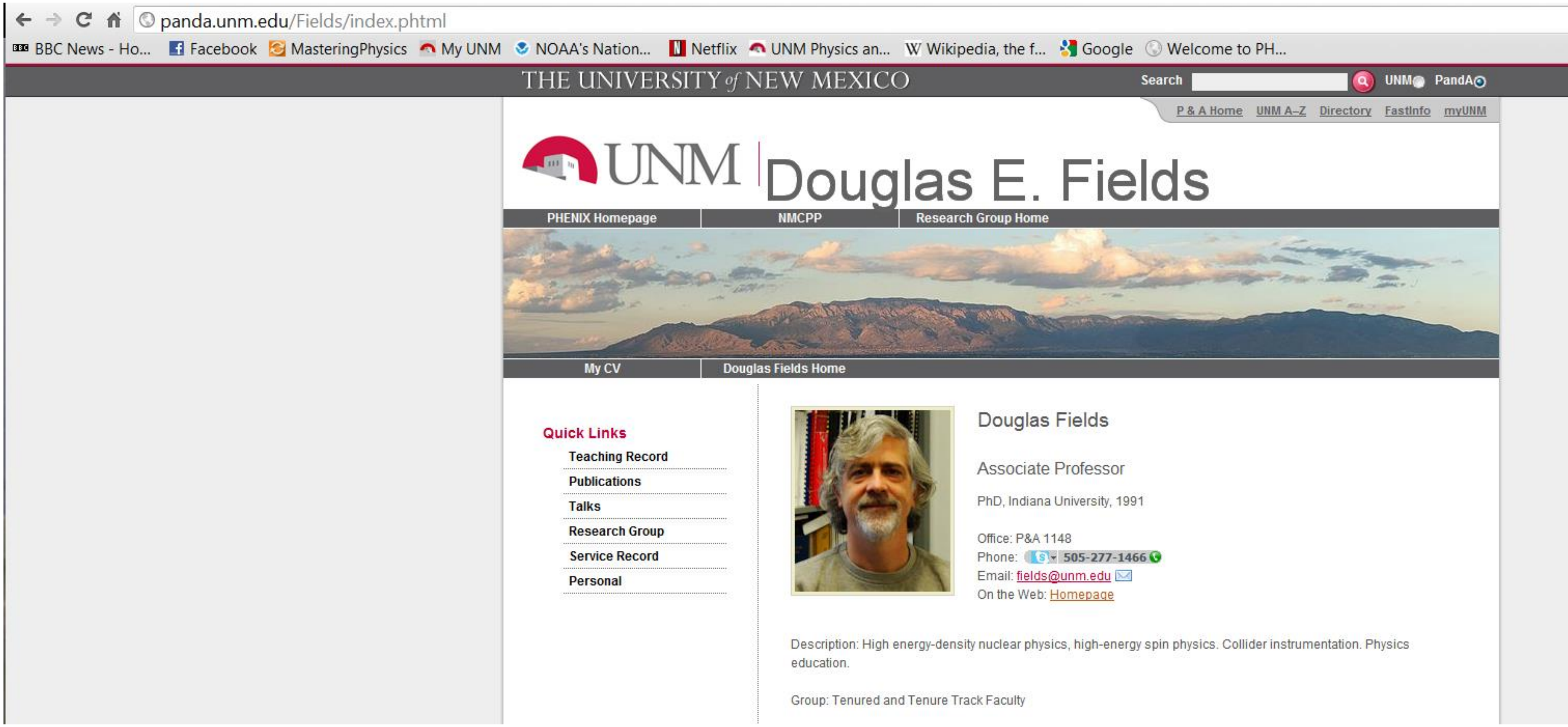
Lecture 1
(Introduction and Units)

Physics 160-01 Spring 2017

Douglas Fields

My Info



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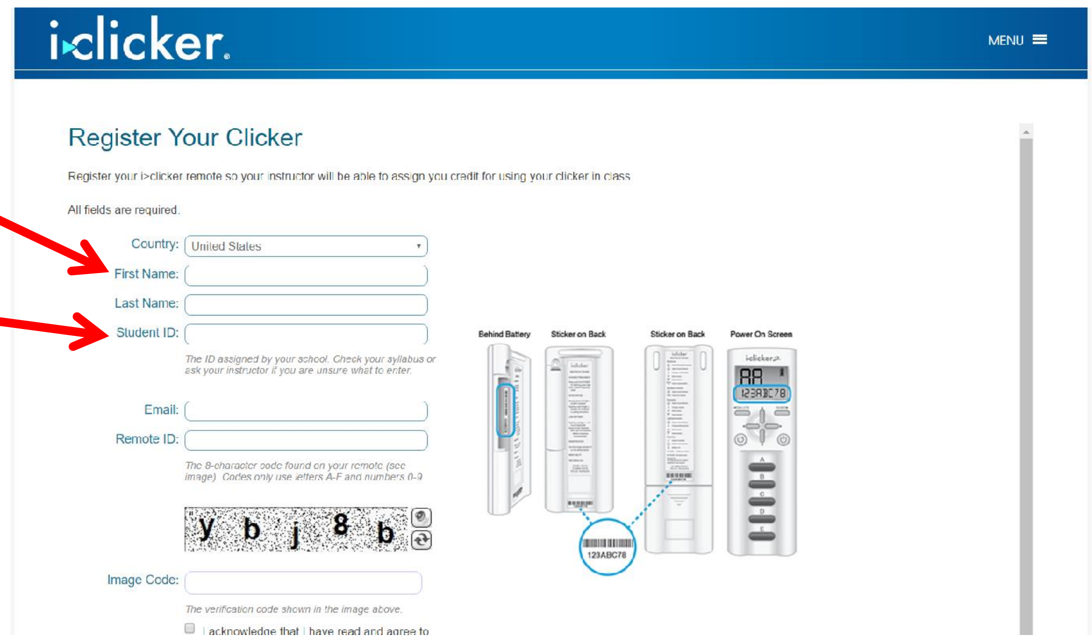
Description: High energy-density nuclear physics, high-energy spin physics. Collider instrumentation. Physics education.
Group: Tenured and Tenure Track Faculty

General Class Info

http://panda.unm.edu/Courses/Fields/Phys160/Phys160.html

Registering Your iClicker

- http://www.iclicker.com/registration/
- Use **your name** as it appears in banner.
- For student ID, **use your banner ID**.
- Clicker ID is on the back of your clicker.
- You only need to register your clicker once, so if you used it last semester (and registered it), then you don't have to do this.



Mastering Physics

- http://www.masteringphysics.com/
- Two types of homework due before class every day:
  - Pre-Class:
    - Designed to get you to read the chapter ***before*** I lecture.
    - Fairly easy.
  - Post-Class:
    - Designed to tell you if you understood the material.
    - A bit harder.

Units and Significant Figures

Units

- We will use SI (Systeme International) units
- Length
  - Meter [m] = 3.281 feet
- Time
  - Second [s]
- Mass
  - Kilogram [kg] = 1/14.593903 slugs
  - Gravitational force on 1 kg = 2.20462 lbs

Unit Prefixes

Length

1 nanometer $= 1$ nm $= 10^{-9}$ m (a few times the size of the largest atom)

1 micrometer $= 1$ μm $= 10^{-6}$ m (size of some bacteria and living cells)

1 millimeter $= 1$ mm $= 10^{-3}$ m (diameter of the point of a ballpoint pen)

1 centimeter $= 1$ cm $= 10^{-2}$ m (diameter of your little finger)

1 kilometer $= 1$ km $= 10^{3}$ m (a 10-minute walk)

Mass

1 microgram $= 1$ μg $= 10^{-6}$ g $= 10^{-9}$ kg (mass of a very small dust particle)

1 milligram $= 1$ mg $= 10^{-3}$ g $= 10^{-6}$ kg (mass of a grain of salt)

1 gram $= 1$ g $= 10^{-3}$ kg (mass of a paper clip)

Time

1 nanosecond $= 1$ ns $= 10^{-9}$ s (time for light to travel 0.3 m)

1 microsecond $= 1$ μs $= 10^{-6}$ s (time for an orbiting space shuttle to travel 8 mm)

1 millisecond $= 1$ ms $= 10^{-3}$ s (time for sound to travel 0.35 m)

I work at length scales of femtometer = 1fm = 10^{-15}m

Unit Consistency

- Besides being an essential part of any answer, units can help you to make sure that your answer is correct:
- What is the equation for a one dimensional trajectory with constant acceleration?
  - $x(t) = x_0 + v_0 t^2 + ½at$?
  - $[m] = [m] + [m/s][s^2] + [m/s^2][s]$

Uncertainties

- When making a measurement, results are NEVER exact.
- *A visitor to the Royal Tyrrell Museum was admiring a* Tyrannosaurus *fossil, and asked a nearby museum employee how old it was. "That skeleton's sixty-five million and three years, two months and eighteen days old," the employee replied. "How can you know it that well?" she asked. "Well, when I started working here, I asked a scientist the exact same question, and he said it was sixty-five million years old – and that was three years, two months and eighteen days ago."*
- We can express the uncertainty in a measurement explicitly by:
  - The desk is 2m +/- 0.1m long.
  - The desk is 2m +/- 5% long.

Significant Figures

- Or, we can express them implicitly by using the correct number of significant figures:
  - A measurement is made with the result 2.94 cm.
    - The implicit uncertainty is 0.01 cm.
  - A measurement is made with the result 0.0054 s
    - The implicit uncertainty is 0.0001 s.
- Leading and sometimes trailing zeros are not considered significant:
  - 0.0054 has only two significant figures.
  - 78100 has only three significant figures.
  - 78100.00 has seven significant figures.
- It is easier to see how many significant figures there are when written in scientific notation:
  - $0.0054 = 5.4 \times 10^{-3}$
  - $78100 = 7.81 \times 10^{3}$
  - $78100.00 = 7.810000 \times 10^{3}$

Significant Figures

- Calculations using numbers with uncertainties must correctly propagate those uncertainties:
  - 15.0/5.0000 = 3.00, not 3.0000 or 3.0
  - 100.00 + 5.0 = 105.0

Mathematical Operation	**Significant Figures in Result**
Multiplication or division	No more than in the number with the fewest significant figures *Example:* $(0.745 \times 2.2)/3.885 = 0.42$ *Example:* $(1.32578 \times 10^{7}) \times (4.11 \times 10^{-3}) = 5.45 \times 10^{4}$
Addition or subtraction	Determined by the number with the largest uncertainty (i.e., the fewest digits to the right of the decimal point) *Example:* $27.153 + 138.2 - 11.74 = 153.6$

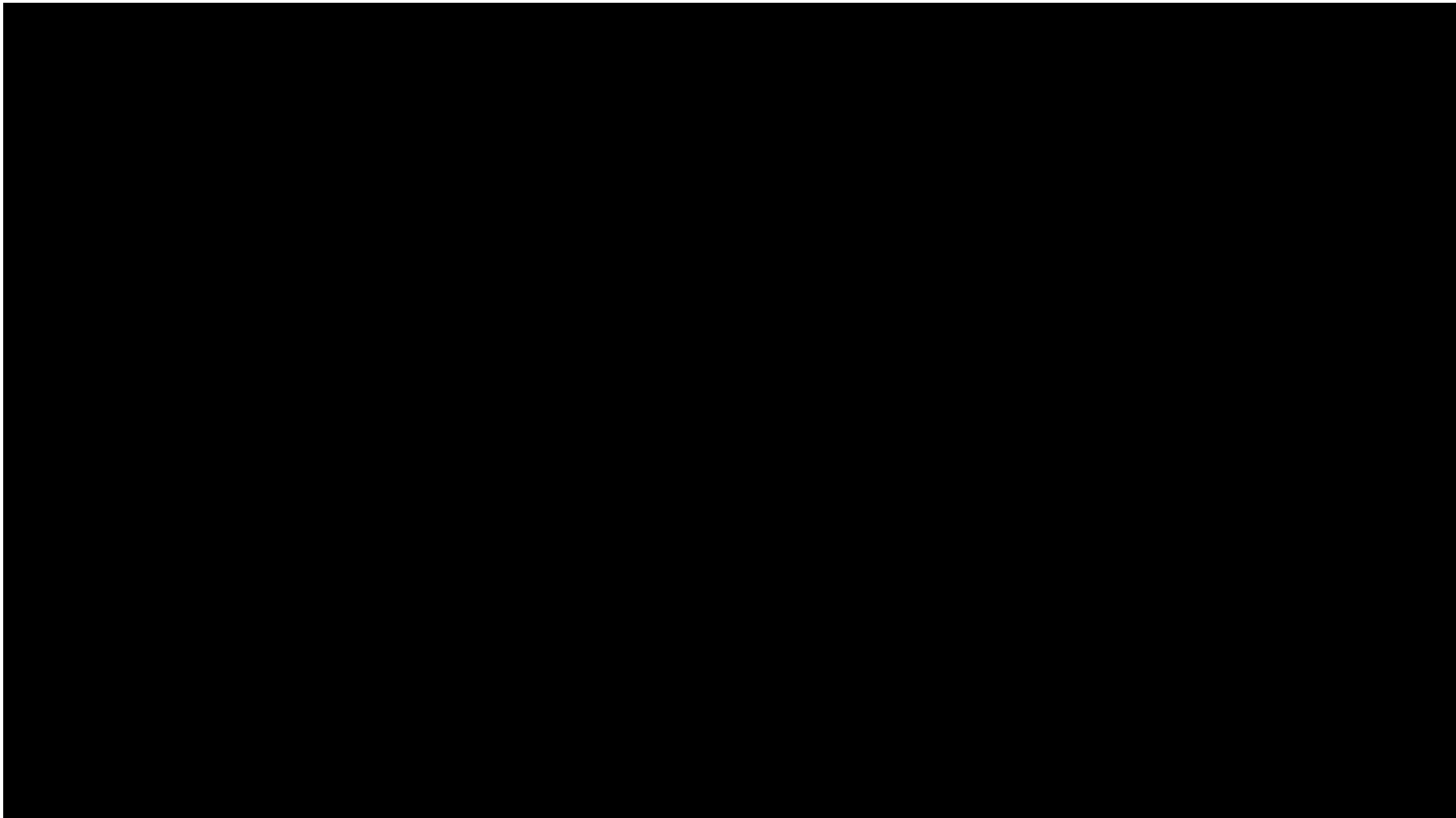
Note: In this book we will usually give numerical values with three significant figures.

Vectors and Trigonometry Review

Scalars and Vectors

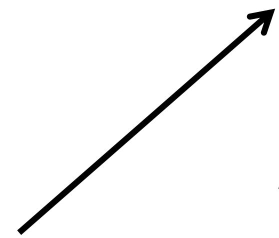
- A scalar only has a magnitude
  - Number of apples
  - Size of desk
  - Distance to Santa Fe
- A vector has a magnitude and a direction
  - If someone ask you how to get to Santa Fe from Albuquerque, your answer wouldn’t be “Go sixty miles.”

Vector



Vectors

- Represented by an arrow:



$\vec{A}$

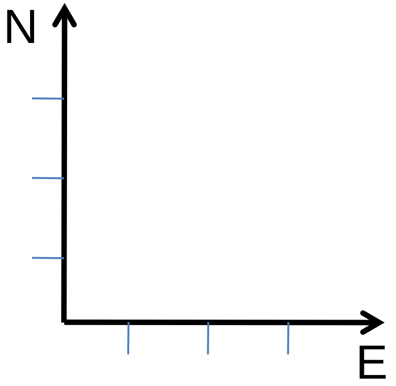
- The length of the arrow represents the magnitude.
- The orientation represents the direction.
- In which direction is the following arrow?

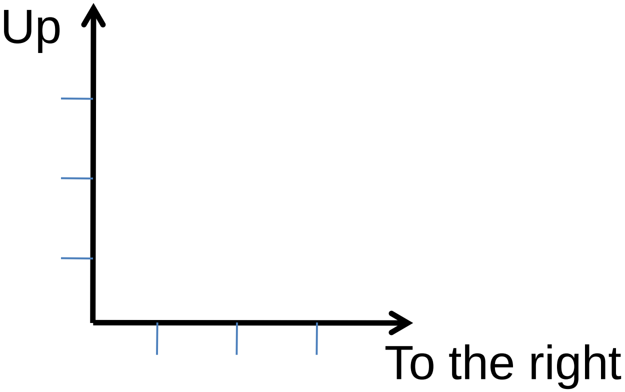
$\vec{A}$

- What is its length?

Coordinate Systems

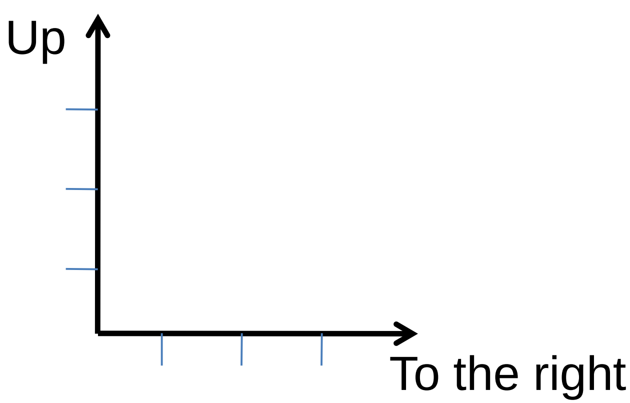
- A coordinate system is a reference for both direction and scale.
- Axes are perpendicular.
- Examples:

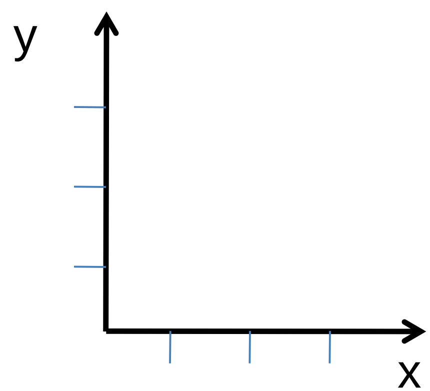




Coordinate Systems

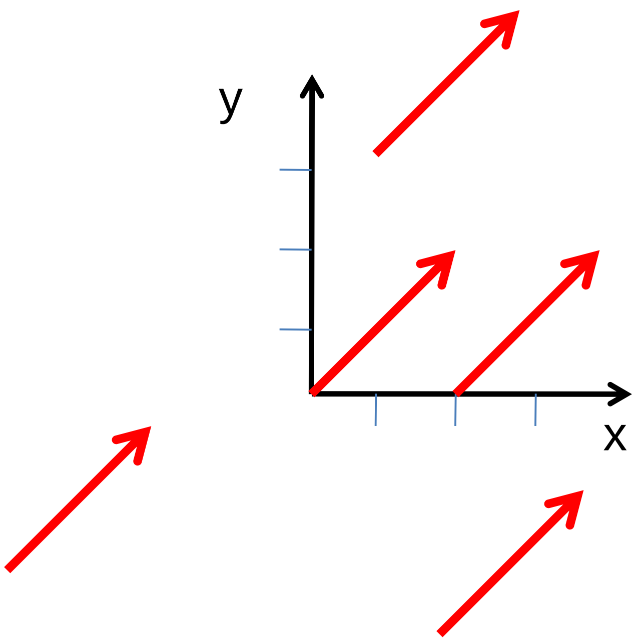
- In many cases, we generalize the directions using variable names.
  - So, instead of up and to the right, we can use the names “y” and “x”
  - This makes equations much more manageable…





Coordinate Systems

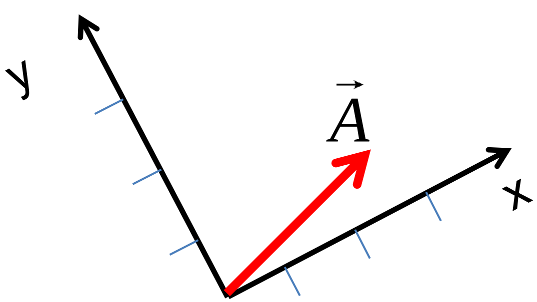
- Vectors can be drawn on a coordinate system in an infinite number of ways:

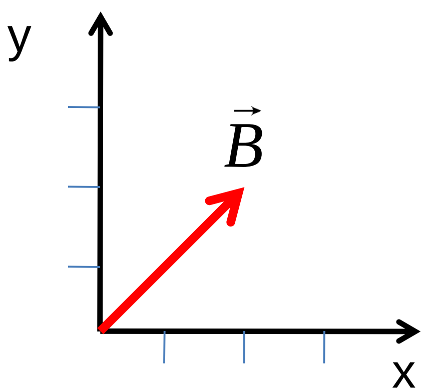


All of these vectors are the same – vectors ONLY have magnitude and direction!

Coordinate Systems

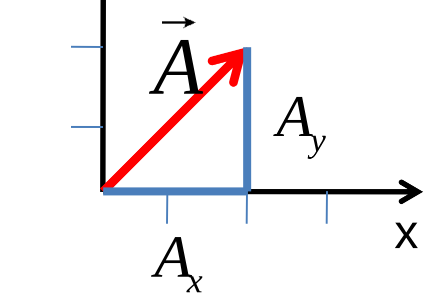
- However, you must remember that a vector is only defined uniquely when a coordinate system is defined, so vectors that are defined with different coordinate systems may LOOK the same but be different:

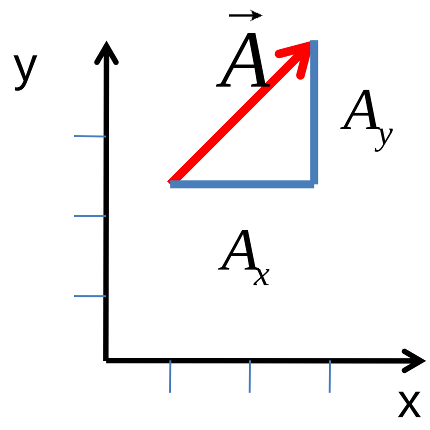




Components of Vectors

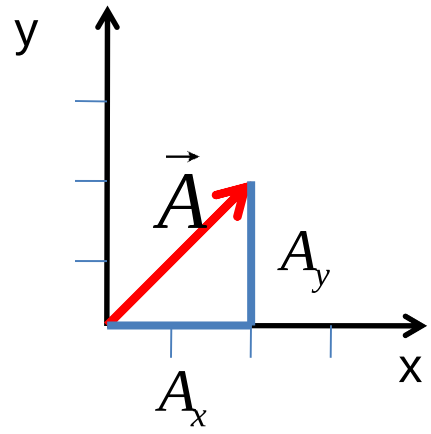
- Once we have a coordinate system as a reference, we can break down a vector in terms of its length along the direction of the coordinates:





Length of Vectors

- The length of a vector can be found using Pythagorean theorem:



$$\left|\vec{A}\right|^2 = A_x^{\ 2} + A_y^{\ 2}$$

Direction of Vectors

- The direction of a vector can be defined any way you choose relative to a coordinate system, but there is a conventional choice:
  - Angle from the positive x-axis with a positive angle in the counter-clockwise direction.