Riverboat Simulation Activity

Purpose:

The purpose of this activity is to analyze the relationship between the two vector components of motion for a river boat as it travels across a river in the presence of a current.

Getting Ready

Navigate to the Riverboat Simulator page:

www.physicsclassroom.com => Physics Interactives => Vectors and Projectiles => Riverboat Simulator

http://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Riverboat-Simulator

Once at the page, begin exploring the use of the simulator. Learn how to modify the **Boat Speed** and **Heading**, the **River Width**, and the **River Speed**. Experiment with the **Play** and **Pause** and **Reset** buttons. Finally, reset the **Heading** to **Due East** and complete the **Procedure and Questions** section below.

Procedure and Questions:

1. Will a change in **River Speed** change the time required for a boat to cross a 100-m wide river? _________ In the space below, display some collected data that provide evidence for your claim. Use reasoning to show how the evidence lead logically to the claim.

2. For a constant **River Width** and a **Due East** boat **Heading**, what variable(s) effects the time required to cross a 100 m wide river? ___________________________ In the space below, display some collected data that provide evidence for your claim. Use reasoning to show how the evidence lead logically to the claim.

3. Suppose that a motor boat can provide a maximum speed of 10 m/s with respect to the water. What **Heading** will minimize the time for that boat to cross a 100-m wide river? ___________ In the space below, display some collected data that provide evidence for your claim. Use reasoning to show how the evidence lead logically to the claim.

4. Run the simulation with the following combinations of **Boat Speed** and **River Speed** values with a **Heading** of 0 degrees (Due East). Before running each simulation, perform quick calculations to determine the time required for the boat to reach the opposite bank (of a 100-meter wide river) and the distance that the boat will be carried downstream by the river current. Use the simulation to check your answer(s).

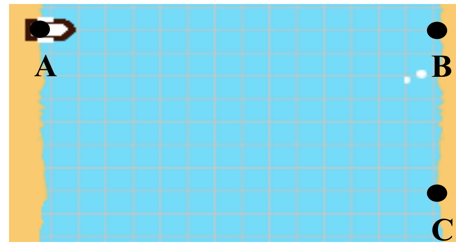
Boat Speed (m/s)	Current Speed (m/s)	Time to Cross River (s)	Distance Downstream (m)
12	2		
12	3		
12	4		
20	2		
20	5		

5. Study your results in the table above and answer the following two questions.
   - What feature in the table is capable of changing the time required for the boat to reach the opposite bank of a 100-meter wide river? ________________________ Explain.
   - What two quantities are needed to calculate the distance the boat travels downstream?

6. Use the distance-speed-time relationships to solve the following two problems.

   A waterfall is located 45.0 m downstream from where the boat is launched. The current speed is 3 m/s. What minimum boat speed is required to cross the 100-m wide river before falling over the falls? Show your calculations; use the simulation to check your prediction.

   Repeat the above calculations to determine the boat speed required to cross the 100-m wide river in time if the current speed was 5 m/s and the waterfall was located 45.0 m downstream. Again, check your predictions using the simulation.



For **Questions 7 and 8**: Consider a boat which begins at **point A** and heads straight across a 100-meter wide river with a speed of 8 m/s (relative to the water). The river water flows south at a speed of 3 m/s (relative to the shore). The boat reaches the opposite shore at **point C**.

7. Which of the following would cause the boat to reach the opposite shore in MORE time? Circle all that apply.
   a. The river is 80 meters wide. b. The river is 120 meters wide.
   c. The boat heads across the river at 6 m/s. d. The boat heads across the river at 10 m/s.
   e. The river flows south at 2 m/s. f. The river flows south at 4 m/s.
   g. Nonsense! None of these effect the time to cross the river.

8. Which of the following would cause the boat to reach the opposite shore at a location SOUTH of C? Circle all that apply.
   a. The boat heads across the river at 6 m/s. b. The boat heads across the river at 10 m/s.
   c. The river flows south at 2 m/s. d. The river flows south at 4 m/s.
   e. Nonsense! None of these effect the location where the boat lands.

9. Observe that the resultant velocity (v) is the vector sum of the boat velocity (v_x) and the river velocity (v_y). Use the principles of vector addition to determine the resultant velocity for each combination of boat/current velocities listed below. Use a sketch of the two vectors and the resultant accompanied by the use of the Pythagorean theorem and trigonometric functions to determine the magnitude and direction of the resultant.

Boat Velocity = 15 m/s, East Current Velocity = 4 m/s, South	Boat Velocity = 20 m/s, East Current Velocity = 5 m/s, South
$v_{resultant}$	$v_{resultant}$
Magnitude: ____________________ m/s	Magnitude: ____________________ m/s
Direction: _________________	Direction: _________________

10. For the two sets of boat and current velocities listed above, use the Pythagorean theorem to calculate the resultant displacement of the boat in order to cross the 190-meter wide river. Show your calculations for each case in the provided space.

Boat Velocity = 15 m/s, East	Boat Velocity = 20 m/s, East
River Velocity = 4 m/s, South	River Velocity = 5 m/s, South
d_{across} = 190 m	d_{across} = 190 m
$d_{downstream}$ = _______________	$d_{downstream}$ = _______________
$d_{resultant}$ = _______________	$d_{resultant}$ = _______________

Summary Statement:

It is often said that *perpendicular components of motion are independent of each other*. Explain the meaning of this statement and apply it to the motion of a river boat in the presence of a current.