



## Mark schemes

1

(a) **Level 2 (3–4 marks):**

A detailed and coherent description of a plan covering all the major steps is provided. The steps are set out in a logical manner that could be followed by another person to obtain valid results.

**Level 1 (1–2 marks):**

Simple statements relating to relevant apparatus or steps are made but they may not be in a logical order. The plan would not allow another person to obtain valid results.

**0 marks:**

No relevant content.

**Indicative content**

- measure the distance the ruler falls before being stopped
- the greater this distance the greater the reaction time
- repeat measurements and calculate a mean
- repeat several times with the student listening to music (through earphones). Calculate a mean.
- a (significant) difference between the two means would show that music affects reaction time.

4

(b) reaction time decreases with practice

*allow Y has a shorter reaction time*

1

*allow Y has faster reaction times (than X)*

(c) the stop clock was started before the computer test started

1

the student was distracted

1

[7]

2

(a) D

1

(b) C

1

(c)  $W = 300 \times 45$

1

$W = 13\,500$

1

*allow 13 500 with no working shown for 2 marks*

(d) straight line drawn from 13 m / s to 0 m / s

1

finishing on x-axis at 65 s

1

[6]

|          |  |             |
|----------|--|-------------|
| <b>3</b> | (a) Third Law  | 1           |
|          | (b) elastic potential  | 1           |
|          | (c) weight = mass × gravitational field strength<br><i>accept gravity for gravitational field strength</i>   | 1           |
|          | <i>accept <math>W = mg</math></i>  |             |
|          | <i>accept correct rearrangement ie mass = weight / gravitational field strength <b>or</b> <math>m = W / g</math></i>   |             |
|          | (d) $343 = m \times 9.8$   | 1           |
|          | $m = \frac{343}{9.8}$  |             |
|          | $m = 35$   | 1           |
|          | <i>allow 35 with no working shown for 3 marks</i>  |             |
|          | (e) force = spring constant × compression<br><i>accept force = spring constant × extension</i><br><i>accept <math>F = k e</math></i><br><i>accept correct rearrangement ie constant = force / extension <b>or</b> <math>k = F / e</math></i> | 1           |
|          | (f) compression = 0.07m  | 1           |
|          | $343 = k \times 0.07$  | 1           |
|          | $k = 343 \div 0.07$  | 1           |
|          | $k = 4900$   | 1           |
|          | <i>allow 4900 with no working shown for 4 marks</i><br><i>allow 49 with no working shown for 3 marks</i>   |             |
|          |  | <b>[11]</b> |

|          |                                       |   |
|----------|---------------------------------------|---|
| <b>4</b> | (a) It will have a constant speed.    | 1 |
|          | (b) distance travelled = speed × time | 1 |

(c)  $a = \frac{18 - 9}{6}$

6

1

$a = 1.5$

*allow 1.5 with no working shown for 2 marks*

1

(d) resultant force = mass  $\times$  acceleration

1

(e)  $F = (1120+80) \times 1.5$

1

$F = 1800 \text{ (N)}$

*allow 1800 with no working shown for 2 marks*

1

*accept their  $10.3 \times 1200$  correctly calculated for 2 marks*

(f)  $18^2 - 9^2 = 2 \times 1.5 \times s$

1

$s = \frac{18^2 - 9^2}{2 \times 1.5}$

1

$s = 81 \text{ (m)}$

1

*allow 81 (m) with no working shown for 3 marks*

*accept answer using their 10.3 (if not 1.5) correctly calculated for 3 marks*

(g) **Level 2 (3–4 marks):**

A detailed and coherent explanation is provided. The response makes logical links between clearly identified, relevant points that include references to the numerical factor.

**Level 1 (1–2 marks):**

Simple statements are made. The response may fail to make logical links between the points raised.

**0 marks:**

No relevant content.

**Indicative content**

- doubling speed increase the kinetic energy
- kinetic energy increases by a factor of 4
- work done (by brakes) to stop the car increases
- work done increases by a factor of 4
- work done is force  $\times$  distance and braking force is constant
- so if work done increases by 4 then the braking distance must increase by 4

4

[14]

5

(a) any sensible suggestion eg

- theory supported by results from other experiments
- could not believe the 'theory' could be wrong
- 'theory' is the basis of many other ideas

1

(b) any **two** from:

- to allow peer review of data
- to assess the reproducibility of the data
- to promote further enquiry / experiments
- to encourage other scientists to develop explanations / new theories

2

(c)  $730\,000 = 300\,007\,400 \times \text{time}$

1

$$\text{time} = \frac{730\,000}{300\,007\,400}$$

*this step without the previous step stated gains 2 marks*

1

$$2.43(3273) \times 10^{-3} \text{ s}$$

*accept 0.00243(3273) s*

1

*allow  $2.43(3273) \times 10^{-3}$  with no working for 4 marks*

(d)  $60 \times 10^{-9} \text{ s}$

1

(e) systematic error

1

(f) add on 60 nanoseconds to each time recorded (then recalculate)

1

[9]

6

(a) distance is a scalar and displacement is a vector

**or**

distance has magnitude only, displacement has magnitude and direction

1

(b) 37.5 km

*accept any value between 37.0 and 38.0 inclusive*

1

062° or N62°E

*accept 62° to the right of the vertical*

1

*accept an angle in the range 60° – 64°*

*accept the angle correctly measured and marked on the diagram*

(c) train changes direction so velocity changes 1

acceleration is the rate of change of velocity 1

(d) number of squares below line = 17 1

*accept any number between 16 and 18 inclusive* 1

each square represents 500 m 1

distance = number of squares × value of each square correctly calculated – 8500 m 1

**[8]**

**7** (a) the distance travelled under the braking force 1

(b) the reaction time will increase 1

increasing the thinking distance (and so increasing stopping distance)

*(increases stopping distance is insufficient)* 1

(c) No, because although when the speed increases the thinking distance increases by the same factor the braking distance does not. 1

eg

increasing from 10 m / s to 20 m / s increases thinking distance from 6 m to 12 m but the braking distance increases from 6 m to 24 m 1

(d) If the sled accelerates the value for the constant of friction will be wrong. 1

(e) only a (the horizontal) component of the force would be pulling the sled forward 1

the vertical component of the force (effectively) lifts the sled reducing the force of the surface on the sled 1

(f)  $-u^2 = 2 \times -7.2 \times 22$  1

*award this mark even with  $0^2$  and / or the negative sign missing* 1

$u = 17.7(99)$  1

*allow 18 with no working shown for 3 marks*

*allow 17.7(99) then incorrectly rounded to 17 for 2 marks*

[11]

8

- (a) starting / stopping the stopwatch

*human error is insufficient*

*reaction time is insufficient*

**or**

timing over the smaller distances

*accept not timing accurately*

*do not accept references to measuring distance incorrectly*

1

- (b) (i) before

1

- (ii) increasing

*accept accelerating*

*it is not constant is insufficient*

*it is less than after four seconds is insufficient*

*it reaches a constant speed negates*

1

- (iii) calculate the gradient of the straight/steepest/constant section

*accept gradient of any section after 5.5 seconds/30 cm*

1

- (iv) drag (force) increases (as the ball bearing gets faster)

*accept frictional/upward force for drag*

1

(until) drag (force) = weight

**or**

(until) resultant force is zero

*accept upward force = downward force*

*accept till forces are balanced*

1

(c) less than

1

ball bearing increases speed at a greater rate

*accept it travels the same distance in less time*

**or**

ball bearing has a greater acceleration

*accept the ball bearing is going faster*

**or**

terminal velocity has not been reached

1

so resultant force must be greater

**or**

as weight is the same (the drag must be less)

*accept warmer oil has a lower density/viscosity for 1 mark if neither of the two reason marks score*

1

[9]

9

(a) resultant force = zero

**or**

upward force = downward force

*accept forces are balanced*

*accept weight for downward force*

1

(b) (i) 84

*allow 1 mark for correct substitution ie  $840 = m \times 10$*

2

(ii) 12

*accept 12.02 for both marks*

**or**

1010 ÷ their (b)(i) correctly calculated

*a resultant force of 1010 (N) gains 1 mark*

*an answer 22(.02) gains 1 mark*

2

m/s<sup>2</sup>

*accept m/s/s*

1

[6]

10

(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

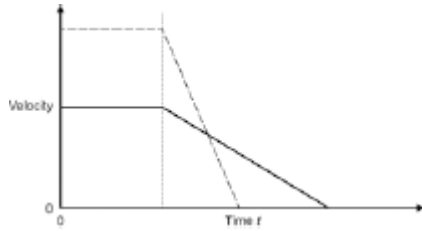
1

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.

11 (a) 3 (.0)

allow 1 mark for correct substitution i.e.  $25 \times 0.12$  provided no subsequent step

2

(b) (i) elastic potential  
correct order only

1

kinetic

1

(ii) increases

1

to 80 (mm) (or more)

accept any number greater than 75

an answer 'it (more than) doubles' gains both marks

1

(c) (i) weight

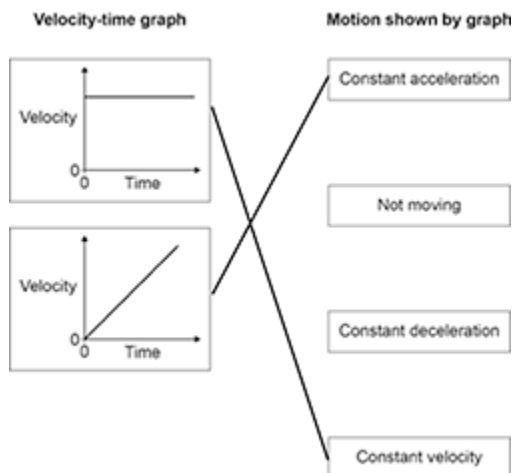
1

(ii) downward speed increases

1

[8]

12 (a)



if more than one line is drawn from a graph then all those lines are wrong allow 1 mark for 1 correct line

2

(b) speed

1

(c) (i) 2.25

*allow 1 mark for correct substitution i.e.*

$$a = \frac{9-0}{4} \text{ or } a = \frac{9}{4}$$

*provided no subsequent step*

2

(ii) the air resistance increases

1

(d) 2000 J

1

mass is half

**or**

kinetic energy depends on mass

*do not accept weight for mass*

1

[8]

13

(a) (i) distance travelled under the braking force

*accept distance travelled between applying the brakes and stopping*

1

(ii) any **one** from:

- icy / wet roads

*accept weather (conditions)*

- (worn) tyres
- road surface

*accept gradient of road*

- mass (of car and passengers)  
*accept number of passengers*
- (efficiency / condition of the) brakes.  
*friction / traction is insufficient*

1

(iii) greater the speed the greater the braking force (required)

*must mention both speed and force*

1

(b) 22.5

*allow 1 mark for showing correct use of the graph with misread figures*

**or**

*for showing e.g.  $90 \div 4$*

*an answer 17 gains 1 mark*

*any answer such as 17.4 or 17.5 scores 0*

2

- (c) (i) momentum before = momentum after  
**or**  
(total) momentum stays the same  
*accept no momentum is lost*  
*accept no momentum is gained*  
*ignore statements referring to energy*

1

- (ii) 5

*allow 2 marks for correctly obtaining momentum before as*  
*12 000*

**or**

*allow 2 marks for*  
 $1500 \times 8 = 2400 \times v$

**or**

*allow 1 mark for a relevant statement re conservation of momentum*

**or**

*allow 1 mark for momentum before =  $1500 \times 8$*

3

- (d) the seat belt stretches

1

driver takes a longer (*impact*) time to slow down and stop (than a driver hitting a hard surface / windscreen / steering wheel)

1

for the (same) change of momentum

*accept so smaller deceleration / negative acceleration*

1

a smaller force is exerted (so driver less likely to have serious injury than driver without seat belt)

**or**

the seat belt stretches (1)

*do not accept impact for force*

driver travels a greater distance while slowing down and stopping (than a driver hitting a hard surface / windscreen / steering wheel) (1)

for (same) amount of work done (1)

*accept for (same) change of KE*

a smaller force is exerted (so driver less likely to have serious injury than driver without seat belt) (1)

*do not accept impact for force*

1

[13]

|           |   |             |
|-----------|---|-------------|
| <b>14</b> | (a) (i) decreases (to zero)   | 1           |
|           | resultant force acts in opposite direction to motion<br><i>accept air resistance and weight for resultant force</i><br><i>accept resultant force acts downwards</i><br><i>do <b>not</b> accept air resistance increases</i>   | 1           |
|           | (ii) velocity includes direction<br><b>or</b><br>velocity is a vector (quantity)  | 1           |
|           | (b) (i) 3.6<br><i>allow 1 mark for correct substitution i.e.</i><br><i><math>\frac{1}{2} \times 0.05 \times 12^2</math> provided no subsequent step</i>   | 2           |
|           | (ii) 3.6 <b>or</b> their (i)  | 1           |
|           | (iii) 7.2<br><b>or</b><br>their (ii) $\div 0.5$ correctly calculated<br><i>allow 1 mark for correct substitution i.e.</i><br><i>3.6 or their (ii) = <math>0.05 \times 10 \times h</math></i>  | 2           |
|           | (iv) <b>B</b>   | 1           |
|           | (c) range increases up to $45^\circ$  | 1           |
|           | range decreases from $45^\circ$<br><i>the range is a maximum at <math>45^\circ</math> gains both marks</i><br><i>for any two angles that add up</i><br><i>to <math>90^\circ</math> the range is the same gains both marks</i><br><i>the range increases then decreases gains 1 mark</i> | 1           |
|           |   | <b>[11]</b> |

|           |   |   |
|-----------|---|---|
| <b>15</b> | (a) the forces are equal in size and act in opposite directions   | 1 |
|           | (b) (i) forwards / to the right / in the direction of the 300 N force<br><i>answers in either order</i> | 1 |
|           | accelerating  | 1 |

(ii) constant velocity to the right

1

(iii) resultant force is zero

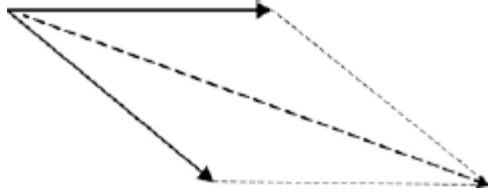
*accept forces are equal / balanced*

1

so boat continues in the same direction at the same speed

1

(iv) parallelogram or triangle is correctly drawn with resultant



3

value of resultant in the range 545 N – 595 N

*parallelogram drawn without resultant gains 1 mark*

*If no triangle or parallelogram drawn:*

*drawn resultant line is **between** the two 300 N forces gains 1 mark*

*drawn resultant line is between and longer than the two 300 N forces gains 2 marks*

1

[10]

16

(a) terminal

1

(b) 5.4 (kg)

*correct substitution of  $54 = m \times 10$  gains 1 mark*

2

(c) (i)  $0 < a < 10$

1

some upward force

*accept some drag / air resistance*

1

reduced resultant force

1

(ii) 0

1

upward force = weight (gravity)

1

resultant force zero

1

[9]

|    |     |  |   |
|----|-----|--|---|
| 17 | (a) | increases  | 1 |
|    |     | increases  | 1 |
|    | (b) | 23 (m)   |   |
|    |     | <i>accept 43 circled for 1 mark</i>                              |   |
|    |     | <i>accept 9 + 14 for 1 mark</i>                                  | 2 |
|    | (c) | (i)  |   |
|    |     | all points correctly plotted                                     |   |
|    |     | <i>all to <math>\pm \frac{1}{2}</math> small square</i>          |   |
|    |     | <i>one error = 1 mark</i>  |   |
|    |     | <i>two or more errors = 0 marks</i>                              | 2 |
|    |     | line of best fit   | 1 |
|    |     | (ii)   |   |
|    |     | correct value from their graph ( $\pm \frac{1}{2}$ small square) | 1 |
|    | (d) | (i)  |   |
|    |     | 70   |   |
|    |     | <i><math>\frac{1}{2} \times 35 \times 4</math> gains 2 marks</i> |   |
|    |     | <i>attempt to estimate area under the graph for 1 mark</i>       | 3 |
|    |     | (ii)   |   |
|    |     | line from (0.6,35)   | 1 |
|    |     | sloping downwards with a less steep line than the first line     | 1 |
|    |     | cutting time axis at time > 4.6 s                                |   |
|    |     | <i>accept cutting x-axis at 6</i>                                | 1 |
|    | (e) | (i)  |   |
|    |     | 42 000   |   |
|    |     | <i>1200 <math>\times</math> 35 gains 1 mark</i>                  | 2 |
|    |     | kgm / s  |   |
|    |     | Ns   | 1 |
|    |     | (ii)   |   |
|    |     | 10 500 (N)   |   |
|    |     | <i>42 000 / 4 gains 1 mark</i>                                   |   |
|    |     | <i>alternatively:</i>  |   |
|    |     | <i><math>a = 35 / 4 = 8.75 \text{ m / s}^2</math></i>            |   |
|    |     | <i><math>F = 1200 \times 8.75</math></i>                         | 2 |



|           |  |             |
|-----------|--|-------------|
| <b>18</b> | (a) (i) 100 (m)  | 1           |
|           | (ii) stationary  | 1           |
|           | (iii) accelerating   | 1           |
|           | (iv) tangent drawn at $t = 45$ s   | 1           |
|           | <i>attempt to determine slope</i>  | 1           |
|           | speed in the range 3.2 – 4.2 (m / s)<br><i>dependent on 1st marking point</i>  | 1           |
|           | (b) (i) 500 000 (J)<br><i>ignore negative sign</i>   | 1           |
|           | (ii) 20 000 (N)<br><i>ignore negative sign</i><br><i>allow 1 mark for correct substitution, ie</i><br>$500\,000 = F \times 25$<br><i>or their part (b)(i) = <math>F \times 25</math></i><br><i>provided no subsequent step</i> | 2           |
|           | (iii) <i>(kinetic) energy transferred by heating</i>   | 1           |
|           | to the brakes<br><i>ignore references to sound energy</i><br><i>if no other marks scored allow k.e. decreases for 1 mark</i>   | 1           |
|           |  | <b>[11]</b> |
| <b>19</b> | (a) pitch  | 1           |
|           | loudness   | 1           |
|           | (b) (i) as length (of prongs) decreases frequency / pitch increases<br><i>accept converse</i><br><i>accept negative correlation</i><br><i>ignore inversely proportional</i>  | 1           |

(ii) 8.3 (cm)  
*accept  $8.3 \pm 0.1$  cm*

1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)  
*ecf from part (ii)*

1

(so  $f$  must be) between 384 (Hz) and 480 (Hz)

1

$410 \text{ (Hz)} \leq f \leq 450 \text{ (Hz)}$   
*if only the estimated frequency given, accept for 1 mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high  
*accept frequency above 20 000 (Hz) or audible range*

1

so tuning fork **or** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)  
*accept any correct rounding 286, 290, 300*  
*allow 2 marks for 285*  
*allow 2 marks for correct substitution  $0.0035 = 1 / f$*   
*allow 1 mark for  $T = 0.0035$  s*  
*allow 1 mark for an answer of 2000*

3

[13]

**20** (a) (i) not moving

1

(ii) straight line from origin to (200,500)  
*ignore a horizontal line after (200,500)*

1

(b) 35 000  
*allow 1 mark for correct substitution, ie  $14\,000 \times 2.5$  provided no subsequent step*  
*an answer of 87 500 indicates acceleration (2.5) has been squared and so scores zero*

2

[4]

**21** (a) (i) friction

1

- (ii) air resistance
  - accept drag*
  - friction is insufficient*

- (iii) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) 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)**

There is an attempt to explain in terms of forces A and B why the velocity of the cyclist changes between any two points

**or**

a description of how the velocity changes between any two points.

**Level 2 (3–4 marks)**

There is an explanation in terms of forces A and B of how the velocity changes between X and Y and between Y and Z

**or**

a complete description of how the velocity changes from X to Z.

**or**

an explanation and description of velocity change for either X to Y or Y to Z

**Level 3 (5–6 marks)**

There is a clear explanation in terms of forces A and B of how the velocity changes between X and Z

**and**

a description of the change in velocity between X and Z.

**examples of the points made in the response**

***extra information***

**X to Y**

- at X force A is greater than force B
- cyclist accelerates
- and velocity increases
- as cyclist moves toward Y, force B (air resistance) increases (with increasing velocity)
- resultant force decreases
- cyclist continues to accelerate but at a smaller value
- so velocity continues to increase but at a lower rate

**Y to Z**

- from Y to Z force B (air resistance) increases
- acceleration decreases
- force B becomes equal to force A
- resultant force is now zero
- acceleration becomes zero
- velocity increases until...
- cyclist travels at constant / terminal velocity

*accept speed for velocity throughout*

(b) (i) 3360

*allow 1 mark for correct substitution,  
ie  $140 \times 24$  provided no subsequent step  
accept 3400 for 2 marks if correct substitution is shown*

2

joule / J

*do **not** accept j*

*do **not** accept Nm*

1

(ii) decreases

*accept an alternative word / description for decrease*

*do not accept slows down*

1

temperature

*accept thermal energy*

*accept heat*

1

**[13]**

22

- (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans  
**or**  
a (sound) wave (of frequency) above 20 000 Hz  
*sound waves that cannot be heard is insufficient*  
*a wave of frequency 20 000 Hz is insufficient*

1

- (b) 640

*an answer of 1280 gains 2 marks*

*allow 2 marks for the correct substitution*

*ie  $1600 \times 0.40$  provided no subsequent step*

*allow 2 marks for the substitution  $\frac{1600 \times 0.80}{2}$*

*provided no subsequent step*

*allow 1 mark for the substitution  $1600 \times 0.80$  provided no subsequent step*

*allow 1 mark for the identification that time (boat to bed) is 0.4*

3

- (c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

*accept heart*

*do **not** allow brain **or** lungs (either of these negates a correct answer)*

- Doppler scanning blood flow

1

- (d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution  
*clearer / better image is sufficient*
- (scan) produces a slice through the body
- image can be viewed from any direction  
*allow images are (always) 3D / 360°*
- an image can be made of any part (inside the body)  
*allow whole body can be scanned*
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are ionising  
*allow a description of what ionising is*
- mutate cells **or** cause mutations **or** increase chances of mutations  
*allow for cells:*  
*DNA / genes / chromosomes / nucleus / tissue*

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells  
*damage cells is insufficient*
- shielding is needed  
*can be dangerous (to human health) unqualified, is insufficient*

1

[7]

23

(a) (i) 20

1

20 000

*either order*

*accept ringed answers in box*

1

(ii) (frequency) above human range  
*accept pitch for frequency*

**or**

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning  
*accept any other appropriate scanning use*  
*do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle  
*accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation*  
*accept physiotherapy*  
*accept curing prostate cancer or killing prostate cancer cells*
- removing plaque from teeth  
*cleaning teeth is insufficient*

1

(b)  $7.5 \times 10^{-4}$  (m)

$1.5 \times 10^3 = 2.0 \times 10^6 \times \lambda$  gains 1 mark

2

(c) for reflected waves

*must be clear whether referring to emitted or detected / reflected waves*

*if not specified assume it refers to reflected wave*

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased

*allow amplitude / energy has decreased*

*allow the beam is weaker*

2

[8]

24

(a) (i) 9.5

*accept  $\pm 1$  mm*

1

10.5

1

(ii) 9.5

*ecf from (a)(i)*

1

(iii) 190

*20  $\times$  (a)(ii) ecf*

1

(iv) medium

*ecf from (a)(iii)*

1

(b) (i) any **two** from:

- position of ball before release
- same angle **or** height of runway
- same ball
- same strip of grass

2

(ii) long

**or**

longer than in part (a)

**or**

uneven

*do **not** allow reference to speed*

1

(c) (i) as humidity increases mean distance decreases

*accept speed for distance*

1



(ii)  $71 \times 180 = 12780$

$79 \times 162 = 12798$

$87 \times 147 = 12789$

*all three calculations correct with a valid conclusion gains 3 marks*

**or**

find  $k$  from  $R = k / d$

*all three calculations correct gains 2 marks*

**or**

$87 / 71 \times 147 = 180.1 \sim 180$

$87 / 79 \times 147 = 161.9 \sim 162$

*two calculations correct with a valid conclusion gains 2 marks*

conclusion based on calculation

*one correct calculation of  $k$  gains 1 mark*

3

(iii) only three readings **or** small range for humidity

*accept not enough readings*

*accept data from Internet could be unreliable*

*ignore reference to repeats*

1

(d) distance is a scalar **or** has no direction **or** has magnitude only

*allow measurements from diagram of distance and displacement*

1

displacement is a vector **or** has direction

1

[15]

25

(a) (i) gravitational potential (energy)

1

(ii) kinetic (energy)

1

(b) (i) slope or gradient

1

(ii) area (under graph)

*do **not** accept region*

1

(iii) starts at same y-intercept

1

steeper slope than original and cuts time axis before original

*the entire line must be below the given line*

*allow curve*

1

(c) (i) 31  
and  
31

*correct answers to 2 significant figures gains 3 marks even if no working shown*

*both values to more than 2 significant figures gains 2 marks:*

*30.952.....*

*30.769....*

*65 / 2.1 and / or*

*80 / 2.6 gains 1 mark*

*if incorrect answers given but if both are to 2 significant figures allow 1 mark*

3

(ii) student 1 incorrect because  $80 \neq 65$

1

student 2 correct because average velocities similar

*ecf from (c)(i)*

1

student 3 incorrect because times are different

1

[12]

26

(a) time

*correct order only*

1

force

1

(b) The car tyres being badly worn

1

(c) (i) braking distance increases with speed

*accept positive correlation*

*do **not** accept stopping distance for braking distance*

1

relevant further details, eg

- but not in direct proportion
- and increases more rapidly after 15 m/s  
*accept any speed between 10 and 20*  
*accept numerical example*

- double the speed, braking distance increases  $\times 4$

1

(ii) line drawn above existing line starting at the origin  
*as speed increases braking distance must increase*  
*each speed must have a single braking distance* 1

(d) (i) reaction time / reaction (of driver) does not depend on speed (of car) 1

(ii) (on the reduced speed limit roads) over the same period of time  
*accept a specific time, eg 1 year* 1

monitor number of accidents before and after (speed limit reduced)  
*allow 1 mark only for record number of vehicles / cars using the (20 mph) roads or collect data on accidents on the (20 mph) roads*  
*to score both marks the answer must refer to the roads with the reduced speed limit* 1

[9]

27

(a) (produces) a force from water on the boat 1

in the forward direction  
*accept in the opposite direction*  
*this must refer to the direction of the force not simply the boat moves forwards*  
*an answer produces an (equal and) opposite force gains 1 mark* 1

(b) (i) 1.5  
*allow 1 mark for correct substitution, ie  $\frac{16-4}{8}$  or  $\frac{12}{8}$*   
*provided no subsequent step shown*  
*ignore sign* 2

m/s<sup>2</sup> 1

(ii) 102  
**or**  
their (b)(i) × 68 correctly calculated  
*allow 1 mark for correct substitution, ie 1.5 × 68*  
**or** their (b)(i) × 68  
*provided no subsequent step shown* 2

(iii) greater than  
*reason only scores if greater than chosen* 1

need to overcome resistance forces  
*accept named resistance force*  
*accept resistance forces act (on the water skier)*  
do **not** accept gravity

1

[9]

28

(a) (i) distance vehicle travels during driver's reaction time  
*accept distance vehicle travels while driver reacts*

1

(ii) any **two** from:

- tiredness
- (drinking) alcohol
- (taking) drugs
- speed
- age

*accept as an alternative factor distractions, eg using a mobile phone*

2

(b) (i) 320 000

*allow 1 mark for correct substitution, ie  $\frac{1}{2} \times 1600 \times 20^2$  provided no subsequent step shown*

2

(ii) 320000 **or** their (b)(i)

1

(iii) 40

**or**

their (b)(ii) correctly calculated  
8000

*allow 1 mark for statement work done = KE lost*

**or**

*allow 1 mark for correct substitution, ie  
 $8000 \times \text{distance} = 320\,000$  **or** their (b)(ii)*

2

(iv) any **one** from:

- icy / wet roads  
*accept weather conditions*
- (worn) tyres
- road surface
- mass (of car and passengers)  
*accept number of passengers*
- (efficiency / condition of the) brakes

1

(v) (work done by) friction  
(between brakes and wheel)

*do **not** accept friction between road and tyres / wheels*

1

(causes) decrease in KE and increase in thermal energy

*accept heat for thermal energy accept*

*KE transferred to thermal energy*

1

(c) the battery needs recharging less often

*accept car for battery*

1

**or**

increases the range of the car

*accept less demand for other fuels **or** lower emissions **or** lower fuel costs*

*environmentally friendly is insufficient*

as the efficiency of the car is increased

*accept it is energy efficient*

1

the decrease in (kinetic) energy / work done charges the battery (up)

*accept because not all work done / (kinetic) energy is wasted*

1

[14]

29

(a) 4 N to the right

1

(b) (i) bigger than

1

equal to

1

(ii) reduces it 1  
increases air resistance / drag / force C  
*accept parachute has large(r) (surface) area*

1

[5]

30

(a) any **two** from:

- (make shape / body) more streamlined  
*accept a correct description*  
*accept lower the seating position of the driver*
- increase power of engine  
*faster engine is insufficient*
- reduce mass / weight (of go-kart)  
*change wheel size is insufficient*

2

(b) (i) A–B

*reason only scores if A–B is chosen*

1

steepest / steeper gradient / slope

1

(iii) 1820

*allow 1 mark for correct substitution, ie  $140 \times 13$  provided no subsequent step shown*

2

[6]

31

(a) gravitational / gravity / weight

*do **not** accept gravitational potential*

1

(b) accelerating

*accept speed / velocity increases*

1

the distance between the drops increases

1

but the time between the drops is the same

*accept the time between drops is (always) 5 seconds*  
*accept the drops fall at the same rate*

1

(c) (i) any **one** from:

- speed / velocity
- (condition of) brakes / road surface / tyres
- weather (conditions)  
*accept specific examples, eg wet / icy roads*  
*accept mass / weight of car friction is insufficient*  
*reference to any factor affecting thinking distance negates this answer*

1

(ii) 75 000

*allow 1 mark for correct substitution, ie  $3000 \times 25$  provided no subsequent step shown*

**or allow 1 mark for an answer 75**

**or allow 2 marks for**

*75 k(+ incorrect unit), eg 75 kN*

2

joules / J

*do **not** accept j*

*an answer 75 kJ gains **3** marks*

*for full marks the unit and numerical answer must be consistent*

1

**[8]**

**32**

(a) more streamlined

*accept decrease surface area*

1

air resistance is smaller (for same speed)

*accept drag for air resistance*

*friction is insufficient*

1

so reaches a higher speed (before resultant force is 0)

*ignore reference to mass*

1

(b) (i) 1.7

*allow 1 mark for correct method, ie  $\frac{5}{3}$*

**or allow 1 mark for an answer with more than 2 sig figs that rounds to 1.7**

**or allow 1 mark for an answer of 17**

2

(ii) 7.5  
*allow 1 mark for correct use of graph, eg  $\frac{1}{2} \times 5 \times 3$*

2

(iii) air (resistance)  
*accept wind (resistance)*  
*drag is insufficient*  
*friction is insufficient*

1

**[8]**

**33**

(a) 96 (m)

1

(b) (i) similar shape curve drawn above existing line going through (0,0)  
*allow 1 mark for any upward smooth curve or straight upward line*  
*above existing line going through (0,0)*

2

(ii) Rain on the road

1

(c) (i) all three lines correctly labelled  
*allow 1 mark for one correctly labelled*

top line – **C**  
*accept 1.2*

middle line – **B**  
*accept 0.9*

bottom line – **A**  
*accept 0.7*

2

(ii) any **two** from:

- (table has) both variables are together  
*accept tired and music as named variables*
- both (variables) could / would affect the reaction time  
*accept cannot tell which variable is affecting the drive (the most)*
- cannot tell original contribution
- need to measure one (variable) on its own  
*accept need to test each separately*
- need to control one of the variables  
*fair test is insufficient*

2

**[8]**



34

(a) D – E

*reason only scores if D – E chosen*

1

shallowest slope / gradient

*accept smallest distance in biggest time  
accept longest time to travel the same distance  
accept the line is not as steep  
accept it is a less steep line  
do **not** accept the line is not steep*

1

(b) 80 000

*allow 1 mark for correct substitution, ie 16 000 x 5 provided no subsequent step shown*

2

(c) (i) straight line starting at origin

*accept within one small square of the origin*

1

passing through t = 220 and d = 500

1

(i) 186

*accept any value between 180 and 188  
accept where their line intersects given graph line correctly read  
±4 s*

1

[7]

35

(a) (i) longer reaction time

*accept slower reactions  
do **not** accept slower reaction time unless qualified*

**or**

greater thinking distance  
*accept greater thinking time*

**or**

greater stopping distance  
*accept greater stopping time  
greater braking distance negates answer*

1

(ii) lines / slopes have the same gradient

*accept slopes are the same*

**or**

velocity decreases to zero in same time / in 2.6 seconds

*accept any time between 2.4 and 2.8*

*accept braking distances are the same*

1

(iii) 12

*accept extracting both reaction times correctly for 1 mark  
(0.6 and 1.4)*

**or**

*time = 0.8 (s) for 1 mark*

*accept  $0.8 \times 15$  for 2 marks*

*accept calculating the distance travelled by car **A** as 28.5 m*

**or**

*the distance travelled by car **B** as 40.5 m for 2 marks*

3

(b) **Z**

1

different force values give a unique / different resistance

*only scores if **Z** chosen*

*do **not** accept force and resistance are (directly) proportional*

*accept answers in terms of why either **X** or **Y** would not be best eg*

***X** – same resistance value is obtained for 2 different force values*

***Y** – all force values give the same resistance*

1

[7]

36

(a) any **two** from:

- (acceleration occurs when) the direction (of each capsule) changes
- velocity has direction
- acceleration is (rate of) change of velocity

2

(b) to(wards) the centre (of the wheel)

1

(c) the greater the radius / diameter / circumference (of the wheel) the smaller the (resultant) force (required)

*accept 'the size' for radius*

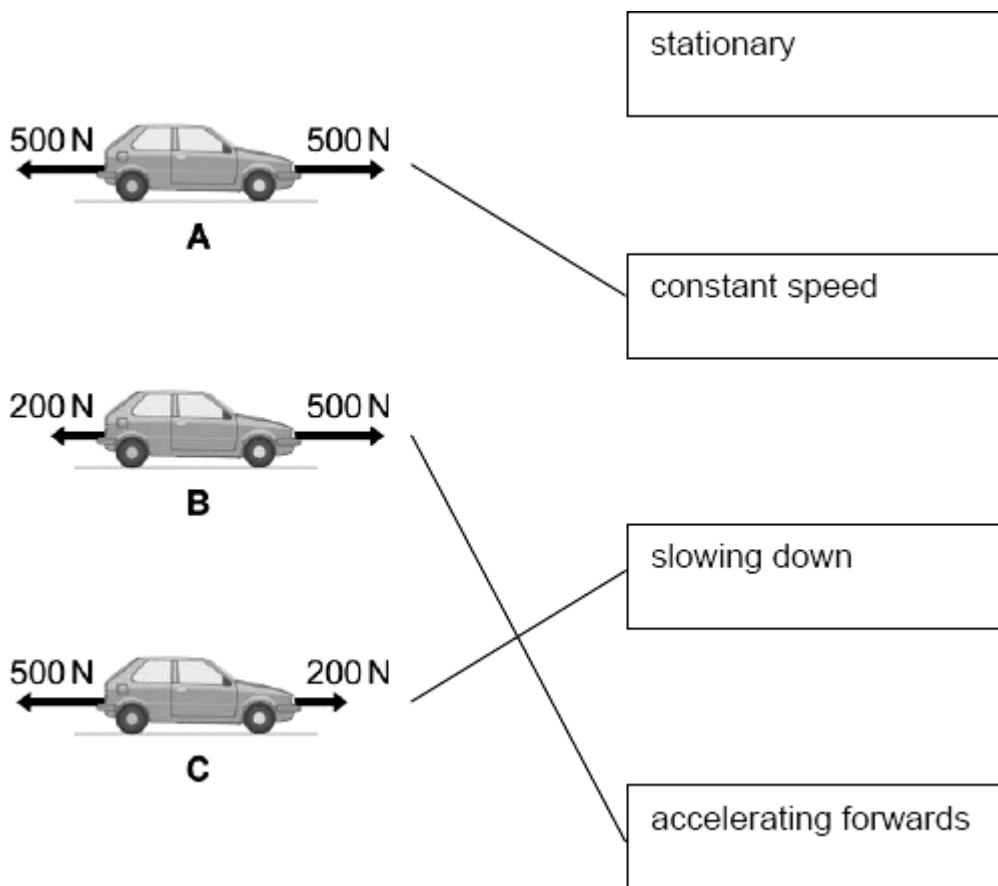
*both parts required for the mark*

1

[4]

37

- (a) 3 lines drawn  
all correct  
allow 1 mark for each correct line  
if two or more lines are drawn from any diagram then all these lines are incorrect



3

- (b) (i) horizontal arrow to the right  
*judge by eye*  
*accept an arrow drawn outside the box if it is labelled correctly*
- (ii) horizontal arrow to the left  
*judge by eye*  
*accept an arrow drawn outside the box if it is labelled correctly*
- (iii) equal to
- (iv) to measure the forces exerted on the dummy during the impact

1

1

1

1

[7]

38

- (a) A constant speed / velocity  
*accept steady pace*  
*do not accept terminal velocity*  
*do not accept stationary*

1

**B acceleration**

*accept speeding up*

1

**C deceleration**

*accept slowing down*

*accept accelerating backwards*

*accept accelerating in reverse*

*do **not** accept decelerating backwards*

1

- (b) (i) the distance the car travels under the braking force

*accept braking distance*

1

- (ii) speed/velocity/momentum

1

- (c) (i) 5000 (N) to the left

***both** required*

*accept 5000(N) with the direction indicated by an arrow drawn pointing to the left*

*accept 5000(N) in the opposite direction to the force of the car (on the barrier)*

*accept 5000(N) towards the car*

1

- (ii) to measure/detect forces exerted (on dummy / driver during the collision)

1

- (iii) 4

*allow **1** mark for showing a triangle drawn on the straight part of the graph*

***or** correct use of two pairs of coordinates*

2

$\text{m/s}^2$

*do **not** accept  $\text{mps}^2$*

1

[10]

39

- (a) 98

*allow **1** mark for correct substitution*

*ie  $\frac{1}{2} \times 0.16 \times 35 \times 35$  provided no subsequent step shown*

*an answer of 98 000 scores 0*

2

- (b) (i) 9.6

*allow **1** mark for (change in velocity =) 60*

*ignore negative sign*

2

(ii) 9600  
*ignore negative sign*  
**or**  
 their (b)(i)  $\div 0.001$  correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

1

to reduce/change momentum (to zero)  
*only scores if 1<sup>st</sup> mark scored*  
*decreases rate of change of momentum scores both marks*  
*provided there are no contradictions*  
*accept decreased acceleration/deceleration*  
*equations on their own are insufficient*

1

[7]

40

(a) (i) 3

1

(ii) 30 000 **or** 10 000  $\times$  their (a)(i) correctly calculated

1

(iii) any **two** from:

- frequency is above 20 000 (Hz)  
*accept the frequency is 30 000*
- frequency is above the upper limit of audible range
- upper limit of audible range equals 20 000 (Hz)  
*ignore reference to lower limit*
- it is ultrasound/ultrasonic

2

(b) (i) wave (partially) reflected

1

at crack to produce **A** and end of bolt to produce **B**  
*accept at both ends of the crack*

1

(ii) 0.075 (m) allow **2** marks for time = 0.0000125  
*allow 1 mark for time = 0.000025*  
*answers 0.15 **or** 0.015 **or** 0.09 gain 2 marks*  
*answers 0.18 **or** 0.03 gain 1 mark*  
*the unit is not required but if given must be consistent with*  
*numerical answer for the available marks*

3

[9]

41

(a) 750

*allow 1 mark for correct substitution, ie  $75 \times 10$  provided no subsequent step shown*

2

newton(s) / N

*do **not** accept  $n$*

1

- (b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response.  
Examiners should also refer to the Marking Guidance, and apply a 'best-fit' approach to the marking.

**0 marks**

No relevant content.

**Level 1 (1-2 marks)**

There is a brief attempt to explain why the velocity / speed of the parachutist changes.

**or**

the effect of opening the parachute on velocity/speed is given.

**Level 2 (3-4 marks)**

The change in velocity / speed is clearly explained in terms of force(s)

**or**

a reasoned argument for the open parachute producing a lower speed.

**Level 3 (5-6 marks)**

There is a clear and detailed explanation as to why the parachutist reaches terminal velocity

**and**

a reasoned argument for the open parachute producing a lower speed

**examples of the physics points made in the response to explain first terminal velocity**

- on leaving the plane the only force acting is weight (downwards)  
*accept gravity for weight throughout*
- as parachutist falls air resistance acts (upwards)  
*accept drag / friction for air resistance*
- weight greater than air resistance  
**or**  
resultant force downwards
- (resultant force downwards) so parachutist accelerates
- as velocity / speed increases so does air resistance
- terminal velocity reached when air resistance = weight  
*accept terminal velocity reached when forces are balanced*

**to explain second lower terminal velocity**

- opening parachute increases surface area
- opening parachute increases air resistance
- air resistance is greater than weight

- resultant force acts upwards / opposite direction to motion
- parachutist decelerates / slows down
- the lower velocity means a reduced air resistance

air resistance and weight become equal but at a lower (terminal) velocity

6

(c) (i) any **one** from:

- mass of the (modelling) clay  
*accept size/shape of clay size/amount/volume/shape of clay*  
*accept plasticine for (modelling)clay*
- material parachute made from  
*accept same (plastic) bag*
- number / length of strings

1

(ii) **C**

*reason only scores if C is chosen*

1

smallest (area) so falls fastest (so taking least time)

*accept quickest/quicker for fastest*

*if A is chosen with the reason given as 'the largest area so falls slowest' this gains 1 mark*

1

[12]

42

(a) **B**

*reason only scores if B is chosen*

1

gradient / slope is the steepest / steeper

*answers must be comparative*

*accept steepest line*

*ignore greatest speed*

1

(b) (velocity includes) direction

*'it' refers to velocity*

1

[3]



|           |     |  |  |            |
|-----------|-----|--|--|------------|
| <b>43</b> | (a) | 2.75   |  |            |
|           |     |  | <i>allow 1 mark for correct substitution, ie <math>\frac{11}{4}</math></i> |            |
|           |     |  | <i>or <math>\frac{23 - 12}{4}</math></i>                                   |            |
|           |     |  | <i>provided no subsequent step shown</i>                                   | 2          |
|           |     | m/s <sup>2</sup>   |  | 1          |
|           | (b) | driving force increases                                  |  | 1          |
|           |     | frictional force increases                               |  |            |
|           |     | <i>accept air resistance / drag for frictional force</i> |  | 1          |
|           |     | driving force > frictional force                         |  | 1          |
|           |     |  |  | <b>[6]</b> |
| <b>44</b> | (a) | (i)  | 12   | 1          |
|           |     | (ii)   | 0.2  |            |
|           |     |  | <i>allow 1 mark for their (a)(i) ÷ 60 and correctly calculated</i>         | 1          |
|           |     | m/s <sup>2</sup>   |  |            |
|           |     |  | <i>accept correct unit circled in list</i>                                 |            |
|           |     |  | <i>accept ms<sup>-2</sup></i>  |            |
|           |     |  | <i>do <b>not</b> accept mps<sup>2</sup></i>                                | 1          |
|           | (b) | <b>B</b>   |  | 1          |
|           |     |  |  | <b>[4]</b> |
| <b>45</b> | (a) | (i)  | 120  | 1          |
|           |     | (ii)   | 20   |            |
|           |     |  | <i>accept 140—their (a)(i) provided answer is not negative</i>             | 1          |
|           |     | (iii)  | as speed increases   | 1          |
|           |     |  | drag force / water resistance / friction / <b>D</b> increases              | 1          |

(until)  $D = 140\text{ N}$  or (until)  $D = T$   
*forces balance is insufficient*

1

(b) (i) (average) speed (of swimmer)

1

(ii) any **two** from:

- more data  
*accept results for data*  
*do **not** accept more accurate data*
- force may vary (a lot) / change
- give more reliable average  
*ignore references to anomalies*  
*ignore accurate / precise*

2

(iii) examples of acceptable responses:

- most / some females produce smaller forces  
*do **not** accept all females produce smaller forces*
- most / some males produce larger forces  
*do **not** accept all males produce larger forces*
- some females swim as fast as males but use a smaller force
- most of the faster swimmers are male  
*do **not** accept all males swim faster*
- most of the slower swimmers are female  
*do **not** accept all females swim slower*
- range of the (average) speed of males is smaller than the range of the (average) speed of females
- range of the (average) force of the males is greater than the range of the (average) force of the females

1

(iv) exert maximum (hand) force (throughout the swim / stroke)

*accept (any method to) increase (hand) force*  
*practise more is insufficient*

1

[10]

46

(a) (i) lorry

*reason only scores if lorry chosen*

1

greatest mass

*accept weight for mass*

*accept heaviest*

*accept correct calculations for all 3 vehicles*

*the biggest is insufficient*

1

(ii) 2450

*allow 1 mark for correct substitution*

*ie 175 x 14*

2

(b) (i) increases

*accept any clear indication of the correct answer*

1

(ii) speed increases

*accept velocity for speed*

*accept gets faster*

*do **not** accept it accelerates on its own*

*moves more is insufficient*

1

(iii) straight line going to 6, 20

*allow 1 mark for a curve going to 6,20*

***or** a straight line diagonally upwards but missing 6,20*

2

horizontal line from 6,20 to 8,20

*allow a horizontal line from where their **diagonal** meets 20m/s to 8,20*

1

[9]

47

(a) The driver has been drinking alcohol.

*reason only scores if this box is ticked*

1

driver's reaction time increases

*accept slower reactions*

*accept slower reaction time*

**or**

thinking distance / stopping distance increases

*do not accept braking distance increases*

**or**

driver less alert

*accept driver may fall asleep / be tired*

1

- (b) they are all variables that could affect outcome / results  
*accept specific effect of changing one of the variables*  
*accept to make the test valid*  
*ignore reliable*

1

so data / barriers can be compared  
*accept to see which is / works best / safest*  
*do **not** accept fair test on its own*

1

- (c) ticks in both the top and middle boxes

1

[5]

48

- (a) 48

*allow for 1 mark correct method shown, ie  $6 \times 8$*   
***or** correct area indicated on the graph*

2

- (b) diagonal line from (0,0) to (6,48) / (6, their (a))  
*if answer to (a) is greater than 50, scale must be changed to gain this mark*

1

horizontal line at 48m between 6 and 10 seconds  
*accept horizontal line drawn at their (a) between 6 and 10 seconds*

1

[4]

49

- (a) 4.2

*2 marks for correct substitution **and** transformation, ie  $1155/275$*   
*allow 1 mark for correct resultant force with a subsequent incorrect method, ie 1155*  
*allow 1 mark for an incorrect resultant force with a subsequent correct method,*  
*eg answers of 7.27 or 10.34 gain 1 mark*

3

(b) (i) YES

*marks are for the explanation*

any **two** from:

- data (from police files) can be trusted
- data answers the question asked  
*allow a conclusion can be made from the data*
- large sample used

NO

any **two** from:

- the sample is not representative
- the sample size is too small
- accident files do not indicate age / experience of riders  
*an answer YES and NO can score 1 mark from each set of mark points*

2

(ii) more accidents with motorbikes up to 125 cc

*accept for 2 marks an answer in terms of number of under 125 cc to accidents ratio compared correctly with number of over 500 cc to accidents ratio*

1

even though there are fewer of these bikes than bikes over 500 cc

1

(c) (i) increases the time taken to stop

*accept increases collision time*

1

decreases rate of change in momentum

*accept reduces acceleration / deceleration*

*accept  $F = \frac{\Delta mv}{\Delta t}$*

*reduces momentum is insufficient*

1

reduces the force (on the rider)

1

(ii) YES

any sensible reason, eg:

*the mark is for the reason*

- cannot put a price on life / injury  
*accept may save lives*
- fewer (serious) injuries  
*accept reduces risk of injury*
- reduces cost of health care / compensation

NO

any sensible suggestion, eg:

- money better spent on ...  
*needs to be specific*
- total number of riders involved is small

1

[11]

50

(a) 96

*allow 1 mark for correct substitution  
ie  $80 \times 1.2$*

2

newton or N

*allow Newton  
do **not** allow n*

1

(b) (i) direction

1

(ii) velocity and time are continuous (variables)

*answers must refer to both variables  
accept the variables are continuous / not categoric  
accept the data / 'it' is continuous  
accept the data / 'it' is not categoric*

1

(iii) C

1

velocity is not changing

*the 2 marks for reason may be scored even if A or B are chosen*

*accept speed for velocity*

*accept speed is constant (9 m/s)*

*accept **not** decelerating*

*accept **not** accelerating*

*accept reached terminal velocity*

1

forces must be balanced

*accept forces are equal*

*accept arrows are the same length / size*

**or**

resultant force is zero

*do **not** accept the arrows are equal*

1

[8]

51

(a) distance travelled under the braking force

*accept braking (distance)*

1

(b) (directly) proportional

*accept a correct description using figures*

**or**

increase in the same ratio

*eg if speed doubles then*

*thinking distance doubles*

*accept for 1 mark positive correlation*

*accept for 1 mark as speed*

*increases so does thinking distance*

*accept as one increases the other increases*

*accept as thinking distance increases speed increases*

2

(c) (i) control variable

1

(ii) experiment done, student listens to music / ipod (etc)

1

experiment (repeated), student not listening to music

*for both marks to be awarded there must be a comparison*

1

(d) increase it

*accept an answer which implies reactions are slower*

*do **not** accept answers in terms of thinking distance only*

1

(e) Y

1

[8]

52

(a) (i) longer reaction time

*accept slower reactions*

*do not accept slower reaction time unless qualified*

**or**

greater thinking distance

*accept greater thinking time*

**or**

greater stopping distance

*accept greater stopping time*

*greater braking distance negates answer*

1

(ii) lines / slopes have the same gradient

*accept slopes are the same*

**or**

velocity decreases to zero in same time / in 2.6 seconds

*accept any time between 2.3 and 2.8*

*accept braking distances are the same*

1

(iii) 12

*accept extracting both reaction times correctly for 1 mark*

*(0.6 and 1.4 ) or time = 0.8(s) for 1 mark*

*accept  $0.8 \times 15$  for 2 marks*

*accept calculating the distance*

*travelled by car A as 28.5 m or the distance travelled by car B as 40.5 m for 2 marks*

3

(b) Z

1

different force values give a unique / different resistance

*only scores if Z chosen*

*do not accept force and resistance are (directly) proportional*

*accept answers in terms of why*

*either X or Y would not be the best eg*

*X – same resistance value is obtained for 2 different force values*

*Y – all force values give the same resistance*

1

[7]

53

(a) (i) 4.5

*allow 1 mark for correct substitution i.e.  $9 \div 2$*

2



- (ii)  $m/s^2$   
*accept answer given in (a)(i) if not contradicted here* 1
- (iii) speed 1
- (iv) straight line from the origin passing through (2s, 9m/s)  
*allow 1 mark for straight line from the origin passing through to  $t = 2$  seconds*  
*allow 1 mark for an attempt to draw a straight line from the origin passing through (2,9)*  
*allow 1 mark for a minimum of 3 points plotted with no line provided if joined up would give correct answer. Points must include(0,0) and (2,9)* 2
- (b) (i) **B**  
*if A or C given scores 0 marks in total* 1
- smallest (impact) force 1
- on all/ every/ any surfaces  
*these marks are awarded for comparative answers* 1
- (ii) (conditions) can be repeated
- or**
- difficult to measure forces with human athletes  
*accept answers in terms of variations in human athletes e.g.*  
*athletes may have different weights area / size of feet may be different difficult to measure forces athletes run at different speeds*  
*accept any answer that states or implies that with humans the conditions needed to repeat tests may not be constant*  
 e.g.  
*athletes unable to maintain constant speed during tests (or during repeat tests)*  
*do **not** accept the robots are more accurate*  
*removes human error is insufficient*  
*fair test is insufficient* 1

[10]

54

(a) shallowest slope/ gradient  
*accept smallest distance in biggest time*  
*accept longest time to travel the same distance*  
*accept the line is not as steep*  
*accept it is a less steep line*  
*do **not** accept the line is not steep* 1

(b) **A – B**  
*If 2 or 3 boxes are ticked no mark* 1

(c) (i) 200 m 1

(ii) 20 s  
*allow 1 mark for correctly identifying 60 s or 40 s from the graph* 2

(d) (i) straight line starting at origin  
*accept within one small square of the origin* 1

passing through t = 200 and d = 500 1

(ii) 166  
*accept any value between 162 and 168*  
*accept where their line intersects*  
*given graph line correctly read ± 3 s* 1

[8]

55

(i) the thicker the tile, the greater the(fall) height  
*accept the higher (the fall) the thicker the tile*  
*accept there is a positive correlation*  
*do **not** accept they are proportional* 1

(ii) 60 (mm)

*accept any number or range between 60 and 85 inclusive  
if units are given must match range*

1

(minimum thickness) needed to reduce risk of injury

*reason must match thickness choice  
do **not** accept to keep child safe*

*accept an answer in terms of – the thicker the tile, the less chance  
there is of a serious injury if the answer given is greater than 60*

*accept answers in terms of use of graph e.g. the graph shows that  
for a 2m fall a thickness of 60 mm is needed*

*minimum level answer' the graph shows that's what's needed'  
accept only if 60 is the answer*

1

[3]

56

(a) gravity

*accept weight  
do **not** accept mass  
accept gravitational pull*

1

(b) (i) Initially force L greater than force M

*accept there is a resultant force downwards*

1

(as speed increases) force M increases

*accept the resultant force decreases*

1

when  $M = L$ , (speed is constant)

*accept resultant force is 0*

*accept gravity/weighty for L*

*accept drag/ upthrust/resistance/friction for M*

*do **not** accept air resistance for M but penalise only once*

1

(ii) terminal velocity

1

(iii) 0.15

*accept an answer between 0.14 – 0.16*

*an answer of 0.1 gains no credit*

*allow 1 mark for showing correct use of the graph*

2

[7]

57

(a) (i) same frequency / period / pitch / wavelength

*ignore references to amplitude*

1

(ii) differences in waveform / shape / quality  
*accept the diagrams are not identical* 1

(b) (i) 20 000 Hz / hertz  
**or** 20 kHz / kilohertz  
*in both cases, if the **symbol** rather than the name is used, it must be correct in every detail* 1

(ii) material(s) / substance(s) (through which sound travels) 1

(iii) is absorbed  
*accept (some) sound (energy) is transformed / transferred as heat / thermal energy* 1

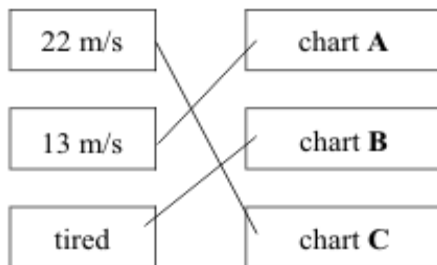
is transmitted  
*accept is refracted*  
*accept changes speed*  
*accept changes velocity*  
*do **not** accept is diffracted*  
*do **not** accept is diffused*  
*do **not** accept is dissipated* 1

[6]

58

(a) (i) constant 1  
(ii) heat 1

(b) (i) 3 links correct



*allow 1 mark for 1 correct link*  
*if more than one line is drawn from a condition mark all lines from that condition incorrect* 2

(ii) increased 1

[5]

- 59** (a) (i) a single force that has the same effect as all the forces combined  
*accept all the forces added / the sum of the forces / overall force* 1
- (ii) constant speed (in a straight line)  
*do not accept stationary*
- or** constant velocity 1
- (b) 3
- allow 1 mark for correct substitution into transformed equation*  
*accept answer 0.003 gains 1 mark*  
*answer = 0.75 gains 1 mark* 2
- m/s<sup>2</sup> 1
- (c) as speed increases air resistance increases  
*accept drag / friction for air resistance* 1
- reducing the resultant force 1
- [7]**
- 60** (a) (i) velocity includes direction  
*accept velocity is a vector* 1
- (ii) 64
- allow 1 mark for obtaining values of 16 and 4 from the graph*  
*or marking correct area or correct attempt to calculate an area* 2
- (iii) any **two** from:
- velocity zero from 0 to 4 seconds
  - increasing in 0.2 s (or very rapidly) to 8 m/s
  - decreasing to zero over the next 8 seconds
- 2
- (iv) momentum before does not equal momentum after  
*ignore reference to energy*
- or** total momentum changes
- or** an external force was applied 1

(b) to reduce the momentum of the driver

1

a smaller (constant) force would be needed

*do **not** accept reduces the impact / impulse on the driver*

1

**[8]**