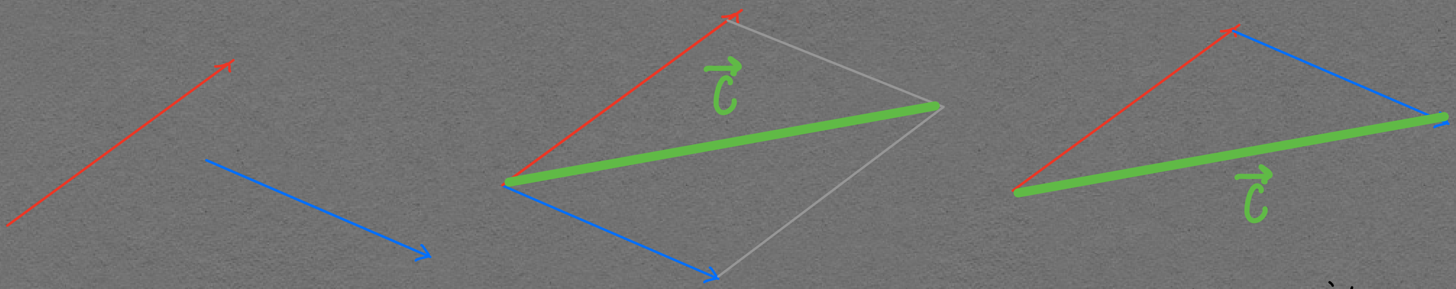
$\vec{A}$ = $\underset{\text{magnitude}}{A}$ $\underset{\text{direction}}{\theta}$

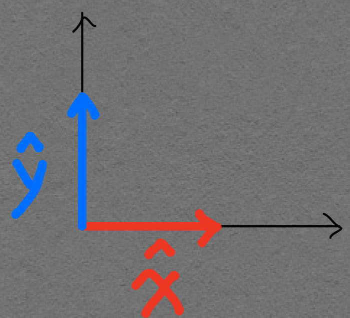
$\vec{A} + \vec{B}$

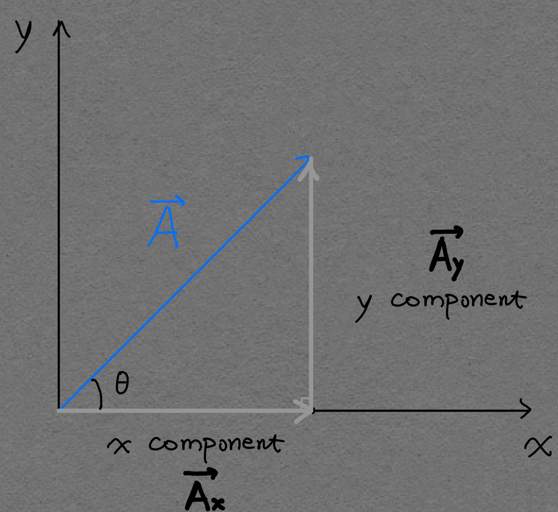


parallelogram method

tip to tail method

Unit Vector





$\cos\theta = A_x / A$

$\sin\theta = A_y / A$

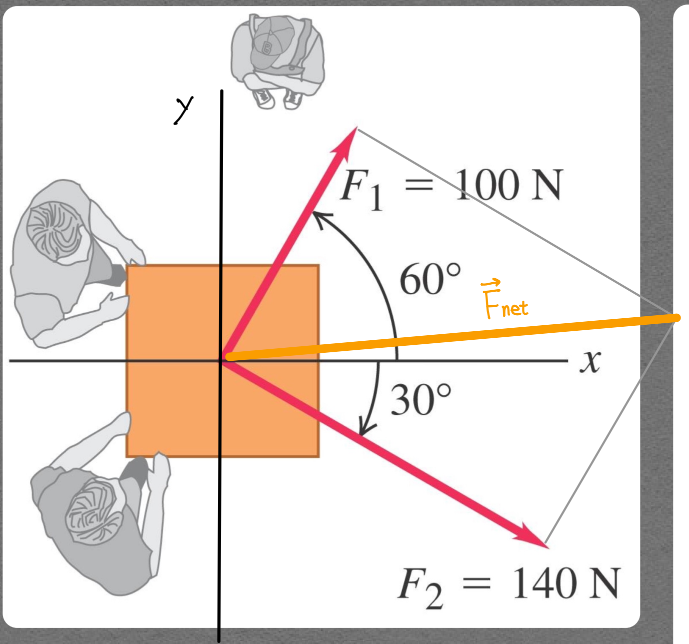
$A_x = \cos\theta A$

$A_y = \sin\theta A$

$\vec{A_x} = A_x \hat{x}$

$\vec{A_y} = A_y \hat{y}$

$\vec{A} = A_x \hat{x} + A_y \hat{y}$



Vector Addition Example with Forces

Consider the two forces exerted on the crate in the previous diagram.

a) Express *each* force in component form.

b) Express the net force in component form.

c) Express the net force as magnitude and direction.

d) What third force could be applied to the crate to prevent it from moving?

a) $\vec{F_1} = F_{1x} * \hat{x} + F_{1y} * \hat{y} = (F_1 \cos 60^\circ)\hat{x} + (F_1 \sin 60^\circ)\hat{y}$

$= 50N\,\hat{x} + 86.6N\,\hat{y}$

$\vec{F_2} = F_{2x} * \hat{x} + F_{2y} * \hat{y} = (F_1 \cos(-30^\circ))\hat{x} + (F_1 \sin(-30^\circ))\hat{y}$

$= 121.2N\,\hat{x} - 70N\,\hat{y}$

b) $\vec{F}_{net} = \vec{F_1} + \vec{F_2} = 171.2N\,\hat{x} + 16.6N\,\hat{y}$

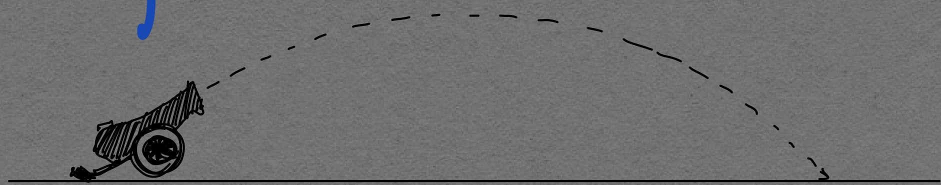
c) $F_{net} = \sqrt{F_{net\,x}^2 + F_{net\,y}^2} = 172N$

$\alpha = \tan^{-1}\left(\frac{F_{net\,y}}{F_{net\,x}}\right) = 5.54^\circ$

d) $\vec{F_3} = -\vec{F}_{net} = 172N, \alpha = 185.5^\circ$

$= -172N\,\hat{x} - 16.6N\,\hat{y}$

Projectile Motion

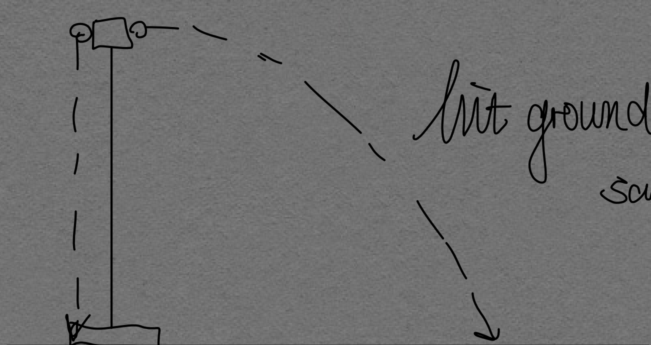


Projectile Motion

Motion in two dimensions during which the sole force that acts is gravity (i.e., under circumstances in which air resistance may be neglected).

Equations of Kinematics for Constant Acceleration in Two-Dimensional Motion

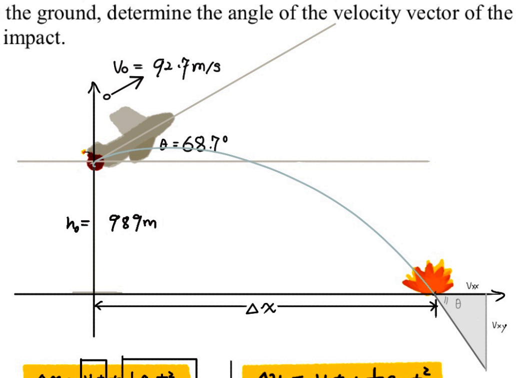
x Component	Variable	y Component
x	Displacement	y
a_x	Acceleration	a_y
v_x	Final velocity	v_y
v_{0x}	Initial velocity	v_{0y}
t	Elapsed time	t
$v_x = v_{0x} + a_x t$		$v_y = v_{0y} + a_y t$
$\Delta x = \frac{1}{2}(v_{0x} + v_x)t$		$\Delta y = \frac{1}{2}(v_{0y} + v_y)t$
$\Delta x = v_{0x}t + \frac{1}{2}a_x t^2$	except x&y	$\Delta y = v_{0y}t + \frac{1}{2}a_y t^2$
$v_x^2 = v_{0x}^2 + 2a_x\Delta x$		$v_y^2 = v_{0y}^2 + 2a_y\Delta y$



hit ground at same time

same y-axis motion

3.37 An airplane with a speed of 92.7 m/s is climbing upward at an angle of 68.1 ° with respect to the horizontal. When the plane's altitude is 989 m, the pilot releases a package. **(a)** Calculate the distance along the ground, measured from a point directly beneath the point of release, to where the package hits the earth. **(b)** Relative to the ground, determine the angle of the velocity vector of the package just before impact.



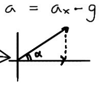
a

$$\Delta x = \boxed{V_0 t} + \boxed{\tfrac{1}{2} a_x t^2}$$

$a_y = -9.8\ m/s^2$

$a_x = 0\ m/s^2$

$a = a_x - g$



$$\Delta y = V_0 t + \tfrac{1}{2} a_y t^2$$

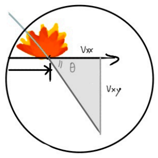
$\Delta y = (V_0 \sin\theta) t - \frac{1}{2} * g t^2$

$t = 25.479s$ or $-7.92s$

$\Delta x = (V_0 \cos\theta) t$

$= 881\ m$

b

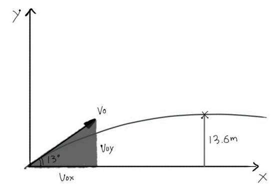


$\alpha = \tan^{-1}\left(\frac{V_{xy}}{V_{xx}}\right) = \frac{V_{0y} + at}{V_{0x}}$

$= \frac{V_0 \cdot \sin\theta - gt}{V_0 \cos\theta}$

$= 78.1°$ < Below the horizontal >

3.32 The highest barrier that a projectile can clear is 13.6 m, when the projectile is launched at an angle of 13.0 ° above the horizontal. What is the projectile's launch speed?



$$V_y^2 = V_{0y}^2 + 2a\Delta y$$

$0 = V_{0y}^2 - 2g\Delta y$

$V_{0y} = 72.6\ m/s$

$V_{0x} = V_{0y} / \tan(13°)$

$=$