Forces 1

Name: _____

Class: _____

Date: _____

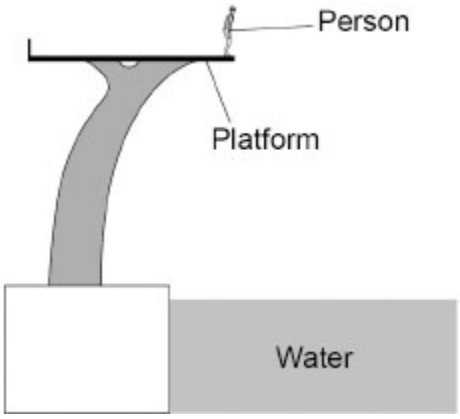
Time: **66 minutes**

Marks: **60 marks**

Comments:

1. **Figure 1** shows a person about to dive from a high platform into a pool of water.

Figure 1



(a) The person dived from the platform into the water.

The time taken between the person leaving the platform and entering the water was measured by four people.

The measurements were:

2.1 s 1.9 s 1.3 s 2.0 s

Which measurement is anomalous?

Tick (✓) **one** box.

2.1 s ☐

1.9 s ☐

1.3 s ☐

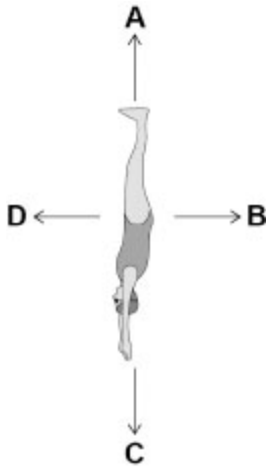
2.0 s ☐

(1)

(b) Air resistance acted on the person during the dive.

Figure 2 shows the person moving vertically downwards.

Figure 2



Which arrow on **Figure 2** shows the direction of the air resistance acting on the person?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(c) Air resistance is a contact force.

Which force is also a contact force?

Tick (✓) **one** box.

Friction ☐

Gravitational force ☐

Magnetic force ☐

(1)

(d) What happened to the size of the air resistance force as the speed of the person increased?

_____

_____

(1)

(e) After entering the water, the person decelerated for a time of 0.35 s.

The deceleration of the person was 60 m/s^2.

Calculate the change in velocity of the person.

Use the equation:

change in velocity = deceleration × time

_____

_____

_____

Change in velocity = _____ m/s

(2)

(f) The mass of the person was 75 kg.

Calculate the resultant force on the person when the deceleration was 60 m/s^2.

Use the equation:

resultant force = mass × deceleration

_____

_____

_____

Resultant force = _____ N

(2)

(Total 8 marks)

2. A student went on a cycling journey that lasted for three days.

The student recorded information about the journey using a cycling app on a mobile phone.

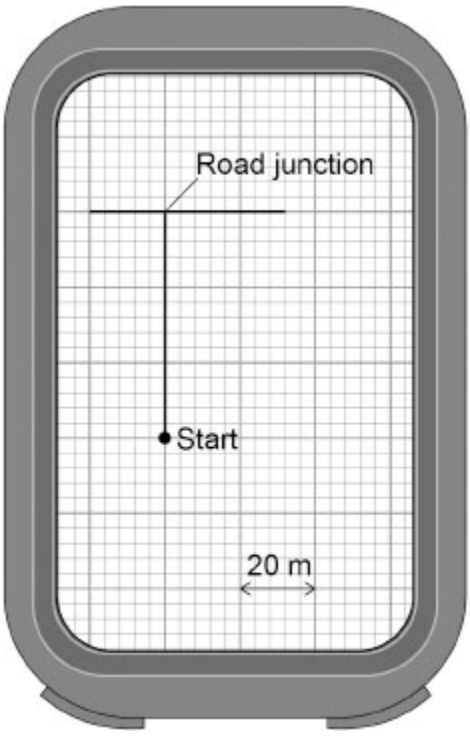
(a) At the start of the journey, the student travelled along a straight road to a road junction.

A map on the cycling app showed the road.

Figure 1 shows the map.

The scale of the map is 1 cm **:** 20 m

Figure 1



Calculate the distance travelled by the student between the start and the road junction.

Use **Figure 1**.

_____

_____

_____

Distance travelled = _____ m

(2)

(b) The bicycle had a mass of 15 kg.

gravitational field strength = 9.8 N/kg

Calculate the weight of the bicycle.

Use the equation:

weight = mass × gravitational field strength

_____

_____

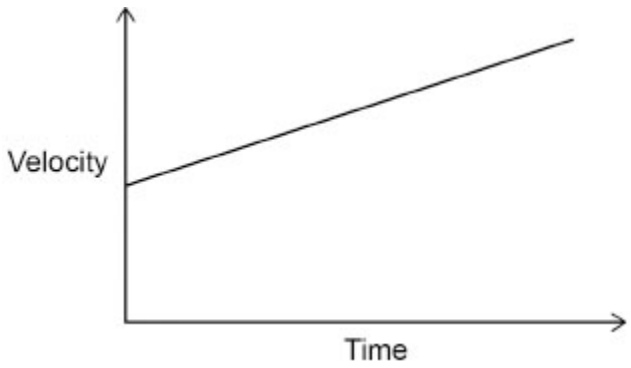
_____

Weight = _____ N

(2)

(c) **Figure 2** shows a velocity–time graph for a downhill part of the journey.

Figure 2



The gradient of the graph represents acceleration.

How does **Figure 2** show that the acceleration was constant?

_____

_____

(1)

(d) As the student accelerated downhill, the forward force on the student was 250 N.

The work done by the forward force was 4500 J.

Calculate the distance travelled as the student accelerated downhill.

Use the equation:

$$\text{distance travelled} = \frac{\text{work done}}{\text{force}}$$

_____

_____

_____

Distance travelled = _____ m

(2)

(e) Most of the roads on the journey were not straight.

Figure 3 shows a map of the route taken for the whole journey.

Figure 3

The line in **Figure 3** represents the total distance travelled when the student reached the end of the journey.

How does the total distance travelled compare with the magnitude of the displacement of the student from the start?

Tick (✓) **one** box.

Total distance travelled is less than the displacement. ☐

Total distance travelled is equal to the displacement. ☐

Total distance travelled is greater than the displacement. ☐

(1)

(f) Why is distance a scalar quantity?

Tick (✓) **one** box.

Distance has direction only. ☐

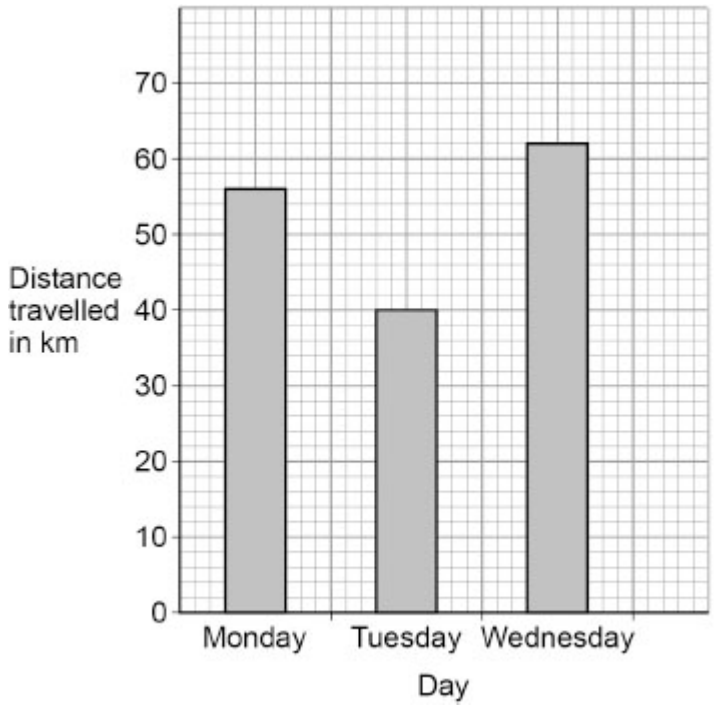
Distance has magnitude only. ☐

Distance has direction and magnitude. ☐

(1)

(g) **Figure 4** shows the distance travelled by the student each day.

Figure 4



Calculate the total distance travelled by the student.

Use **Figure 4**.

_____

_____

_____

Total distance travelled = _____ km

(2)

(Total 11 marks)

3. In a dog-sled race, a team of dogs pull on a rope attached to a sled.

Figure 1 shows a dog-sled team.

Figure 1

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

(a) What equation links distance travelled, speed and time?

Tick (✓) **one** box.

distance travelled = speed × time ☐

speed = time × distance travelled ☐

time = distance travelled × speed ☐

(1)

(b) The longest dog-sled race in the world covers a distance of 1 500 000 m.

One team finished the race in a time of 670 000 s.

Calculate the average speed of this team during the race.

Average speed = _____ m/s

(3)

(c) At the start of the race, 6 dogs pulled on the rope.

The average forward force on the sled from **each** dog was 370 N.

The backwards force on the sled from friction was 520 N.

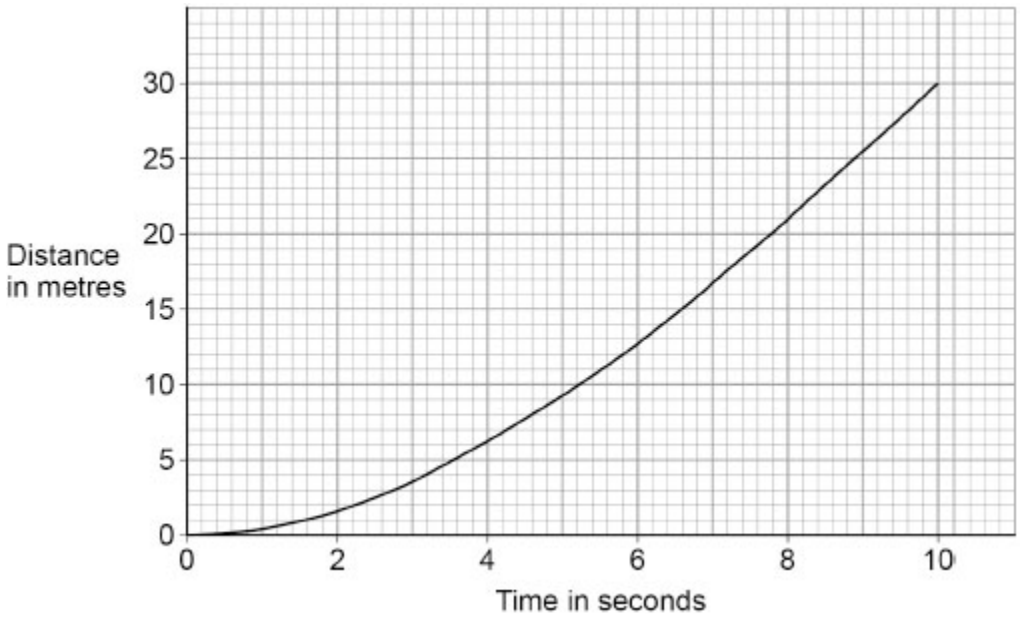
Calculate the resultant force on the sled.

Resultant force = _____ N

(2)

Figure 2 shows a distance–time graph for the sled at the start of the race.

Figure 2



(d) What does the gradient of the graph in **Figure 2** represent?

_____

_____

(1)

(e) Later in the race, the sled moved at a constant speed along a flat, horizontal path.

What was the relationship between the size of the horizontal forces acting when the sled moved at a constant speed?

Tick (✓) **one** box.

friction + air resistance < pull of the rope on the sled ☐

friction + air resistance = pull of the rope on the sled ☐

friction + air resistance > pull of the rope on the sled ☐

(1)

(f) The rope exerted a force on the sled when the sled was moving.

What is the Newton's Third Law pair to the force of the rope on the sled?

Tick (✓) **one** box.

The force of friction on the sled ☐

The force of the dogs on the rope ☐

The force of the sled on the rope ☐

(1)

(Total 9 marks)

4. The stopping distance of a car is affected by the condition of the brakes and tyres.

A car is being driven around a corner when the driver sees some roadworks.

(a) The driver applies the brakes when the car is 24 m away from the roadworks.

The velocity of the car changes from 18 m/s to 0 m/s.

Calculate the constant deceleration needed to stop the car in a distance of 24 m.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

Deceleration = _____ m/s^2

(3)

(b) As a safety measure, the speed limit on the road was reduced.

Explain how the safety of road users is affected by:

- the condition of the brakes and tyres
- reduced speed.

You should refer to thinking distance and braking distance.

(6)

(c) Two identical cars were driven along a straight, level road.

One car had a greater speed than the other car.

The driver of each car applied the brakes until the cars stopped.

Both cars travelled the same distance while braking.

Explain how braking from a greater speed affected the risk of the brakes overheating.

_____

_____

_____

_____

_____

_____

(3)

(Total 12 marks)

5. A triathlon race consists of swimming, cycling and running.

(a) One athlete in a triathlon swims at a speed of 1.5 m/s.

How does the athlete's swimming speed compare with the typical speed of a person walking?

Tick (✓) **one** box.

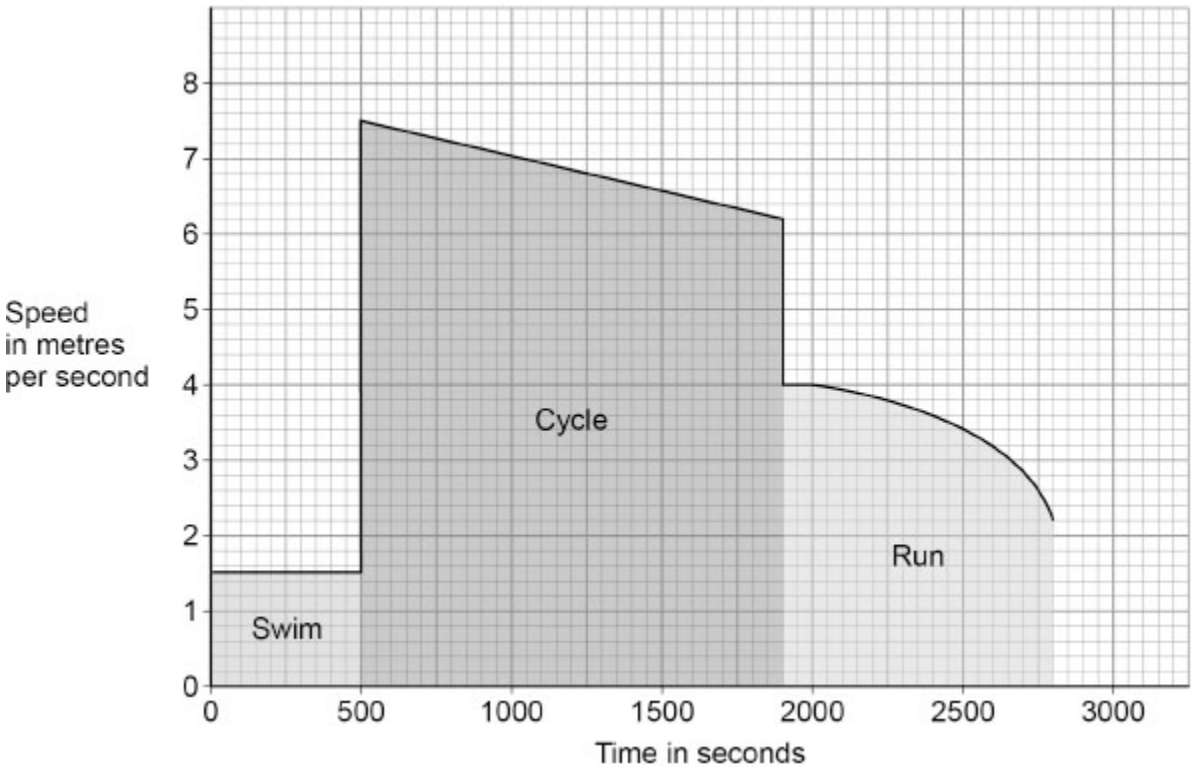
athlete's swimming speed > typical walking speed ☐

athlete's swimming speed = typical walking speed ☐

athlete's swimming speed < typical walking speed ☐

(1)

The figure below shows a speed–time graph for the athlete for the whole triathlon.



(b) The cycling part of the race was on a straight road.

The work done by the forward force on the bicycle was 110 000 J.

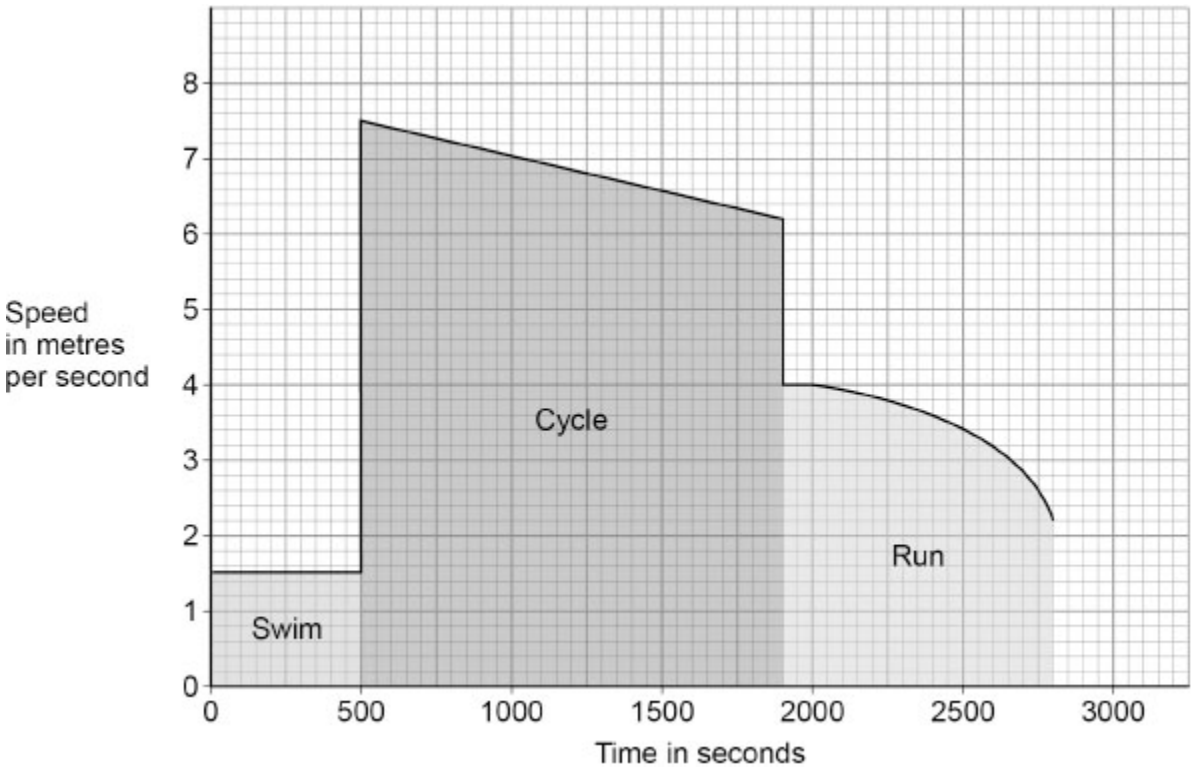
Determine the mean forward force on the bicycle.

Use the Physics Equations Sheet.

Mean forward force = _____ N

(6)

The figure is repeated below.



(c) The first part of the **run** was on a circular track.

The time taken for the athlete to run round the track was 100 s.

Describe the velocity of the athlete during the first 100 s of the **run**.

Use the figure above.

_____

_____

_____

_____

(2)

(d) After running round the track once, the rest of the run was on a straight, horizontal road.

Explain how the figure above shows that the magnitude of the deceleration of the athlete increased.

_____

_____

_____

_____

(2)

(Total 11 marks)

6. **Figure 1** shows a skydiver jumping from an aeroplane.

The skydiver is accelerating downwards.

Figure 1

(a) Which force causes the skydiver to accelerate?

Tick (✓) **one** box.

Electromagnetic force ☐

Gravitational force ☐

Magnetic force ☐

(1)

(b) Which force increases as the skydiver accelerates?

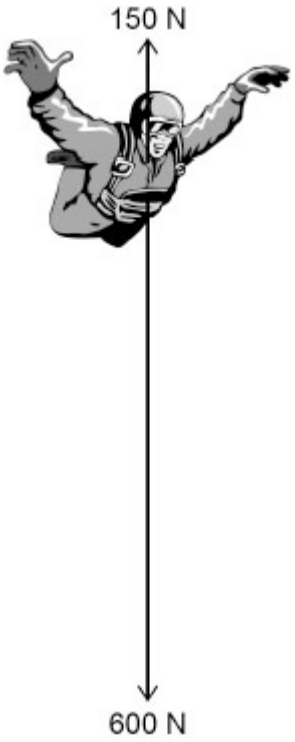
Tick (✓) **one** box.

Air resistance	☐
Normal contact force	☐
Tension	☐

(1)

Figure 2 shows the two forces acting on the skydiver a few seconds after jumping from the aeroplane.

Figure 2



(c) Calculate the resultant force acting on the skydiver in **Figure 2**.

_____

Resultant force = _____ N

(1)

(d) Eventually the skydiver stops accelerating and falls at a constant velocity.

What is the resultant force acting on the skydiver when falling at a constant velocity?

Tick (✓) **one** box.

0 N ☐

150 N ☐

600 N ☐

(1)

(e) What name is given to the constant velocity of the skydiver?

Tick (✓) **one** box.

Average velocity ☐

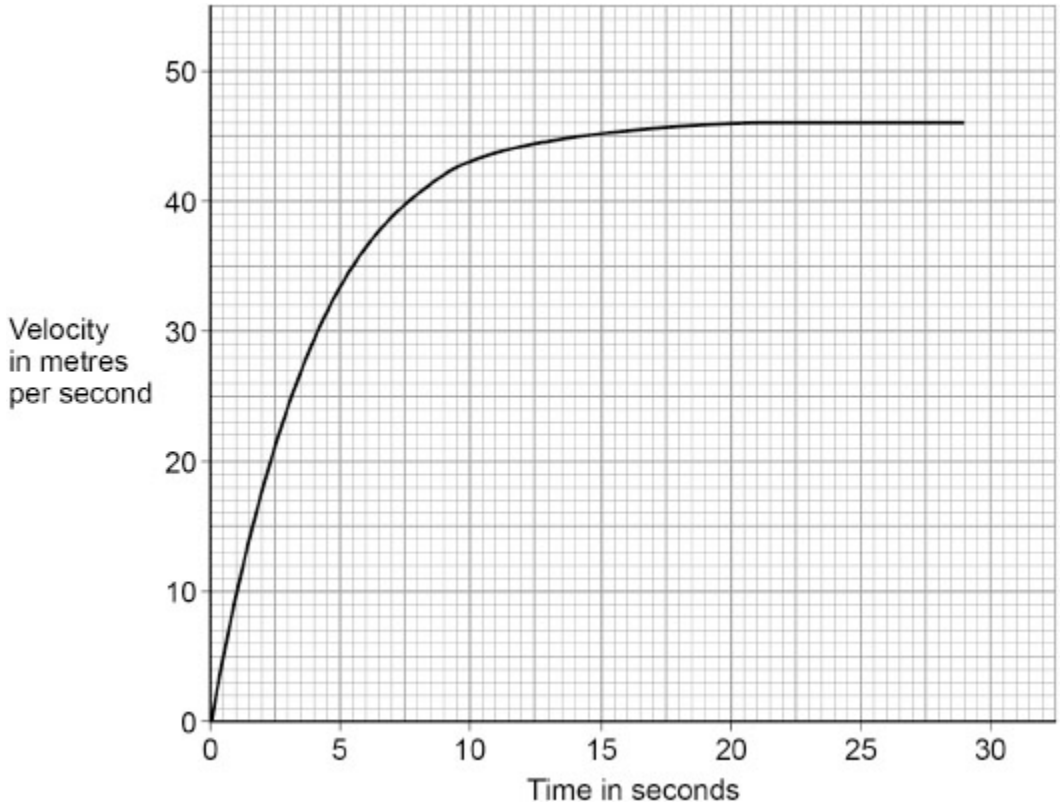
Initial velocity ☐

Terminal velocity ☐

(1)

Figure 3 shows a velocity–time graph for the skydiver.

Figure 3



(f) How many seconds did the skydiver accelerate for?

Use **Figure 3**.

_____ s

(1)

(g) What was the constant velocity of the skydiver?

Use **Figure 3**.

_____ m/s

(1)

(h) After opening a parachute, the skydiver fell at a constant speed of 3.6 m/s for 25 seconds.

Calculate the distance travelled by the skydiver during this time.

Use the equation:

distance travelled = speed × time

_____

_____

_____

Distance travelled = _____ m

(2)

(Total 9 marks)

1.

(a) 1.3 s

1

(b) A

1

(c) friction

1

(d) (air resistance) increased

1

(e) $\Delta v = 60 \times 0.35$

1

$\Delta v = 21$ (m/s)

allow − 21 (m/s)

1

(f) $F = 75 \times 60$

1

$F = 4500$ (N)

allow − 4500 (N)

1

[8]

2.

(a) distance travelled = 3.0 × 20

both marks may be awarded if a length in the range 2.9 to 3.1 cm is used

1

distance travelled = 60 (m)

1

(b) weight = 15 × 9.8

1

weight = 147 (N)

allow weight = 150 (N)

1

(c) the line has a constant gradient

allow the line is straight

*do **not** accept directly proportional*

1

(d) $\text{distance travelled} = \frac{4500}{250}$

1

distance travelled = 18 (m)

1

(e) total distance travelled is greater than the displacement

1

(f) distance has magnitude only

1

(g) total distance = 158 (km)

*allow **1** mark for 56, 40 and 62 read from graph*

*allow **1** mark for a total distance calculated using two correct values and one incorrect value from the bar chart*

2

[11]

3. (a) distance travelled = speed × time

1

(b) 1 500 000 = v × 670 000

1

$$v = \frac{1\,500\,000}{670\,000}$$

1

V = 2.2… (m/s)

1

(c) F = (6 × 370) - 520

1

F = 1700 (N)

*if no other mark awarded allow **1** mark for 370 - 520 = (−)150 (N)*

1

(d) speed

allow velocity

1

(e) friction + air resistance = pull of the rope on the sled

1

(f) the force of the sled on the rope

1

[9]

4. (a) $(0^2-)\ 18^2 = 2 \times a \times 24$

allow $18^2 = 2 \times a \times 24$

1

$$a = \frac{(-)18^2}{2 \times 24}$$

1

a = (−) 6.75 (m/s^2)

allow (−) 6.8 (m/s^2)

1

(b) **Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

5-6

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3-4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1-2

No relevant content

0

Indicative Content

Thinking distance

- condition of brakes and tyres does not affect thinking distance
- speed does not affect reaction time
- decreased speed decreases thinking distance

Braking distance

- condition of tyres affects friction between tyres and road
- poor condition of tyres and brakes increases braking distance
- decreased speed decreases braking distance

Safety

- stopping distance = thinking distance + braking distance
- poor condition of brakes and tyres increases stopping distance
- decreased speed decreases stopping distance
- decreased speed decreases the chance of the driver losing control of the vehicle
- decreased speed decreases the chance of a collision
- decreased speed decreases the risk of injury during a collision

for **Level 3,** answers must include references to brakes / tyres, speed, thinking distance, braking distance, and safety.

(c) frictional / braking force is greater (for the faster car)
or
the faster car has more kinetic energy

1

(so) more work done (by the brakes to stop the faster car)

allow so more energy is transferred (by the brakes to stop the faster car)

ignore more heating

1

(so) the risk of the brakes overheating is greater (for the fast car)

allow (at greater speed) there is a risk of overheating

MP3 dependent on MP1 or MP2

1

[12]

5. (a) athlete's swimming speed = typical walking speed

1

(b) time taken = 1400

subsequent marks may be awarded if time taken is determined from the graph

1

mean speed = $\frac{7.5 + 6.2}{2}$

allow mean speed calculated using a maximum speed between 7.4 m/s and 7.6 m/s

(= 6.85 m/s)

1

distance (= 6.85 × 1400)

= 9590 (m)

allow a distance consistent with their calculated mean speed

subsequent marks may only be awarded if values of speed and time from the graph have been used to determine a distance

subsequent marks may be awarded using their value of total distance

1

110 000 = F × 9590

1

$F = \frac{110\,000}{9590}$

1

F = 11(.470…) (N)

1

OR

time taken = 1400 (1)

subsequent marks may be awarded if time taken is determined from the graph

area of triangle
= 0.5 × 1400 × (7.5 - 6.2)
(= 910)
and
area of rectangle
= 1400 × 6.2 (= 8680) (1)

allow area calculated using a maximum speed between 7.4 m/s and 7.6 m/s

distance (1)
(= 910 + 8680) = 9590 (m)

allow a distance consistent with their calculated areas

subsequent marks may only be awarded if values of speed and time from the graph have been used to determine a distance

subsequent marks may be awarded using their value of total distance

110 000 = F × 9590 (1)

$$F = \frac{110\,000}{9590}$$

F = 11(.470…) (N) (1)

OR

time taken = 1400 (1)

subsequent marks may be awarded if time taken is determined from the graph

$$\text{acceleration} = \frac{6.2 - 7.5}{1400}$$

allow acceleration calculated using a maximum speed between 7.4 m/s and 7.6 m/s

(= (-)0.00092857…)

subsequent marks may be awarded if their calculated value for acceleration is rounded

distance (1)

$$\left(= \frac{6.2^2 - 7.5^2}{(-)2 \times 0.00092857 \ldots} \right)$$

allow a distance consistent with their calculated acceleration

= 9590 (m)

subsequent marks may only be awarded if values of speed and time from the graph have been used to determine a distance
subsequent marks may be awarded using their value of total distance

110 000 = F × 9590 (1)

$$F = \frac{110\,000}{9590}$$

F = 11(.470…) (N) (1)

(c) constant magnitude (of velocity)

allow speed was constant

allow speed was 4 m/s allow (magnitude of) velocity was 4 m/s

*do **not** accept constant velocity*

1

direction (of velocity) kept changing

*if no other mark awarded allow **1** mark for the velocity is constantly changing*

1

(d) the gradient is equal to the deceleration / acceleration

1

(and) the (magnitude of the) gradient increased

1

[11]

6. (a) gravitational force

1

(b) air resistance

1

(c) 450 (N)

1

(d) 0 N

1

(e) terminal velocity

1

(f) 20 (s)

allow an answer in the range 18 to 21 (s)

1

(g) 46 (m/s)

1

(h) $s = 3.6 \times 25$

1

90 (m)

1

[9]