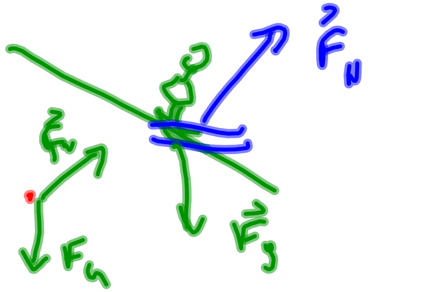
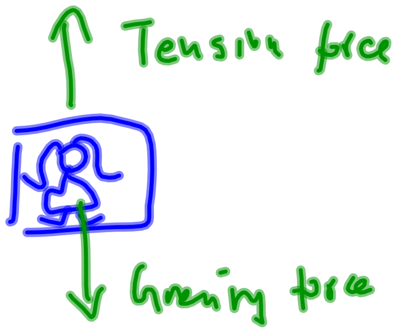
Problem solving tips



Drawing a free body diagram

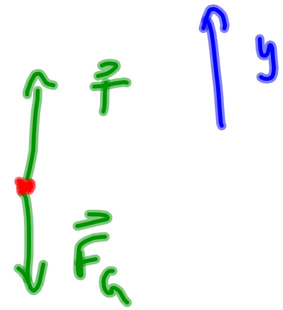
1. Identify the object of interest & all forces acting on it
2. Represent the object as a dot
3) Draw vectors for only forces acting on the object

1)



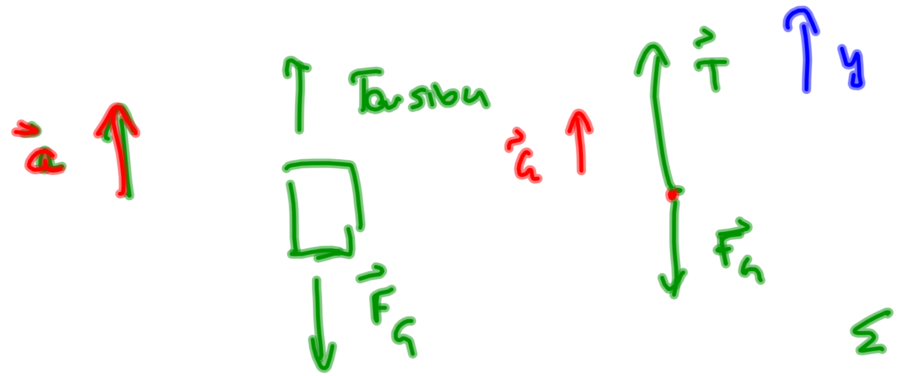
2)

3)



Example

A 750 kg elevator accelerates upward at $1.1\ m/s^2$ pulled by a cable of negligible mass. Find the tension force in the cable.



$m = 750\ kg$

$a_y = 1.1\ m/s^2$

$T = ?$

$\Sigma \vec{F} = m\vec{a}$ N. 2nd law

$\Sigma F_y = m a_y$

$$\Sigma F_y = m a_y$$

$$T - mg = m a_y$$

$$T = m(a_y + g)$$

$$T = 740\,kg\,(1.1\,m/s^2 + 9.8\,m/s^2)$$

$$= 8.1\,kN$$

2 forces $\vec{T}$ & $\vec{F}_g$

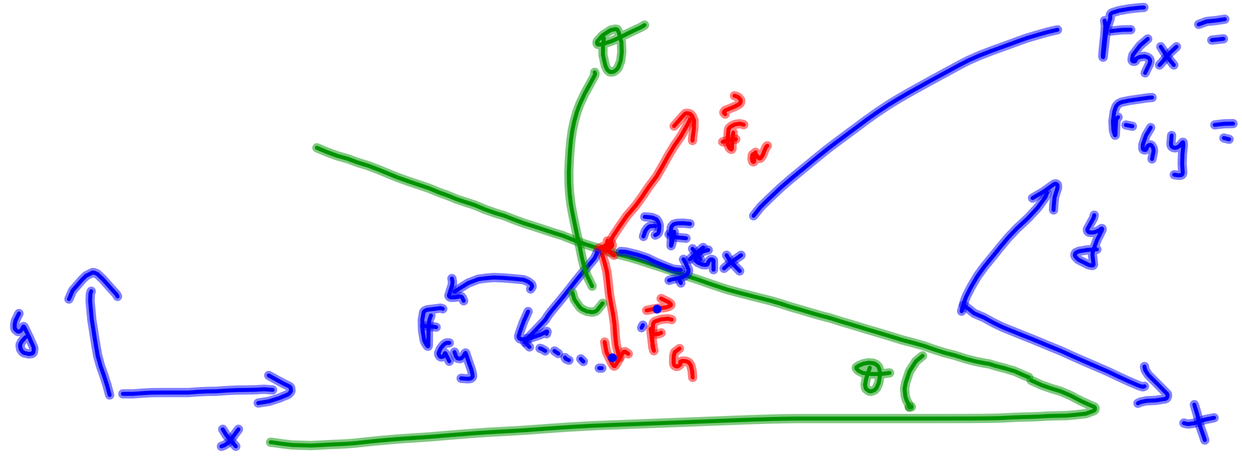
side note

$$\Sigma \vec{F} = \vec{T} + \vec{F}_g$$

$$\Sigma F_y = T - F_g$$

$$F_g = mg$$

Ex. A skier of mass $m = 65$ kg glides down the slope at $\theta = 32°$. What is her acceleration? What is the force that the snow exerts on the skier? (neglect friction)



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

$F_{gy} = -F_g \cos\theta$

$\theta = 32°$

$m = 65$ kg

$\vec{a} = ?$

$\vec{F}_N = ?$

$$\sum \vec{F} = m\vec{a}$$

$\theta = 32°$

x $\quad \sum F_x = m a_x \qquad a_x = ?$

$F_g = mg$

y $\quad \sum F_y = m a_y \qquad a_y = 0$

(1) $F_g \sin\theta = m a_x$

$mg \sin\theta = m a_x$

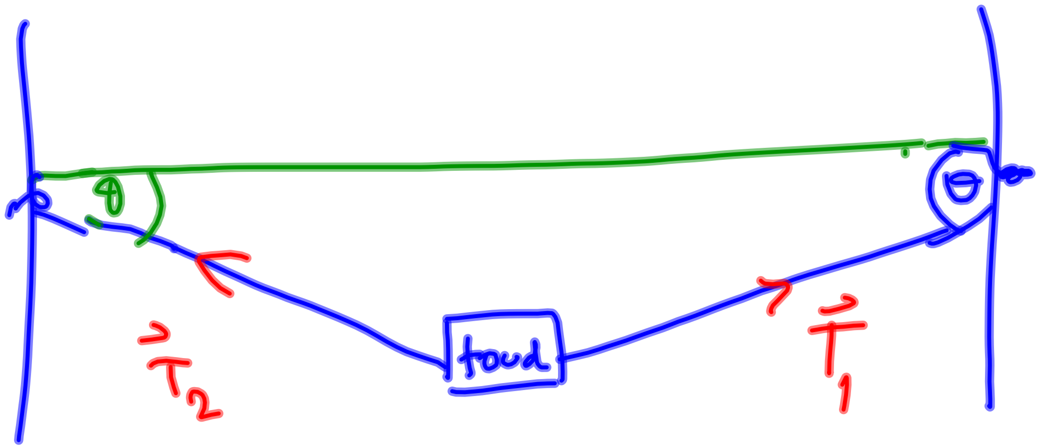
a) $a_x = g\sin\theta$

$= 5.2 \, m/s^2$

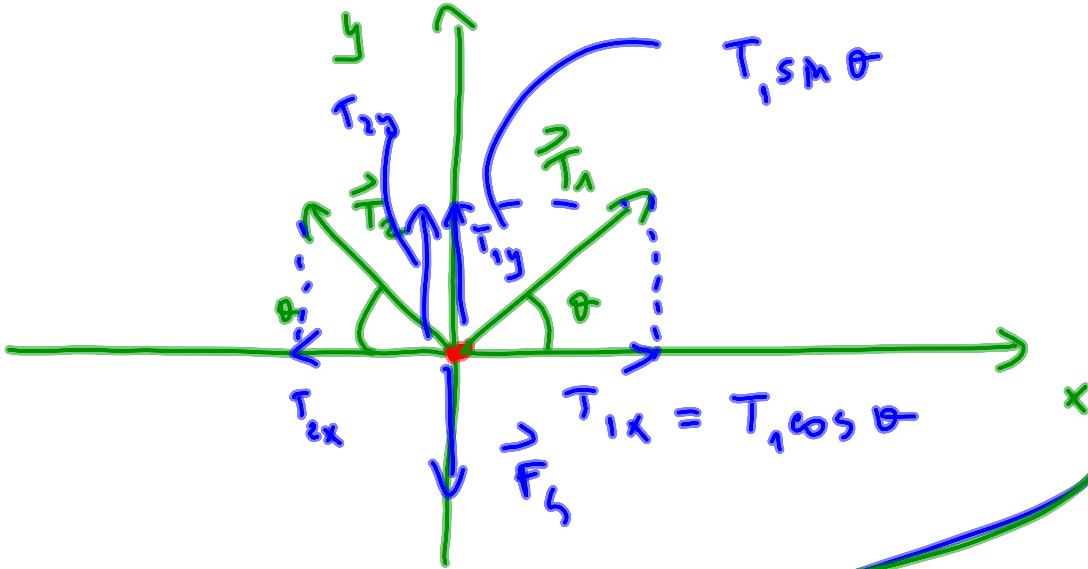
(2) $F_N - F_g \cos\theta = 0$

b) $F_N = ?$ $\quad F_N = F_g \cos\theta = 55.1 \, N$

To protect our 17 kg pack of food from the bears/moose, we, the campers hang it from ropes between 2 trees. What is the tension in each rope if θ at which you hang food is 22°?



$|\vec{T}_1| = |\vec{T}_2|$



$$\sum F_x = m a_x$$

$$\sum F_y = m a_y$$

$$|\vec{T}_1| = |\vec{T}_2| = T$$

(1) $T\cos\theta - T\cos\theta = 0$ ✓

(2) $T\sin\theta + T\sin\theta - mg = 0$

$$T = \frac{mg}{2\sin\theta}$$

$$T = 220\,N$$

Friction

- the force that opposes the relative motion of 2 surfaces in contact

Static friction - when the piano is at rest & microscopic bonds between piano & floor are strong

Kinetic friction - bonds break after you pushed hard enough that piano had moved

f_s & f_k friction

[N]

Experiments show

- static friction $f_s \leq \mu_s F_N$

where F_N is normal force &

μ_s is coefficient of static friction

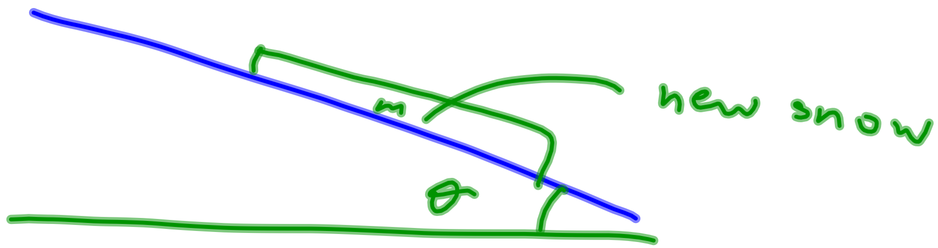
- kinetic friction $f_k = \mu_k F_N$

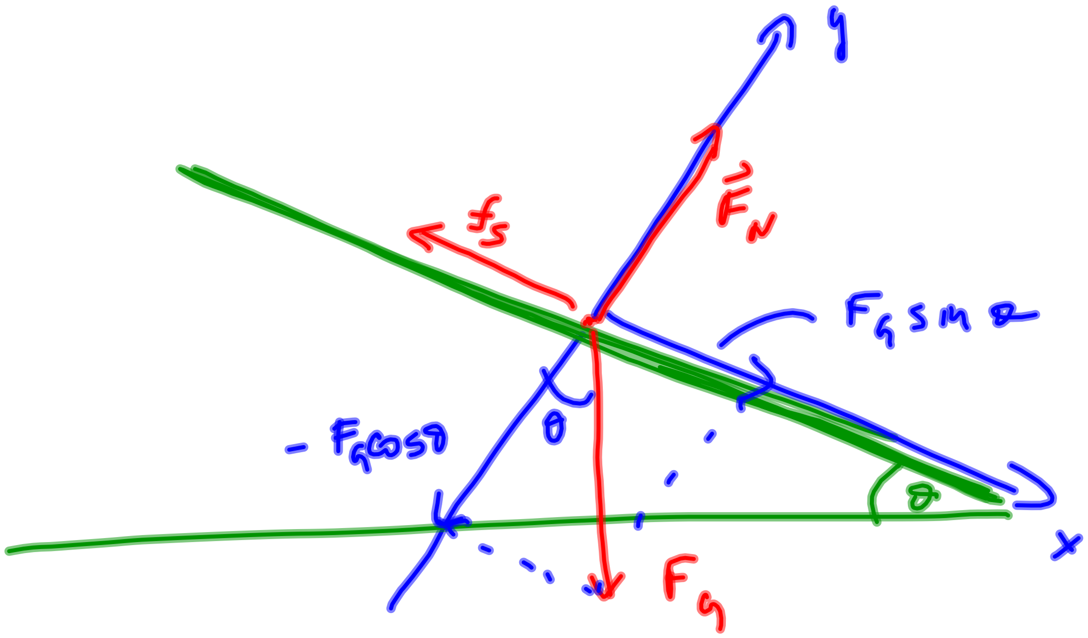
$\mu_k < \mu_s$

μ_k coeff. of kinetic friction

Ex.

A storm dumps new snow on a ski slope. The coefficient of static friction between new & old snow is 0.46. What is the maximum slope angle to which the new snow can adhere?





$\mu_s = 0.46$

$\theta = ?$

$\Sigma F_x = m a_x$

$\Sigma F_y = m a_y$

$F_g \sin\theta - f_s = 0$ x direction

$F_N - F_g \cos\theta = 0$

$$F_g \sin\theta - \mu_s F_N = 0$$

$$F_N - F_g \cos\theta = 0 \quad \rightarrow \quad F_N = F_g \cos\theta$$

$$f_s = \mu_s \cdot F_N$$

$$F_g = mg$$

$$mg \sin\theta - \mu_s mg \cos\theta = 0$$

$$\sin\theta - \mu_s \cos\theta = 0 \quad | : \cos\theta$$

$$\tan\theta = \mu_s \qquad \theta = 25^\circ$$

angle smaller than θ → not much action

$> \theta \Rightarrow$ avalanche !