Newton's Second Law and Forces at Angles

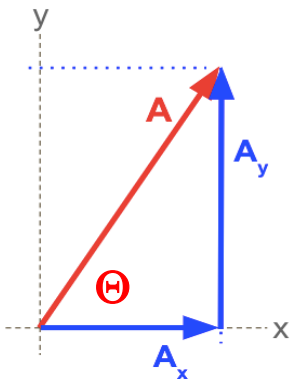
Lesson Notes

Learning Outcomes

- How do you analyze a situation where an angled force causes an acceleration along a horizontal surface?

Vector Resolution - A Quick Review

Vectors directed at angles to the coordinate axes can be thought of as having two parts or **components**. On the diagram at the right, A_x and A_y are the components of vector A.

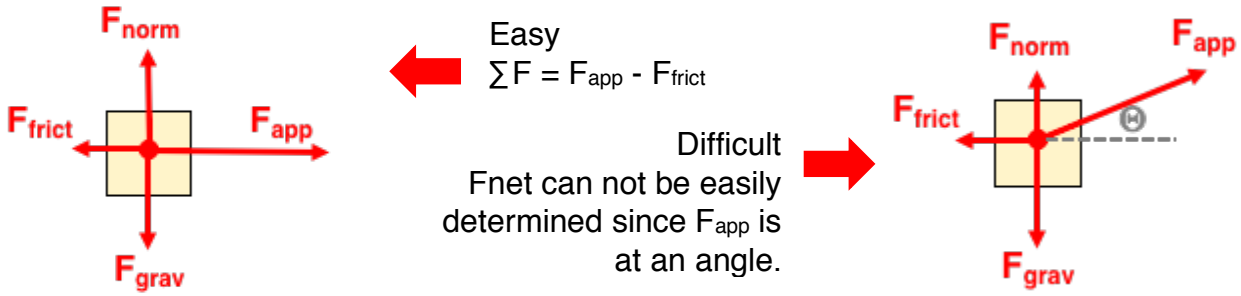


Using tirgonometric functions, they can be calculated as follows:

$A_x = A \cdot \cos \Theta$ $A_y = A \cdot \sin \Theta$

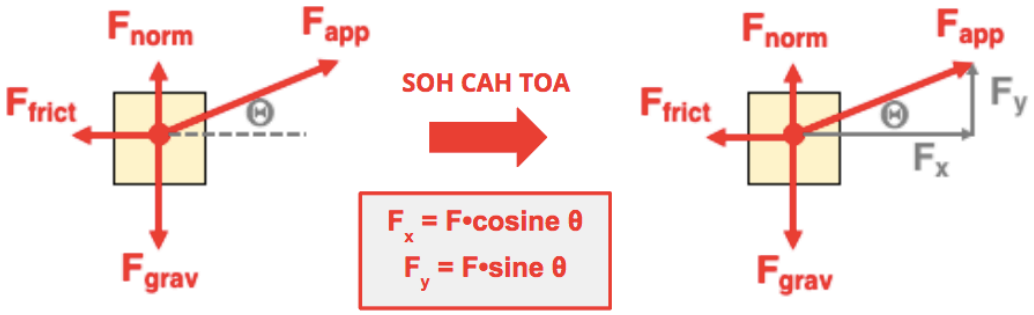
Easy vs. Difficult Fnet = m·a Analyses

Situations are relatively easy to analyze when all the forces are directed opposite to or at right angles to each other.



SOH CAH TOA

Use trigonometry to simpligy the difficult problem by resolving the angled force into x- and y-components.

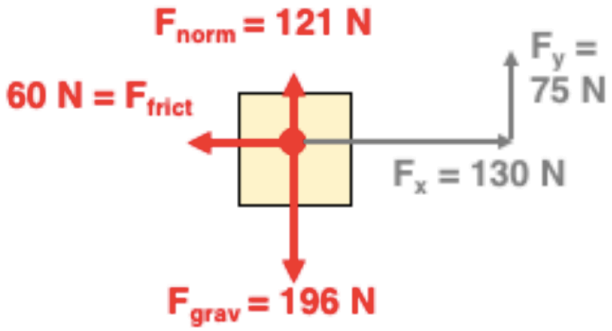


Horizontal Analysis: $F_{net} = F_x - F_{frict}$

Vertical Analysis: $\sum F = 0$ N. ... so $F_{grav} = F_y + F_{norm}$

An Example with Numbers

A 150-N force at 30° above the horizontal is used to accelerate a 20-kg object across a level surface. There is 60 N of friction. Determine the acceleration.



$F_x = 150 \cdot \cos 30° = 130$ N

$F_y = 150 \cdot \sin 30° = 75$ N

$F_{net} = F_x - F_{frict}$

$F_{net} = 130\text{ N} - 60\text{ N} = \mathbf{70\text{ N}}$

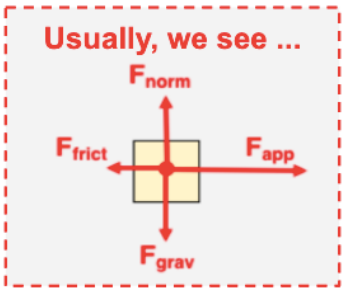
$a = F_{net} / m$

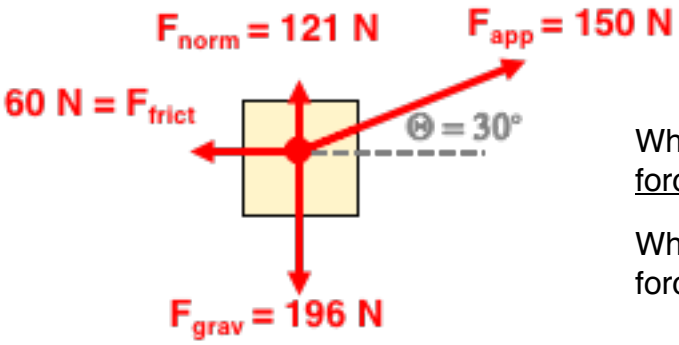
$a = 70\text{ N} / 20\text{ kg}$

$\mathbf{a = 3.5\text{ m/s/s}}$

Normal Force

Normal force (**F_{norm}**) is the force resulting from two surfaces being pressed against each other. When objects rest upon or move across the floor, they experience an **F_{norm}** from their interaction with the floor.



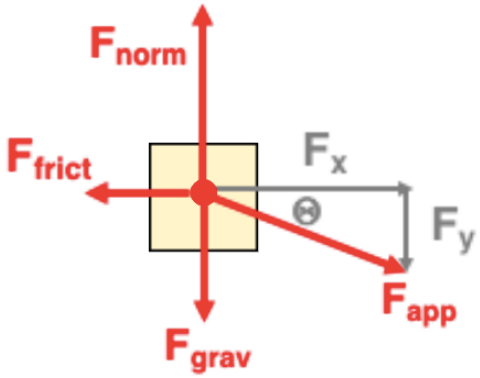


When $\sum F_y = 0$ and there are only 2 vertical forces, … $\mathbf{F_{grav} = F_{norm}}$

When $\sum F_y = 0$ and there are 3 vertical forces (like here), ... $\mathbf{F_{grav} = F_{norm} + F_y}$

What if the Angled Force is Downward?

How do you analyze a situation where a force is at an angle to the horizontal but directed downward?



When $\sum F_y = 0$ and there are 3 vertical forces (like here), …

$\mathbf{F_{grav} + F_y = F_{norm}}$