

Q1.

|       |      |   |     |
|-------|------|---|-----|
| 2 (a) | (i)  | distance from a (fixed) point.....M1<br>in a specified direction ..... A1<br>(Allow 1 mark for 'distance in a given direction')   |     |
|       | (ii) | (displacement from start is zero if) car at its starting position..... B1   | [3] |
| (b)   | (i)1 | $v^2 = u^2 + 2as$<br>$28^2 = 2 \times a \times 450$ (use of component of 450 scores no marks)..... C1<br>$a = 0.87 \text{ m s}^{-2}$ ..... A1<br>(-1 for 1 sig. fig. but once only in the question) | [2] |
|       | (i)2 | $v = u + at$ or any appropriate equation<br>$28 = 0.87t$ or appropriate substitution..... C1<br>$t = 32 \text{ s}$ ..... A1   | [2] |

Q2.

|       |      |  |                |     |
|-------|------|--|----------------|-----|
| 3 (a) | (i)  | scatter of points (about the line)   | B1             |     |
|       | (ii) | intercept (on $t^2$ axis)<br>(note that answers must relate to the graph)  | B1             | [2] |
| (b)   | (i)  | gradient = $\Delta y / \Delta x = (100 - 0) / (10.0 - 0.6)$<br>gradient = $10.6 \text{ (cm s}^{-2}\text{)}$ (allow $\pm 0.2$ )<br><br>(Read points to within $\pm \frac{1}{2}$ square. Allow 1 mark for $11 \text{ cm s}^{-2}$<br>i.e. 2 sig fig, -1. Answer of 10 scores 0/2 marks) | C1<br>A1       | [2] |
|       | (ii) | $s = ut + \frac{1}{2}at^2$<br>so acceleration = 2 x gradient<br>acceleration = $0.212 \text{ m s}^{-2}$  | B1<br>B1<br>B1 | [3] |
|       |      |  | <b>Total</b>   | [7] |

Q3.

|     |      |  |    |     |
|-----|------|--|----|-----|
| (c) | (i)  | horizontal velocity = $18 \text{ m s}^{-1}$  | B1 | [1] |
| (d) | (i)  | correct shape of diagram<br>(two sides of right-angled triangle with correct orientation)  | B1 |     |
|     | (ii) | angle = $41^\circ \rightarrow 48^\circ$ (allow trig. solution based on diagram)<br>(for angle $38^\circ \rightarrow 41^\circ$ or $48^\circ \rightarrow 51^\circ$ , allow 1 mark) | A2 | [3] |

Q4.

- 2 (a) 2.4s ..... A1 [1]
- (b) in (b) and (c), allow answers as (+) or (-)  
 recognises distance travelled as area under graph line ..... C1  
 height =  $(\frac{1}{2} \times 2.4 \times 9.0) - (\frac{1}{2} \times 1.6 \times 6.0)$  ..... C1  
 = 6.0 m (allow 6 m) ..... A1 [3]  
 (answer 15.6 scores 2 marks  
 answer 10.8 or 4.8 scores 1 mark)
- alternative solution:  $s = ut - \frac{1}{2}at^2$   
 $= (9 \times 4) - \frac{1}{2} \times (9 / 2.4) \times 4^2$   
 $= 6.0$  m  
 (answer 66 scores 2 marks  
 answer 36 or 30 scores 1 mark)

Q5.

- 2 (a) scalar ..... B1  
 scalar ..... B1  
 vector ..... B1 [3]
- (b) (i) 1 gradient (of graph) is the speed/velocity (can be scored here or in 2)..... B1  
 initial gradient is zero ..... B1 [2]
- 2 gradient (of line/graph) becomes constant ..... B1 [1]
- (ii) speed =  $(2.8 \pm 0.1) \text{ m s}^{-1}$  ..... A2 [2]  
 (if answer  $> \pm 0.1$  but  $\leq \pm 0.2$ , then award 1 mark)
- (iii) curved line never below given line and starts from zero ..... B1  
 continuous curve with increasing gradient ..... B1  
 line never vertical or straight ..... B1 [3]

Q6.

- 2 (a) e.g. initial speed is zero  
 constant acceleration  
 straight line motion  
 (any two, one mark each) .....B2 [2]
- (b) (i)  $s = \frac{1}{2}at^2$   
 $0.79 = \frac{1}{2} \times 9.8 \times t^2$  ..... C1  
 $t = 0.40$  s allow 1 SF or greater ..... A1  
 2 or 3 SF answer ..... A1 [3]
- (ii) distance travelled by end of time interval = 90 cm ..... C1  
 $0.90 = \frac{1}{2} \times 9.8 \times t^2$   
 $t = 0.43$  s allow 2 SF or greater ..... C1  
 time interval = 0.03 s ..... A1 [3]
- (c) (air resistance) means ball's speed/acceleration is less ..... M1  
 length of image is shorter ..... A1 [2]

**Q7.**

- 3 (a)** evidence of use of area below the line  
 distance = 39 m (*allow  $\pm 0.5$  m*)  
*(if  $> \pm 0.5$  m but  $\leq 1.0$  m, then allow 1 mark)* B1  
A2 [3]

**Q8.**

- 1 (a)** scalar has only magnitude  
 vector has magnitude and direction B1  
B1 [2]

- (b)** kinetic energy, mass, power all three underlined B1 [1]

- (c) (i)**  $s = ut + \frac{1}{2} at^2$   
 $15 = 0.5 \times 9.81 \times t^2$   
 $T = 1.7$  s C1  
A1 [2]

if  $g = 10$  is used then  $-1$  but only once on paper

- (ii)** vertical component  $v_v$ :  
 $v_v^2 = u^2 + 2as = 0 + 2 \times 9.81 \times 15$  or  $v_v = u + at = 9.81 \times 1.7(5)$   
 $v_v = 17.16$   
 resultant velocity:  $v^2 = (17.16)^2 + (20)^2$   
 $v = 26 \text{ m s}^{-1}$  C1  
C1  
A1 [3]

If  $u = 20$  is used instead of  $u = 0$  then 0/3  
 Allow the solution using:  
 initial (potential energy + kinetic energy) = final kinetic energy

- (iii)** distance is the actual path travelled B1  
 displacement is the straight line distance between start and finish points (in that direction) / minimum distance B1 [2]

**Q9.**

- 2 (a) (i) base units of  $D$ :  
 force:  $\text{kg m s}^{-2}$  B1  
 radius: m velocity:  $\text{ms}^{-1}$  B1
- base units of  $D$ :  $[F / (R \times v)] \text{ kg m s}^{-2} / (\text{m} \times \text{m s}^{-1})$  M1  
 $= \text{kg m}^{-1} \text{ s}^{-1}$  A0 [3]
- (ii) 1.  $F = 6\pi \times D \times R \times v = [6\pi \times 6.6 \times 10^{-4} \times 1.5 \times 10^{-3} \times 3.7]$   
 $= 6.9 \times 10^{-5} \text{ N}$  A1 [1]
2.  $mg - F = ma$  hence  $a = g - [F / m]$   
 $m = \rho \times V = \rho \times 4/3 \pi R^3 = (1.4 \times 10^{-5})$  C1  
 $a = 9.81 - [6.9 \times 10^{-5}] / \rho \times 4/3 \pi \times (1.5 \times 10^{-3})^3$  (9.81 - 4.88) M1  
 $a = 4.9(3) \text{ ms}^{-2}$  A1 [3]
- (b) (i)  $a = g$  at time  $t = 0$  B1  
 $a$  decreases (as time increases) B1  
 $a$  goes to zero B1 [3]
- (ii) Correct shape below original line M1  
 sketch goes to terminal velocity earlier A1 [2]

Q10.

- 2 (a) (i)  $v = u + at$  C1  
 $= 4.23 + 9.81 \times 1.51$  M1  
 $= 19.0(4) \text{ ms}^{-1}$  (Allow 2 s.f.) A0 [2]  
 (Use of  $-g$  max 1/2. Use of  $g = 10$  max 1/2. Allow use of 9.8. Allow  $19 \text{ ms}^{-1}$ )
- (ii) either  $s = ut + \frac{1}{2} at^2$  (or  $v^2 = u^2 + 2as$  etc.)  
 $= 4.23 \times 1.51 + 0.5 \times 9.81 \times (1.51)^2$  C1  
 $= 17.6 \text{ m}$  (or  $17.5 \text{ m}$ ) A1 [2]  
 (Use of  $-g$  here wrong physics (0/2))

Q11.

- 2 (a) (i)  $v^2 = u^2 + 2as$   
 $= (8.4)^2 + 2 \times 9.81 \times 5$  C1  
 $= 12.99 \text{ ms}^{-1}$  (allow 13 to 2 s.f. but not 12.9) A1 [2]
- (ii)  $t = (v - u) / a$  or  $s = ut + \frac{1}{2} at^2$   
 $= (12.99 - 8.4) / 9.81$  or  $5 = 8.4t + \frac{1}{2} \times 9.81t^2$  M1  
 $t = 0.468 \text{ s}$  A0 [1]
- (b) reasonable shape M1  
 suitable scale A1  
 correctly plotted 1<sup>st</sup> and last points at (0,8.4) and (0.88 - 0.96,0)  
 with non-vertical line at 0.47 s A1 [3]

Q12.

- 2 (a) (i) 1. distance of path / along line AB B1 [1]
2. shortest distance between AB / distance in straight line between AB or displacement from A to B B1 [1]
- (ii) acceleration = rate of change of velocity A1 [1]
- (b) (i) distance = area under line or  $(v/2)t$  or  $s = (8.8)^2 / (2 \times 9.81)$  C1  
 $= 8.8 / 2 \times 0.90 = 3.96 \text{ m}$  or  $s = 3.95 \text{ m} = 4(.0) \text{ m}$  A1 [2]
- (ii) acceleration =  $(-4.4 - 8.8) / 0.50$  C1  
 $= (-) 26(.4) \text{ m s}^{-2}$  A1 [2]
- (c) (i) the accelerations are constant as straight lines B1
- the accelerations are the same as same gradient or  
 no air resistance as acceleration is constant or  
 change of speed in opposite directions (one speeds up one slows down) B1 [2]
- (ii) area under the lines represents height  
 or KE at trampoline equals PE at maximum height B1
- second area is smaller / velocity after rebound smaller hence KE less B1
- hence less height means loss in potential energy A0 [2]

Q13.

- 3 (a)  $v^2 = u^2 + 2as$  OR use of triangle etc ..... C1  
 $4.0^2 = 2 \times 9.8 \times s$  OR  $s = \frac{1}{2} \times 4.0 \times 0.4$   
 $s = 0.82 \text{ m}$  OR  $0.80 \text{ m}$  ..... A1 [2]
- (b)  $\Delta p = m(v - u)$  OR  $p = mv$  ..... C1  
 speeds are  $4.2 \text{ m s}^{-1}$  and  $3.6 \text{ m s}^{-1}$  ..... C1  
 $\Delta p = 0.045 (4.2 + 3.6)$  (2/4 only if speeds not added) ..... C1  
 $= 0.35 \text{ N s}$  ..... A1 [4]  
 (1 mark only if only one speed used)
- (c) any time between 0.14 s and 0.17 s ..... C1  
 force =  $\Delta p / \Delta t = 0.35 / 0.14$  (allow e.c.f.)  
 $= 2.5 \text{ N}$  ..... A1 [2]

Q14.

- 1 (a) (i) acceleration (allow a definition of acceleration)..... B1
- (ii) the velocity is decreasing or force/acceleration is in negative direction – accept 'body is decelerating'/'slowing down' ..... B1 [2]
- (b) (i) e.g. separation of dots becomes constant/does not continue to increase (must make a reference to the diagram) ..... B1
- (ii)1 distance = 132 cm..... B1
- (ii)2 at constant speed, distance travelled in 0.1 s = 25 cm (allow  $\pm 1$  cm)..... C1  
 distance = 132 + (4 x 25)  
 = 232 cm ..... A1 [4]
- (c)  $s = ut + \frac{1}{2}at^2$   
 $1.6 = \frac{1}{2} \times 9.8 \times t^2$  (allow  $g = 10 \text{ m s}^{-2}$  ..... C1  
 $t = 0.57 \text{ s}$  ..... C1  
 hence 6 photographs ('bald' answer scores 2 marks only)..... A1 [3]

Q15.

- 3 (a) constant gradient/straight line B1 [1]
- (b) (i) 1.2 s A1
- (ii) 4.4 s A1 [2]
- (c) either use of area under line or  $h = \text{average speed} \times \text{time}$  C1
- $h = \frac{1}{2} \times (4.4 - 1.2) \times 32$  C1
- $= 51.2 \text{ m}$  A1 [3]
- (allow 2/3 marks for determination of  $h = 44 \text{ m}$  or  $h = 58.4 \text{ m}$   
 allow 1/3 marks for answer 7.2 m)
- (d)  $\Delta p = m\Delta v$  OR  $p = mv$  C1
- $= 0.25 \times (28 + 12)$  C1
- $= 10 \text{ N s}$  A1 [3]
- (answer 4 N s scores 2/3 marks)

- 3 (e) (i)** total/sum momentum before = total/sum momentum after **B1**  
in any closed system **B1 [2]**
- (ii)** *either* the system is the ball and Earth **B1**  
momentum of Earth changes by same amount **B1**  
but in the opposite direction **B1**
- or* Ball is not an isolated system/there is a force on the ball (B1)  
Gravitational force acts on the ball (B1)  
causes change in momentum/law does not apply here (B1) **[3]**  
*(if explains in terms of air resistance, allow first mark only)*

**Q16.**

- 3 (a)** change in velocity/time (taken) **B1 [1]**
- (b)** velocity is a vector/velocity has magnitude & direction **B1**  
direction changing so must be accelerating **B1 [2]**

**Q17.**

- 4 (a) (i)** use of tangent at time  $t = 0$  **B1**  
acceleration =  $42 \pm 4 \text{ cm s}^{-2}$  **A1 [2]**
- (ii)** use of area of loop **B1**  
distance =  $0.031 \pm 0.001 \text{ m}$  **B2 [3]**  
allow 1 mark if  $0.031 \pm 0.002 \text{ m}$

**Q18.**

- 2 (a)** uses a tangent (anywhere), not a single point **C1**  
draws tangent at correct position **B1**  
acceleration =  $1.7 \pm 0.1$  **A2 [4]**  
*(outside 1.6 → 1.8 but within 1.5 → 1.9, allow 1 mark)*
- (b) (i)** because slope (of tangent of graph) is decreasing **M1**  
acceleration is decreasing **A1 [2]**
- (ii)** e.g. air resistance increases (with speed) **B1 [1]**  
(angle of) slope of ramp decreases
- (c) (i)** scatter of points about line **B1 [1]**  
**(ii)** intercept / line does not go through origin **B1 [1]**

**Q19.**

- 2 (a) 3.5 T B1 [1]
- (b) (i) distance = average speed  $\times$  time (however expressed)  
= 14 m C1  
A1 [2]
- (ii) distance =  $5.6 \times (T - 5)$  (or  $3.5T - 14$ ) A1 [1]
- (c)  $3.5T = 14 + 5.6(T - 5)$  C1  
 $T = 6.7$  s A1 [2]
- (d) (i) acceleration =  $(5.6 / 5) = 1.12$  m s<sup>-2</sup> C1  
force =  $ma$  C1  
= 75 N A1 [3]
- (ii) power = (force  $\times$  speed) =  $\{75 + 23\} \times 4.5$  C1  
= 440 W A1 [2]  
(allow 1/2 for 234 W, 0/2 for 338 W or 104 W)

Q20.

- 2 (a) (i)  $v^2 = 2as$   
 $v^2 = 2 \times 0.85 \times 9.8 \times 12.8$  C1  
 $v = 14.6$  m s<sup>-1</sup> A1 [2]
- (ii) time =  $29.3 / 14.6$  C1  
= 2.0 s A1 [2]  
(any acceleration scores 0 marks; allow 1 s.f.)
- (b) either  $60$  km h<sup>-1</sup> =  $16.7$  m s<sup>-1</sup>  
or  $14.6$  m s<sup>-1</sup> =  $53$  km h<sup>-1</sup>  
or  $22.1$  m s<sup>-1</sup> =  $79.6$  km h<sup>-1</sup> M1  
so driving within speed limit A1  
but reaction time is too long / too slow B1 [3]

Q21.



- 2 (a) (i) (air) resistance increases with speed .....M1  
 resultant / accelerating force decreases ..... A1 [2]
- (ii) either (air) resistance is zero  
 or weight / gravitational force is only force ..... B1 [1]
- (b) use of gradient of a tangent .....M1  
 acceleration =  $1.9 \pm 0.2 \text{ m s}^{-2}$  ..... A2 [3]  
 (for values  $> \pm 0.2$  but  $\leq 0.4$ , allow 1 mark)  
 (answer  $3.3 \text{ m s}^{-2}$  scores no marks)
- (c) (i) 1 weight =  $90 \times 9.8 = 880 \text{ N}$  ..... A1 [1]  
 (use of  $g = 10 \text{ m s}^{-2}$  then deduct mark but once only in the Paper)  
 2 accelerating force =  $90 \times 1.9 = 170 \text{ N}$  ...(allow ecf) ..... A1 [1]
- (ii) resistive force =  $880 - 170 = 710 \text{ N}$  ..... A1 [1]  
 (allow ecf but only if resistive force remains positive)

[Total: 9]

Q22.

- 3 (a) (i) speed =  $4.0 \text{ m s}^{-1}$  ...(allow 1 s.f.) ..... A1 [1]
- (ii)  $v^2 = 2gh$   
 $= 2 \times 9.8 \times 1.96$  .....M1  
 $v = 6.2 \text{ m s}^{-1}$  ..... A0 [1]  
 (use of  $g = 10 \text{ m s}^{-2}$  loses the mark)
- (b) correct basic shape with correct directions for vectors .....M1  
 speed =  $(7.4 \pm 0.2) \text{ m s}^{-1}$  ..... A1  
 at  $(33 \pm 2)^\circ$  to the vertical ..... A1 [3]  
 (for credit to be awarded, speed and angle must be correct on the diagram – not calculated)
- (c) (i) either  $v^2 = 2 \times 9.8 \times 0.98$  or  $v = 6.2 / \sqrt{2}$  ..... C1  
 speed =  $4.4 \text{ m s}^{-1}$  ..... A1 [2]  
 (allow calculation of  $t = 0.447 \text{ s}$ , then  $v = 4.4 \text{ m s}^{-1}$ )
- (ii) 1 momentum =  $mv$  ..... C1  
 change in momentum =  $0.034 (6.2 + 4.4)$  ..... C1  
 $= 0.36 \text{ kg m s}^{-1}$  ..... A1 [3]  
 (use of  $0.034 (6.2 - 4.4)$  loses last two marks)  
 2 force =  $\Delta p / \Delta t$  .....(however expressed) ..... C1  
 $= \frac{0.36}{0.12}$   
 $= 3.0 \text{ N}$  .....(allow 1 s.f.) ..... A1 [2]

[Total: 12]

Q23.

- 2 (a) (i) horizontal speed constant at  $8.2 \text{ m s}^{-1}$   
 vertical component of speed =  $8.2 \tan 60^\circ$   
 =  $14.2 \text{ m s}^{-1}$  C1  
 M1  
 A0 [2]
- (ii)  $14.2^2 = 2 \times 9.8 \times h$  (using  $g = 10$  then  $-1$ ) C1  
 vertical distance =  $10.3 \text{ m}$  A1 [2]
- (iii) time of descent =  $14.2 / 9.8 = 1.45 \text{ s}$  C1  
 $x = 1.45 \times 8.2$   
 =  $11.9 \text{ m}$  A1 [2]
- (b) (i) smooth path curved and above given path  
 hits ground at more acute angle M1  
 A1 [2]
- (ii) smooth path curved and below given path  
 hits ground at steeper angle M1  
 A1 [2]

Q24.

- 2 (a) (i)  $V_H = 12.4 \cos 36^\circ (= 10.0 \text{ m s}^{-1})$  C1  
 distance =  $10.0 \times 0.17$   
 =  $1.7 \text{ m}$  A1 [2]
- (ii)  $V_V = 12.4 \sin 36^\circ (= 7.29 \text{ m s}^{-1})$  C1  
 $h = 7.29 \times 0.17 - \frac{1}{2} \times 9.81 \times 0.17^2$  C1  
 =  $1.1 \text{ m}$  A1 [3]
- (b) smooth curve with ball hitting wall below original B1  
 smooth curve showing rebound to ground with correct reflection at wall B1 [2]

Q25.

- 4 (a) acceptable straight line drawn (touching every point) B1 [1]
- (b) the distance fallen is not  $d$  C1  
 $d$  is the distance fallen plus the diameter of the ball A1 [2]  
 (' $d$  is not measured to the bottom of the ball' scores 2/2)
- (c) (i) diameter: allow  $1.5 \pm 0.5 \text{ cm}$  (accept one SF) A1 [1]  
 no ecf from (a)
- (ii) gradient =  $4.76, \pm 0.1$  with evidence that origin has not been used C1  
 gradient =  $g / 2$  C1  
 $g = 9.5 \text{ m s}^{-2}$  A1 [3]

Q26.

- 3 (a) (i)** horizontal velocity =  $15 \cos 60^\circ = 7.5 \text{ m s}^{-1}$  A1 [1]
- (ii)** vertical velocity =  $15 \sin 60^\circ = 13 \text{ m s}^{-1}$  A1 [1]
- (b) (i)**  $v^2 = u^2 + 2as$   
 $s = (13)^2 / (2 \times 9.81) = 8.6(1) \text{ m}$   
 using  $g = 10$  then max. 1 A1 [1]
- (ii)**  $t = 13 / 9.81 = 1.326 \text{ s}$  or  $t = 9.95 / 7.5 = 1.327 \text{ s}$  A1 [1]
- (iii)** velocity =  $6.15 / 1.33$   
 $= 4.6 \text{ m s}^{-1}$  M1  
 A0 [1]
- (c) (i)** change in momentum =  $60 \times 10^{-3} [-4.6 - 7.5]$  C1  
 $= (-)0.73 \text{ N s}$  A1 [2]
- (ii)** final velocity / kinetic energy is less after the collision or  
 relative speed of separation < relative speed of approach  
 hence inelastic M1  
 A0 [1]

**Q27.**

- 1 (a)** average velocity =  $540 / 30$  C1  
 $= 18 \text{ m s}^{-1}$  A1 [2]
- (b)** velocity zero at time  $t = 0$  B1  
 positive value and horizontal line for time  $t = 5 \text{ s}$  to  $35 \text{ s}$  B1  
 line / curve through  $v = 0$  at  $t = 45 \text{ s}$  to negative velocity B1  
 negative horizontal line from  $53 \text{ s}$  with magnitude less than positive value and  
 horizontal line to time =  $100 \text{ s}$  B1 [4]

**Q28.**

- 2 (a) 1. constant velocity / speed B1 [1]
2. *either* constant / uniform decrease (in velocity/speed)  
or constant rate of decrease (in velocity/speed) B1 [1]
- (b) (i) distance is area under graph for both stages C1  
stage 1: distance  $(18 \times 0.65) = 11.7$  (m)  
stage 2: distance  $= (9 \times [3.5 - 0.65]) = 25.7$  (m)  
total distance  $= 37.4$  m A1 [2]  
(-1 for misreading graph)  
{for stage 2, allow calculation of acceleration  $(6.32 \text{ m s}^{-2})$   
and then  $s = (18 \times 2.85) + \frac{1}{2} \times 6.32 (2.85)^2 = 25.7$  m}
- (ii) *either*  $F = ma$  or  $E_k = \frac{1}{2}mv^2$  C1  
 $a = (18 - 0)/(3.5 - 0.65)$  or  $E_k = \frac{1}{2} \times 1250 \times (18)^2$  C1
- $F = 1250 \times 6.3 = 7900$  N or  $F = \frac{1}{2} \times 1250 \times (18)^2 / 25.7 = 7900$  N A1 [3]  
or initial momentum  $= 1250 \times 18$  (C1)  
 $F = \text{change in momentum} / \text{time taken}$  (C1)  
 $F = (1250 \times 18) / 2.85 = 7900$  (A1)
- (c) (i) stage 1: *either* half / less distance as speed is half / less  
or half distance as the time is the same  
or sensible discussion of reaction time B1 [1]
- (ii) stage 2: *either* same acceleration and  $s = v^2 / 2a$  or  $v^2$  is  $\frac{1}{4}$   
 $\frac{1}{4}$  of the distance B1  
B1 [2]

Q29.

- 1 (a) units for  $D$  identified as  $\text{kg m s}^{-2}$  M1  
all other units shown: units for  $A$ :  $\text{m}^2$  units for  $v^2$ :  $\text{m}^2 \text{ s}^{-2}$  units for  $\rho$ :  $\text{kg m}^{-3}$
- $C = \frac{\text{kg m s}^{-2}}{\text{kg m}^{-3} \text{ m}^2 \text{ m}^2 \text{ s}^{-2}}$  with cancelling / simplification to give  $C$  no units A1 [2]
- (b) (i) straight line from (0,0) to (1,9.8)  $\pm$  half a square B1 [1]
- (ii)  $\frac{1}{2} mv^2 = mgh$  or using  $v^2 = 2as$  C1  
 $v = (2 \times 9.81 \times 1000)^{1/2} = 140 \text{ m s}^{-1}$  A1 [2]
- (c) (i) weight = drag ( $D$ ) (+ upthrust) B1 [1]  
Allow  $mg$  or  $W$  for weight and  $D$  or expression for  $D$  for drag
- (ii) 1.  $mg = 1.4 \times 10^{-5} \times 9.81$  C1  
 $1.4 \times 10^{-5} \times 9.81 = 0.5 \times 0.6 \times 1.2 \times 7.1 \times 10^{-6} \times v^2$  M1  
 $v = 7.33 \text{ m s}^{-1}$  A0 [2]
2. line from (0,0) correct curvature to a horizontal line at velocity of  $7 \text{ m s}^{-1}$  M1  
line reaches  $7 \text{ m s}^{-1}$  between 1.5s and 3.5s A1 [2]

Q30.

- 3 (a) (a) power is the rate of doing work or power = work done / time (taken) or  
power = energy transferred / time (taken) B1 [1]
- (b) (i) as the speed increases drag / air resistance increases B1  
resultant force reduces hence acceleration is less B1  
constant speed when resultant force is zero B1 [3]  
(allow one mark for speed increases and acceleration decreases)
- (ii) force from cyclist = drag force / resistive force B1  
 $P = 12 \times 48$  M1  
 $P = 576\text{W}$  A0 [2]
- (iii) tangent drawn at speed =  $8.0\text{ m s}^{-1}$  M1  
gradient values that show acceleration between  $0.44$  to  $0.48\text{ m s}^{-2}$  A1 [2]
- (iv)  $F - R = ma$  C1  
 $600 / 8 - R = 80 \times 0.5$  [using  $P = 576$ ]  $576 / 8 - R = 80 \times 0.5$  C1  
 $R = 75 - 40 = 35\text{ N}$   $R = 72 - 40 = 32\text{ N}$  A1 [3]
- (v) at  $12\text{ m s}^{-1}$  drag is  $48\text{ N}$ , at  $8\text{ m s}^{-1}$  drag is  $35$  or  $32\text{ N}$   
 $R / v$  calculated as  $4$  and  $4$  or  $4.4$   
and consistent response for whether  $R$  is proportional to  $v$  or not B1 [1]

Q31.

- 3 (a) (i) velocity = rate of change of displacement  
OR displacement change / time (taken) A1 [1]
- (ii) acceleration = rate of change of velocity  
OR change in velocity / time (taken) A1 [1]
- (b) (i) initial constant velocity as straight line / gradient constant B1  
middle section deceleration/ speed / velocity decreases / slowing down as  
gradient decreases B1  
last section lower velocity (than at start) as gradient (constant and) smaller B1 [3]  
[special case: all three stages correct descriptions but no reasons 1/3]
- (ii) velocity =  $45 / 1.5 = 30\text{ m s}^{-1}$  A1 [1]
- (iii) velocity at  $4.0\text{ s}$  is  $(122 - 98) / 2.0 = 12\text{ (m s}^{-1}\text{)}$  (allow  $12$  to  $13$ ) B1  
acceleration =  $(12 - 30) / 2.5 = -7.2\text{ m s}^{-2}$  (if answer not this value then  
comment needed to explain why, e.g. difficulty in drawing tangent) A1 [2]
- (iv)  $F = ma$  C1  
 $= (-)1500 \times 7.2 = (-)11000\text{ (10800) N}$  A1 [2]



