Vectors

By the end of this unit you will be able to:

- Describe the components of a vector
- Add vectors graphically
- Add vectors that are parallel and perpendicular
- Add vectors that are neither parallel nor perpendicular

- **Vectors**
  - Distance and speed are only half of what physicists need
  - Distance and speed are examples of scalars
    - A scalar is something that can be described as a single number
    - Examples: $20^{\circ C}$ or 55 mph
  - Vectors have both a magnitude (number) and direction
    - When typed, a vector is written as a bold, capital letter
    - When handwritten, a vector is a letter with an arrow over it
      - Remember this for your lab reports!!!

$\mathbf{F}$

Typed Vectors

$\vec{F}$

Handwritten Vectors

– Direction of Vectors

- In physics, a negative sign is used to indicated direction
  - Specifically, it is used to indicate that the vector is in the opposite direction from a vector that is positive

$\vec{K} = 2 \text{ at } 90°$

Vector K as a length of 2 in the direction of 90°

$\vec{L} = -3 \text{ at } 90°$

Vector L as a length of 3 in the opposite direction of 90°, which is what?

  - In each problem, you can choose which direction is positive
    - » Right is typically positive on the x-axis
    - » Up is typically positive on the y-axis
    - » These can change though depending on your needs

– Drawing Vectors

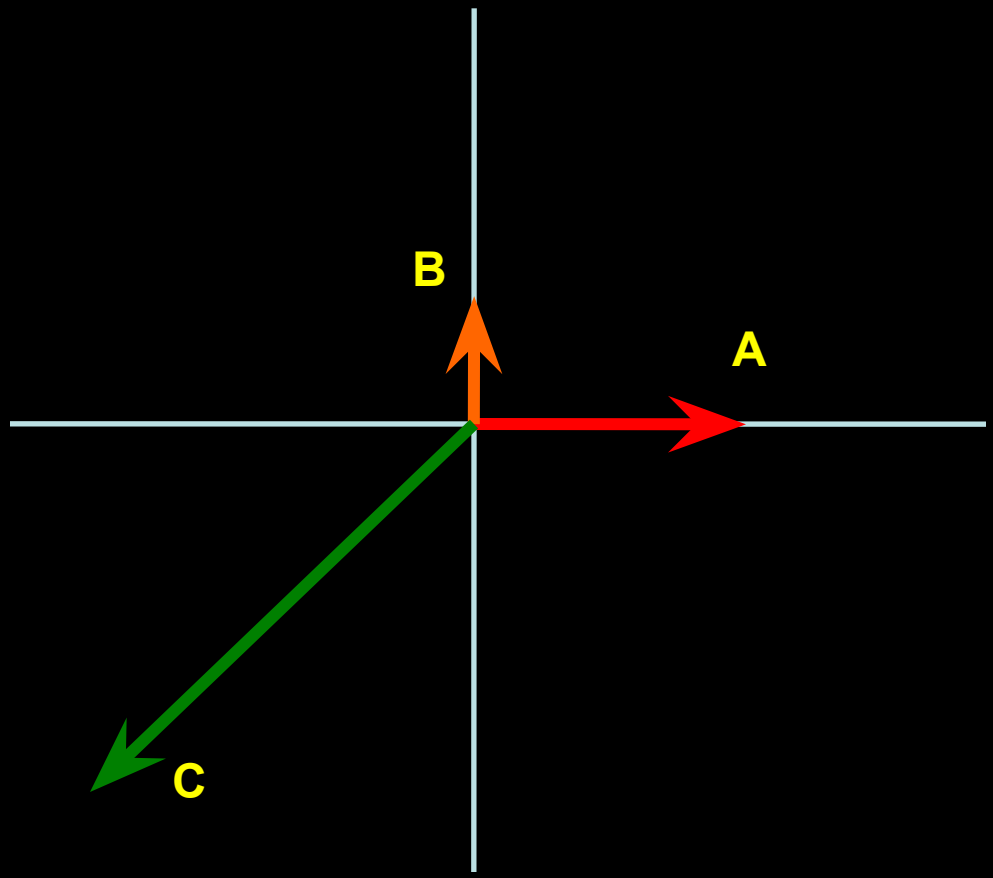
- By convention, a vector is an arrow pointing towards the direction specified with the length of the arrow representing the magnitude

$\vec{A} = 10 \text{ at } 0°$

$\vec{B} = 5 \text{ at } 90°$

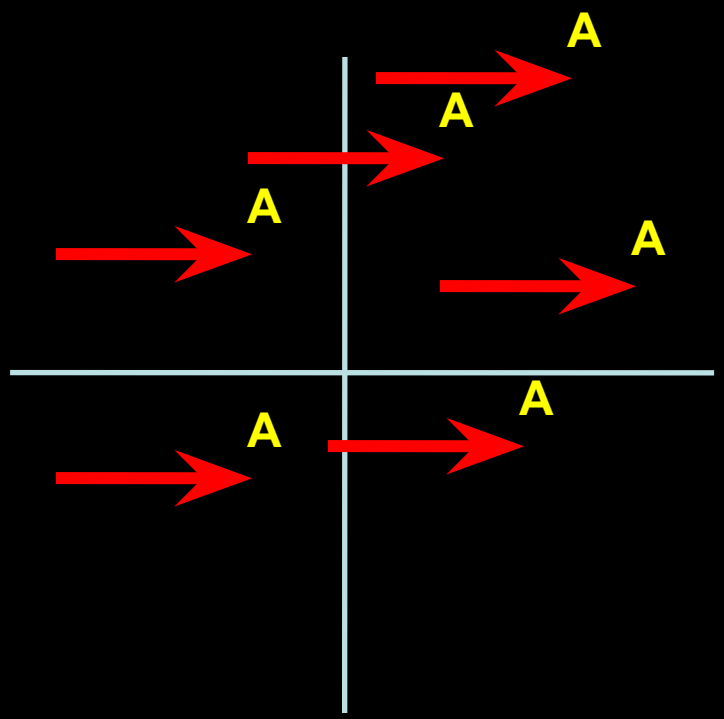
$\vec{C} = 20 \text{ at } 225°$

As you can see, A is drawn so that it is twice as long as B and half as long as C.

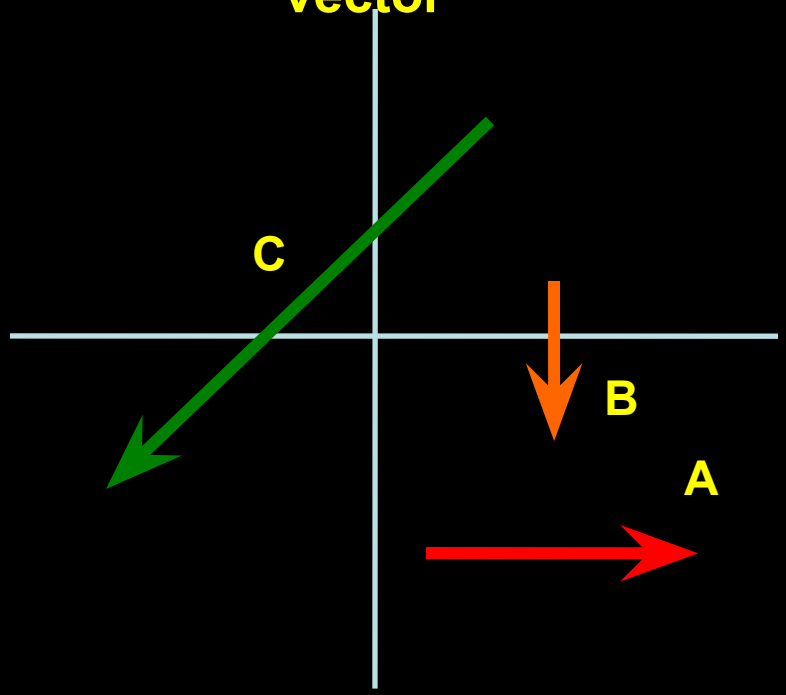


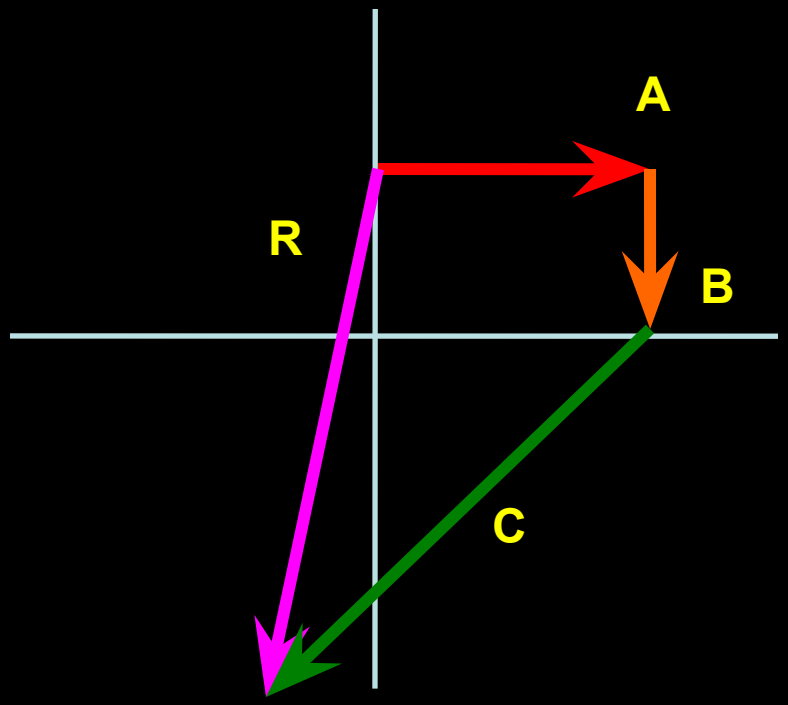
- A vector will have a set direction and magnitude, it will not have a set starting and ending point
- This means that I can move the vectors wherever I want to as long as I keep the magnitude and direction the same
  - All of the vectors below are the same, since I have kept the same magnitude and direction

$\vec{A} = 10 \text{ at } 0°$

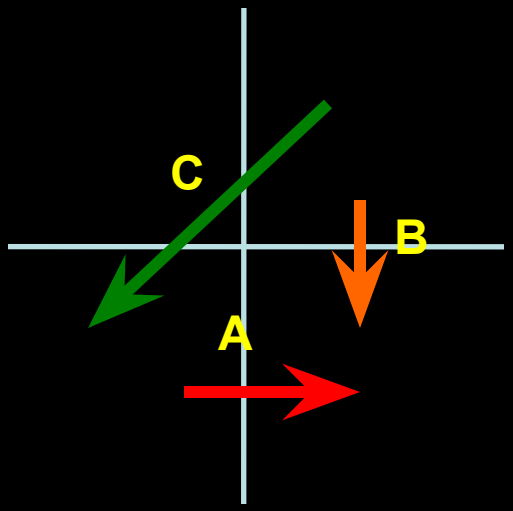


- **Vector Addition**
  - **Graphically Adding Vectors**
    - **Use the Head-to-Tail method**
    - **Line up the vectors head to tail, and the resultant is the sum of the vectors**
      - **The resultant vector is the vector that is drawn from the tail of the first vector to the head of the last vector**

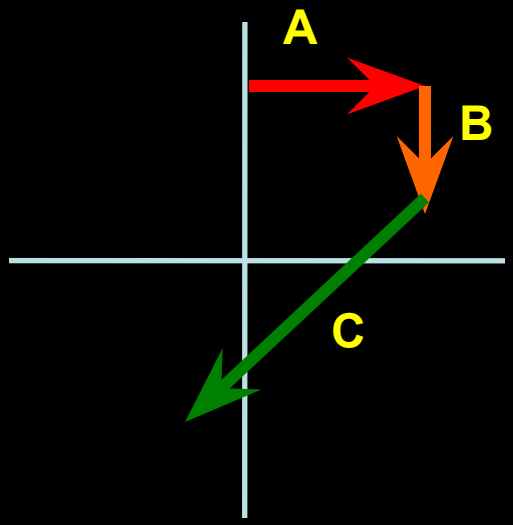




– Example



I have three vectors I want to add graphically

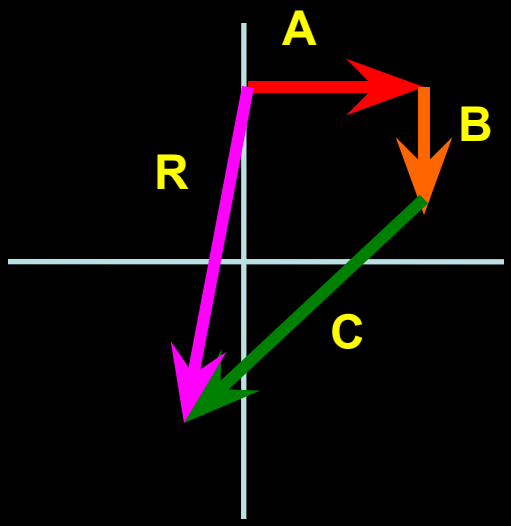


I am going to start by moving **A**, then **B**, then **C**

For the first vector, it doesn't matter where you start

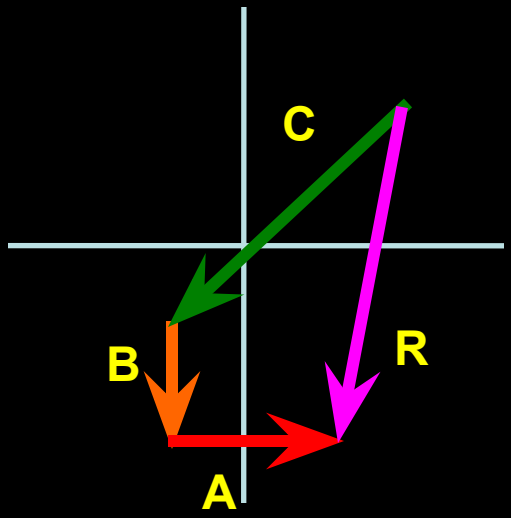
Notice how the second vector I used starts at the head of the first vector

The third vector starts at the head of the second



The sum of these three vectors is the straight line distance from where you started to where you ended

The sum is also called the resultant **R**



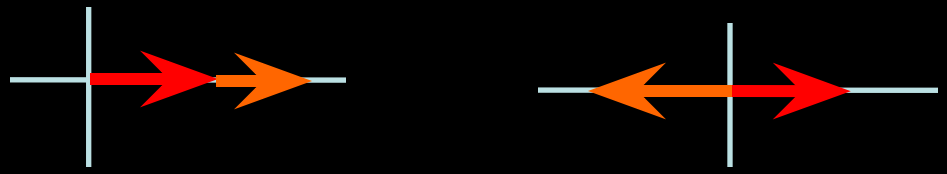
I could have just as easily have moved **C** then **B** then **A**

The sum is the same (or **R** has the same length and direction)

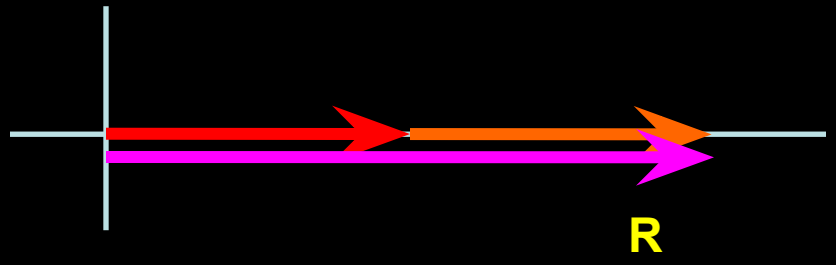
Vector addition, just like regular addition, is commutative

– Adding Parallel Vectors

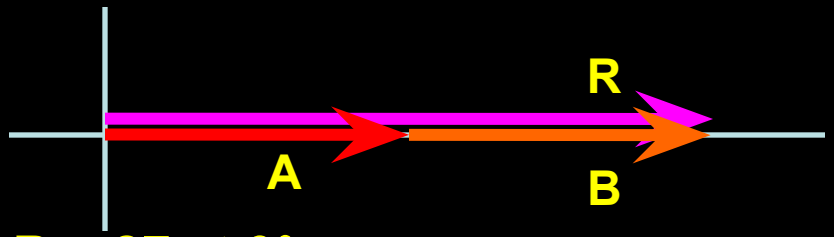
- Parallel vectors lie on the same line
  - Both sets of vectors below are parallel



- To add parallel vectors, add the magnitudes of the vectors
- The direction of the resultant will be in the direction of the original vectors

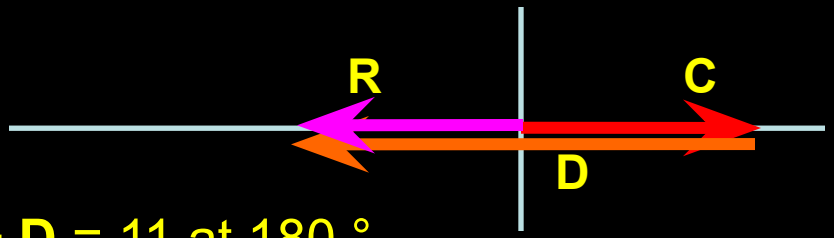


- **Examples**
  - **A has a magnitude of 10 and is oriented along the positive x-axis. B has a magnitude of 17 and is also along the positive x-axis. What is A + B?**



» **A + B** = 27 at 0°

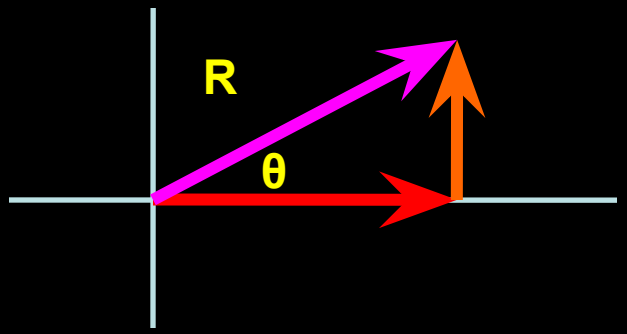
  - **C has a magnitude of 8 and is oriented along the positive x-axis. D has a magnitude of 19 and is along the negative x-axis. What is C + D?**



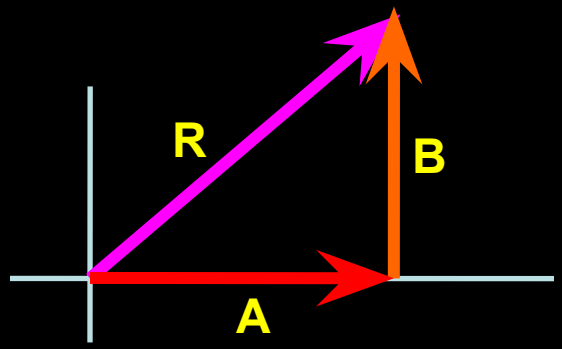
» **C + D** = 11 at 180 °

– Adding Perpendicular Vectors

- Perpendicular vectors lie at right angles to each other
  - To find the magnitude of the resultant, use the Pythagorean Theorem
    - » Why?
      - » When the vectors are added graphically and the resultant is drawn, they form a triangle where the resultant is the hypotenuse
  - To find the direction of the resultant, use a trig function, either sine, cosine or tangent

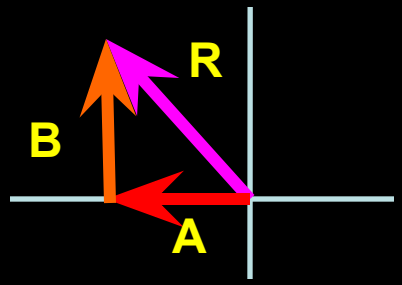


- **Examples**
  - A has a magnitude of +15 along the x-axis. B has a magnitude of +17 along the y-axis. What is A + B?



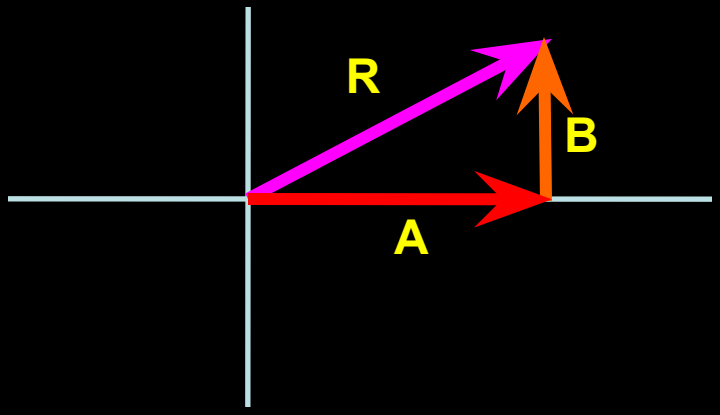
» A + B = 22.67 at 48°above the positive x-axis

  - C has a magnitude of -3 along the x-axis. D has a magnitude of +4 along the y-axis. What is C + D?



» C + D = 5 at 53°above the negative x-axis

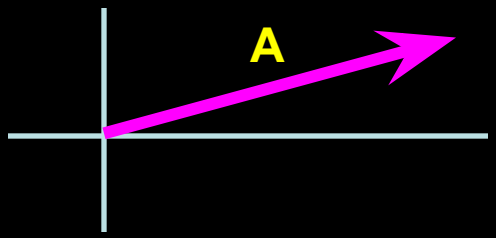
- Resolving Vectors
  - When you resolve a vector, you are taking it apart
  - Any vector can be resolved into two components
    - The component vectors, when added, will give you the original vector
    - One component will be a vector on the x-axis
    - The other will be along the y-axis
      - » This process is the opposite of adding perpendicular vectors
      - » It is also the same as giving you the hypotenuse of a triangle and asking you to find the length of the sides



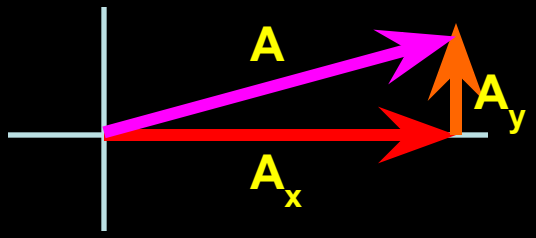
R has two components, **A** and **B**

The components are graphically added to show that they add up to **R**

- Examples
  - **A** has a magnitude 12 at an angle of 20° from the positive x-axis. Find the components of **A**.



First thing to do is draw out the vector



Then, I would draw in the components and label them

I typically use the subscripts x and y for the components

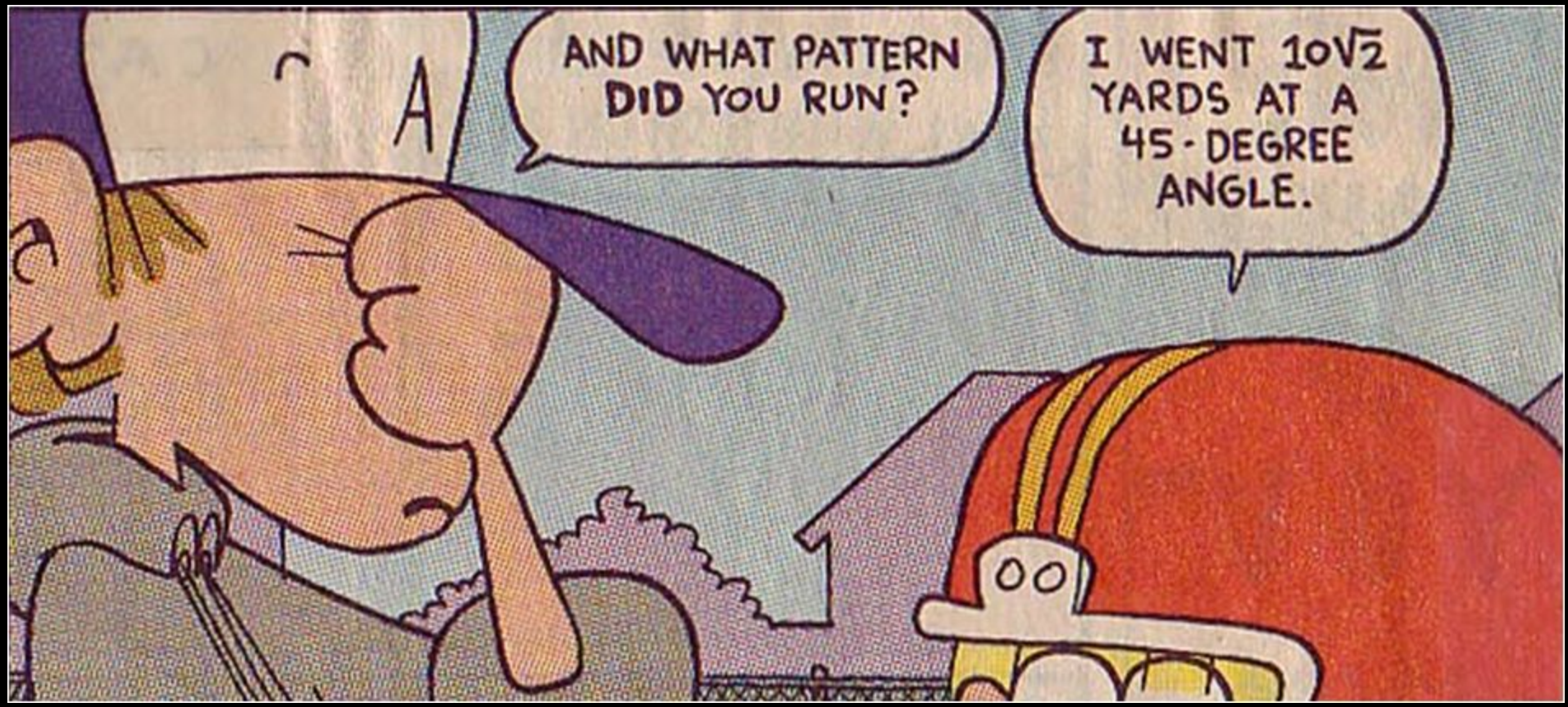
From here you just need to solve for the two sides of the triangle

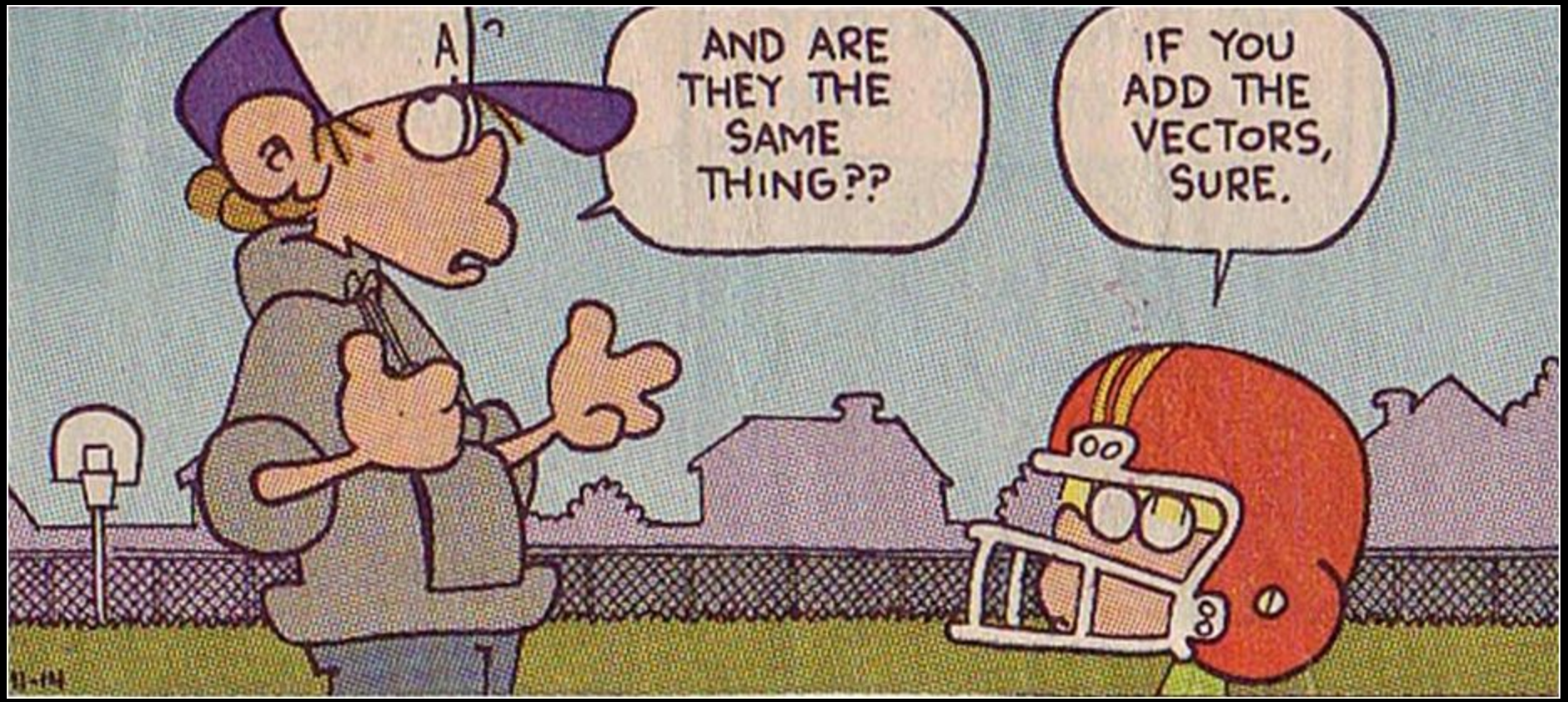
» $A_x = +11.28$

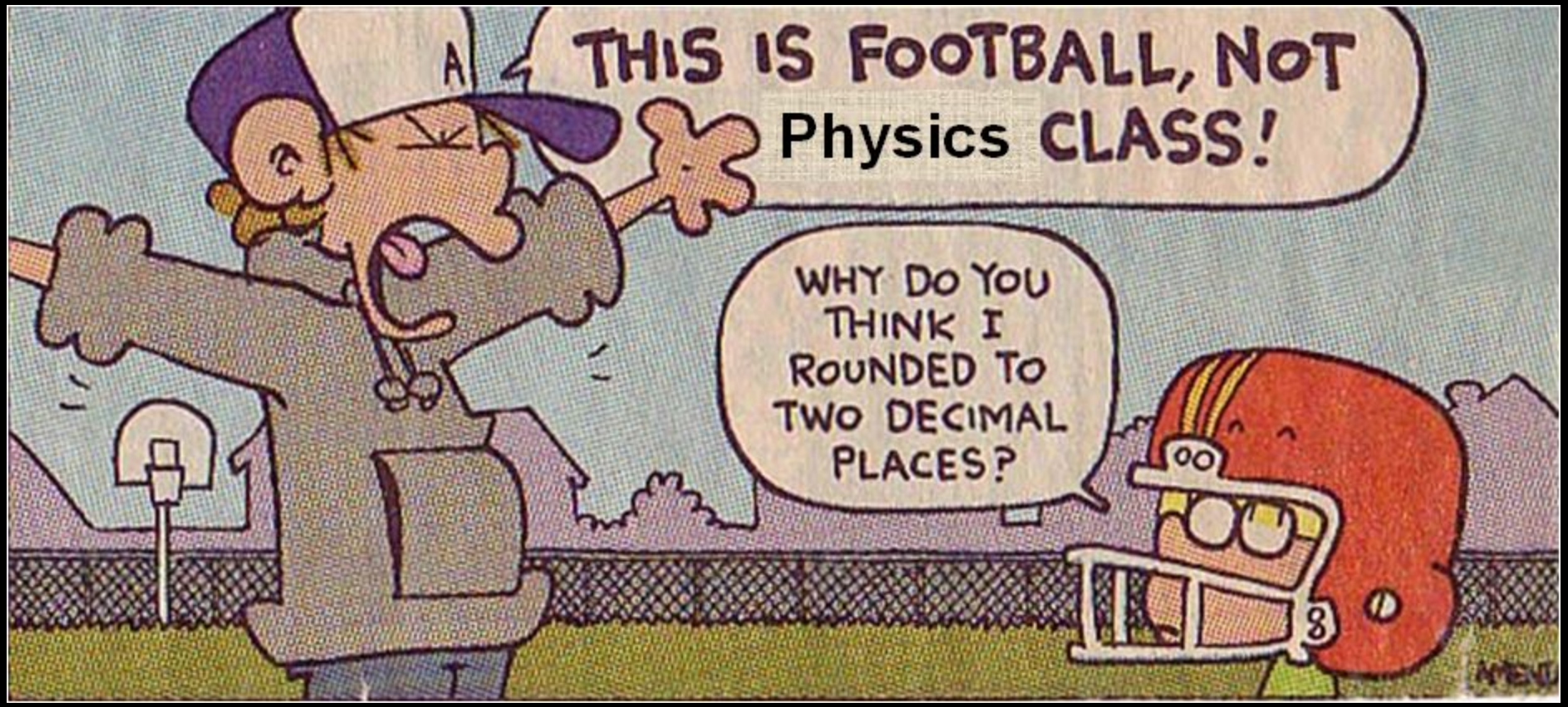
» $A_y = +4.10$

- Adding Non-Parallel and Non-Perpendicular Vectors
  - You can only add vectors when they are parallel or perpendicular
  - Therefore, when you have two or more non-parallel, non-perpendicular vectors you need to break them down into vectors that are parallel and/or perpendicular
    - You start this by resolving vectors into components
    - Once done you need to add up all vectors that are parallel until you are left with two vectors
      - One of these vectors will be in the **x** and one in the **y**
      - Once this is done, the two perpendicular vectors can be added and the resultant found


A
JASON, WHAT PATTERN DID I TELL YOU TO RUN?
YOU SAID TO GO 10 YARDS OUT, THEN 10 YARDS TO THE RIGHT.


A
AND WHAT PATTERN DID YOU RUN?
I WENT $10\sqrt{2}$ YARDS AT A 45-DEGREE ANGLE.


A
AND ARE THEY THE SAME THING??
IF YOU ADD THE VECTORS, SURE.


THIS IS FOOTBALL, NOT Physics CLASS!
WHY DO YOU THINK I ROUNDED TO TWO DECIMAL PLACES?