Physics Reference: Forces on an Incline

When given any vector, $\vec{\mathbf{A}}$, you are now an expert at finding the *x*- and *y*-components this way:

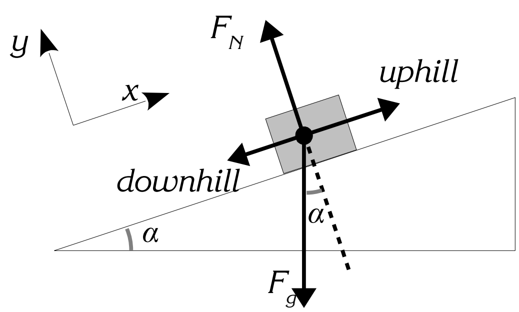
$$A_x = A \cdot \cos(\theta) \qquad A_y = A \cdot \sin(\theta)$$

A common example of a two-dimensional problem is an object moving or resting on an incline. Problems like this will have a minimum of two forces, and may have more:

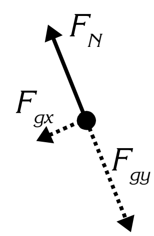
- $\vec{\mathbf{F}}_g$ (force of gravity) will point straight down, as always
- $\vec{\mathbf{F}}_{ramp}$ or $\vec{\mathbf{F}}_N$ (normal force) will point perpendicular to the ramp
- Forces pointing uphill and downhill may be present, and will be parallel to the ramp. “Push” forces and friction are the most common examples and can point either direction.

Directions for the forces

We measure the steepness of the incline by its angle, α (alpha), and tilt the *x*-*y* axes of our reference frame at the same angle. By tilting the reference frame, we keep most of the forces pointing directly along an axis. Only the gravitational force $\vec{\mathbf{F}}_g$ will be “diagonal” now, and you can know from the start that F_{net} in the newly tilted *y*-direction must be zero.



For F_g... $\theta = 270° - \alpha$
For F_N... $\theta = 90°$
For uphill forces... $\theta = 0°$
For downhill forces... $\theta = 180°$



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

Components of the forces

Because $\vec{\mathbf{F}}_g$ is on a diagonal now, you must use the cosine and sine formulas to get both of its components. Most other forces will end up with a zero for one component or the other, as shown below. If you see another force that isn't directly uphill or downhill, you'll need to calculate its components based on the angle.

Force	x-component	y-component
$\vec{\mathbf{F}}_g$	$F_g \cdot \cos[\,270° - \alpha\,]$	$F_g \cdot \sin[\,270° - \alpha\,]$
$\vec{\mathbf{F}}_N$	0	[positive]
[uphill force if present]	[positive]	0
[downhill force if present]	[negative]	0
$\vec{\mathbf{F}}_{total}$	[depends on problem]	0