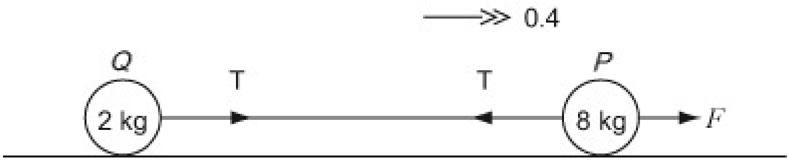
Exercise 4E

1



a $R(\rightarrow)$, $F = (2+8)\times 0.4$
$= 4$

Hence F is 4 N.

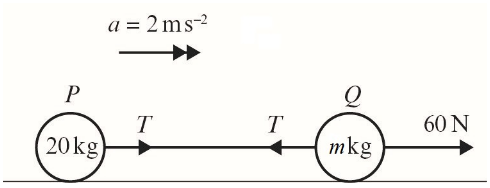
b For Q:

$R(\rightarrow)$, $T = 2\times 0.4$
$= 0.8$

The tension in the string is 0.8 N.

c Treating the string as inextensible (i.e. it does not stretch) allows us to assume that the acceleration of both masses is the same. Treating the string as light (i.e. having no/negligible mass) allows us to assume that the tension is the same throughout the length of the string and that its mass does not need to be considered when treating the system as a whole.

2

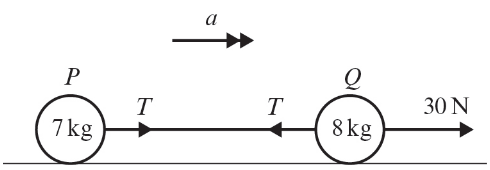


$F = ma$

a For the whole system: $F = 60$, $m = 20 + m = 10$, $a = 2$
$60 = (20 + m) \times 2$
$20 + m = 60 \div 2$
$m = 30 - 20$
The mass of Q is 10 kg.

b For P: $F = T$, $m = 20$, $a = 2$
$T = 20 \times 2$
The tension in the string is 40 N.

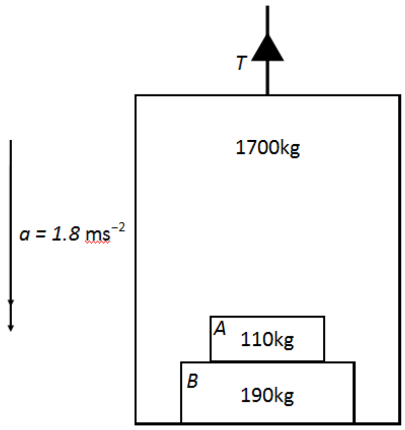
3 $F = ma$



3 **a** For the whole system: $F = 30$, $m = 8 + 7 = 15$, $a = ?$
$30 = 15a$
The acceleration of the system is 2 m s^{-2}.

b For P: $F = T$, $m = 7$, $a = 2$
$T = 7 \times 2$
The tension in the string is 14 N.

4



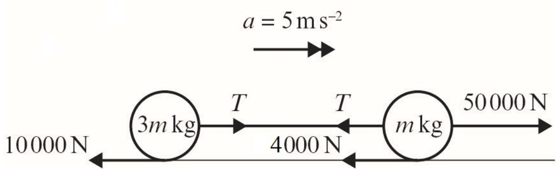
a Considering the system as a whole: total mass, m = 1700 + 110 + 190 = 2000 kg
Taking down as positive:
$F = ma = mg - T$
$2000 \times 1.8 = (2000 \times 9.8) - T$
$T = 19600 - 3600$
The tension in the cable is 16 000 N.

b **i** Force exerted on box A by box B is a normal reaction force, R_1 which acts upwards.
For box A, taking down as positive:
$110 \times 1.8 = 110g - R_1$
$R_1 = 110(g - 1.8)$
$R_1 = 110 \times 8$
Box B exerts an upwards force of 880 N on box A.

ii Let downward force exerted on lift by box B be S.
For lift alone, taking down as positive:
$1700 \times 1.8 = 1700g + S - T$
$S = T + 1700(1.8 - g)$
$S = 16\,000 - 13600 = 2400$

Alternatively (or as check), use Newton's third law of motion:
|Force exerted box B by box A| = |Force exerted on box A by box B| = 880 N
|Force exerted on lift by box B| = |Force exerted on box B by lift| = $|R_2|$
For box B, taking down as positive:
$190 \times 1.8 = 880 + 190g - R_2$
$R_2 = 880 + 190(g - 1.8)$
$R_2 = 880 + 1520 = 2400$

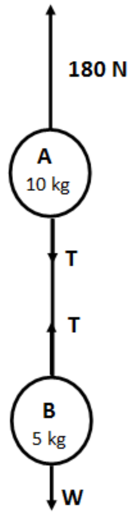
5 $F = ma$



a For the whole system:
$F = 50\,000 - 10\,000 - 4000 = 36\,000$
$a = 5$
total mass $= 3m + m = 4m$
$36\,000 = a \times$ total mass $= 4m \times 5 = 20m$
$m = 1800$
so $3m = 5400$
The mass of the lorry is 1800 kg, and that of the trailer is 5400 kg.

b For the trailer:
$F = T - 10\,000$, $m = 5400$, $a = 5$
$T - 10\,000 = 5400 \times 5 = 27\,000$
$T = 37\,000$
The tension in the tow-bar is 37 000 N.

c Treating the tow-bar as inextensible (i.e. it does not stretch) allows us to assume that the acceleration of the truck and the trailer are the same. Treating the tow-bar as light (i.e. having no/negligible mass) allows us to assume that the tension is the same throughout its length and that its mass does not need to be considered when treating the system as a whole.

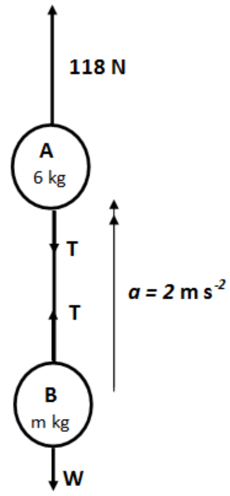


6 $F = ma$, $W = mg$
Taking upwards as positive

a For the whole system:
$180 - 15g = 15a$
$15a = 180 - (15 \times 9.8)$
$$a = \frac{180 - 147}{15} = 2.2$$
The acceleration is 2.2 m s^{-2}.

b For B:
$ma = T - W$
$5 \times 2.2 = T - (5 \times 9.8)$
$11 = T - 49$
The tension in the string is 60 N.

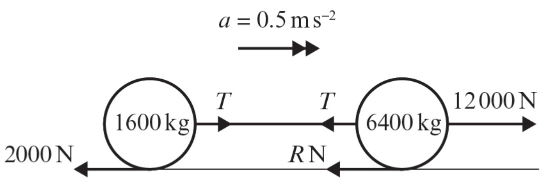
7 $F = ma$, $W = mg$
Taking up as positive



a For the whole system:
$118 - (6 + m)g = (6 + m) \times 2$
$118 = (6 + m)(2 + g) = (6 + m)(2 + 9.8)$
$\frac{118}{11.8} = 6 + m$
$10 = 6 + m$
The mass of B is 4 kg.

b For B:
$ma = T - W$
$4 \times 2 = T - (4 \times 9.8)$
$8 = T - 39.2$
The tension in the string is 47.2 N.

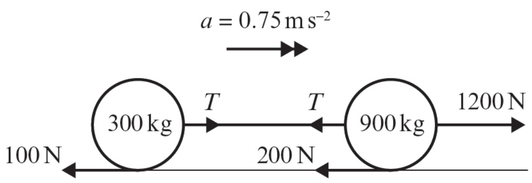
8 $F = ma$



a For the whole system:
$F = 12\,000 - 2000 - R$
$m = 1600 + 6400 = 8000$
$a = 0.5$
$10\,000 - R = 8000 \times 0.5 = 4000$
The resistance to the motion of the engine is 6000 N.

b For the carriage:
$F = T - 2000$, $m = 1600$, $a = 0.5$
$T - 2000 = 1600 \times 0.5 = 800$
The tension in the shunt is 2800 N.

9 $F = ma$



a For the whole system:
$F = 1200 - 1000 - 200 = 900$
$m = 900 + 300 = 1200$
$900 = 1200a$
$a = 900 \div 1200 = 0.75$
The acceleration is 0.75 m s^{-2}, as required.

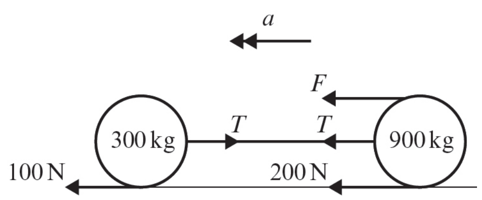
9 b For the trailer:

$F = T - 100$, $m = 300$, $a = 0.75$

$T - 100 = 300 \times 0.75 = 225$

The tension in the towbar is 325 N.

c



Taking ← as positive

Deceleration = α

Force on trailer = resistance to motion + thrust from tow-bar

Using $F = ma$

$100 + 100 = 300\alpha$

$$\alpha = \frac{200}{300} = \frac{2}{3}$$

For car:

$F + 200 - 100 = 900\alpha$

$$F = \left(900 \times \frac{2}{3}\right) - 100 = 500$$

The force the brakes produce on the car is 500 N.