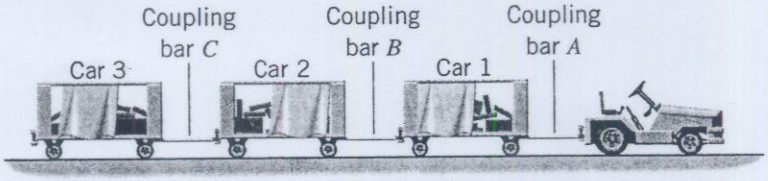
Connected objects problems

1. Two separate blocks with masses m1 = 10 kg and m2 = 5 kg sit next to each other on a level surface. You push both by applying a force of 2.0 N to m1. What is the acceleration of each block? What force exists between the two blocks as a result of your pushing force?

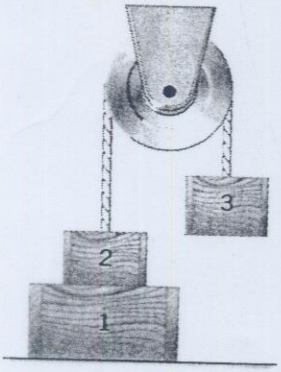
2. At the airport, luggage is unloaded from a plane into the three carts of a luggage carrier, as shown. The acceleration of the carrier is 0.12 $m/s^2$, and friction is negligible. The coupling bars have negligible mass.

a. If each cart is loaded to have a total mass of 80 kg, find the tension in each coupling bar.

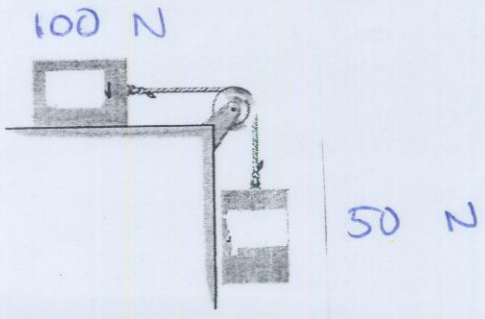
b. If 35 kg of luggage is moved from cart 1 to cart 2, which tensions change?

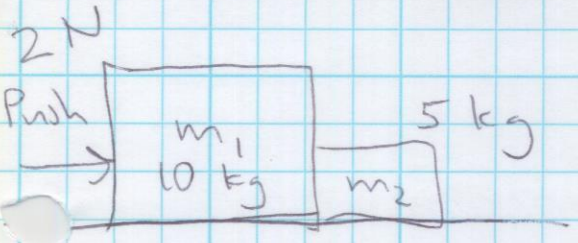



2. In the drawing, box 1 rests on a table, with box 2 resting on top of box 1. A massless rope passes over a massless frictionless pulley. One end of the rope is connected to box 2, and the other end is connected to box 3. The weights of the three boxes are w1 = 55 N, w2 = 35 N, and w3 = 28 N. Find the magnitude of the normal force that the table exerts on box 1.




4. In the system below, what coefficient of static friction is needed between the 100 N block and the tabletop to hold the system motionless?






Do it first.

Let's say no friction

"One big object" – only one accel in this problem

$\therefore a_1 = a_2$

$\therefore \frac{\Sigma F_1}{m_1} = \frac{\Sigma F_2}{m_2}$

$\Sigma F = ma$

$2N = (15\ kg)\,a$

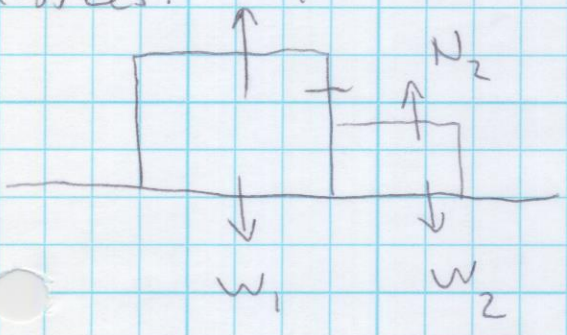
$a = 0.133\ m/s^2$

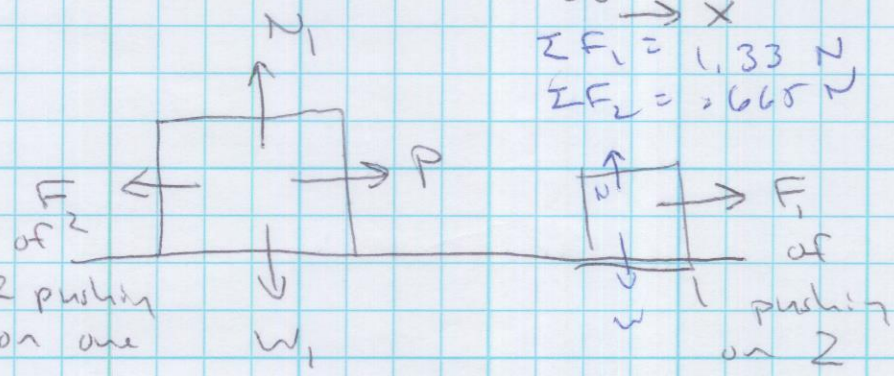
0.133 → x

$\Sigma F_1 = 1.33\ N$

$\Sigma F_2 = .665\ N$

Forces:




3rd law: $F_1 = F_2$ in magnitude

call both F

1: $\Sigma F = ma$

$P - F = m_1 a_1$

$a_1 = \frac{P - F}{m_1}$

2: $\Sigma F = ma$

$F = m_2 a_2$

$a_2 = F/m_2$

but $a_1 = a_2$, so

$\frac{P - F}{m_1} = \frac{F}{m_2}$

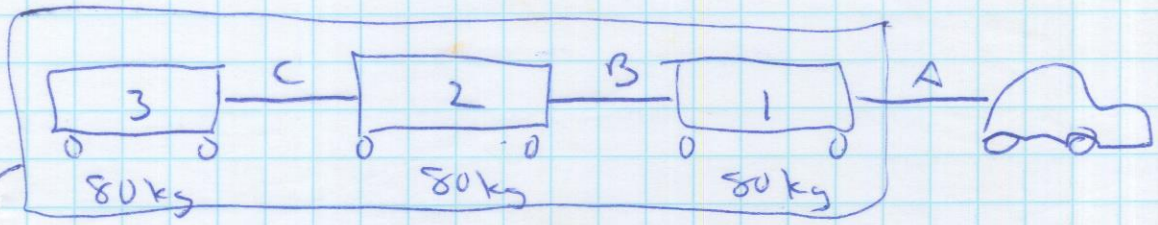
$m_2 P - m_2 F = m_1 F$

$F(m_1 + m_2) = m_2 P$

$F = \frac{P m_2}{m_1 + m_2} = \frac{(2N)(5\ kg)}{10\ kg + 5\ kg} = 0.666\ N$

So $a_1 = \frac{2 - .666}{10} = 0.133$

$a_2 = \frac{0.666}{5} = 0.133$




One:

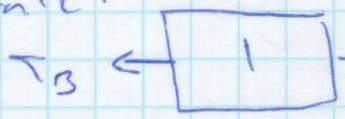
Big: $m_{TOTAL} = 240\ kg$ $\quad a = 0.12\ m/s^2$

$$\Sigma F = ma = (240\ kg)(0.12\ m/s^2)$$
$$= 29\ N$$

Supplied by A:

$$T_A = 29\ N$$

Separate:




$$\Sigma F_1 = m_1 a_1$$
$$T_A - T_B = m_1 a_1$$
$$29\ N - T_B = (80\ kg)(0.12\ \tfrac{m}{s^2})$$
$$T_B = 19\ N$$


$$\Sigma F_2 = m_2 a_2$$
$$T_B - T_C = m_2 a_2$$
$$19\ N - T_C = (80\ kg)(0.12\ m/s^2)$$
$$T_C = 9.4\ N$$

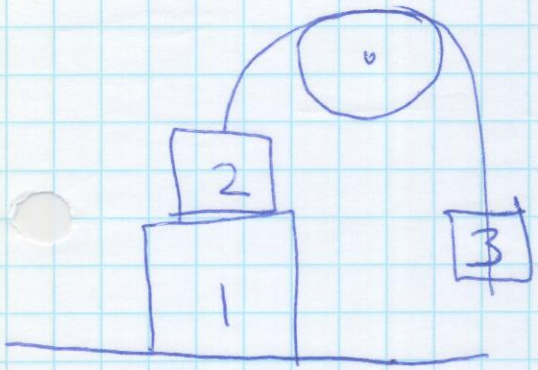
Check:


$$\Sigma F_3 = m_3 a_3$$
$$T_C = m_3 a_3 \quad ?$$
$$9.4\ N = (80\ kg)(0.12\ \tfrac{m}{s^2}) \quad \checkmark$$

5. Total mass 1 + 2 + 3 is same, so $T_A$ same
mass of 3 is same, so $T_C$ same

mass of 2 up from 80 to 115 kg; $T_B$ will change since that bar is accelerating more mass.

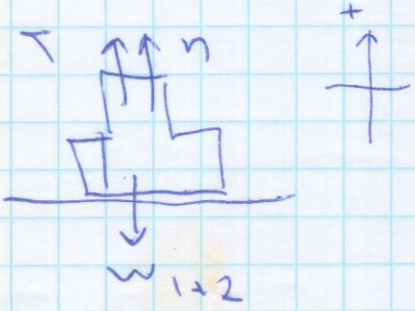
$$\text{new } T_B = m_2 a_2 + T_C$$
$$= (80 + 35\ kg)(0.12\ \tfrac{m}{s^2}) + 9.4\ N$$
$$= 23\ N$$




Is this a 1D or 2D problem?

Is T on left same magnitude as right, or different?

Let 1+2 be one big object:

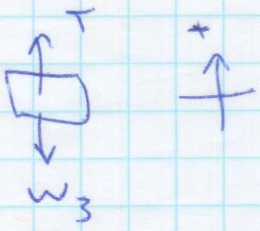



$$\Sigma F_{1+2} = m_{1+2} a_{1+2}$$

$$T + n - w_{1+2} = 0$$

$$T + n = w_{1+2}$$

Obj 3:




$$\Sigma F_3 = m_3 a_3$$

$$T - w_3 = 0$$

$$T = w_3$$

1+2: $T + n = w_{1+2}$

3: $T = w_3$

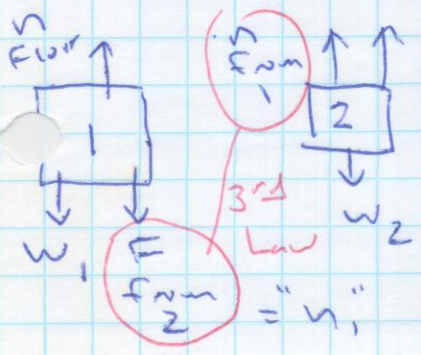
$$w_3 + n = w_{1+2}$$

$$n = w_{1+2} - w_3 = (55 + 35\ N) - 28\ N$$

$$n = 62\ N$$

$n_{Floor}$

Suppose we also want forces between 1 & 2:




$$\Sigma F_1 = n_{Floor} - w_1 - n_1 = 0$$

$$62\ N = 55\ N + n_1$$

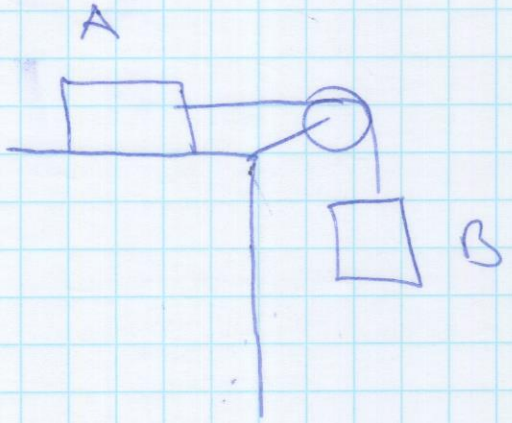
$$n_1 = 7\ N$$

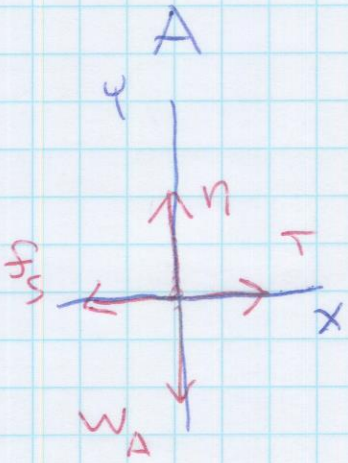
$$\Sigma F_2 = T + n_1 - w_2 = 0$$

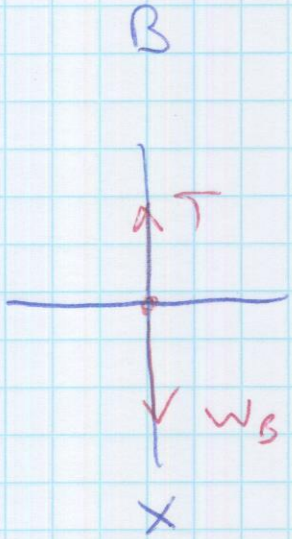
$$T = 35 - 7\ N = 28\ N$$ ✓

WHICH IS WEIGHT OF #3

24.




A: $\Sigma F_x = m_A a_x$ $\quad$ $\Sigma F_y = m_A a_y$

$T - f_s = 0$ $\quad$ $n - w_A = 0$

$T = \mu_s n$ $\quad$ $n = m_A g$

$T = \mu_s m_A g$

B: $\Sigma F_x = m_B a_x$

$w_B - T = 0$

$T = m_B g = 50\ N$

$T = \mu_s m_A g$

$50\ N = \mu_s (100\ N)$

$\mu_s = 0.50$