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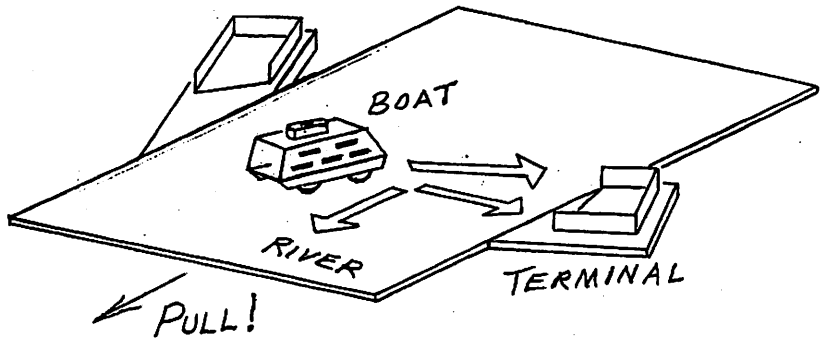
Vectors - velocities associated with river currents and boat travel (winds and aircraft travel?); also touches on frames of reference.

We still have boats plying our larger rivers. Until the interstate highway system was developed in the late 1950's, few of our wider rivers were spanned by bridges. Instead, they were crossed by ferry boats that had to contend with the currents. This series of demonstrations simulates the relative motion, i.e., the velocity vectors involved, among a boat, the river, and its shoreline; they are meant to enhance textbook discussions. And they can be entertaining. Like many good demos, it does require much first-time preparation; after that, little effort is needed. For real life examples, we in New York can imagine crossing our Hudson River on ferry boats before the bridges came; you should choose a river in your locale that had ferry boats on it. The diagram illustrates my set-up and the props used; alter as you see fit. I chose a modified, constant-speed, "physics" vehicle as my "ferry boat". However, any small, slow-moving, battery-powered toy vehicle might work as well. For the moving "river", I prefer to use a large, long-lasting sheet of 1/8" masonite (tempered); some people prefer to use heavy brown wrapping paper that can be rolled up for easy storage. The "terminals" on the shoreline can be parts of cut-down boxes, etc.; use your imagination. Remember, you need the terminals as <u>fixed</u> reference points; they must be fastened down. Can you perform this demo on a table(s), or must you use the floor? On a table top, the terminals might be clamped down rather than taped down. Cardboard vector "arrows" of different lengths that can be layed on the "river" to represent the various velocities involved might make the "picture" clearer for students. (I use wooden arrows.) This is a "Get out of your seats and gather around.", classroom demo, <u>not</u> for large lecture halls. Scale up or down to fit your situation.

Diagram:



Materials: "river" - 3' x 5' 1/8" masonite (tempered) sheet; heavy brown wrapping paper?
"ferry boat" - #10-103 Constant Speed Vehicle from The Science Source, Waldoboro, ME (www.thesciencesource.com)
"terminals" - made of wood and masonite; maybe the slips (docks) can be made from heavy cardboard?
vector "arrows" - cardboard or wood

Presentation: (a) With the "river" and "terminals" in place, aim the boat downstream. Lay the current vector arrow on the "river" and pull the "river" with the boat on it. What are the results relative to the river and to the terminals? With the boat's motor running and you pulling on the "river" (two vector arrows), note the final velocity of the boat relative to the terminals.

(b) Rotate the boat and its vector arrow 180° (upstream) and pull the "river" slowly; note the slow progress of the boat upstream. Now pull the "river" downstream at the same velocity as the boat's velocity upstream; the boat appears to stand still relative to the "terminals".

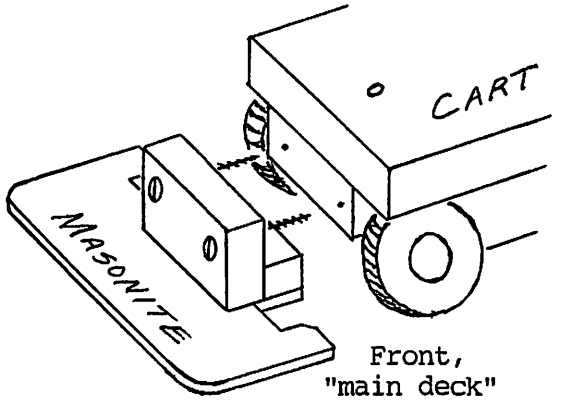
(c) With a vector arrow downstream and one directly across to a terminal (90°), aim the boat directly toward the terminal. Pull the "river" while the boat crosses. Where will the boat wind up?

(d) How must the captain of the boat compensate for the current's velocity? Where should he or she aim to reach the terminal correctly? Place vector arrows on the "river" to show the possible solution. Aim the boat in the direction of its vector arrow, and pull the "river" carefully (steadily). The result is that the boat is "crabbing" or appearing to move sideways (sideslipping) across the river from one terminal to the other. (This is natural for boats and airplanes everyday.)

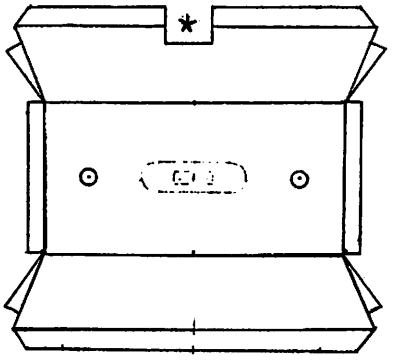
(e) Repeat this demo, with the boat returning to the original terminal. Do vectors make more sense now?

Storage: Never leave batteries in the motor when the "boat" is stored until next year. I store my "boat" in a labeled shoebox to keep it clean and dust-free. Also, put the vector arrows in the box, if possible.

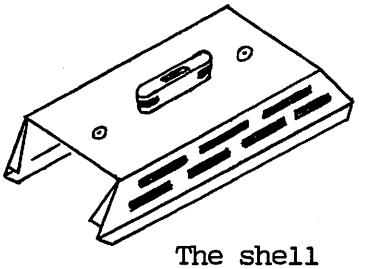
Plan for the modified, constant speed vehicle (ferry boat):



Front, "main deck" (bumper)



The flat, cardboard shell before bending it into shape.



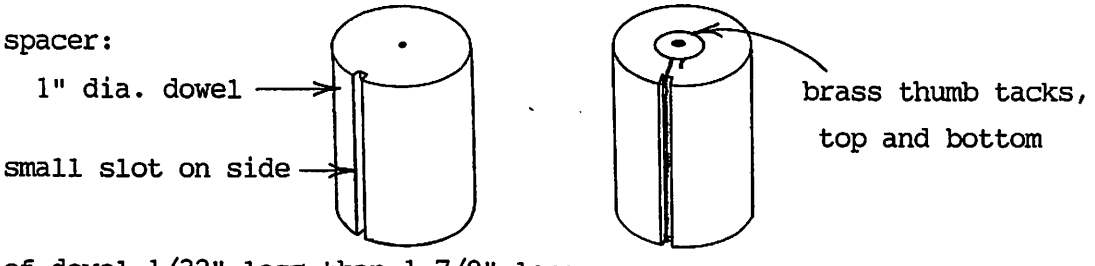
The shell fits over the cart.

* An opening is needed to reach the control lever.

Make and attach the masonite bumper with two screws.
Cut up small pieces of black, plastic tape for "windows", etc.
Attach the shell to the cart top with PH screws.

Addendum: You may find that the two C-cell batteries make the cart (ferry) go too fast for this demo. (I did!) Simply remove one battery and replace it with a battery spacer, either the one enclosed with the cart or a better one that you can simply make.

Plan for the battery spacer:



Cut off a length of dowel 1/32" less than 1 7/8" long.
Cut a small slot on the side of the dowel for the solid copper wire. (#22?)
Hammer a brass thumb tack partially into the center of one end of the dowel. Wrap an end of the solid copper wire twice around the tack's stem and hammer the tack all the way in.
Using the slot, run the wire down the side of the dowel to the other end and repeat the "thumb tack" procedure.
Nip off any excess wire. Your spacer should be very close to the same size as the battery it replaces.