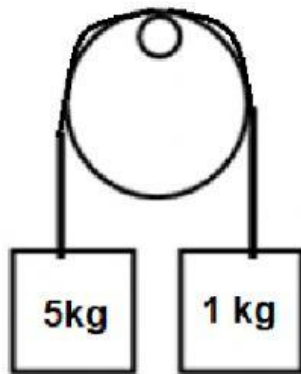


Newton laws worksheet 11

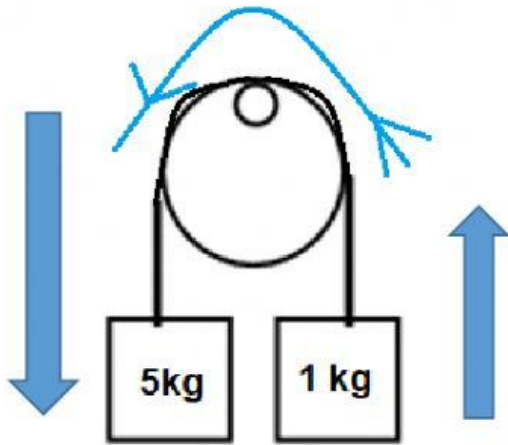
Objects not in a straight line

Eg 1. Calculate the (a) acceleration and (b) the tension in the string between the two boxes (F_T) of the system below



Look at this video first before starting the question

<https://www.youtube.com/watch?v=kvCnjVSpuv0&t=308s>



Firstly determine in what direction this system will move. Since the heavier object is the 5kg. The whole system will move in the direction of the 5kg block (**anti-clockwise**)

There is no normal force on the object, since it is not resting on a surface.

For acceleration – look at the system as a whole (add all the masses)

$$F_{\text{net}} = m \cdot a$$

$$F_g(5\text{kg}) - F_g(1\text{kg}) = m \cdot a$$

$$m \cdot g - m \cdot g = m \cdot a$$

$$5(9,8) - 1(9,8) = 6 \cdot a$$

$$a = \text{_____ m.s}^{-2} \text{ anti-clockwise}$$

The only forces that are going to cause the system to move is gravity. There is

-no frictional force and

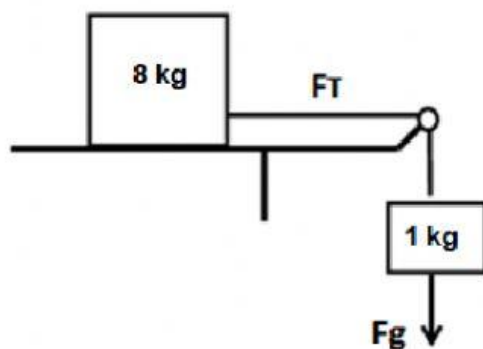
-remember that the tension cancels out within the system

To calculate the tension – isolate all the blocks

5 kg object	1 kg object
Direction of motion	
$F_{\text{net}} = m \cdot a$ $F_g - F_T = m \cdot a$ $m \cdot g - F_T = m \cdot a$ $5(9,8) - F_T = 5(6,53)$ $F_T = 16,35 \text{ N}$	$F_{\text{net}} = m \cdot a$ $F_T - F_g = m \cdot a$ $F_T - m \cdot g = m \cdot a$ $F_T - 1(9,8) = 1(6,53)$ $F_T = 16,33 \text{ N}$

Watch this video before looking at the next example

Eg 2. Calculate the (a) acceleration and (b) the tension in the string between the two boxes (F_T) of the system below



When determining the acceleration we usually look at the system as a whole – however:

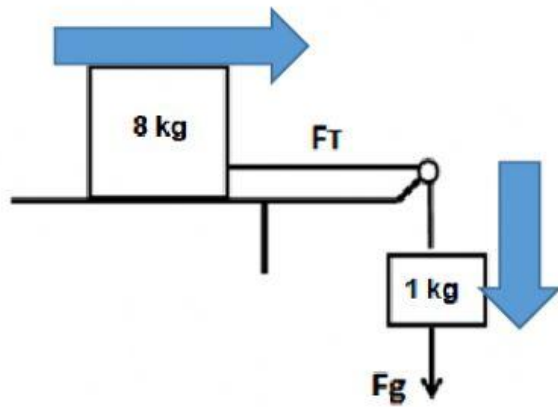
We are not allowed to in these situations, since the forces on objects are not moving in the same straight line

$$F_{\text{net}} = m \cdot a$$

$$F_g = m \cdot a$$

$$1(9.8) = (8+1) \cdot a$$

$$a = 1.09 \text{ m} \cdot \text{s}^{-2}$$



The 8 kg object is moving to the right and the 1 kg block is moving downwards.
Thus we need to break to objects up and then solve the equations simultaneously

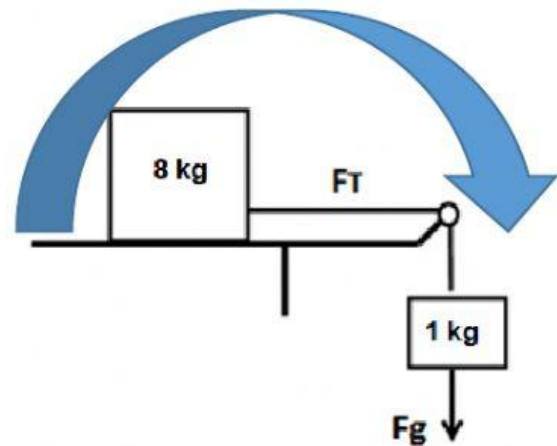
8 kg object	1 kg object
$F_{\text{net}} = m \cdot a$ $F_T = 8 \cdot a \dots\dots\dots 1$	$F_{\text{net}} = m \cdot a$ $F_g - F_T = m \cdot a$ $m \cdot g - F_T = m \cdot a$ $1(9,8) - F_T = 1 \cdot a$ $1(9,8) - 1 \cdot a = F_T \text{ (get } F_T \text{ by itself)} \dots\dots 2$

Now solve the equations simultaneously

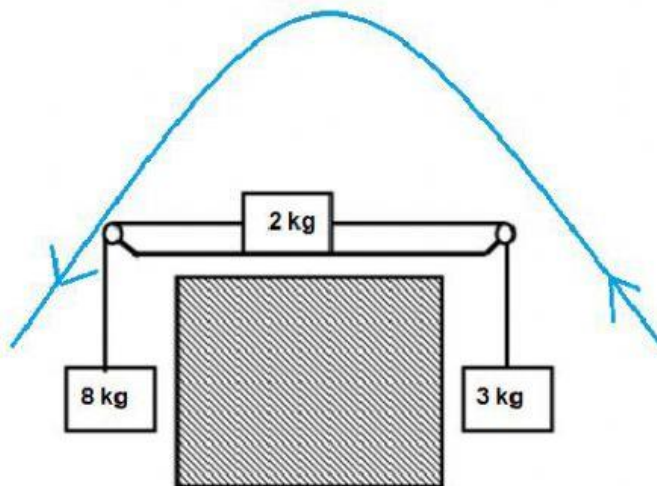
$$8.a = 1(9,8) - 1.a$$

$$9.a = 9,8$$

$$a = \underline{\hspace{2cm}} \text{ m.s}^{-2} \text{ clockwise}$$



Eg 3 Calculate the acceleration of the system and the tension in both strings



The system will move anti-clockwise, since the heavier weight is on the left.

Remember that the system is frictionless at the moment, so you can imagine the system as laying on a block of ice.

For acceleration – we usually look at the system as a whole – however

We are not allowed to in these situations, since the forces on objects are not moving in the same straight line

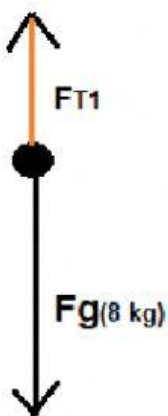
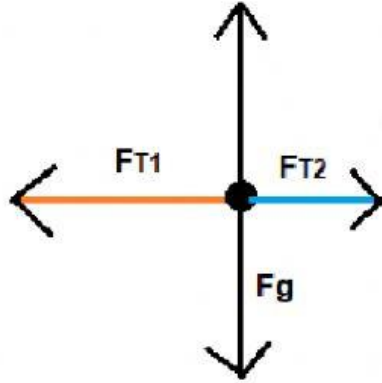
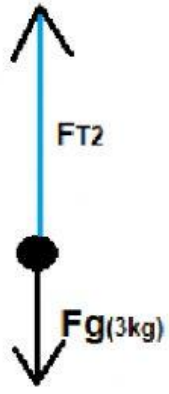
$$F_{\text{net}} = m.a$$

$$F_{g8\text{kg}} - F_{g3\text{kg}} = m.a$$

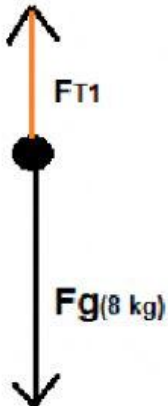
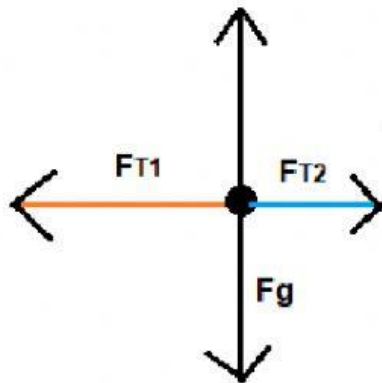
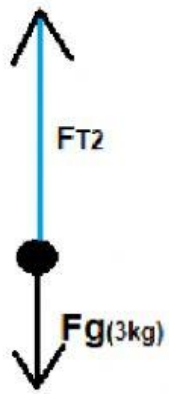
$$m.g - m.g = m.a$$

$$8(9,8) - 3(9,8) = (8+3+2)a$$

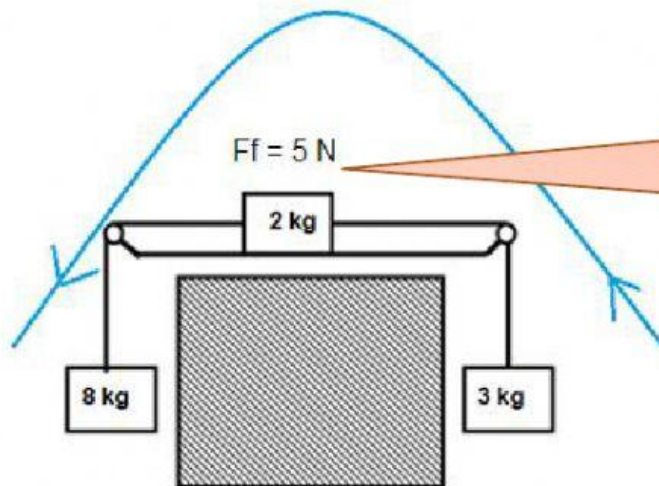
$$a = 3,77 \text{ m.s}^{-2} \text{ anti-clockwise}$$

8 kg  $F_{net} = m \cdot a$ $F_g - F_{T1} = m \cdot a$ $m \cdot g - F_{T1} = 8 \cdot a$ $8(9,8) - F_{T1} = 8a$ Get F_{T1} by itself $78,4 - 8 \cdot a = F_{T1} \dots\dots\dots 1$	2 kg  $F_{net} = m \cdot a$ $F_{T1} - F_{T2} = m \cdot a$ $F_{T1} - F_{T2} = (2) \cdot a$ $F_{T1} - F_{T2} = 2 \cdot a$ $F_{T1} = 2 \cdot a + F_{T2} \dots\dots\dots 2$	3kg  $F_{net} = m \cdot a$ $F_{T2} - F_g = m \cdot a$ $F_{T2} - m \cdot g = 3 \cdot a$ $F_{T2} - 3(9,8) = 3 \cdot a$ $F_{T2} = 3(9,8) + 3 \cdot a \dots\dots\dots 3$
$78,4 - 8 \cdot a = F_{T1} \dots\dots\dots 1$ $F_{T1} = 2 \cdot a + F_{T2} \dots\dots\dots 2$ Equate F_{T1} to F_{T1} first $78,4 - 8 \cdot a = 2 \cdot a + F_{T2}$ $F_{T2} = 3(9,8) + 3 \cdot a \dots\dots\dots 3$ Then substitute the above into the F_{T2}'s place $78,4 - 8 \cdot a = 2 \cdot a + 3(9,8) + 3 \cdot a$ $49 = 13 \cdot a$ $a = 3,77 \text{ m} \cdot \text{s}^{-2} \text{ anti-clockwise}$ Label the tensions F_{T1} and F_{T2}, since it is 2 different strings with different tensions in them		

Only now you can calculate the FT_1 and FT_2 , by using any of the boxes below

8 kg  $F_{net} = m \cdot a$ $F_g - F_{T1} = m \cdot a$ $8(9,8) - F_{T1} = 8 \cdot (3,77)$ $78,4 - F_{T1} = 30,16$ $F_{T1} = 48,24 \text{ N}$	2 kg  $F_{net} = m \cdot a$ $FT_1 - FT_2 = m \cdot a$ $F_{T1} - F_{T2} = (2) \cdot a$ $F_{T1} - F_{T2} = 2 \cdot a$ $F_{T1} = 2 \cdot a + F_{T2} \dots \dots \dots 2$ I prefer not this block as I am missing both the tensions	3kg  $F_{net} = m \cdot a$ $F_{T2} - F_g = m \cdot a$ $F_{T2} - m \cdot g = 3 \cdot a$ $F_{T2} - 3(9,8) = 3 \cdot (3,77)$ $F_{T2} = 3(9,8) + 3(3,77)$ $F_{T2} = 40,71 \text{ N}$
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Eg 4. Let's look at the above example 3 again, but this time, let's add in friction into the question. Calculate the acceleration of the system and the tension in both strings



The friction has to be to the right, since the system will accelerate to the left.

8 kg $F_{\text{net}} = m \cdot a$ $F_g - F_{T1} = m \cdot a$ $m \cdot g - F_{T1} = 8 \cdot a$ $\text{---} (9,8) - F_{T1} = 8a$ Get F_{T1} by itself $78,4 - 8 \cdot a = F_{T1} \dots\dots\dots 1$	2 kg $F_{\text{net}} = m \cdot a$ $F_{T1} - F_{T2} = m \cdot a$ $F_{T1} - F_{T2} - F_f = \text{---} \cdot a$ $F_{T1} - F_{T2} = 2 \cdot a$ $F_{T1} = 2 \cdot a + F_{T2} + F_f \dots\dots\dots 2$	3 kg $F_{\text{net}} = m \cdot a$ $F_{T2} - F_g = m \cdot a$ $F_{T2} - m \cdot g = 3 \cdot a$ $F_{T2} - 3(\text{---}) = 3 \cdot a$ $F_{T2} = 3(9,8) + 3 \cdot a \dots\dots\dots 3$
$78,4 - 8 \cdot a = F_{T1} \dots\dots\dots 1$ $F_{T1} = 2 \cdot a + F_{T2} + F_f \dots\dots\dots 2$ Equate F_{T1} to F_{T1} first		

$$78,4 - 8.a = 2.a + F_f + F_{T2}$$

$$F_{T2} = 3(9,8) + 3.a \dots\dots\dots 3$$

Then substitute the above into the F_{T2} 's place

$$78,4 - 8.a = 2.a + 5 + 3(9,8) + 3.a$$

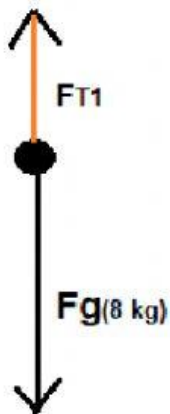
$$44 = 13.a$$

$$a = \text{_____ m.s}^{-2} \text{ anti-clockwise}$$

Label the tensions F_{T1} and F_{T2} , since it is 2 different strings with different tensions in them

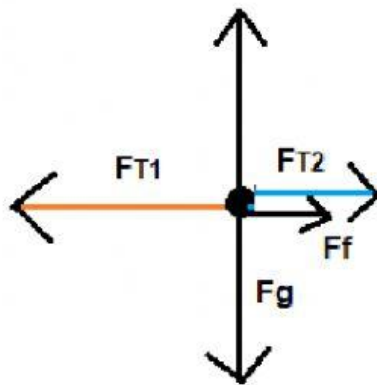
Then to calculate the tension:

8 kg

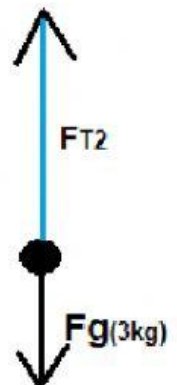


$$\begin{aligned} F_{\text{net}} &= m.a \\ F_g - F_{T1} &= m.a \\ 8(9,8) - F_{T1} &= 8.(3,38) \\ 78,4 - F_{T1} &= 30,16 \\ F_{T1} &= \text{_____ N} \end{aligned}$$

2 kg



3kg



$$\begin{aligned} F_{\text{net}} &= m.a \\ F_{T2} - F_g &= m.a \\ F_{T2} - m.g &= 3.a \\ F_{T2} - 3(9,8) &= 3.(3,38) \\ F_{T2} &= 3(9,8) + 3(3,38) \\ F_{T2} &= \text{_____ N} \end{aligned}$$