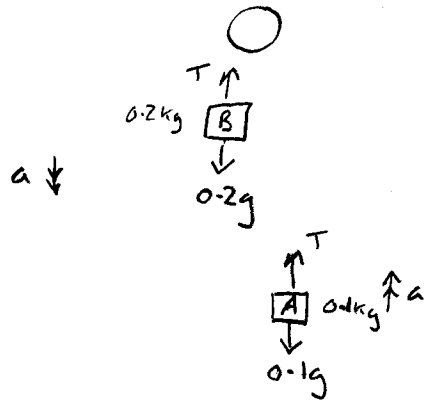
1) i)



ii) Block A accelerates upwards

Using $F = ma$ for Block A

$$T - 0.1g = 0.1a \quad (1)$$

Block B accelerates downwards

Using $F = ma$ for Block B

$$0.2g - T = 0.2a \quad (2)$$

iii) (1)+(2) $0.1g = 0.3a$

$$\frac{0.98}{0.3} = a$$

$$a = 3.27 \text{ ms}^{-2}$$

Subst for a in (1)

$$T - 0.98 = 0.327$$

$$T = 1.31 \text{ N}$$

iv) B falls 2m with acceleration of 3.27 ms^{-2}

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

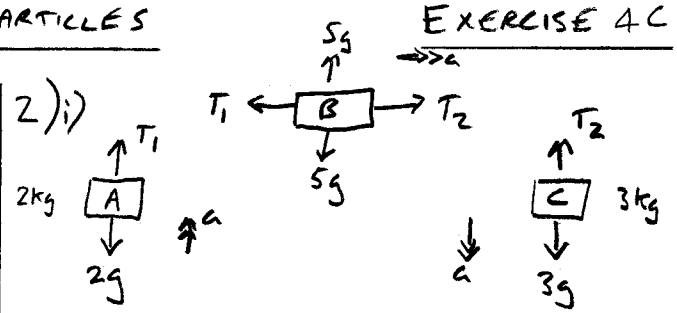
$$2 = 0t + \tfrac{1}{2} \times 3.27t^2$$

$$2 = 1.635t^2$$

$$\frac{2}{1.635} = t^2$$

$$t = 1.11 \text{ s} \quad \text{to 2dp}$$

2) i)



ii) For Block A moving upwards

$$T_1 - 2g = 2a \quad (1)$$

For Block B moving right

$$T_2 - T_1 = 5a \quad (2)$$

For Block C moving down

$$3g - T_2 = 3a \quad (3)$$

iii)

From (1) $T_1 = 2a + 2g$

$$T_1 = 2a + 20$$

From (3) $3g - 3a = T_2$

$$30 - 3a = T_2$$

Subst for T_1 and T_2 in (2)

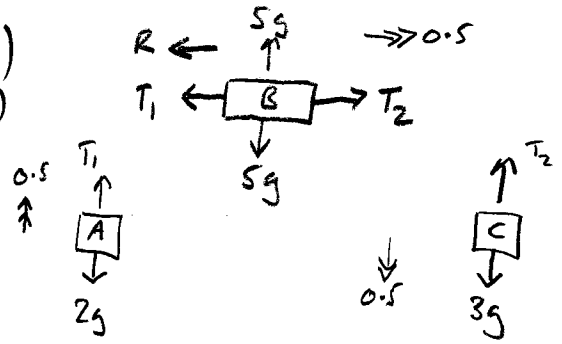
$$30 - 3a - (2a + 20) = 5a$$
$$30 - 3a - 2a - 20 = 5a$$
$$10 = 10a$$

$$a = 1 \text{ ms}^{-2}$$

$\therefore$ $T_1 = 2 \times 1 + 20 = 22 \text{ N}$

$T_2 = 30 - 3 \times 1 = 27 \text{ N}$

2 cont) iv)



For Block A moving upwards

$$T_1 - 2g = 2 \times 0.5$$
$$T_1 = 1 + 2g$$
$$T_1 = 21 \text{ N}$$

For Block C moving downwards

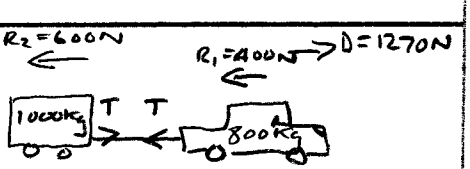
$$3g - T_2 = 3 \times 0.5$$
$$30 - 1.5 = T_2$$
$$T_2 = 28.5 \text{ N}$$

For Block B moving right

$$T_2 - T_1 - R = 5 \times 0.5$$
$$28.5 - 21 - R = 2.5$$
$$7.5 - 2.5 = R$$
$$R = 5 \text{ N}$$

Frictional force = 5 N

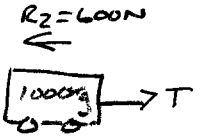
3) i)



For whole system $F = ma$

$$1270 - 400 - 600 = (1000 + 800)a$$
$$270 = 1800a$$
$$a = \frac{270}{1800} = 0.15 \text{ ms}^{-2}$$

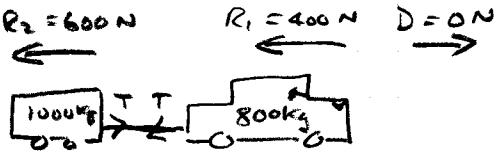
ii)



Eqn of motion for caravan

$$T - 600 = 1000 \times 0.15$$
$$T = 150 + 600$$
$$T = 750 \text{ N}$$

iii)



For whole system $F = ma$

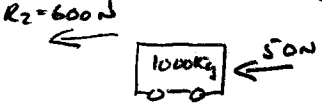
$$0 - 600 - 400 = 1800a$$
$$-1000 = 1800a$$
$$-0.556 = a$$

For caravan eqn of motion

$$T - 600 = 1000 \times -0.556$$
$$T = -556 + 600$$
$$T = 44 \text{ N}$$

$T > 0$ ∴ towbar in tension

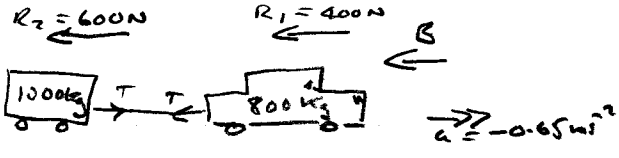
iv) Caravan brakes come on when there is a 50 N compression force



Eqn of motion

$$0 - 50 - 600 = 1000a$$
$$-650 = 1000a$$
$$a = -0.65 \text{ ms}^{-2}$$

when caravan brakes come on



$$F = ma$$
$$0 - 400 - 600 - B = 1800 \times -0.65$$

3 cont) $-1000 - B = -1170$

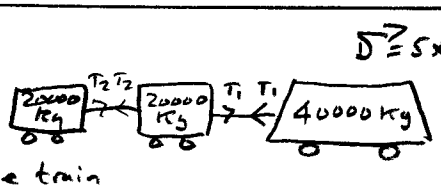
$-1000 + 1170 = B$

$170 = B$

Car braking force required = 170 N

---

4)



Whole train

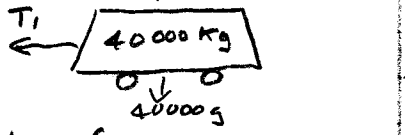
i) Eqn of motion $F = ma$

$5 \times 10^4 = 80000a$

$\frac{50000}{80000} = a$

$a = 0.625 \text{ ms}^{-2}$

ii)



Eqn of motion for engine

$D - T_1 = 40000a$

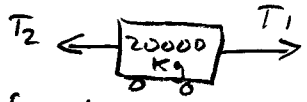
$50000 - T_1 = 40000 \times 0.625$

$50000 - T_1 = 25000$

$50000 - 25000 = T_1$

$T_1 = 25000 \text{ N}$

iii) 1st truck



Eqn of motion

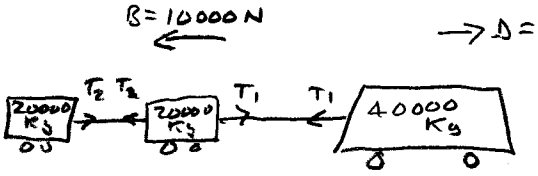
$T_1 - T_2 = 20000 \times 0.625$

$25000 - T_2 = 12500$

$25000 - 12500 = T_2$

$T_2 = 12500 \text{ N}$

iv)



Whole train eqn of motion

$D - B = 80000a$

$50000 - 10000 = 80000a$

$40000 = 80000a$

$\Rightarrow \quad a = 0.5 \text{ ms}^{-2}$

2nd truck

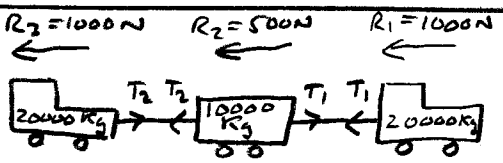
Eqn of motion

$T_2 = 20000 \times 0.5$

$T_2 = 10000 \text{ N}$

---

5)



i) Whole train eqn of motion

$D - R_1 - R_2 - R_3 = 50000 \times a$

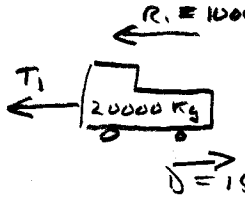
$15000 - 1000 - 500 - 1000 = 50000a$

$12500 = 50000a$

$\Rightarrow \quad a = 0.25 \text{ ms}^{-2}$

ii) See diagram above.

Front train



Eqn of motion

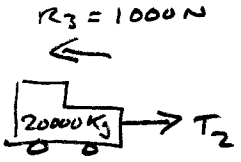
$15000 - 1000 - T_1 = 20000 \times 0.25$

$14000 - T_1 = 5000$

$14000 - 5000 = T_1$

$\Rightarrow \quad T_1 = 9000 \text{ N}$

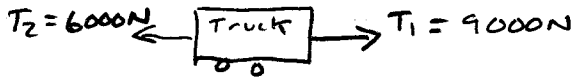
5 cont) Rear Train



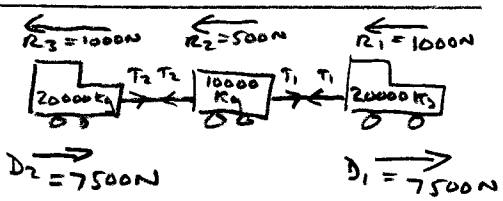
Eqn of motion

$$T_2 - 1000 = 20000 \times 0.25$$
$$T_2 - 1000 = 5000$$
$$T_2 = 6000 \text{ N}$$

Middle truck



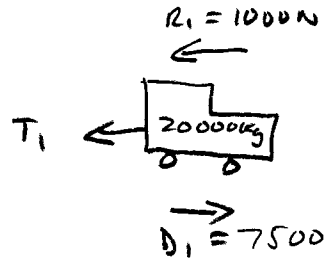
iii)



Whole train eqn of motion

$$D_1 + D_2 - R_1 - R_2 - R_3 = 50000a$$
$$7500 + 7500 - 1000 - 500 - 1000 = 50000a$$
$$12500 = 50000a$$
$$\Rightarrow a = 0.25 \text{ ms}^{-2}$$

Front train

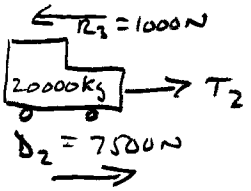


Eqn of motion

$$D_1 - R_1 - T_1 = 20000 \times 0.25$$
$$7500 - 1000 - T_1 = 5000$$
$$6500 - 5000 = T_1$$

$$\underline{T_1 = 1500 \text{ N}}$$

Rear train



Eqn of motion

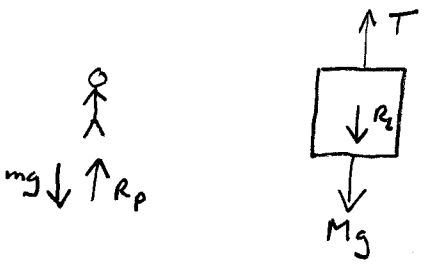
$$D_2 + T_2 - R_2 = 20000 \times 0.25$$
$$7500 + T_2 - 1000 = 5000$$
$$T_2 = 5000 - 7500 + 1000$$
$$\underline{T_2 = -1500 \text{ N}}$$

First coupling 1500 N Tension
Second coupling 1500 N Compression

Rear engine is now pushing rather than being pulled along by truck

6)

i)



ii) $m = 50$ kg $M = 450$ kg

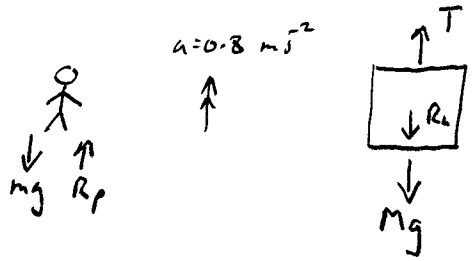
For passenger stationary

$$R_p = mg$$
$$\underline{R_p = 50 \times 9.8 = 490 \text{ N}}$$
$$\underline{R_L = mg = 490 \text{ N}}$$

For lift stationary

$$T = R_L + Mg$$
$$T = 490 + 450 \times 9.8$$
$$\underline{T = 4900 \text{ N}}$$

6 cont)



Passenger eqn of motion

$R_p - mg = ma$

$R_p - 490 = 50 \times 0.8$

$R_p = 40 + 490 = 530\ N$

$R_L = R_p = 530\ N$

Lift eqn of motion

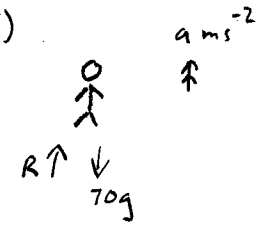
$T - R_L - Mg = Ma$

$T = Ma + R_L + Mg$

$T = 450 \times 0.8 + 530 + 450 \times 9.8$

$T = 5300\ N$

7) i)



ii) Eqn of motion for man

$R - 70g = 70a$

$770 - 700 = 70a$

$70 = 70a$

$a = 1\ ms^{-2}$

iii) From t=0 to 2 s lift stationary

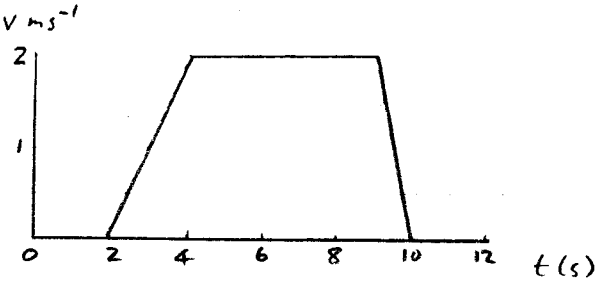
From t=2 to 4 s lift accelerating at $1\ ms^{-2}$ upwards

From t=4 to 9 s lift constant speed upwards

From t=9 to 10 s lift decelerates at $2\ ms^{-2}$

From t=10 to 12 s lift stationary

iv)

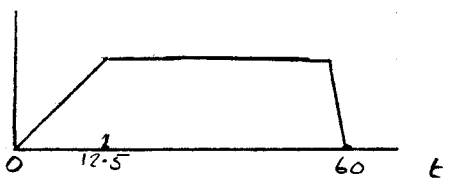


Height ascended = area under graph

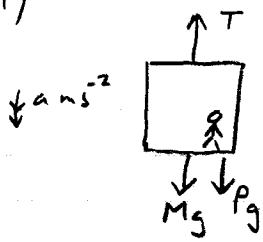
Area of trapezium $\frac{2}{2}(8+5)$

Height = 13 m

8) i)



ii)



P = Mass of passengers = 80 × 12 = 960 kg

Eqn of motion for whole system

$Mg + Pg - T = (M+P)a$

$5000 \times 9.8 + 960 \times 9.8 - 53640 = 5960a$

$4768 = 5960a$

$a = 0.8\ ms^{-2}$

8 cont) Lift accelerates for 12.5 s

iii) at 0.8 ms^{-2}

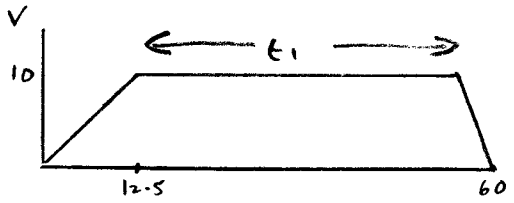
Using

$v = u + at$

$v = 0 + 0.8 \times 12.5$

$v = 10\ ms^{-1}$

Constant speed part of journey is at 10 ms^{-1}



Distance travelled in 60s = 500m

= Area under graph

$\therefore \frac{10}{2}(60 + t_1) = 500$

$10(60 + t_1) = 1000$

$60 + t_1 = 100$

$t_1 = 40$ s

Travels at constant speed for 40 s

12.5s for acceleration

40 s constant speed

leaves $60 - (12.5 + 40) = 7.5$ s for deceleration

Using $v = u + at$

$0 = 10 + 7.5a$

$-10 = 7.5a$

$a = -1.333\ ms^{-2}$

Deceleration = 1.333 ms^{-2}

iv) Maximum T is when lift is decelerating

Eqn of motion for whole system

$Mg + Pg - T = (M+P)a$

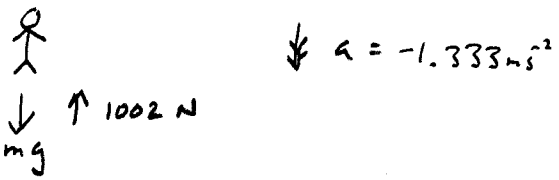
$5000 \times 9.8 + 960 \times 9.8 - T = 5960 \times -1.333$

$58408 - T = -7945$

$58408 + 7945 \quad T$

$T = 66,353$ N

N)



For miner $mg - 1002 = m \times -1.333$

$9.8m - 1002 = -1.333m$

$11.133m = 1002$

$m = 90$ kg

Miner has mass of 90 kg