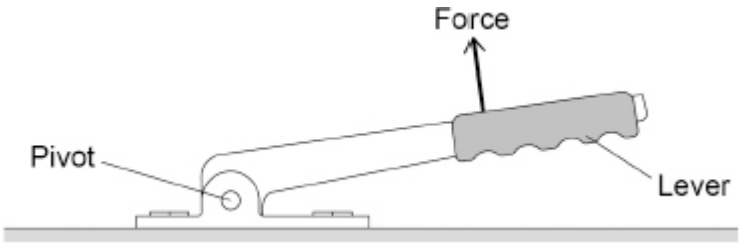
(1)

(Total 10 marks)

3. Some cars have a lever that is used to apply the handbrake.

Figure 1 shows the handbrake lever in a car.

Figure 1



(a) The driver applies the force shown in **Figure 1**. The force produces a moment about the pivot.

How could the driver increase the moment about the pivot without increasing the size of the force?

_____

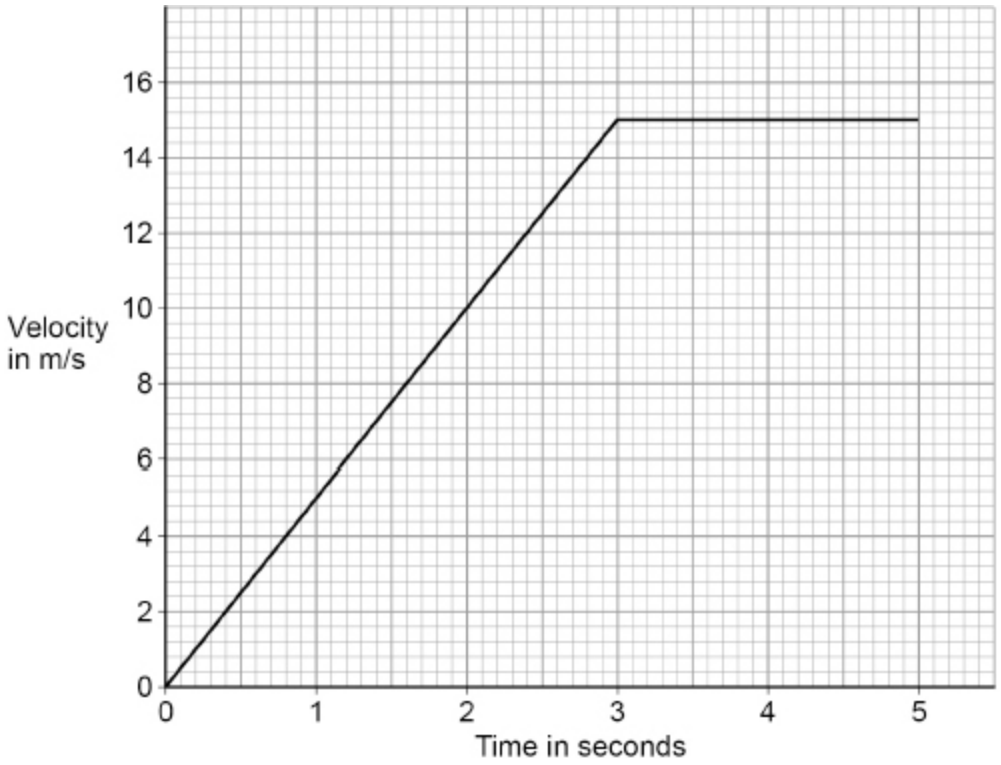
_____

(1)

The driver releases the handbrake.

Figure 2 shows how the velocity of the car changes during the first 5 seconds of a journey.

Figure 2



(b) After 3 seconds, the momentum of the car is 24 000 kg m/s.

Calculate the mass of the car.

Use the Physics Equations Sheet.

Mass = _____ kg

(4)

(c) Determine the distance travelled by the car during the first 5 seconds of the journey.

Use **Figure 2**.

Distance travelled by the car = _____ m

(3)

(d) In an emergency the driver needs to apply the brakes suddenly to stop the car quickly.

The driver of the car is distracted.

Explain why the distraction will increase the stopping distance.

(3)

(e) Explain why the temperature of the brakes increases as they are used.

(2)

(Total 13 marks)

4. The figure below shows some bumper cars.

Bumper cars are designed to withstand collisions at low speeds.

(a) During a collision between a bumper car and the barrier, the bumper car and barrier act as a closed system.

What is meant by a 'closed system'?

_____

_____

_____

(1)

(b) How does Newton's Third Law of motion apply to the collision between the bumper car and the barrier?

_____

_____

_____

(1)

(c) During the collision, the change in momentum of the bumper car is 700 kg m/s.

The time taken for the collision is 0.28 s.

Calculate the force on the bumper car during the collision.

Use the Physics Equations Sheet.

Force = _____ N

(2)

(d) The bumper car has a flexible bumper.

Explain how the flexible bumper reduces the risk of injury to the people in the bumper car during the collision.

(3)

(e) A bumper car moved with an initial constant velocity and then accelerated at 2.0 m/s^2.

While accelerating, the bumper car travelled a distance of 1.5 m.

The final velocity of the bumper car was 2.5 m/s.

Calculate the initial constant velocity of the bumper car.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

Initial constant velocity = _____ m/s

(3)

(Total 10 marks)

5. Hailstones are small balls of ice. Hailstones form in clouds and fall to the ground.

Figure 1 shows different-sized hailstones.

Figure 1

(a) Which force causes the hailstones to fall to the ground?

Tick (✓) **one** box.

- Air resistance ☐
- Gravitational force ☐
- Magnetic force ☐
- Tension ☐

(1)

(b) As the hailstones begin to fall they accelerate.

Which force increases as the hailstones accelerate?

Tick (✓) **one** box.

- Air resistance ☐
- Gravitational force ☐
- Magnetic force ☐
- Tension ☐

(1)

(c) After a short time hailstones fall at terminal velocity.

Which of the following statements is true at terminal velocity?

Tick (✓) **one** box.

The hailstones begin to slow down. ☐

The mass of the hailstones increases. ☐

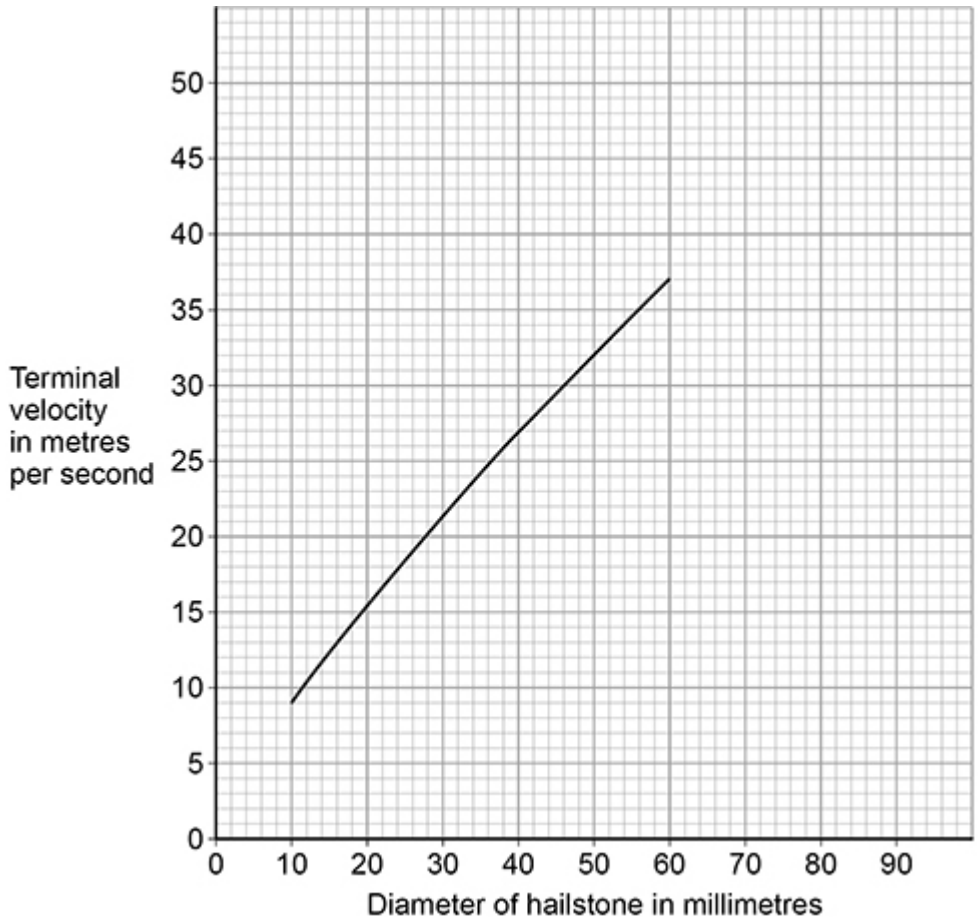
The resultant force on the hailstones is zero. ☐

(1)

A scientist investigated how the terminal velocity of hailstones varies with their diameter.

Figure 2 shows the results.

Figure 2



(d) Estimate the terminal velocity for a hailstone with a diameter of 80 mm.

Show how you obtain your answer.

_____

_____

_____

Terminal velocity = _____ m/s

(2)

(e) Give **one** reason why a hailstone with a large diameter has a greater terminal velocity than a hailstone with a smaller diameter.

Tick (✓) **one** box.

It has a greater power. ☐

It has a greater pressure. ☐

It has a greater temperature. ☐

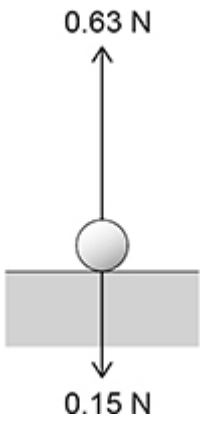
It has a greater weight. ☐

(1)

After falling, the hailstone hits the ground.

Figure 3 shows the forces acting on the hailstone at the moment it hits the ground.

Figure 3



(f) What is the magnitude of the resultant force on the hailstone in **Figure 3**?

Tick (✓) **one** box.

0.15 N ☐

0.48 N ☐

0.63 N ☐

0.78 N ☐

(1)

(g) What is the direction of the resultant force on the hailstone in **Figure 3**?

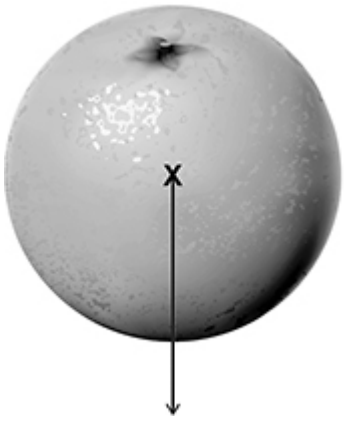
_____

(1)

(Total 8 marks)

6. **Figure 1** shows the weight of an orange acting from a point labelled **X**.

Figure 1



(a) What name is given to point **X** in **Figure 1**?

Tick (✓) **one** box.

Centre of force ☐

Centre of mass ☐

Centre of balance ☐

Centre of weight ☐

(1)

(b) Weight and mass are not the same.

The relationship between weight and mass for an object can be written as:

$$\text{weight} \propto \text{mass}$$

Which sentence describes the relationship between weight and mass?

Tick (✓) **one** box.

Weight is approximately equal to mass. ☐

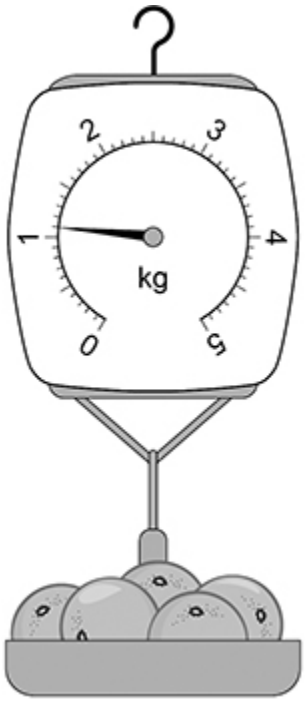
Weight is directly proportional to mass. ☐

Weight is less than mass. ☐

(1)

Figure 2 shows a balance used to measure the mass of 5 oranges.

Figure 2



(c) All 5 of the oranges have the same mass.

Determine the mass of 1 orange.

_____

Mass = _____ kg

(2)

(d) Calculate the weight of 1 orange.

gravitational field strength = 9.8 N/kg

Use the equation:

weight = mass × gravitational field strength

_____

_____

_____

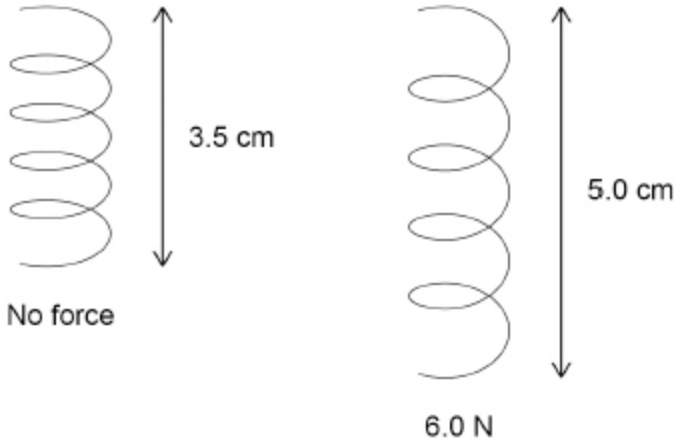
Weight = _____ N

(2)

The balance shown in **Figure 2** contains a spring.

Figure 3 shows the spring with no force acting on it and with a force of 6.0 N acting on it.

Figure 3



(e) What is the extension of the spring when a force of 6.0 N acts on it?

Tick (✓) **one** box.

0.015 m ☐

0.035 m ☐

0.050 m ☐

0.085 m ☐

(1)

(f) Calculate the spring constant of the spring.

Use the equation:

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}$$

Spring constant = _____ N/m

(2)

(g) What will happen to the spring when the force is removed?

_____

_____

(1)

(Total 10 marks)

7. The Earth is surrounded by an atmosphere.

(a) The radius of the Earth is 6400 km.

Which of the following could be an approximate depth of the Earth's atmosphere?

Tick (✓) **one** box.

100 km ☐

6400 km ☐

100 000 km ☐

640 000 km ☐

(1)

(b) What state of matter is most of the Earth's atmosphere?

Tick (✓) **one** box.

Gas ☐

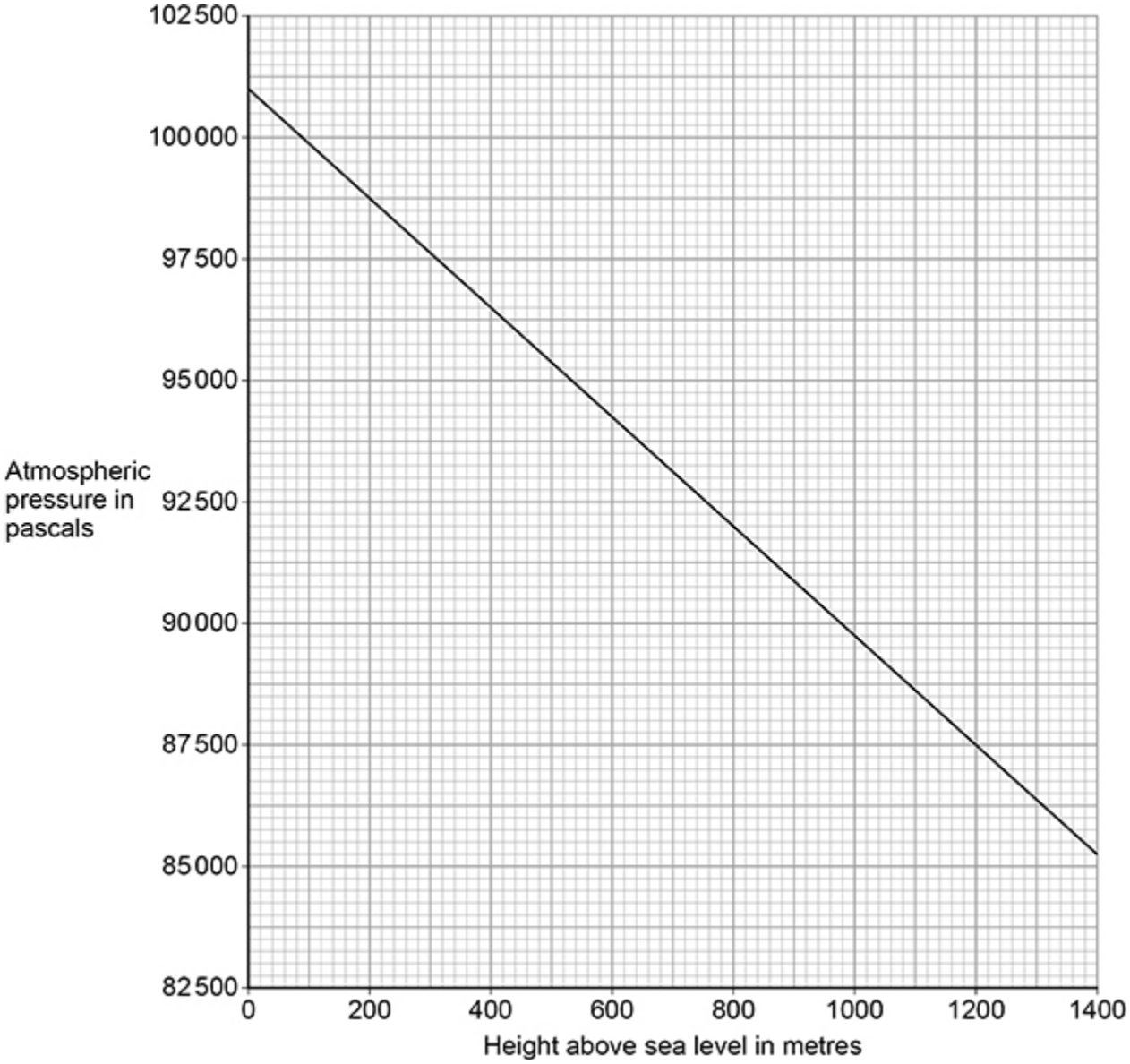
Liquid ☐

Solid ☐

(1)

Figure 1 shows how atmospheric pressure varies with height above sea level.

Figure 1



(c) The highest point above sea level in England is the top of a mountain called Scafell Pike.

The height above sea level of Scafell Pike is 978 m.

Determine the atmospheric pressure at the top of Scafell Pike.

Use **Figure 1**.

_____

_____

Atmospheric pressure = _____ Pa

(1)

(d) Determine the difference between the atmospheric pressure at sea level and at the top of Scafell Pike.

Use **Figure 1** and your answer from part (c)

_____

_____

Difference in atmospheric pressure = _____ Pa

(1)

(e) A student climbs Scafell Pike.

Why does the atmospheric pressure decrease as the student climbs higher?

Tick (✓) **two** boxes.

The air exerts a greater force on the student.	☐
The density of the air decreases.	☐
The mass of air above the student decreases.	☐
The temperature of the air increases.	☐
The volume of air above the student increases.	☐

(2)

(f) **Figure 2** shows a mountain lake.

Figure 2

The lake has a surface area of 2000 m^2.

Atmospheric pressure exerts a force of 188 000 000 N on the surface of the lake.

Calculate the atmospheric pressure at the surface of the lake.

Use the equation:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

Atmospheric pressure = _____ Pa

(2)

(Total 8 marks)

1. (a) kinetic

1

thermal

1

this order only

(b) (minimum braking) distance increases with increasing speed

allow positive correlation

1

(c) increases

1

(d) 12.5 - 5.0 = 7.5 (m/s)

1

$t = \frac{7.5}{0.25}$

this mark may be awarded if the change in velocity is incorrectly calculated

1

t = 30 (s)

allow a correctly calculated answer using a change in velocity incorrectly calculated

1

(e) *F* = 1600 × 0.25

1

F = 400 (N)

1

(f) initial height of the ruler above the person's hand

1

(g) there will be more variation in distances

allow reaction times for distances

allow the three students tested are not typical

1

(h) carry out the experiment listening to music

1

then not listening to music (and compare the results)

allow compare with original results

1

[13]

2.

(a) 7.1 (cm)

allow 7.0 to 7.3 (cm)

1

497 (m)

allow 70 × their measurement of displacement

1

(b) 0 (N)

1

(c) constant velocity

allow constant speed (in a straight line)

*do **not** accept stationary*

*allow constant acceleration if a **mathematical error** in (b) gives a non-zero value for resultant force*

1

(d) any **one** from:

- tension
- normal contact (force)
- upthrust

allow lift, thrust and water resistance

allow normal reaction (force)

ignore drag

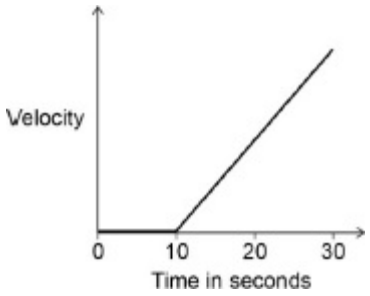
1

(e) horizontal line drawn to 10s along the *x*-axis

1

line with a positive gradient starting from 10 s

allow an upward curving line with increasing gradient starting from 10 s



1

(f) line of best fit drawn and extrapolated to 10 km

*do **not** accept a straight line*

1

28 (kPa)

allow 26 to 32 (kPa)

allow a value correctly extrapolated from their line

allow 2 marks for a correct mathematically extrapolated value

1

(g) the average density of the air above the aeroplane decreases

1

[10]

3. (a) apply the force further away from the pivot

do not allow increase the length of the lever

1

(b) v = 15 (m/s)

1

24 000 = m × 15

allow a value of v = 14.5 (m/s)

1

$$m = \frac{24\,000}{15}$$

1

m = 1600 (kg)

1

(c) distance travelled during first 3 seconds = 22.5 (m)

1

distance travelled during last 2 seconds = 30 (m)

1

total distance = 52.5 (m)

allow 53 (m)

allow 1 mark for the correct addition of their calculated distances

allow a maximum of 2 marks for total distance = 50.75 (m) if velocity used = 14.5 (m/s)

1

(d) stopping distance includes thinking distance

allow stopping distance = braking distance + thinking distance

1

there is an additional time before the driver applies the brakes.

allow the driver's reaction time will increase (due to the distraction)

1

(so) the thinking distance will increase

1

(e) work is done due to friction (in the brakes)

ignore friction alone

1

(causing) an increase in the internal / thermal energy (of the brakes)

1

[13]

4. (a) the total amount of energy (of the bumper car and barrier) remains constant.
or
total momentum (of bumper car and barrier) before collision equals total momentum (of bumper car and barrier) after collision
or
the resultant external force acting (on the system) is zero

allow there are no external forces (acting on the system)

1

(b) the force of the car on the barrier is equal to the force of the barrier on the car and in the opposite direction

1

(c) $F = \frac{700}{0.28}$

1

F = 2 500 (N)

1

(d) increases the time taken for the collision to occur

allow increases contact time

*do **not** accept slows down time*

1

(so) the rate of change of momentum decreases

allow reduces acceleration / deceleration

1

reducing the force (on the people)

reduces impact is insufficient

1

(e) $2.5^2 - u^2 = 2 \times 2.0 \times 1.5$

1

$u^2 = 2.5^2 - (2 \times 2.0 \times 1.5)$

1

$u = 0.50$ (m/s)

allow 0.5 (m/s)

1

[10]

5. (a) gravitational force

1

(b) air resistance

1

(c) the resultant force on the hailstones is zero

1

(d) line extrapolated to 80 mm

allow a straight line

1

46 (m/s)

allow 44 − 48 but not if inconsistent with their extrapolated line

1

(e) it has a greater weight

1

(f) 0.48 (N)

1

(g) upwards

allow up

ignore north

1

[8]

6. (a) centre of mass

1

(b) weight is directly proportional to mass

1

(c) reading from balance = 1.1 kg

1

mass = $\frac{1.1}{5}$ = 0.22 kg

allow correct calculation using incorrectly read value from the balance

1

(d) weight = 0.22 × 9.8

*allow ecf from part **(c)***

1

2.156 (N)

allow correct answer to 2 or 3 sig figs

1

(e) 0.015 m

1

(f) spring constant = $\frac{6.0}{0.015}$

*allow ecf from part **(e)***

1

400 (N/m)

1

(g) returns to its original length/shape

allow returns to 3.5 cm

1

[10]

7. (a) 100 km

1

(b) gas

1

(c) 90 000 Pa

allow 89 500 to 90 500

1

(d) 101 000 – 90 000 = 11 000 Pa

*allow ecf from part **(c)***

1

(e) the density of the air decreases

1

the mass of air above the student decreases

1

(f) $P = \frac{188\,000\,000}{2000}$

1

94 000 (Pa)

1

[8]