Apparatus for Teaching Physics

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An Old Favorite: The Noncircular "Wheel"

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For many years, Prof. H.R. Crane of the University of Michigan wrote a wonderful series of notes for *The Physics Teacher* under the running title "How Things Work." I find myself going back regularly to them for inspiration and remembrance.

In the column for December 1991,[1] he presented a couple of counterintuitive mechanical devices, including three- and five-sided wheels and a plausible-appearing perpetual motion machine. I became intrigued with the wheels and ultimately built the three-sided one shown in Fig. 1.

Fig. 1. A board placed on top of this wheel may be pulled along without any vertical movement taking place.

A board placed on top of two of these wheels may be rolled sideways with no up and down motion. The key point is that "a side opposite an edge forms part of a circular cylinder whose axis is that edge. The edges are uniformly spaced, and all of the radii (edge to opposite surface) are the same."

Here is how I constructed the pattern for the three-sided wheel: Using a pair of compasses, draw a circle about 15 cm in diameter and with the compass at the same setting, divide the circumference into six parts. Now, using a setting about equal to the diameter of the circle, use alternate points on the circumference of the circle as a center to draw arcs. The result will be the pattern for the "wheel." Crane's wheels were solid and rather small; I built a larger pair of wheels and connected them with dowel "axles." The total construction time was about a half hour. The blanks were bandsawed out of ¾-in birch plywood and sanded to final shape with a disk sander.

The article also includes a discussion of the Roberval balance that is the basis for many commercial weighing machines. Again, I built one and can recommend it to readers of the journal. The theory of the balance has also been discussed by Chagnon.[2]

References

1. H.R. Crane, "Three intuition teasers," *Phys. Teach.* **29**, 593–594 (Dec. 1991).
2. Paul Chagnon, "The Roberval balance," *Phys. Teach.* **30**, 238 (April 1992).

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Editor's Note: It is instructive to place a mark at the center of mass of one of the plywood sides of the "wheel," so that those observing the demo can easily see that the center moves up and down as the "wheel" rolls. This immediately shows that this kind of wheel would not be useful (or at least not very comfortable for passengers) if it were mounted conventionally on, say, a car axle, as mentioned in Ref. 1. In addition, if the car engine were to turn the axle at constant angular velocity, and the "wheel" rolled without slipping, the forward velocity of the car would not be constant, but would be subject to alternating accelerations and decelerations. A passenger would need a strong stomach to avoid motion sickness!

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