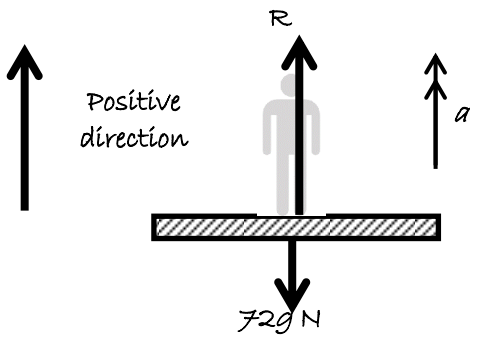
Section 3: Connected objects

Solutions to Exercise level 1

1. (i)



(ii) $R - 72g = 72a$

$R - 72g = 72 \times 0$

$R = 72g = 705.6$ N

(iii) $R - 72g = 72 \times 2$

$R = 144 + 72g = 849.6$ N

(iv) $R - 72g = 72 \times -3$

$R = -216 + 72g = 489.6$ N

(v) $R - 72g = 72 \times -2$

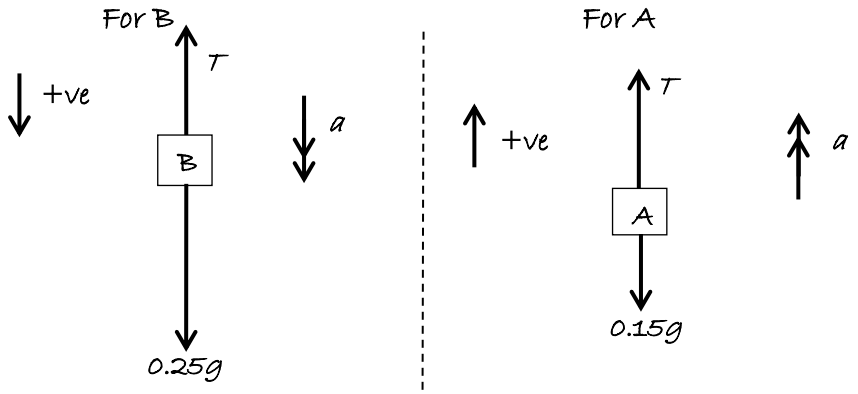
$R = -144 + 72g = 561.6$ N

(vi) Using downwards as the positive direction:

$72g - R = 72 \times -3$

$R = 72g + 216 = 921.6$ N

2. (i)



(ii) For A: $T - 0.15g = 0.15a$ (1)

For B: $0.25g - T = 0.25a$ (2)

(iii) (1) + (2): $0.1g = 0.4a$

$$a = 0.25g = 2.45 \text{ m s}^{-2}$$

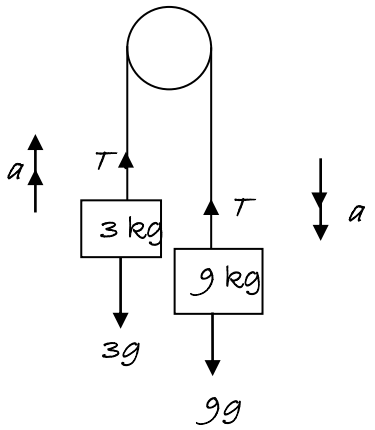
(iv) Putting $a = 0.25g$ in (1):

$$T - 0.15g = 0.15 \times 0.25g$$
$$T = 0.15g + 0.0375g$$
$$T = 1.84 \text{ N (3 s.f.)}$$

(v) $s = 1$, $u = 0$, $a = 2.45$, $t = ?$

$$s = ut + \tfrac{1}{2}at^2$$
$$1 = 0 + \tfrac{1}{2} \times 2.45t^2$$
$$1 = 1.225t^2$$
$$t = 0.904 \text{ s (3 s.f.)}$$

3.



Considering 3 kg mass: $T - 3g = 3a$ (1)

Considering 9 kg mass: $9g - T = 9a$ (2)

Adding: $6g = 12a$

$$a = \tfrac{1}{2} \times 9.8 = 4.9$$

The acceleration of the system is 4.9 ms^{-2}.

(1) gives $T = 3g + 3a$

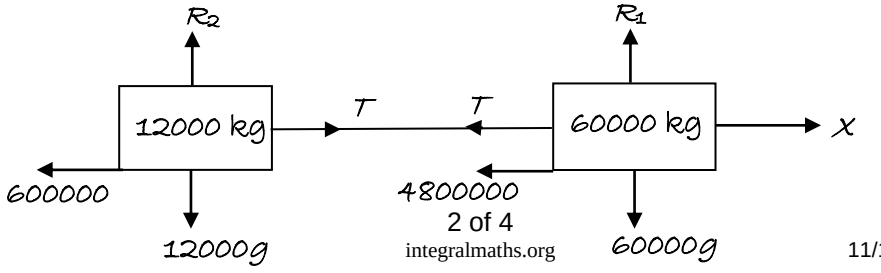
$$= 3(9.8 + 4.9)$$
$$= 44.1$$

The tension in the string is 44.1 N.

4. Resistance experienced by engine $= 60000 \times 80 = 4800000$

Resistance experienced by truck $= 12000 \times 50 = 600000$

Train is travelling at constant speed, so acceleration is zero.



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Considering whole system: $X - 4800000 - 600000 = 0$

$X = 5400000$

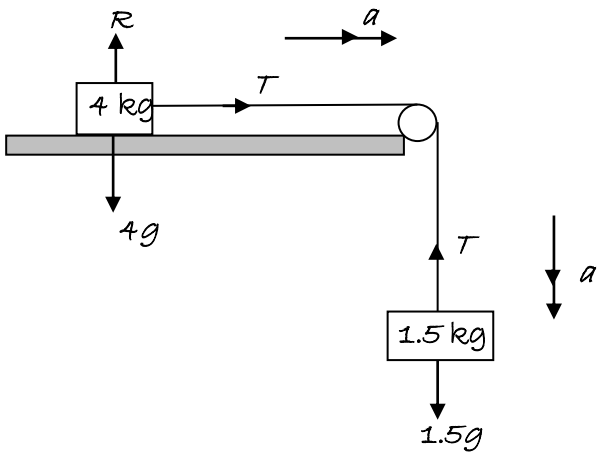
The driving force of the engine = 5400 kN.

Considering truck: $T - 600000 = 0$

$T = 600000$

The tension in the coupling = 600 kN.

5.



For the 4 kg mass: $T = 4a$ (1)

For the 1.5 kg mass: $1.5g - T = 1.5a$ (2)

Adding: $1.5g = 5.5a$

$$a = \frac{1.5 \times 9.8}{5.5} = 2.67$$

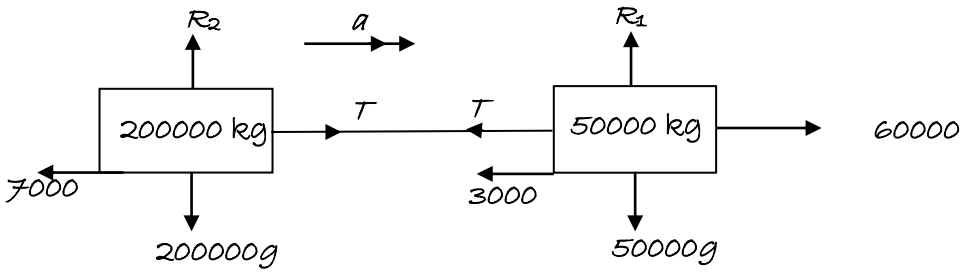
The acceleration of the system is 2.67 ms^{-2} (3 s.f.)

Substituting into (1): $T = 4a$

$$T = 4 \times \frac{1.5 \times 9.8}{5.5} = 10.7$$

The tension in the string is 10.7 N (3 s.f.)

6.



Considering the whole system: $60000 - 3000 - 7000 = 250000a$

$50000 = 250000a$

$a = 0.2$

The acceleration of the system is 0.2 ms^{-2}.

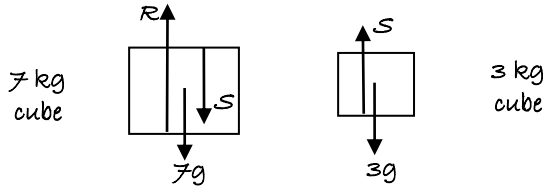
Considering the truck: $T - 7000 = 200000 \times 0.2$

$T - 7000 = 40000$

$T = 47000$

The tension in the coupling is 47000 N.

7. R is the reaction between the 7 kg cube and the table, and S is the reaction between the two cubes.



For the 3 kg cube: $S - 3g = 0$

$S = 3g = 29.4$

For the 7 kg cube: $R - S - 7g = 0$

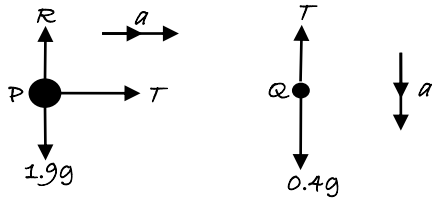
$R = 3g + 7g = 10g$

$R = 98$

The reaction between the two cubes is 29.4 N

The reaction between the larger cube and the table is 98 N

8.



For Q: $0.4g - T = 0.4a$ (1)

For P: $T = 1.9a$ (2)

Substituting (2) into (1): $0.4g - 1.9a = 0.4a$

$0.4g = 2.3a$

$a = \frac{0.4 \times 9.8}{2.3} = 1.70$ (3 s.f.)

From (2): $T = 1.9 \times \frac{0.4 \times 9.8}{2.3} = 3.24$ (3 s.f.)

The acceleration is 1.70 ms^{-2} and the tension in the string is 3.24 N.