PHY115: Introduction

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Digipen

Spring 2023

General information of the course

Grading Policy

1. Assigments (20 %)
2. Midterm exam (40%)
3. Final exam (40%)

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5. Light and physics of shading

Why to study Physics?

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3. Too many errors in the motion will distract viewers and remind them that it's just a story.
   - Wrong response of material to light
   - Objects that move as if they were heavier than they look
   - Different falling acceleration for different bodies
   - ...

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- Dynamics describes what causes the motion

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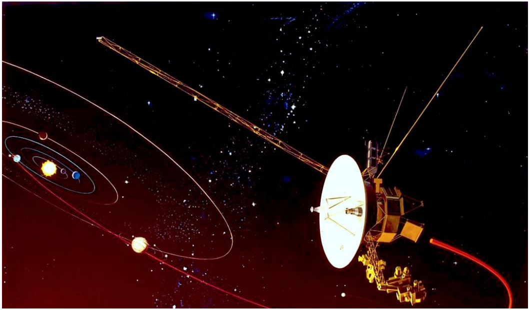

On the other hand...

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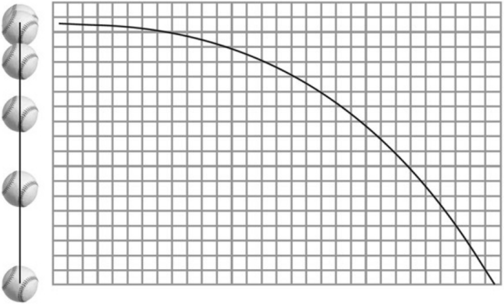
Knowing Dynamics can help us figure out accurate timing. Even if you plan to exaggerate your motion for effect, it helps to start with reality and work from there.

Kinematics



- Describes the motion path: Position vs. time $x(t), y(t)$ and $z(t) \rightarrow$ timing and spacing.

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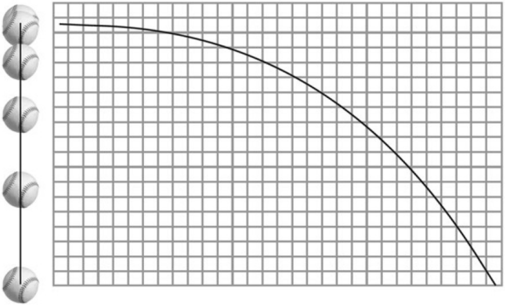

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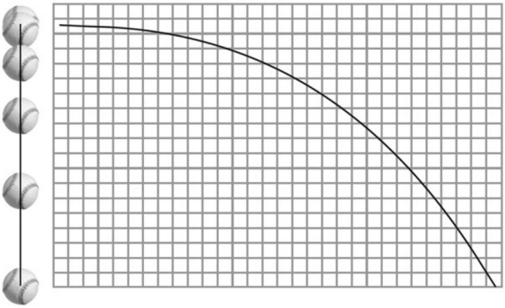

- Describes the motion path: Position vs. time $x(t), y(t)$ and $z(t) \rightarrow$ timing and spacing.
- There are three main quantities that describe the motion: acceleration, velocity and position
- The position is related with velocity and the velocity is related with acceleration.

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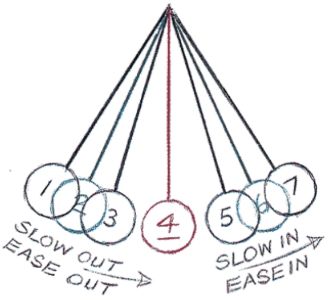

So our chart will look like this.

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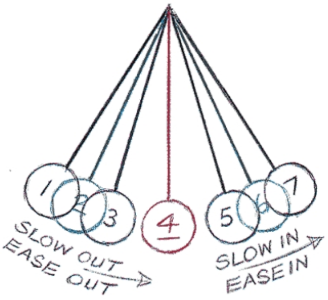

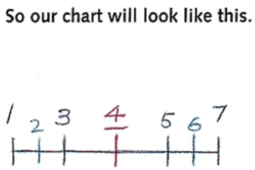

What is the right separation?

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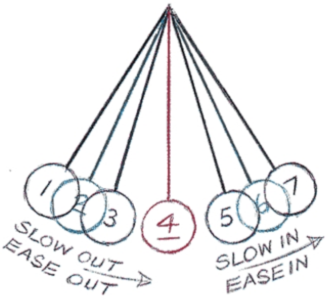

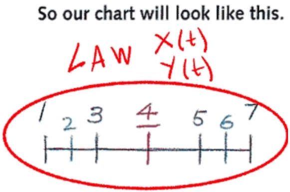

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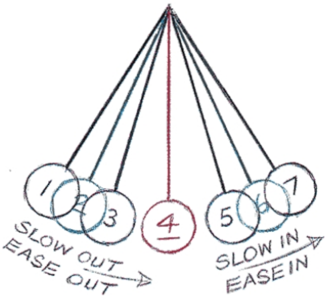

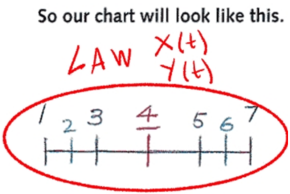

What generate that exact separation?

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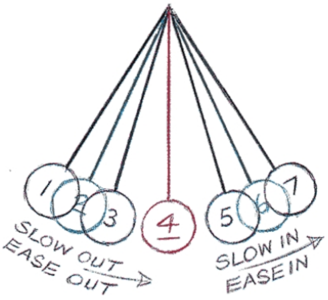

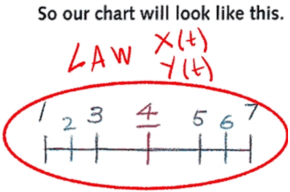

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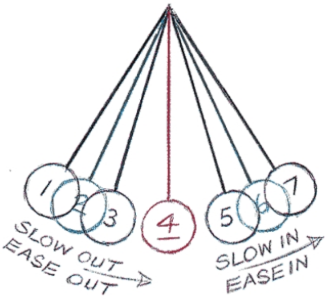

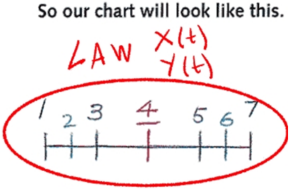

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- Frames of Reference
- escalar and vectors
- funcions
- trigonometry

Frame of reference

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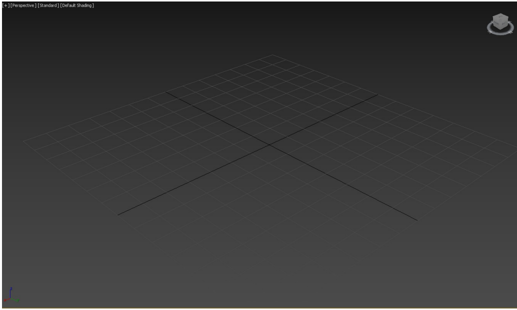

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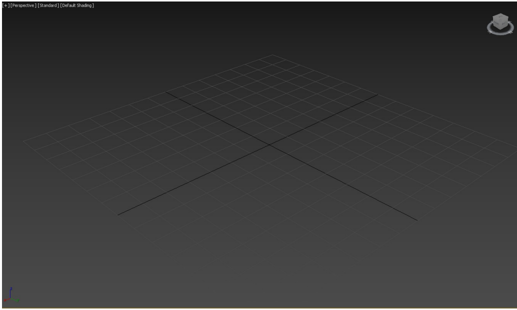
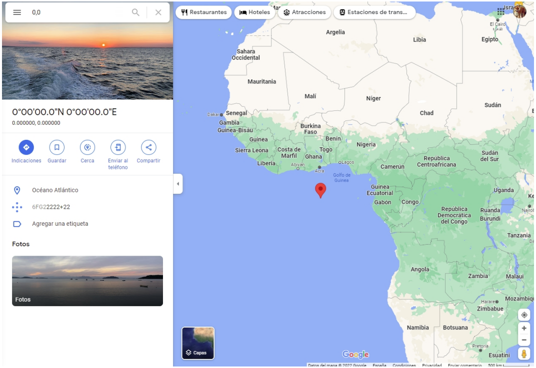


Another example of a reference system . . .



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- Some physical quantities, such as time, temperature, mass, and density, can be described completely by a single number with a unit.
- But many other important quantities in physics have a direction associated with them and cannot be described by a single number

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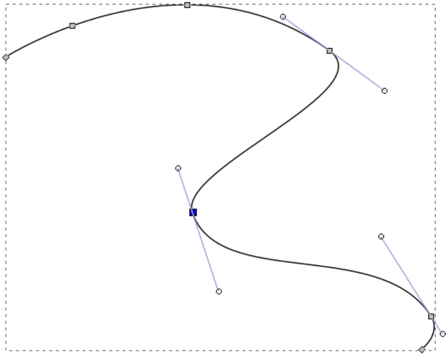

Another examples of vectors?

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- velocity
- acceleration
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How do we use them?

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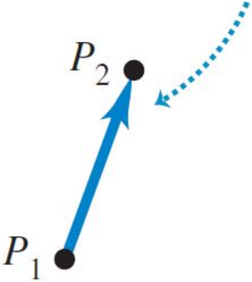
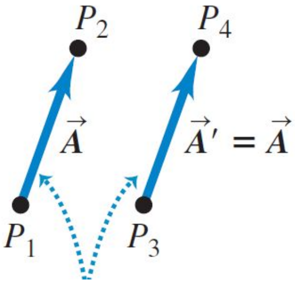
- We represent a vector quantity by a single letter, italic type with an arrow above it: $\vec{v}$

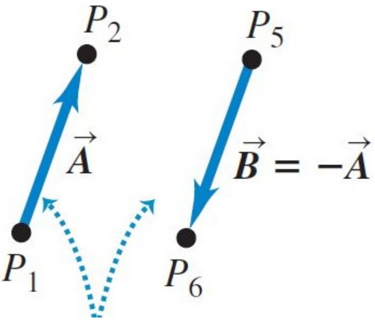
- Vectors are represented by arrows in diagrams.
- the magnitude is just the length of the arrow.
- $\vec{A} = \vec{A}'$



- If two vectors have the same magnitude and the same direction, they are equal, no matter where they are located in space.
- $\vec{A} = \vec{A}'$



- We define the negative of a vector as a vector having the same magnitude as the original vector but the opposite direction.
- $\vec{A} = -\vec{B}$
- When two vectors are parallel and have opposite directions, we say that they are antiparallel.



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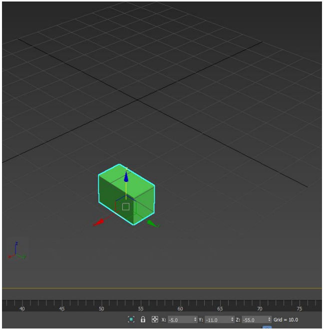
- The magnitude of a vector is a positive scalar (a positive number).
- A vector can never be equal to a scalar because they are different kind of quantities.

Displacement

- Displacement is simply a change in the position of an object.



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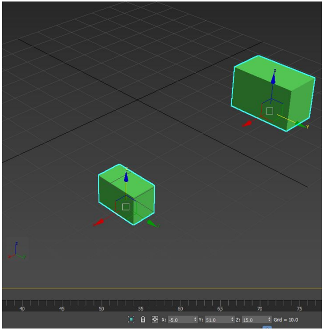

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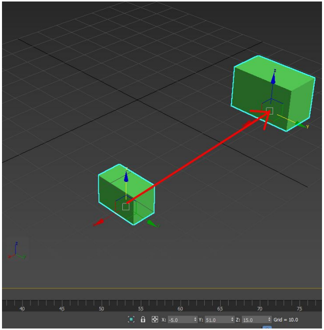

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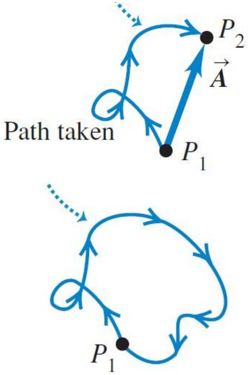
- The displacement only depend on the initial and final positions.



Operations with vector: Addition and subtraction

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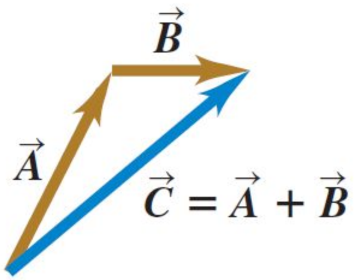
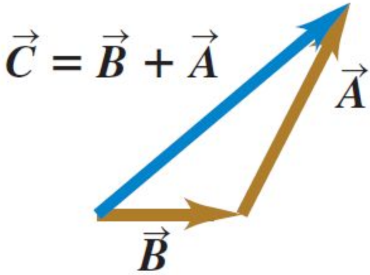
Suppose a particle undergoes a displacement $\vec{A}$ followed by a second displacement $\vec{B}$. The final result is the same as if the particle had started at the same initial point and undergone a single displacement $\vec{C}$.



Operations with vector: Addition and subtraction

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

- vector addition obeys the commutative law
- $\vec{A} + \vec{B} = \vec{B} + \vec{A}$
- note that the magnitude of $|C| \leq |A| + |B|$

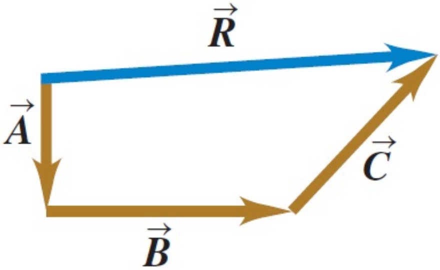


Sum of more than two vector:

$$\vec{R} = (\vec{A} + \vec{B}) + \vec{C} = \vec{D} + \vec{C}$$

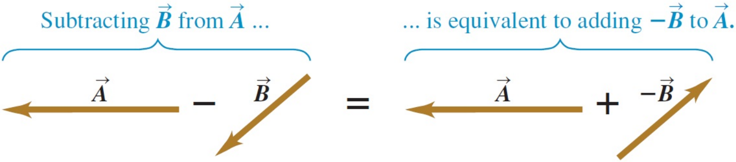
or

$$\vec{R} = \vec{A} + (\vec{B} + \vec{C}) = \vec{A} + \vec{E}$$



We define the difference of two vectors $\vec{A}$ and $\vec{B}$ to be the vector sum of $\vec{A}$ and $-\vec{B}$:

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

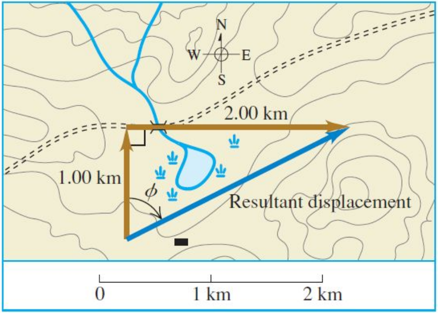


A vector can be multiplied by a positive (negative) scalar quantity. The result is a vector in the same direction (opposite) as the vector but with a different magnitud.
The magnitude is $|c||\vec{A}|$

EXAMPLE 1: Adding two vectors that are perpendicular

A cross-country skier skis 1.00 km north and then 2.00 km east on a horizontal snowfield. How far and in what direction is she from the starting point?

Distance from the starting point:



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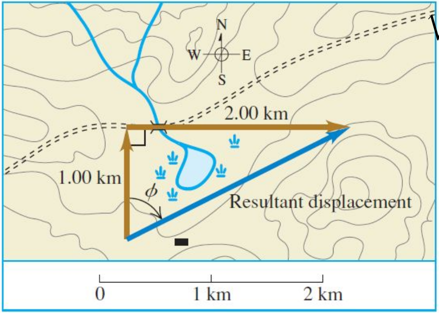

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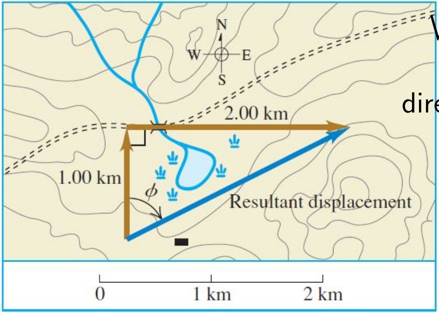

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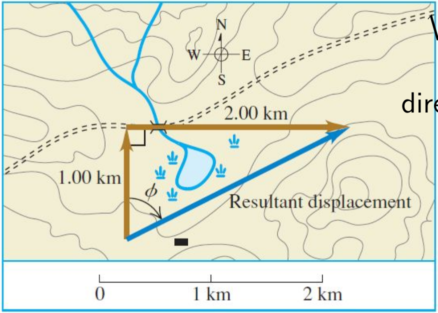

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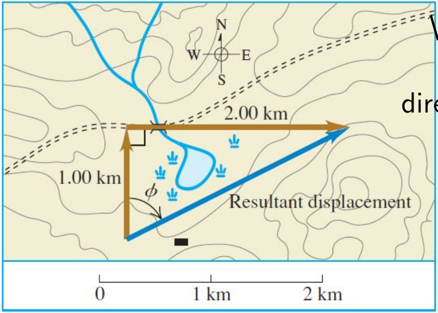

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$$\phi = 63.4^\circ$$

EXAMPLE 2: Test Your Understanding

Two displacement vectors, $\vec{u}$ and $\vec{v}$ have magnitudes 3 and 4. Which of the following could be the magnitude of the difference vector (There may be more than one correct answer.)

- 9 m
- 7 m
- 5 m
- 1 m
- 0 m
- -1 m

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- This is called the method of components.

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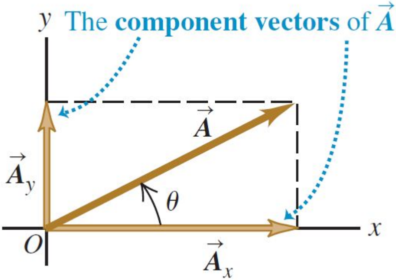

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The two numbers A_x and A_y are called the components of $\vec{A}$.

We represent $\vec{A}$ using its components as:

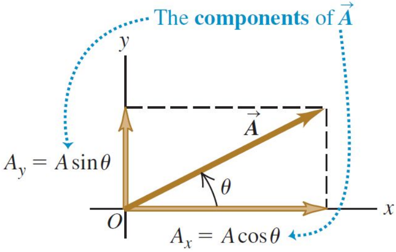
$$\vec{A} = (A_x, A_y) \tag{3}$$

- If we know the direction and the magnitude of a vector, we can know the components.

$$\frac{A_x}{A} = cos\theta, \ and \ \frac{A_y}{A} = sin\theta$$

$$A_x = Acos\theta, \ and \ A_y = Asin\theta$$

$$\rightarrow \vec{A} = \vec{A}_x + \vec{A}_y$$



Finding a vector's magnitude and direction from its components.

$$A = \sqrt{A_x^2 + A_y^2} \tag{4}$$

$$tan\theta = \frac{A_y}{A_x} \quad and \quad \theta = arctan(\frac{A_y}{A_x}) \tag{5}$$

Multiplying a vector by a scalar.

$$\vec{D} = c\vec{A} \tag{6}$$

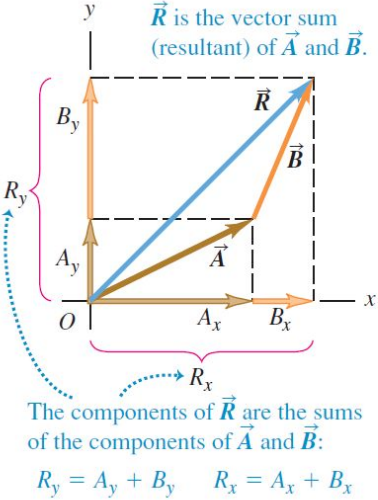
$$D_x = cA_x \quad and \quad D_y = cA_y \tag{7}$$

Using the components to calculate the vector sum

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

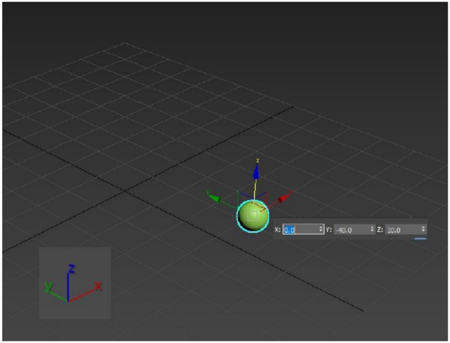
$$R_x = A_x + B_x$$

$$R_y = A_y + B_y$$



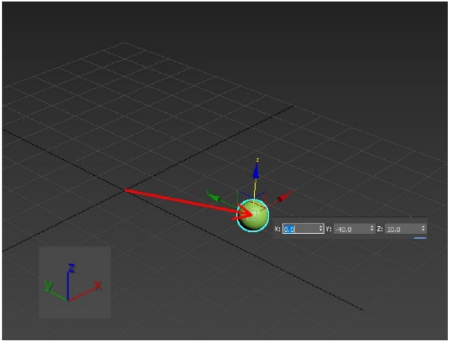
EXAMPLE:

You are using vector sums to move objects in 3ds Max all the time...



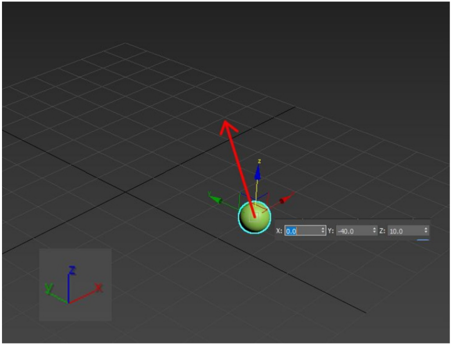
EXAMPLE:

Position vector



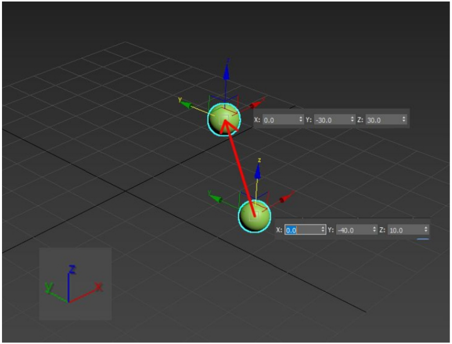
EXAMPLE:

Displacement Vector



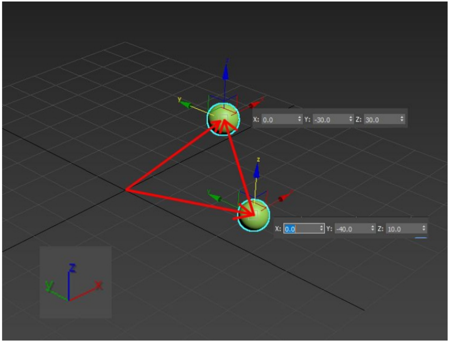
EXAMPLE:

Displacement Vector



EXAMPLE:

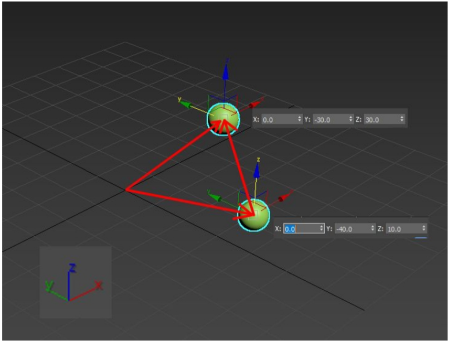
Final Position=Position Vector + Displacement Vector



EXAMPLE:

A more elegant notation...

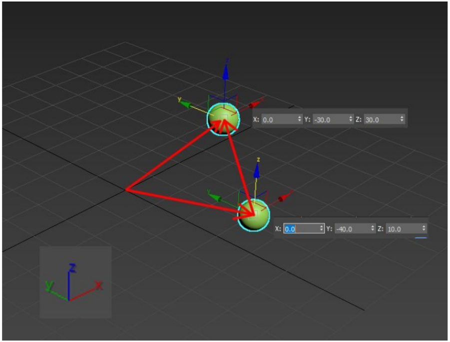
$$\vec{r}_f = \vec{r}_i + \Delta\vec{r} \qquad (8)$$



EXAMPLE:

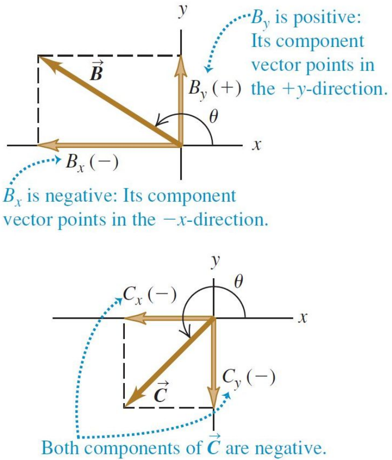
so, the displacement vector is...

$$\Delta\vec{r}+ = \vec{r}_f - \vec{r}_i \qquad (9)$$

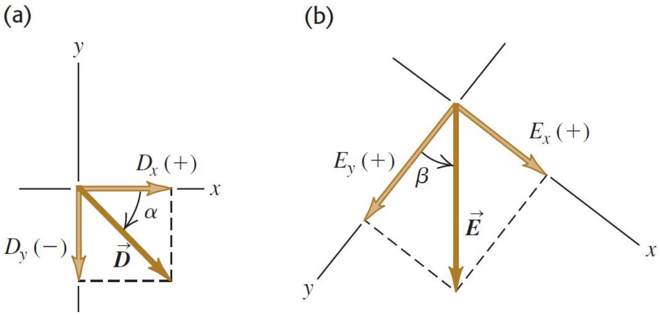


In general, we use the symbol Δ to represent the change of a magnitude...

- In the previous definitions we measure the angles as in the figure.



EXAMPLE: (a) What are the x and y components of vector in the figure? The magnitude of the vector $\vec{D}$ is $D = 3.00\ m$, and the angle $\alpha = 45°$. (b) What are the x- and y-components of vector $\vec{E}$ in? The magnitude of the vector is $E = 4.50\ m$, and the angle $\beta = 45°$



Adding more than one vector:

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

$$\rightarrow R_x = A_x + B_x + C_y$$

$$\rightarrow R_y = A_y + B_y + C_y$$

$$\rightarrow R_y = A_z + B_z + C_z$$

Magnitude of a vector with 3 components:

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Test your understanding:

Two vectors $\vec{A}$ and $\vec{B}$ both lie in the xy-plane.

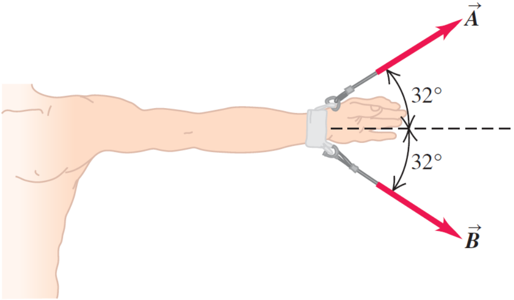
- Is it possible for $\vec{A}$ to have the same magnitude as $\vec{B}$ but different components?
- Is it possible for $\vec{A}$ to have the same components as $\vec{B}$ but a different magnitude?

Let's solve some exercises from Sears & Zemansky's Book[1]:

A disoriented physics professor drives 3.25 *km* north, then 2.90 *km* west, and then 1.5 *km* south. Find the magnitude and direction of the resultant displacement, using the method of components. In a vector-addition diagram (roughly to scale), show that the resultant displacement found from your diagram is in qualitative agreement with the result you obtained using the method of components.

[1] Sears & Zemansky with modern physics 13th edition.

A patient with a dislocated shoulder is put into a traction apparatus as shown in the figure[2]. The pulls and have equal magnitudes and must combine to produce an outward traction force of 5.60 N on the patient's arm. How large should these pulls be?



[2] Image from Sears & Zemansky with modern physics 13th edition

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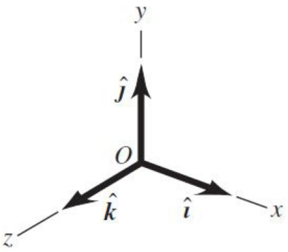
$$\hat{\imath},\ \hat{\jmath},\ and\ \hat{k}$$



We can represent component vectors like this:

$$\rightarrow \vec{A}_x = A_x \hat{\imath}$$

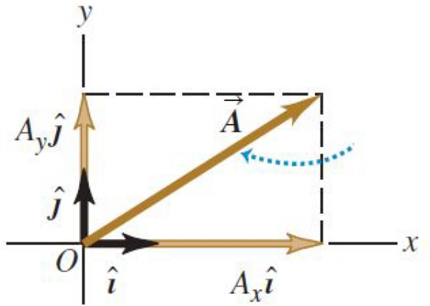
$$\rightarrow \vec{A}_y = A_y \hat{\jmath}$$

$$\rightarrow \vec{A}_z = A_z \hat{k}$$

We can represent a vector using this notation:

$$\vec{A} = \vec{A}_x + \vec{A}_y$$

$$\rightarrow \vec{A} = A_x\hat{\imath} + A_y\hat{\jmath}$$



How can we represent the sum of two vectors using this notation?

Guess!

Test your understanding

Arrange the following vectors in order of their magnitude, with the vector of largest magnitude first.

1. $\vec{A} = (3\hat{\imath} + 5\hat{\jmath} - 2\hat{k})$
2. $\vec{A} = (-3\hat{\imath} + 5\hat{\jmath} - 2\hat{k})$
3. $\vec{A} = (3\hat{\imath} - 5\hat{\jmath} - 2\hat{k})$
4. $\vec{A} = (3\hat{\imath} + 5\hat{\jmath} + 2\hat{k})$

Functions

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- some useful functions:
  1. linear functions
  2. quadratic functions
  3. sin, cos
  4. exponential, logarithmic function

Examples . . .

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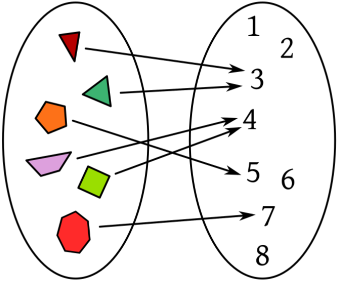

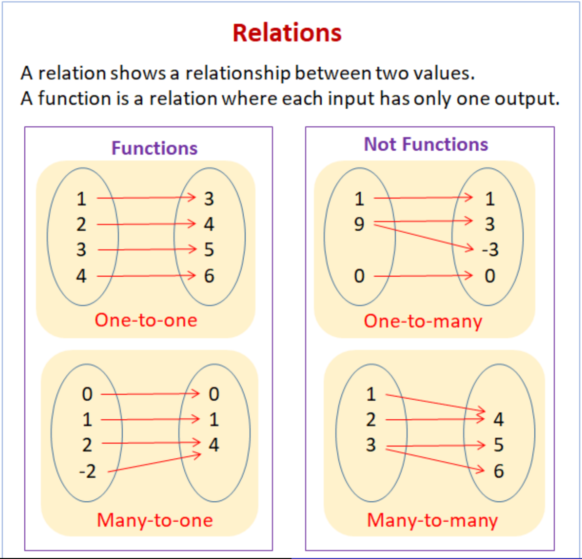
Relations
A relation shows a relationship between two values.
A function is a relation where each input has only one output.
Functions
1 2 3 4
3 4 5 6
One-to-one
0 1 2 -2
0 1 4
Many-to-one
Not Functions
1 9 0
1 3 -3 0
One-to-many
1 2 3
4 5 6
Many-to-many

Instead of using diagrams, we can use a law to draw the function in the x-y axes . . .

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$$\boxed{y = f(x)}$$

Linear Functions:

$$f(x) = Ax + C$$

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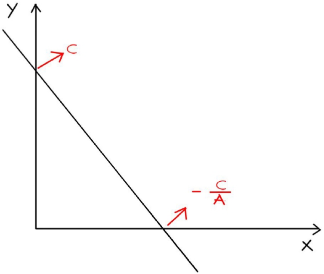
Representation in the xy axes coordinates:

$$y = Ax + C$$



Cuadratic Functions:

$$f(x) = ax^2 + bx + c$$

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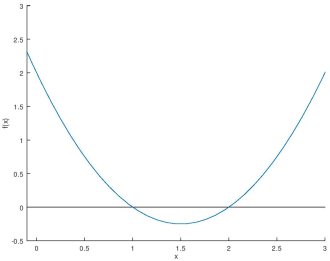
$$f(x) = ax^2 + bx + c$$

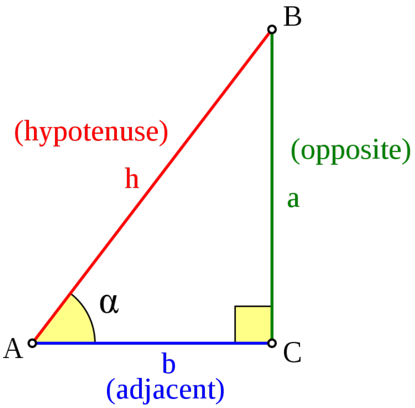
Representation in the xy axes coordinates:

$$y = ax^2 + bx + c$$



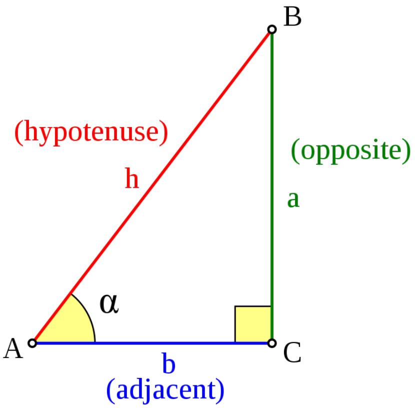
Trygonometric Functions:

$$sin(\alpha) = \frac{opposite}{hypotenuse}$$



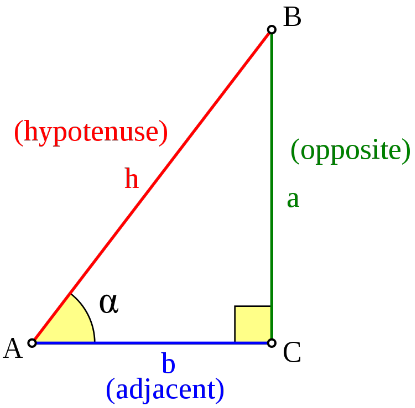
Trygonometric Functions:

$$cos(\alpha) = \frac{adjacent}{hypotenuse}$$



Trygonometric Functions:

$$tan(\alpha) = \frac{opposite}{adjacent}$$



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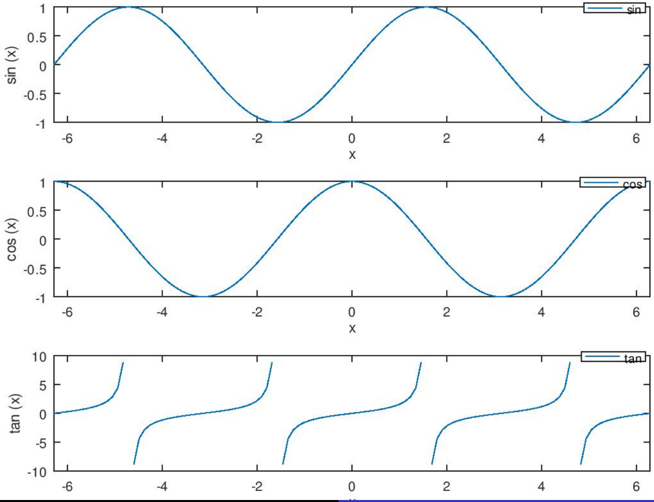
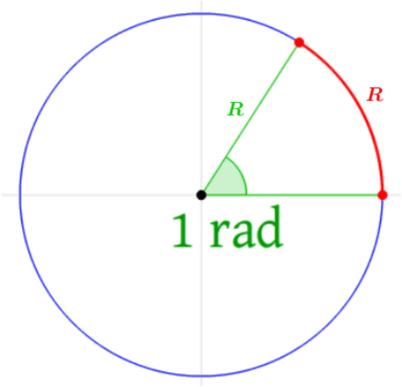


Measuring angles: radians



Radians to degrees

How many rads are 360 deg?

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$$2\pi\ rad \rightarrow 360 deg$$

$$x\ rad \rightarrow \frac{360}{2\pi}x = \frac{180}{\pi}x$$

How do I calculate the angle if I know the sin/cos/tan?

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You have to check what are the units of the angles...