Forces 4

Name:

Class:

Date:

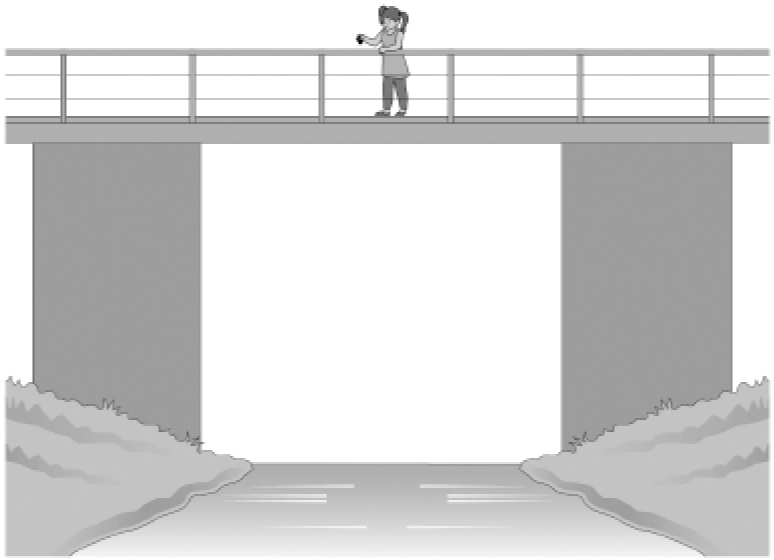
Time: **67 minutes**

Marks: **61 marks**

Comments:

1. **Figure 1** shows a child dropping a stone into water.

Figure 1



(a) When the child drops the stone it passes the child’s feet with a velocity of 3.1 m/s.

The child’s feet are 6.3 m above the water.

acceleration due to gravity = 9.8 m/s^2

Calculate the velocity of the stone as it hits the water.

Use the Physics Equations Sheet.

Give your answer to 2 significant figures.

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Velocity (2 significant figures) = ____________________ m/s

(4)

(b) Velocity is a vector.

Describe the velocity of the stone as it falls through the air.

Assume there is no air resistance.

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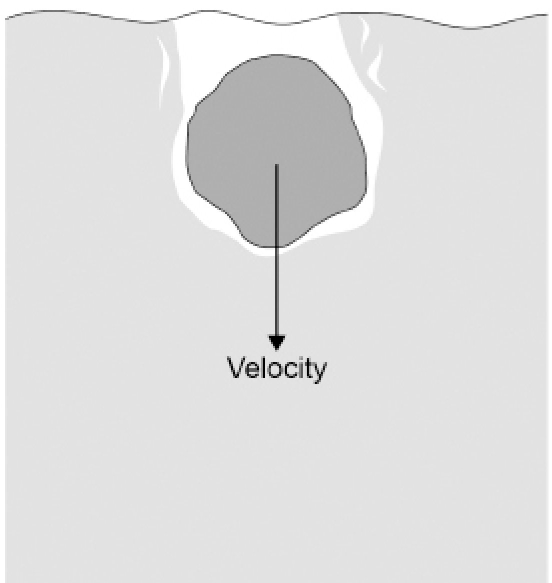
(2)

(c) **Figure 2** shows the stone just after it has entered the water.

Figure 2



As the stone moves through the water, the stone slows to a constant velocity.

Explain why.

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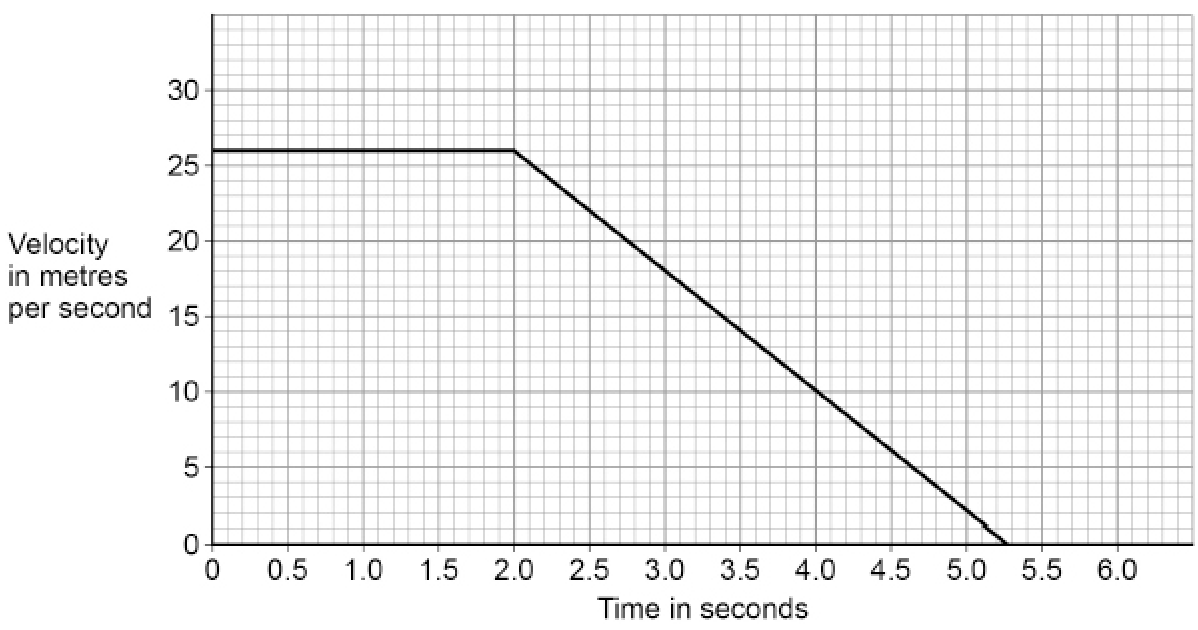
(4)
(Total 10 marks)

2. A car contains a device called a black box. The black box records the velocity and acceleration of the car.

The car was travelling at a constant velocity. The driver then reacted to a hazard.

The figure below shows the velocity–time graph for the car.



(a) Determine the deceleration of the car.

Give the unit.

Deceleration = ____________________ Unit __________

(3)

(b) The driver of the car has a reaction time of 0.75 s.

Determine the stopping distance of the car.

Use the Physics Equations Sheet.

Use the figure above.

Stopping distance = ____________________ m

(5)

(c) If the black box records large decelerations, it identifies that the driving may be dangerous.

Explain why large decelerations may be dangerous.

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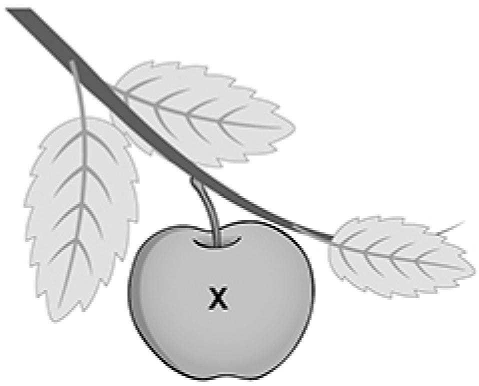
(2)

(Total 10 marks)

3. The figure below shows an apple hanging from a tree.

The **X** marks the centre of mass of the apple.



(a) Draw an arrow on the figure above to represent the weight of the apple.

(1)

(b) The apple has a mass of 0.150 kg

gravitational field strength = 9.8 N/kg

Calculate the weight of the apple.

Use the equation:

$$\text{weight} = \text{mass} \times \text{gravitational field strength}$$

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Weight = ________________ N

(2)

(c) The apple in above diagram is stationary.

Why is the apple stationary?

Tick (✓) **one** box.

The resultant force on the apple is downwards.	☐
The resultant force on the apple is upwards.	☐
The resultant force on the apple is zero.	☐

(1)

When the apple is ripe it falls from the tree and accelerates towards the ground.

(d) Why does the apple accelerate?

Tick (✓) **one** box.

The resultant force on the apple is downwards.	☐
The resultant force on the apple is upwards.	☐
The resultant force on the apple is zero.	☐

(1)

(e) The acceleration of the apple is 9.8 m/s^2

The velocity of the apple changes from 0 to 4.9 m/s

Calculate the time taken for the apple to fall to the ground.

Use the equation:

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

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Time taken = _______________ s

(2)

(Total 7 marks)

4. The stopping distance of a car is the sum of the thinking distance and the braking distance.

(a) Which factors affect the thinking distance?

Tick (✓) **two** boxes.

Condition of the tyres ☐

Driving on wet roads ☐

Mass of the car ☐

Tiredness of the driver ☐

Using a mobile phone ☐

(2)

(b) Explain why a person should **not** drink alcohol and then drive.

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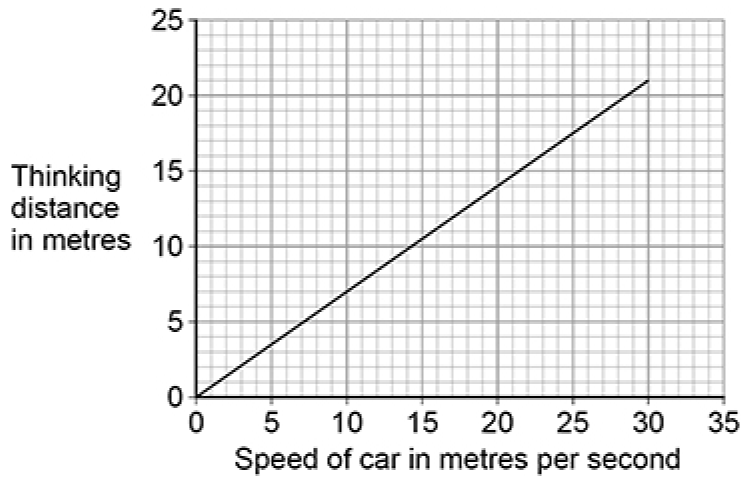
(3)

The Highway Code gives information on how thinking distance depends on the speed of a car.

The figure below shows the information as a graph.



(c) What is the speed of a car if the thinking distance is 16 m?

Speed of car = _______________ m/s

(1)

(d) Describe the relationship between speed and thinking distance.

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(2)

(e) The Highway Code assumes the driver's reaction time is 0.70 seconds.

Draw a line on the figure above to show the relationship for a driver with a reaction time of 1.4 seconds.

(2)

(f) A car accelerates at 5.0 m/s^2 over a distance of 45 m

initial velocity of the car = 0 m/s

Calculate the final velocity of the car.

Use the Physics Equations Sheet.

Give your answer to 2 significant figures.

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Final velocity (2 significant figures) = _______________ m/s

(4)

(Total 14 marks)

5. The figure below shows competitors in the wheelchair race at the London Marathon.

The distance of the London Marathon is 42 000 m

Use the Physics Equations Sheet to answer parts (a) and (b).

(a) Write down the equation that links distance (*s*), force (*F*) and work done (*W*).

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(1)

(b) During the race competitors work against air resistance.

The work done against air resistance by the winner of the race was 3 360 000 J

Calculate the average air resistance acting on the winner of the race.

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Average air resistance = _______________ N

(3)

Use the Physics Equations Sheet to answer parts (c) and (d).

(c) Which equation links distance travelled, speed and time?

Tick (✓) **one** box.

distance travelled = speed × time ☐

time = distance travelled × speed ☐

speed = distance travelled × time ☐

(1)

(d) The distance of the London Marathon is 42 000 m

The winning time for the race was 5600 seconds.

Calculate the average speed of the winner of the race.

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Average speed = ________________ m/s

(3)

(e) Explain why the speed of a competitor changes during the race.

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(4)

(Total 12 marks)

6. The figure below shows a child playing with a toy train.

The train is on a bridge.

When the child lets go of the train, the train rolls down the bridge.

(a) The momentum of the train at the bottom of the bridge is 0.216 kg m/s

mass of the train = 180 g

Calculate the velocity of the train at the bottom of the bridge.

Use the Physics Equations Sheet.

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Velocity = ________________ m/s

(4)

(b) The train collides with a stationary carriage on the track.

Explain why the velocity of the train after the collision is less than it was before the collision.

Use ideas about momentum in your answer.

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(4)

(Total 8 marks)

Mark schemes

1. (a) $v^2 - 3.1^2 = 2 \times 9.8 \times 6.3$

1

$v = \sqrt{(3.1^2 + (2 \times 9.8 \times 6.3))}$

allow $v^2 = 3.1^2 + (2 \times 9.8 \times 6.3)$

1

$v = 11.5...$

1

$v = 12$ (m/s)

this mark can only be awarded if the correct equation is used and a value of v is calculated

1

(b) (magnitude) increases (uniformly)

1

direction remains constant

1

(c) drag is greater than weight

allow upward force is greater than downward force

1

(so) there is a resultant force acting in the opposite direction to the velocity (causing deceleration)

1

as velocity decreases the drag decreases

1

(until) drag is equal to weight (so velocity is constant)

allow until the resultant force is zero

ignore upthrust

1

allow resistive / frictional force for drag throughout

[10]

2. (a) $a = \frac{26 - 0}{5.25 - 2.0}$

allow any pair of correct points substituted

allow ± half a small square for reading of time

1

$a = 8$

allow 8.0

allow a correct calculation using their acceptable values from the graph

ignore any minus sign

1

m/s^2

1

(b) **thinking distance**

s = 26 × 0.75

to award MP1 and MP2 a time of 0.75 must have been used

1

s = 19.5 (m)

1

braking distance

$s = \frac{(5.25 - 2.0) \times 26}{2}$

or

$s = \frac{26^2 - 0^2}{2 \times 8.0}$

allow a range of 5.2 to 5.3 for final time

1

s = 42.25 (m)

1

marks for thinking distance and braking distance may be awarded independently

stopping distance

s = 19.5 + 42.25 = 61.75 (m)

for this mark to be awarded both the thinking distance and braking distance must have been calculated using correct equations

allow an answer correctly rounded to 2 or 3 sig figs

1

allow ecf for acceleration and initial velocity from part (a)

(c) the brakes can overheat

1

(so) the brakes will not work properly

dependent on MP1

OR

can lead to loss of control (1)

allow the car may skid

(because) the tyres lose traction / grip (1)

dependent on MP1

OR

the greater the deceleration the greater the force (1)

(and) large forces can cause injury (1)

dependent on MP1

ignore accidents and crashes throughout

1

[10]

3. (a) vertical arrow from **X** pointing downwards

ignore any labels

1

(b) $W = 0.150 \times 9.8$

1

$W = 1.47$ (N)

allow 1.5 (N)

1

(c) the resultant force on the apple is zero

1

(d) the resultant force on the apple is downwards

1

(e) $t = \frac{4.9}{9.8}$

1

$t = 0.50$ (s)

allow 0.5 (s)

1

[7]

4. (a) tiredness of the driver

1

using a mobile phone

1

(b) increases reaction time

1

so increases the thinking distance

1

so more likely to have a collision

allow travels a greater distance before stopping (in an emergency)

1

(c) 23 m/s

1

(d) directly proportional

*allow **1** mark for as speed increases thinking distance increases*

2

(e) straight line from the origin with a greater gradient

1

through (15,21)

allow a line that passes within half a small square of (15,21)

dependent on MP1

1

(f) $v^2 - 0^2 = 2 \times 5.0 \times 45$

1

$v^2 = 450$ **or** $v = \sqrt{450}$

1

v = 21.21320343

1

v = 21 (m/s)

allow a correctly rounded value of v calculated using the correct equation

1

[14]

5. (a) work done = force × distance (along the line of action of the force)

or

$W = Fs$

1

(b) 3 360 000 = F × 42 000

1

$F = \frac{3360000}{42000}$

1

F = 80 (N)

1

(c) distance travelled = speed × time

1

(d) 42 000 = v × 5600

1

$$v = \frac{42\,000}{5600}$$

1

v = 7.5 (m/s)

1

(e) **Level 2:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

3−4

Level 1: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

1−2

No relevant content

0

Indicative content

the effect on speed must be consistent with the cause of the change

- competitors accelerate at the start
- so speed increases

- the road is not flat
- so speed increases going downhill and / or speed decreases going uphill

- the competitor goes round a bend
- so speed decreases

- competitors may tire towards the end (so the force they exert decreases)
- so they slow down

- competitors may sprint during the race
- causing speed to increase

- may get a puncture
- so speed would decrease or they would stop

- resistive forces on competitors may increase/decrease
- so speed would decrease/increase

[12]

6. (a) $m = 0.180$ kg

1

$0.216 = 0.180 \times v$

allow a correct substitution using an incorrectly / not converted value of m

1

$v = \frac{0.216}{0.180}$

allow a correct rearrangement using an incorrectly / not converted value of m

1

$v = 1.2$ (m/s)

allow a correct calculation using an incorrectly / not converted value of m

1

(b) (total) momentum is conserved in the collision

allow (total) momentum before collision = (total) momentum after collision

1

during the collision the momentum of carriage increases

1

so the momentum of train decreases

1

since momentum = mass × velocity, velocity (of train) decreases

allow since mass (of train) is constant, velocity (of train) decreases

1

[8]