

**Equipment needed:**

small battery driven car	1.5-2.0m length of paper	
markers/pens	stopwatch	masking tape
meter stick	open floor space	

**General Procedure.....**

Be sure to record the description of your car and fill in the preliminary information in the analysis sections.

In these activities, the car will serve as the boat, the paper will serve as the river water, and the floor will serve as the dry ground or shore.

When it becomes necessary for the river to "flow", pick one person from the group to be the river engineer. This person needs to practice slowly and smoothly pulling the river straight along the floor. We will always make our river flow south. You must work together as a group to coordinate data collection, so stay alert!

You will be asked to measure the distance traveled and the time traveled for various scenarios of boat and river motion. From this information you will deal with the concepts of distance, displacement, speed, and velocity. Your objective is to relate these quantities to one another, (re)discover how to add vectors, and become familiar with relative velocity.

**General Directions for Each Activity.....**

- Your "boat" will start with all wheels on the paper.
- Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.
- DO NOT use markers or pens to mark the floor--instead use small pieces of tape.
- Record the distances and displacements.
- Clearly construct the displacement vector diagram. Use an appropriate scale to fill the provided space and clearly represent the vector lengths. Label the vectors  $d_{BW}$ ,  $d_{WG}$ ,  $d_{BG}$ , where B=boat, W=water, G=ground or shore.
- Summarize your findings and your insights.

When you are finished with the displacement analysis, move on to the analysis concerning speed and velocity.

Of course, answer all questions.

PRELAB:

1a. You will be using the "boat", "river", and "shore" to create and measure four different scenarios. Read through them below so you know what the scenarios specifically involve....

**PART I--still waters**

In this activity the river water is still. Have your boat travel south on the still paper for 5.0 seconds. Make three consistent trials and report the average value. Carefully mark where the car begins and ends the trip according to both the paper AND the floor.

**PART II--going with the flow**

In this activity the river water is moving slowly southward. Have your boat travel south on the moving paper for 5.0 seconds. Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.

**PART III--up the creek**

In this activity the river water is moving slowly southward. Have your boat travel north on the moving paper for 5.0 seconds. Pull the paper slower than the boat can travel along the paper. Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.

**PART IV--carried away**

In this activity the river water is moving very quickly southward. Have your boat travel north on the moving paper for 5.0 seconds. Pull the paper faster than the boat can travel along the paper. Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.

1b. You will measure three distances in every scenario: the distance the car travels relative to the paper, the distance the paper travels relative to the floor, and the distance the car travels relative to the floor. Of these three distances, is there one that should always come out the same, regardless of the scenario? Why?

2. Read pages 64-66 in your text Physics Principles and Problems. Work problems 19 on page 78. A vector addition diagrams is required for this problem. Be sure to scale all of your vectors and label them in the diagram.

3. Work problems 20 on page 78. A vector addition diagrams is required for this problem. Be sure to scale all of your vectors and label them in the diagram.

4. Work problems 21 on page 78. A vector addition diagrams is required for this problem. Be sure to scale all of your vectors and label them in the diagram.

one dimensional motion  
***DISPLACEMENT ANALYSIS***

my name \_\_\_\_\_

my partners' names \_\_\_\_\_ , \_\_\_\_\_

**preliminary information.....**

Description of car, including any identifying number or letter:

Instead of "positive" and "negative", direction will be indicated by \_\_\_\_\_ and \_\_\_\_\_ in this series of activities.

definitions & characteristics:

- Distance is
  
  
  
- Displacement is

**PART I--still waters**

In this activity the river water is still. Have your boat travel south on the still paper for 5.0 seconds. Make three consistent trials and report the average value. Carefully mark where the car begins and ends the trip according to both the paper AND the floor.

Boat's distance traveled relative to water in 3.00 seconds = _____cm	Boat's displacement relative to water in 3.00 seconds = $d_{BW}$ = _____cm South
Boat's distance traveled relative to shore in 3.00 seconds = _____cm	Boat's displacement relative to shore in 3.00 seconds = $d_{BS}$ = _____cm South
Water's distance traveled relative to shore in 3.00 seconds = _____cm	Water's displacement relative to shore in 3.00 seconds = $d_{WS}$ = _____cm

SCALED DISPLACEMENT VECTOR DIAGRAM:

short summary of findings so far:

**PART II--going with the flow**

In this activity the river water is moving slowly southward. Have your boat travel south on the moving paper for 5.0 seconds. Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.

Boat's distance traveled relative to water in 3.00 seconds = _____cm	Boat's displacement relative to water in 3.00 seconds = $d_{BW}$ = _____cm South
Boat's distance traveled relative to shore in 3.00 seconds = _____cm	Boat's displacement relative to shore in 3.00 seconds = $d_{BS}$ = _____cm South
Water's distance traveled relative to shore in 3.00 seconds = _____cm	Water's displacement relative to shore in 3.00 seconds = $d_{WS}$ = _____cm South

SCALED DISPLACEMENT VECTOR DIAGRAM:

short summary of findings so far:

**PART III--up the creek**

In this activity the river water is moving slowly southward. Have your boat travel north on the moving paper for 5.0 seconds. Pull the paper slower than the boat can travel along the paper. Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.

Boat's distance traveled relative to water in 3.00 seconds = _____cm	Boat's displacement relative to water in 3.00 seconds = $d_{BW}$ = _____cm North
Boat's distance traveled relative to shore in 3.00 seconds = _____cm	Boat's displacement relative to shore in 3.00 seconds = $d_{BS}$ = _____cm _____
Water's distance traveled relative to shore in 3.00 seconds = _____cm	Water's displacement relative to shore in 3.00 seconds $d_{WS}$ = _____cm South

SCALED DISPLACEMENT VECTOR DIAGRAM:

short summary of findings so far:

**PART IV--carried away**

In this activity the river water is moving very quickly southward. Have your boat travel north on the moving paper for 5.0 seconds. Pull the paper faster than the boat can travel along the paper. Carefully mark where the car begins and ends the trip according to both the paper AND the floor. Carefully mark where the paper begins and ends the trip according to the floor.

Boat's distance traveled relative to water in 3.00 seconds = _____cm	Boat's displacement relative to water in 3.00 seconds = $d_{BW}$ = _____cm _____
Boat's distance traveled relative to shore in 3.00 seconds = _____cm	Boat's displacement relative to shore in 3.00 seconds = $d_{BS}$ = _____cm _____
Water's distance traveled relative to shore in 3.00 seconds = _____cm	Water's displacement relative to shore in 3.00 seconds = $d_{WS}$ = _____cm _____

SCALED DISPLACEMENT VECTOR DIAGRAM:

short summary of findings so far:

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Overall conclusion about finding relative displacements:

# VELOCITY ANALYSIS

my name \_\_\_\_\_

my partners' names \_\_\_\_\_ , \_\_\_\_\_

**preliminary information.....**

- Speed is
  
- Velocity is
  
- Average speed is determined by
  
- Average velocity is determined by

\*\*Show your calculations of speed and velocity and then the results in the blanks provided. Don't forget to include direction where appropriate.\*\*

**PART I--still waters**

Boat's speed relative to water = _____ = _____ cm/s	Boat's velocity relative to water $v_{BW}$ = _____ = _____ cm/s _____
Boat's speed relative to shore = _____ = _____ cm/s	Boat's velocity relative to shore $v_{BS}$ = _____ = _____ cm/s _____
Water's speed relative to shore = _____ = _____ cm/s	Water's velocity relative to shore $v_{WS}$ = _____ = _____ cm/s

SCALED VELOCITY VECTOR DIAGRAM:

short summary of findings so far:

**PART II--going with the flow**

Boat's speed relative to water = _____ = _____ cm/s	Boat's velocity relative to water $v_{BW}$ = _____ = _____ cm/s _____
Boat's speed relative to shore = _____ = _____ cm/s	Boat's velocity relative to shore $v_{BS}$ = _____ = _____ cm/s _____
Water's speed relative to shore = _____ = _____ cm/s	Water's velocity relative to shore $v_{WS}$ = _____ = _____ cm/s _____

SCALED VELOCITY VECTOR DIAGRAM:

short summary of findings so far:

**PART III--up the creek**

Boat's speed relative to water = _____ = _____ cm/s	Boat's velocity relative to water $v_{BW}$ = _____ = _____ cm/s _____
Boat's speed relative to shore = _____ = _____ cm/s	Boat's velocity relative to shore $v_{BS}$ = _____ = _____ cm/s _____
Water's speed relative to shore = _____ = _____ cm/s	Water's velocity relative to shore $v_{WS}$ = _____ = _____ cm/s _____

SCALED VELOCITY VECTOR DIAGRAM:

short summary of findings so far:

PART IV--carried away

Boat's speed relative to water = _____ = _____ cm/s	Boat's velocity relative to water $v_{BW}$ = _____ = _____ cm/s _____
Boat's speed relative to shore = _____ = _____ cm/s	Boat's velocity relative to shore $v_{BS}$ = _____ = _____ cm/s _____
Water's speed relative to shore = _____ = _____ cm/s	Water's velocity relative to shore $v_{WS}$ = _____ = _____ cm/s _____

SCALED VELOCITY VECTOR DIAGRAM:

short summary of findings so far:

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Overall conclusion about finding relative velocities:

**END-OF-LAB QUESTIONS TO ANSWER....**

1. Relative to the shoreline, does the boat always move in the direction in which it is pointing? Explain fully.
2. Did the boat move faster when the river was still or when the river was flowing? Explain fully--don't forget to discuss relative to the water and to the shore.
3. Which would have the greatest speed relative to the ground, a plane flying due north at full throttle in still air, an identical plane flying due north at full throttle in air moving due south, or an identical plane flying due north at full throttle in air moving due north? Explain fully.
4. Does it take longer for a particular plane to make a trip from city A to city B with a headwind or with a tailwind? Explain fully. (look up headwind and tailwind if you do not know their meanings)