PHYS 1441 – Section 002
Lecture #7

Wednesday, Feb. 6, 2008
Dr. Jaehoon Yu

- Motion in Two Dimension
  - Motion under constant acceleration
  - Vector recap
  - Projectile Motion
  - Maximum ranges and heights

Announcements

- 1st term exam on Wednesday, Feb. 20
  - Time: 1 – 2:20pm
  - Place: SH103
  - Covers: Appendices, CH 1 – what we learn till next Wednesday, Feb. 13
  - Class on Monday, Feb. 18: Jason will be here to go over the any problems you would like to review
- Colloquium
  - Today at 4pm in SH101, following the refreshment at 3:30pm in SH108
  - Please be sure to sign in the sign-in sheet

Physics Department
The University of Texas at Arlington

COLLOQUIUM

Gravitational Wave Astronomy: will it ever exist?

Dr. Mario Diaz
University of Texas at Brownsville

4:00 pm Wednesday, February 6, 2007
Room 101 SH

Abstract

In this talk I review the current status of the field of gravitational wave detection and its potential for utilization in astrophysics. I will report particularly on the results of observations with more than a year of LIGO interferometers operating at design sensitivity. I will discuss the meaning of the upper limit studies performed with these results and its impact on astronomical observations. I will also talk about the existing collaborations among different gravitational wave observatories throughout the world and how different interferometers are integrated to operate as a network. I will finally discuss plans for future detectors including Enhanced LIGO, Advanced LIGO and space based interferometers like LISA.

Refreshments will be served in the Physics Library at 3:30 pm

Kinematic Quantities in 1D and 2D

Quantities	1 Dimension	2 Dimension
Displacement	$\Delta x = x_f - x_i$	$\Delta \vec{r} = \vec{r}_f - \vec{r}_i$
Average Velocity	$v_x = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$	$\vec{v} \equiv \frac{\Delta \vec{r}}{\Delta t} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i}$
Inst. Velocity	$v_x \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$	$\vec{v} \equiv \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t}$
Average Acc.	$a_x \equiv \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xi}}{t_f - t_i}$	$\vec{a} \equiv \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i}$
Inst. Acc.	$a_x \equiv \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t}$	$\vec{a} \equiv \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$

What is the difference between 1D and 2D quantities?

Kinematic Equations

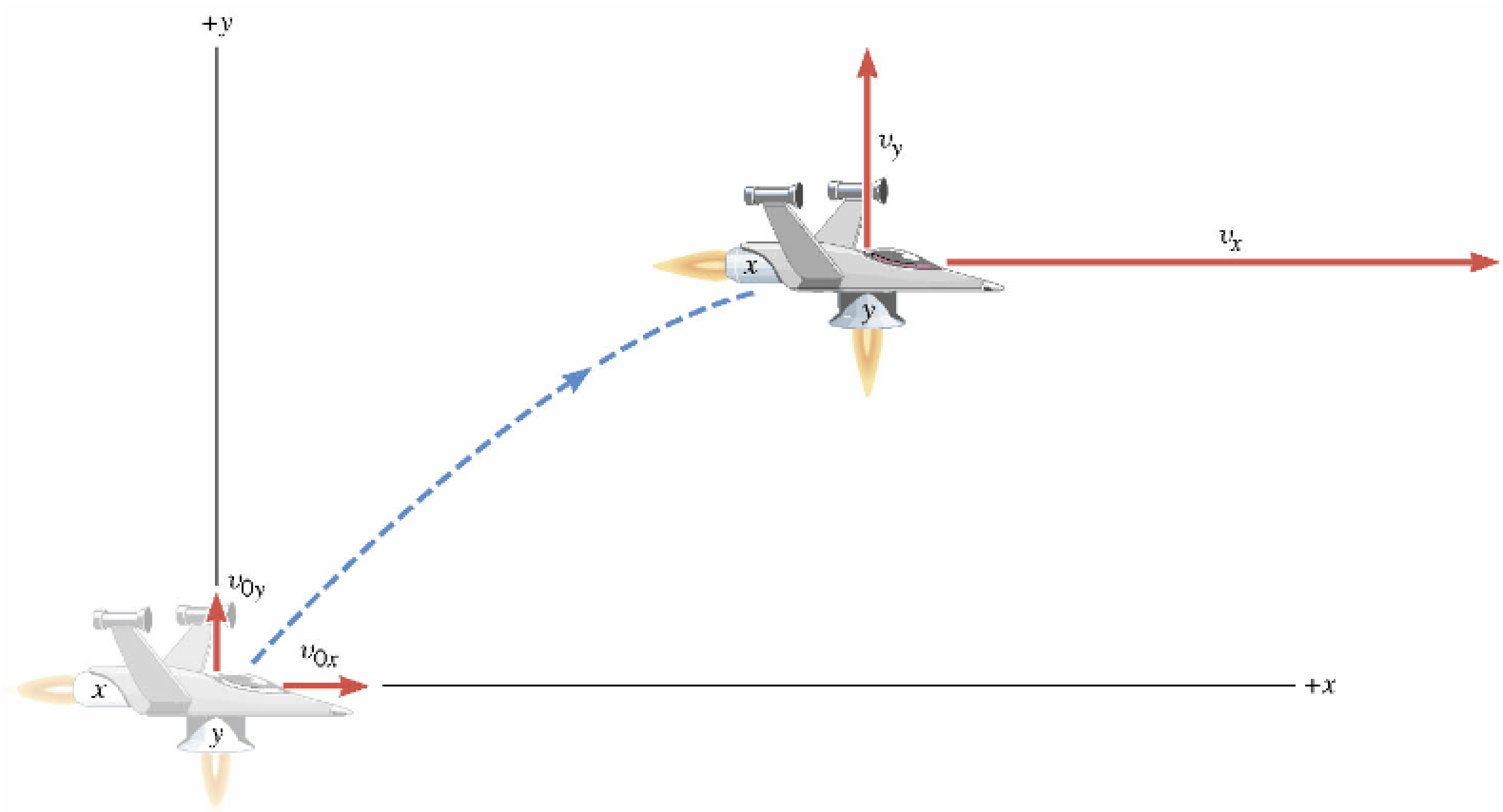
$$v = v_o + at$$

$$x = \tfrac{1}{2}\left(v_o + v\right)t$$

$$v^2 = v_o^2 + 2ax$$

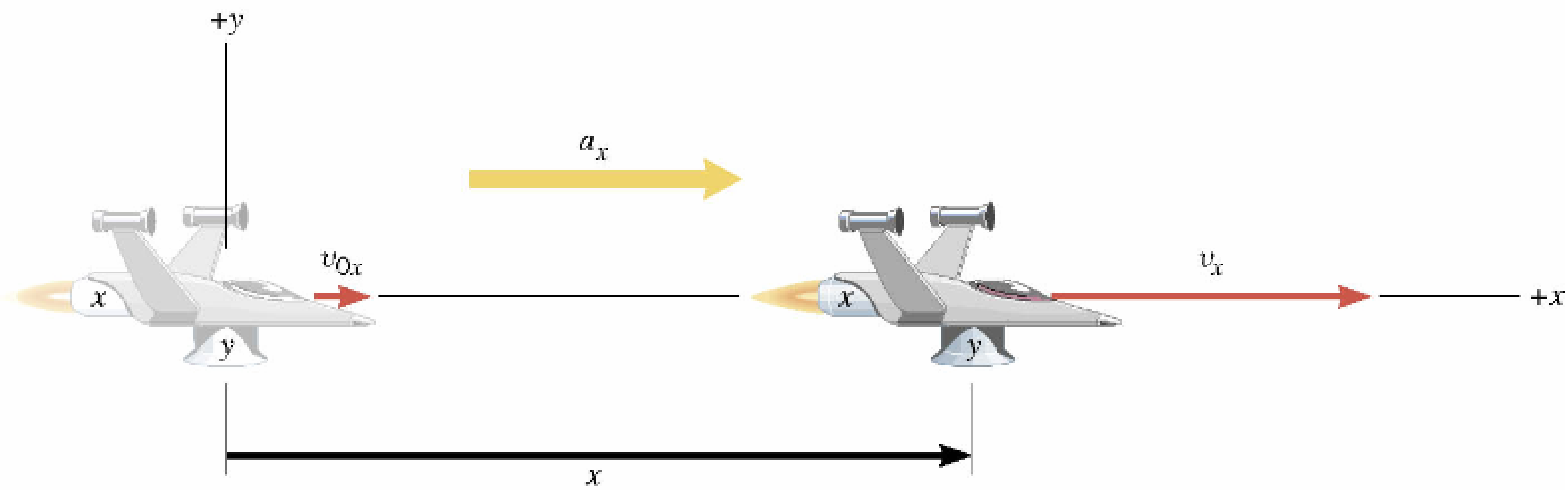
$$x = v_o t + \tfrac{1}{2}at^2$$

A Motion in 2 Dimension



This is a motion that could be viewed as two motions combined into one.

Motion in horizontal direction (x)



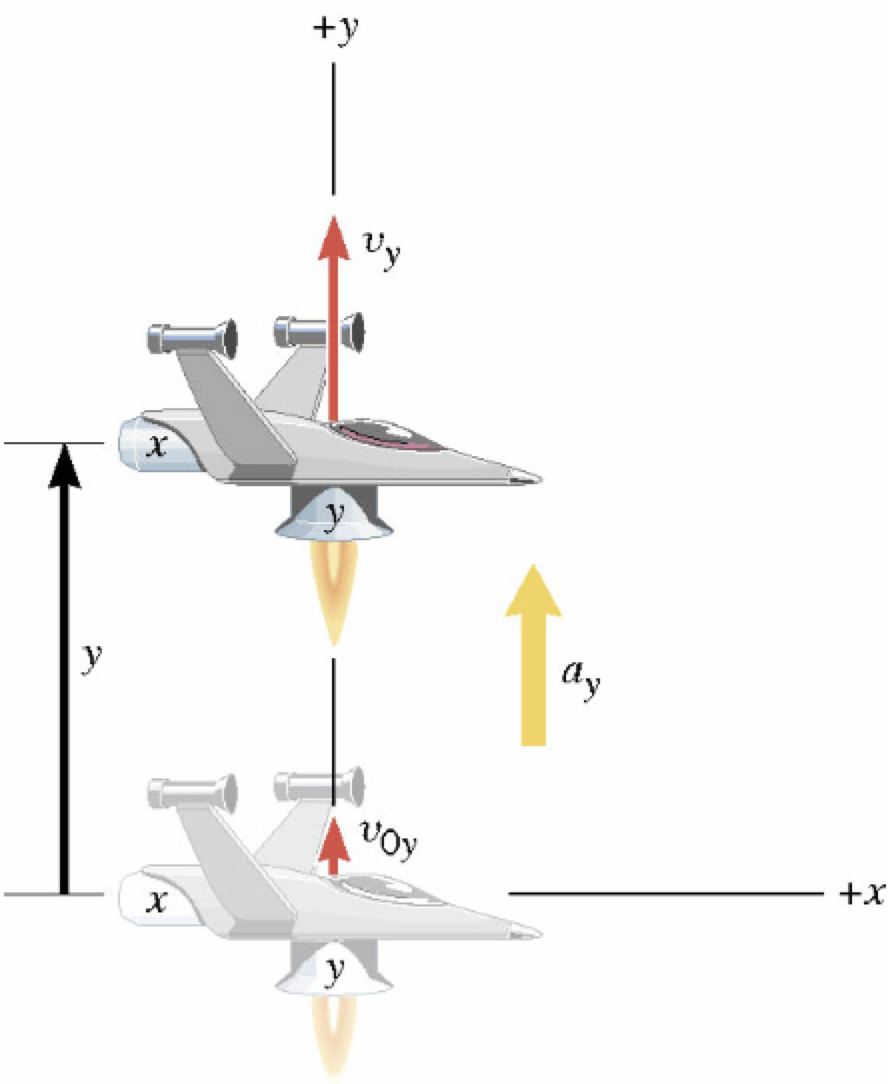
$$v_x = v_{xo} + a_x t$$

$$x = \tfrac{1}{2}\left(v_{xo} + v_x\right)t$$

$$v_x^2 = v_{xo}^2 + 2a_x x$$

$$x = v_{xo}t + \tfrac{1}{2}a_x t^2$$

Motion in vertical direction (y)



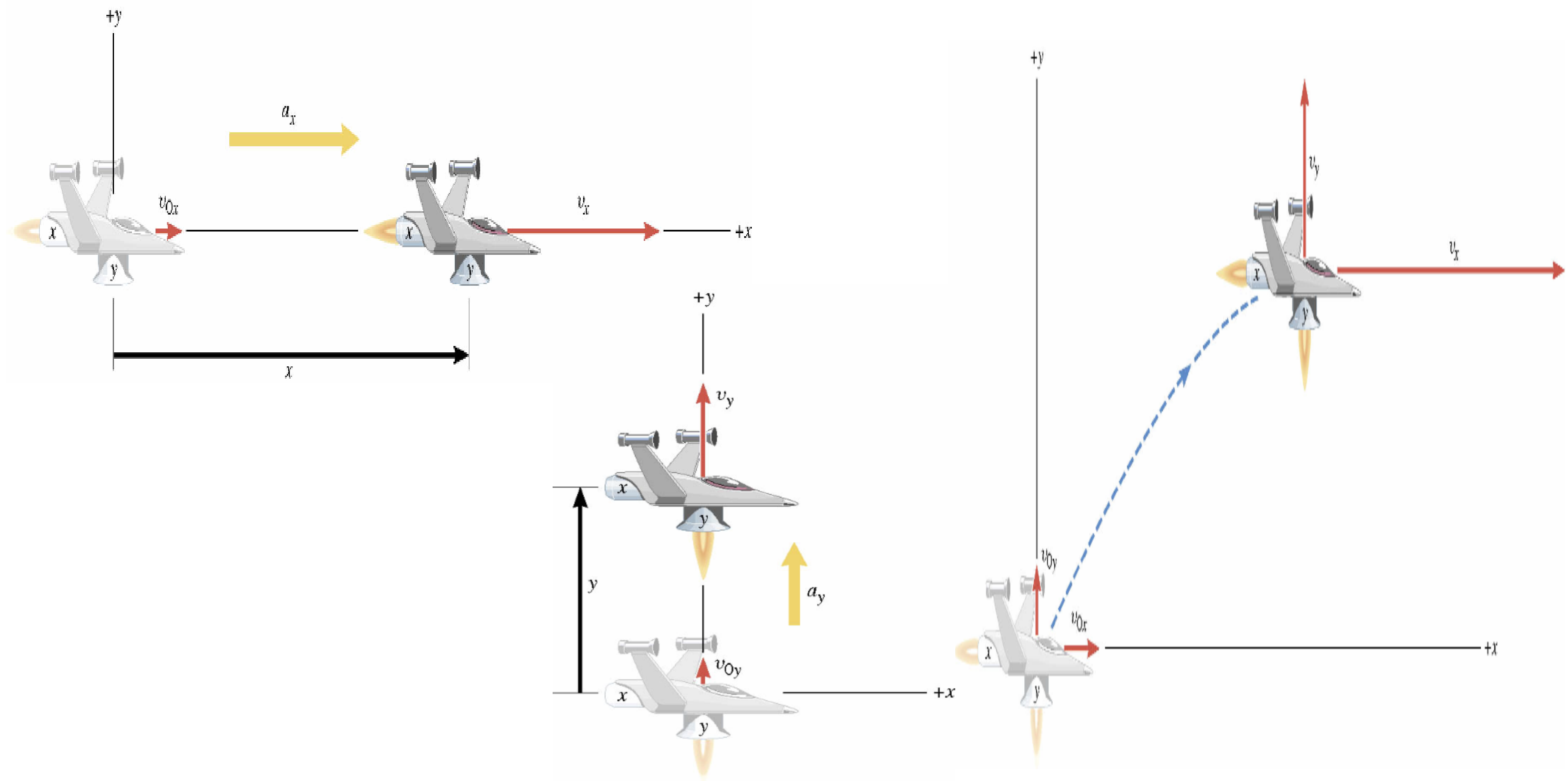
$$v_y = v_{yo} + a_y t$$

$$y = \tfrac{1}{2}\left(v_{yo} + v_y\right)t$$

$$v_y^2 = v_{yo}^2 + 2a_y y$$

$$y = v_{yo}t + \tfrac{1}{2}a_y t^2$$

A Motion in 2 Dimension



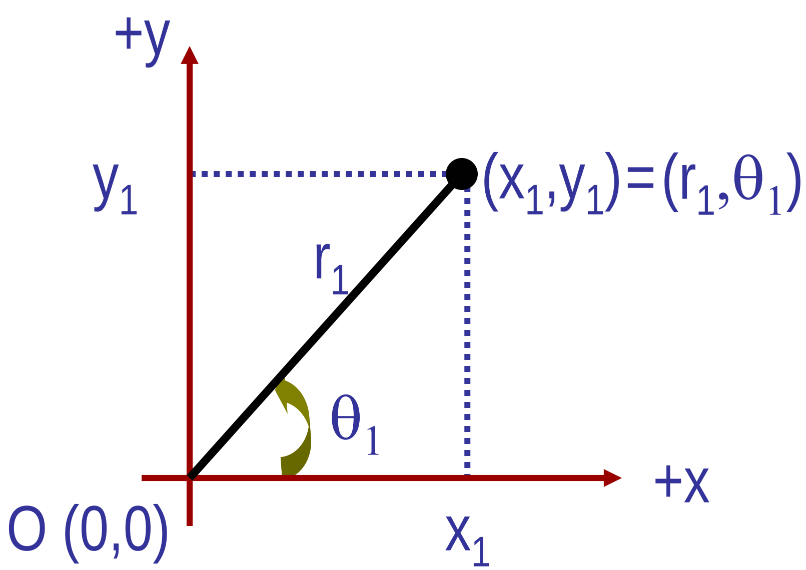
Imagine you add the two 1 dimensional motions on the left. It would make up a one 2 dimensional motion on the right.

Kinematic Equations in 2-Dim

x-component	y-component
$v_x = v_{xo} + a_x t$	$v_y = v_{yo} + a_y t$
$x = \frac{1}{2}\left(v_{xo} + v_x\right)t$	$y = \frac{1}{2}\left(v_{yo} + v_y\right)t$
$v_x^2 = v_{xo}^2 + 2a_x x$	$v_y^2 = v_{yo}^2 + 2a_y y$
$x = v_{xo}t + \frac{1}{2}a_x t^2$	$y = v_{yo}t + \frac{1}{2}a_y t^2$

Coordinate Systems

- They make it easy and consistent to express locations or positions
- Two commonly used systems, depending on convenience, are
  - Cartesian (Rectangular) Coordinate System
    - Coordinates are expressed in (x,y)
  - Polar Coordinate System
    - Coordinates are expressed in distance from the origin ® and the angle measured from the x-axis, θ (r,θ)
- Vectors become a lot easier to express and compute



How are Cartesian and Polar coordinates related?

$$x_1 = r_1 \cos\theta_1$$

$$y_1 = r_1 \sin\theta_1$$

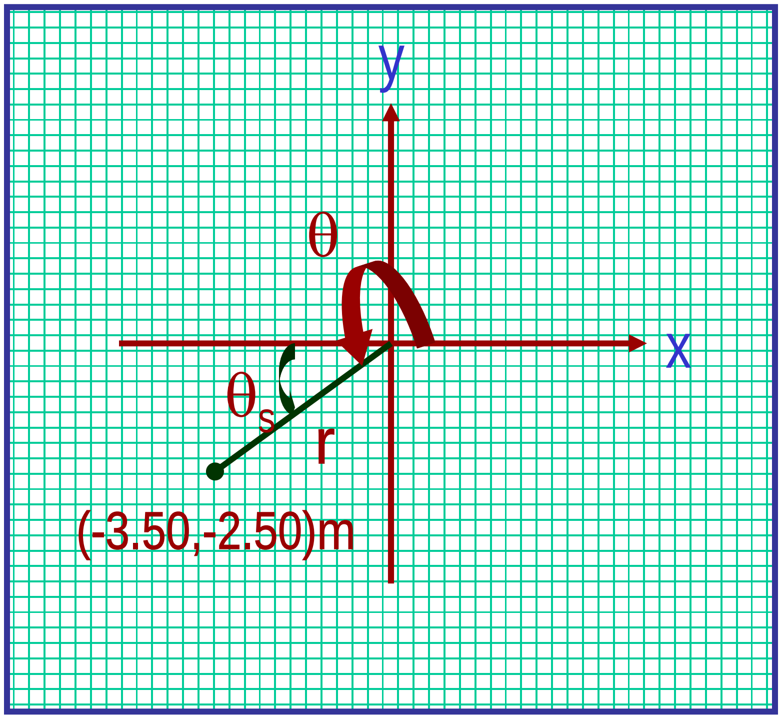
$$r_1 = \sqrt{\left(x_1^2 + y_1^2\right)}$$

$$\tan\theta_1 = \frac{y_1}{x_1}$$

$$\theta_1 = \tan^{-1}\left(\frac{y_1}{x_1}\right)$$

Example

Cartesian Coordinate of a point in the xy plane are (x,y)= (-3.50,-2.50)m. Find the equivalent polar coordinates of this point.



$$r = \sqrt{\left(x^2 + y^2\right)}$$

$$= \sqrt{\left(\left(-3.50\right)^2 + \left(-2.50\right)^2\right)}$$

$$= \sqrt{18.5} = 4.30(m)$$

$$\theta = 180 + \theta_s$$

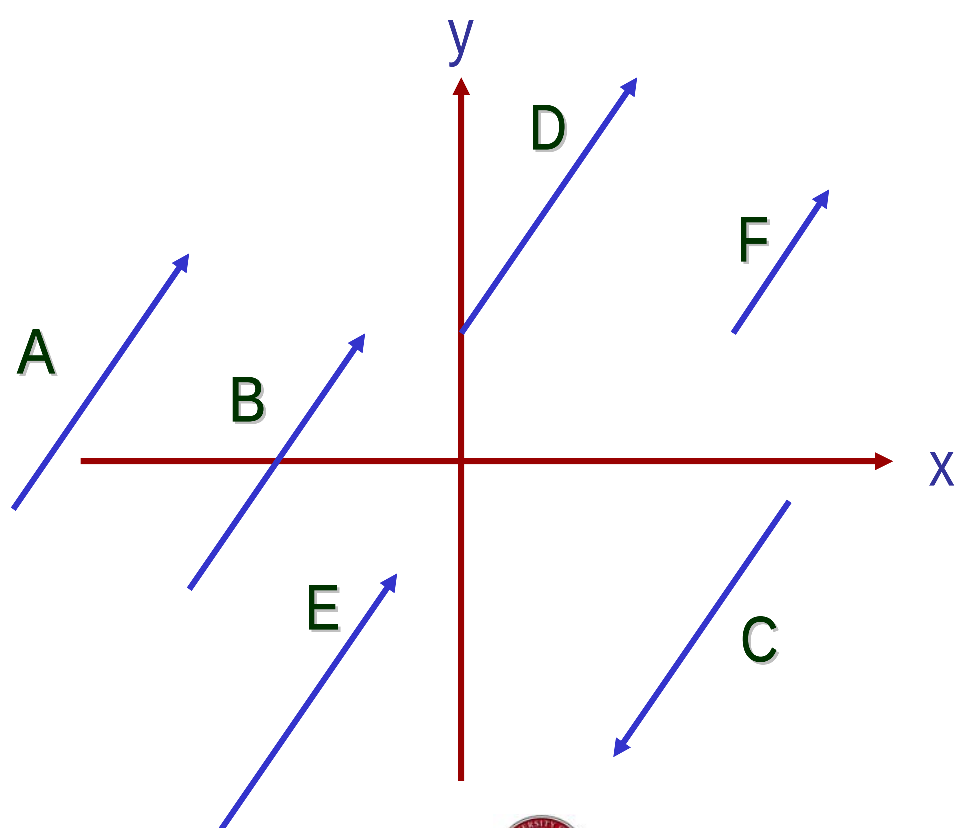
$$\tan\theta_s = \frac{-2.50}{-3.50} = \frac{5}{7}$$

$$\theta_s = \tan^{-1}\left(\frac{5}{7}\right) = 35.5^\circ$$

$$\therefore \theta = 180 + \theta_s = 180^\circ + 35.5^\circ = 216^\circ$$

Properties of Vectors

- Two vectors are the same if their sizes and the directions are the same, no matter where they are on a coordinate system!!



Which ones are the same vectors?

A=B=E=D

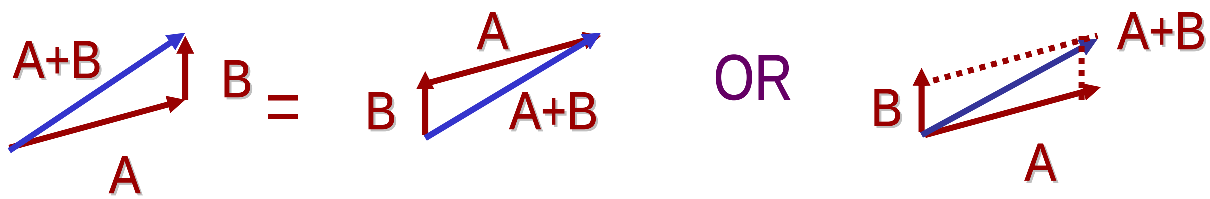
Why aren't the others?

C: The same magnitude but opposite direction:
C=-A: A negative vector

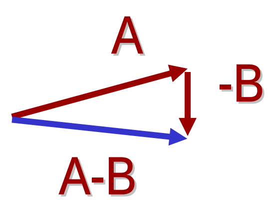
F: The same direction but different magnitude

Vector Operations

- Addition:
  - Triangular Method: One can add vectors by connecting the head of one vector to the tail of the other (head-to-tail)
  - Parallelogram method: Connect the tails of the two vectors and extend
  - Addition is commutative: Changing order of operation does not affect the results A+B=B+A, A+B+C+D+E=E+C+A+B+D



- Subtraction:
  - The same as adding a negative vector: A - B = A + (-B)



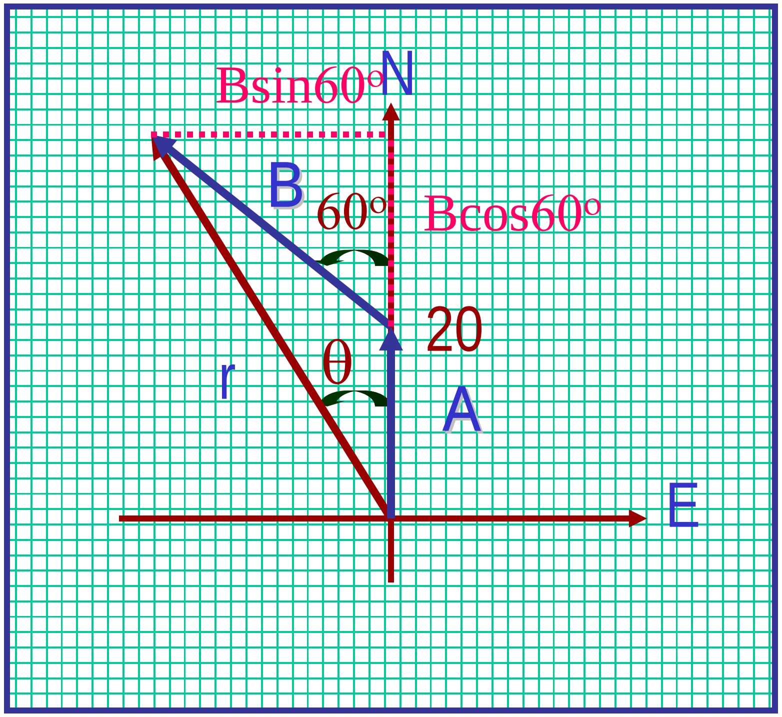
Since subtraction is the equivalent to adding a negative vector, subtraction is also commutative!!!

- Multiplication by a scalar is increasing the magnitude A, B=2A

$$\left|\mathcal{B}\right| = 2\left|\mathcal{A}\right|$$

Example for Vector Addition

A car travels 20.0km due north followed by 35.0km in a direction 60.0º west of north. Find the magnitude and direction of resultant displacement.



$$r = \sqrt{(A + B\cos\theta)^2 + (B\sin\theta)^2}$$
$$= \sqrt{A^2 + B^2(\cos^2\theta + \sin^2\theta) + 2AB\cos\theta}$$
$$= \sqrt{A^2 + B^2 + 2AB\cos\theta}$$
$$= \sqrt{(20.0)^2 + (35.0)^2 + 2\times 20.0\times 35.0\cos 60}$$
$$= \sqrt{2325} = 48.2(km)$$

$$\theta = \tan^{-1}\frac{|\vec{B}|\sin 60}{|\vec{A}| + |\vec{B}|\cos 60}$$
$$= \tan^{-1}\frac{35.0\sin 60}{20.0 + 35.0\cos 60}$$
$$= \tan^{-1}\frac{30.3}{37.5} = 38.9^\circ \text{ to W wrt N}$$

Find other ways to solve this problem…