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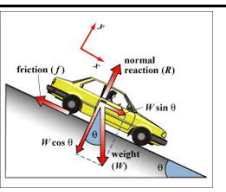
Chapter 7: Applications of Vectors

7.1 Vectors as Forces & 7.2 Velocity



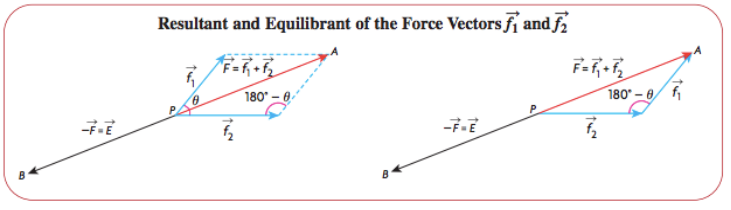
In general, forces are things that change, or tend to change, the state of rest or uniform motion of a body. It is described with magnitude and direction, so it is a vector quantity. Those of you that have taken physics are experts in forces, and those of you that have not do not need to be, but we will take a quick look at them here.

Force = mass of object (kg) x acceleration due to gravity (m/s^2)

F = ma, measured in $kg \cdot m/s^2$ or Newtons (N)

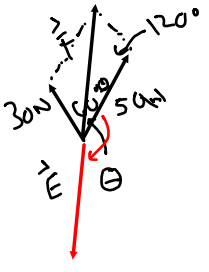
Usually we have two or more forces acting on an object at the same time. To understand the effect of these, we want to find the single force that would produce the same effect as all of the forces acting together (resultant or sum). This process is called the composition of forces.

The equilibrant of several forces is the opposite force to the resultant (the force that would allow the object to maintain a state of equilibrium - sum of zero)



Example 1: The composition of forces

Two forces of 30 N and 50 N act at an angle of 60° to each other. Determine the resultant and the equilibrant of these forces.



$|\vec{F}|^2 = 30^2 + 50^2 - 2(30)(50)\cos 120°$

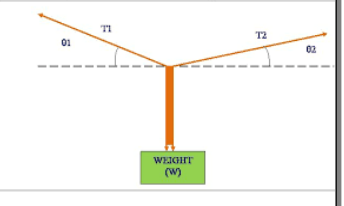
$|\vec{F}| = \sqrt{4900}$

$|\vec{F}| = 70N$

$\frac{\sin\theta}{30} = \frac{\sin 120°}{70}$

$\theta = 21.8°$ from the 50N force

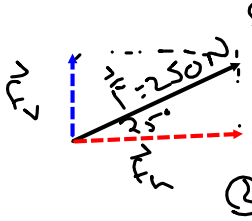
$\vec{E} = 70N, 158.2N$ from the 50N force



Example 2: Resolving a force to its components

Riad pulls on the handle of a wagon with a force of 250 N. If the handle makes an ~~example~~ angle of 25° with the horizontal, determine the force that pulls the wagon forward and the force that tends to lift the wagon.

This is the opposite of the composition of forces - we want to take the resultant force and determine the vertical and horizontal components of it.



① Horizontal component

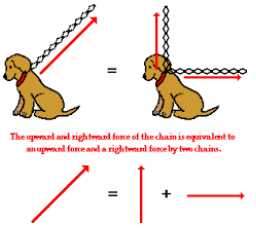
$\cos 25° = \frac{|\vec{F}_h|}{250}$

$|\vec{F}_h| = 226.6$ N horizontally

② Vertical component

$\sin 25° = \frac{|\vec{F}_v|}{250}$

$|\vec{F}_v| = 105.7$ N vertically

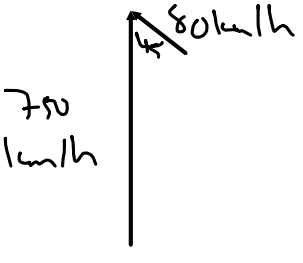


We have already looked quickly at velocity problems (crossing rivers, planes being blown off course, etc.). Today we are going to specifically look at finding the resultant. When you are setting up these problems PLEASE MAKE SURE THAT YOU JOIN YOUR VECTORS IN A VALID CONFIGURATION (head to tail or tail to tail). You usually need to draw a position diagram before you can draw the vector diagram.

Example 3: Resultant velocity

A plane is heading due north at 750 km/h when it encounters a wind **from** the southeast at 80 km/h. What is the resultant velocity of the airplane?

Position Diagram



Vector Diagram

$|\vec{v}+\vec{w}|^2 = 750^2 + 80^2 - 2(750)(80)\cos 135°$

$|\vec{v}+\vec{w}| = 808.5$ km/h

$\frac{\sin\theta}{80} = \frac{\sin 135°}{808.5}$

$\theta = 4.0°$, W of N

$\vec{v}+\vec{w} = 808.5$ km/h, [N 4° W]