Vectors

**Unit:** Vectors

### Knowledge/Understanding Goals:

* what a vector is

### Skills:

* adding & subtracting vectors

### Language Objectives:

* Understand and correctly use the terms “vector,” “scalar,” and “magnitude.”
* Accurately describe and apply the concepts described in this section using appropriate academic language.

### Notes: (Definitions and general notes)

vector: a quantity that has both a magnitude (value) and a direction.

scalar: a quantity that has a value but does not have a direction. (A scalar is what you think of as a “regular” number, including its unit.)

magnitude: the scalar part of a vector (*i.e.,* the number and its units, but without the direction). If you have a force of 25 N to the east, the magnitude of the force is 25 N.

The mathematical operation of taking the magnitude of a vector is represented by two double vertical bars (like double absolute value bars) around the vector. For example, if  is 25 N to the east, then 

resultant: a vector that results from a mathematical operation (such as the addition of two vectors).

unit vector: a vector that has a magnitude of 1.

Unit vectors are typeset as vectors, but with a “hat” instead of an arrow.

The purpose of a unit vector is to turn a scalar into a vector without changing its magnitude (value). For example, if *d* represents the scalar quantity 25 cm, and [[1]](#footnote-1) represents a unit vector pointing southward, then  would represent a vector of 25 cm to the south.

The letters  and  are often used to represent unit vectors along the *x,* *y,* and *z* axes, respectively.

Variables that represent vectors are traditionally typeset in ***bold Italics***. Vector variables may also optionally have an arrow above the letter:



Variables that represent scalars are traditionally typeset in *plain Italics:*

*V, t, λ*

Note that a variable that represents only the magnitude of a vector quantity is generally typeset as a scalar:

For example,  is a vector representing a force of 25 N to the east. (Notice that the vector includes the magnitude or amount ***and*** the direction.) The magnitude would be 25 N, and would be represented by the variable *F*.

Vectors are represented graphically using arrows. The length of the arrow represents the magnitude of the vector, and the direction of the arrow represents the direction of the vector:

|  |  |  |
| --- | --- | --- |
|  |  |  |
| magnitude 10 direction: 0° (to the right) | magnitude 15 direction: +180° (to the left) | magnitude 7 direction: +90° (up) |

Vectors

Definition:

Examples:

Scalars

Definition:

Examples:

This is how you draw a vector…

**Direction of Vectors**

Vector direction is the direction of the arrow, given by an angle.

**Vector angle ranges**

What quadrant is the angle of Vector **B in**?

**B**

What would be the exact angle, and how would you determine it?

**Magnitude of Vectors**

The best way to determine the magnitude of a vector is to measure its length.

The length of the vector is proportional to the magnitude (or size) of the quantity it represents.

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**Equal Vectors**

Equal vectors have the same length and direction, and represent the same quantity (such as force or velocity).

Draw several equal vectors.

**Inverse Vectors**

Inverse vectors have the same length, but opposite direction.

Draw a set of inverse vectors.

**Right Triangles**

Draw a right triangle, designating the opposite, adjacent, and hypotenuse.

State the Pythagorean Theorem.

List the trig functions you need for Physics 1

List the inverse trig functions you need.

**2. Sample problem**

A surveyor stands on a riverbank directly across the river from a tree on the opposite bank. She then walks 100 m downstream, and determines that the angle from her new position to the tree on the opposite bank is 50o. How wide is the river, and how far is she from the tree in her new location?

**3. Sample problem**

You are standing erect at the very top of a tower and notice that in order to see a manhole cover on the ground 50 meters from the base of the tower, you must look down at an angle 75o below the horizontal. If you are 1.80 m tall, how high is the tower?

**Vectors: x-component**

How do you determine the x-component of a vector?

**Vectors: y-component**

How do you determine the y-component of a vector?

**Vectors: angle**

How do you determine the angle a vector makes with the x-axis?

**Vectors: magnitude**

How do you determine the magnitude of a vector?

**4. Sample Problem**

You are driving up a long inclined road. After 1.5 miles you notice that signs along the roadside indicate that your elevation has increased by 520 feet.

a) What is the angle of the road above the horizontal?

b) How far do you have to drive to gain an additional 150 feet of elevation?

**5. Sample Problem**

Find the x- and y-components of the following vectors

**R** = 175 meters @ 95o

**v** = 25 m/s @ -78o

**a** = 2.23 m/s2 @ 150o

**Graphical Addition of Vectors**

1. Add vectors **A** and **B** graphically by drawing them together in a head to tail arrangement.
2. Draw vector **A** first, and then draw vector **B** such that its tail is on the head of vector **A**.
3. Then draw the sum, or resultant vector, by drawing a vector from the tail of **A** to the head of **B**.
4. Measure the magnitude and direction of the resultant vector.

**Practice Graphical Addition**

**The Resultant and the Equilibrant**

Definition of Resultant:

Definition of Equilibrant:

**Graphical Subtraction of Vectors**

1. Subtract vectors **A** and **B** graphically by adding vector **A** with the inverse of vector **B** (**-B**).
2. First draw vector **A**, then draw **-B** such that its tail is on the head of vector **A**.
3. The difference is the vector drawn from the tail of vector **A** to the head of -**B**.

**Practice Graphical Subtraction**

**6. Sample Problem**

Vector **A** points in the +x direction and has a magnitude of 75 m. Vector **B** has a magnitude of 30 m and has a direction of 30o relative to the x axis. Vector **C** has a magnitude of 50 m and points in a direction of -60o relative to the x axis.

1. Find **A** + **B** graphically.

Find **A** + **B** + **C** graphically.

c) Fnd **A** – **B** graphically.

**Component Addition of Vectors**

1. Resolve each vector into its x- and y-components.

Ax = Acosθ Ay = Asinθ

Bx = Bcosθ By = Bsinθ

Cx = Ccosθ Cy = Csinθ

2. Add the x-components (Ax, Bx, etc.) together to get Rx and the y-components (Ay, By, etc.) to get Ry.

3. Calculate the magnitude of the resultant with the Pythagorean Theorem (R = √Rx2 + Ry2).

4. Determine the angle with the equation θ = tan-1 Ry/Rx.

**7. Sample Problem**

In a daily prowl through the neighborhood, a cat makes a displacement of 120 m due north, followed by a displacement of 72 m due west. Find the magnitude and displacement required if the cat is to return home. Do this by the component method.

**8. Sample Problem**

If the cat in the previous problem takes 45 minutes to complete the first displacement and 17 minutes to complete the second displacement, what is the magnitude and direction of its average velocity during this 62-minute period of time? Do this by the component method.

1.  is pronounced “n hat” [↑](#footnote-ref-1)