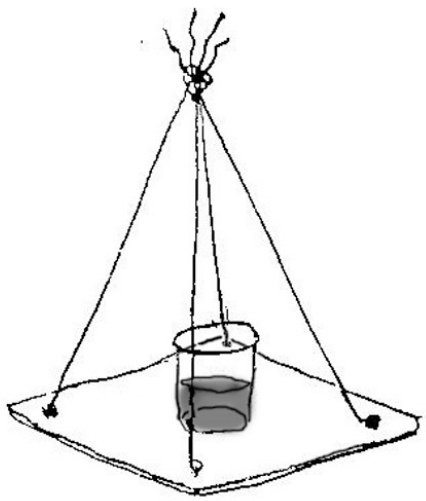
Whirling Bucket and Waiter's Tray

Put water in a plastic bucket until the water is 2 or 3 inches deep. Whirl the bucket in a vertical circle at arm's length, being sure to whirl fast enough so that the water doesn't fall out.

Put a clear plastic cup on a rigid platform (wood, plastic, etc.) suspended by three or four cords all tied in a common knot at their ends. (See drawing below.) Whirl the platform in a vertical circle in the same way as the bucket was whirled. At first this may seem harder to do than the bucket, but a little practice will make it a piece of cake (if you're hesitant to risk spilling water inside, go outside and try it until you gain confidence).



For a variation, try imitating the Orleans Orbit by starting out whirling the bucket or cup in a horizontal circle, making the transition to a vertical circle, and then ending with a horizontal circle again.

•••••••••••••••••••

To move in a circle, a roller coaster car must be acted upon by a centrípetal force -- that is, a net unbalanced force directed toward the center of the circle.

The **size** of the **required** centrípetal force is determined by the mass and velocity of the car, and the radius of the circle.

If the car is at the top of a vertical loop, the centrípetal force is **provided** partly by the **tracks**, and partly by **gravity** (the car's weight).

If the centrípetal force **provided** is **greater** than the centrípetal force **required** to keep it in the circle, then the car will fall downward off the tracks (unless there are restraining wheels -- called "upstop" wheels -- to prevent this).

The same situation holds for the rider in the car, with the' safety bar or hamess serving the same function for the rider as the upstop wheels do, for the car. The slower the car goes around the top of the loop, the smaller the centrípetal force required to keep it in the circle, and the less force the tracks have to supply. If the car goes so slowly around the top of the loop that the centrípetal force required to keep it in the circle is actually less than its own weight, then the tracks will not supply any centrípetal force, and the centrípetal force supplied by its weight will cause it to fall off the tracks, in the absence of upstop wheels.

In the same way, if the bucket of water is whirled too slowly at the top of the circle, the water will fall out, and if the waiter's tray is whirled too slowly, the cup and water will fall off.

In the case of the horizontal circle with the waiter's tray, the only centripetal force on the cup and water is provided by the tray, since gravity acts downward and not toward the center of the circle. The upward-directed friction force between the cup and the tray depends on the centripetal force against the bottom of the cup. If the tray whirls too slowly, the friction force between the cup and the tray will become less than the weight of the cup and water, and the cup will slide downward off the tray.

Don Rathjen....Exploratorium Teacher Institute....3601 Lyon St., San Francisco, CA 94123...donr@exploratorium.edu

Don Rathjen....Exploratorium Teacher Institute....3601 Lyon St., San Francisco, CA 94123...donr@exploratorium.edu