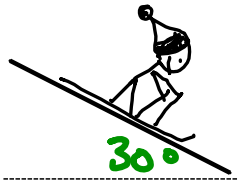
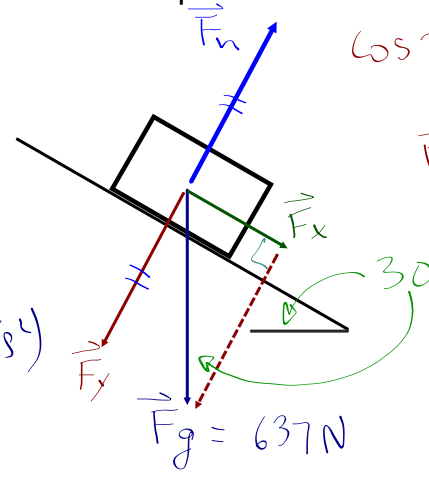
3.7 Inclined Planes

So far we have considered vector components that are either horizontal or vertical. But what happens when objects move down an inclined plane?

ex. Consider a 65 kg skier on a 30.0° slope. What is the normal force?





$\vec{F}_g = (65\ kg)(9.8\ m/s^2)$
$= -637\ N$

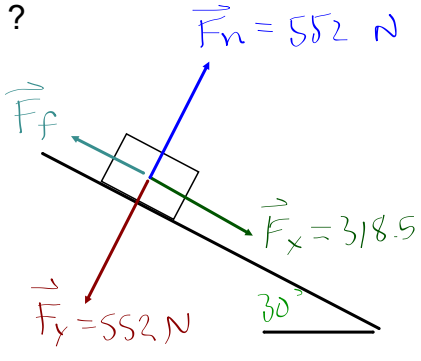
$\cos 30° = \frac{F_y}{F_g}$

$\vec{F}_y = \vec{F}_g \cos 30°$
$= 552\ N$

$\vec{F}_x = \vec{F}_g \sin 30°$
$= 318.5\ N$

When doing calculations involving inclined planes, we must consider the forces that act in the direction of motion and perpendicular to that plane. Usually, we must resolve these forces into components.

ex. Consider the same skier as above. If there is a coefficient of friction between the skis and the snow of 0.15, what acceleration does the skier experience ?



$\vec{F}_f = \mu \vec{F}_n$
$= (0.15)(552\ N)$
$= 82.8\ N$

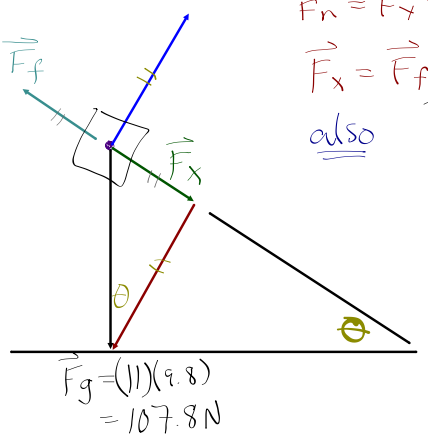
$\vec{F}_{netx} = \vec{F}_x - \vec{F}_f$
$= 318.5 - 82.8\ N$
$= 235.7\ N$

Now: $\frac{\vec{F}_{netx}}{m} = \frac{m\vec{a}}{m}$

$\frac{235.7\ N}{65\ kg} = \vec{a}$

$\vec{a} = 3.6\ m/s^2$ [downhill]

ex. An 11 kg box rests on a rough surface with a coefficient of static friction of 0.44. What is the maximum angle of inclination that the box can tolerate before slipping down the ramp?



$\vec{F}_n = \vec{F}_y = \vec{F}_g \cos\theta = 107.8\cos\theta$

$\vec{F}_x = \vec{F}_f = \vec{F}_g \sin\theta = 107.8\sin\theta$

also $\vec{F}_f = \mu F_n$

$= 0.44(107.8\cos\theta)$

$\vec{F}_f = 47.432\cos\theta$

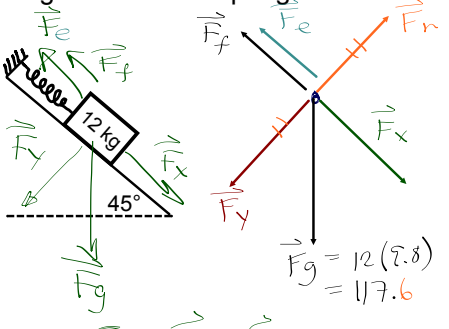
but $\vec{F}_f = \vec{F}_x$

$\frac{47.432}{107.8}\frac{\cos\theta}{\cos\theta} = \frac{107.8}{107.8}\frac{\sin\theta}{\cos\theta}$

$0.44 = \tan\theta$

$\theta = 23.7°$

ex. A 12 kg mass is tethered to a spring on a 45° inclined ramp as depicted below. The coefficient of kinetic friction between the mass and the ramp is 0.15. When the system is released, the spring stretches and the system bounces but eventually comes to rest. How far does the spring stretch if the spring constant is 350 N/m?



$\vec{a}_x = 0$

$\vec{F}_{net_x} = 0$

① $\vec{F}_n = \vec{F}_y = \vec{F}_g\cos\theta$

$\vec{F}_n = 117.6\cos 45°$

$\vec{F}_n = 83.16\,N$

$\therefore \vec{F}_f = \mu\vec{F}_n = 0.15(83.16\,N)$

$= 12.47\,N$

② $\vec{F}_x = \vec{F}_g\sin\theta$

$= 117.6\sin 45°$

$= 83.16\,N$

NOW $F_{net_x} = 0$

$\therefore \vec{F}_x = \vec{F}_f + \vec{F}_e$

practice: Textbook Chapter 5 #33, 35, 39, 41, 95, 99, 101, 105

$\vec{F}_e = k\Delta x$

$83.16 = 12.47 + \vec{F}_e$

$\vec{F}_e = 70.69\,N$

$\frac{70.69}{350} = \frac{(350\,N/m)\Delta x}{350}$

$0.20\,m = \Delta x$

The spring stretches about 20 cm