Forces 8

Name: ______________________

Class: ______________________

Date: ______________________

Time: **80 minutes**

Marks: **76 marks**

Comments:

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1. Four students tested their reaction times using a computer program.

When a green light appeared on the screen the students had to press a key.

Table 1 shows their results.

Table 1

Student	**Reaction time in s**			**Mean reaction time in s**
	Test 1	**Test 2**	**Test 3**	
Boy 1	0.28	0.27	0.26	0.27
Boy 2	0.28	0.47	0.22	0.29
Girl 1	0.31	0.29	0.27	0.29
Girl 2	0.32	0.30	0.29	0.30

(a) What is meant by 'reaction time' in this experiment?

____

____

(1)

(b) Boy 2 had an anomalous result in **Test 2**.

Suggest a reason why.

____

____

(1)

(c) Give **one** conclusion that can be made from the results in **Table 1**.

____

____

(1)

(d) Suggest further evidence that you could collect to support your conclusion.

____

____

(1)

(e) Reaction time is important at the start of a race.

Table 2 shows the time taken by a boy to run different distances.

Table 2

Distance in m	Time in s
100	12.74
200	25.63
800	139.46

Reaction time is more important in a 100 m race than in an 800 m race.

Explain why.

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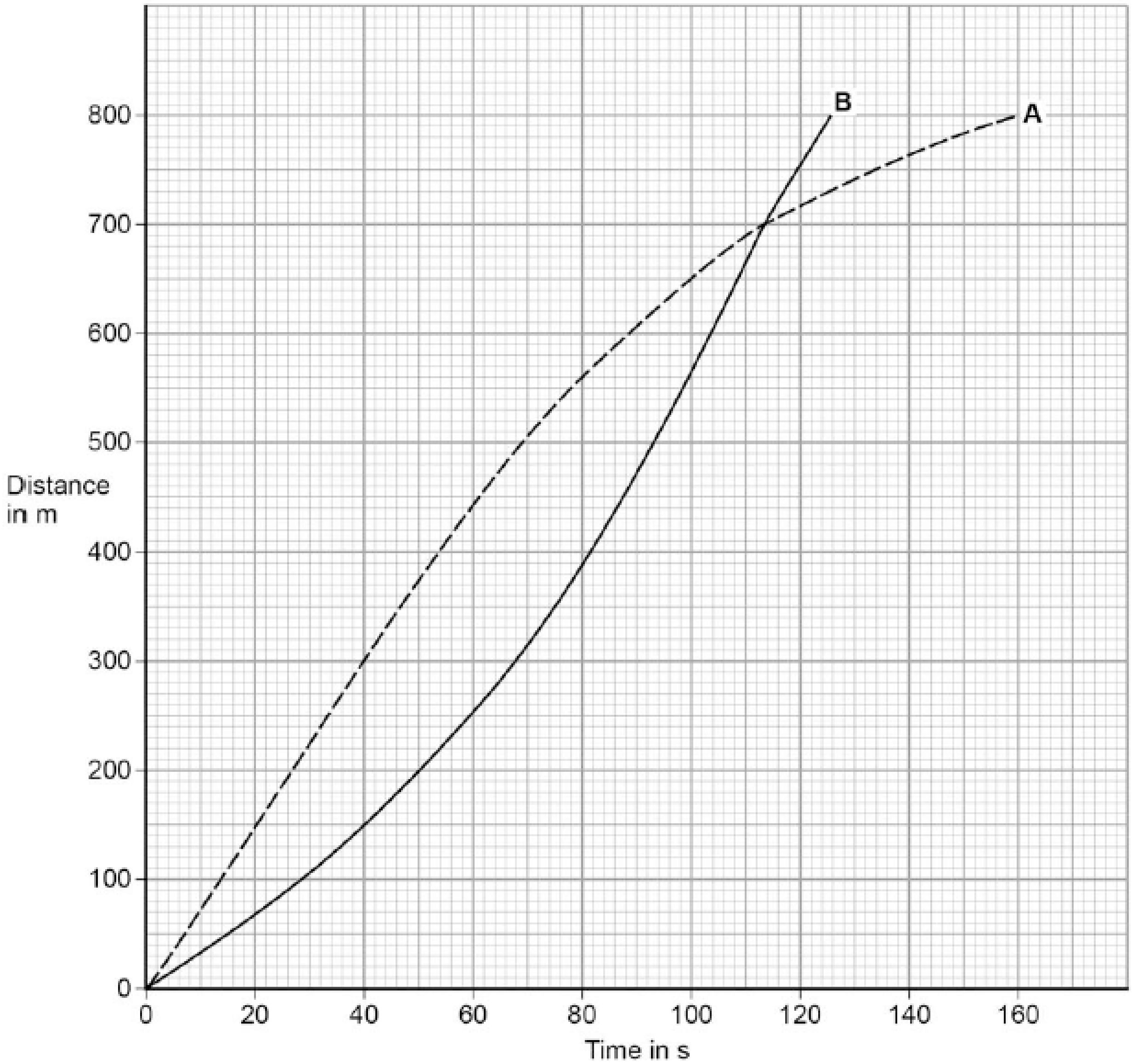
(2)

(f) Two girls, **A** and **B**, ran an 800 m race.

The figure below shows how the distance changed with time.



Compare the motion of runners **A** and **B**.

Include data from the figure above.

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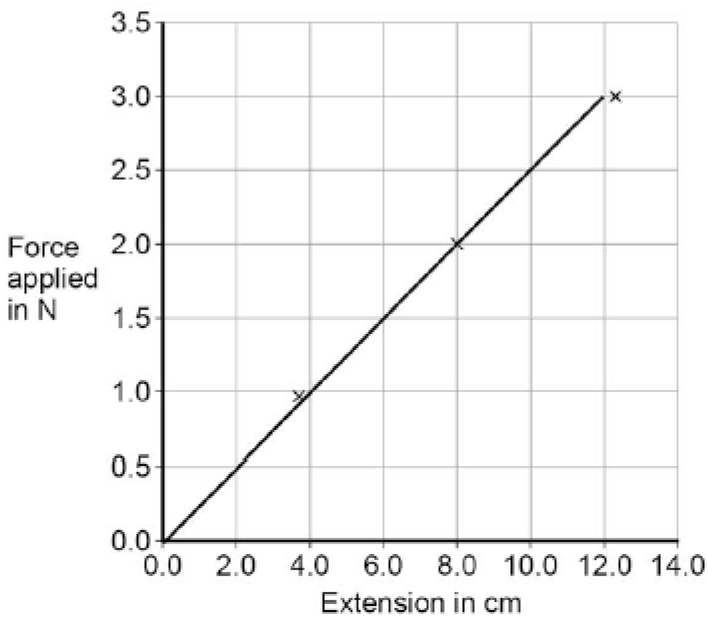
(6)

(Total 12 marks)

2. A student changed the force applied to a spring by adding weights.

The figure below shows a graph of her results.



(a) Write down the equation that links the force applied and extension for a spring.

____

(1)

(b) Identify the pattern shown in the figure above.

Explain your answer.

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(2)

(c) Give **one** way the student could improve her investigation.

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(1)

(d) Describe the relationship between work done and elastic potential energy in stretching a spring.

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(2)

(e) Draw a line on the figure above to show the results for a stiffer spring.

Explain the reason for the line you have drawn.

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(3)

(f) Explain what would happen to the spring if the student kept adding weights?

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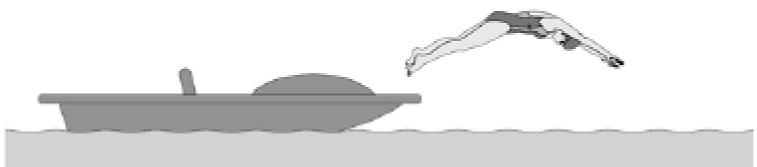
(2)

(Total 11 marks)

3. A swimmer dives off a boat.

Look at **Figure 1**.

Figure 1



(a) What **two** factors determine the momentum of the swimmer?

1. ____

2. ____

(2)

(b) What is the unit of momentum?

Tick **one** box.

J / s	☐
kg m / s	☐
N m	☐
m / s^2	☐

(1)

(c) The boat was stationary.

As the swimmer dives forwards, the boat moves backwards.

Use the idea of conservation of momentum to explain why the boat moves backwards.

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(4)

(d) Explain what would happen to the motion of the boat if there were more people on the boat when the swimmer dived off.

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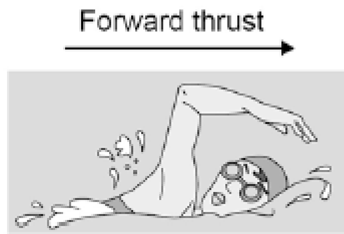
(2)

(e)



The swimmer’s speed increases as she swims away from the boat.

The swimmer has a top speed.

Explain why.

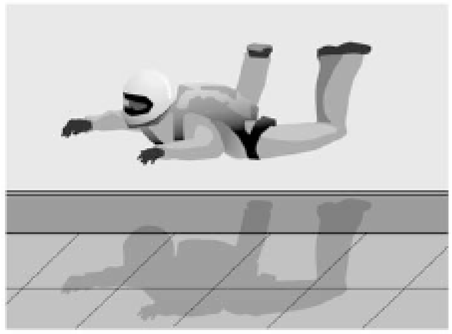
(5)

(Total 14 marks)

4. **Figure 1** shows a skydiver training in an indoor wind tunnel.

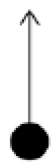
Large fans below the skydiver blow air upwards.

Figure 1



(a) The skydiver is in a stationary position.

Complete the free body diagram for the skydiver.



(2)

(b) The skydiver now straightens his legs to increase his surface area.

This causes the skydiver to accelerate upwards.

Explain why straightening his legs cause the skydiver to accelerate upwards.

____

____

____

____

(2)

(c) A small aeroplane used for skydiving moves along a runway.

The aeroplane accelerates at 2 m / s^2 from a velocity of 8 m / s.

After a distance of 209 m it reaches its take-off velocity.

Calculate the take-off velocity of the aeroplane.

____

____

____

Take-off velocity = ____________________ m / s

(3)

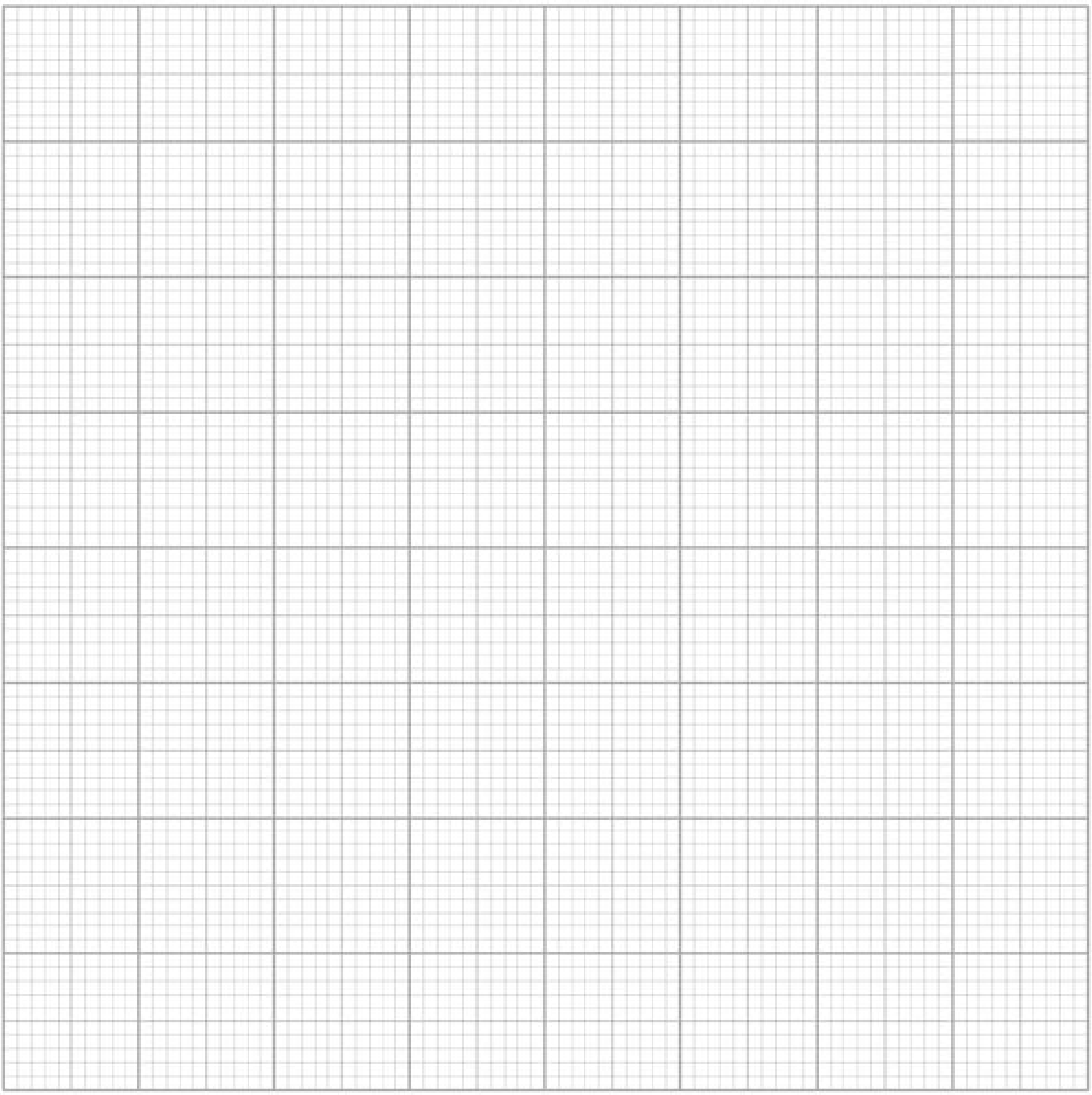
(d) A skydiver jumps from an aeroplane.

There is a resultant vertical force of 300 N on the skydiver.

There is a horizontal force from the wind of 60 N.

Draw a vector diagram on **Figure 2** to determine the magnitude and direction of the resultant force on the skydiver.

Figure 2



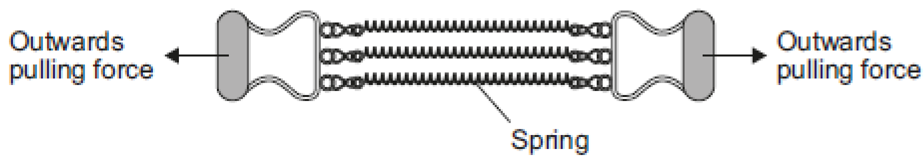
Magnitude of resultant force = ____________________ N

(5)

(Total 12 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.

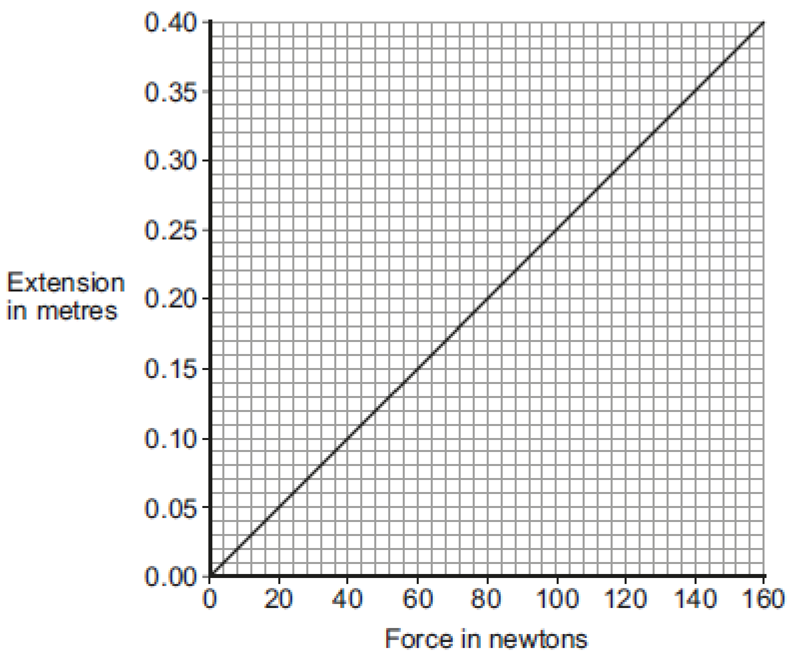
(a) Complete the following sentence.

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.

____

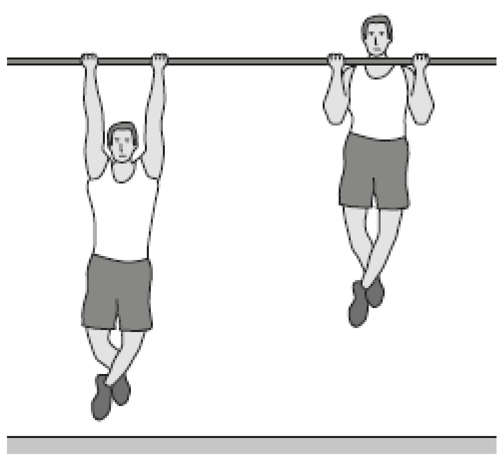
____

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

____

____

____

____

____

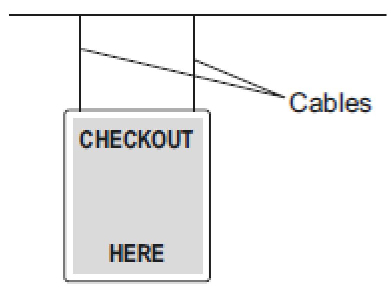
Power = ____________ W

(3)

(Total 10 marks)

6. A sign hangs from the ceiling using two cables, as shown in **Figure 1**.

Figure 1



(a) On **Figure 1**, mark the centre of mass of the sign using an X.

(1)

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

concentrated	**greatest**	**pivoted**

The centre of mass of an object is the point where the mass appears

to be ______________________ .

(1)

(c) A breeze made the sign swing forwards and backwards like a pendulum.
The frequency of oscillations of the sign was 2 hertz.

Calculate the periodic time for the sign.

____

____

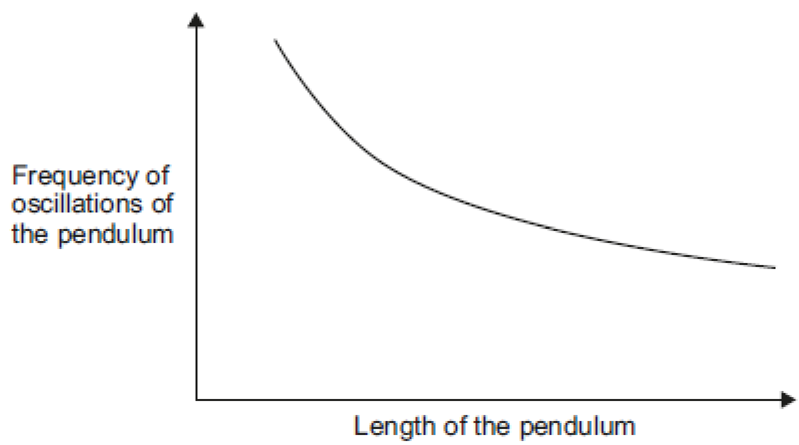
____

Periodic time = _______ seconds

(2)

(d) **Figure 2** is a sketch graph showing how the frequency of the oscillations of a pendulum changes as the length of the pendulum is increased.

Figure 2



Give **one** way the sign could be made to swing with a lower frequency.

Use **only** the information in the sketch graph.

____

____

(1)

(Total 5 marks)

7. 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?

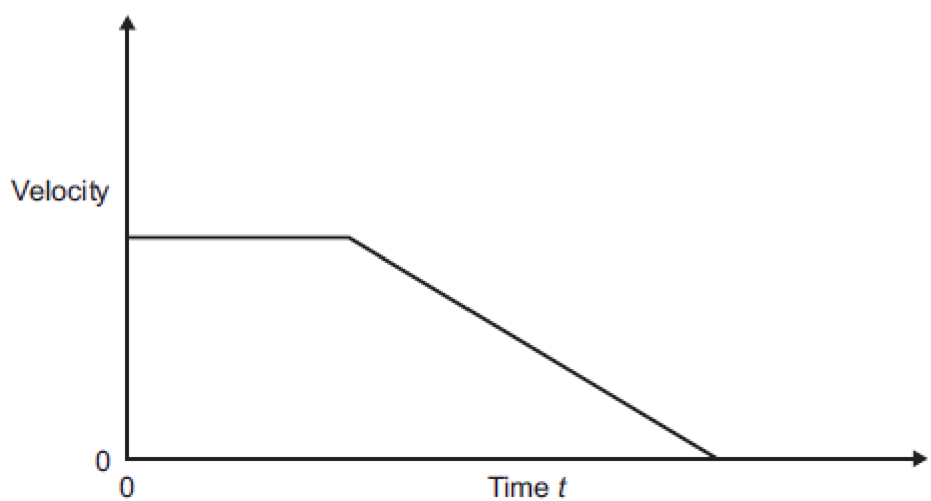
Tick (✓) **one** box.

	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)

Mark schemes

1. (a) the time it took from seeing the green light to pressing a key **1**

(b) he could have been distracted **1**

(c) boys have a shorter reaction time than girls

or

reaction time improves with practice **1**

(d) collect more data / larger sample size

must link to response in 06.3

or

take more repeat readings per person **1**

(e) reaction time will have less effect (as distance increases) **1**

because it is a smaller proportion of the total race time **1**

(f) **Level 3 (5–6 marks):**
A coherent description of the race, which uses data from the graph, including discussion of the meanings of the changing gradient of both of the lines.

Level 2 (3–4 marks):
Multiple pieces of data taken from the graphs used to evidence a comparison between the runners. Likely to include discussion of the meaning of the (changing) gradient of one of the lines. Answer not coherently structured.

Level 1 (1–2 marks):
Some data taken from the graph, but may be limited to one aspect or simple readings. Lack of coherence in answer.

0 marks:
No relevant content.

Indicative content

- A starts at constant speed *for 440 m / 60 s*
- A then slows down *from 60 s*
- the gradient for B is lower at the start so B starts at a slower speed
- the gradient for B increases so B accelerates
- B overtook A *at 700 m / 114 s*
- B has a greater top speed because the maximum gradient is greater
- B won the race *in 126 s* / beat A *by 34 s*

6

[12]

2. (a) force = spring constant × extension

accept f = ke

1

(b) extension is directly proportional to the force applied

1

because it is straight line through the origin

1

(c) test a greater range of load

or

test more springs

1

(d) work done is equal to elastic potential energy

1

as long as the spring does not go past the limit of proportionality

1

(e) line extending with a greater gradient than existing line

1

a stiffer spring has a greater spring constant (k)

1

k = F / e

1

(f) the spring will be deformed

accept not gone back to original shape

1

because it has passed the elastic limit

1

[11]

3. (a) mass

1

velocity

1

(b) kg m / s

1

(c) momentum before = momentum after

1

and before diving in the momentum of the diver and (small) boat is zero

1

after diving the diver has forwards momentum / momentum to the right

1

therefore the (small) boat has equal backwards momentum / equal momentum to the left 1

(d) the boat moves back more slowly 1

because there is more mass (but momentum stays the same) 1

(e) as she swims there is a drag force 1

as speed increases so does the drag force 1

she accelerates less 1

drag force = thrust force

accept resultant force = 0 1

the swimmer reaches terminal velocity 1

[14]

4. (a) arrow of equal size pointing vertically downwards

judged by eye 1

labelled 'weight' 1

(b) the upwards force is greater than the downwards force 1

because air resistance increases 1

(c) $v^2 = (2 \times 2 \times 209) + 8^2$ 1

$v = \sqrt{900}$ 1

v = 30 (m / s) 1

allow 30 (m / s) without working shown for ***3*** *calculation marks*

(d) vertical force (300 N) drawn with a suitable scale 1

horizontal force (60 N) drawn to the same scale 1

resultant force drawn in correct direction 1 value of resultant in the range 304 N – 308 N

1

[11]

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) X marked in the centre of the sign

Check position by eye

1

(b) concentrated

1

(c) 0.5 (s)

*allow **1** mark for correct substitution, ie*

$\frac{1}{2}$

provided no subsequent step

2

(d) make the cables longer

accept pendulum / sign for cables

1

[5]

7. (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

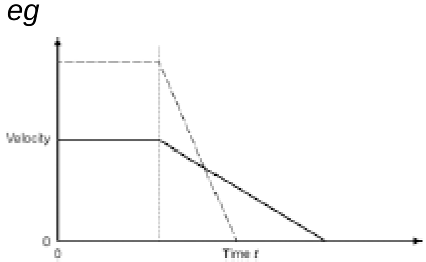
1

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]