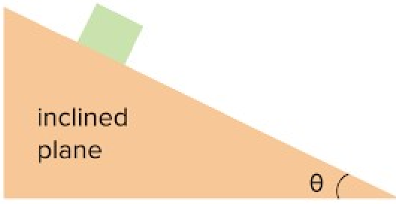
The Inclined Plane



- Incline - at an angle (other than 0^0)
- Plane - a flat surface
- Also called a "ramp" or "slope" among others

Can an object move along an inclined plane without any Applied force? Why?

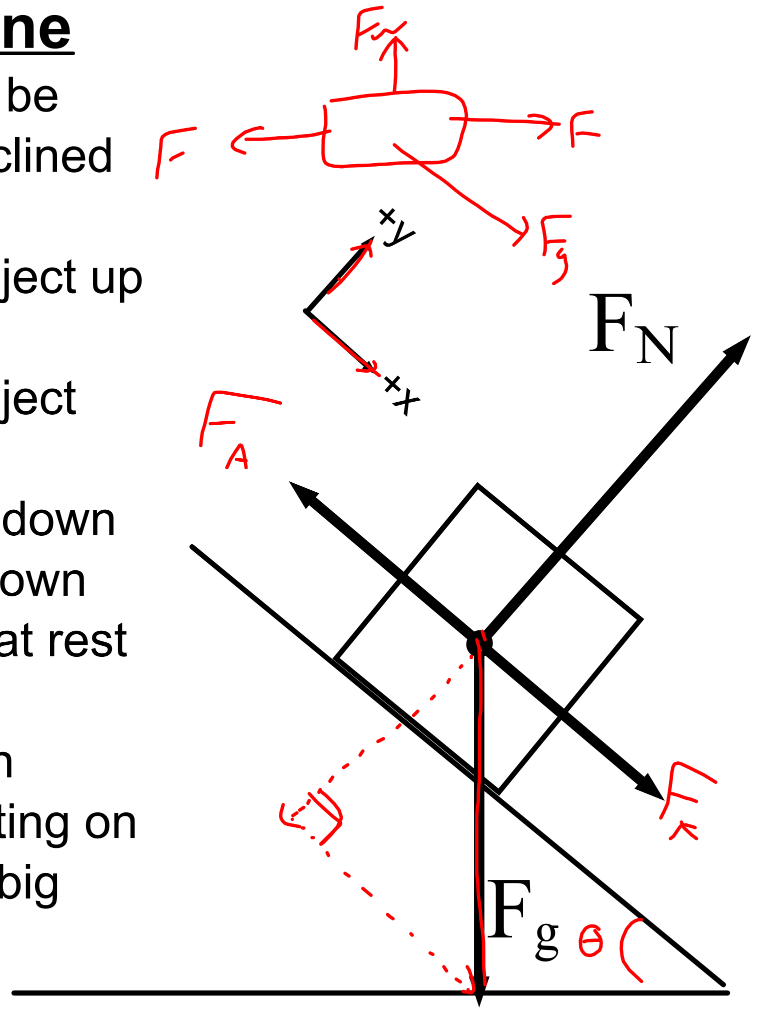
Gravity acts along the ramp

How do the Forces change in this setup?

- Consider how the direction of the basic forces behave
  - > **Friction** is ALWAYS opposite motion
    - – If object moving down slope, friction is up slope
  - > **Gravity** is ALWAYS pointed downward towards centre of the Earth (or whatever planet object is on)
  - > **Normal** is ALWAYS perpendicular to the surface
    - – This means the direction of the Normal force will depend on the angle, θ
- It will be easiest (but not always necessary) to choose an axes angled with the ramp
  - > +x will be along slope
    - – up or down depending on situation
  - > +y will be perpendicular to surface

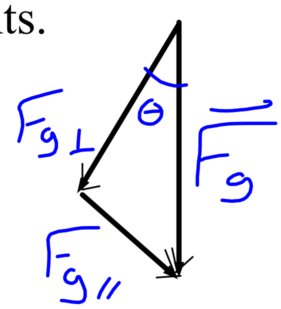
The Inclined Plane

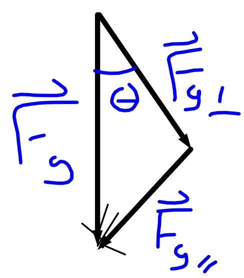
- Different things can be happening on an inclined plane
  - > Pull/Pushing object up the ramp
  - > Pull/Pushing object down the ramp
  - > Let object slide down the ramp on its own
  - > Object just sits at rest on the ramp
- These all depend on which forces are acting on the object and how big each of them are

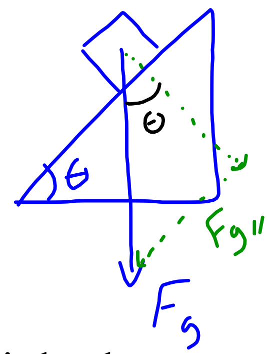


- By choosing the axes to be along the incline, we see that only 1 force is not acting along one of the axes: F_g.

The weight, F_g, can be broken into two perpendicular components.







The parallel component, $F_{g//}$, is the component of weight that acts parallel to the inclined surface. This force is accelerating it along the ramp

$$F_{g//} = F_g \sin\theta$$

F_{gx}

The perpendicular component, $F_{g\perp}$, is the component of weight that perpendicular to the inclined surface. This force is related to Normal force which in turn relates friction.

$$F_{g\perp} = F_g \cos\theta$$

Inclined Plane Examples

Ex 1: A crate of weight 675 N is placed on a ramp with negligible friction. The ramp is inclined at 30. degrees.

a) What is the acceleration of the crate as it moves down the ramp?

b) What is the acceleration down the ramp if there is a kinetic friction force of 125 N opposing the slippage of the crate along the ramp?

Ex 2 : How much force, exerted parallel to the plane, would you need to apply to a 35.8 kg crate in order to accelerate it up a frictionless ramp at 0.35 m/s^2 inclined at 25^0 to the horizontal?

Ex 3: A crate slides down a ramp, inclined at 33 ^{o} to the horizontal, with increasing speed. If the crate accelerates at 1.25 m/s^2 and has a mass of 22 kg, what is the coefficient of kinetic friction between the surfaces?

Practice Problems

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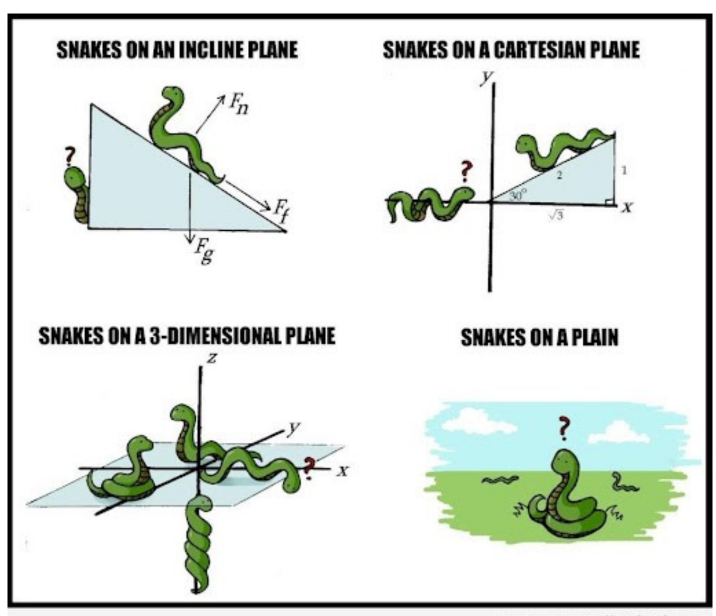
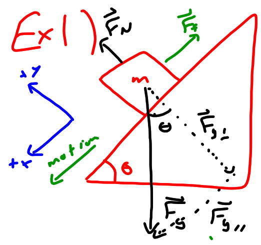


Ex 1)



$\vec{F}_g = 675\text{N}$ [down]

$\theta = 30.°$

$\vec{g} = 9.81\,\text{m/s}^2$ [down]

$\vec{a}_x = ?$

$$F_{Net,x} = F_{g\parallel} = ma_x$$

$$F_g \sin\theta = ma_x$$

$$\cancel{m}g\sin\theta = \cancel{m}a_x$$

$$a_x = g\sin\theta$$

$$= (9.81\,\text{m/s}^2)\sin(30.°)$$

$$= 4.905\,\text{m/s}^2$$

$$\vec{a}_x = \boxed{4.9\,\text{m/s}^2 \text{ [down ramp]}}$$

b) $\vec{F}_f = 125\text{N}$ [up ramp]

$\vec{a}_x = ?$

$$F_{Net,x} = F_{g\parallel} - F_f = ma_x$$

$$\frac{mg\sin(\theta) - F_f}{m} = \frac{ma_x}{m}$$

$$g\sin\theta - \frac{F_f}{m} = a_x$$

$$g\sin(\theta) - \frac{F_f}{(F_g/g)} = a_x$$

$$g\sin(\theta) - F_f\left(\frac{g}{F_g}\right) = a_x$$

$$g\sin(\theta) - g\left(\frac{F_f}{F_g}\right) = a_x$$

$$a_x = (9.81\,\text{m/s}^2)\sin(30°) - (9.81\,\text{m/s}^2)\left(\frac{125\text{N}}{675\text{N}}\right)$$

$$= 3.0883\,\text{m/s}^2$$

$$\boxed{= 3.1\,\text{m/s}^2 \text{ down ramp}}$$