Forces part 2 AQA Triple Physics

Name: _____

Class: _____

Date: _____

Time: **106 minutes**

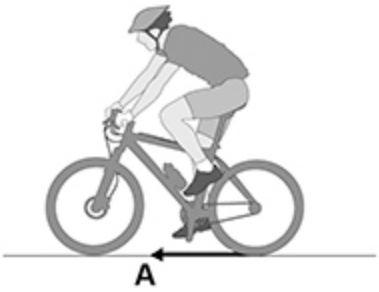
Marks: **101 marks**

Comments:

1. **Figure 1** shows a cyclist riding a bicycle.

Force **A** causes the bicycle to accelerate forwards.

Figure 1



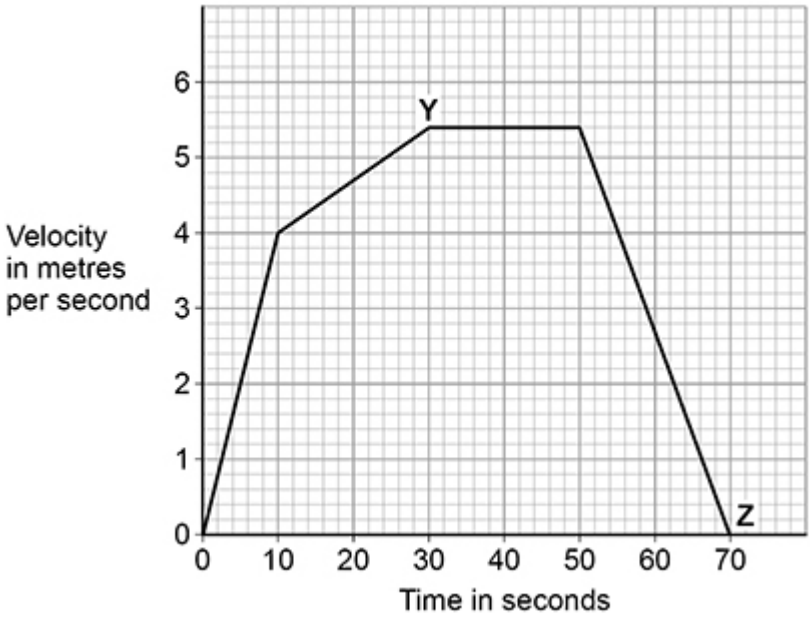
(a) What name is given to force **A**?

_____

(1)

Figure 2 shows how the velocity of the cyclist changes during a short journey.

Figure 2



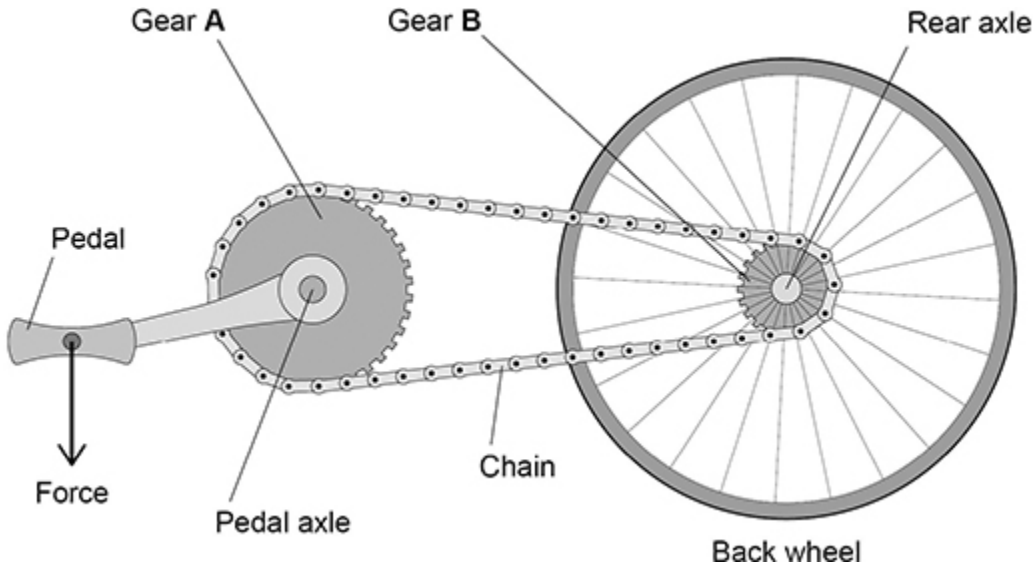
(b) Determine the distance travelled by the cyclist between **Y** and **Z**.

Distance travelled by the cyclist between **Y** and **Z** = _____ m

(3)

(c) **Figure 3** shows the gears on the bicycle.

Figure 3



Describe how the force on the pedal causes a moment about the rear axle.

_____

_____

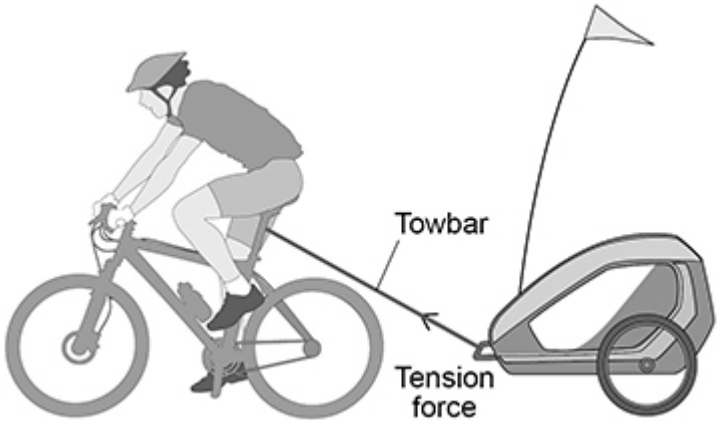
_____

_____

(2)

Figure 4 shows a different cyclist towing a trailer.

Figure 4



(d) The speed of the cyclist and trailer increased uniformly from 0 m/s to 2.4 m/s.

The cyclist travelled 0.018 km while accelerating.

Calculate the initial acceleration of the cyclist.

_____

_____

_____

_____

_____

Acceleration = _____ m/s^2

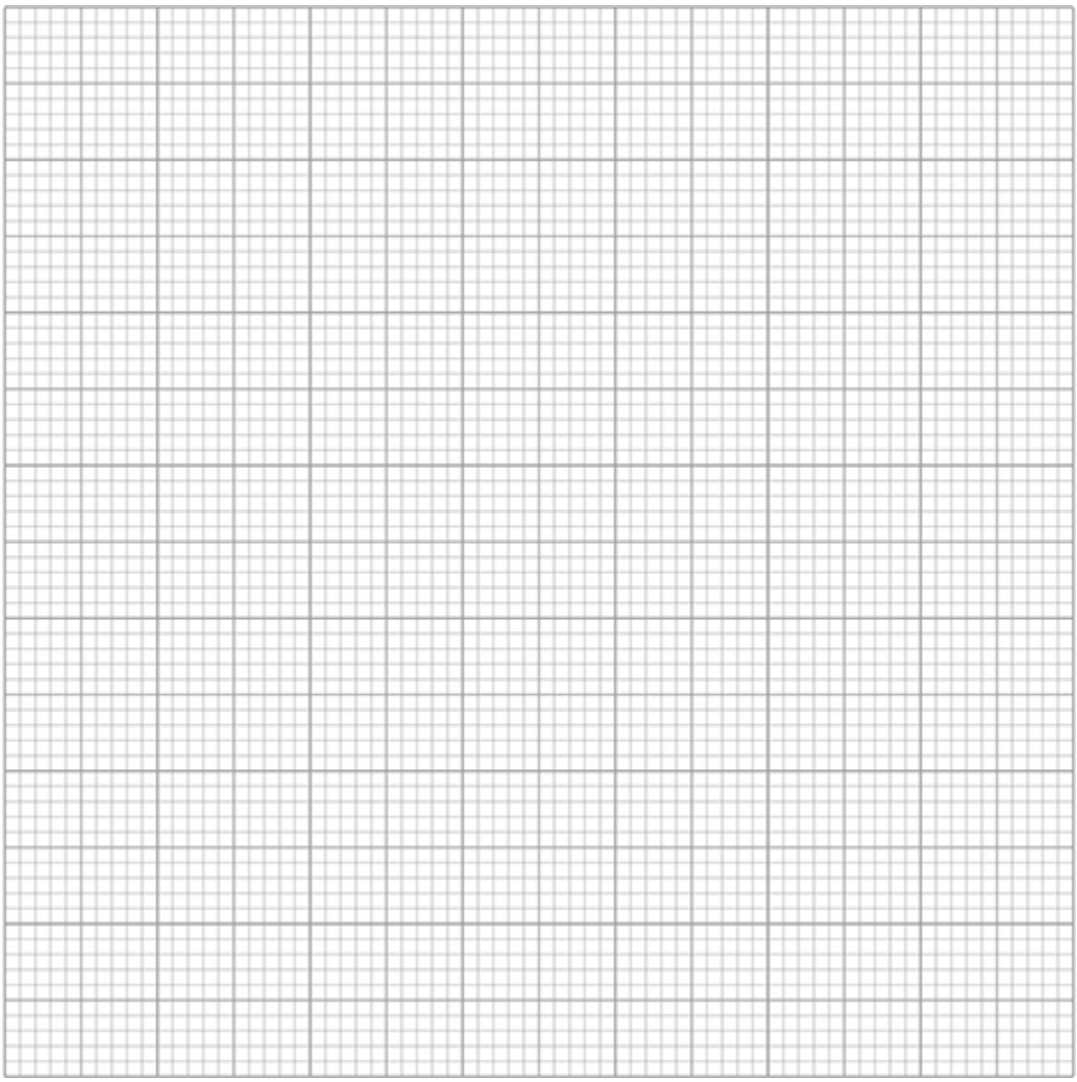
(3)

(e) The resultant force of the towbar on the trailer has a horizontal component and a vertical component.

horizontal force = 200 N

vertical force = 75 N

Determine the magnitude and direction of the resultant force of the towbar on the trailer by drawing a vector diagram.



Magnitude of force = _____ N

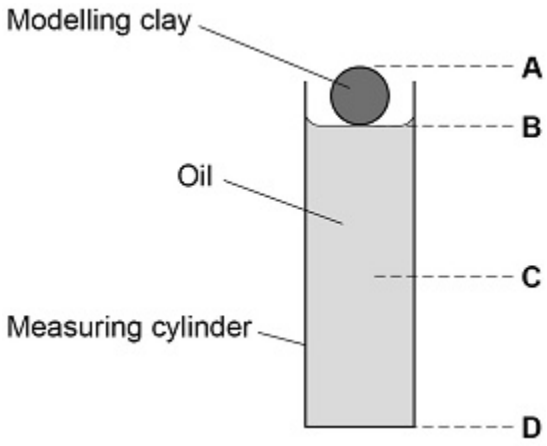
Direction of force = _____ degrees

(4)

(Total 13 marks)

2. A student dropped a piece of modelling clay into oil.

The diagram below shows the modelling clay just before it was dropped into the oil.



(a) What was the distance fallen by the modelling clay?

Tick (✓) **one** box.

from A to C ☐

from A to D ☐

from B to C ☐

from B to D ☐

(1)

(b) What measuring instrument should be used to measure the distance fallen?

_____

(1)

The student dropped four pieces of modelling clay, each with a different shape.

For each piece the student measured the time taken to fall the same distance through the oil.

(c) The student removed each piece of modelling clay from the oil before dropping the next piece.

Suggest **one** reason why.

_____

_____

_____

(1)

The student repeated the measurements and calculated mean values.

The table below shows the results.

Shape	Time taken in seconds			
	Drop 1	Drop 2	Drop 3	Mean
 Sphere	47	38	41	42
 Cube	68	49	57	58
 Cylinder	34	37	34	**X**
 Cone	29	23	26	26

(d) Calculate value **X** in the table above.

_____

_____

_____

X = _____ s

(2)

(e) Each piece of modelling clay had the same mass.

Which shape in the table above had the smallest resistive force acting against it as it fell?

Tick (✓) **one** box.

Give **one** reason for your answer.

Cone ☐

Cube ☐

Cylinder ☐

Sphere ☐

Reason _____

_____

(2)

(f) How would the time taken to fall change if the modelling clay was dropped through air instead of through oil?

Tick (✓) **one** box.

Time through air would be less. ☐

Time through air would be more. ☐

Time through air would be the same. ☐

(1)

(g) The mass of a piece of modelling clay was 0.050 kg.

gravitational field strength = 9.8 N/kg

Calculate the weight of the piece of modelling clay.

Use the equation:

weight = mass × gravitational field strength

_____

_____

Weight = _____ N

(2)

(h) Weight causes the modelling clay to fall through the oil.

Weight is a non-contact force.

Which of the following are also non-contact forces?

Tick (✓) **two** boxes.

Air resistance ☐

Electrostatic force ☐

Friction ☐

Magnetic force ☐

Tension ☐

(2)

(Total 12 marks)

3. (a) An aircraft travels at a constant velocity.

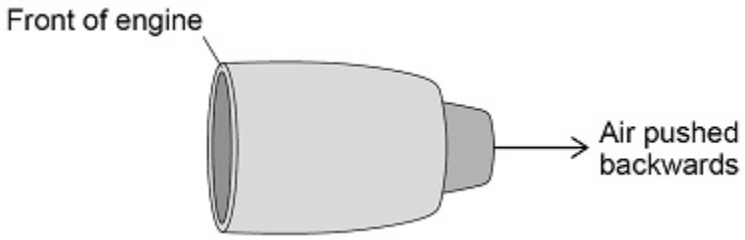
How is the velocity of the aircraft different to the speed of the aircraft?

_____

_____

(1)

(b) The diagram below shows one of the engines on the aircraft.



Air is taken into the front of the engine and pushed out of the back of the engine.

Explain the effect this has on the engine.

_____

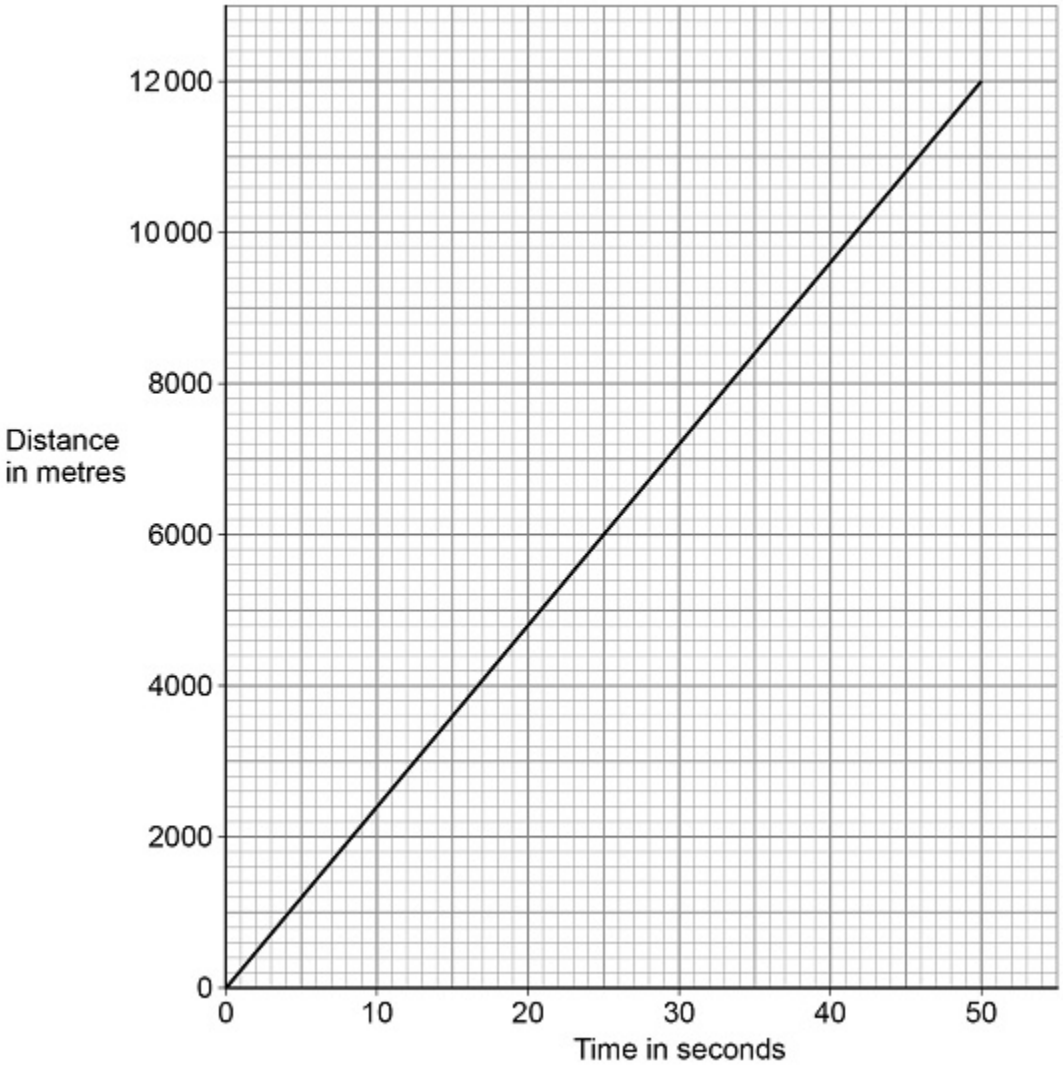
_____

_____

_____

(2)

(c) The graph below shows a distance-time graph for the aircraft.



Determine the speed of the aircraft.

_____

_____

_____

_____

_____

Speed = _____ m/s

(3)

(d) Write down the equation that links acceleration (a), change in velocity (Δv) and time taken (t).

_____

(1)

(e) At a different stage of the flight, the aircraft was travelling at a velocity of 250 m/s.

The aircraft then decelerated at 0.14 m/s^2.

Calculate the time taken for the aircraft to decelerate from 250 m/s to 68 m/s.

Time = _____ s

(4)

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

(1)

(g) When the aircraft landed, it travelled 2000 m before stopping.

The work done to stop the aircraft was 140 000 000 J.

Calculate the mean force used to stop the aircraft.

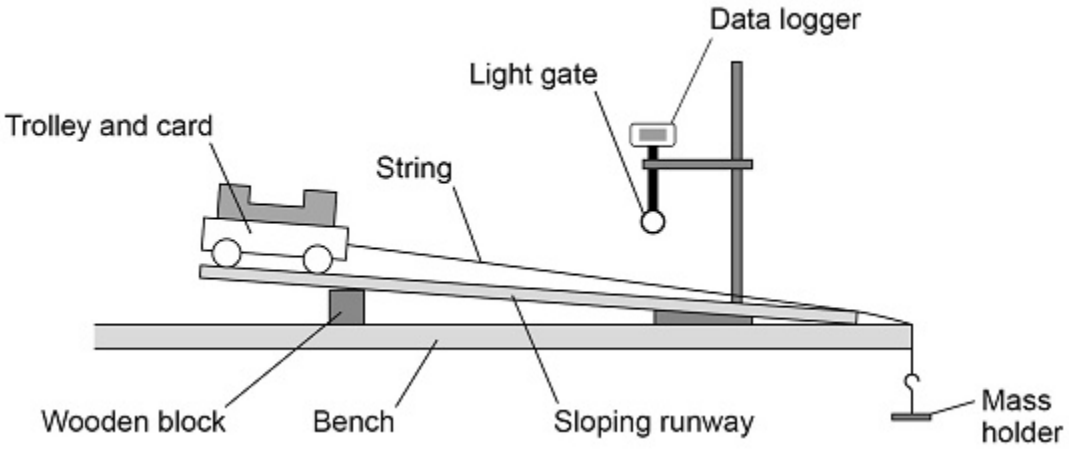
Mean force = _____ N

(3)

(Total 15 marks)

4. A student investigated the acceleration of a trolley.

The diagram below shows how the student set up the apparatus.



(a) Before attaching the mass holder the student placed the trolley at the top of the runway. The trolley rolled down the runway without being pushed.

What change to the apparatus in the diagram could be made to prevent the trolley from starting to roll down the runway?

Tick (✓) **one** box.

Move the wooden block to the left. ☐

Shorten the length of the runway. ☐

Use a taller wooden block. ☐

(1)

(b) The student attached the mass holder to the string.

The string rubbed along the edge of the bench as the mass holder fell to the floor.

Suggest what the student could do to prevent the string from rubbing.

_____

_____

(1)

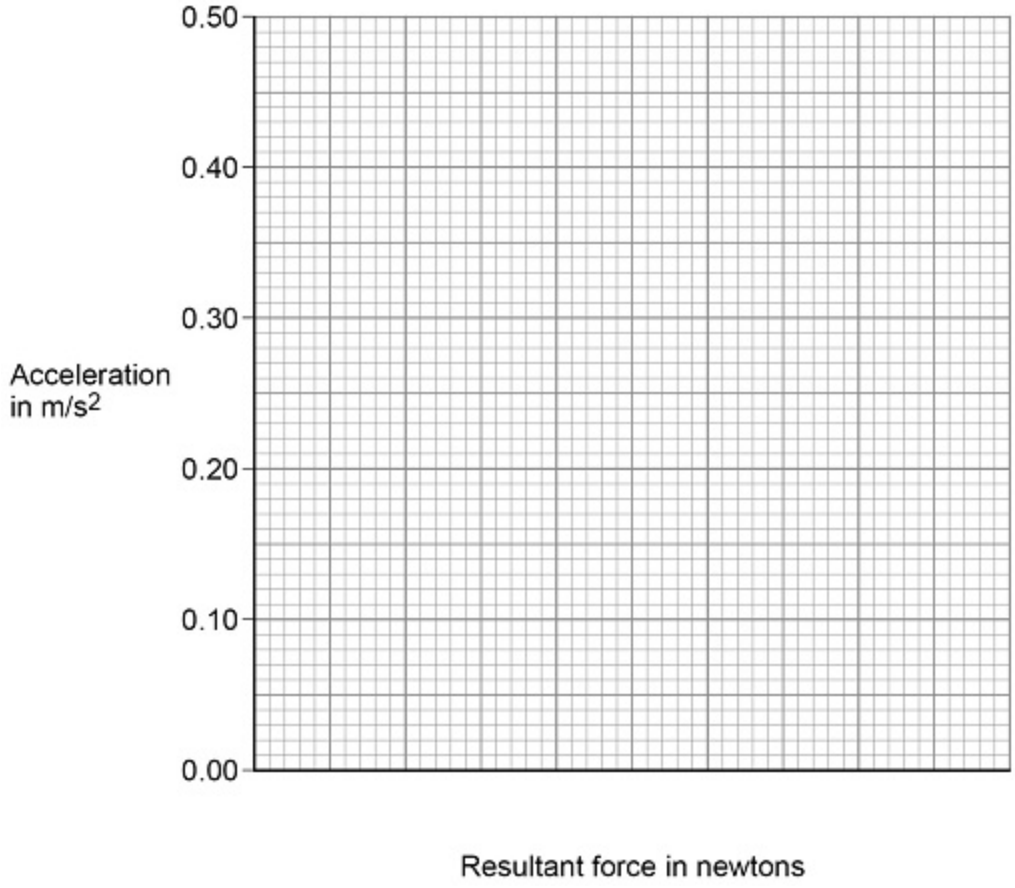
The light gate and data logger were used to determine the acceleration of the trolley.

The student increased the resultant force on the trolley and recorded the acceleration of the trolley.

The table below shows the results.

Resultant force in newtons	**Acceleration in m/s²**
0.05	0.08
0.10	0.18
0.15	0.25
0.20	0.32
0.25	0.41

The graph below is an incomplete graph of the results.



(c) Complete the graph.

- Choose a suitable scale for the x-axis.
- Plot the results.
- Draw a line of best fit.

(4)

(d) Describe the relationship between the resultant force on the trolley and the acceleration of the trolley.

_____

_____

(1)

(e) Describe how the investigation could be improved to reduce the effect of random errors.

_____

_____

_____

_____

(2)

(f) Write down the equation that links acceleration (*a*), mass (*m*) and resultant force (*F*).

_____

(1)

(g) The resultant force on the trolley was 0.375 N.

The mass of the trolley was 0.60 kg.

Calculate the acceleration of the trolley.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

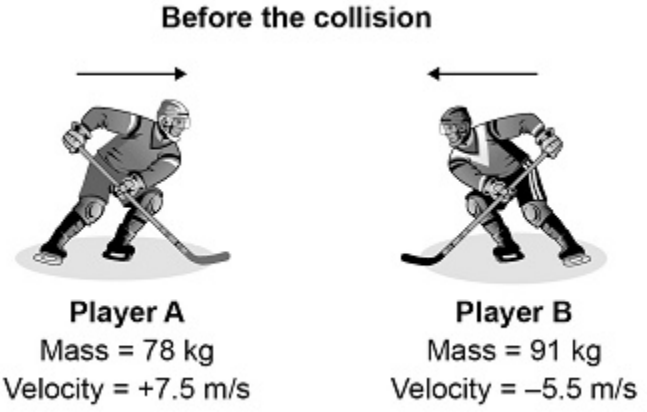
Acceleration (2 significant figures) = _____ m/s^2

(4)

(Total 14 marks)

5. The image below shows two ice hockey players moving towards each other.

They collide and then move off together.



During the collision, the total momentum of the players is conserved.

(a) What is meant by 'momentum is conserved'?

_____

_____

(1)

(b) Immediately after the collision the two players move together to the right.

Calculate the velocity of the two players immediately after the collision.

Velocity = _____ m/s

(4)

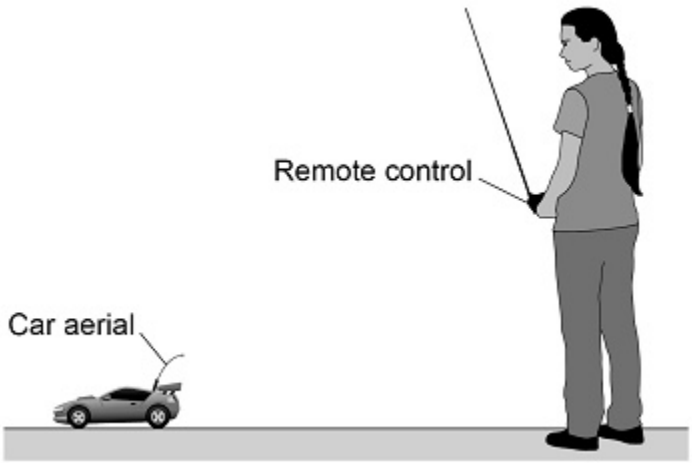
(c) The ice hockey players wear protective pads filled with foam.

Explain how the protective pads help to reduce injury when the players collide.

(3)

(Total 8 marks)

6. The image below shows a student playing with a remote-controlled car.



(a) The remote control transmits radio waves to the car aerial.

The transmitted radio waves have a frequency of 320 MHz.

speed of radio waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give the unit.

Wavelength = _____ Unit _____

(5)

(b) The car aerial is connected to an electrical circuit in the car.

Describe what happens in the electrical circuit when the car aerial absorbs radio waves.

_____

_____

_____

_____

_____

(2)

(c) The car produces sound waves.

Give **two** ways in which radio waves are different to sound waves.

1 _____

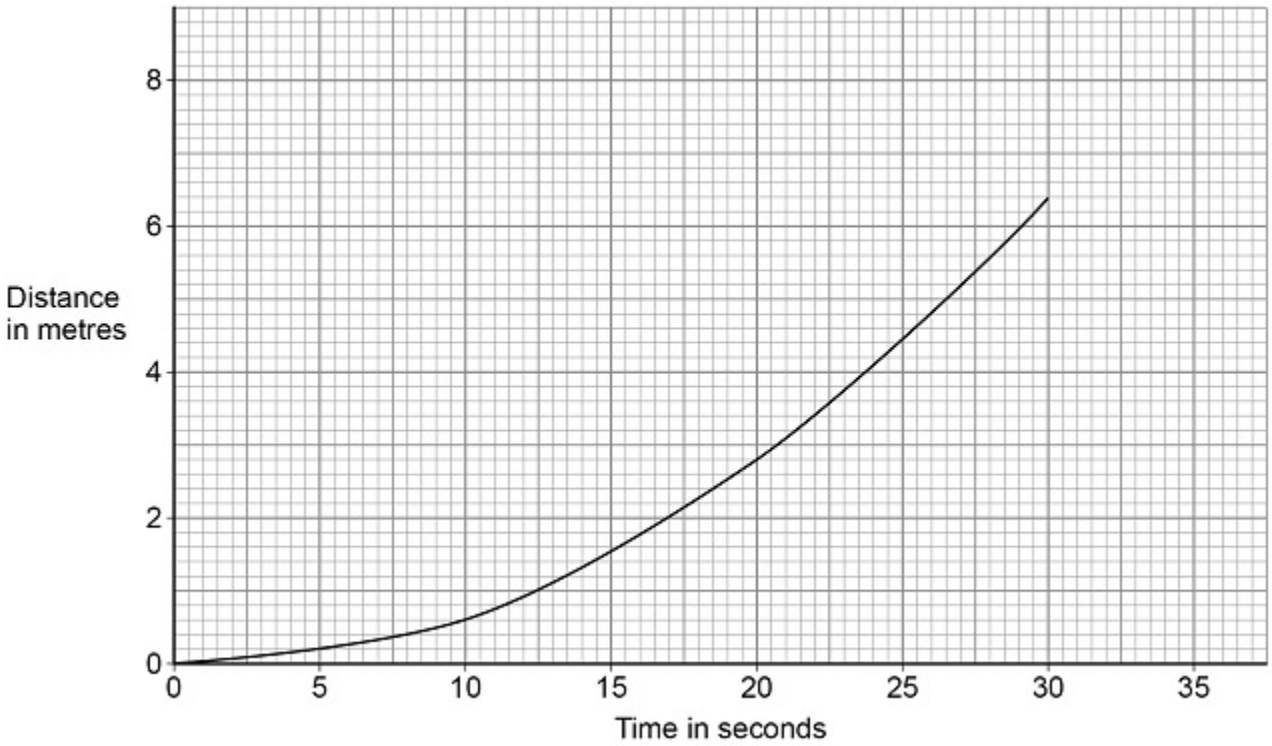
_____

2 _____

_____

(2)

The graph below shows the distance-time graph for the first 30 seconds of the car's motion.



(d) Describe the motion of the car during the first 30 seconds.

_____

(1)

(e) Determine the speed of the car 20 seconds after it started to move.

_____

_____

_____

_____

_____

Speed = _____ m/s

(4)

(f) A different car accelerated from 0.12 m/s to 0.52 m/s.

The acceleration of the car was 0.040 m/s^2.

The work done to accelerate the car was 0.48 J.

Calculate the resultant force needed to accelerate the car.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Resultant force = _____ N

(6)

(g) Explain why the car has a maximum speed.

_____

_____

_____

_____

_____

_____

_____

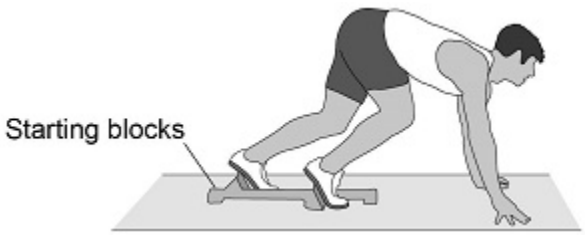
_____

(4)

(Total 24 marks)

7. **Figure 1** shows an athlete on starting blocks waiting to start a 100 metre race.

Figure 1



(a) Complete the sentence.

Choose the answer from the box.

equal to	**greater than**	**less than**

The force from the athlete pushing backwards on the starting blocks

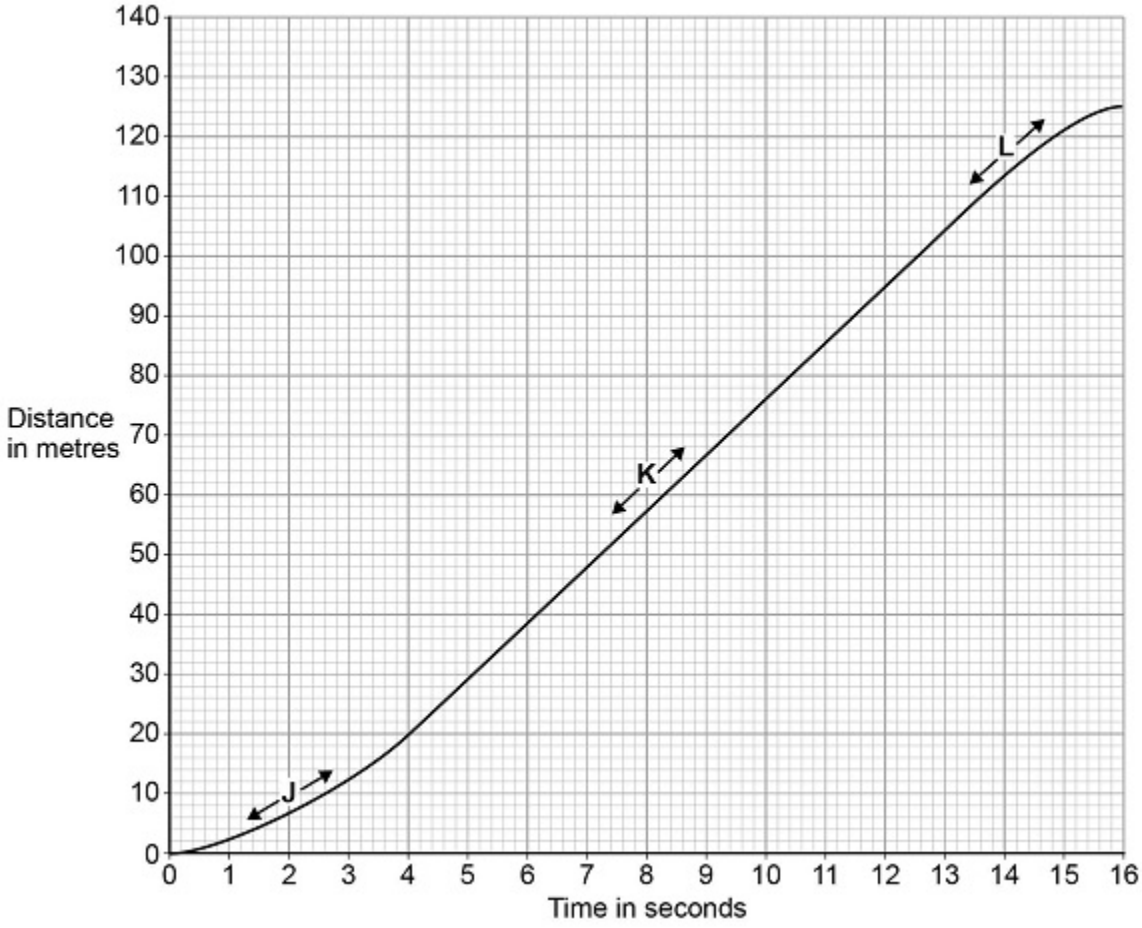
is _____ the force from the starting

blocks pushing forwards on the athlete.

(1)

Figure 2 shows a distance-time graph for the athlete from the moment the race starts.

Figure 2



(b) Three parts of the distance-time graph are labelled **J**, **K** and **L**.

Draw **one** line from **each** of the labels to the correct description of the athlete's motion for that part of the graph.

Labels	Description of motion
J	not moving
K	constant speed
L	decreasing speed
	increasing speed

(2)

(c) What distance does the athlete travel after the end of the race before stopping?

Distance = _____ m

(1)

(d) Calculate the average speed of the athlete between the start and finish of the 100 metre race.

Use the equation:

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

_____

_____

_____

Average speed = _____ m/s

(2)

(e) The athlete runs faster than a typical person.

What is the average running speed of a typical person in metres per second?

Tick (✓) **one** box.

1.5 ☐

3.0 ☐

4.5 ☐

6.0 ☐

(1)

(Total 7 marks)

8. The following statements describe parts of a short train journey between two railway stations.

Part A: The train accelerates at a constant rate from 0 m/s to 20 m/s in 40 s

Part B: The train travels at a constant velocity for 260 s

Part C: The train decelerates at a constant rate coming to a stop in 60 s

(a) During which part of the journey is the resultant force on the train zero?

Tick (✓) **one** box.

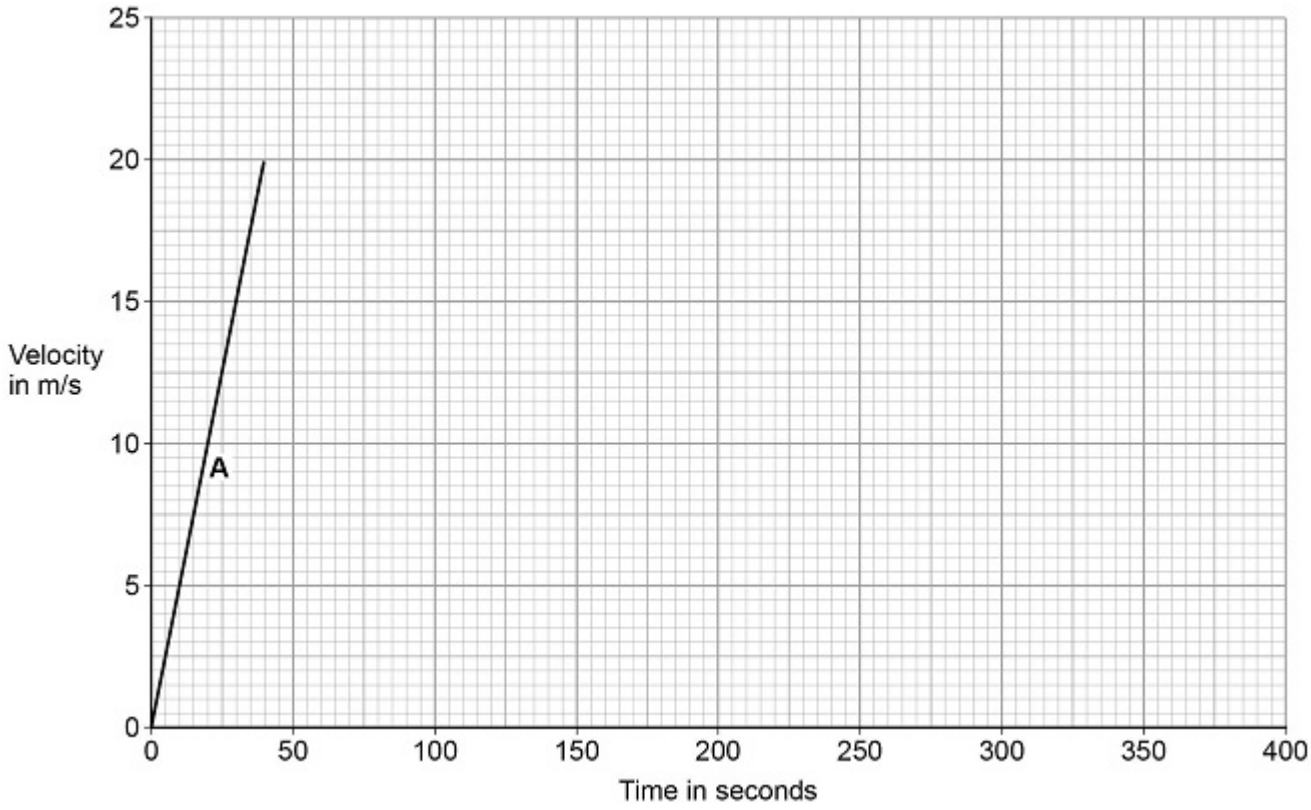
A ☐ **B** ☐ **C** ☐

(1)

(b) **Figure 1** shows part of the velocity-time graph for the train journey.

Complete **Figure 1** showing part **B** and part **C** of the train journey.

Figure 1



(3)

(c) Write down the equation which links acceleration, change in velocity and time taken.

_____

(1)

(d) Another train accelerated at 1.15 m/s^2 for 22.0 s

Calculate the increase in velocity of the train.

_____

_____

_____

Increase in velocity = _____ m/s

(3)

(Total 8 marks)

Mark schemes

1.

(a) friction

1

(b) (area of rectangle =) 108 (m)

1

(area of triangle =) 54 (m)

1

(total area / distance =) 162 (m)

allow a correctly calculated total area / distance from an incorrectly calculated area of rectangle and / or triangle

1

(c) (the force on the pedal) causes a moment about the pedal axle

1

which causes a force on the chain (which causes a moment about the rear axle)

allow gear B for chain

1

(d) $2.4^2 (- 0^2) = 2 \times a \times 18$

1

$$a = \frac{2.4 \times 2.4}{36}$$

1

$a = 0.16$ (m/s^2)

1

<u>alternative method</u>

t = 18 / 1.2
t = 15 (s) (1)

a = 2.4 / 15 (1)

this mark may be awarded if the time is incorrectly calculated

a = 0.16 (m/s^2) (1)

allow a correctly calculated acceleration from an incorrectly calculated time 1

(e) horizontal (200N) **and** vertical (75N) forces drawn to the same scale

1

resultant force drawn in the correct direction

shown by an arrow head from bottom right to top left

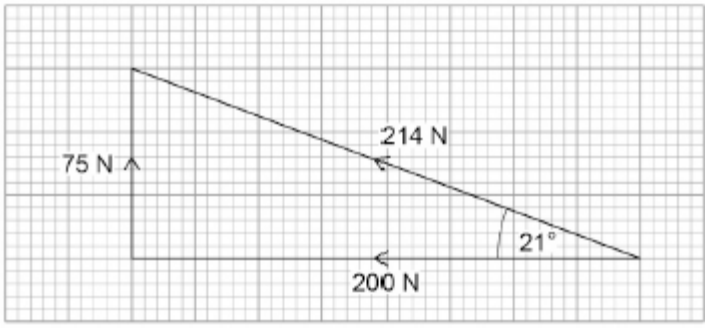
1

resultant force with a value in the range 212 to 218 (N)

allow a calculated value of 213.6 ***or*** *214 (N)*

1

direction in the range 20–22 (degrees from the horizontal)



allow 68–70 (degrees from the vertical)

allow a bearing in the range 290–292

to gain full marks a vector diagram must have been drawn

1

[13]

2. (a) B to D

1

(b) metre rule

allow tape measure

allow ruler

1

(c) so that each piece falls the same distance

allow to stop them from building up at the bottom

1

(d)

$$\frac{34 + 37 + 34}{3}$$

allow $\frac{105}{3}$

1

35 (s)

1

(e) cone

1

the (mean) time is the lowest

reason only scores if correct shape is selected

allow it fell the fastest

allow it had the most streamlined shape

ignore reference to surface area

1

(f) Time through air would be less.

1

(g) w = 0.050 × 9.8

1

w = 0.49 (N)

1

(h) Electrostatic force

1

Magnetic force

1

[12]

3. (a) velocity includes direction

allow velocity is a vector (quantity) ***and*** *speed is a scalar (quantity)*

1

(b) (an equal) force from the air pushes on the engine/aircraft

1

in the opposite direction

only scores if first marking point scored

accept to the left ***or*** *forwards*

if no other marks scored, allow ***1*** *mark for pushes the engine forwards*

1

(c) correct value for distance and corresponding time
(e.g. 12 000 m and 50 s)

1

$$v = \frac{\text{their change in distance}}{\text{their change in time}}$$

this mark may be awarded if distance and/or time are incorrectly read ***from the graph***

1

speed = 240 (m/s)

allow a correctly calculated answer using their values of distance and time ***from the graph***

1

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

or

$a = \frac{\Delta v}{t}$

1

(e) 250 – 68 = 182

1

$0.14 = \frac{182}{t}$

this mark may be awarded if the change in velocity is incorrectly/not calculated

1

$t = \frac{182}{0.14}$

this mark may be awarded if the change in velocity is incorrectly/not calculated

1

t = 1300 (seconds)

allow a correctly calculated answer using a change in velocity incorrectly/not calculated

1

(f) work done = force × distance

or

W = F s

1

(g) 140 000 000 = force × 2000

1

force = $\frac{140\,000\,000}{2000}$

1

force = 70 000 (newtons)

1

[15]

4. (a) Move the wooden block to the left.

1

(b) use a pulley (on the edge of the bench)

allow any feasible method to stop the string from rubbing

1

(c) suitable scale

1

points plotted correctly

*allow 5 correctly plotted for **2** marks **OR** 3–4 correctly plotted for **1** mark*

2

line of best fit

1

(d) (directly) proportional

allow a correct description of direct proportionality
ignore positive correlation
allow weight (added to mass holder) for force
*allow f = ma for **1** mark*

1

(e) repeat the measurements/investigation

1

ignore anomalies **and** calculate the mean / average

1

(f) resultant force = mass × acceleration

or

F = m a

1

(g) 0.375 = 0.60 × a

1

$a = \frac{0.375}{0.60}$

1

a = 0.625 (m/s^2)

1

a = 0.63 (m/s^2)

1

[14]

5. (a) (total) momentum before = (total) momentum after

allow (total) momentum stays the same

1

(b) momentum of player A = 585 (kg m/s)

1

momentum of player B = –500.5 (kg m/s)

1

$$\frac{(-500.5 + 585)}{(78 + 91)}$$

OR

$$\frac{84.5}{169}$$

allow $\frac{1085.5}{169}$

1

= 0.5 (m/s)

this answer only

1

(c) (protective pads) increase the time taken to stop (during the collision)

allow increases impact / contact / collision time
*do **not** allow slows down time*

1

so the rate of change of momentum decreases

allow reduces acceleration/deceleration
*allow increases the time to reduce the momentum to zero for **2** marks*

1

reducing the force (on the ice hockey player)

allow impact for force
*do **not** allow if linked to an incorrect explanation*

1

[8]

6.

(a) 320 MHz = 3.2×10^8 Hz

allow 320 000 000

1

$3.0 \times 10^8 = 3.2 \times 10^8 \times \lambda$

this mark may be awarded if frequency is incorrectly/not converted

1

$$\lambda = \frac{3.0 \times 10^8}{3.2 \times 10^8}$$

this mark may be awarded if frequency is incorrectly/not converted

1

wavelength = 0.9375

allow correct calculation using an incorrectly/not converted frequency

allow an answer that rounds to 0.94

1

metres **or** m

1

(b) (alternating) current induced (in the electrical circuit)

allow electrons vibrate / oscillate (in the electrical circuit)

1

with the same frequency as the radio wave

1

(c) Any **two** from:

- (radio waves are) transverse

  allow sound waves are longitudinal

  allow a description of transverse/longitudinal waves
- (radio waves) travel at a higher speed
- (radio waves) don't need a medium

  allow (only) radio waves travel through a vacuum
- (radio waves are) electromagnetic

  allow sound waves are mechanical

2

(d) accelerating

allow speeding up

1

(e) appropriate tangent drawn

1

correct reading from graph for change in distance and change in time (eg 5.6 (m) and 20 (s))

allow correct reading from their tangent for change in distance and change in time

1

gradient of tangent shown (eg 5.6/20)

allow correct gradient from their tangent

1

0.28 (m/s)

this answer only
allow 0.25 to 0.30 (m/s) if the tangent is appropriate
*allow 2.8 / 20 = 0.14 (m/s) for **1** mark*

1

(f) $0.52^2 - 0.12^2 = 2 \times 0.04 \times s$

1

$s = \frac{0.52^2 - 0.12^2}{2 \times 0.04}$

1

s = 3.2 (m)

1

0.48 = F x 3.2

this mark may be awarded if the displacement is incorrectly calculated

1

$F = \frac{0.48}{3.2}$

this mark may be awarded if the displacement is incorrectly calculated

1

F = 0.15 (N)

allow a correctly calculated F using and incorrectly calculated displacement

1

OR

Alternative method 1

$t = \frac{0.52 - 0.12}{0.04}$ (1)

t = 10 (s) (1)

s = 0.32 × 10
= 3.2 (m) (1)

allow a correctly calculated displacement from an incorrectly calculated t

0.48 = F x 3.2 (1)

this mark may be awarded if the displacement is incorrectly calculated

$F = \frac{0.48}{3.2}$

this mark may be awarded if the displacement is incorrectly calculated

F = 0.15 (N) (1)

allow a correctly calculated F from incorrectly calculated values for displacement and / or t

OR

Alternative method 2

$0.48 = (0.5 \times m \times 0.52^2) - (0.5 \times m \times 0.12^2)$ (1)

0.48 = 0.1352m – 0.0072m (1)

0.48 = 0.128m (1)

m = 3.75 (1)

F = 3.75 x 0.040 (1)

allow their calculated m

F = 0.15 (N) (1)

allow correctly calculated F using an incorrectly calculated m

(g) there is a maximum forward force (provided by the motor)

allow driving force for forward force - throughout

the car has a maximum acceleration is insufficient

1

as the speed of the car increases air resistance increases

allow friction / drag for air resistance - throughout

1

until air resistance is equal in size to forward force

allow (until) the resultant force is zero

allow forces are in equilibrium / balanced

1

so the car can no longer accelerate

allow the car travels at terminal velocity

1

[24]

7.

(a) equal to

allow the symbol =

allow a correct answer indicated in the box provided the answer space is blank

1

(b) J -------- increasing speed

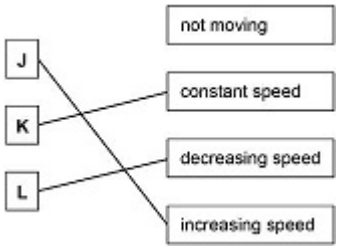
K--------- constant speed

L --------- decreasing speed

all three lines correct

*allow **1** mark for **1** line correct*

*more than three lines are drawn scores **0***



2

(c) 25 (m)

1

(d)

$$\text{av speed} = \frac{100}{12.5}$$

an answer of 8(.0) (m/s) scores 2 marks

1

av speed = 8(.0) (m/s)

1

OR

$$\text{av speed} = \frac{100}{12.6}$$

av speed = 7.93… (m/s)

allow 7.9 or 7.94

(e) 3.0

1

[7]

8. (a) B

1

(b) horizontal line drawn from (40, 20) to (300, 20)

1

straight line drawn from the point where line B finishes to 0 m/s

1

finishing on the x-axis at 360 s

allow a straight line showing time to decelerate as 60s

1

(c)

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

allow $a = \frac{(\Delta)v}{t}$

1

(d)

$$1.15 = \frac{\Delta v}{22}$$

*an answer 25.3 scores **3** marks*

1

$\Delta v = 1.15 \times 22$

1

$\Delta v = 25.3$ (m/s)

1

[8]