

Topic: Vectors

Grade Level: 6-8

Lesson Objectives

- Students will understand that vectors consist of two pieces of information: a distance and a direction.
- Students will understand how vectors in two dimensions are combined.

Materials

- Deck of cards with face cards removed (only use A-10)
- Activity sheets (see attached)
- Internet access
- Calculator

Engagement

- Activity Sheet One
 - Students will get up and go on a random walk based on the draw of cards, recording the distance that they move.
 - They will then calculate the total distance they walked, as well as the final vector of their movement.

Exploration

- Activity Sheet Two
 - Students will calibrate the program to various maps, draw vectors on the maps and learn how the vectors relate to each other.

Explanation

- Activity Sheet Two
 - Students will do math and answer questions about vectors, their relationships to one another and how this all relates to the maps and the real world.

Extension

- Activity Sheet Two
 - Students can examine / modify the code used to simulate the vectors on the maps.

Evaluation

- The teacher will assess the students throughout the activities, and will be able to tell if the students understand the concept from the informal presentations of their map results/conclusions.
- An exit slip will be filled out by each student.

Differentiation Strategies

- EL Students
 - Translated sheets can be used to bridge gaps in language for non-native English speakers.
- Accelerated Students
 - Students who are able to complete the given tasks in the allotted time will be able to go on to the Extension portion and modify the code.
- Students with LD
 - Students who have trouble finishing the assignment can draw fewer cards for Activity One.

Next Generation Science Standards (NGSS)

<https://www.nextgenscience.org/>

Science and Engineering Practices (SEP)

SEP 2 - Developing and Using Models

SEP 5 - Using Mathematics and Computational Thinking

Integration with Math Practices (MP)

MP 4 - Model with Mathematics

MP 5 - Use appropriate tools

Common Core State Standards (CCSS)

Name: _____

Activity One - Random Walk with Cards

So today you will be taking a walk. It will be a “random walk” - your path will be determined by the luck of the draw. First we need to determine how long each of your steps are:

1. Mark your starting point, and take 10 steps (use a comfortable walking pace; the important thing is to be consistent)
2. Mark your ending point, and measure the distance of this walk.
3. Take this distance and divide by 10. (Note: any number of steps can be used, in fact the more you take the more accurate your measurement will be - 10 is just a good number for easy math.)
4. Record this number here:

Average step distance: _____ m

Now you will take a 7 part walk. The number of steps and direction for each part will be determined by a card you draw for each part:

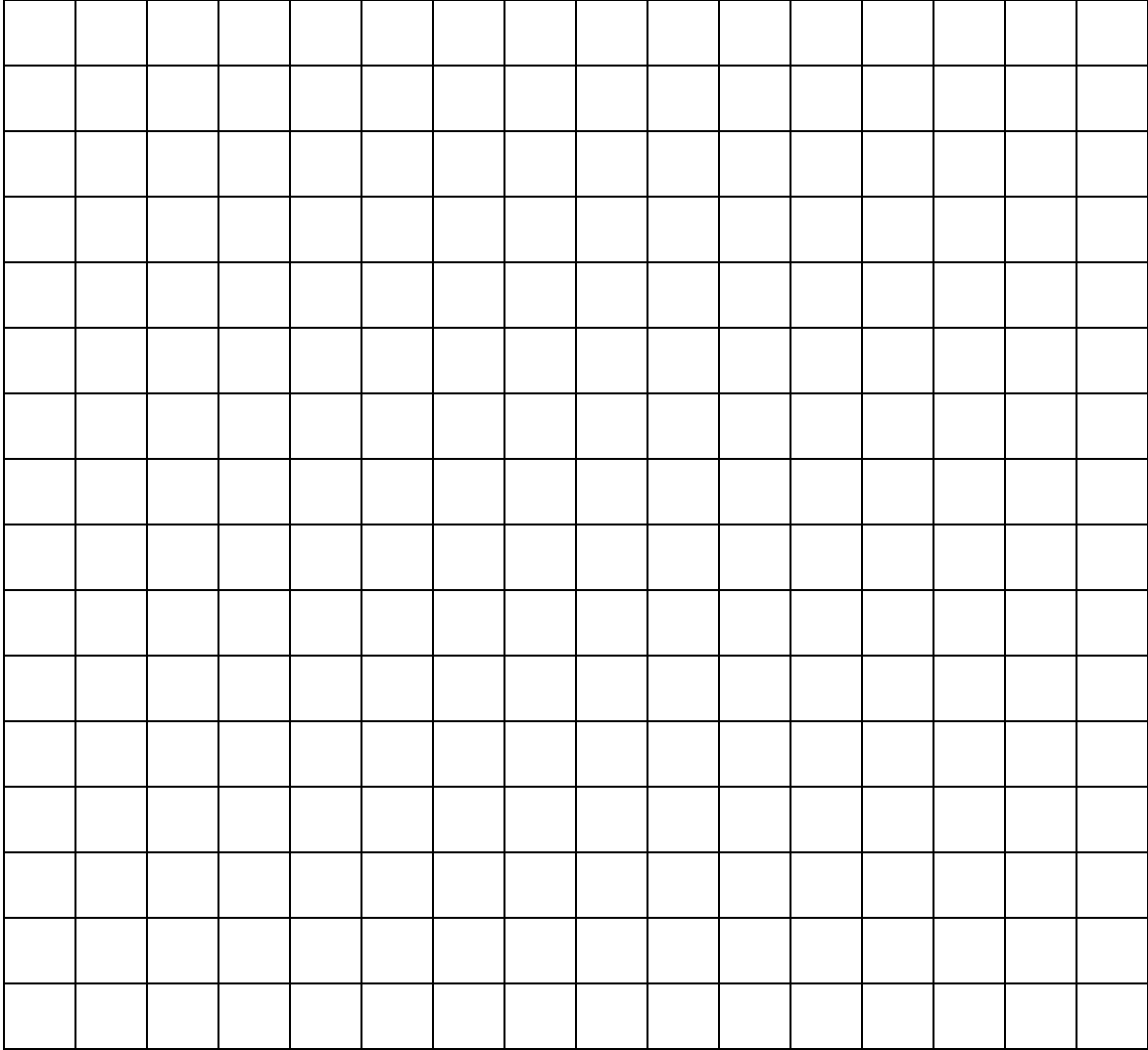
- The number on the card tells you the number of steps/paces you take (count aces as one).
 - The suit of the card determines the direction:
 - Hearts go forward
 - Spades go backwards
 - Diamonds go to the right
 - Clubs go to the left
1. Now mark your starting point and draw a card to begin your walk.
 2. Record each of your draws here. How can we determine the length of each part without directly measuring it? (Hint: you know how many steps you took and your average step length.)
 3. When you are finished with all 7 parts of the walk, mark your ending point, measure the distance between the start and finish and record it below.

	Card	Direction	Steps	Length (m)
Card 1				
Card 2				
Card 3				
Card 4				
Card 5				
Card 6				
Card 7				

Distance from start to finish: _____ m

Now let's investigate the data you collected.

- 1) First we can draw a "map" on the graph paper below of our motion. Record both the number of steps and the direction walked on each part by drawing an arrow for each part of your walk. Each arrow you draw represents a vector.



- 2) Now find all left and right parts of your walk and group them together. Do this for all forward and backward parts of the walk too:

Left/Right	Distance	Forward/Backward	Distance
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

- 3) Next take all the right distances, add them together and subtract all the left distances from this sum. Then add all the forward distances together and subtract all the backward distances from that sum. This gives you two numbers, one represents the left / right motion, and the other represents the forward / backward motion. These two numbers together represent a new vector! Draw an arrow from your starting point (the beginning or “tail” of the first vector) to your ending point (the point or “tip” of the last vector) to show this new vector on the graph.

left/right sum, forward/backward sum = [_____ , _____]

- 4) Now we want to find the size of this new vector. Is there any formula from geometry that can help us calculate this without directly measuring it?
- 5) Is the size of this new vector close to the distance we actually measured between your starting and ending position for the walk?

Name: _____

Activity Two - Vectors and Maps

We will be working with a computer program to give us a chance to work with vectors in a simulation of a real world setting. The simulator allows us to draw vectors on maps by using the mouse.

Getting Started!

Load the simulator in a web browser using the link <https://trinket.io/glowscript/3d36f7b735>. You will get a site with two windows side by side. The window on the left will contain a lot of text; the window on the right will show part of the map of the USA.

The simulation was made with a programming environment called trinket. This environment allows you to run **python** code without the need to install anything. An added benefit is that with trinket we get to have access to the code of the simulation - the text contained in the left window.

To proceed, click the button that is three horizontal lines that is located to the left of a yellow circle with a key inside it, and is just above and to the left of the text for the code. This button will pull up a black menu. Click full screen on this menu to see the entirety of the program.

Next hit the Run/play button. This button is located to the right of the three line button and above the code window. This will start/restart the simulation. If you cannot get something to work during this activity this is always a great button to press to restart things.

Read the white box over the map. This will give you instructions to start using the simulation. To remove the white box and get started, click on the top button labeled "Load Map". This is always a good button to keep in mind as this will erase any vectors you draw on the map. If you wish to view the instructions again, you may do so at any time by clicking the "Instructions" tab at the top right of the program.

Drawing Vectors and recording distances and directions

Now we can start making vectors. Remember vectors have both size and direction.

1. To draw your first vector Click and HOLD on Washington DC, without taking your finger off of the mouse button, move the cursor to Chicago. If you are having difficulty reading the map, the scroll wheel on the mouse zooms in and out on the map. This should now give us a vector pointing from DC to Chicago. The simulation gives you the magnitude (size) of the vector and the parts of the vector (components) with no calculations listed in the text box below the map. Record this distance and the components.
2. Take each of the components, square them, add them together and then take the square root.
3. How does the calculated number compare to the distance/size of the vector?
4. Does the calculation performed remind you of any formulas used in math/geometry? Which one(s)?

5. Determine the formula for finding the size of a vector given the parts/components.
6. This is now your opportunity to investigate the basics of this simulation and draw a few vectors. Whenever your map is too crowded remember the "Load Map" button will clear your map.
7. Find the distance between 3 other sets of major cities in the continental US. Record the distances and city pairs.
8. Find the longest horizontal vector you can make while staying within the continental US, note the distance and rough locations.
9. Find the longest vertical vector you can make while staying within the continental US, note the distance and rough locations.
10. Find the longest vector you can make while staying within the continental US, note the distance and rough locations.
11. Normally different maps have different scales. How does this simulator know what scale we should use? (Hint: The instructions in the white box help here, and you should be looking for a red vector!)
12. How do you think the simulation knows how to determine the cardinal directions on the map. (How does the simulation know if you draw a vector pointing to the top right of the map, that the vector has both a north part and an east part? Hint: look for the purple vector).
13. Do you think the direction of the scale (red) vector matters? Why or why not?
14. Do you think the size of the orientation (purple) vector matters? Why or why not?

Vector Addition with maps

We will now use the simulations to do vector addition. While this simulation does not take in any numbers, it does allow us to draw vectors and get numbers out. This means that if we use the tip to tail method of adding vectors, we can always draw in the the resultant vector. The program will tell us what its length is without us having to do any work.

To start let's pretend we are all on a trip together. We start in Chicago and travel to New York City. From New York City we travel to Miami. The final leg of the trip will be from Miami to Houston.

Draw these three vectors in order on the map. If you have done things correctly the final tip of the last vector should be in Houston and the tail of the first vector should be in Chicago. To find the resultant vector, or the sum of all three vectors, draw a fourth vector from Chicago to Houston.

1. Add up the distances of the first three vectors draw, this number is the total distance of our trip (NOT vector addition!), record this distance.
2. The size of the last (or resultant) vector is the displacement of our trip (this is vector addition!), record this number as well.
3. Use this same method to find the distance and displacement of a trip that goes from LA to Denver to Seattle.
4. For this trip record the components of each part of the trip. You will add all east directions and subtract all west directions to get one number. You will add all north directions and subtract all south direction to get a second number. Plug these two numbers into the Pythagorean theorem. Does this number match the distance or displacement of your trip?
5. Now create your own trip in the US using at least 4 total vectors! Record the cities you are stopping in, the distance of each vector and the total distance of the trip and the total displacement.

Playing and editing the code for science!

Now we want to show you the reason it is useful to have to code along side the simulator. It turns out green is the easiest color detected by the human eye. As such I think it would be best to change the color of the scale vector from red to green. With normal simulations this would not be possible, but with ours it is!

In the following section be very careful with what you press on the keyboard. If your cursor is in the code section and something get added or deleted the simulation might no longer work. If this does happen just reload the simulation from the link.

1. Click on the code section of the simulation so that your cursor is inside the text. Now press control+f to open up the search box. Search for the word "red." It turns out that you will find every time the three letters "red" appear unless you click the "\b" button in the search window. This limits the search to only whole words.
2. The first instance "red" appears (as a whole word) should be written on line 173 hidden in the middle of the line with something that says: "color = color.red". If we change just the word red to green to get "color = color.green" and hit run again this will change the color of the calibration vector to green.
3. This is the only instance of red in the code so once we change red to green there will be no other things to find with the name "red."
4. So let us switch to black. Search for the whole word "black." This word occurs much more on several different lines. Change each of these words on each of the following lines, 42, 45, and 50, to one of the following colors: orange, yellow, and blue.
- 5. Record what changes.**
6. If you continue to search for the word "black" it will occur twice on the same line, line 161. The first occurrence on this line should appear in black text, the second occurrence should be in green text. Start by changing the green "black" to a green "red" and hit run.
- 7. Did you notice any changes in the simulation?**
8. Next change the black text "black" on line 161 to "red", and hit run.
- 9. What changed this time?**
10. Use what is discussed in the text and what changed to help determine the different roles the black and green text have in the code.
11. In the starting message (after you hit run) in the white box, you find the phrase "calibration stick length." Change the word "stick" to the word "vector." Verify this by showing me the changes to the simulation.
- 12. Why do you think the text where "stick" is found is mostly red?**
13. In the wall of red text, there are pink/purplish parts that are either "\n" or "\n\n" Using the context of where these appear in the code, and what appears in the white box, figure out what these symbols do.

Off to explore new land (or maps)!

While everything we have done up till now has been very useful. The true power of this simulator is the ability to work with almost any map! To get a new map into the simulator the map first need to be an image hosted on a web site. We have found that images hosted on the web site www.imgur.com work best. We will attempt to upload our own map later, but for now let us upload a map that is ready to go!

At the top of the simulator window is website/hyperlink listed in a box. This website is where the current map is located. To get the new map, first click the "Load a new map" button again, then click inside this box. You will then delete the text up till the first forward slash turning

<http://i.imgur.com/z1YPbWo.png> to <http://i.imgur.com/>

We will then replace the section we deleted with a new portion to finally get

<http://i.imgur.com/D6rrPjI.png>

IMPORTANT NOTES: The last letter in the new map web address is a capitol i

The num pad will not work to enter numbers anywhere in this program!

If successful, a new map should appear with a new warning message about this map not being calibrated.

First we need to fix the resolution of the image. The resolution for the new map is 1273 x 964 put these numbers into the Image resolution boxes. You do not need to hit delete to remove the previous number in these boxes, just select the box, type the new number and hit enter. If successful, the image should change size on the screen.

We need to calibrate the map so it knows what distances and directions the map displays.

The instructions in the white box tell you how to handle this!

Once we have the calibration vector drawn we change the calibration stick length number to 500 and the units to ft (feet).

With this done we can check to see if we are successful, what is the distance of Kimball ave between Bryn Mawr and Foster?

If you get something around 2560 ft (roughly) then you are good to go!

EXIT SLIP

What are the two pieces of information that are used to describe a vector?



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