General announcements

- Check out lab covers outside the classroom door for amusement, inspiration, etc.

- This is a short unit! Next test is next Thursday, 9/14 for the B folks and Friday, 9/15 for the C folks
  - It will cover:
  - Vectors vs scalars Graphical and mathematical vector manipulation
  - 2D kinematics (i.e. projectile motion!)
- 2 labs this unit:
  - Tilted Table lab: we collected data yesterday—
  - To Catch a Ball lab: "run and shoot" – you predict, and we do in class. No formal write up. This will be done this Friday.

Vectors and scalars

- ***SCALARS*** have only magnitude

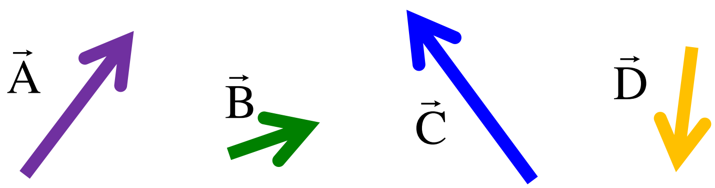
  $T = 78^{\circ}F$ (not 78 degrees *down* or *up,* just 78 degrees—just a relative measure of the average amount of kinetic energy per molecule of air)

- ***VECTORS*** have a magnitude AND a direction

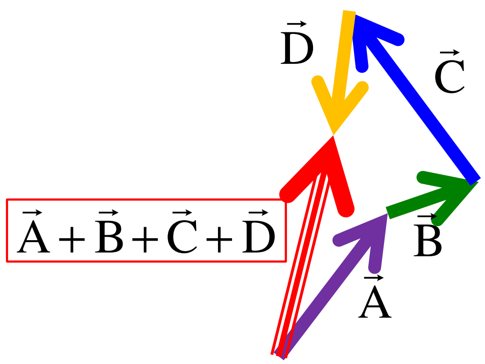
  There are two ways to deal with vectors, graphically and in conjunction with a coordinate axis. We'll start with the graphical approach first.

Graphical addition of vectors

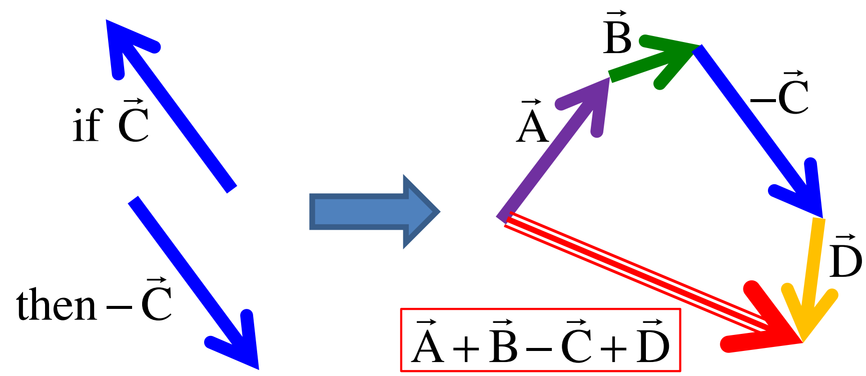
This is also known as the "tip to tail" method



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

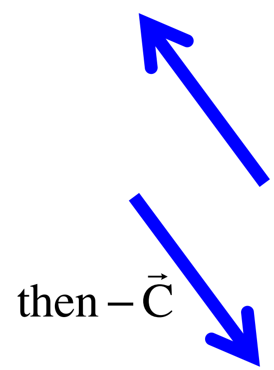


$\vec{A}+\vec{B}-\vec{C}+\vec{D}$

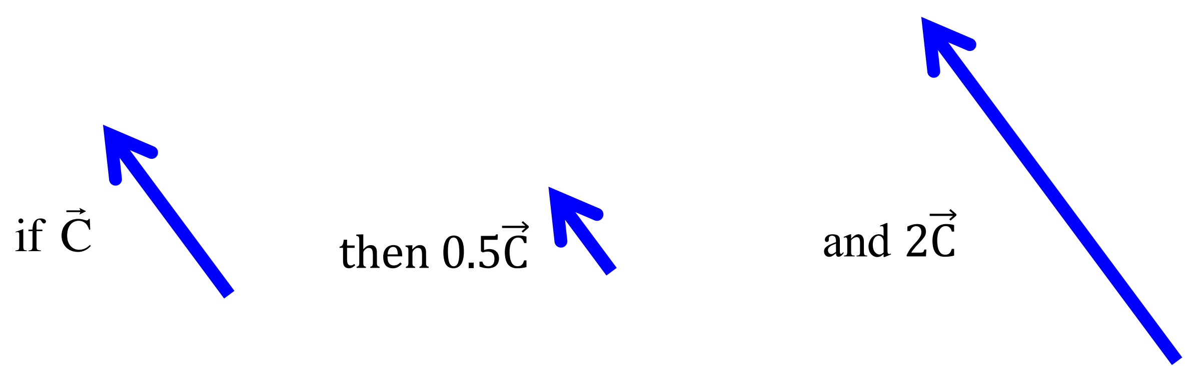


Vector odds n' ends

- *Subtracting* a vector just means reversing its direction 180º without changing its magnitude, as we saw on the previous slide.



- You can also change the magnitude of a vector by scaling it!



Graphical manipulation

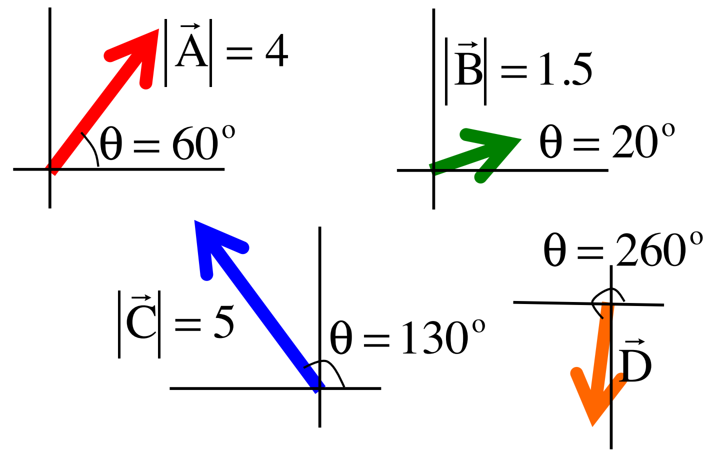
$\vec{A} = 4\measuredangle 60^{o}$

$\vec{B} = 1.5\measuredangle 20^{o}$

$\vec{C} = 5\measuredangle 130^{o}$

$\vec{D} = 3\measuredangle 260^{o}$

individual vectors:

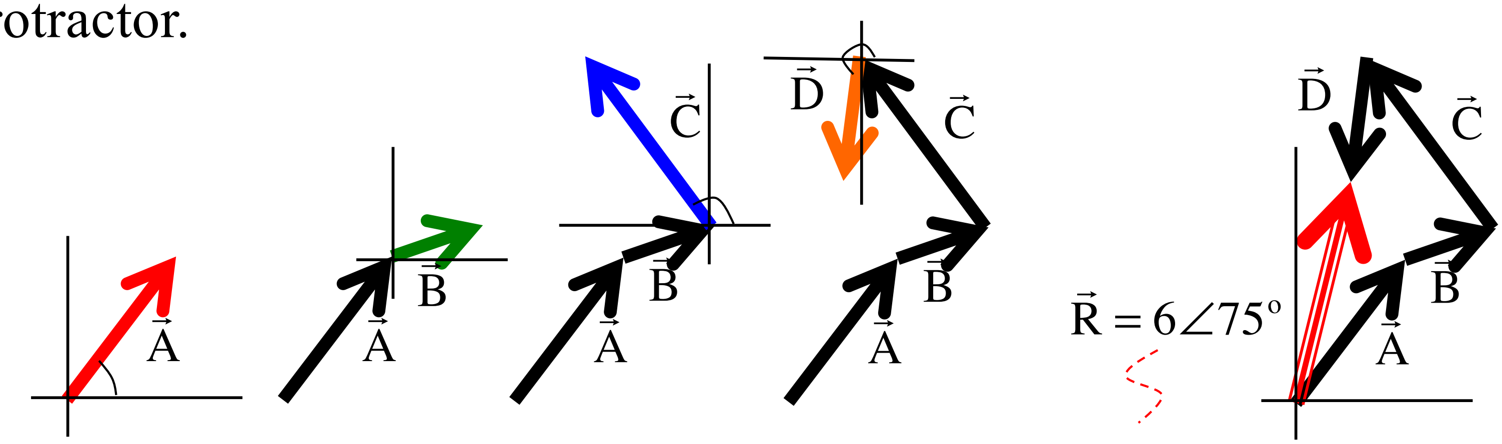


- *Given* information about the magnitude (length) and orientation (angle) of each vector, use a **ruler** and a **protractor** to draw vectors to scale.

Graphical manipulation

- *To* graphically add vectors, draw each scaled vector **tip to tail** in order, being careful to keep lengths and orientations accurate.

- *Draw* the **resultant vector** from the **starting point (tail) of the first vector to the ending point (tip) of the last vector.** Measure with ruler and protractor.



(using cm. stick and protractor)

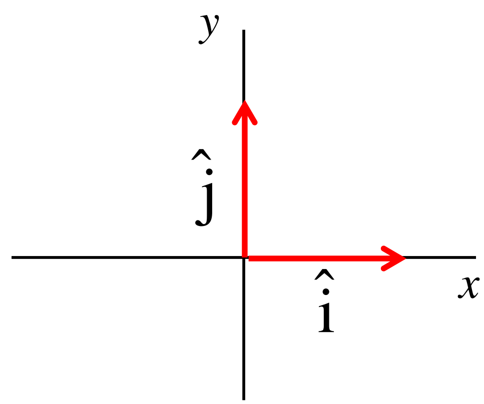
VECTORS

Vectors (defined in *polar notation*)

$\vec{F} = (8 \text{ nt}) \measuredangle 125^\circ$ (a force whose magnitude is 8 newtons oriented at an angle of 125 degrees relative to the +x-axis)

Vectors (defined in *unit vector notation*)

A vector with magnitude ONE defined to be in the x-direction is called a UNIT VECTOR in the x-direction. It's symbol is $\hat{i}$ (pronounced "i-hat"). The unit vector in the y-direction is $\hat{j}$.



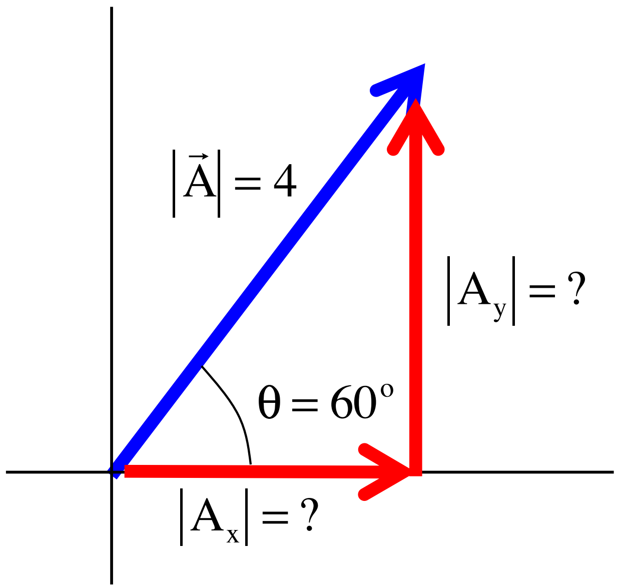
A vector framed in Cartesian coordinates in *unit vector notation* might look like:

$\vec{v} = (3 \text{ m/s})\hat{i} + (4 \text{ m/s})(-\hat{j})$ (this is really the addition of a mini-vector of magnitude 3 m/s in the x-direction and a min-vector of magnitude 4 in the minus y-direction)

Vector conversions

- How do we go from polar to unit vector notation?
  - Example 1:

$$\vec{A} = 4\measuredangle 60^{o} \text{ to unit vector}$$



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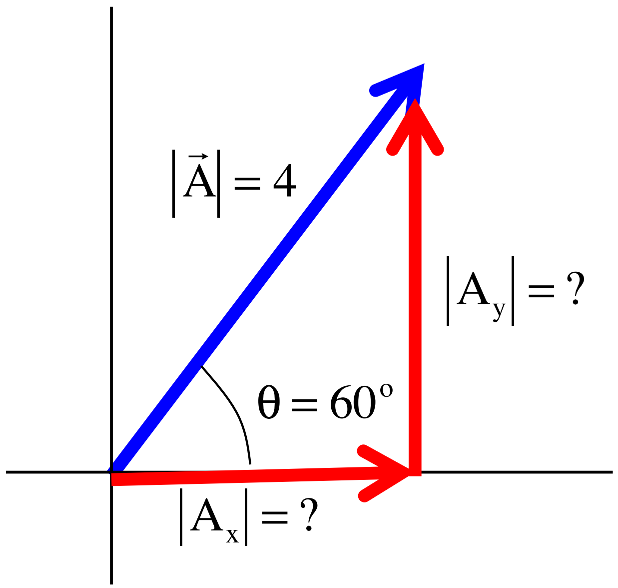


$$\vec{A} = A_x\hat{i} + A_y\hat{j}$$

$$= \left(|\vec{A}|\cos\theta\right)\hat{i} + \left(|\vec{A}|\sin\theta\right)\hat{j}$$

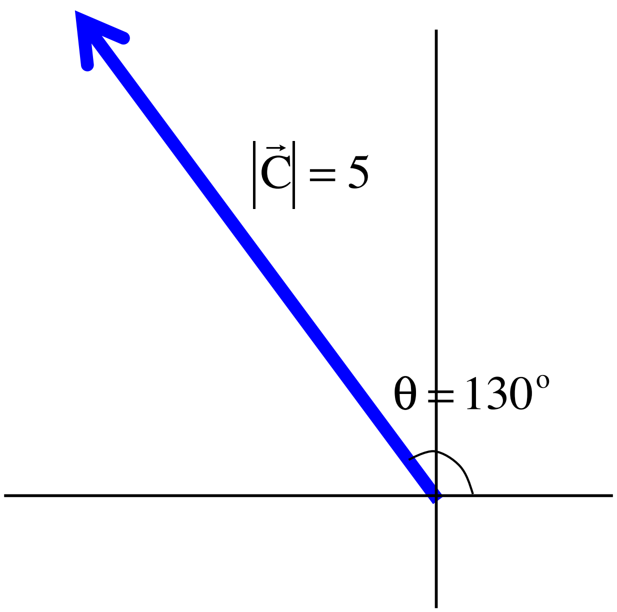
$$= \left(4\cos 60^{o}\right)\hat{i} + \left(4\sin 60^{o}\right)\hat{j}$$

$$= 2\hat{i} + 3.46\hat{j}$$

Vector conversions

- *How* do we go from polar to unit vector notation?
  - Example 2:

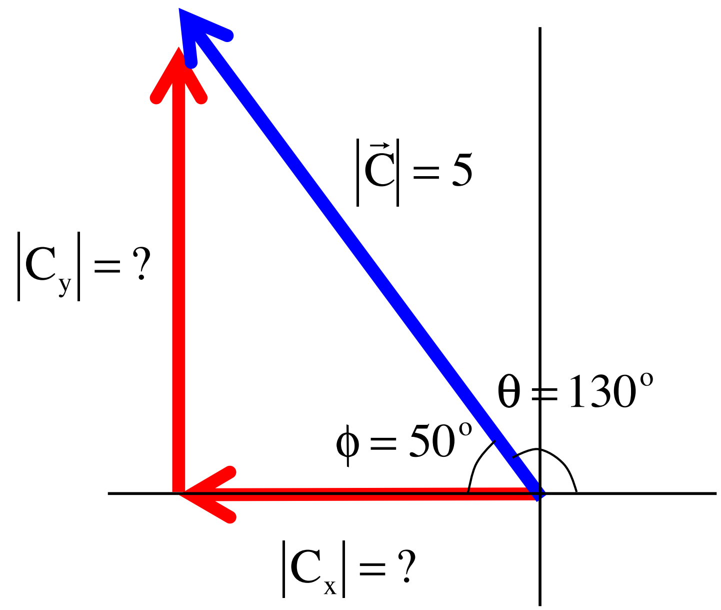
$$\vec{C} = 5\measuredangle 130^{\circ} \text{ to unit vector}$$



This is a little bit trickier because you are no longer looking at a first-quadrant triangle. There are two ways to do this. The easiest is to create a triangle that IS a right triangle (see sketch), determine its sides, then add whatever signs and unit vectors are needed to characterize the vector. Remember, what you are doing with unit vector notation is creating mini-vectors, one in the x-direction, one in the y-direction, and adding them.

Vector conversions

$\vec{C} = 5\measuredangle 130^{o}$ to unit vector

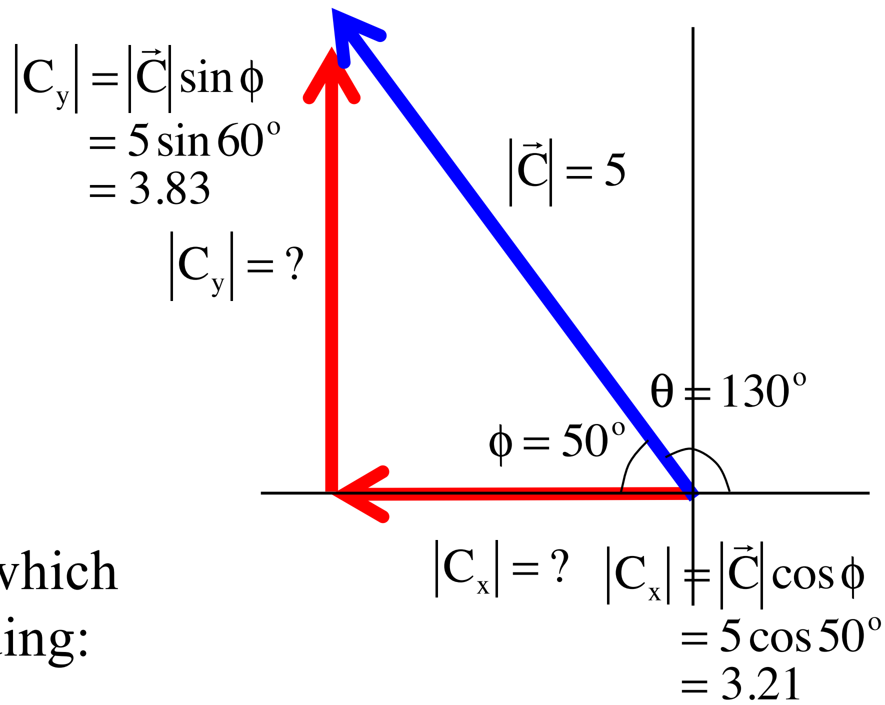


Vector conversions

$\vec{C} = 5\measuredangle 130^{\circ}$ to unit vector

In looking at the sketch, you can either use the magnitudes, which are always positive, and manually put in the signs for the unit vectors, yielding:

$$\vec{C} = |C_x|(\pm\hat{i}) + |C_y|(\pm\hat{j})$$
$$= 3.21(-\hat{i}) + 3.83\hat{j}$$



OR write it in terms of components, which carry along the signs with them, yielding:

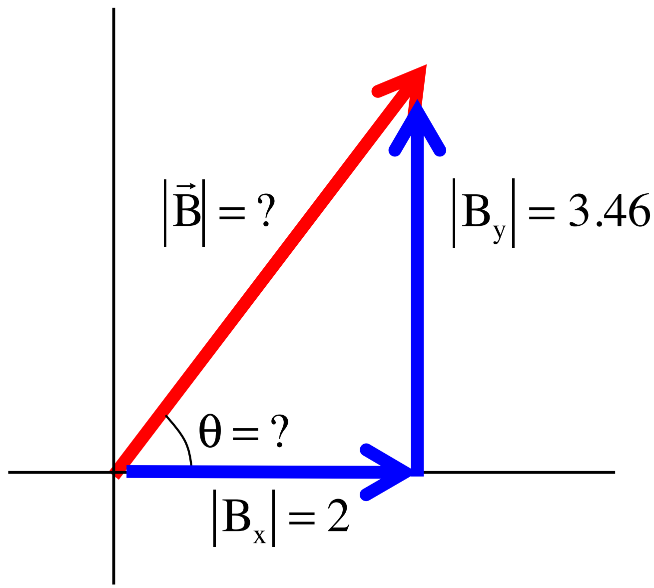
$$\vec{C} = C_x\hat{i} + C_y\hat{j}$$
$$= (-3.21)\hat{i} + 3.83\hat{j}$$

You get the same result either way.

Vector conversions

- *How* do we go from unit vector to polar notation?
  - Example 1:

$\vec{B} = 2\hat{\imath} + 3.46\hat{\jmath}$ to polar



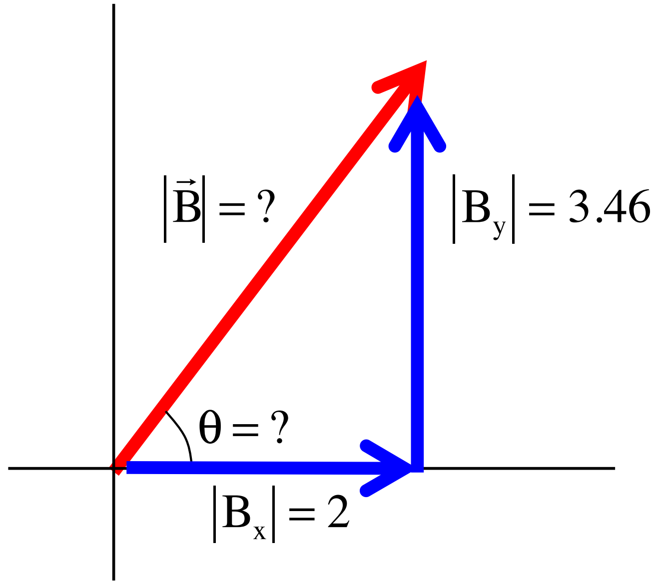
In looking at the sketch and noting that you can get the magnitude using the Pythagorean relationship and the angle using the *tangent function*, we can write:

Vector conversions

- *How* do we go from unit vector to polar notation?
  - Example 1:

$\vec{A} = 2\hat{i} + 3.46\hat{j}$ to polar

$$\vec{A} = \left|\vec{A}\right| \measuredangle \theta$$
$$= \left[(A_x)^2 + (A_y)^2 \right]^{1/2} \measuredangle \tan^{-1}\left(\frac{A_y}{A_x}\right)$$
$$= \left[(2)^2 + (3.46)^2 \right]^{1/2} \measuredangle \tan^{-1}\left(\frac{3.46}{2}\right)$$
$$= 4 \measuredangle 60^{\circ}$$

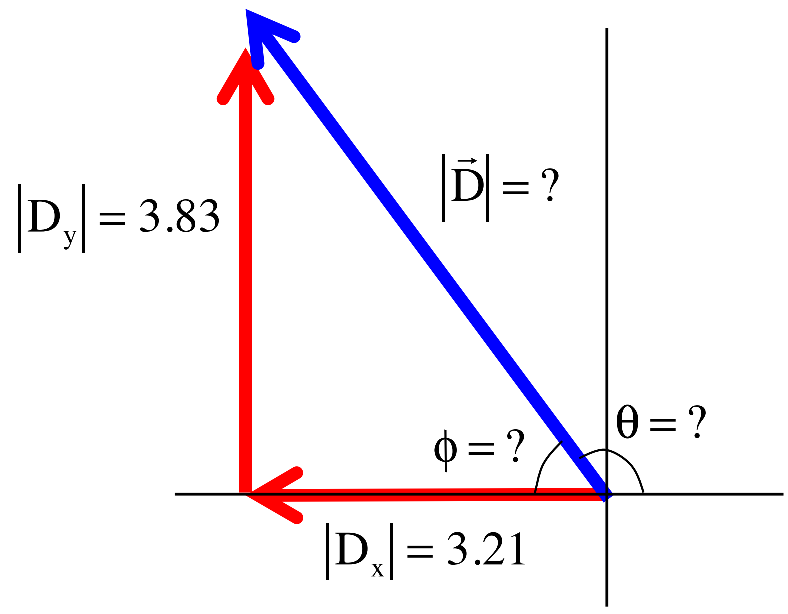


Note that $\left|\vec{A}\right|$ is ALWAYS positive.

Vector conversions

- Example 2:

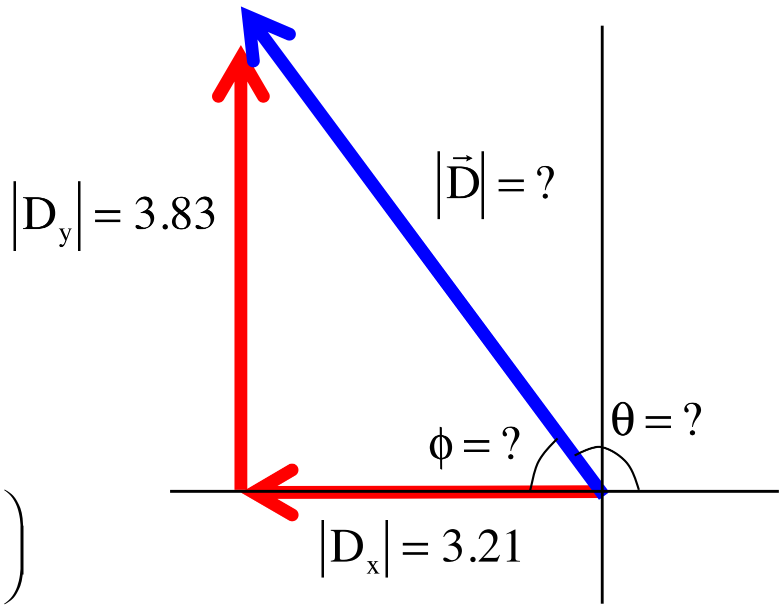
$$\vec{C} = -3.21\hat{i} + 3.83\hat{j} \quad \text{to polar}$$



Vector conversions

- Example 2:

$$\vec{C} = -3.21\hat{i} + 3.83\hat{j} \quad \text{to polar}$$



$$\vec{C} = \left|\vec{C}\right| \measuredangle \theta$$
$$= \left[(C_x)^2 + (C_y)^2\right]^{1/2} \measuredangle \tan^{-1}\left(\frac{C_y}{C_x}\right)$$
$$= \left[(-3.21)^2 + (3.83)^2\right]^{1/2} \measuredangle \tan^{-1}\left(\frac{3.83}{-3.21}\right)$$
$$= 5 \measuredangle -40^\circ$$

except this clearly isn't a fourth quadrant vector, so we need to add 180° to get it into the third quadrant . . .

$$\Rightarrow \quad \vec{C} = 5\measuredangle\left(-40^\circ + 180^\circ\right) = 5\measuredangle 130^\circ$$

Force table mini-lab

- See the apparatus at the front of the room. As a class, we need to figure out how to balance out the contraption!

Why bother with vectors?

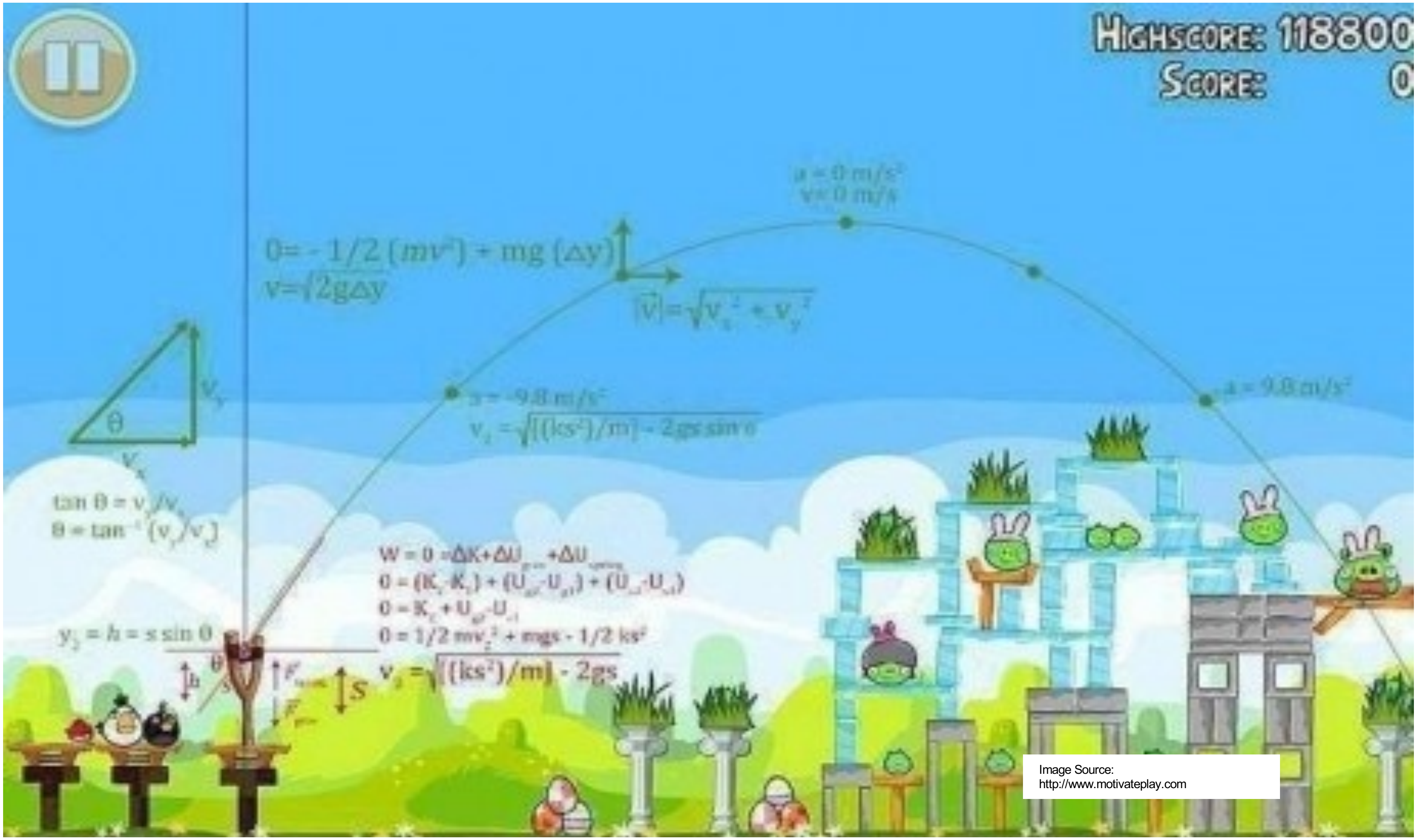


Image Source:
http://www.motivateplay.com