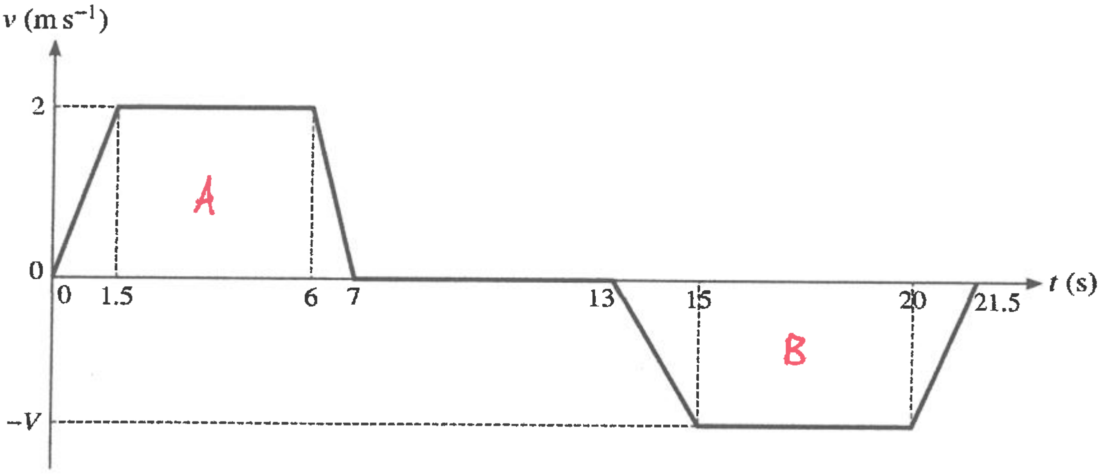
4



An elevator moves vertically, supported by a cable. The diagram shows a velocity-time graph which models the motion of the elevator. The graph consists of 7 straight line segments.

The elevator accelerates upwards from rest to a speed of $2\,\text{m s}^{-1}$ over a period of 1.5 s and then travels at this speed for 4.5 s, before decelerating to rest over a period of 1 s.

The elevator then remains at rest for 6 s, before accelerating to a speed of $V\,\text{m s}^{-1}$ downwards over a period of 2 s. The elevator travels at this speed for a period of 5 s, before decelerating to rest over a period of 1.5 s.

(a) Find the acceleration of the elevator during the first 1.5 s. [1]

$s =$ | $v = u + at$

$u = 0$ | $2 = 0 + 1.5a$

$v = 2$ | $a = \frac{2}{1.5}$

$a =$ | $= \frac{4}{3}\,\text{ms}^{-2}$

$t = 1.5$

(b) Given that the elevator starts and finishes its journey on the ground floor, find V. [2]

If elevator starts and finishes in same place, displacements A and B are equal: Area A = Area B

$\frac{1}{2}(4.5 + 7) \times 2 = \frac{1}{2}(5 + 8.5) \times V$

$\frac{1}{2}(11.5) \times 2 = \frac{1}{2}(13.5) \times V$

$11.5 = 6.75V$

$V = 1.70\,\text{ms}^{-1}$

(c) The combined weight of the elevator and passengers on its upward journey is 1500 kg. Assuming that there is no resistance to motion, find the tension in the elevator cable on its upward journey when the elevator is decelerating. [3]

$s =$ | $v = u + at$

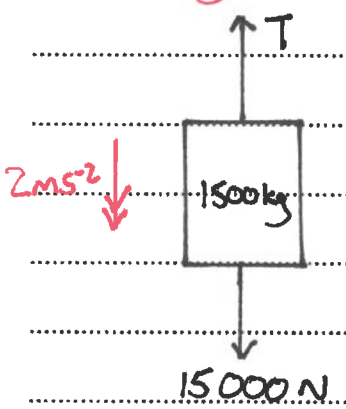
$u = 2$ | $0 = 2 + a \times 1$

$v = 0$ | $0 = 2 + a$

$a =$ | $a = \underline{-2\ \text{ms}^{-2}}$

$t = 1$

Force diagram:



$R(\uparrow)$: $T - 15000 = ma$

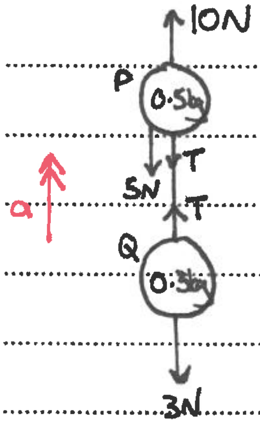
$T - 15000 = 1500 \times -2$

$T - 15000 = -3000$

$T = \underline{12000\ \text{N}}$

2 Two particles P and Q, of masses 0.5 kg and 0.3 kg respectively, are connected by a light inextensible string. The string is taut and P is vertically above Q. A force of magnitude 10 N is applied to P vertically upwards.

Find the acceleration of the particles and the tension in the string connecting them. [5]



Q:

$R(\uparrow): T - 3 = ma$

$T - 3 = 0.3a$ (1)

P:

$R(\uparrow): 10 - 5 - T = ma$

$5 - T = 0.5a$ (2)

(1) + (2):

$5 - 3 = 0.3a + 0.5a$

$2 = 0.8a$

$\underline{a = 2.5\,ms^{-2}}$

Sub into (1): $T - 3 = 0.3 \times 2.5$

$T - 3 = 0.75$

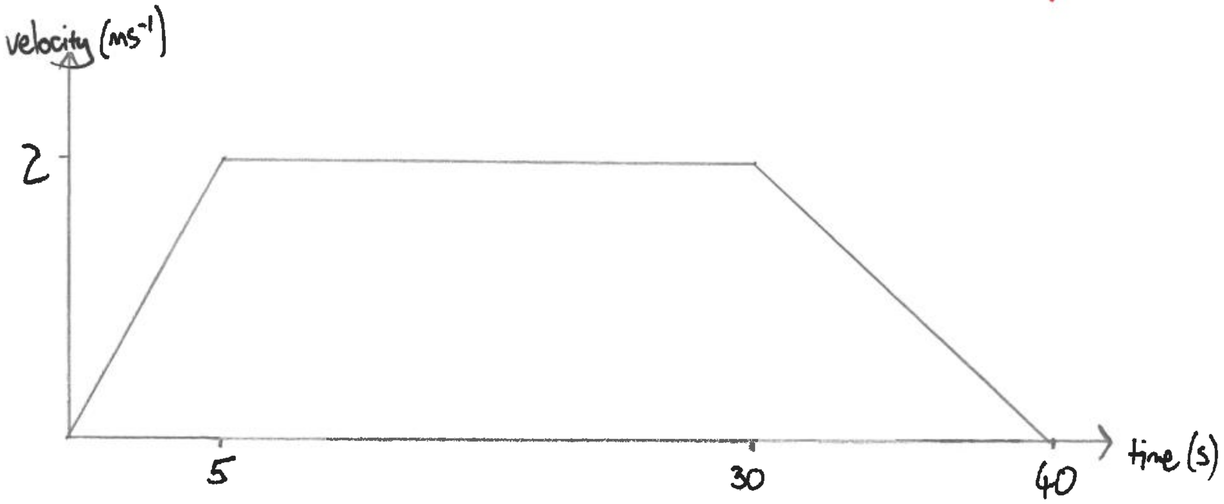
$\underline{T = 3.75\,N}$

6 An elevator is pulled vertically upwards by a cable. The elevator accelerates at $0.4\,\mathrm{m\,s^{-2}}$ for 5 s, then travels at constant speed for 25 s. The elevator then decelerates at $0.2\,\mathrm{m\,s^{-2}}$ until it comes to rest.

(a) Find the greatest speed of the elevator and hence draw a velocity-time graph for the motion of the elevator. [3]

$s =$ | $v = u + at$
$u = 0$ | $= 0 + 0.4 \times 5$
$v =$ | $= 2\,\mathrm{ms^{-1}}$
$a = 0.4$
$t = 5$

deceleration: $s =$ | $v = u + at$
$u = 2$ | $0 = 2 + (-0.2)t$
$v = 0$ | $-2 = -0.2t$
$a = -0.2$ | $t = 10\mathrm{s}$
$t =$



(b) Find the total distance travelled by the elevator. [2]

distance = area = $\frac{1}{2}(25 + 40) \times 2$

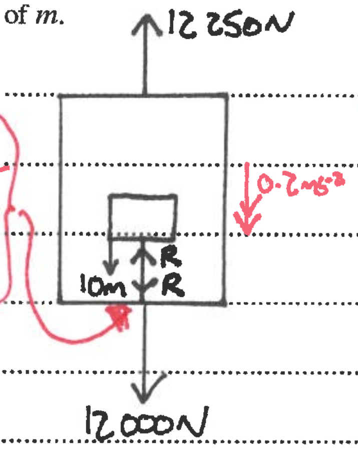
$= \frac{1}{2} \times 65 \times 2$

$= 65\mathrm{m}$

The mass of the elevator is 1200 kg and there is a crate of mass m kg resting on the floor of the elevator.

(c) Given that the tension in the cable when the elevator is decelerating is 12 250 N, find the value of m. [3]

Drawing an imaginary tow-bar helps in questions like these



Consider whole system:

$$R(\uparrow): 12250 - 12000 - 10m = (1200+m)a$$
$$250 - 10m = (1200+m) \times -0.2$$
$$250 - 10m = -240 - 0.2m$$
$$490 = 9.8m$$
$$m = \underline{\underline{50\text{kg}}}$$

(d) Find the greatest magnitude of the force exerted on the crate by the floor of the elevator, and state its direction. [3]

Greatest magnitude will be when elevator is accelerating (at 0.4ms^{-2})

Consider crate:

$$R(\uparrow): R - 10m = ma$$
$$R - 10\times 50 = 50 \times 0.4$$
$$R - 500 = 20$$
$$R = \underline{\underline{520\text{N upwards}}}$$

