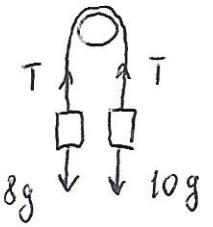
Forces worksheet 3

1. Two masses 8 kg and 10 kg are suspended by a light inextensible string over a smooth pulley.
a Find the tension in the string.
b Find the acceleration of the system.



$10g - T = 10a$ (1)

$T - 8g = 8a$ (2)

(1) + (2)

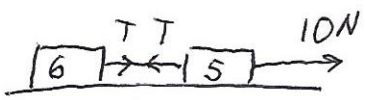
$2g = 18a$

$a = \frac{g}{9} = 1.09 \, m s^{-2}$

$T = 10(g - a)$

$T = 87.1 \, N$

2. Two particles of mass 6 kg and 5 kg connected with a light inextensible string are pulled along a smooth horizontal plane with a force of 10 N. Find:
a the acceleration of the system
b the tension in the string.



For 6 kg : $T = 6a$ (1)

For 5 kg : $10 - T = 5a$ (2)

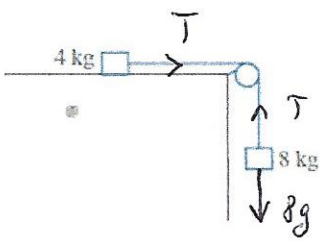
(1) + (2)

$10 = 11a$

$a = 0.91 \, m s^{-2}$

$T = 6 \times 0.91 = 5.46 \, N = 5.5 \, N$

3. The diagram shows a particle of mass 4 kg on a smooth horizontal table. The particle is connected by a light inelastic string which passes over a smooth pulley to a particle of mass 8 kg which hangs vertically. Find:
a the acceleration of the system
b the tension in the string



For 4 kg : $T = 4a$ (1)

8 kg : $8g - T = 8a$ (2)

(1) + (2)

$8g = 12a$

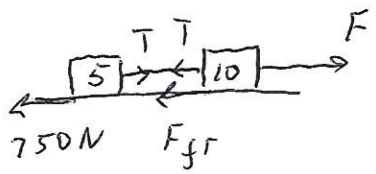
$a = \frac{2g}{3}$

$a = 6.5 \, m s^{-2}$

$T = 4 \times 6.5$

$T = 26 \, N$

4. A truck of mass 10 tonnes pulls a trailer of mass 5 tonnes with an acceleration of magnitude 2 $m\,s^{-2}$. The truck exerts a tractive force of magnitude 40 000 N. If the trailer has resistance to motion of 750 N:
a what is the tension in the coupling?
b what is the resistance to motion of the truck?



For trailer: $T - 750 = 5000 \times 2$ (1)

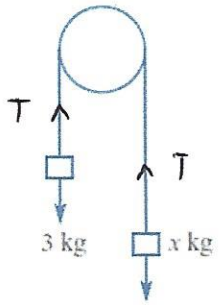
For truck: $40000 - T - F_{fr} = 10000 \times 2$ (2)

From (1) $T = 10750\ N$

$40000 - 10750 - F_{fr} = 20000$

$F_{fr} = 9250\ N$

5. Two particles of respective mass 3 kg and x kg ($x > 3$) are connected by a light inextensible string passing over a smooth fixed pulley. The system is released from rest while the hanging portion of the string is taut and vertical. Given that the tension in the string is 37.5 N, calculate the value of x.



$xg - T = xa$ (1)

$T - 3g = 3a$ (2)

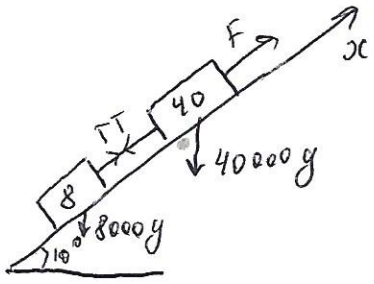
From (2): $a = \dfrac{T - 3g}{3}$

$a = \dfrac{37.5 - 3 \times 9.8}{3} = 2.7\ ms^{-2}$

From (1): $x(g - a) = T$

$x = \dfrac{T}{g - a}$ $\quad x = \dfrac{37.5}{9.8 - 2.7} = 5.3\ kg$

6. An engine of mass 40 tonnes is pulling a truck of mass 8000 kg up a smooth plane inclined at the angle of 10°. If the tractive force exerted by the engine is 85 000 N, calculate:
a the acceleration of the engine
b the tension in the coupling between the engine and the truck



Truck: $T - 8000g\sin 10° = 8000a$ (1)

Engine: $F - T - 40000g\sin 10° = 40000a$ (2)

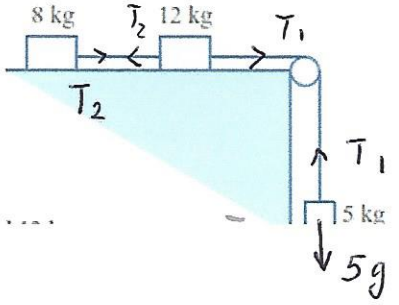
(1) + (2) $\quad F - 48000 \times 9.8 \sin 10° = 48000a$

$a = 0.07\ ms^{-2}$

$T = 8000(a + g\sin 10°)$

$T = 14174\ N$

7. The diagram shows masses of 8 kg and 12 kg lying on a smooth horizontal table and joined, by a light inextensible string, to a mass of 5 kg hanging freely. This string passes over a smooth pulley at the edge of the table.
The system is released from rest. Find:
a the tension in the string connecting the 8 kg and 12 kg masses
b the tension in the string connecting the 12 kg and 5 kg masses
c the acceleration of the system



5 kg : $5g - T_1 = 5a$ (1)

12 kg : $T_1 - T_2 = 12a$ (2)

8 kg : $T_2 = 8a$ (3)

Sub in T_2 from (3) into (2)

$T_1 - 8a = 12a$

$T_1 = 20a$ (4)

(1) + (4)

$5g = 25a$

$a = \frac{g}{5}$

$a = 1.96 \text{ m s}^{-2}$

$T_1 = 20 \times 1.96$

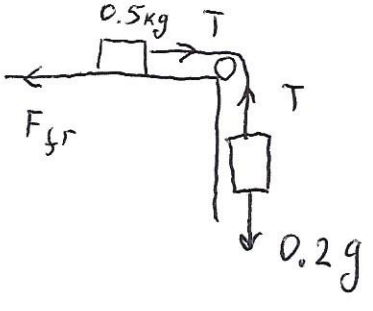
$T_1 = 39.2 \text{ N}$

$T_2 = 8 \times 1.96$

$T_2 = 15.68$

$= 15.7 \text{ N}$

8. hanging mass of 200 g drags a mass of 500 g along a rough table three metres from rest in three seconds. What is the friction force?



$S = \frac{at^2}{2}$ $\quad a = \frac{2S}{t^2}$ $\quad a = \frac{2 \times 3}{3^2} = 0.67 \text{ m s}^{-2}$

$T - F_{fr} = 0.5a$ (1)

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

(1) + (2)

$0.2g - F_{fr} = 0.7a$

$F_{fr} = 0.2g - 0.7a$

$F_{fr} = 0.2 \times 9.8 - 0.7 \times 0.67$

$= 1.5 \text{ N}$

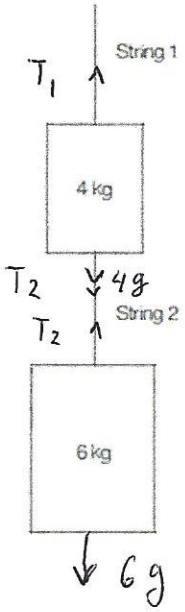
9. Two masses are connected by a string and are hanging from the ceiling of an elevator as shown. Find the tensions in each string if elevator:

a moving up at 3.0 $m\,s^{-1}$

b moving down at 3.0 $m\,s^{-2}$

c moving up at 3.0 $m\,s^{-2}$

d Newton's third law is sometimes stated as 'To every action there is an equal and opposite reaction'. If the weight (the gravitational force by Earth) of the 4 kg mass is taken as the 'action' force, identify the corresponding 'reaction' force and give its direction.



a) $a = 0$

$T_2 - 6g = 0$ (1)

$T_1 - T_2 - 4g = 0$ (2)

(1) + (2) $T_1 = 10g$ $T_1 = 98\ N$ $T_2 = 58.8\ N$

b) $6g - T_2 = 6 \times 3$ (1)

$4g + T_2 - T_1 = 4 \times 3$ (2)

(1) + (2) $10g - T_1 = 30$ $T_1 = 10g - 30 = 68\ N$

$T_2 = 6g - 18$ $T_2 = 40.8\ N$

c) $T_1 - 4g - T_2 = 4 \times 3$ (1)

$T_2 - 6g = 6 \times 3$ (2)

From (2) $T_2 = 6g + 18$ $T_2 = 76.8\ N$

Sub in (1) $T_1 = 4g + 76.8 + 12$

$T_1 = 128\ N$

d) As action force is by Earth on 4kg down, reaction will be 4kg on Earth up.