

1. (a) scales (1)  
 six points correctly plotted (1)  
 trendline (1) 3
- (b) average acceleration =  $\frac{26}{25}$  (1)  
 $= 1.0(4) \text{ m s}^{-2}$  (1)  
 (allow C.E. for incorrect values used in acceleration calculation) 2
- (c) area under graph (1)  
 $= 510 \pm 30 \text{ m}$  (1) 2
- (d) (graph to show force starting from y-axis)  
 decreasing (not a straight line) (1)  
 to zero (at end of graph) (1) 2
- (e) (since) gradient of a velocity-time graph gives acceleration (1)  
 first graph shows acceleration is decreasing (1) 2

[11]

2. (a) (i) (gravitational) potential energy to kinetic energy (1)  
 (ii) kinetic energy to heat energy  
 [or work done against friction] (1) 2
- (b) e.g. when using light gates  
 place piece of card on trolley of measured length (1)  
 card obscures light gate just before trolley strikes block (1)  
 calculate speed from length of card/time obscured (1)  
 alternative 1: measured horizontal distance (1)  
 speed = distance/time (1)  
 time (1)  
 alternative 2: measure  $h$  (1)  
 equate potential and kinetic energy (1)  
 $v^2 = gh$  (1)  
 alternative 3: data logger + sensor (1)  
 how data processed (1)  
 how speed found (1) 3

QWC 2

- (c) vary starting height of trolley  
 [or change angle] (1)  
 the greater the height the greater the speed of impact (1)  
 [or alter friction of surface (1)  
 greater friction, lower speed] (1) 2 [7]

3. (a) weight/gravity causes raindrop to accelerate/move faster (initially) (1)  
 resistive forces/friction **increase(s)** with **speed** (1)  
 resistive force (eventually) equals weight (1)  
 [or upward forces equal downward forces]  
 resultant force is now zero (1)  
 [or forces balance or in equilibrium]  
 no more acceleration (1)  
 [or correct application of Newton's Laws]  
 [if Newton's third law used, then may only score first two marks] Max 4  
 QWC 1

- (b) (i)  $E_k (= \frac{1}{2}mv^2) = \frac{1}{2} \times 7.2 \times 10^{-9} \times 1.8^2$  (1)  
 $= 1.2 \times 10^{-8} \text{ J}$  (1) ( $1.17 \times 10^{-8} \text{ J}$ )  
 (ii) work done ( $= mgh$ )  $= 7.2 \times 10^{-9} \times 9.81 \times 4.5$  (1)  
 $= 3.2 \times 10^{-7} \text{ J}$  (1) ( $3.18 \times 10^{-7} \text{ J}$ ) 4

- (c)  $v_{\text{resultant}} = \sqrt{1.8^2 + 1.4^2}$  (1)  
 $= 2.2(8) \text{ m s}^{-1}$  (1)  
 $\theta = \tan^{-1} (1.4/1.8) = 38^\circ$  (1) ( $37.9^\circ$ )  
 [or correct scale diagram] 3 [11]

4. (a) loss of potential energy  $= m \times 9.81 \times 6.0$  (1)  
 gain in kinetic energy = loss of potential energy (1)  
 $\frac{1}{2} mv^2 = 58.9 \text{ m}$  gives  $v = 10.8 \text{ (m s}^{-1}\text{)}$  ( $\approx 11 \text{ m s}^{-1}$ ) 3

- (b) loses potential energy (as it moves to B) (1)  
 gains kinetic energy (as it moves to B) (1)  
 regains some potential energy at the expense of kinetic energy  
 as it moves from B to C (1)  
 some energy lost as heat (due to friction) (1) 4  
 QWC [7]

5. (a) suitable calculation using a pair of values of  $x$  and corresponding  $t$   
 to give an average of  $2.2 \text{ m s}^{-1}$  ( $\pm 0.05 \text{ m s}^{-1}$ ) (1)  
 valid reason given (1)

(e.g. larger values are more reliable/accurate  
or use of differences eliminates zero errors)

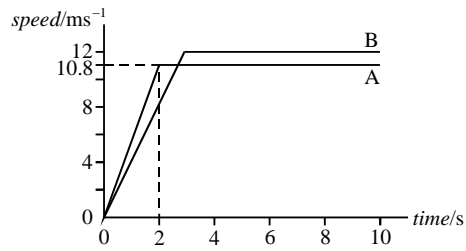
2

- (b) (i) column D ( $y/t$  ( $\text{cm s}^{-1}$ ))  
186  
210  
233  
259  
284  
307  
all values correct to 3 s.f. (1)
- (ii) graph: chosen graph gives a straight line (e.g.  $y/t$  against  $t$ ) (1)  
axes labelled correctly (1)  
suitable scale chosen (1)  
minimum of four points correctly plotted (1)  
best straight line (1)
- (iii)  $u$  (=  $y$  - intercept) =  $162 \text{ cm s}^{-1}$  ( $\pm 4 \text{ cm s}^{-1}$ ) (1)  
gradient =  $495 \text{ (cm s}^{-2}\text{)}$  ( $\pm 25 \text{ cm s}^{-2}$ ) (1)  
 $k$  = gradient (=  $495 \text{ cm s}^{-2}$ ) (1) 9
- (c) (i)  $u$  : initial vertical component of velocity (1)  
(ii)  $k$  : =  $\frac{1}{2} g$  (1) 2
- (d)  $v^2 = u^2 + 2.2^2$  (1)  
gives  $v = (1.62^2 + 2.2^2)^{1/2} = 2.7 \text{ m s}^{-1}$  ( $\pm 0.1 \text{ m s}^{-1}$ ) (1) 2

[15]

6. (a) (i) ( $v = \frac{s}{t}$  gives)  $v = \frac{100}{10.2} = 9.8 \text{ m s}^{-1}$  (1)
- (ii) ( $v = at$  gives)  $v = 5.4 \times 2 = 11 \text{ m s}^{-1}$  (10.8  $\text{m s}^{-1}$ )
- (iii) ( $s = ut + \frac{1}{2} at^2$  gives)  $s = \frac{1}{2} \times 5.4 \times 2^2$  (1)  
= 11 m (1) (10.8 m) 4

(b)



positive slope and then horizontal (1)  
initial slope correct (1)  
horizontal line with correct  
value from (a)(ii) (1)

3  
QWC

(c) (i)  $t = 2.8$  s (1)

(ii) (area under graph gives)  
athlete B : 15 m (1)

athlete A : 11 (1) + 8.6(4) = 20 m (1) (10.8 + 8.64 = 19.4 m)

(iii) 20 – 15 = 5.0 m (1) (19 – 15 = 4.0 m)  
(allow e.c.f. from(c)(ii))

max 4

[11]

7. (a) (rate of change of horizontal) displacement is constant (1)  
hence (horizontal) velocity is constant (1)  
thus no (horizontal) force acting (1)

max 2

(b) there is a vertical force  
[or weight/force of gravity acting on ball] (1)  
ball therefore accelerates (in vertical direction) (1)  
acceleration is constant (1)

max 2

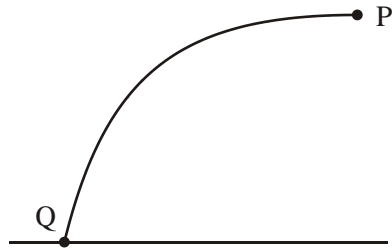
(c) (i) (horizontal) displacement would be less (1)

(ii) (vertical) displacement or acceleration would be less (1)  
effect would increase with time (1)  
[or air resistance increases with speed until equals weight (1)  
hence reaches terminal velocity/speed (1)]

3

[7]

8. (a) (i)



(1)

- (ii) no **horizontal** force acting (1)  
(hence) no (horizontal) acceleration (1)  
[or correct application of Newton's First law]

3

(b) (i) (use of  $v^2 = u^2 + 2as$  gives)  $32^2 = (0) + 2 \times 9.81 \times s$  (1)  
 $s = \frac{1024}{19.62}$  (1) (= 52.2 m)

(ii) (use of  $s = \frac{1}{2}at^2$  gives)  $52 = \frac{1}{2} \times 9.81 \times t^2$  (1)  
 $t = \sqrt{\left(\frac{104}{9.81}\right)} = 3.3 \text{ s}$  (1) (3.26 s)

[or use of  $v = u + at$  gives  $32 = (0) + 9.81 \times t$  (1)

$t = \frac{32}{9.81} = 3.3 \text{ s}$  (1) (3.26 s)]

(iii) (use of  $x = vt$  gives)  $x (= QR) = 95 \times 3.26$  (1)  
 $= 310 \text{ m}$  (1)

(use of  $t = 3.3$  gives  $x = 313.5 \text{ m}$ )  
(allow C.E. for value of  $t$  from (ii)

6

- (c) maximum height is greater (1)  
because vertical acceleration is less (1)  
[or longer to accelerate]

2

[11]