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 ± 30 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 <u>horizontal distance</u> **(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 (= $\frac{1}{2}mv^2$) = ½ × 7.2 × 10^{-9} × 1.8^2 **(1)**
= 1.2 × 10^{-8} J **(1)** (1.17 × 10^{-8} J)

(ii) work done (= mgh) = 7.2 × 10^{-9} × 9.81 × 4.5 **(1)**
= 3.2 × 10^{-7} J **(1)** (3.18 × 10^{-7} J) 4

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

[11]

4. (a) loss of potential energy = m × 9.81 × 6.0 **(1)**
gain in kinetic energy = loss of potential energy **(1)**
½ mv^2 = 58.9 m gives v = 10.8 (m s^{-1}) (≈ 11m 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 m s^{-1} (± 0.05 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 (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 cm s^{-1} (± 4 cm s^{-1}) **(1)**
gradient = 495 (cm s^{-2}) (± 25 cm s^{-2}) **(1)**
k = gradient (= 495 cm s^{-2}) **(1)** 9

(c) (i) u : initial vertical component of velocity **(1)**

(ii) k : = ½ g **(1)** 2

(d) $v^2 = u^2 + 2.2^2$ **(1)**
gives $v = (1.62^2 + 2.2^2)^{1/2}$ = 2.7 m s^{-1} (± 0.1 m s^{-1}) **(1)** 2

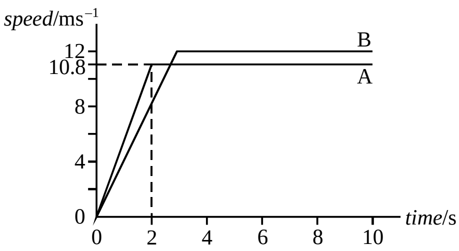
[15]

6. (a) (i) ($v = \frac{s}{t}$ gives) $v = \frac{100}{10.2}$ = 9.8 m s^{-1} **(1)**

(ii) ($v = at$ gives) $v = 5.4 \times 2$ = 11 m s^{-1} (10.8 m s^{-1})

(iii) ($s = ut + ½ at^2$ gives) $s = ½ \times 5.4 \times 2^2$ **(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

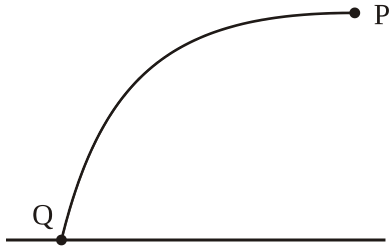
(b) there is a vertical force
[or weight/force of gravity acting on ball] **(1)**
ball therefore accelerates (in vertical direction) **(1)**
acceleration is constant **(1)** max 2

(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)**

$s = \dfrac{1024}{19.62}$ **(1)** (= 52.2 m)

(ii) (use of $s = ½ at^2$ gives) $52 = ½\ 9.81 \times t^2$ **(1)**

$t = \sqrt{\left(\dfrac{104}{9.81}\right)} = 3.3$ s **(1)** (3.26 s)

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

$t = \dfrac{32}{9.81} = 3.3$ s **(1)** (3.26 s)]

(iii) (use of $x = vt$ gives) x (= QR) = 95 × 3.26 **(1)**
= 310 m **(1)**

(use of t = 3.3 gives x = 313.5 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]