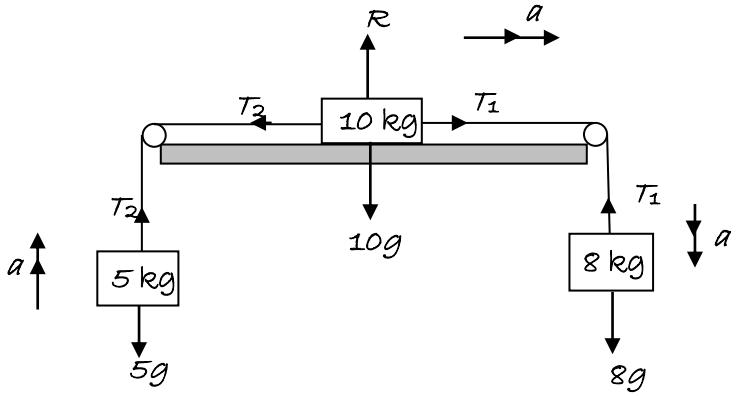
Section 3: Connected objects

Solutions to Exercise level 2

1. (i)



(ii) Considering 8 kg mass: $8g - T_1 = 8a$

$T_1 = 8g - 8a$ (1)

Considering 5 kg mass: $T_2 - 5g = 5a$

$T_2 = 5g + 5a$ (2)

Considering the 10 kg mass: $T_1 - T_2 = 10a$ (3)

Substituting (1) and (2) into (3): $8g - 8a - (5g + 5a) = 10a$

$3g = 23a$

$a = \frac{3 \times 9.8}{23} = 1.28$

The acceleration of the system is 1.28 ms^{-2} (3 s.f.)

Substituting into (1): $T_1 = (8 \times 9.8) - 8\left(\frac{3 \times 9.8}{23}\right)$

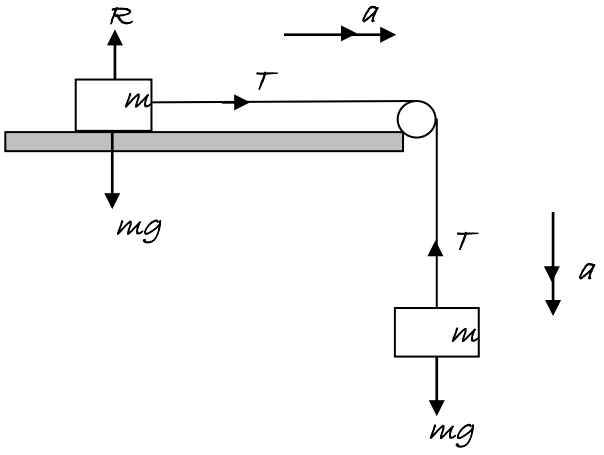
$= 68.2$

Substituting into (2): $T_2 = (5 \times 9.8) + 5\left(\frac{3 \times 9.8}{23}\right)$

$= 55.4$

The tensions in the strings are 68.2 N and 55.4 N (3 s.f.)

2.



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Considering particle on table: $T = ma$

Considering hanging particle: $mg - T = ma$

Adding: $mg = 2ma$

$a = \frac{1}{2}g = 4.9$

$a = 4.9, u = 0, t = 0.5$

$s = ut + \frac{1}{2}at^2$

$= 0 + \frac{1}{2} \times 4.9 \times 0.5^2$

$= 0.6125$

Distance travelled $= 0.6125$ m

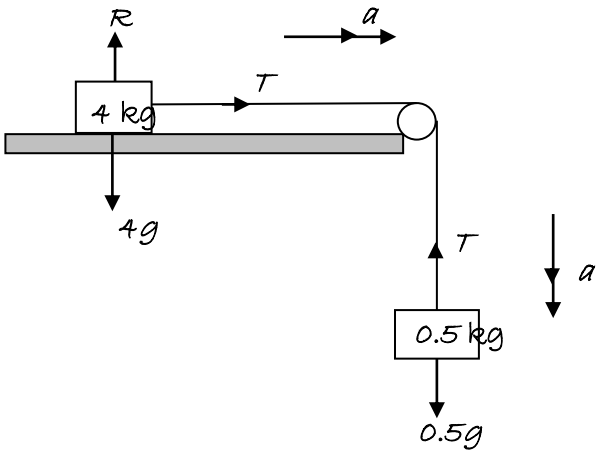
$v = u + at$

$= 0 + 4.9 \times 0.5$

$= 2.45$

Speed $= 2.45\ ms^{-1}$.

3.



Considering the 0.5 kg particle: $0.5g - T = 0.5a$ (1)

Considering the 4 kg package: $T = 4a$ (2)

Substituting (2) into (1): $0.5g - 4a = 0.5a$

$0.5 \times 9.8 = 4.5a$

$a = \frac{4.9}{4.5} = \frac{49}{45}$

For the motion of the package:

$u = 0$ $\quad v^2 = u^2 + 2as$

$s = 2.5$ $\quad = 0 + 2 \times \frac{49}{45} \times 2.5$

$a = \frac{49}{45}$ $\quad v = 2.33$

$v = ?$

The speed of the package as it reaches the shelf is $2.33\ ms^{-1}$.

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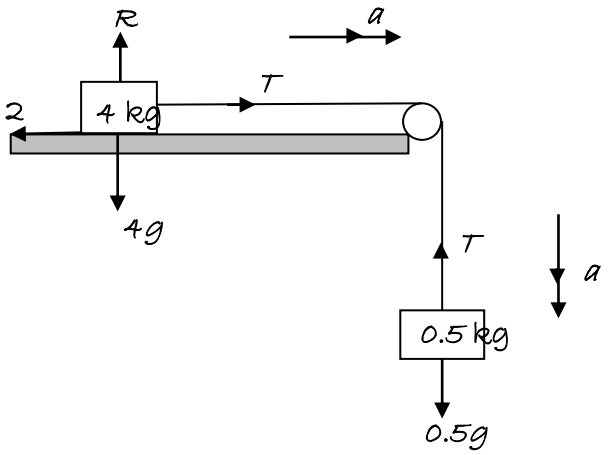
4.



Considering the 0.5 kg particle: $0.5g - T = 0.5a$ (1)

Considering the 4 kg package: $T - 2 = 4a$ (2)

$T = 2 + 4a$

Substituting (2) into (1): $0.5g - (2 + 4a) = 0.5a$

$0.5 \times 9.8 - 2 - 4a = 0.5a$

$2.9 = 4.5a$

$a = \frac{2.9}{4.5} = \frac{29}{45}$

For the motion of the package:

$u = 0$ $\quad v^2 = u^2 + 2as$

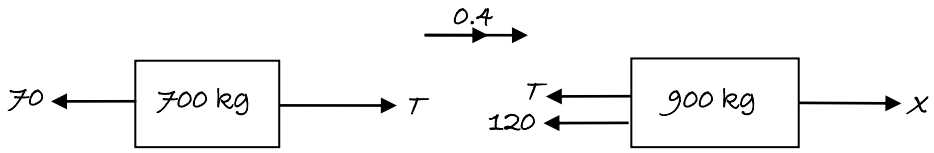
$s = 2.5$ $\quad = 0 + 2 \times \frac{29}{45} \times 2.5$

$a = \frac{29}{45}$ $\quad v = 1.80$

$v = ?$

The speed of the package as it reaches the shelf is 1.80 ms^{-1}.

5.



(i) For caravan: $T - 70 = 700 \times 0.4$

$T = 70 + 280$

$T = 350$

The tension in the tow-bar is 350 N

(ii) For car: $X - T - 120 = 900 \times 0.4$

$X = 350 + 120 + 360$

$X = 830$

The force from the engine of the car = 830 N.

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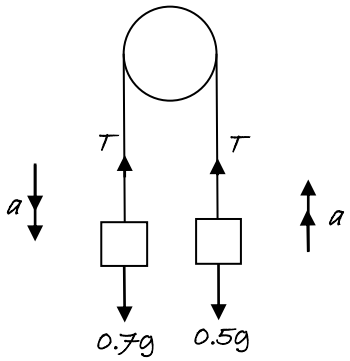
6.



For 700g mass: $0.7g - T = 0.7a$

For 500g mass: $T - 0.5g = 0.5a$

Adding: $0.2g = 1.2a$

$a = \frac{1}{6}g$

The 500g mass will rise with this acceleration until the 700g mass hits the floor, after which the tension in the string will be zero and it will then move under gravity (continuing upwards until the velocity becomes zero and it begins to descend again. So we need to know its velocity at the point when the 700g mass hits the floor.

For the motion until the 700g mass reaches the floor:

$s = 0.2$ $\quad v^2 = u^2 + 2as$

$a = \frac{1}{6}g$ $\quad = 0 + 2 \times \frac{1}{6}g \times 0.2$

$u = 0$ $\quad = \frac{1}{15}g$

$v = ?$

For the motion of the 500g mass under gravity, until it reaches greatest height:

$u = \sqrt{\frac{1}{15}g}$ $\quad v^2 = u^2 + 2as$

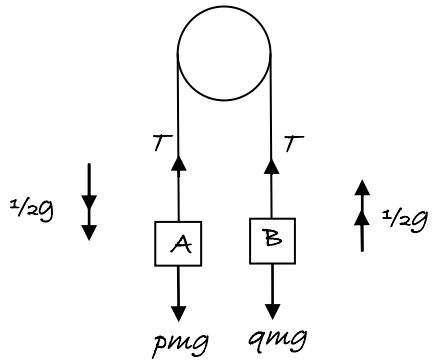
$v = 0$ $\quad 0 = \frac{1}{15}g - 2gs$

$s = ?$ $\quad s = \frac{1}{30} = 0.033$ (3 d.p.)

$a = -g$

Height above ground = 0.2 + 0.2 + 0.033 = 0.433 m = 43.3 cm (3 s.f.)

7.



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(a) (i) For A: $pmg - T = \frac{1}{2}pmg$

$T = \frac{1}{2}pmg$

(ii) For B: $T - qmg = \frac{1}{2}qmg$

$T = \frac{3}{2}qmg$

$\frac{1}{2}pmg = \frac{3}{2}qmg$

$p = 3q$

(b) (i) In the result $p = 3q$, replace p by $p + q$ and replace q by 4.

$p + q = 12$

(ii) $p + q = 12$ and $p = 3q$

$3q + q = 12$

$4q = 12$

$q = 3$

$p = 9$