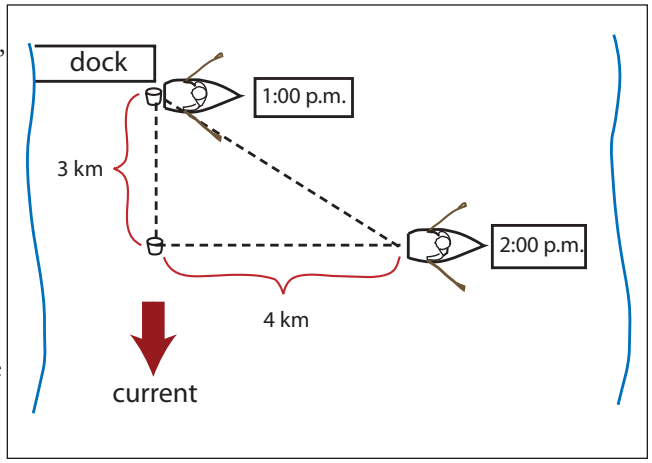
# The River Needs a Cork

*Guy Vandegrift,* Wright State University Lake Campus, Celina OH, 45822
guy.vandegrift@wright.edu

Since the Galilean transformation[1-3] does not involve the concept of force, the procedure for calculating relative velocity can serve as the first nontrivial physical application of vector addition and subtraction. The concept is also important because special relativity cannot be appreciated or even fully understood until the nonrelativistic velocity addition rule is made so transparent that it seems "obvious." Only then is the advanced student ready to discard the Galilean transformation as false!




A student and I were recently engaged in a bit of distance learning when I found myself searching the Internet for images that resemble what I usually draw on the board when introducing relative motion. The situation is familiar and often discussed in textbooks: A boat is crossing a river with a heading perpendicular to the current. I do not recall ever seeing a textbook that places a cork in the water to depict the motion of the current. Unable to find an adequate image on the web, I eventually discovered an article in *The Physics Teacher* that conveys a similar concept by sketching passengers on two escalators traveling in cross directions. (Fortunately it is not absolutely necessary to visit the mall where said escalators are likely to be found).[1] My embellishment of the standard textbook's figure of a boat crossing a river could serve as an introduction to the material introduced in this paper. And, it should be part of the introduction of the subject as found in most textbooks.

The figure depicts the situation at two different times by overlapping the positions of cork and boat at the two times. This also reinforces the concept of $\Delta t$ as a time interval: "Two o'clock minus one o'clock represents one hour." The dock serves to prompt the question: How far has the boat traveled in that hour?

Sometimes I like to make the odd assertion that the cork is where it is, at a given time, only because an observer sees it there. As the person rowing the boat looks at the cork, there is an extremely small time delay associated with the transit time of light. This "look-back-time" becomes significant if boat and current are traveling at speeds near that of light. It is no coincidence that this is where the Galilean velocity transformation breaks down.

## References

1. R. W. Robinett, "It's, like, relative motion at the mall," *Phys. Teach.* **41**, 140-142 (March 2003).
2. Dean Zollman, "A quantitative demonstration of relative velocities," *Phys. Teach.* **19**, 44 (Jan.1981).
3. Eli Maor, "Some applications of the Galilean transformation," *Phys. Teach.* **13**, 399–403 (Oct.1975).