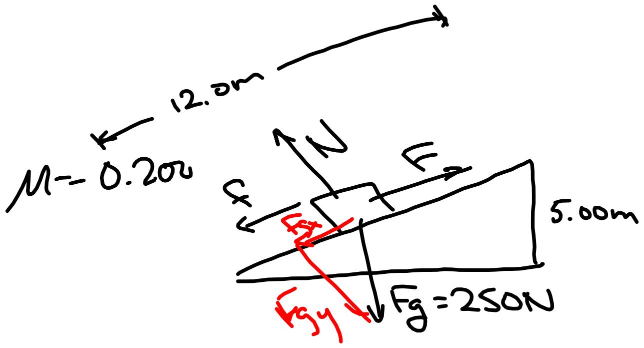
Homework Questions

4.



$a = 0 \Leftrightarrow \Sigma F = 0$

$\cos\theta = \frac{\sqrt{119}}{12} \approx \frac{11}{12}$

$F_{gx} = F_g \sin\theta$

$= 250N \left(\frac{5}{12}\right)$

$= 104\ N$

$f = \mu N$

$= (0.2) F_{gy}$

$= (0.2)\ 250N \cos\theta$

$= 50 \times \frac{11}{12}$

$= 46N$

$\Sigma F = F - (f + F_{gx}) = 0$ ☺

$F = f + F_{gx}$

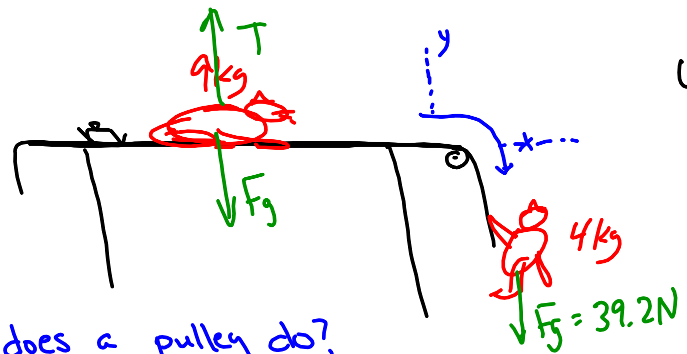
$= 46 + 104\ N$

$= 150N$

Pulleys

Fat Cat and Thin Cat

$\mu = ☺$



What is the acceleration of fat cat?

What does a pulley do?

Changes the direction of the force

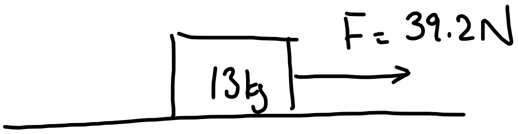
$$\Sigma F = F_g = ma$$

← **both** masses are being accelerated by this force.

$$39.2\,N = (4+9\,kg)a$$

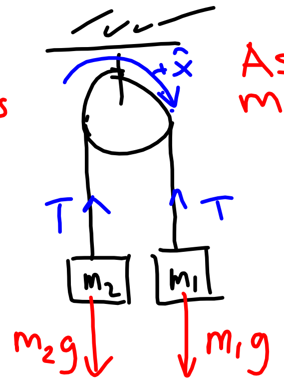
$$a = 3.0\,m/s^2$$

$\mu = ☺$



FBDs and Tension

Atwood Machine



Assume $m_1 \geq m_2$

Assumptions:

1) Rope is "light" $m_{rope} << m_1, m_2$ (≈ ☺) ← much less than.
2) Pulley is light $m_{pulley} << m_1, m_2$ (≈ ☺)
3) Axle of pulley is frictionless.

$$\Sigma F = m_1 g - m_2 g = (m_1 + m_2) a$$

$$\vec{a} = \frac{m_1 - m_2}{m_1 + m_2} g \, \hat{x}$$

Does this equation still work if $m_2 > m_1$?

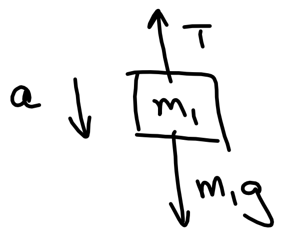
yes !! ☺

$a =$ ☺ when $m_1 = m_2$

$a = g$ when $m_1 >> m_2$ or $m_2 =$ ☺

What is the tension in the rope?

We need an FBD.



$$\Sigma F = m_1 g - T = m_1 a$$

This ΣF is only accelerating m_1

$$m_1 (g - a) = T$$

$$m_1 \left(g - \frac{m_1 - m_2}{m_1 + m_2} g \right) =$$

$$m_1 g \left(1 - \frac{m_1 - m_2}{m_1 + m_2} \right) =$$

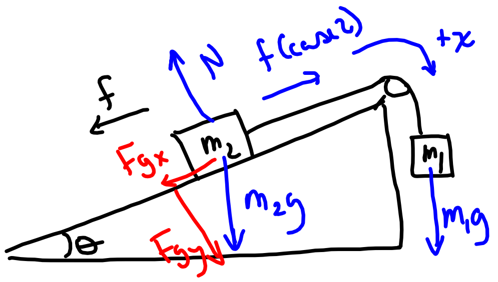
$$m_1 g \left(\frac{m_1 + m_2}{m_1 + m_2} - \frac{m_1 - m_2}{m_1 + m_2} \right) =$$

$$\frac{2 m_1 m_2}{m_1 + m_2} g = T$$

Exercise: Use a FBD of m_2 to show that T is the same.

Pulleys and Inclines

μ



3 possibilities

1) m_1 moves downward
2) m_1 moves upward
3) m_1 stays at rest.

Case 1: $m_1 g \geq f + F_{gx}$

$f = \mu N = \mu F_{gy}$

$$\Sigma F = m_1 g - (F_{gx} + f) = (m_1 + m_2) a$$

$$m_1 g - (m_2 g \sin\theta + \mu m_2 g \cos\theta) = (m_1 + m_2) a$$

$$a = \frac{m_1 - m_2(\sin\theta + \mu\cos\theta)}{m_1 + m_2} g \hat{x} \qquad a \geq 0$$

True when $m_1 \geq m_2(\sin\theta + \mu\cos\theta)$

Case 2: $F_{gx} \geq m_1 g + f$

All that has changed is the direction of f.
Flip sign of the friction term(s).

$$a = \frac{m_1 - m_2(\sin\theta - \mu\cos\theta)}{m_1 + m_2} g \hat{x} \qquad a \leq 0$$

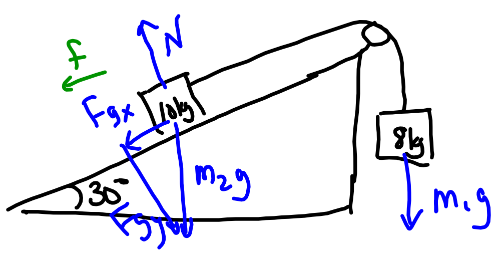
True when $m_1 \leq m_2(\sin\theta - \mu\cos\theta)$

Case 3: $a = 0$

$$m_2(\sin\theta - \mu\cos\theta) \leq m_1 \leq m_2(\sin\theta + \mu\cos\theta)$$

$$\sin\theta - \mu\cos\theta \leq \frac{m_1}{m_2} \leq \sin\theta + \mu\cos\theta$$

$\mu = 0.20$



1) Compare $m_1 g$ with F_{gx} to determine direction of f.

$m_1 g = 8 \cdot g = 78.4N$

$m_2 g = 10 \cdot g = 98.0N$

$F_{gx} = m_2 g \sin\theta = 49.0N$

$m_1 g > F_{gx}$ so friction acts downhill

2) Calculate f_{max} and compare with $|m_1 g - F_{gx}|$

If $f_{max} \geq |m_1 g - F_{gx}|$ it remains at rest (if $v_i = 0$)

$f_{max} = \mu N = \mu F_{gy} = 0.2(98.0N)\cos 30° = 17.0N$

$m_1 g - F_{gx} = 78.4 - 49 = 29.6N$

Else write ΣF equation

If v_i is not 0 we can skip this step

3) Write ΣF equation

$$\Sigma F = m_1 g - (F_{gx} + f) = (m_1 + m_2)a$$

$$78.4N - (49.0 + 17.0) = (18\,kg)a$$

$$a = \frac{12.6N}{18kg} = 0.70\,m/s^2\ \hat{x}.$$

Homework: Questions 6-8, Inclines, 1-2 Pulleys

PS 1

5. What must the coefficient of friction be so the package just comes to rest at the bottom of the hill.