Poets say science takes away from the beauty of the stars–mere globs of gas atoms. Nothing is "mere." I too can see the stars on a desert night, and feel them. But do I see less or more? The vastness of the heavens stretches my imagination–stuck on this carousel my little eye can catch one-million-year-old light. A vast pattern, of which I am a part....

What is the pattern, or the meaning, or the why? It does not do harm to the mystery to know a little about it. For far more marvelous is the truth than any artists of the past imagined! Why do the poets of the present not speak of it? What men are poets who can speak of Jupiter if he were like a man, but if he is an immense spinning sphere of methane and ammonia must be silent?

–Richard Feynman, from *Lectures on Physics*, vol. 1, ch. 3

Vectors and 2D kinematics

Physics 211
Syracuse University, Physics 211 Spring 2019
Walter Freeman

January 23, 2019

Announcements

- Homework 2 posted tonight or tomorrow, due next Friday
- Group practice test next Friday
  - If you must miss the group exam for an excused reason, let your recitation TA know
  - We'll just use your main exam grade to replace it
  - We don't expect you to study specially for this – doing your homework is preparation enough
  - The group tests will serve as a practice exam for your exam on Tuesday, February 5

Volunteer with Engineering Ambassadors!

As an SU student, you can become an ambassador and volunteer at local middle schools.

Do science activities with younger students and inspire them to pursue interests in science!

If you are interested in volunteering with us, attend **ONE** training session:

Hall of Languages 215, Thursday 1/24: 5 PM-6 PM

Schine 228B, Friday 1/25: 3:45 PM– 4:45 PM

Any Questions? Contact litinits@syr.edu

Ask a Physicist: Polarization

Homework questions?

Vectors

You've been doing math with numbers, which are things that live in one dimension: they only have a magnitude and a sign.

Vectors are things that have a magnitude and a direction: "arrows in space"

Many of the things we deal with in physics are vectors:

- Position

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So, we need to learn to do math with arrows.

- We indicate that an object is a vector by writing an arrow over it: "the vector $\vec{V}$".
- "Scalar": object that isn't a vector (mass, time)
- Equations can mix vectors and scalars: $\vec{F} = m\vec{a}$.
- ... or $\vec{s} = \frac{1}{2}\vec{a}t^2 + \vec{v}_0 t + \vec{s}_0$

Notation

- $\vec{A}$: "the vector A" (a vector)
- A: "the magnitude of A" (a scalar)
- $\hat{A}$: "the direction A points in" (a vector with magnitude 1, called a "unit vector")
- A_x: the component of A along the $x-$axis (a scalar)
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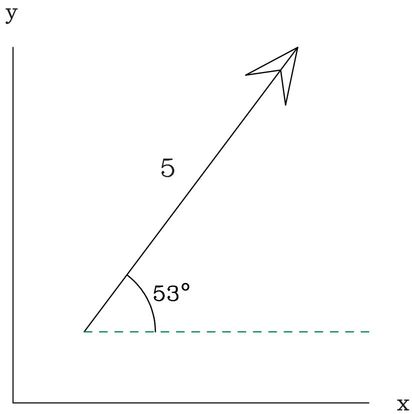
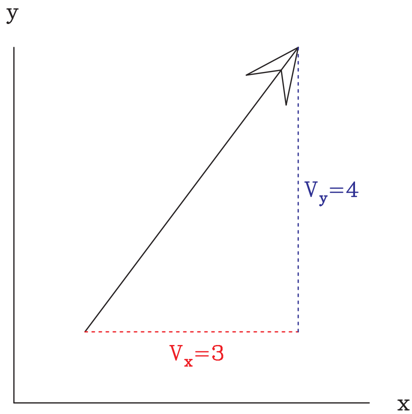
- $\hat{i}$ or $\hat{x}$: a unit vector pointing along the $x-$axis
- $\hat{j}$ or $\hat{j}$: a unit vector pointing along the $y-$axis
- $\hat{k}$ or $\hat{k}$: a unit vector pointing along the $z-$axis

Two ways to describe a vector



Angle and direction



X and Y components

How do we convert from one to the other?

How do we convert from one to the other?

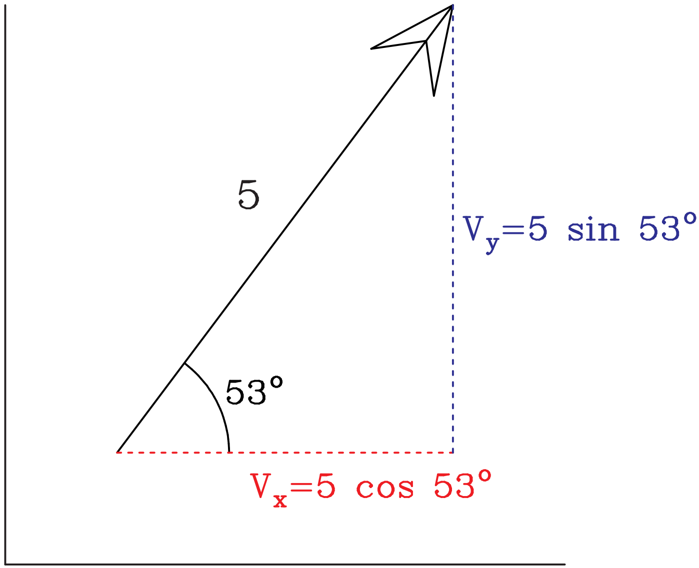
A: Using algebra

B: Using trigonometry

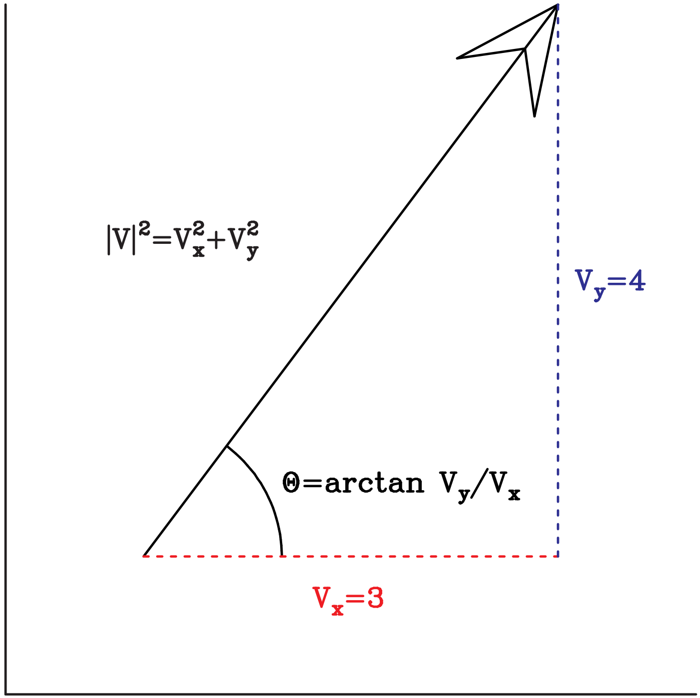
C: Using calculus

D: Using differential equations

From "direction and magnitude" to components



From components to direction and magnitude



Suppose you have some vector $\vec{A}$ that you want to convert into components. The x-component A_x is:

A: $A\cos\theta$

B: $A\sin\theta$

C: $A\tan\theta$

D: $\dfrac{A}{\cos\theta}$

E: It depends

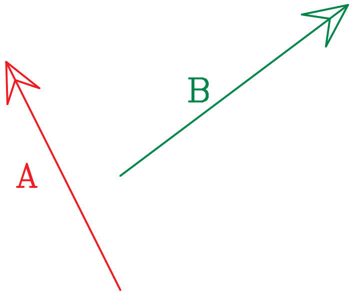
A warning!

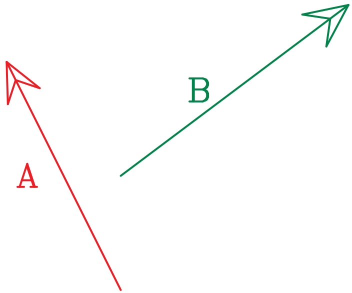
You cannot memorize "$V \sin\theta$ is the y component,
$V \cos\theta$ is the x component"!

This does *not* work in general; you have to actually draw the triangle.

Adding vectors

We can also add vectors together by drawing them “head to tail”. Here are two vectors:





Does $\vec{A} + \vec{B} = \vec{B} + \vec{A}$?

- A: Yes
- B: No

Does $\vec{A}+\vec{B}=\vec{B}+\vec{A}$?

- A: Yes
- B: No

Yes: vector addition obeys the commutative property, just like ordinary addition

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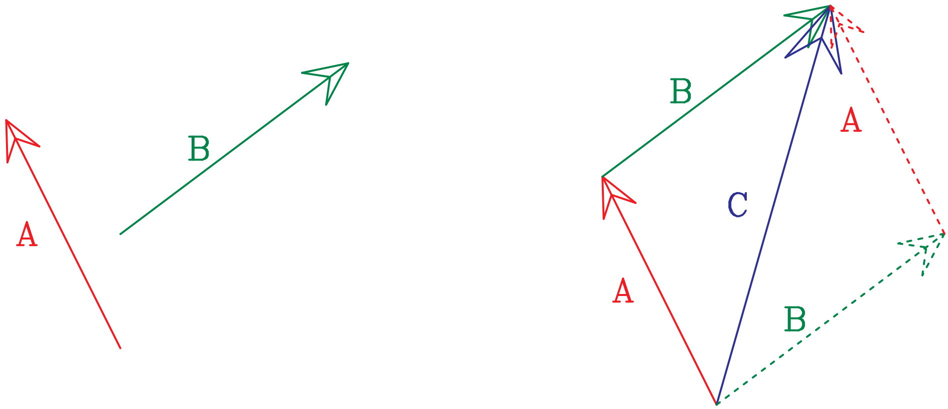


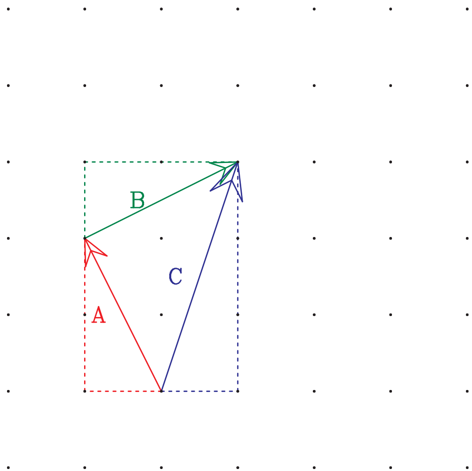
$$\vec{A} + \vec{B} = \vec{C}$$

Adding vectors: components

The component representation is much easier to work with!

$$\vec{A} + \vec{B} = \vec{C} \rightarrow \begin{pmatrix} A_x + B_x = C_x \\ A_y + B_y = C_y \end{pmatrix}$$

Adding vectors: components



To add two vectors, just add their components!

This is why it is almost always easiest to work in the component representation!

What does this do to our kinematics?

Acceleration, velocity, and position relationships are still the same; they just apply independently for each component.

$$\vec{v}(t) = \vec{a}t + \vec{v}_0$$
$$\vec{s}(t) = \frac{1}{2}\vec{a}t^2 + \vec{v}_0 t + \vec{s}_0$$

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$$\vec{x}(t) = \frac{1}{2}a_x t^2 + v_{x,0}t + x_0$$
$$\vec{y}(t) = \frac{1}{2}a_y t^2 + v_{y,0}t + y_0$$

Which statement does *not* make sense?

- a. $\vec{A}t = \vec{B}$
- b. $\vec{A} + \vec{B} + t = \vec{C}$
- c. $k(\vec{A} + \vec{B}) = k\vec{A} + k\vec{B}$
- d. $\vec{A} - \vec{B} = \vec{C}$

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B: You can't add a vector and a scalar. "One mile north plus one inch" – which way is the inch?

Problem solving: 2D kinematics, constant acceleration

1. 1. If you have vectors in the "angle and magnitude" form, convert them to components
2. 2. Write down the kinematics relations, separately for x and y
   - Many terms will usually be zero
   - Freefall: $a_x = 0$, $a_y = -g$ (with conventional choice of axes)
3. 3. Understand what instant in time you want to know about (write a sentence like we've practiced)
4. 4. Put in what you know; solve for what you don't (using substitution, if necessary)
5. 5. Convert vectors into whatever format the problem asks for

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Every kinematics problem we will encounter can be done this way!

Sample problems

A rock is thrown at $v_0 = 10m/s$ at $\theta = 30^\circ$ above the horizontal.

- How far from its starting point is it after 2 seconds?

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Sample problems

A rock is thrown at $v_0 = 10 m/s$ at $\theta = 30^\circ$ above the horizontal.

- How far from its starting point is it after 2 seconds?
- How far does it travel?
- How high does it go?
- What will its speed be when it strikes the ground?