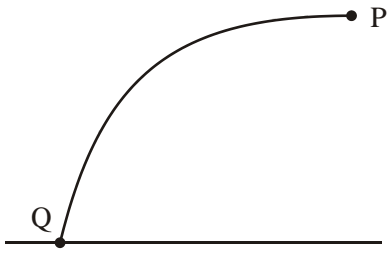


1. (a) (i)



(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 $s = \frac{1}{2}at^2$ gives) $52 = \frac{1}{2} \times 9.81 \times t^2$ (1)
 $t = \sqrt{\left(\frac{104}{9.81}\right)} = 3.3$ 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) $x (= QR) = 95 \times 3.26$ (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 $E_k = \frac{1}{2}mv^2$ gives) $E_k = \frac{1}{2} \times 70 \times 45^2$ **(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) $a = \frac{(12+8)}{6.5} = 3.1$ m s⁻² **(1)** (3.08 m s⁻²)
- (ii) subtraction of forces (12 – 8) **(1)**
 $a = \frac{(12-8)}{6.5} = 0.62$ 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)
 $= 5.0(2) \times 10^4 \text{J}$ (1)
- (ii) (use of $P = \frac{W}{t}$ gives) $P = \frac{5.02 \times 10^4}{4.5} = 1.1(2) \times 10^4 \text{W}$ (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)
 $= 80 \text{ m}$ (1)
- (ii) car B: (distance = area under graph)
 distance = $[5.0 \times \frac{1}{2} (18 + 14)]$ (1)
 $= 80 \text{ m}$ (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 \times 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)
 $F = 250 \text{ N}$ (1) (252 N)
- (iii) $F_R = (1800 - 252)$ (1)
 $= 1500 \text{ N}$ (1) (1548 N)
 [use of $F = 250 \text{ N}$ gives $F_R = 1550 \text{ N}$ or 1600 N]
 (allow C.E. for incorrect value of F from (ii)) 5

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

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

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

(c) (use of $v^2 = u^2 + 2as$ gives) $0 = 18^2 - (2 \times 4.9 \times s)$ (1)
 $s = 33(1) \text{ m}$ (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)
 $= 1.0(4) \text{ m s}^{-2}$ (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]**
- 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)
 $P = 89 \text{ N}$ (88.9 N)
- (ii) $Q = (160 - 89) = 71 \text{ N}$ (1)
(allow C.E. for value of P from (i)) 3
- (c) (minimum) force $\times 0.10 = 160 \times 0.40$ (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 = $2 \times 15 \sin 20$ (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(1) 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
[12]

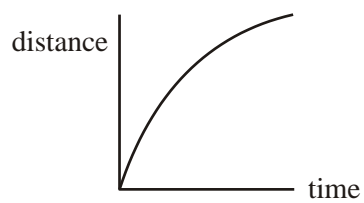
16. (a) resultant force zero (1)
 resultant torque about any point zero (1) 2
- (b) (i) force due to wire $P = 5.0 - 2.0 = 3.0 \text{ N}$ (1)
 (ii) (moments give) $5.0 \times d = 2.0 \times 0.90$ (1)
 $d = 0.36 \text{ m}$ (1) 3
- [5]**

- (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 $(= 0.42 \times 5.4) = 2.3 \text{ m}$ (1)
 (2.27m)
(allow C.E. for value of v_h from (b))
- (ii) $v_v = 9.8 \times 0.42$ (1)
 $= 4.1(1) \text{ m s}^{-1}$ (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]**

17. (a) (i) (use of $a = \frac{\Delta v}{\Delta t}$ gives) $a = \frac{4.5}{3600}$ (1)
 $= 1.25 \times 10^{-3} \text{ ms}^{-2}$ (1)
- (ii) (use of $v^2 = u^2 + 2as$ gives) $0 = 4.5^2 - 2 \times 1.25 \times 10^{-3} \times s$ (1)
 $s \left(= \frac{20.25}{2.5 \times 10^{-3}} \right) = 8.1 \times 10^3 \text{ m}$ (1) 4

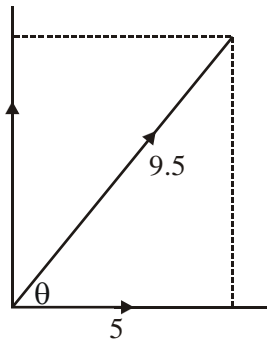
- (b) increasing curve (1)
 correct curve (1) 2



- (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 \pm 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 $\theta = 58^\circ$ (1) ($\pm 2^\circ$ if taken from scale diagram) 4

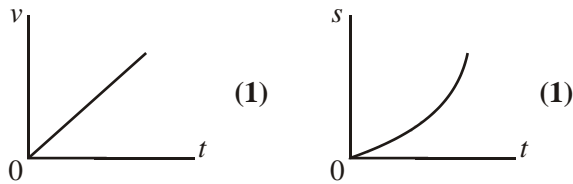
[7]

19. (a) (i) (use of $F = ma$ gives) $1.8 \times 10^3 = 900 a$ (1)
 $a = 2.0 \text{ m s}^{-2}$ (1)
(ii) (use of $v = u + at$ gives) $v = 2.0 \times 8.0 = 16 \text{ m s}^{-1}$ (1)
(allow C.E. for a from (i))
(iii) (use of $p = mv$ gives) $p = 900 \times 16$
 $= 14 \times 10^3 \text{ kg m s}^{-1}$ (or N s) (1) ($14.4 \times 10^3 \text{ kg m s}^{-1}$)
(allow C.E. for v from (ii))
(iv) (use of $s = ut + \frac{1}{2}at^2$ gives) $s = \frac{1}{2} \times 2.0 \times 8^2$ (1)
 $= 64 \text{ m}$ (1)
(allow C.E. for a from (i))
(v) use of $W = Fs$ gives) $W = 1.8 \times 10^3 \times 64$ (1)
 $= 1.2 \times 10^5 \text{ J}$ (1) ($1.15 \times 10^5 \text{ J}$)
(allow C.E. for s from (iv))

$$\begin{aligned}
 [\text{or } E_k = \frac{1}{2}mv^2 &= \frac{1}{2} \times 900 \times 16^2 \quad (1) \\
 &= 1.2 \times 10^5 \text{ J} \quad (1) \\
 &(\text{allow C.E. for } v \text{ from (ii)})]
 \end{aligned}$$

9

b)



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 about a point (1)
 are equal to (the sum of) the anticlockwise moments (1)
 [or resultant torque about a point (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 $2.2 \text{ m s}^{-1} (\pm 0.05 \text{ m s}^{-1})$ (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 (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 = $495 (\text{cm s}^{-2}) (\pm 25 \text{ cm s}^{-2})$ (1)
 k = gradient (= 495 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]**