College Physics I: 1511
Mechanics & Thermodynamics

Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Announcements

- We'll start using Turning Point Cloud on Friday
  - Please register for your account (through the link on ICON) before then if you want to participate
  - At the start of class I'll give you the session ID - you can then access the polling through the app, the Turning Point web site, or https://rwpoll.com
  - We'll practice to make sure things are working!

Topics for Today

- Math review
  - Trigonometry
  - Vector math
  - Algebra

Position

- How do we specify the position of an object?
  - We must have a reference (coordinate system)
  - We need units (otherwise "how far" is meaningless)
  - We don't live in a one-dimensional world, so we need vectors

Units are Important

International System of Units (SI)

SI Base Units

Base Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI Derived Units

Derived Quantity	Name	Symbol	Equivalent SI units
Frequency	hertz	Hz	s^{-1}
Force	newton	N	$m \cdot kg \cdot s^{-2}$
Pressure	pascal	Pa	N/m^2
Energy	joule	J	N·m
Power	watt	W	J/s
Electric charge	coulomb	C	s·A
Electric potential	volt	V	W/A
Electric resistance	ohm	Ω	V/A
Celsius temperature	degree Celsius	°C	K*

*Unit degree Celcius is equal in magnitude to unit kelvin.

SI Prefixes

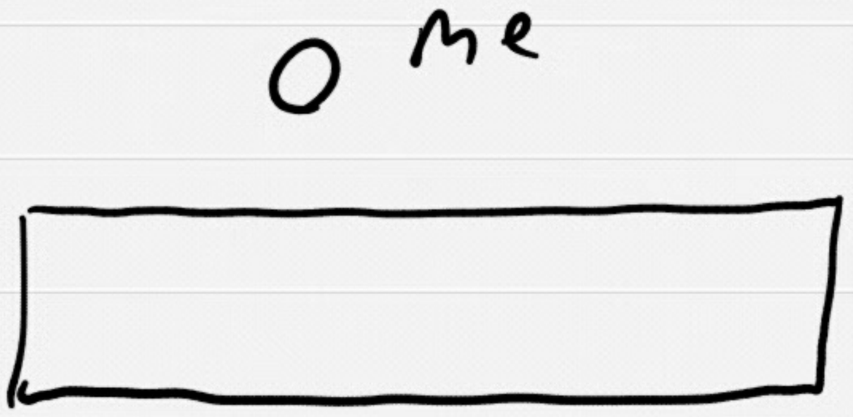
Factor	Name	Symbol	Numerical Value
10^{12}	tera	T	1 000 000 000 000
10^{9}	giga	G	1 000 000 000
10^{6}	mega	M	1 000 000
10^{3}	kilo	k	1 000
10^{2}	hecto	h	100
10^{1}	deka	da	10
10^{-1}	deci	d	0.1
10^{-2}	centi	c	0.01
10^{-3}	milli	m	0.001
10^{-6}	micro	μ	0.000 001
10^{-9}	nano	n	0.000 000 001
10^{-12}	pico	p	0.000 000 000 001

• Adapted from NIST Special Publication 811
• SI rules and style conventions recommend using spaces rather than commas to separate groups of three digits.

International Standards

Position

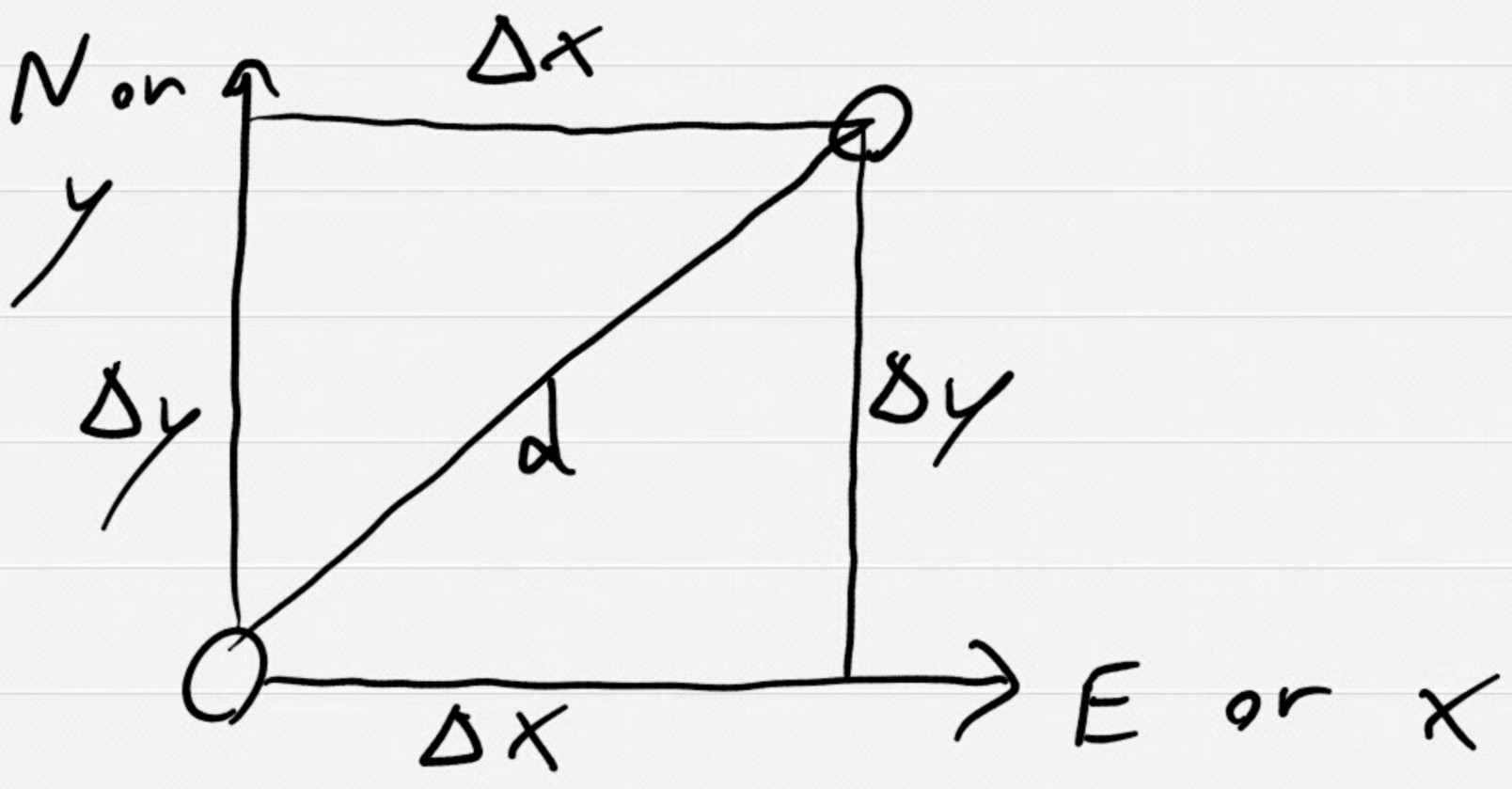
Position of me w/ respect to student A?



student A

"In front of and to the right" — depends on orientation of student

Use fixed coordinates



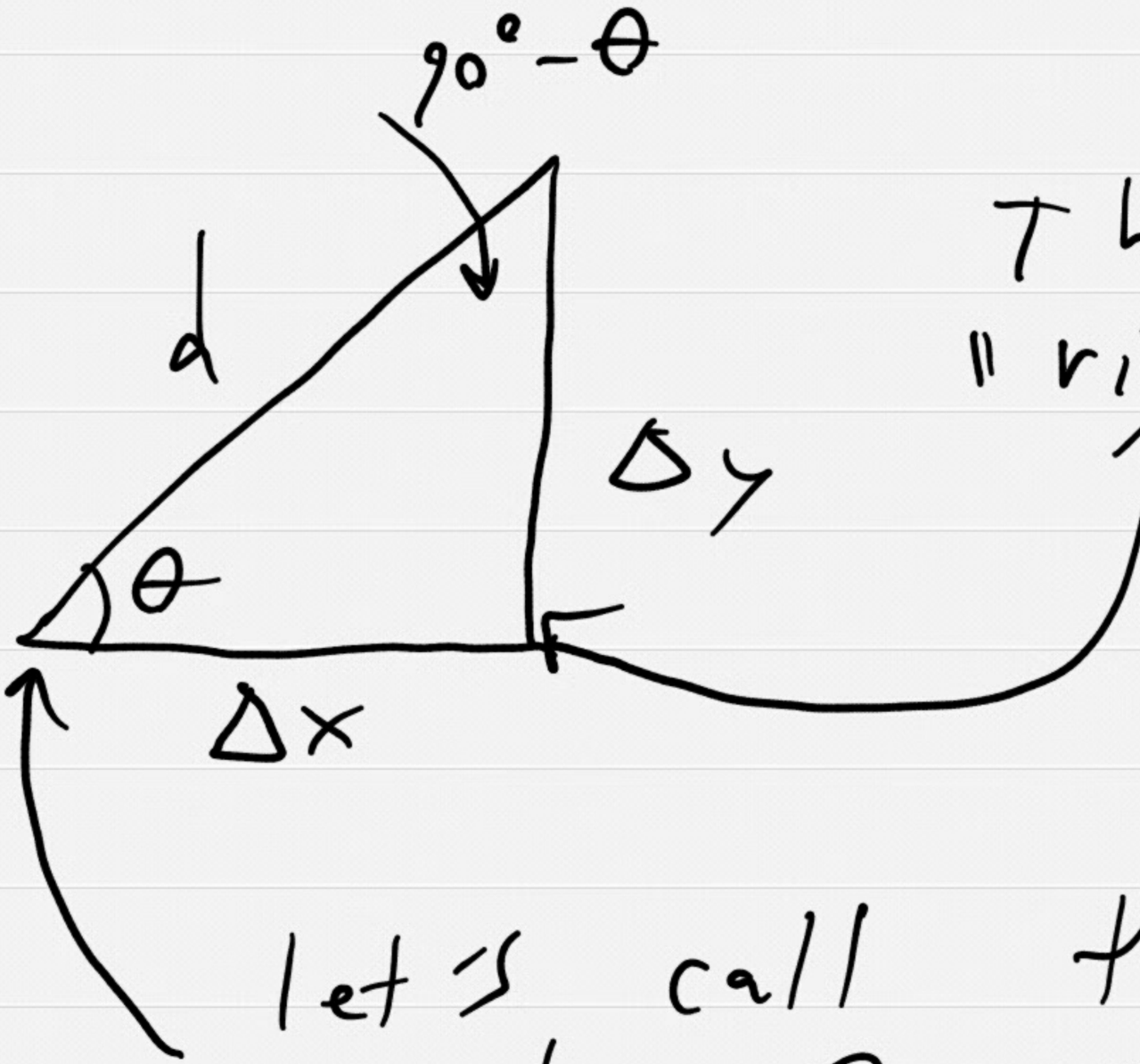
- How far are Δx, Δy?
- Need to specify units

How far is student A from me?

Pythagorean theorem says:

$$d^2 = \Delta x^2 + \Delta y^2$$

or $$d = \sqrt{\Delta x^2 + \Delta y^2}$$



This is a "right triangle"

corner angle = 90°

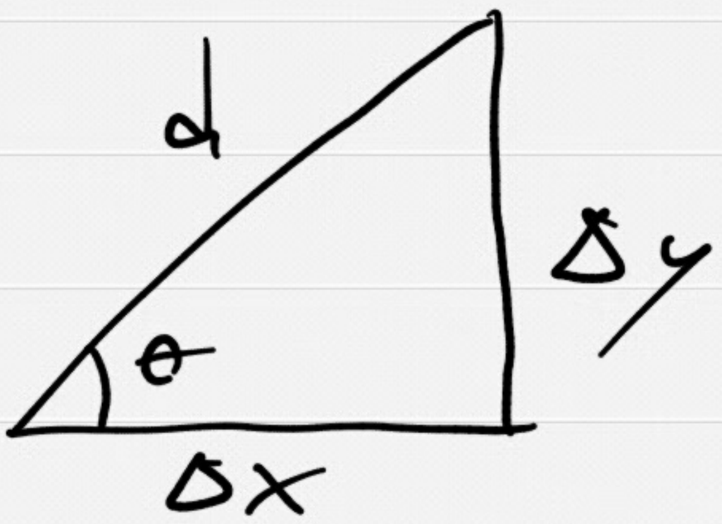
let's call this angle θ =

angle N-ward of East that student A has to look to see me.

– Sum of angles in any triangle = 180° so other angle

= 180° − 90° − θ

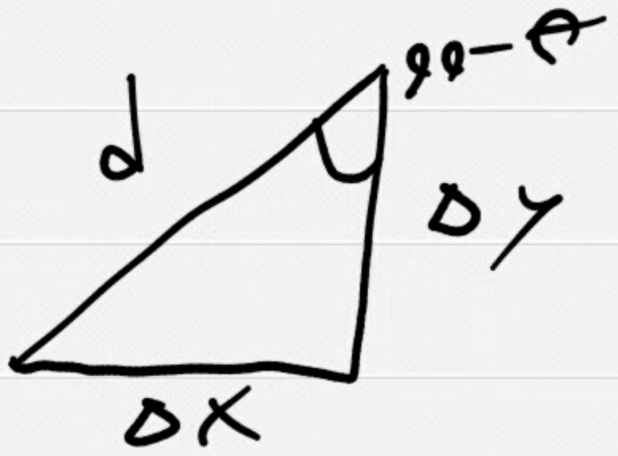
= 90° − θ



$$\sin\theta = \Delta y / d$$

$$\cos\theta = \Delta x / d$$

$$\tan\theta = \Delta y / \Delta x$$



$$\sin(90^\circ - \theta) = \Delta x / d$$

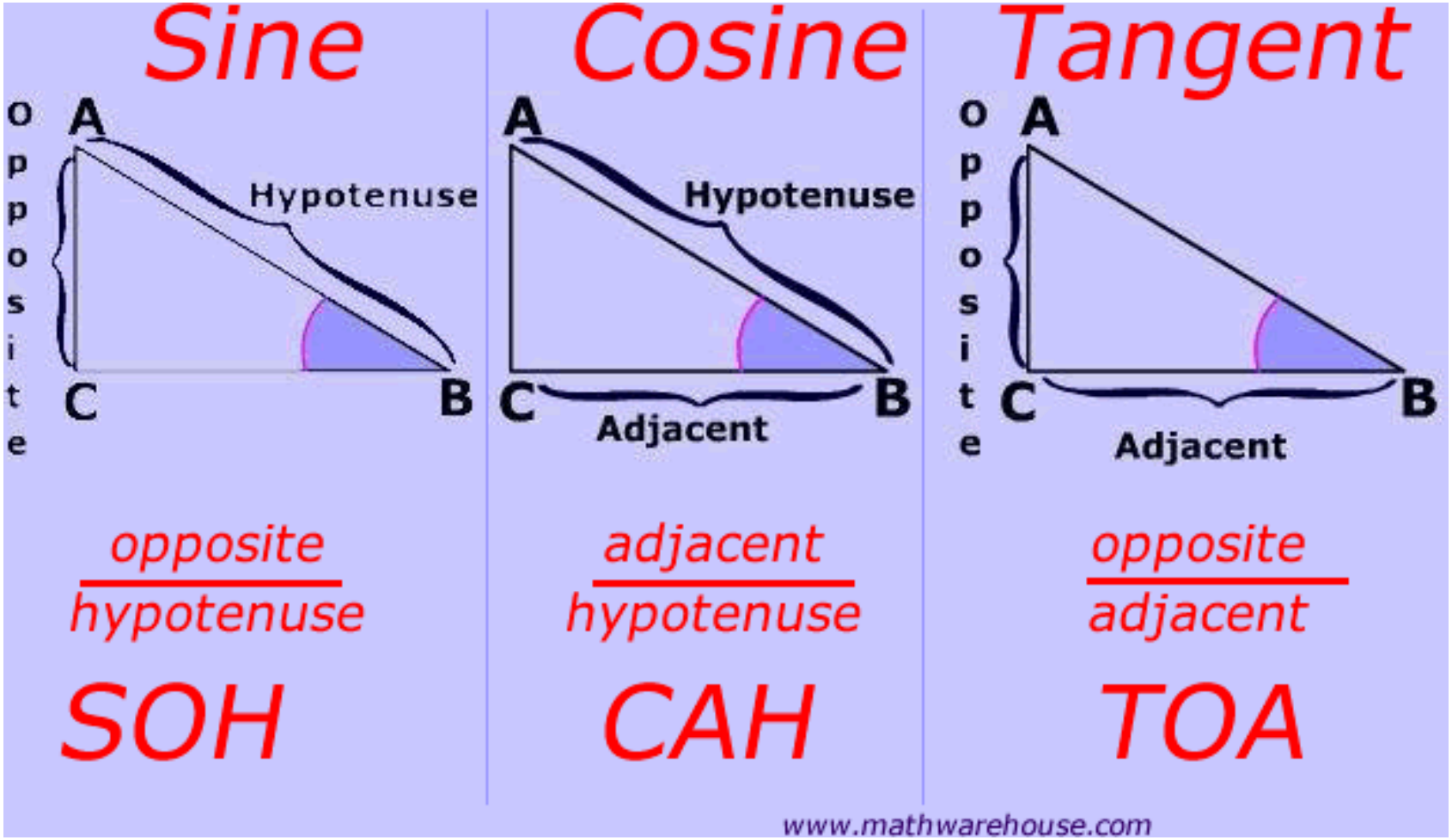
$$\cos(90^\circ - \theta) = \Delta y / d$$

$$\tan(90^\circ - \theta) = \Delta x / \Delta y$$

comparing : $\sin(90^\circ - \theta) = \cos\theta$

$\cos(90^\circ - \theta) = \sin\theta$

SOHCAHTOA


Sine
Cosine
Tangent
Opposite
A
C
B
Hypotenuse
Adjacent
opposite / hypotenuse
adjacent / hypotenuse
opposite / adjacent
SOH
CAH
TOA
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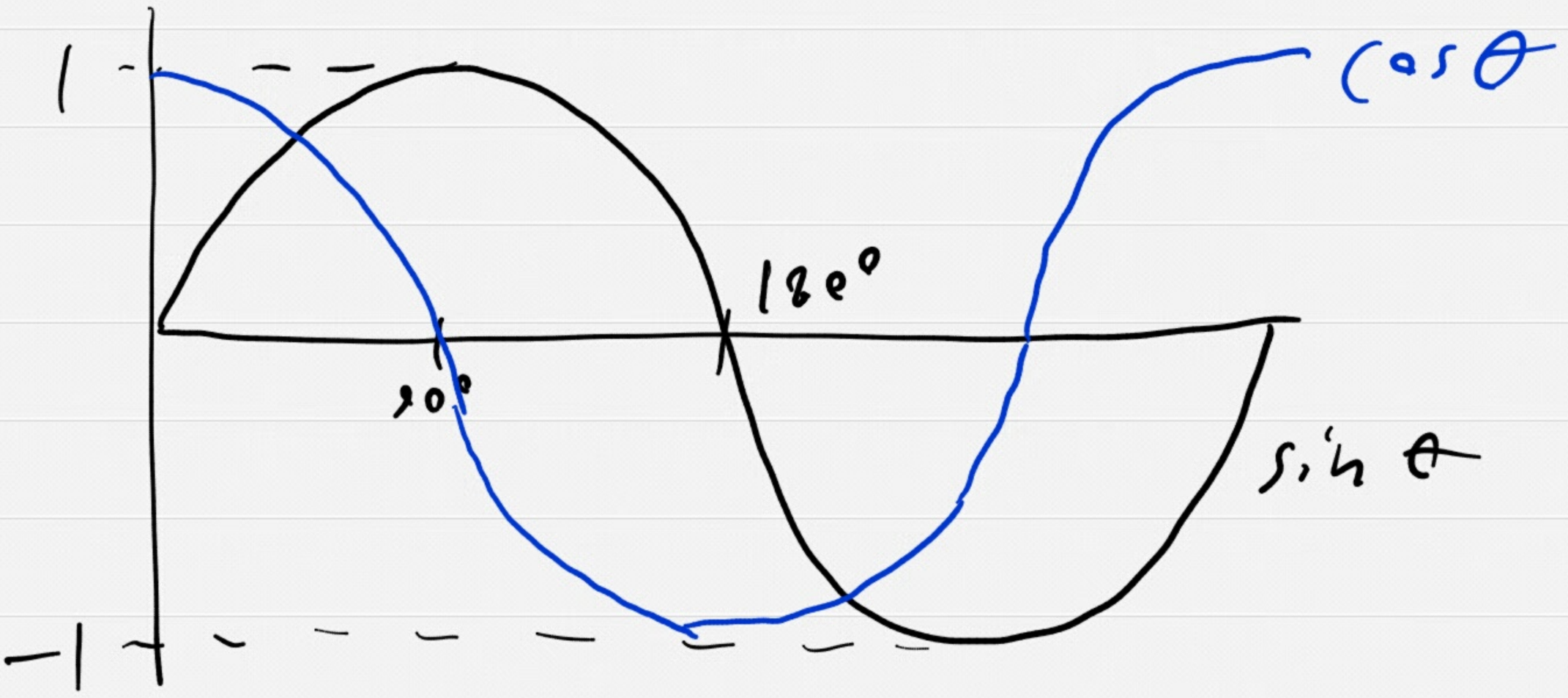
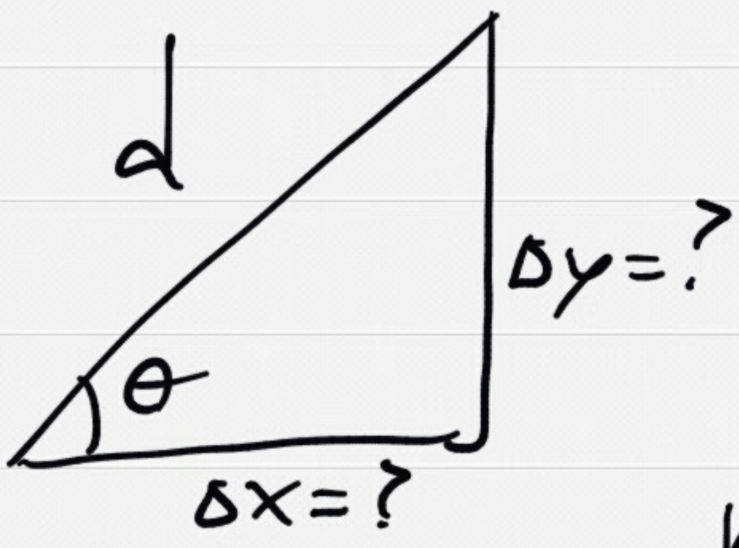


Can solve for unknowns



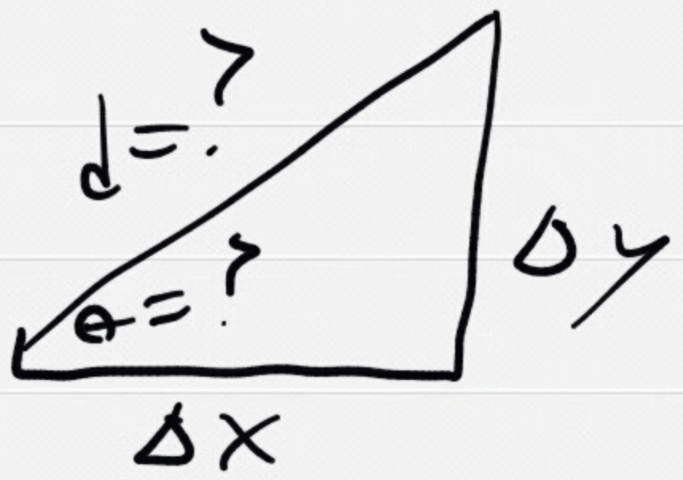
If I know d and θ:

Know $\cos\theta = \Delta x / d$

multiply by d:

$\Rightarrow d\cos\theta = \Delta x$

similarly $d\sin\theta = \Delta y$



- Know Δx, Δy

- get $d = \sqrt{\Delta x^2 + \Delta y^2}$

Know $\Delta y / \Delta x = \tan\theta$

$\Rightarrow \theta = \tan^{-1}(\Delta y / \Delta x)$

$= \sin^{-1}(\Delta y / d)$

$= \cos^{-1}(\Delta x / d)$

- My position w/ respect to student A has both magnitude and direction

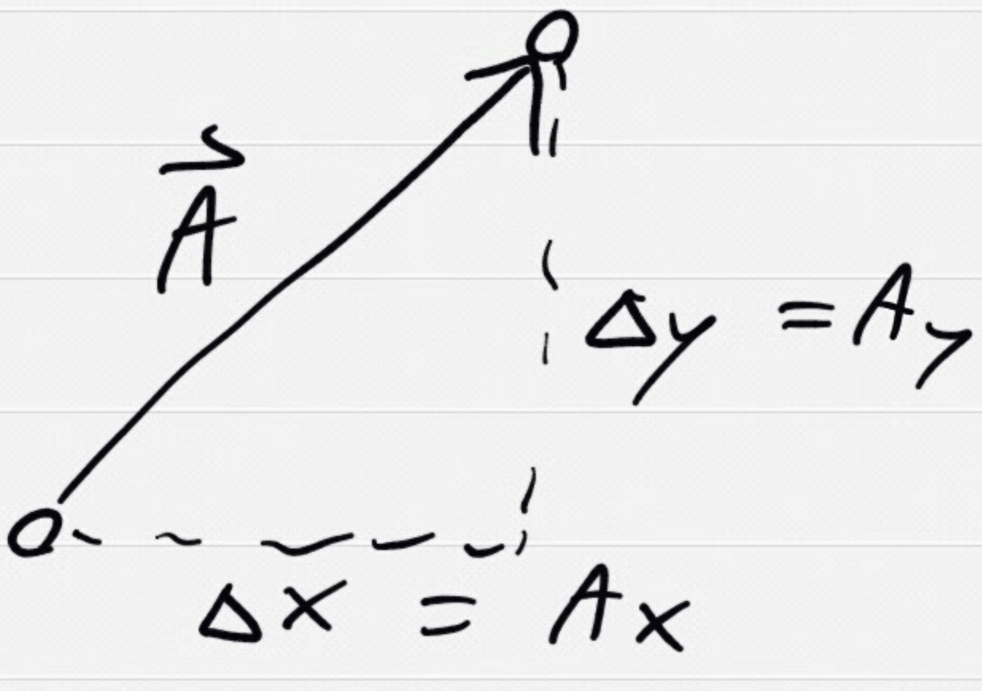
- this is a vector!

Lets call it $\vec{A}$

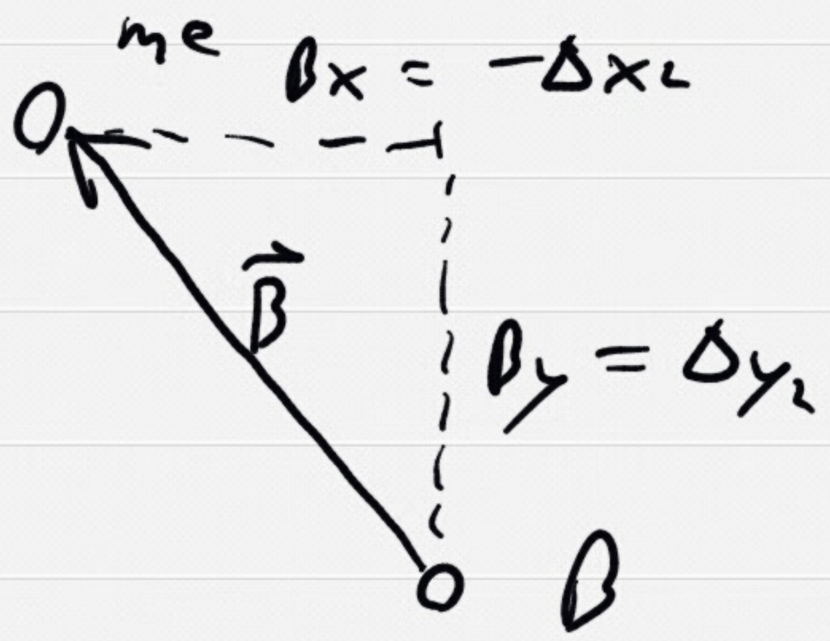
$\vec{A} = [A_x, A_y, A_z]$

$= [\Delta x, \Delta y, \Delta z]$

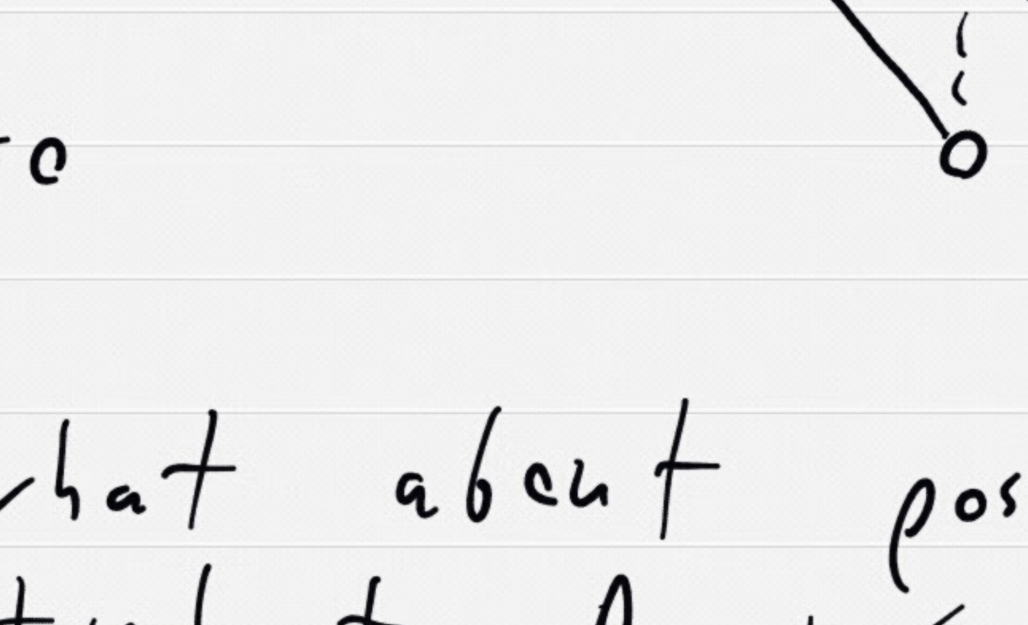
$= [\Delta x, \Delta y, 0]$



- what about my position w/ respect to student B?



- what about position of student B w/ respect to me?



Notice

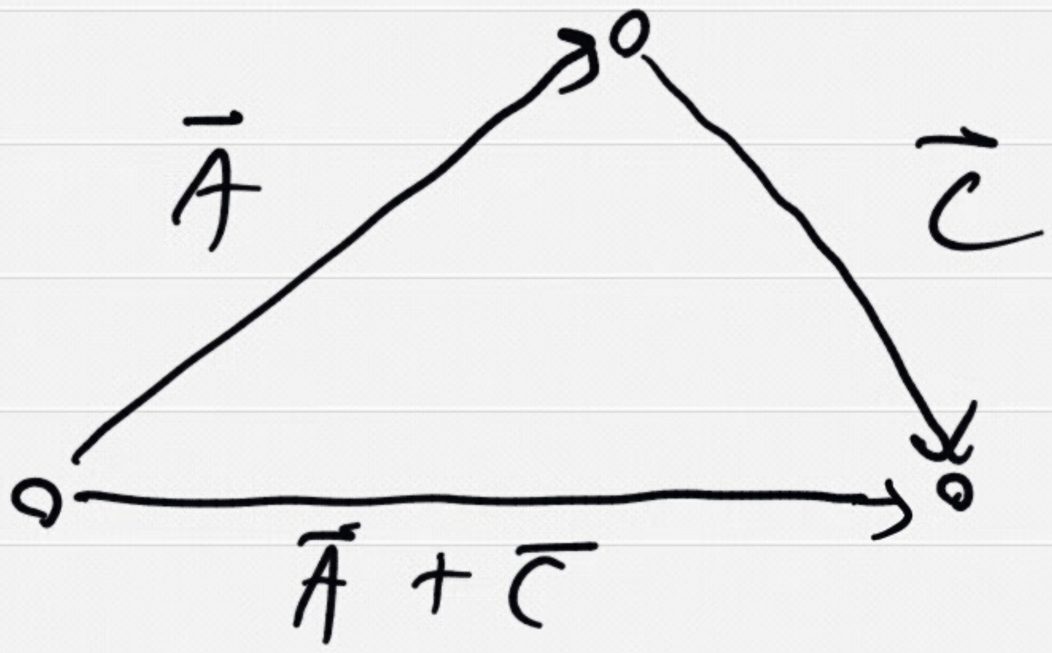
$\vec{C} = -\vec{B}$

$[C_x, C_y, C_z]$

$= -[B_x, B_y, B_z]$

$= [-B_x, -B_y, -B_z]$

How far from
student A to student B?



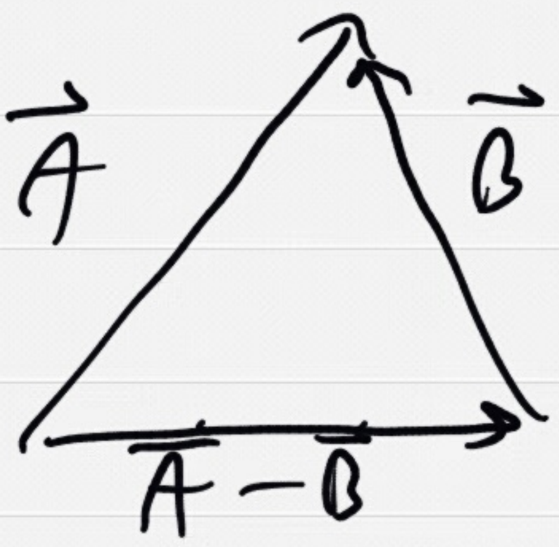
$$\vec{A}+\vec{C} = [A_x, A_y, A_z] + [C_x, C_y, C_z]$$

$$= [A_x + C_x, A_y + C_y, A_z + C_z]$$

$$= [\Delta x + \Delta x_2, \Delta y - \Delta y_2, 0]$$

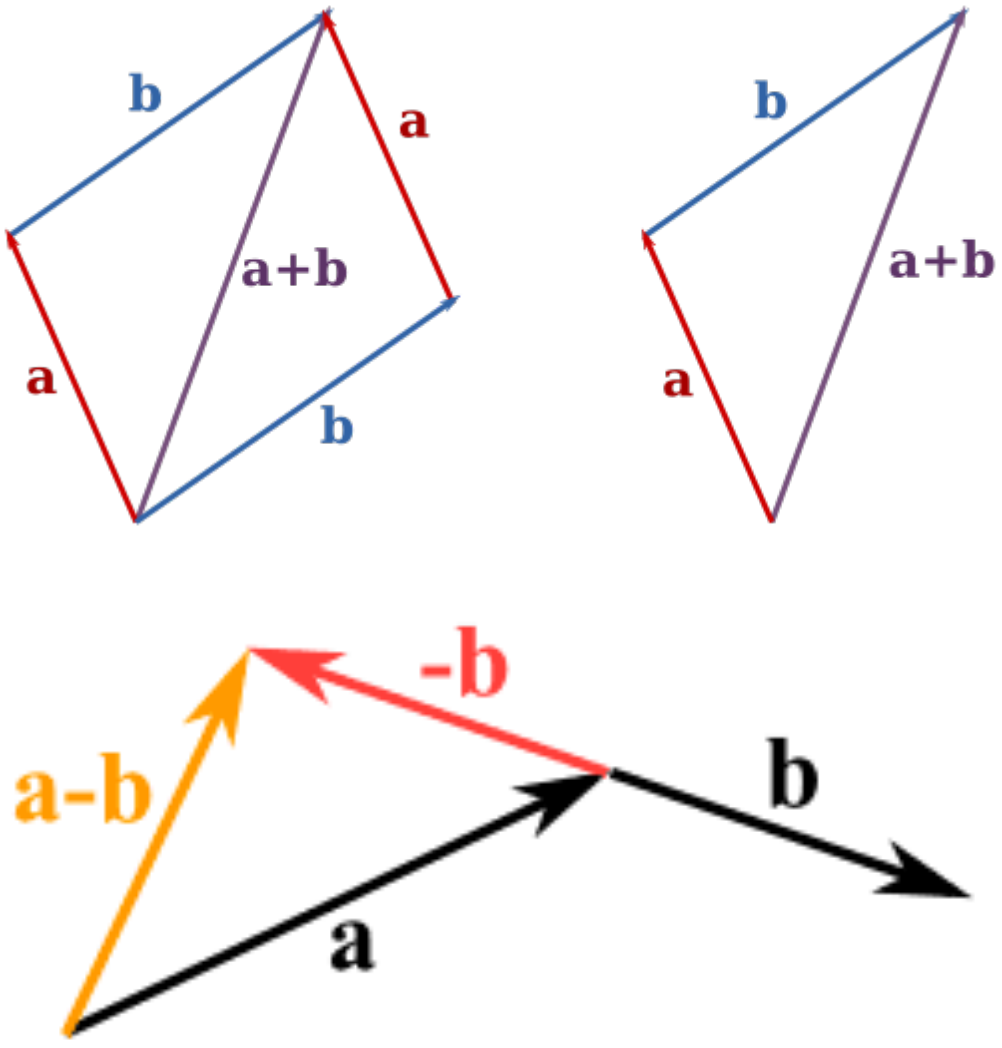
notice $|\vec{A}+\vec{C}| < |\vec{A}| + |\vec{C}|$
true unless $\vec{A} \parallel \vec{C}$

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



Easiest to compute
$\vec{A} - \vec{B}$ as $\vec{A} + (-\vec{B})$

Vector Math



Some algebra:

$$4x - 3 = 0$$

Always try to isolate variables:

Add 3 to both sides

$$4x = 3$$

Divide by 4

$$x = 3/4$$

Verify: $4(3/4) - 3 = 0$ ✓

What about;

$$x + 3y = 2$$

$$x - y = 3$$

isolate x in Eq. 1

$$x = 2 - 3y$$

plug in to Eq. 2

$$2 - 3y - y = 3$$

or $2 - 4y = 3$

$$\Rightarrow -4y = 1$$

$$\Rightarrow y = 1/(-4) = \boxed{-1/4}$$

Now use Eq. 1 to get x

$$x = 2 - 3y = 2 - 3(-1/4)$$

$$= 2 + 3/4$$

$$= \boxed{11/4}$$