Assignment: Forces
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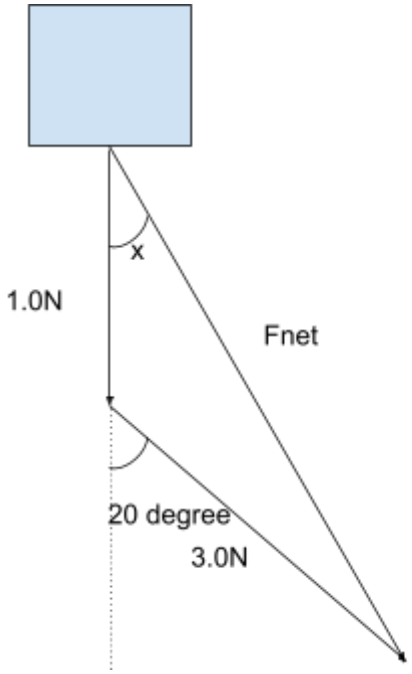
1. **A force of 3.0 N act on a 6.0 kg mass as shown. What is the acceleration of the 6.0 kg mass? (7 marks)**



The following is given data.

$m = 6.0kg,\ F_1 = 1N,\ F_2 = 3N,\ \theta = 20^o$

Using the cosine law to get the value of Fnet using the cosine of the opposite angle and its other two sides.

$$acceleration = \frac{F_{net}}{m} = \frac{\sqrt{1^2+3^2-3\times2\times cos160^o}}{6} \approx 0.66m/sec^2$$

Using the sine law to get the angle x.

$$\frac{sin\ 160}{\sqrt{1^2+3^2-3\times2\times cos160^o}} = \frac{sin\ x}{3}$$

$$x = sin^{-1}\left(\frac{3sin\ 160^o}{\sqrt{1^2+3^2-3\times2\times cos160^o}}\right) = 15^o$$

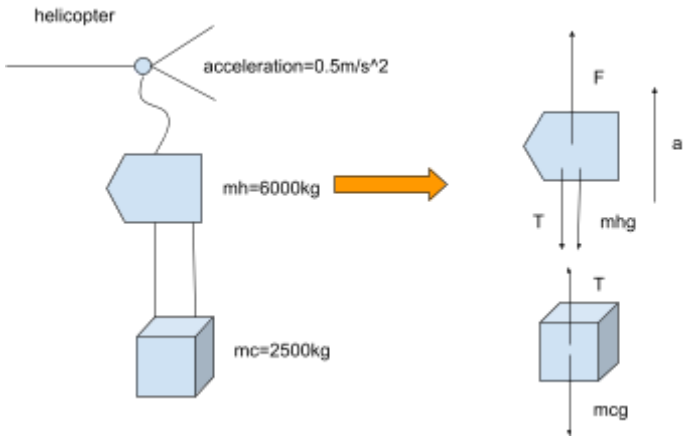
Therefore, the acceleration is $0.66m/sec^2$[S15°E]

2. **In a rescue, a helicopter of mass 6000 kg accelerates upwards at the rate of 0.50 m/s2 while lifting a 2500 kg piece of concrete. What is the upward force exerted by the rotors of the helicopter? What is the tension in the cable attaching the concrete to the helicopter? (8 marks)**

Solution.

The following is the given data.

$m_H = 6000kg,\ m_c = 2500kg,\ a = 0.5m/s^2,\ upward\ force = f$



The first equation is $F - m_H g - T = m_H a$ which is the first diagram (mh).

The second equation is $T - m_c g = m_c a$ which is the second diagram (mc).

Add both equation.

$F - m_H g - m_c g = m_H a + m_c a$

$F = (m_H + m_c)g + (m_H + m_c)a$

$= (m_H + m_c)(g + a)$

--- This force is countering the effect of gravity and also giving an acceleration to the helicopter.

$= (6000 + 2500)(9.81 + 0.5)$

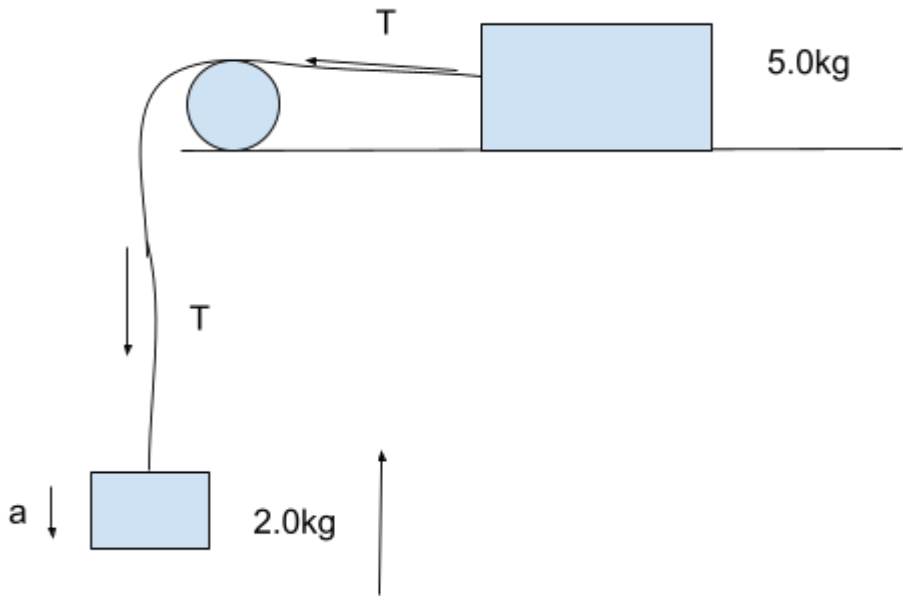
$= 87635N$

$= 9 \times 10^4 N$

$T = m_c g + m_c a = m_c(g + a) = 2500(9.81 + 0.5) = 25775N = 3 \times 10^4 N$

Thus, the upward force exerted by the rotors of the helicopter is $9 \times 10^4 N$, while the tension in the cable is $3 \times 10^4 N$.

3. **In diagram of the pulley, there is a coefficient, μ, of 0.15 between the 5.0 kg mass and the surface. Calculate the tension in the cable connecting the two masses and the resulting acceleration. (10 marks)**



Solution.
Let the body accelerate downward for a 5kg block.
$T - F_k = 5a,\ T = F_k + 5a$ --- the equation 1.

The following is for a 2kg block.
$m_g - T = m_a$
$2g - T = 2a$ --- the equation 2.

Add first equation to the second equation.
$2g - (F_k + 5a) = 2a$
$2g - F_k - 5a = 2a$
$2g - F_k = 7a$
$2g - \mu \times 5g = 7a$
$2g - 0.15 \times 5g = 7a$
$1.25g = 7a$
$a = \frac{1.25 \times 9.8}{7} = 1.75 m/s^2$

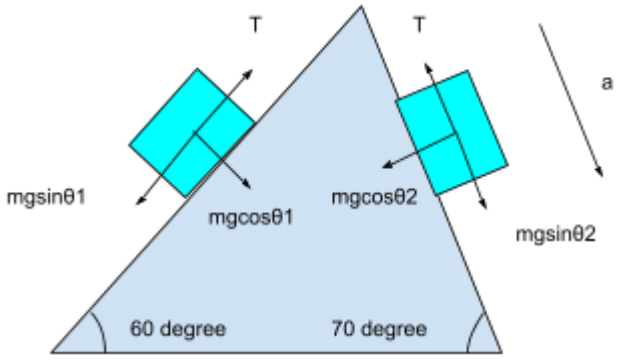
Thus, the resulting acceleration is $a = 1.8 \times 10^0 m/s^2$.

From the second equation, we can get the following involved.
$2g - T = 2a \rightarrow T = 2g - 2a$
$T = 2(g - a) = 2(9.8 - 1.75) = 16.1N$

Thus, the tension between the cable connecting two masses is $1.6 \times 10^1 N$.

4. **Calculate the tension in the cable connecting the two masses. Assume all surfaces are frictionless. (8 marks)**

Solution.



From the diagram see above,

$m_2 g \bullet sin\theta_2 - T = m_2 a$ ... the equation 1

$T - m_1 g \bullet sin\theta_1 = m_1 a$ ... the equation 2

Add the first equation to the second equation.

$m_2 g \bullet sin\theta_2 - T = m_2 a$

$T - m_1 g \bullet sin\theta_1 = m_1 a$

$m_2 g \bullet sin\theta_2 - m_1 g \bullet sin\theta_1 = a(m1 + m2)$

$a = \frac{m_2 g \bullet sin\theta_2 - m_1 g \bullet sin\theta_1}{m_1 + m_2} = \frac{6.00 \times 9.8 \times sin70^o - 5.00 \times 9.8 \times sin60^o}{5+6} = \frac{55.25 - 49 \times sin60^o}{11}$

$= 1.16 m/s^2$

$= 1.2 \times 10^0 m/s^2$

Put the value of $a = 1.16 m/s^2$ in the first equation.

$m_2 g \bullet sin\theta_2 - T = m_2 a$

$T = m_2 g \bullet sin\theta_2 - m_2 a = 6 \times 9.8 \times sin70^o - 6 \times 1.16$

$= 55.25^o - 6.96$

$= 48.29N$

$= 4.8 \times 10^1 N$

Thus, the tension between the cable connecting two masses is $4.8 \times 10^1 N$

5. **Determine the acceleration of a 1500 kg automobile that rolls down an incline of 30 degrees from the horizontal if a coefficient of friction between the tires and the incline is 0.12. (8 marks)**
Solution.

$m = 1500kg,\ \theta = 30^o,\ \mu(coefficient\ of\ friction) = 0.12,\ g = 9.8 m/s^2$

Recall the equation of forces.

$Friction\ force = mg \bullet sin\theta - \mu mg \bullet cos\,\theta = ma$

$gravity\ force = mg \bullet sin\theta$

Render the friction force as the following.

$ma = m(gsin\theta - \mu gcos\,\theta)$
$a = (gsin\theta - \mu gcos\,\theta)$

Then, $acceleration(a) = 9.8 \times sin30^{o} - 0.12 \times 9.8cos30^{o}$
$= 9.8 \times \frac{1}{2} - 0.12 \times 9.8 \times \frac{\sqrt{3}}{2}$
$= 4.9 - 1.01895$
$= 3.88155m/s^{2}$
$= 3.9 \times 10^{0}m/s^{2}$

Therefore, the acceleration is $3.9 \times 10^{0}m/s^{2}$.