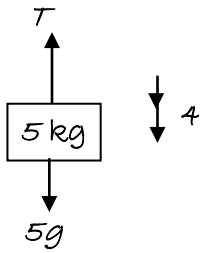
Section 2: Applying Newton's second law

Solutions to Exercise level 2

1. (i)



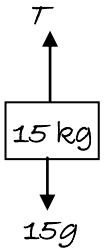
$F = ma$

$5g - T = 5 \times 4$

$T = 5 \times 9.8 - 20 = 29$

The tension is 29 N.

(ii) The pail is moving at constant speed, so the acceleration is zero.

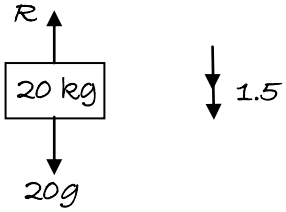


$15g - T = 0$

$T = 15 \times 9.8 = 147$

The tension is 147 N.

2. First stage: acceleration



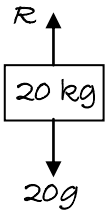
$F = ma$

$20g - R = 20 \times 1.5$

$R = 20 \times 9.8 - 20 \times 1.5 = 166$

The reaction force is 166N.

Second stage: constant speed (so acceleration is zero)

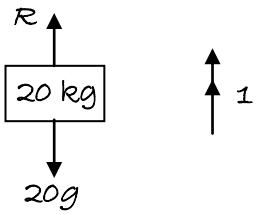


$20g - R = 0$

$R = 20 \times 9.8 = 196$

The reaction force is 196N.

Third stage: deceleration (i.e. negative acceleration)



$F = ma$

$R - 20g = 20 \times 1$

$R = 20 \times 9.8 + 20 \times 1 = 216$

The reaction force is 216N.

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3. (i) $\underset{\sim}{F} = m\underset{\sim}{a}$

$5\underset{\sim}{i} + 2\underset{\sim}{j} + \underset{\sim}{i} - 3\underset{\sim}{j} = 2\underset{\sim}{a}$

$\underset{\sim}{a} = 3\underset{\sim}{i} - \frac{1}{2}\underset{\sim}{j}$

(ii) $\underset{\sim}{v} = \underset{\sim}{u} + \underset{\sim}{a}t$

$0 = \underset{\sim}{u} + 4(3\underset{\sim}{i} - \frac{1}{2}\underset{\sim}{j})$

$\underset{\sim}{u} = -12\underset{\sim}{i} + 2\underset{\sim}{j}$

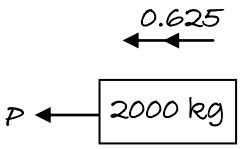
4. $90 \text{ kmh}^{-1} = \frac{90000}{3600} = 25 \text{ ms}^{-1}$

$s = 500$ $\quad v^2 = u^2 + 2as$

$u = 25$ $\quad 0 = 25^2 + 2a \times 500$

$v = 0$ $\quad 1000a = -625$

$a = ?$ $\quad a = -0.625$



$F = ma$

$P = 2000 \times 0.625 = 1250$

$v = u + at$

$0 = 25 - 0.625t$

$t = 40$

It takes 40 seconds to come to rest.

5. During the first 12 seconds:

$t = 12$ $\quad s = ut + \frac{1}{2}at^2$

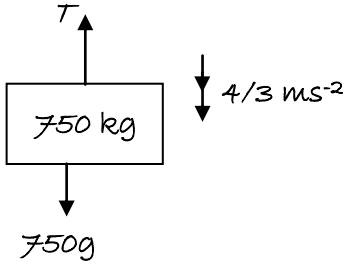
$s = 96$ $\quad 96 = 0 + \frac{1}{2}a \times 144$

$u = 0$ $\quad 96 = 72a$

$a = ?$ $\quad a = \frac{4}{3}$

Acceleration $= \frac{4}{3}$ m s^{-2}

Total mass $= 450 + 300 = 750$ kg



$750g - T = 750 \times \frac{4}{3}$

$T = 750 \times 9.8 - 1000$

$T = 6350$ N

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6. Displacement of particle $= \begin{pmatrix} 2 \\ -1 \end{pmatrix} - \begin{pmatrix} 3 \\ 2 \end{pmatrix} = \begin{pmatrix} -1 \\ -3 \end{pmatrix}$

$\underset{\sim}{s} = \underset{\sim}{u}t + \frac{1}{2}\underset{\sim}{a}t^2$

$\begin{pmatrix} -1 \\ -3 \end{pmatrix} = 2\begin{pmatrix} 1 \\ -2 \end{pmatrix} + \frac{1}{2}\underset{\sim}{a} \times 2^2$

$\begin{pmatrix} -1 \\ -3 \end{pmatrix} = \begin{pmatrix} 2 \\ -4 \end{pmatrix} + 2\underset{\sim}{a}$

$2\underset{\sim}{a} = \begin{pmatrix} -3 \\ 1 \end{pmatrix}$

$\underset{\sim}{a} = \begin{pmatrix} -1.5 \\ 0.5 \end{pmatrix}$

$\underset{\sim}{F} = m\underset{\sim}{a}$

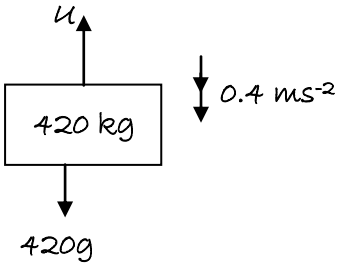
$= 5\begin{pmatrix} -1.5 \\ 0.5 \end{pmatrix}$

$= \begin{pmatrix} -7.5 \\ 2.5 \end{pmatrix}$

7. (i) $420g - U = 420 \times 0.4$

$U = 420 \times 9.8 - 168$

$U = 3948$ N



(ii) Acceleration is now 0.2 ms^{-2} upwards

Let new mass be m kg

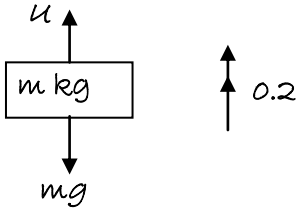
$U - mg = 0.2m$

$3948 - 9.8m = 0.2m$

$3948 = 10m$

$m = 394.8$

Ballast released was 420 – 394.8 kg = 25.2 kg



(iii) $u = 1.5$ $\quad v = u + at$

$v = 0$ $\quad 0 = 1.5 - 0.2t$

$a = -0.2$ $\quad t = 7.5$

$t = ?$

It continues to fall for 7.5 seconds.

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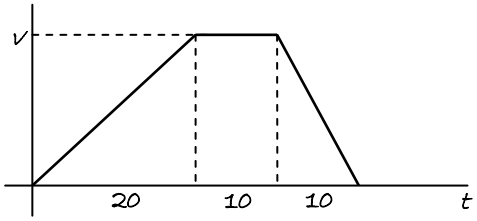
8. Velocity-time graph for the whole journey:



Area under graph = distance travelled

$\frac{1}{2} \times 20V + 10V + \frac{1}{2} \times 10V = 50$

$25V = 50$

$V = 2$

So the maximum speed attained is 2 m s^{-1}.

First stage (acceleration)

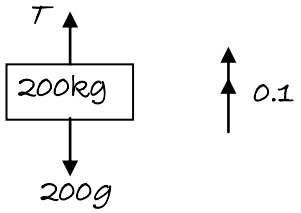
Acceleration $= \frac{2}{20} = 0.1$ m s^{-2}.

$T - 200g = 200 \times 0.1$

$T = 200 \times 9.8 + 20$

$T = 1980$

Tension in cable = 1980 N



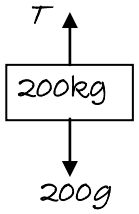
Second stage (constant speed)

$T - 200g = 0$

$T = 200 \times 9.8$

$T = 1960$

Tension in cable = 1960 N



Third stage (deceleration)

Deceleration $= \frac{2}{10} = 0.2$

$200g - T = 200 \times 0.2$

$T = 200 \times 9.8 - 40$

$T = 1920$

Tension in cable = 1920 N