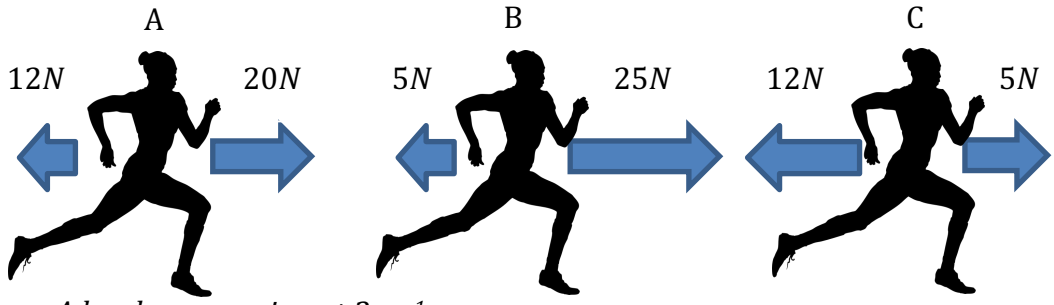
## 4.5.2 Using F=ma

videos

Newton's second law tells us that an unbalanced force ($F$), acting on an object with mass ($m$), will cause it to accelerate ($a$) in the direction of the force. Additionally, we can see that force is directly proportional to acceleration - the bigger the force, the bigger the acceleration.

In terms of units, a force of $1N$ acting on a $1kg$ mass will cause it to accelerate at $1ms^{-2}$.

*(1) Work out the resultant force on each of the runners. What will her motion be like in each case?*




*Runner A has been running at 3ms$^{-1}$*
*Runner B has been running at 2ms$^{-1}$*
*Runner C has been running at 3.5ms$^{-1}$*

*(2) Taking the runner's mass to be 75kg, calculate her acceleration in each situation.*

**Person in a lift**

Consider a person travelling downwards in a lift.

*(3) Draw free body diagrams of the person i) as the lift starts downwards, ii) on the way downwards, iii) slowing down at the bottom. Make sure that you draw arrows to reflect the size of the forces acting on the person.*

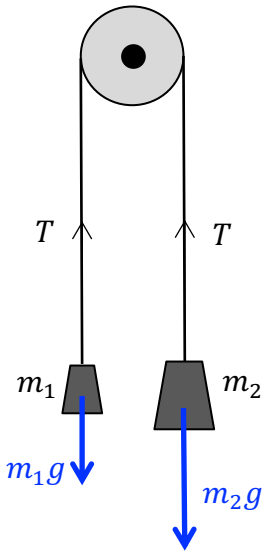
*(4) Where would the person feel lightest? Why?*

*(5) Where would the person feel heaviest? Why?*

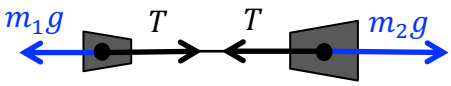
*(6) The person has a mass of 80kg. The lift accelerates and decelerates at 1.5ms$^{-2}$. If the person was standing on bathroom scales, what is the maximum and minimum values it would show on the way down?*

**Pulleys**

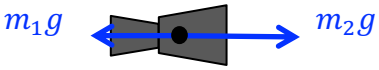
Consider the pulley, below. We are given the masses ($m_1, m_2$) on either side of a frictionless pulley. We want to calculate the resultant motion. *(Note: g is the gravitational field strength = 9.8Nkg$^{-1}$, T is the tension in the cord)*




It appears complicated, but we can simplify it in the following way. Draw it like this:



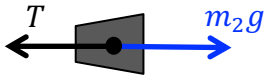

Because we have an inflexible cord joining the masses, we can consider them as one combined body like this:




So, we have a body of mass $M = m_1 + m_2$, and a resultant force of $m_2g - m_1g$. The resulting acceleration:

$$a = \frac{F}{M} = \frac{m_1g - m_2g}{m_1 + m_2}$$

Now we know the acceleration we can consider each mass individually to work out the tension in the cord:



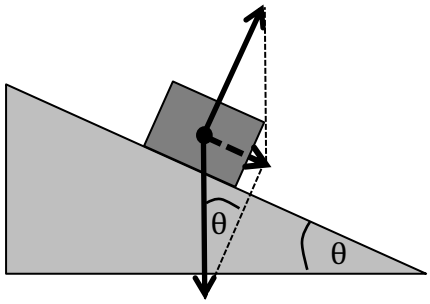

Taking the larger mass, we can see that the resultant force ($m_2g - T$ ) will produce an acceleration $a$ (that we calculated above).

$$F = ma$$
$$\therefore (m_2g - T) = m_2a$$
$$\therefore T = m_2g - m_2a$$

*(7) Consider a pulley (like the above) with two masses of 5kg and 3kg. Work out the acceleration of the masses and the tension in the connecting cord.*

**Block on a slope**

Consider a block on a frictionless slope:




*(8) Label the two forces acting on the block (solid arrows).*

*(9) What does the dashed arrow represent?*

*(10) Write an expression to calculate the size of this force.*

*(11) Describe the motion of the block.*