Name: _____ Period:_____ Date: _____

Lab: Distance vs Displacement

Mr. Fineman

Purpose:

Vectors can be a very dry topic filled with trigonometry and the Pythagorean Theorem. While vectors are one of the most-used tools utilized in Physics, I want to ensure that you have a greater interest in understanding them outside of discussing them in relationship to problems. After all – Physics is a science set in the real world, so why shouldn't the real world be brought into Physics?

Objective:

In order to teach the difference between distance (a scalar quantity – just a number) and displacement (a vector quantity with magnitude and direction), we are going to look at a map of Verona and discover the subtle differences between these two concepts.

Materials:

- One Laminated 24" x 36" Street Map of Verona.
- One Ruler with Inch markings.
- One Protractor.
- One Whiteboard Marker.
- Calculator (student-provided)

Introductory Questions:

Before you lies a map of Verona, which was created in 2003. A 24" x 36" map is one of the standard plan sizes used by architects. All maps and drawings used by engineers and architects are drawn to a specific scale, such that a large distance on a drawing is represented by a common measuring unit.

1. What is the scale of this drawing? _____

Kenwood Avenue measures a distance of 2.5" from Fairview Avenue to Grove Street.

2. Knowing the scale of the map, how long is Kenwood Avenue in reality? *(Show your work)*

3. How long is Kenwood Avenue when measured in miles? *(Show your work)*

For large maps such as the one on your table, row and column markers are used for quick reference to spots in the map. For example, Pompton Avenue can be found at section K-7.

4. Using the row and column markers, where is VHS located? _____

5. Describe the symbol that is used to represent **schools** on this map.

6. Describe the symbols that are used to represent **houses of worship** (churches, synagogues) on this map.

7. Describe the symbol that is used to represent **municipal buildings** on this map.

8. Look at Sampson Drive on the map. How does Sampson Drive appear on the map?

    a. Since Mr. Fineman is not from the area, he's not entirely sure why Sampson Drive appears this way. However, what could you infer about Sampson Drive during the time this map was created in 2003?

Procedure:

Note: Technically, the map is not oriented so that up is north – the drawing has been rotated for readability (a common practice done by engineers and architects). You **do not** need to rotate your distance vectors to compensate for this. **IGNORE THE COMPASS. DO NOT USE IT.**

1. Locate VHS on your map. Like a graph in math class, treat VHS as the origin of your coordinates.
    a. Everything **North** of VHS is **positive** in the y-direction.
    b. Everything **South** of VHS is **negative** in the y-direction.
    c. Everything **East** of VHS is **positive** in the x-direction.
    d. Everything **West** of VHS is **negative** in the y-direction.

ROUTE 1: Displacement To Your / Lab Partner' Homes

2. Find the location of ***your house*** on the map. Mark its location using the whiteboard marker.

3. From the y-axis, measure the horizontal distance you must travel to get to your house. Write this distance down in the table in **DATA** under "MEASURED Horizontal Distance from VHS to House (Inches)".

    a. Using the scale on the map as your conversion factor, convert this measurement in inches into feet. Write this distance down in the table in **DATA** under "CALCULATED Horizontal Distance from VHS to House (Feet)".

4. From the x-axis, measure the vertical distance you must travel to get to your house. Write this distance down in the table in **DATA** under "MEASURED Vertical Distance from VHS to House (Inches)".

    a. Using the scale on the map as your conversion factor, convert this measurement in inches into feet. Write this distance down in the table in **DATA** under "CALCULATED Vertical Distance from VHS to House (Feet)".

5. Using your ruler, measure the "As-The-Crow-Flies" displacement from VHS to your house. Write this displacement down in the table in **DATA** under "MEASURED Displacement from VHS to house (Inches)".

6. **Using the Pythagorean Theorem**, use what we have been doing in class, as well as the information you have collected, to calculate your displacement when traveling from VHS to your house. Write this displacement down in the table in **DATA** under "CALCULATED Displacement from VHS to house (Feet)".

7. Using a protractor, measure the angle your displacement vector creates relative to the *positive X-axis*. Write this angle down in the table in **DATA** under "MEASURED Angle of Displacement from VHS to house (Degrees)".
    NOTE: Remember the convention used in Math class. It is ok to have angles over 180^{o}.

8. Lastly, using the trigonometric identities that we have been learning in class, calculate the angle your displacement vector creates relative to the *positive X-axis*. Write this angle down in the table in **DATA** under "CALCULATED Angle of Displacement from VHS to house (Degrees)".

ROUTE 2: Detour To Your / Lab Partner' Homes

1. Imagine in scenario that you need to go to your friend's house after school before you can head home for the day.

2. Using the lab partner's data to your **right** from the "**ROUTE 1**" section, find their MEASURED and CALCULATED horizontal and vertical distances and fill them in the appropriate boxes in the **DATA** section.

3. Measure the horizontal distance you must travel to get from your lab partner's house to your house. Write this distance down in the table in **DATA** under "MEASURED Horizontal Distance from Lab Partner's House to Your House (Inches)".

    a. Be sure to convert this number into feet, just as you did in "**Route 1**"

4. Measure the vertical distance you must travel to get from your lab partner's house to your house. Write this distance down in the table in **DATA** under "MEASURED Vertical Distance from Lab Partner's House to Your House (Inches)".

    a. Be sure to convert this number into feet, just as you did in "**Route 1**"

5. Using vector addition, calculate the overall horizontal distance travelled, and place this information in the appropriate box.

6. Using vector addition, calculate the overall horizontal distance travelled, and place this information in the appropriate box.

7. **Using the Pythagorean Theorem**, use what we have been doing in class, as well as the information you have collected, to calculate your overall displacement for this route.

8. **Using the trigonometric identities** that we have been learning in class, calculate the angle your displacement vector creates relative to the *positive X-axis*. Write this angle down in the appropriate box.

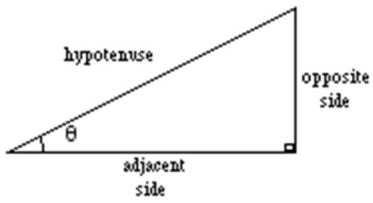
9. Repeat steps 1 – 8 now imagining you are visiting the lab partner to your **left**'s house.

Data:

SOH $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$

CAH $\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$

TOA $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$



$a^2 + b^2 = c^2$

x-component = hyp. x cos θ

y-component = hyp. x sin θ

Route 1: Displacement to Your / Lab Partners' Homes				
Lab Partner's Name	**MEASURED Horizontal Distance from VHS to house (Inches)**	**CALCULATED Horizontal Distance from VHS to house (Feet)**	**MEASURED Vertical Distance from VHS to house (Inches)**	**CALCULATED Vertical Distance from VHS to house (Feet)**
You				
Lab Partner's Name	**MEASURED Displacement from VHS to house (Inches)**	**CALCULATED** *(Using Pythagorean Theorem)* **Displacement from VHS to house (Feet)**	**MEASURED Angle of Displacement (from Positive X-Axis) from VHS to house (Degrees)**	**CALCULATED** *(Using Trigonometric Identities)* **Angle of Displacement (from Positive X-Axis) from VHS to house (Degrees)**
You				

Route 2: Detour to Your / Lab Partners' Homes				
Lab Partner's Name	**MEASURED Horizontal Distance from VHS to Lab Partner's House (Inches)**	**CALCULATED Horizontal Distance from VHS to Lab Partner's House (Feet)**	**MEASURED Vertical Distance from VHS to Lab Partner's House (Inches)**	**CALCULATED Vertical Distance from VHS to Lab Partner's House (Feet)**
(Lab Partner to your Left)				
(Lab Partner to your Right)				
Lab Partner's Name	**MEASURED Horizontal Distance from Lab Partner's House to Your House (Inches)**	**CALCULATED Horizontal Distance from Lab Partner's House to Your House (Feet)**	**MEASURED Vertical Distance from Lab Partner's House to Your House (Inches)**	**CALCULATED Vertical Distance from Lab Partner's House to Your House (Feet)**
(Lab Partner to your Left)				
(Lab Partner to your Right)				
Lab Partner's Name	**CALCULATED Overall Horizontal Distance Traveled (Feet)**	**CALCULATED Overall Vertical Distance Traveled (Feet)**	**CALCULATED** *(Using Pythagorean Theorem)* **Overall Displacement (Degrees)**	**CALCULATED** *(Using Trigonometric Identities)* **Angle of Overall Displacement (Degrees)**
(Lab Partner to your Left)				
(Lab Partner to your Right)				

Analysis and Conclusions:

What did you notice about your overall displacement and direction in both routes home? Why did this happen? _____
_____
_____
_____
_____

Engineers and architects frequently add a scale to their drawings for the sake of the reader. Why would this lab have been challenging if no scale were placed on the map?_____
_____
_____
_____
_____

If the engineers and architects that created this drawing did not note the scale of this drawing on the side, how could you have determined the scale of this drawing?_____
_____
_____
_____
_____
_____
_____

When you get driving directions from Google Map (or other equivalent method), do they tell the displacement to your destination or the distance to your destination? Explain how you know for certain. _____
_____
_____
_____