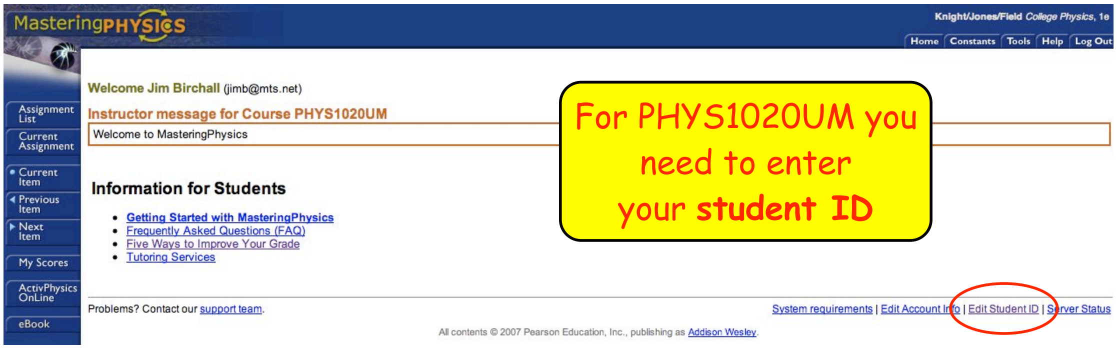
Mastering Physics: Entering/correcting your student ID



The i-clicker

Not required for this course, but is for some others.

On sale at bookstore.

Can be sold back to bookstore for most of purchase price (all but $6?).

Will incorporate some conceptual clicker questions into lectures
- "active learning"
- check of understanding

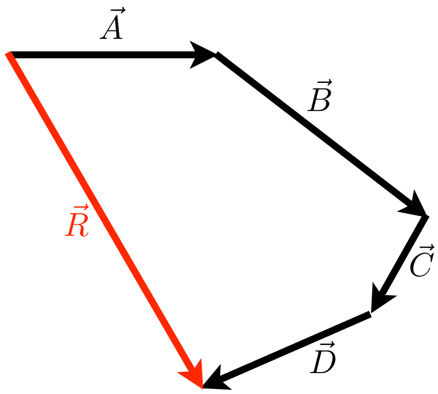
Do you have a clicker?

If you have a clicker, press "A"
If you don't have a clicker... don't

The story so far...

- Vectors have a magnitude and direction and can be broken down into x and y components

- Vectors placed nose to tail – add $\vec{R} = \vec{A} + \vec{B} + \vec{C} + \vec{D}$

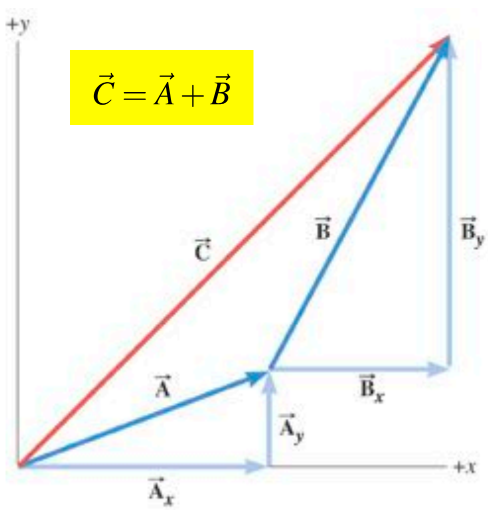


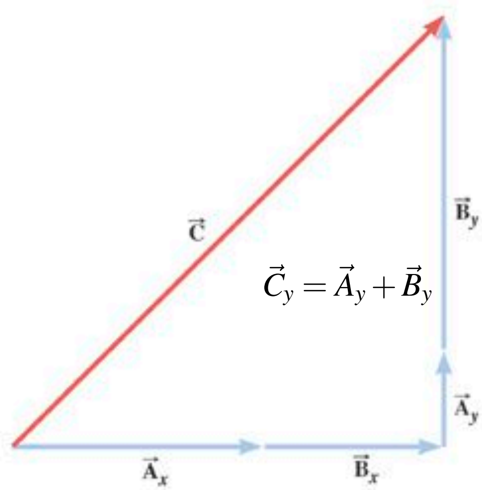
And the components add:

$$R_x = A_x + B_x + C_x + D_x$$

$$R_y = A_y + B_y + C_y + D_y$$

Addition of vectors





$$\vec{C}_x = \vec{A}_x + \vec{B}_x$$

Units

Table 1.1 Units of Measurement

	System		
	SI	CGS	BE
Length	Meter (m)	Centimeter (cm)	Foot (ft)
Mass	Kilogram (kg)	Gram (g)	Slug (sl)
Time	Second (s)	Second (s)	Second (s)

Dimensional Analysis

Express all quantities in terms of basic units (dimensions) of mass, length and time – [M], [L], [T]   (kg, m, s)

$$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{[L]}{[T]}$$

$$\text{Acceleration} = \frac{\text{Change in speed}}{\text{Time}} = \frac{[L]}{[T]} \times \frac{1}{[T]} = \frac{[L]}{[T]^2}$$

Is the following equation dimensionally correct?

$$x = x_0 + v_0 t + \frac{1}{2} a t$$

x, x_0 = positions along x-axis, [L]
v_0 = initial speed, [L]/[T]
t = time, [T]
a = acceleration, $[L]/[T]^2$

Dimensions in equations must match

A mass m is suspended from a spring. The mass is pulled down and released. The mass oscillates up and down in a time T given by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where m is the mass (kg) and k is known as the spring constant. What must the dimensions of k be for the equation to be dimensionally correct?

Rearrange to find k in terms of the other variables:

$$k = 4\pi^2 m/T^2$$

Dimensions:

k is $\frac{[M]}{[T]^2}$ or kg/s^2

Dimensions in equations must match

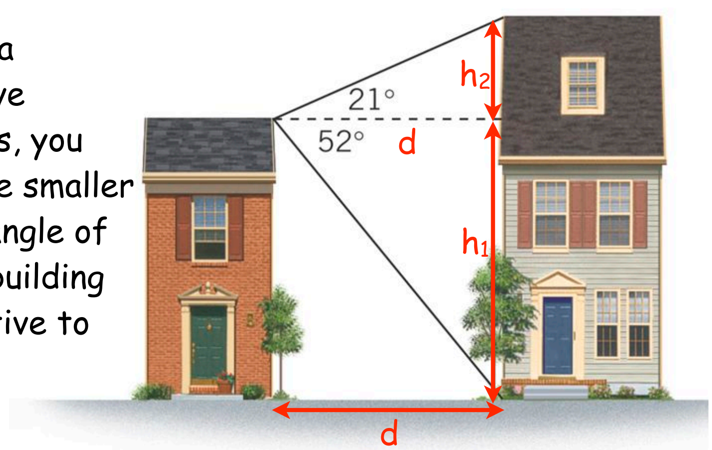
1.8/-: The volume of liquid flowing per second is called the volume flow rate Q and has the dimensions of $[L]^3/[T]$. The flow rate of a liquid through a hypodermic needle during an injection can be estimated with the following equation:

$$Q = \frac{\pi R^n (P_2 - P_1)}{8\eta L}$$ n = dimensionless integer

L, R = length and radius of needle
P_2, P_1 = pressure of liquid at opposite ends of needle, dimensions = $[M]/([L][T]^2)$
η = visosity of the liquid, dimensions = $[M]/([L][T])$.

What is the value of the constant n in the expression?

Prob. 1.62/-: To settle a dispute over the relative heights of two buildings, you climb to the roof of the smaller building and sight the angle of the roof of the other building and of the ground relative to you, as shown.



Trigonometry: $h_1/d = \tan 52°$, $h_2/d = \tan 21°$

so, $h_2/h_1 = \tan 21°/\tan 52° = 0.3$
and $h_2 = 0.3\, h_1$

Taller building has height $h_1 + h_2 = 1.3\, h_1$

Vector notation: $\vec{A}$ is the same as ***A***

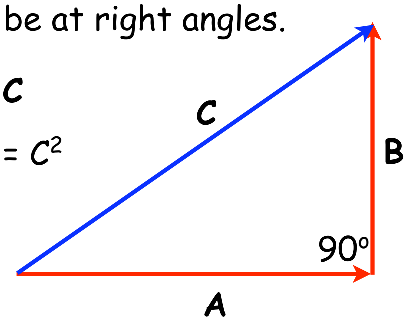
Prob. 1.C16: Vectors ***A***, **B** and ***C*** satisfy the vector equation ***A*** + **B** = ***C***, and their magnitudes are related by the scalar equation $A^2 + B^2 = C^2$.

How is vector ***A*** oriented with respect to vector **B**?

The magnitudes of the vectors satisfy Pythagoras' theorem, so ***A*** and **B** must be at right angles.

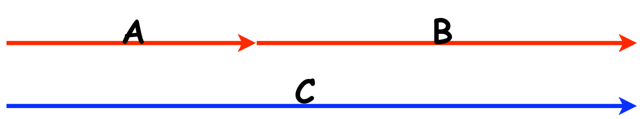
A + **B** = ***C***

$A^2 + B^2 = C^2$



Prob. 1.C17: Vectors ***A***, **B** and ***C*** satisfy the vector equation ***A*** + **B** = ***C***, and their magnitudes are related by the scalar equation A + B = C.

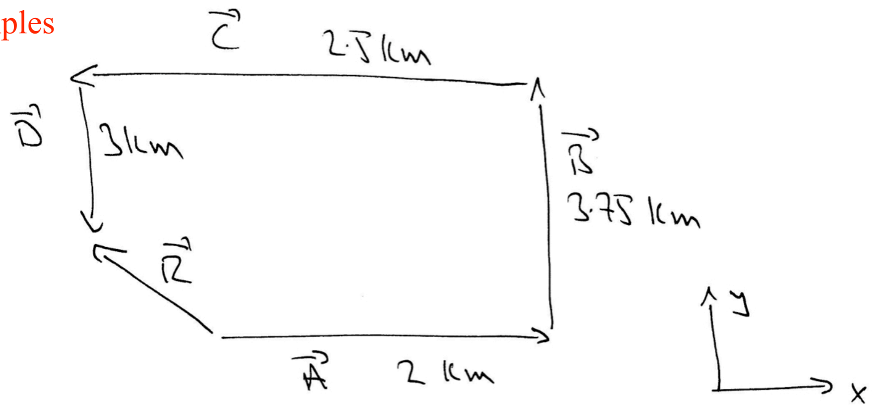
How is the vector ***A*** oriented with respect to vector **B**?



A + **B** = ***C***

A + B = C

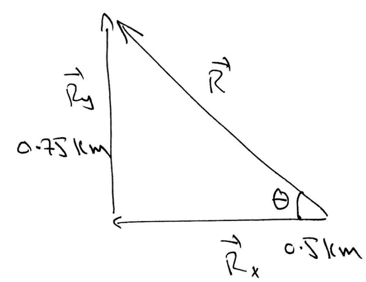
Vector examples



Four displacement vectors, $\vec{A}$, $\vec{B}$, $\vec{C}$, $\vec{D}$, as shown.

What is the resultant displacement $\vec{R} = \vec{A} + \vec{B} + \vec{C} + \vec{D}$?

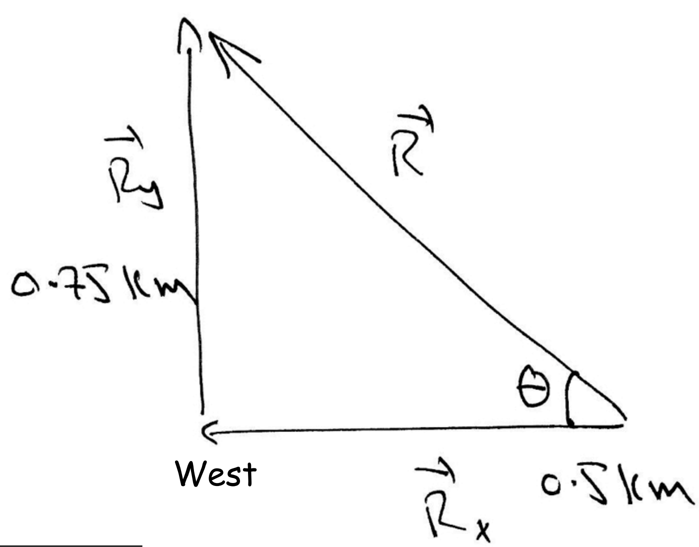
Components:



$$R_x = A_x + B_x + C_x + D_x$$
$$= 2 + 0 - 2.5 + 0 = -0.5 \text{ km}$$

$$R_y = A_y + B_y + C_y + D_y$$
$$= 0 + 3.75 + 0 - 3 = +0.75 \text{ km}$$

$R_x = -0.5$ km
$R_y = +0.75$ km



Magnitude of R:

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{0.5^2 + 0.75^2} = 0.90 \text{ km}$$

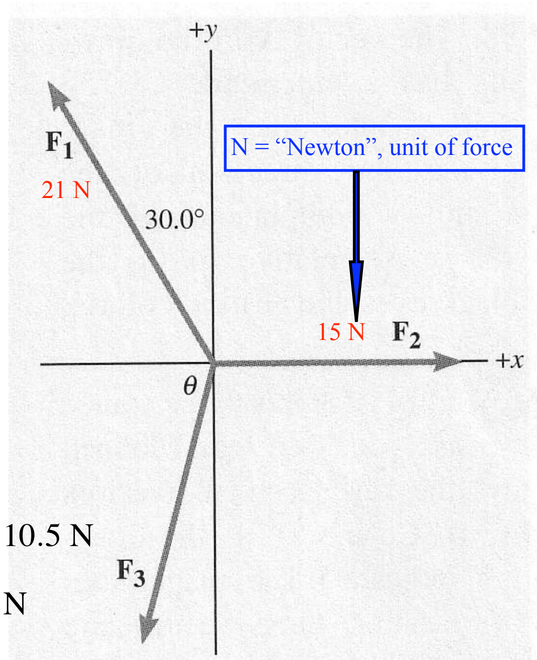
Direction:

$$\tan\theta = 0.75/0.5 = 1.5 \rightarrow \theta = 56.3^\circ \text{ north of west}$$

Prob. 1.46/46:

Three forces are applied to an object.

What must be the magnitude and direction of $\mathbf{F_3}$ if the sum of the forces is zero?



Need $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$

So, $\vec{F}_3 = -\vec{F}_1 - \vec{F}_2$

Components:

$F_{1x} = -F_1 \sin 30^\circ = -21 \sin 30^\circ = -10.5$ N

$F_{1y} = F_1 \cos 30^\circ = 21 \cos 30^\circ = 18.2$ N

$F_{2x} = 15$ N

$F_{2y} = 0$

F_{1x} = -10.5 N, F_{1y} = 18.2 N, F_{2x} = 15 N, F_{2y} = 0

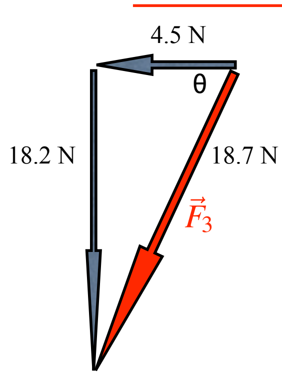
$\vec{F}_3 = -\vec{F}_1 - \vec{F}_2$

Add up the components:

$$F_{3x} = -F_{1x} - F_{2x} = 10.5 - 15.0 = -4.5 \text{ N}$$

$$F_{3y} = -F_{1y} - F_{2y} = -18.2 - 0 = -18.2 \text{ N}$$

So, $F_3 = \sqrt{F_{3x}^2 + F_{3y}^2} = \sqrt{4.5^2 + 18.2^2} = 18.7$ N



$\tan\theta = 18.2/4.5 = 4.04 \rightarrow \theta = 76.1^\circ$ south of west

Summary

Vectors have a magnitude **and** a direction
Scalars have just a magnitude

Vectors add nose to tail
Simplify by breaking vectors into x, y components

Vectors are subtracted by reversing the direction of the vector to be subtracted and then adding:

$$\mathbf{A} - \mathbf{B} = \mathbf{A} + (-\mathbf{B})$$

Dimensions must be the consistent in all terms of an equation
The basic dimensions are mass, length and time
[M], [L] and [T], (kg, m, s)