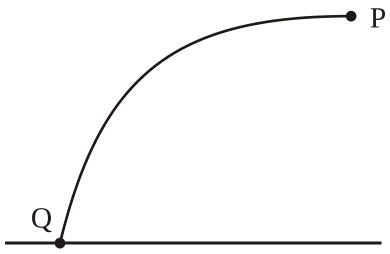
1. (a) (i)



(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 $s = ½\, at^2$ gives) $52 = ½\ 9.81 \times t^2$ **(1)**
$t = \sqrt{\left(\frac{104}{9.81}\right)} = 3.3$ s **(1)** (3.26 s)

[or use of $v = u + at$ gives $32 = (0) + 9.81 \times t$ **(1)**
$t = \frac{32}{9.81} = 3.3$ 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]

2. (a) product of the force and the **perpendicular distance** **(1)**
reference to a point/pivot **(1)** 2

(b) (i) since W is at a greater distance from A **(1)**
then W must be less than P if moments are to be equal **(1)**

(ii) P must increase **(1)**
since moment of girl's weight increases as she moves from A to B **(1)**

correct statement about how P changes
(e.g. P minimum at A, maximum at B, or P increases in a linear fashion) **(1)** max 4

[6]

3. (a) (i) (use of $E_p = mgh$ gives) $E_p = 70 \times 9.81 \times 150$ **(1)**
$= 1.0(3) \times 10^5$ J **(1)**

(ii) (use of $E_k = ½mv^2$ gives) $E_k = ½ \times 70 \times 45^2$ **(1)**
$= 7.1 \times 10^4$ J **(1)** (7.09×10^4 J) 4

(b) (i) work done ($= 1.03 \times 10^5 - 7.09 \times 10^4$) $= 3.2(1) \times 10^4$ J **(1)**
(allow C.E. for values of E_p and E_k from (a)

(ii) (use of *work done* = *Fs* gives) $3.21 \times 10^4 = F \times 150$ **(1)**
(allow C.E. for value of *work done* from (i)
$F = 210$ N **(1)** (213 N) 3

[7]

4. (a) vector quantities have direction (as well as magnitude)
and scalar quantities do not **(1)** 1

(b) vector: e.g. velocity, acceleration, momentum **(1)**
scalar: e.g. mass, temperature, energy **(1)** 2

(c) (i) addition of forces (12 + 8) **(1)**
(use of $F = ma$ gives) $a = \frac{(12+8)}{6.5} = 3.1 \text{ m s}^{-2}$ **(1)** (3.08 m s^{-2})

(ii) subtraction of forces (12 – 8) **(1)**
$a = \frac{(12-8)}{6.5} = 0.62 \text{ m s}^{-2}$ **(1)** (0.615 m s^{-2}) 4

[7]

5. (a) resultant force on crate is zero **(1)**
forces must have equal magnitudes or size **(1)**
(but) act in opposite directions **(1)**
correct statement of 1st or 2nd law **(1)** max 3

QWC 1

(b) (i) work done = $F \times d = 640 \times 9.81 \times 8.0$ **(1)**
$= 5.0(2) \times 10^4$ J **(1)**

(ii) (use of $P = \frac{W}{t}$ gives) $P = \frac{5.02 \times 10^4}{4.5} = 1.1(2) \times 10^4$ W **(1)**
(allow C.E. for value of work done from (i)) 3

[6]

6. (a) (i) car A: travels at constant speed **(1)**

(ii) car B: accelerates for first 5 secs (or up to 18 m s^{-1}) **(1)**
then travels at constant speed **(1)** 3

(b) (i) car A: distance = 5.0×16 **(1)**
= 80 m **(1)**

(ii) car B: (distance = area under graph)
distance = [5.0 × ½ (18 + 14)] **(1)**
= 80 m **(1)** 4

(c) car B is initially slower than car A (for first 2.5 s) **(1)**
distance apart therefore increases **(1)**
cars have same speed at 2.5 s**(1)**
after 2.5 s, car B travels faster than car A (or separation decreases) **(1)** max 3

[10]

7. (a) (moment) force × perpendicular **(1)** distance (from the point) **(1)** 2

(b) (i) the point in a body where the resultant torque is zero
[or where the (resultant) force of gravity acts or where the weight acts through] **(1)**

(ii) $F \times 2.5 = 1800 \times 0.35$ **(1)**
$F = 250$ N **(1)** (252 N)

(iii) $F_R = (1800 - 252)$ **(1)**
= 1500 N **(1)** (1548) N
[use of $F = 250$ N gives $F_R = 1550$ N or 1600 N)
(allow C.E. for incorrect value of F from (ii)) 5

(c) force must have a horizontal component **(1)**
F (therefore) increases in magnitude **(1)**
and act at an angle (to the vertical) towards the car **(1)** 3

QWC 1

[10]

8. (a) (i) horizontal component = 850 × cos 42 **(1)**
= 630 N **(1)** (632 N)

(ii) vertical component = 850 × sin 42 = 570 N **(1)** (569 N)
(if mixed up sin and cos then CE in (ii))

(iii) weight of girder = 2 × 570 = 1100 N **(1)** (1142 N)
(use of 569 N gives weight = 1138 N)
(allow C.E. for value of vertical component in (ii)) 4

(b) arrow drawn vertically downwards at centre of girder **(1)** 1

[5]

9. (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)**
= 1.2×10^{-8} J **(1)** (1.17×10^{-8} J)

(ii) work done (= mgh) = $7.2 \times 10^{-9} \times 9.81 \times 4.5$ **(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]

10. (a) component (parallel to ramp) = $7.2 \times 10^3 \times \sin 30$ **(1)** (= 3.6×10^3 N) 1

(b) mass = $\frac{7.2 \times 10^3}{9.81}$ = 734 (kg) **(1)**

$a = \frac{3600}{734}$ = 4.9(1) m s^{-2} **(1)** 2

(c) (use of $v^2 = u^2 + 2as$ gives) $0 = 18^2 - (2 \times 4.9 \times s)$ **(1)**
s = 33(.1) m **(1)**
(allow C.E. for value of a from (b)) 2

(d) frictional forces are acting **(1)**
increasing resultant force [or opposing motion] **(1)**
hence higher deceleration [or car stops quicker] **(1)**
energy is lost as thermal energy/heat **(1)** □ Max 2

[7]

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

six points correctly plotted **(1)**
trendline **(1)** 3

(b) average acceleration = $\frac{26}{25}$ **(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]

12. (a) (i) (gravitational) potential energy **(1)**
to kinetic energy **(1)**

(ii) both trolley and mass have kinetic energy **(1)**
mention of thermal energy (due to friction) **(1)** 4

(b) masses of trolley and falling mass **(1)**
distance mass falls (or trolley moves) and time taken to fall (or speed) **(1)** 2

(c) calculate loss of gravitational pot. energy of falling mass (mgh) **(1)**
calculate speed of trolley (as mass hits floor),
with details of speed calculation **(1)**
calculate kinetic energy of trolley **(1)**
and mass **(1)**
compare (loss of) potential energy with (gain of) kinetic energy **(1)** Max 4
[10]

13 .(a) the point (in a body) **(1)**
where the weight (or gravity) of the object appears to act
[or resultant torque zero] **(1)** 2

(b) (i) $P \times 0.90 = 160 \times 0.50$ **(1)**
$P = 89$ N (88.9 N)

(ii) $Q = (160 - 89) = 71$ N **(1)**
(allow C.E. for value of P from (i)) 3

(c) (minimum) force × 0.10 = 160 × 0.40 **(1)**
force = 640 N **(1)** 2

(d) force is less **(1)**
because distance to pivot is larger **(1)**
smaller force gives large enough moment **(1)** 3

[10]

14. (a) (i) (horizontal) force = zero **(1)**

(ii) (vertical) force = 2 × 15 sin 20 **(1)**

= 10(.3) N **(1)** 3

(b) (i) weight (of block) = 10(.3) N **(1)**

(allow C.E. for value from (a) (ii))

(ii) resultant force must be zero **(1)**

with reference to an appropriate law of motion **(1)** 3

[6]

15. (a) potential energy to kinetic energy **(1)**
mention of thermal energy and friction **(1)** 2

(b) (use of $\frac{1}{2} mv^2 = mgh$ gives) $\frac{1}{2} v_h^2 = 9.81 \times 1.5$ **(1)**
$v_h = 5.4(2) \text{ms}^{-1}$ **(1)**
(assumption) energy converted to thermal energy is negligible **(1)** 3

(c) component of weight down the slope causes acceleration **(1)**
this component decreases as skateboard moves further down the slope **(1)**
air resistance/friction increases (with speed) **(1)** 2

(d) (i) distance (= 0.42 × 5.4) = 2.3m **(1)**
(2.27m)
(allow C.E. for value of v_h from (b))

(ii) $v_v = 9.8 \times 0.42$ **(1)**
= 4.1(l) m s^{-1} **(1)**

(iii) $v^2 = 4.1^2 + 5.4^2$ **(1)**
$v = 6.8 \text{ m s}^{-1}$ **(1)**
(6.78 m s^{-1}) 5
(allow C.E. for value of v_h from (b))

[12]

16. (a) resultant force zero **(1)**
resultant torque about any point zero **(1)** 2

(b) (i) force due to wire P = 5.0 **-** 2.0 = 3.0 N **(1)**

(ii) (moments give) $5.0 \times d = 2.0 \times 0.90$ **(1)**
$d = 0.36$ m **(1)** 3

[5]

(c) component of weight down the slope causes acceleration **(1)**
this component decreases as skateboard moves further down the slope **(1)**
air resistance/friction increases (with speed) **(1)** 2

(d) (i) distance (= 0.42 × 5.4) = 2.3m **(1)**
(2.27m)
(allow C.E. for value of v_h from (b))

(ii) $v_v = 9.8 \times 0.42$ **(1)**
= 4.1(l) m s^{-1} **(1)**

(iii) $v^2 = 4.1^2 + 5.4^2$ **(1)**
$v = 6.8$ m s^{-1} **(1)**
(6.78 m s^{-1}) 5
(allow C.E. for value of v_h from (b))

[12]

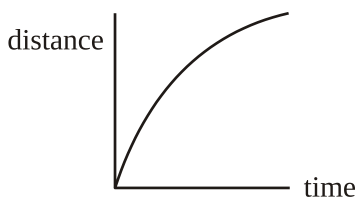
17. (a) (i) (use of $a = \frac{\Delta v}{\Delta t}$ gives) $a = \frac{4.5}{3600}$ **(1)**

$= 1.25 \times 10^{-3}$ ms^{-2} **(1)**

(ii) (use of $v^2 = u^2 + 2as$ gives) $0 = 4.5^2 - 2 \times 1.25 \times 10^{-3} \times s$ **(1)**

$s\left(= \frac{20.25}{2.5 \times 10^{-3}}\right) = 8.1 \times 10^3$ m **(1)** 4

(b) increasing curve **(1)**
correct curve **(1)** 2



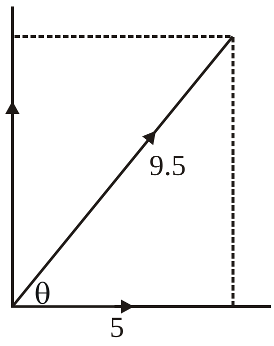
(c) gradient (slope) of graph represents speed **(1)**
hence graph has decreasing gradient **(1)** 2

[8]

18. (a) (i) a quantity that has magnitude only
[or has no direction] **(1)**

(ii) any two: e.g. energy **(1)**
temperature **(1)** 3

(b) (i)



scale **(1)**
5 N and 9.5 N **(1)**
correct answer (8.1 N ± 0.2 N) **(1)**

[or $9.5^2 = 5.0^2 + F^2$ **(1)**
$F^2 = 90.3 - 25$ **(1)**
$F = 8.1$ N **(1)** (8.07 N)]

(ii) $\cos\theta = \frac{5.0}{9.5}$
gives $\theta = 58°$ **(1)** (± 2° if taken from scale diagram) 4

[7]

19. (a) (i) (use of F = ma gives) $1.8 \times 10^3 = 900\,a$ **(1)**
$a = 2.0$ m s^{-2} **(1)**

(ii) (use of $v = u + at$ gives) $v = 2.0 \times 8.0 = 16$ m s^{-1} **(1)**
(allow C.E. for a from (i))

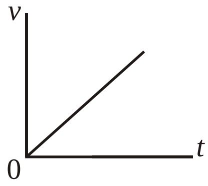
(iii) (use of $p = mv$ gives) $p = 900 \times 16$
$= 14 \times 10^3$ kg m s^{-1} (or N s) **(1)** (14.4×10^3 kg m s^{-1})
(allow C.E. for v from(ii))

(iv) (use of $s = ut + ½at^2$ gives) $s = \frac{1}{2} \times 2.0 \times 8^2$ **(1)**
$= 64$ m **(1)**
(allow C.E. for a from (i))

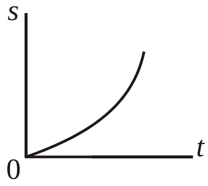
(v) use of $W = Fs$ gives) $W = 1.8 \times 10^3 \times 64$ **(1)**
$= 1.2 \times 10^5$ J **(1)** (1.15×10^5 J)
(allow C.E. for s from (iv))

[or $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 900 \times 16^2$ **(1)**
$= 1.2 \times 10^5$ J **(1)**
(allow C.E. for *v* from (ii))] 9

b)



(1)



(1) 2

(c) (i) decreases **(1)**
air resistance increases (with speed) **(1)**

(ii) eventually two forces are equal (in magnitude) **(1)**
resultant force is zero **(1)**

hence constant/terminal velocity (zero acceleration)
in accordance with Newton's first law **(1)**

correct statement and application of Newton's first
or second law **(1)** max 5
QWC 2
[16]

20. (a) for a body in equilibrium **(1)**
the (sum of the) clockwise moments <u>about a point</u> **(1)**
are equal to (the sum of) the anticlockwise moments **(1)**
[or resultant torque <u>about a point</u> **(1)** is zero **(1)**] 3

(b) (i) diagram to show: pivot/fulcrum/balance point **(1)**
masses or appropriate objects **(1)**

(ii) known masses on either side of pivot **(1)**
move this mass until ruler is in equilibrium/balanced **(1)**
measure distances **(1)**
repeat with other masses **(1)**

(iii) (calculate) weights of masses (on left and right of pivot) **(1)**
product of weight and distance to pivot on either side of pivot **(1)**
hence should be equal **(1)** max 7
QWC 2
[10]

21. (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]