**1.** (a) scales **(1)**

six points correctly plotted **(1)**

trendline **(1)** 3

(b) average acceleration  **(1)**

 1.0(4) 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 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 (= ½*mv*2) = ½ × 7.2 × 10–9 × 1.82 **(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 = √(1.82 + 1.42) **(1)**  
= 2.2(8) m s–1 **(1)**  
*θ* = 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 *m*v2 = 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 + 2.22 **(1)**  
gives *v* = (1.622 + 2.22)1/2 = 2.7 m s–1 ( 0.1 m s –1) **(1)** 2

[15]

**6.** (a) (i) (*v* =  gives) *v* =  = 9.8 m s–1 **(1)**

(ii) (*v* = *at* gives) *v* = 5.4 × 2 = 11 m s–1 (10.8 m s–1)

(iii) (*s* = *ut* + ½ *at*2 gives) *s* = ½ × 5.4 × 22 **(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 + 2*as* gives) 322 = (0) + 2 × 9.81 × *s* **(1)***s* =  **(1)** (= 52.2 m)

(ii) (use of *s* = ½ *at*2 gives) 52 = ½ 9.81 × *t*2 **(1)  
**= 3.3 s **(1)** (3.26 s)

[or use of *v* = *u* + *at* gives 32 = (0) + 9.81 × *t* **(1)**** = 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]