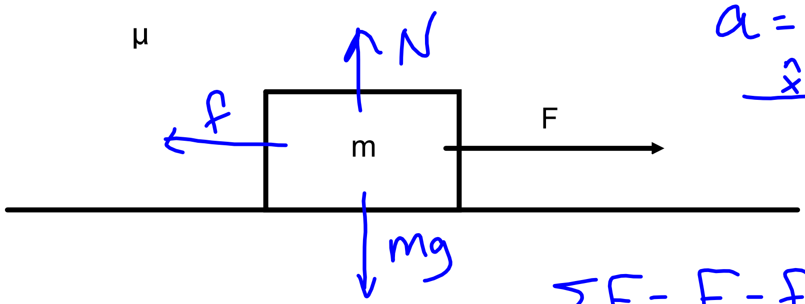
Inclined Planes

A Review of Forces and Acceleration



$a = ?$

$\xrightarrow{\hat{x}}$

If $f = f_{max} \Rightarrow$

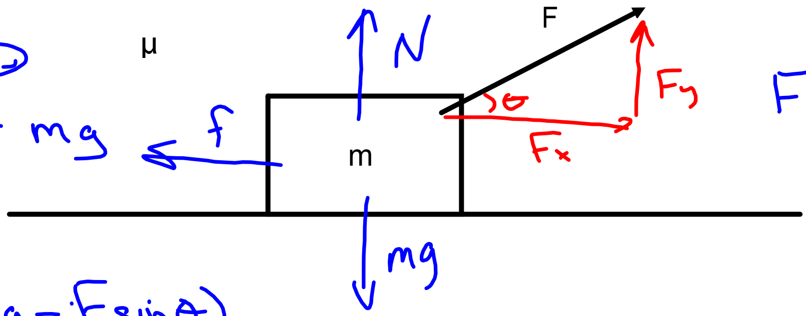
$f_{max} = \mu N$

$\Sigma F = F - f = ma$

$F - \mu mg = ma$

$a = \frac{F}{m} - \mu g$

$$\sum F_y = 0$$
$$F_y + N = mg$$



$$F = |\vec{F}| = \|\vec{F}\|$$

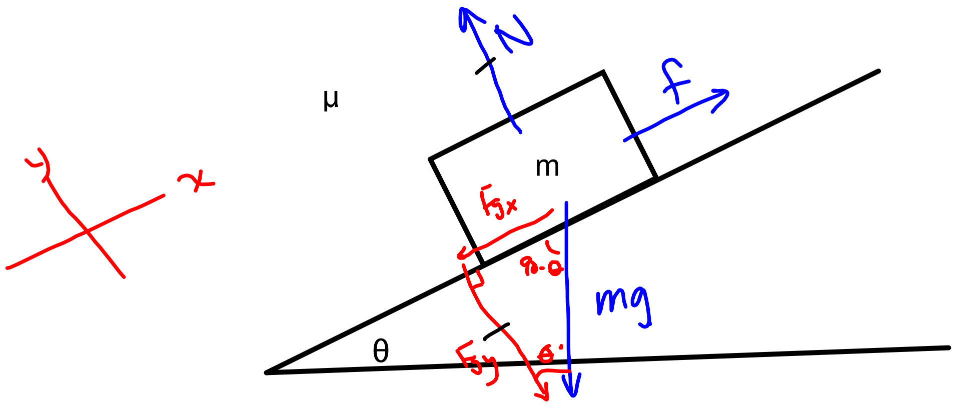
$$f_{max} = \mu N = \mu(mg - F\sin\theta)$$

$$\sum F = F_x - f = ma$$

If $f = f_{max}$

$$\frac{F\cos\theta - \mu(mg - F\sin\theta)}{m} = \frac{ma}{m}$$

$$a = \frac{F(\cos\theta + \mu\sin\theta)}{m} - \mu g$$



$$\Sigma F = F_{g_x} - f = ma$$

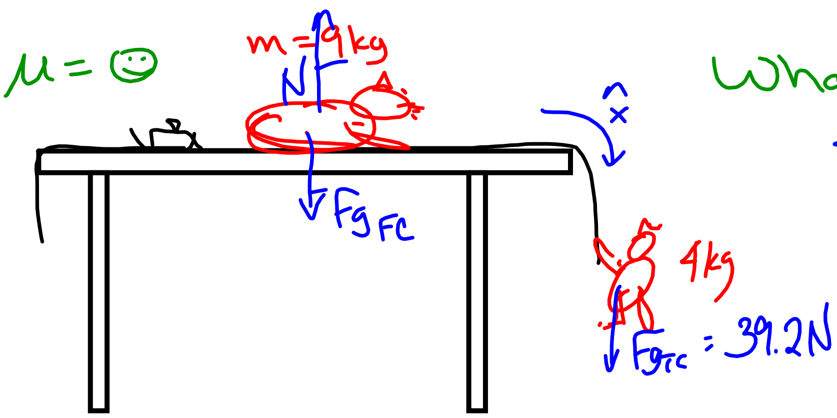
If $f = f_{max}$

$N = F_{g_y}$

$$\cancel{m}g\sin\theta - \mu \cancel{m}g\cos\theta = \cancel{m}a$$

$$\vec{a} = (\sin\theta - \mu\cos\theta)\,g\,(-\hat{x})$$

Pulleys

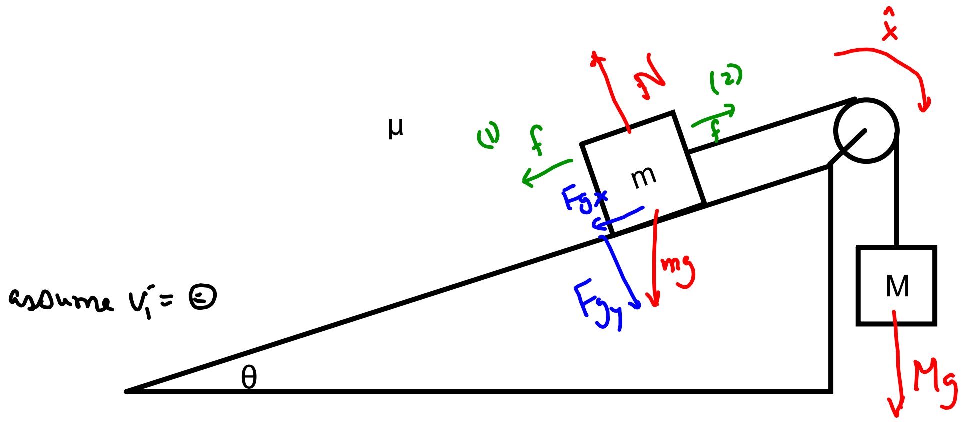


What is $\vec{a}$ of fatcat

$$\Sigma F = Fg_{TC} = ma$$

$$39.2\,N = 13kg\; a$$

$$3.02\,m/s^2 = a$$



3 cases
1) M moves down
2) M moves up
3) M stays still

Case 1: $Mg > F_{gx} + f$

$$\Sigma F = Mg - (F_{gx} + f) = (M+m)a$$
$$Mg - (mg\sin\theta + \mu mg\cos\theta) = (M+m)a$$
$$\vec{a} = \frac{M - m(\sin\theta + \mu\cos\theta)}{M+m} g\,\hat{x}$$

$a > 0$ when $M > m(\sin\theta + \mu\cos\theta)$

Case 2: $F_{gx} > Mg + f$

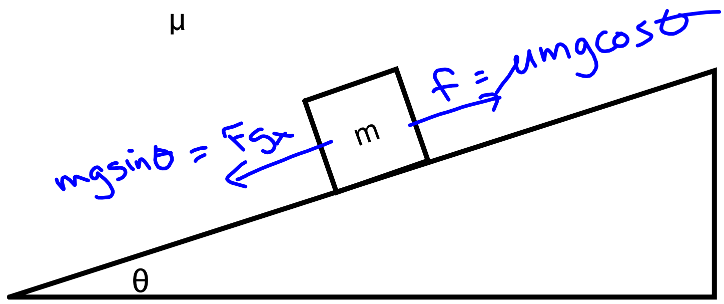
f has flipped directions - change sign of friction term!

$$\vec{a} = \frac{M - m(\sin\theta - \mu\cos\theta)}{M+m} g\,\hat{x}$$ but term is −

$a < 0$ when $M < m(\sin\theta - \mu\cos\theta)$

Case 3: $a = 0$ when

$$m(\sin\theta - \mu\cos\theta) \le M \le m(\sin\theta + \mu\cos\theta)$$



F uphill if
$\sin\theta > \mu\cos\theta$
$\tan\theta > \mu$

If we want a constant speed downhill, which way do we need to push the box and under what conditions?

$$\frac{\sin\theta = \frac{o}{h}}{\cos\theta = \frac{a}{h}} = \frac{o}{a} = \tan\theta$$

F downhill if
$\tan\theta < \mu$
No F if $\mu = \tan\theta$.