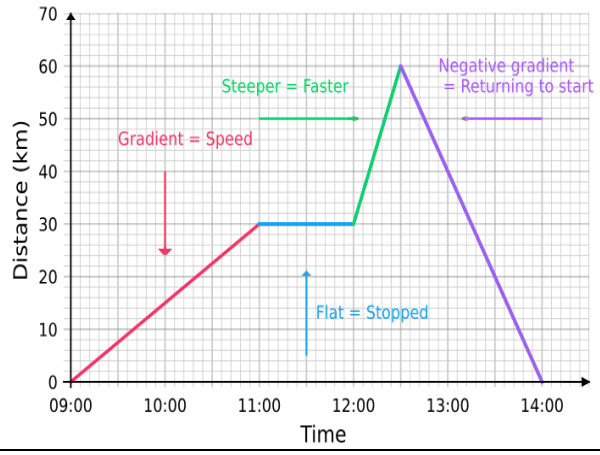
Section 5: Forces 1

Answer Key

1	What is a vector quantity?	A quantity with magnitude and an associated direction.
2	**Give 2 examples of vector quantities.**	**Displacement, velocity**
3	What is a scalar quantity?	A quantity with magnitude only
4	**Give 2 examples of scalar quantities**	**Distance, speed, mass, energy, temperature**
5	**What is a typical speed for walking?**	**1.5m/s**
6	**What is a typical speed for running?**	**3m/s**
7	**What is a typical speed for cycling?**	**6m/s**
8	What is velocity?	The rate of change of distance $velocity = \frac{distance}{time}$
9	What is acceleration?	The rate of change of velocity $a = \frac{v - u}{t}$
10	What is represented by the enclosed area in a velocity-time graph?	Displacement (distance away from the start)
11	**Draw and label the key features of a distance time graph**	

Section 5: Forces 2

Answer Key

1	(HT) What happens to the speed and velocity of an object in a circular orbit?	Constant speed, changing velocity (because of the constant change in direction)
2	State Newton's first law of motion	If there is no resultant force on an object, it will continue with a constant velocity if moving or remain at rest if stationary
3	What does Newton's first law tell us about a vehicle travelling at a steady speed?	The resistive forces balance the driving force. So the resultant force is zero.
4	What does Newton's first law tell us about objects moving with changing speed or direction?	There must be a resultant force on the object
5	**State Newton's second law of motion**	**The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object**
6	(HT) What is inertial mass?	A measure of how difficult it is to change the velocity of an object
7	**State Newton's third law**	**Whenever two objects interact, the forces they exert on each other are equal in size but act in opposite directions.**
8	(HT) What is conservation of momentum?	total momentum before a collision is equal to the total momentum after a collision
9	**What dangers are caused by large decelerations in events such as car crashes?**	**Large forces on passenger – resulting in injury, brakes overheating, losing control**
10	**What is the relationship between weight and mass?**	**Weight = mass x gravity** **Weight is a vector (force) and mass is a scalar**

Answer Key

1.	What is a typical human reaction time?	0.2 – 0.9 seconds
2.	Describe 2 ways of measuring reaction time	1. Dropping a ruler and catching it 2. Computerised tests involving pressing a button in response to seeing something on the screen – time recorded by the computer
3.	**What is stopping distance?**	**The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time and the distance it travels under the braking force**
4.	**What is thinking distance?**	**The distance travelled by the car while the driver reacts to the hazard**
5.	**What is braking distance?**	**The distance travelled by the car while the brakes do work on the wheels to bring them to a stop**
6.	**What factors affect thinking distance?**	**Speed, alcohol, drugs, tiredness, distractions, age**
7.	**What factors affect braking distance?**	**Speed, condition of the road, weather conditions, condition of tyres, condition of brakes**
8.	What are the units of velocity?	m/s (metres per second)
9.	What are the units of acceleration?	m/s^2 (metres per second squared)
10.	**What are the units of force?**	**N (newtons)**
11.	**What are the units of displacement?**	**m (metres)**
12.	**(HT) What are the units of momentum?**	**kg m/s (kilogram-metres per second)**

Answer Key

1	Name 3 non- contact forces	Gravity, electrostatic, magnetism
2	Name 5 contact forces	Friction, normal contact force, air resistance, upthrust, tension, buoyancy
3	What is weight?	The force on an object due to its mass in a gravitational field
4	What is the unit of weight?	N (Newtons)
5	What conditions must occur in order for an object to be bent, compressed or stretched?	More than one force must be applied
6	What is the difference between elastic and inelastic deformation?	Elastic deformation: the object will return to its original size and shape. Inelastic deformation: the object will not return to its original size and shape
7	**What is "work done"?**	**The energy transferred when a force is used to move an object across a distance**
8	What is 1 newton-metre equivalent to?	1 joule
9	**What is Hooke's Law?**	**As the force on an elastic object increases, the extension of the object increases linearly**
10	**How do you calculate the energy stores in an elastic object?**	**Use the relationship:** $E_e = \frac{1}{2}ke^2$

Foundation Tier Questions

Q1.

Figure 1 shows an electric wheelchair.

Figure 1

(a) The wheelchair moves at a constant speed of 2.4 m/s for 4.5 seconds.

Calculate the distance moved by the wheelchair.

Use the equation:

distance = speed × time

_____

_____

_____

_____

Distance = _____ m

(2)

(b) What could be a reason for the speed of the wheelchair decreasing?

Tick **one** box.

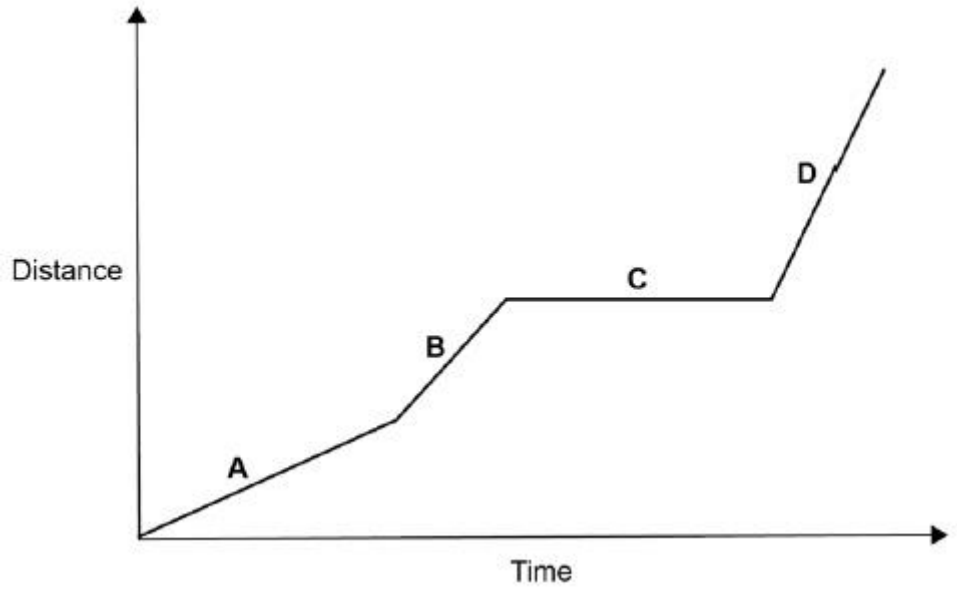
It started going downhill.	☐
It started going uphill.	☐
Its store of kinetic energy increased.	☐
It used more power from its battery.	☐

(1)

A student measured how the distance travelled by the wheelchair changed over time.

Figure 2 shows a sketch-graph of the results.

Figure 2



(c) In which section of the graph, **A**, **B**, **C**, or **D**, did the wheelchair travel fastest?

Give the reason for your answer.

Section _____

Reason _____

_____

(2)

(d) The student used a data logger with a distance sensor to record the data.

Give **two** advantages of using a data logger rather than using a stopclock and tape measure.

1. _____

_____

2. _____

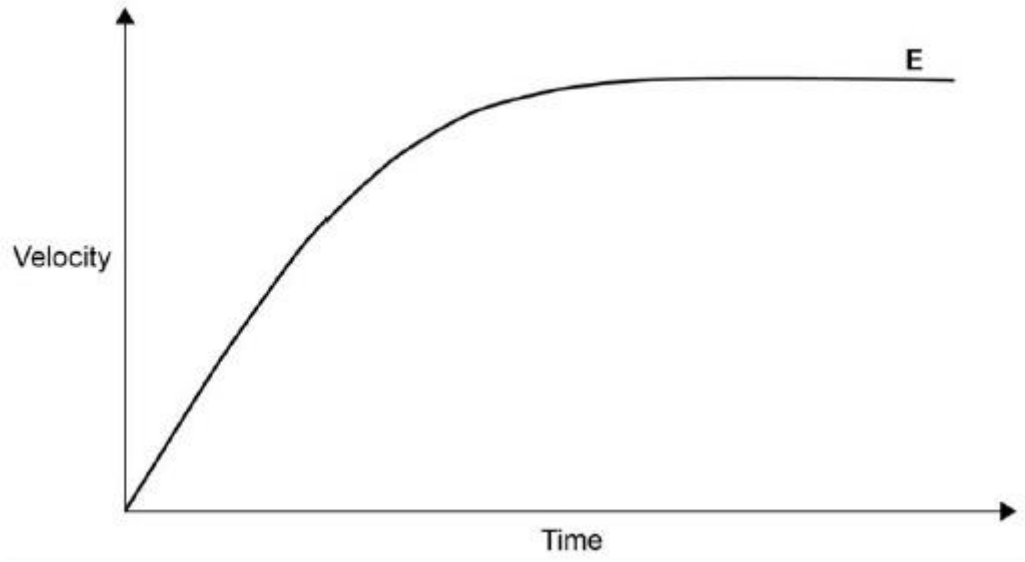
_____

(2)

The velocity of the wheelchair changes as it accelerates to its top speed.

Figure 3 shows a sketch-graph of the changes.

Figure 3



(e) The forward force on the wheelchair is constant as it accelerates on flat ground.

Which force reduces the acceleration?

Tick **one** box.

Air resistance	☐
Magnetism	☐
Tension	☐
Weight	☐

(1)

(f) Explain the acceleration of the wheelchair at point **E** on **Figure 3**.

_____

_____

_____

_____

(2)

(g) The wheelchair starts from rest.

It accelerates at a constant rate until it has a speed of 1.5 m/s

The wheelchair travels a distance of 2.0 m while it is accelerating.

Calculate the acceleration of the wheelchair.

Using the Physics Equations Sheet.

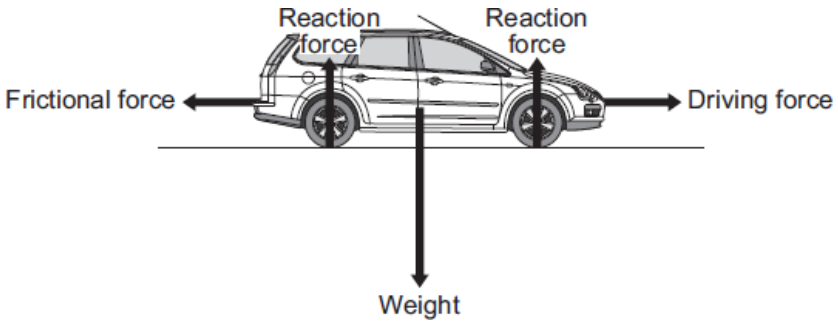
Acceleration = _____ m/s^2

(3)

(Total 13 marks)

Q2.

The diagram shows the forces acting on a car. The car is being driven along a straight, level road at a constant speed of 12 m/s.



(a) The driver then accelerates the car to 23 m/s in 4 seconds.

Use the equation in the box to calculate the acceleration of the car.

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

Show clearly how you work out your answer and give the unit.

Acceleration = _____

(3)

(b) Describe how the horizontal forces acting on the car change during the first **two** seconds of the acceleration.

_____

_____

_____

_____

_____

_____

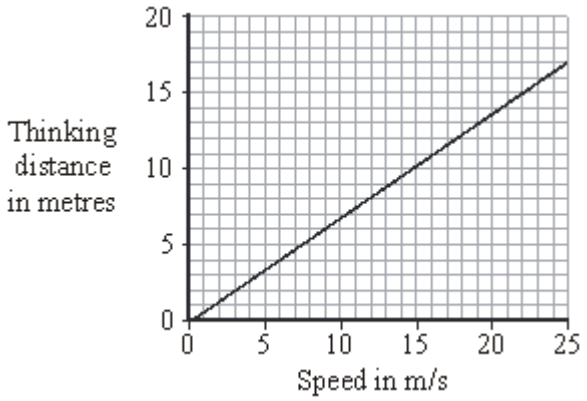
(3)

(Total 6 marks)

Q3.

(a) A car driver takes a short time to react to an emergency before applying the brakes. The distance the car will travel during this time is called the 'thinking distance'.

The graph shows how the thinking distance of a driver depends on the speed of the car.



(i) What is the connection between thinking distance and speed?

_____

(1)

(ii) Many people drive while they are tired.

Draw a new line on the graph to show how thinking distance changes with speed for a tired driver.

(1)

(iii) The graph was drawn using data given in the Highway Code.

Do you think that the data given in the Highway Code is likely to be reliable?

Draw a ring around your answer.

Yes **No** **Maybe**

Give a reason for your answer.

_____

_____

(1)

(b) The distance a car travels once the brakes are applied is called the 'braking distance'.

(i) What is the relationship between thinking distance, braking distance and stopping distance?

_____

(1)

(ii) State **two** factors that could increase the braking distance of a car at a speed of 15 m/s.

1. _____

2. _____

(2)

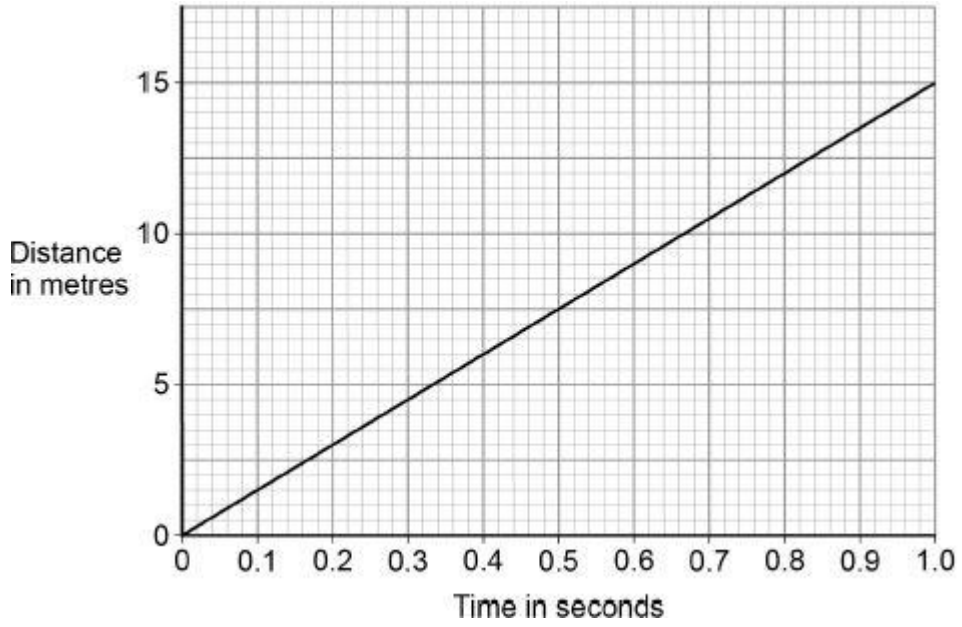
(Total 6 marks)

Higher Tier Questions

Q4.

(a) **Figure 1** shows the distance-time graph for a car travelling at 15 m/s

Figure 1



When the driver is tired, his reaction time increases from 0.50 seconds to 0.82 seconds.

Determine the **extra** distance the car would travel before the driver starts braking.

_____

_____

_____

Distance = _____ m

(2)

(b) When the brakes are used, the temperature of the brakes increases.

Explain why. Use ideas about energy in your explanation.

_____

_____

_____

_____

(2)

(c) A lorry travels 84 m with a constant acceleration of 2.0 m/s^2 to reach a velocity of 19 m/s

Calculate the initial velocity of the lorry.

Use the Physics Equations Sheet.

_____

_____

_____

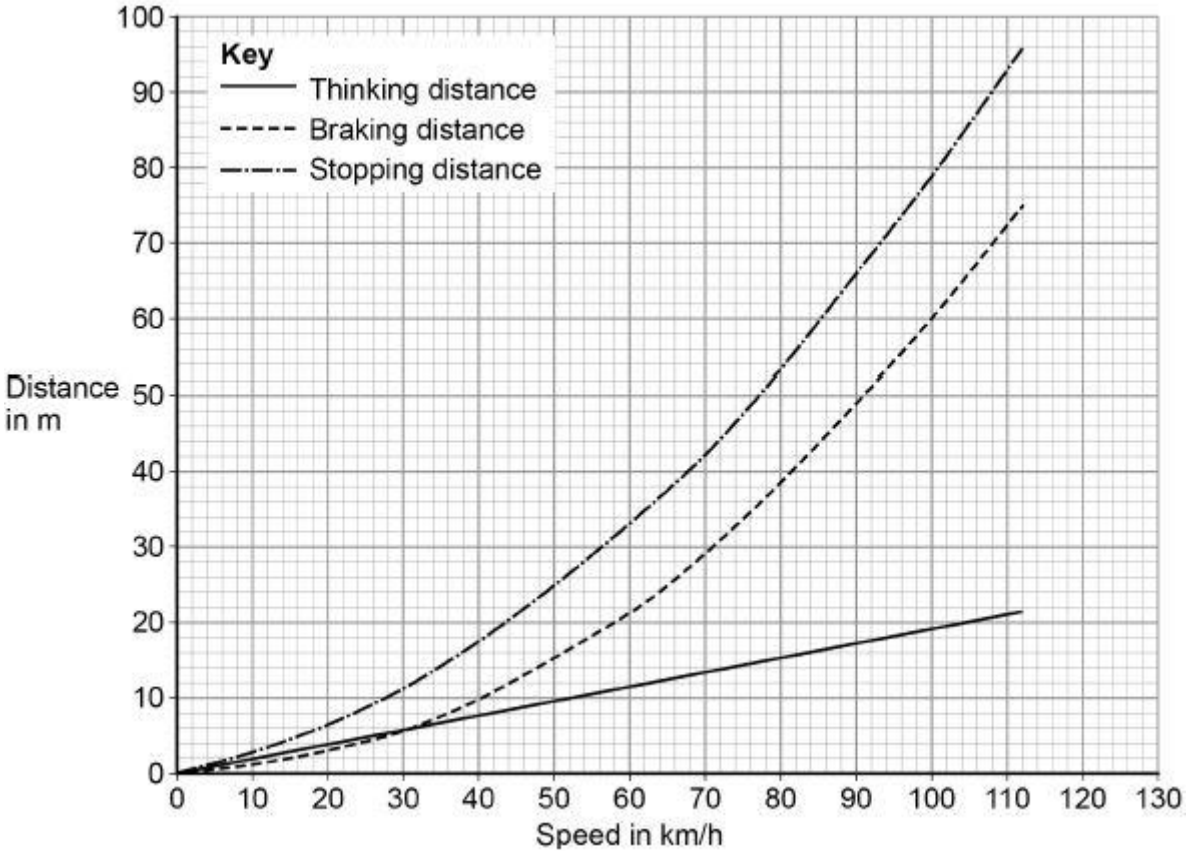
_____

Initial velocity = _____ m/s

(3)

(d) **Figure 2** shows how the thinking distance, braking distance and stopping distance for a car vary with the speed of the car.

Figure 2



Describe the relationships shown in **Figure 2**

You should include factors that would affect the gradient of the lines.

(6)
(Total 13 marks)

Q5.

The diagram below shows a girl bowling a ball along a ten-pin bowling lane.

The girl is trying to knock down the ten pins at the end of the bowling lane.

(a) Velocity is a vector quantity, speed is a scalar quantity.

Describe what is meant by a vector quantity and a scalar quantity.

Vector quantity _____

_____

Scalar quantity _____

_____

(2)

(b) The bowling lane is horizontal.

Explain why the bowling ball decelerates as it travels along the lane.

_____

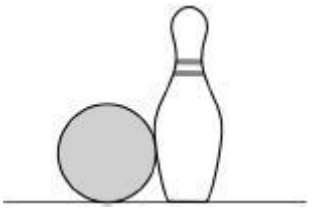
_____

_____

_____

(2)

The diagram below shows the bowling ball hitting one of the pins.



(c) Write down the equation that links mass (*m*), momentum (*p*) and velocity (*v*).

_____

(1)

(d) The bowling ball has a velocity of 5.0 m/s when it hits the pin.

The momentum of the bowling ball is 26 kg m/s

Calculate the mass of the bowling ball.

_____

_____

_____

_____

_____

Mass = _____ kg

(3)

(e) Explain why the bowling ball slows down when it hits the pin.

You should use ideas about momentum in your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 11 marks)

Q6.

The speed limit on many roads in towns is 13.5 m/s

Outside schools this speed limit is often **reduced by** one-third.

(a) Calculate the reduced speed limit.

_____

_____

_____

_____

Reduced speed limit = _____ m/s

(2)

(b) A reduced speed limit may reduce air pollution.

Explain **one** other advantage of a reduced speed limit.

_____

_____

_____

_____

(2)

(c) **Figure 1** shows a car being driven at a constant speed past a speed camera.

Figure 1

The camera recorded two images of the car 0.70 s apart.

The car travelled 14 m between the two images being taken.

The maximum deceleration of the car is 6.25 m/s^2

Calculate the minimum braking distance for the car at the speed it passed the speed camera.

Minimum braking distance = _____ m

(6)

(d) **Figure 2** shows a delivery van full of packages.

Figure 2

The driver delivers all the packages.

The empty van has a shorter stopping distance than the full van when driven at the same speed.

Explain why.

_____

_____

_____

_____

_____

_____

(3)

(Total 13 marks)

Mark schemes

Foundation Tier mark scheme

Q1.

(a) distance = 2.4 m/s × 4.5 s

1

distance = 10.8 (m)

*an answer of 10.8 m scores **2** marks*

1

(b) It started going uphill.

1

(c) **D**

1

the line has the largest gradient

allow it is steepest

allow it travels the furthest distance in the shortest amount of time

1

(d) any **two** from:

- the data logger records time more accurately
- the data logger can take readings more frequently
- there is less chance for human error when using a data logger
- the data logger automatically records data

allow the converse of each argument, eg there is a human reaction time error when using a stopclock

2

(e) air resistance

1

(f) acceleration is zero

1

because the resultant force is zero

allow because the forward force equals the air resistance

there is too much air resistance is insufficient

1

(g) $v^2 - u^2 = 2as$
$1.5^2 (- 0^2) = 2 \times a \times 2$

1

$$a = \frac{1.5^2}{2 \times 2}$$

1

$a = 0.56(25)$ m/s^2

*an answer of 0.56(25) (m/s^2) scores **3** marks*

1

[13]

Q2.

(a) 2.75

*allow **1** mark for correct substitution, ie* $\frac{11}{4}$

or $\frac{23 - 12}{4}$

provided no subsequent step shown

2

m/s^2

1

(b) driving force increases

1

frictional force increases

accept air resistance / drag for frictional force

1

driving force > frictional force

1

[6]

Q3.

(a) (i) as one goes up so does the other

or (directly) proportional

accept change by the same ratio

1

(ii) steeper straight line through the origin

judge by eye

1

(iii) Yes with reason

eg data would have been checked / repeated

accept produced by a reliable/ official/ government source

*do **not** accept it needs to be reliable*

or No with reason

eg does not apply to all conditions / cars / drivers

or are only average values

or Maybe with a suitable reason

eg cannot tell due to insufficient information

1

(b) (i) stopping distance = thinking distance + braking distance

1

(ii) any **two** from:

factors must be to do with increasing braking distance

- smooth road / loose surface
- rain / snow / ice

accept wet road/ petrol spills
*do **not** accept condition of road unless suitably qualified*

- badly maintained brakes

accept worn brakes
accept bad/ worn/ rusty brakes
*do **not** accept old brakes*

- worn tyres

accept bald tyres
accept lack of grip on tyres
*do **not** accept old tyres*

- downhill slope/gradient
- heavily loaded car

2

[6]

Higher Tier mark scheme

Q4.

(a) either:
7.5 (m) **and** 12.3 (m) from the graph
or
15 (m/s) × 0.32 (s) using speed

allow 7.5 (m) and between 12.2 (m) and 12.4 (m)

1

extra distance = 4.8 (m)

1

*an answer between 4.7 (m) and 4.9 (m) scores **2** marks*

(b) there is a decrease in kinetic energy of the car

allow work is done by friction (on the brakes)

1

so this (causes) the internal / thermal energy store of the brakes to increase

1

(c) $19^2 - u^2 = 2 \times 2 \times 84$

1

$u^2 = 19^2 - (2 \times 2 \times 84)$

1

u = 5 (m/s)

$u = \sqrt{19^2 - (2 \times 2 \times 84)}$

1

an answer of 5 (m/s) scores 3 marks

(d) **Level 3:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.

5–6

Level 2: Scientifically relevant facts, events or processes are identified and their relevance is clear. The account is not fully accurate.

3–4

Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.

1–2

No relevant content

0

Indicative content

- use of drugs, alcohol, tiredness and distractions would increase the thinking distance
- thinking distance increases with speed
- thinking distance is directly proportional to speed
- use of drugs, alcohol, tiredness and distractions would increase the gradient of thinking distance

- poor brakes, poor tyres, wet / icy roads and mass would increase the braking distance
- braking distance increases with speed
- braking distance increases at an increasing (accept greater) rate (with speed)
- poor brakes, poor tyres, wet / icy roads and mass would increase the gradient of braking distance
- braking distance is directly proportional to speed squared

- stopping distance = thinking distance + braking distance
- factors that increase thinking and / or braking distance would increase the gradient of stopping distance
- stopping distance increases at an increasing (accept greater) rate (with speed)

[13]

Q5.

(a) (vector quantity) has magnitude and a direction

1

(scalar quantity) has magnitude only

1

(b) resistive force acts on the ball

allow friction or air resistance

1

so (resultant) force in opposite direction to velocity

or

so work is done on the ball

1

(c) momentum = mass × velocity

or

p = mv

1

(d) $26 = m \times 5.0$

1

$m = \frac{26}{5.0}$

1

5.2 (kg)

1

(e) momentum is conserved in the collision (assuming no external forces)

1

momentum of the pin increases

1

therefore the momentum of the ball must decrease.

*if no other mark is awarded, allow **1** mark for when the ball exerts a force on the pin, the pin exerts an equal and opposite force on the ball*

1

[11]

Q6.

(a) $13.5 \times \frac{2}{3}$

1

9.0 (m/s)

allow 9 (m/s)

OR

$13.5 \times \frac{1}{3} = 4.5$ (1)

13.5 - 4.5 = 9.0 (m/s) (1)

1

(b) reduced speed reduces stopping distance

allow reduces thinking / braking distance

1

means less chance of collision

OR

the car will have less kinetic energy (1)

so less likely to cause injury in the event of a collision (1)

1

(c) $14 = v \times 0.70$

1

$v = \frac{14}{0.70}$

1

$v = 20$ (m/s)

1

$0^2 – 20^2 = 2 \times (–6.25) \times s$

1

$s = \frac{20^2}{(2 \times 6.25)}$

ignore minus signs throughout

1

$s = 32$ (m)

1

(d) same maximum force applied by the brakes

1

because mass is less there is a greater deceleration

allow momentum for mass

1

braking distance is less

OR

reducing the mass reduced the kinetic energy of the van (at a given speed) (1)

less work needed to be done to bring the van to a stop (1)

(force from the brakes is the same) so braking distance is less (1)

1

[13]