Forces part 5 AQA Triple Physics

Name: _____

Class: _____

Date: _____

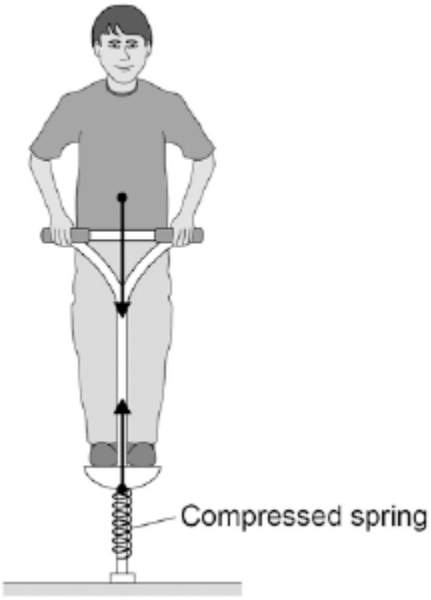
Time: **71 minutes**

Marks: **68 marks**

Comments:

1. The figure below shows the forces acting on a child who is balancing on a pogo stick.

The child and pogo stick are not moving.



(a) The downward force of the child on the spring is equal to the upward force of the spring on the child.

This is an example of which one of Newton's Laws of motion?

Tick **one** box.

First Law ☐

Second Law ☐

Third Law ☐

(1)

(b) Complete the sentence.

Use an answer from the box.

elastic potential	**gravitational potential**	**kinetic**

The compressed spring stores _____ energy.

(1)

(c) The child has a weight of 343 N.

Gravitational field strength = 9.8 N / kg

Write down the equation which links gravitational field strength, mass and weight.

_____

(1)

(d) Calculate the mass of the child.

_____

_____

_____

Mass = _____ kg

(3)

(e) The weight of the child causes the spring to compress elastically from a length of 30cm to a new length of 23cm.

Write down the equation which links compression, force and spring constant.

_____

(1)

(f) Calculate the spring constant of the spring.

Give your answer in newtons per metre.

_____

_____

_____

Spring constant = _____ N / m

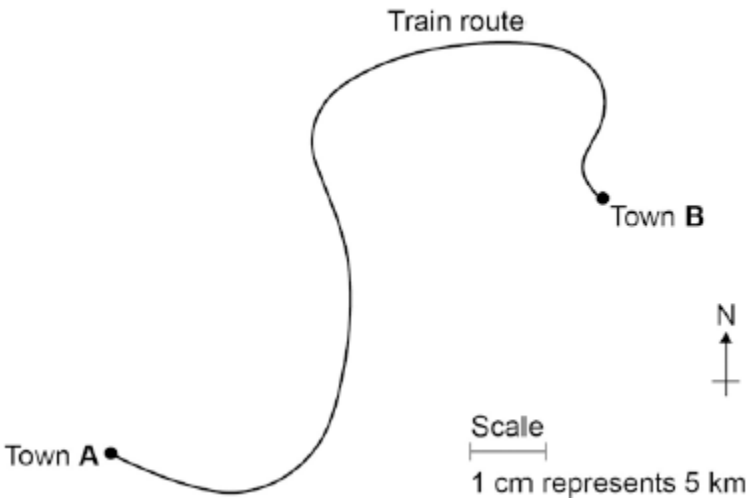
(4)

(Total 11 marks)

2. A train travels from town **A** to town **B**.

Figure 1 shows the route taken by the train.
Figure 1 has been drawn to scale.

Figure 1



(a) The distance the train travels between **A** and **B** is not the same as the displacement of the train.

What is the difference between distance and displacement?

_____

_____

_____

(1)

(b) Use **Figure 1** to determine the displacement of the train in travelling from **A** to **B**.

Show how you obtain your answer.

_____

_____

Displacement = _____ km

Direction = _____

(2)

(c) There are places on the journey where the train accelerates without changing speed.

Explain how this can happen.

_____

_____

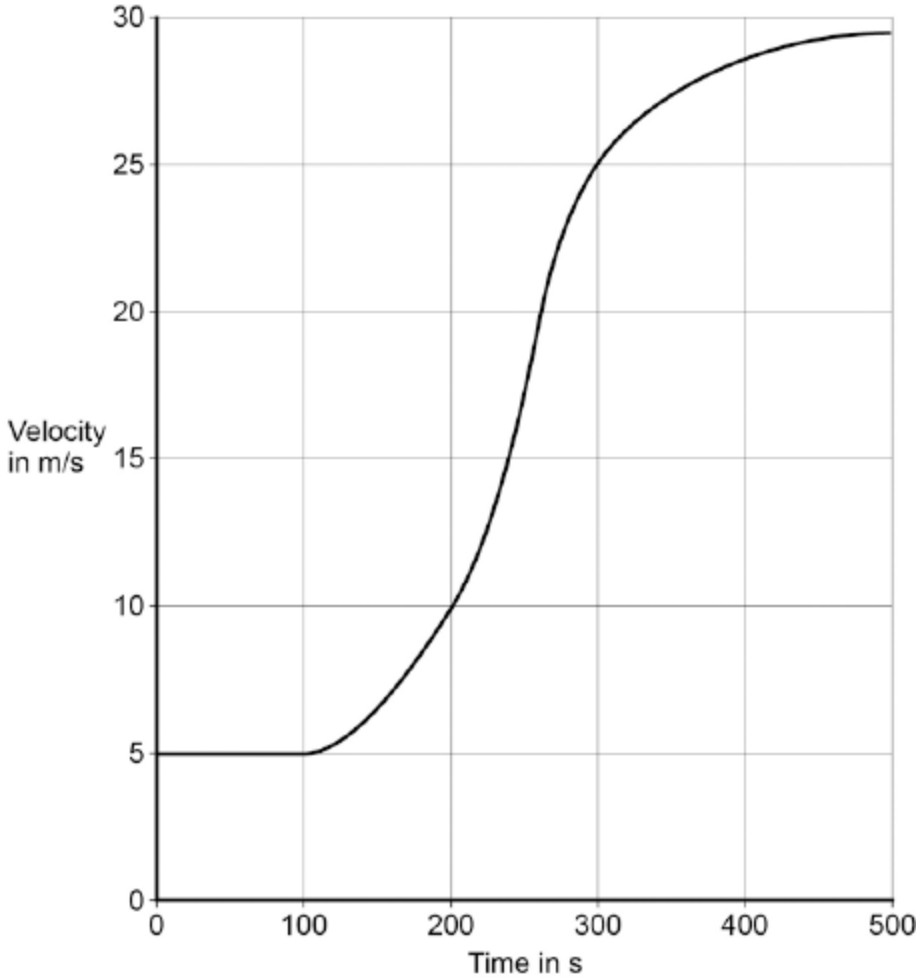
_____

_____

(2)

(d) **Figure 2** shows how the velocity of the train changes with time as the train travels along a straight section of the journey.

Figure 2



Estimate the distance travelled by the train along the section of the journey shown in **Figure 2**.

To gain full marks you must show how you worked out your answer.

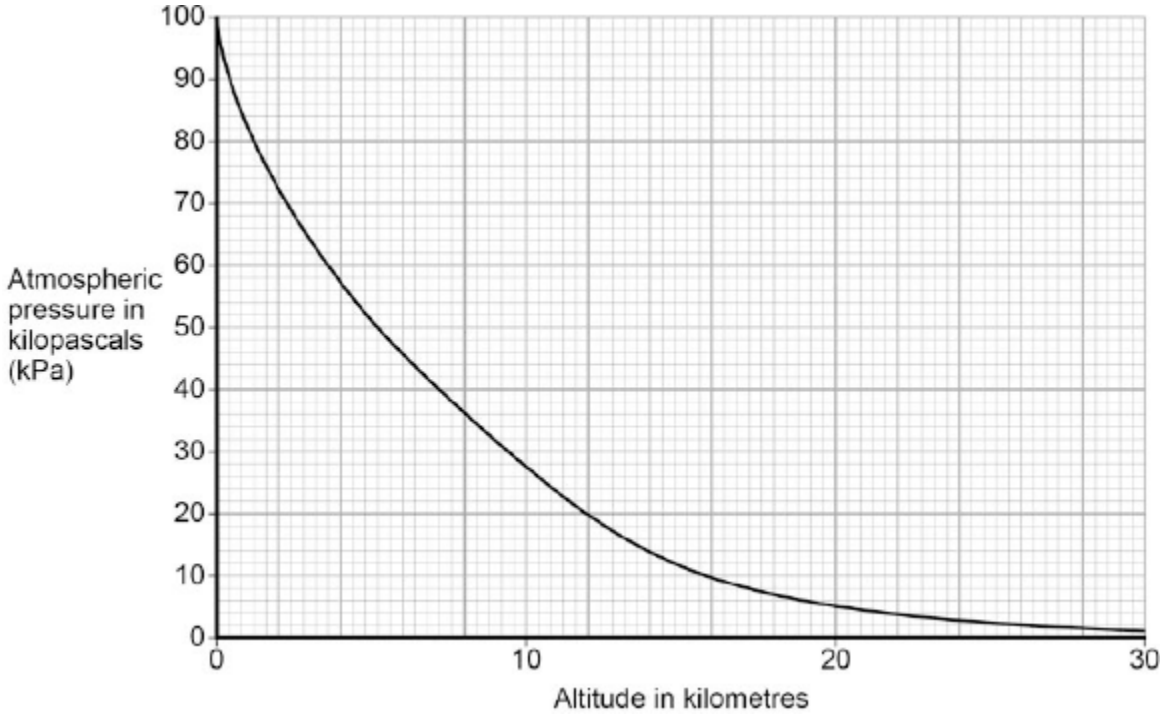
Distance = _____ m

(3)

(Total 8 marks)

3. **Figure 1** shows how atmospheric pressure varies with altitude.

Figure 1



(a) Explain why atmospheric pressure decreases with increasing altitude.

_____

_____

_____

_____

_____

_____

(3)

(b) When flying, the pressure inside the cabin of an aircraft is kept at 70 kPa.

The aircraft window has an area of 810 cm^2.

Use data from **Figure 1** to calculate the resultant force acting on an aircraft window when the aircraft is flying at an altitude of 12 km.

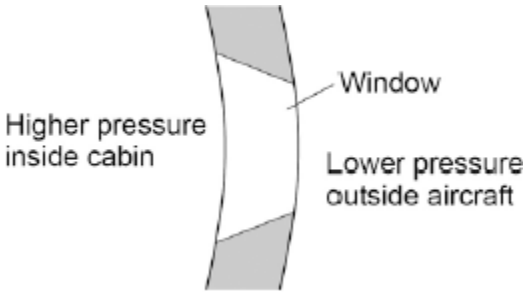
Give your answer to two significant figures

Resultant force = _____ N

(5)

(c) **Figure 2** shows the cross-section of one type of aircraft window.

Figure 2

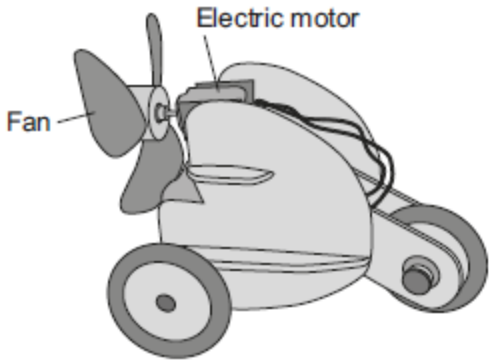


Explain why the window has been designed to have this shape.

(2)

(Total 10 marks)

4. The diagram shows an air-driven toy.
When the electric motor is switched on the fan rotates.
The fan pushes air backwards making the toy move forwards.



(a) (i) The toy has a mass of 0.15 kg and moves forward with a velocity of 0.08 m/s.

How is the momentum of the toy calculated?

Tick (✓) **one** box.

0.15 + 0.08 = 0.230 ☐

0.15 ÷ 0.08 = 1.875 ☐

0.15 × 0.08 = 0.012 ☐

(1)

(ii) What is the unit of momentum?

Tick (✓) **one** box.

kg m/s ☐ m/s^2 ☐ kg/m/s ☐

(1)

(iii) Use the correct answer from the box to complete the sentence.

less than	**equal to**	**more than**

The momentum of the air backwards is _____ the momentum of the toy forwards.

(1)

(b) The electric motor can rotate the fan at two different speeds.

Explain why the toy moves faster when the fan rotates at the higher of the two speeds.

_____

_____

_____

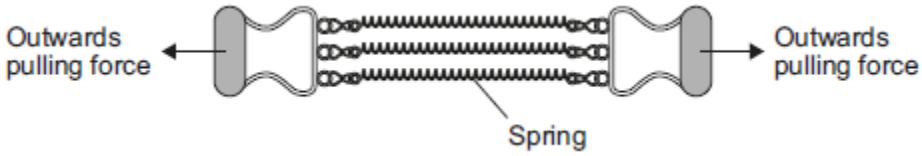
_____

(2)

(Total 5 marks)

5. **Figure 1** shows an exercise device called a chest expander. The three springs are identical.

Figure 1



A person pulls outwards on the handles and does work to stretch the springs.

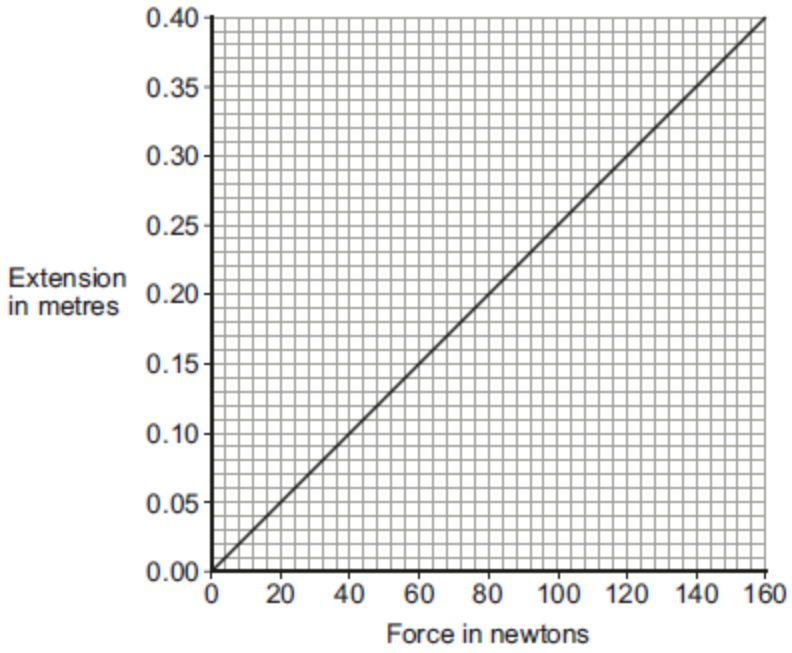
(a) Complete the following sentence.

When the springs are stretched _____ _____ energy is stored in the springs.

(1)

(b) **Figure 2** shows how the extension of a single spring from the chest expander depends on the force acting on the spring.

Figure 2



(i) How can you tell, from **Figure 2**, that the limit of proportionality of the spring has not been exceeded?

_____

_____

(1)

(ii) Use data from **Figure 2** to calculate the spring constant of the spring.
Give the unit.

_____

_____

_____

Spring constant = _____ Unit _____

(3)

(iii) Three identical resistors joined in parallel in an electrical circuit share the total current in the circuit.

In a similar way, the three springs in the chest expander share the total force exerted.

By considering this similarity, use **Figure 2** to determine the total force exerted on the chest expander when each spring is stretched by 0.25 m.

_____

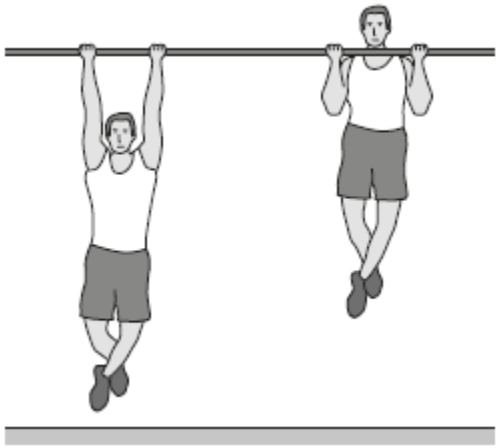
_____

Total force = _____ N

(2)

(c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

_____

_____

_____

_____

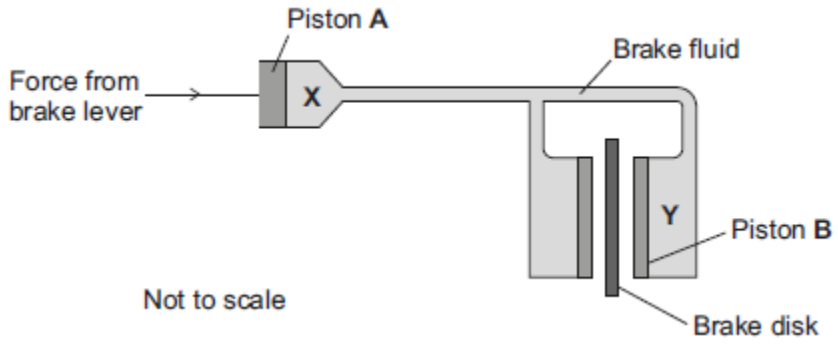
_____

Power = _____ W

(3)

(Total 10 marks)

6. The figure below is a simplified diagram of a hydraulic brake system.



(a) Which is the correct statement about the pressure at **X** and the pressure at **Y**?

Tick (✓) **one** box.

The pressure at **X** is greater than at **Y** ☐

The pressure at **X** is the same as at **Y** ☐

The pressure at **X** is less than at **Y** ☐

(1)

(b) Piston **B** is larger than piston **A**.

How will this affect the size of the force on piston **B**?

Use the correct answer from the box to complete the sentence.

smaller than	**the same as**	**larger than**

The force on piston **B** will be _____ the force on piston **A**.

(1)

(c) (i) A force of 24 N acts on piston **A**. The cross-sectional area of piston **A** is 8 mm^2.

Calculate the pressure in N/mm^2 at position **X**.

_____

_____

_____

_____

Pressure = _____ N/mm^2

(2)

(ii) The unit N/mm^2 is not often used to measure pressure.

Which unit is usually used to measure pressure?

Tick (✓) **one** box.

newton	☐
pascal	☐
watt	☐

(1)

(d) The liquid used in the hydraulic brake system freezes at –30 °C.

Suggest **one** effect a temperature below –30 °C would have on the brake system.

_____

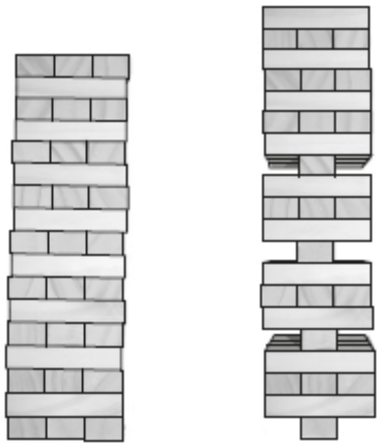
_____

(1)

(Total 6 marks)

7. In a balancing game, wooden blocks are used to build a tower. The shape of the tower at the start of the game is shown in **Figure 1**. During the game, some of the blocks are taken out and put on top of the tower as shown in **Figure 2**. This causes the centre of mass of the tower to change.

Figure 1 **Figure 2**



(a) (i) State what is meant by the term 'centre of mass'.

_____

_____

_____

(1)

(ii) Give **two** reasons why the tower in **Figure 2** is less stable than the tower in **Figure 1**.

1. _____

_____

2. _____

_____

(2)

(b) **Figure 3** shows a different arrangement for the wooden blocks.

Figure 3

A block was placed in position **A** and an identical block was placed in position **B** at the same time.

Explain why the tower did not fall over. You should include reference to moments in your answer.

_____

_____

_____

_____

(2)

(Total 5 marks)

8. A number of different forces act on a moving vehicle.

(a) A car moving at a steady speed has a driving force of 3000 N.

(i) What is the value of the resistive force acting on the car?

Tick (✓) **one** box.

	Tick (✓)
2000 N	
3000 N	
4000 N	

(1)

(ii) What causes most of the resistive force?

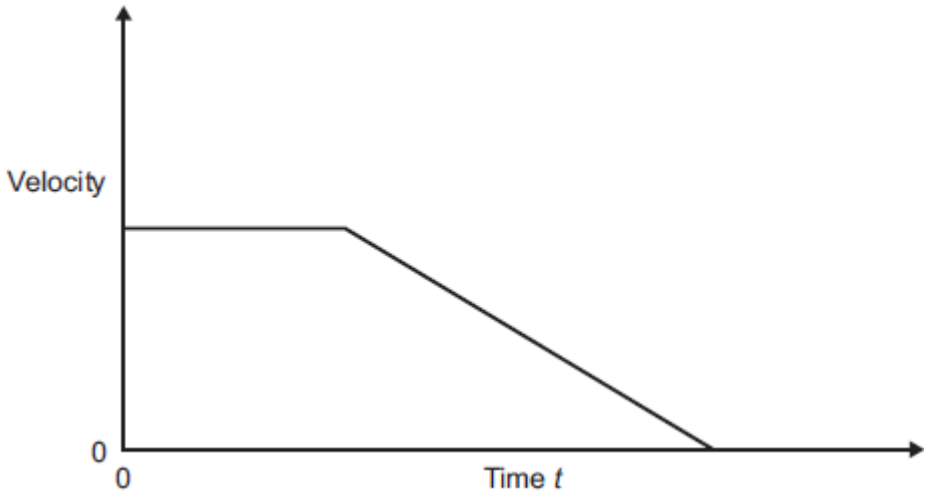
Tick (✓) **one** box.

	Tick (✓)
Air resistance	
Faulty brakes	
Poor condition of tyres	

(1)

(b) A car is moving along a road. The driver sees an obstacle in the road at time $t = 0$ and applies the brakes until the car stops.

The graph shows how the velocity of the car changes with time.



(i) Which feature of the graph represents the negative acceleration of the car?

Tick (✓) **one** box.

	Tick (✓)
The area under the graph	
The gradient of the sloping line	
The intercept on the y-axis	

(1)

(ii) Which feature of the graph represents the distance travelled by the car?

Tick (✓) **one** box.

	Tick (✓)
The area under the graph	
The gradient of the sloping line	
The intercept on the y-axis	

(1)

(iii) On a different journey, the car is moving at a **greater** steady speed.

The driver sees an obstacle in the road at time $t = 0$ and applies the brakes until the car stops.

The driver's reaction time and the braking distance are the same as shown the graph above.

On the graph above draw another graph to show the motion of the car.

(3)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Thinking distance and braking distance affect stopping distance.

Explain how the factors that affect thinking distance and braking distance affect stopping distance.

(6)

(Total 13 marks)

1. (a) Third Law

1

(b) elastic potential

1

(c) weight = mass × gravitational field strength

accept gravity for gravitational field strength

1

accept W = mg

accept correct rearrangement ie mass = weight / gravitational field strength ***or*** *m = W / g*

(d) 343 = m × 9.8

1

$m = \frac{343}{9.8}$

1

m = 35

1

allow 35 with no working shown for ***3*** *marks*

(e) force = spring constant × compression

accept force = spring constant × extension

accept F = k e

accept correct rearrangement ie constant = force / extension ***or*** *k = F / e*

1

(f) compression = 0.07m

1

343 = k × 0.07

1

k = 343 ÷ 0.07

1

k = 4900

1

allow 4900 with no working shown for ***4*** *marks*

allow 49 with no working shown for ***3*** *marks*

[11]

2. (a) distance is a scalar and displacement is a vector

or

distance has magnitude only, displacement has magnitude and direction

1

(b) 37.5 km

accept any value between 37.0 and 38.0 inclusive

1

062° or N62°E

accept 62° to the right of the vertical

1

accept an angle in the range 60° −64°

accept the angle correctly measured and marked on the diagram

(c) train changes direction so velocity changes

1

acceleration is the rate of change of velocity

1

(d) number of squares below line = 17

accept any number between 16 and 18 inclusive

1

each square represents 500 m

1

distance = number of squares × value of each square correctly calculated − 8500 m

1

[8]

3. (a) air molecules colliding with a surface create pressure

1

at increasing altitude distance between molecules increases

or

at increasing altitude fewer molecules (above a surface)

1

so number of collisions with a surface decreases

or

or so always less weight of air than below (the surface)

1

(b) atmospheric pressure = 20 kPa from graph **and** conversion of 810 cm^2 to 0.081 m^2

allow ecf for an incorrect value clearly obtained from the graph

1

$5 \times 10^4 = \frac{F}{0.081}$

1

$F = 5 \times 10^4 \times 0.081$

1

4050

1

4100 (N)

1

*allow 4100 (N) with no working shown for **5** marks*
*allow 4050 with no working shown for **4** marks*

(c) force from air pressure acting from inside to outside bigger than force acting inwards

1

so keeps the window in position

1

[10]

4. (a) (i) $0.15 \times 0.08 = 0.012$

1

(ii) kg m/s

1

(iii) equal to

1

(b) momentum of the air increases
or
force backwards increases

accept air moves faster
accept momentum backwards increases
accept pushes more air back(wards)

1

so momentum of the toy must increase
or
the force forwards (on the toy) increases

accept momentum forwards must increase
it = toy

1

[5]

5. (a) elastic potential

1

(b) (i) line is straight

accept line does not curve

1

(ii) 400

*allow **1** mark for correct substitution of any pair of numbers correctly taken from the graph e.g.160 = k × 0.40*

2

newtons per metre **or** N/m

if symbols are used they must be correct

1

(iii) 300

*allow **1** mark for correctly obtaining force on 1 spring = 100N*

2

(c) 52

*allow **2** marks for calculating change in gpe for 1 chin-up as 260 (J) or for 12 chin-ups as 3120 (J)*

*an answer 4.3 gains **2** marks*

*allow **1** mark for correct substitution into gpe equation ie gpe = 65 × 10 × 0.4 (× 12)*

or

correct use of power equation with an incorrect value for energy transferred

3

[10]

6.

(a) The pressure at X is the same as at Y

1

(b) larger than

1

(c) (i) 3 (N/mm^2)

accept 3 000 000 Pa (correct unit must be given)

*allow **1** mark for correct*

substitution, ie

$\frac{24}{8}$

provided no subsequent step

2

(ii) pascal

1

(d) the brakes would not work

allow the vehicle (car/bike etc) would not stop

*accept they would freeze solid **or** seize up*

1

[6]

7.

(a) (i) the point where the mass is (thought to be) concentrated

1

(ii) the centre of mass is higher

1

the base (area) is smaller / narrower

1

(b) (the blocks at A and B) create equal and opposite moments

1

the resultant moment is zero

accept (moments are in) equilibrium / balanced

or

the block at A creates an anti-clockwise moment (1)
so this must be balanced by an equal clockwise moment from the block at B (1)

1

[5]

8. (a) (i) 3000 N

1

(ii) air resistance

1

(b) (i) the gradient of the sloping line

1

(ii) the area under the graph

1

(iii) horizontal line above previous one

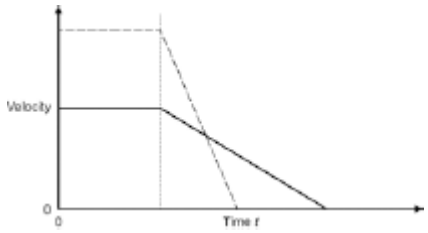
1

for the same time

1

sloping line cutting time axis before previous line

eg



1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1−2 marks)
One factor is given that affects thinking distance
or
one factor is given that affects braking distance

Level 2 (3−4 marks)
One factor and a description of its effect is given for **either** thinking distance **or** braking distance

Level 3 (5−6 marks)
One factor and a description of its effect is given for **both** thinking distance and braking distance
plus
some extra detail

Examples of the points made in the response
stopping distance = thinking distance + braking distance

the faster the car travels the greater the stopping distance

thinking distance is the distance travelled from when the driver sees an obstacle to when the brakes are applied

braking distance is the distance travelled from when the brakes are applied to when the car stops

thinking distance:
- tiredness increases thinking distance
- taking drugs increases thinking distance
- drinking alcohol increases thinking distance
- distractions in the car increase thinking distance.

braking distance:
- poor condition of brakes increases braking distance
- poor condition of tyres increases braking distance
- wet roads increase braking distance
- icy roads increase braking distance.

6

[13]