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The SpillNot

PHY-300

How the SpillNot works:

When you hold a cup of juice while walking, the juice tends to spill because the cup accelerates forward (**ax**, see the green arrow in FIG.1 below) and backward (**-ax**) with each step. The juice tips in response to that acceleration, and may spill over the rim of the cup.

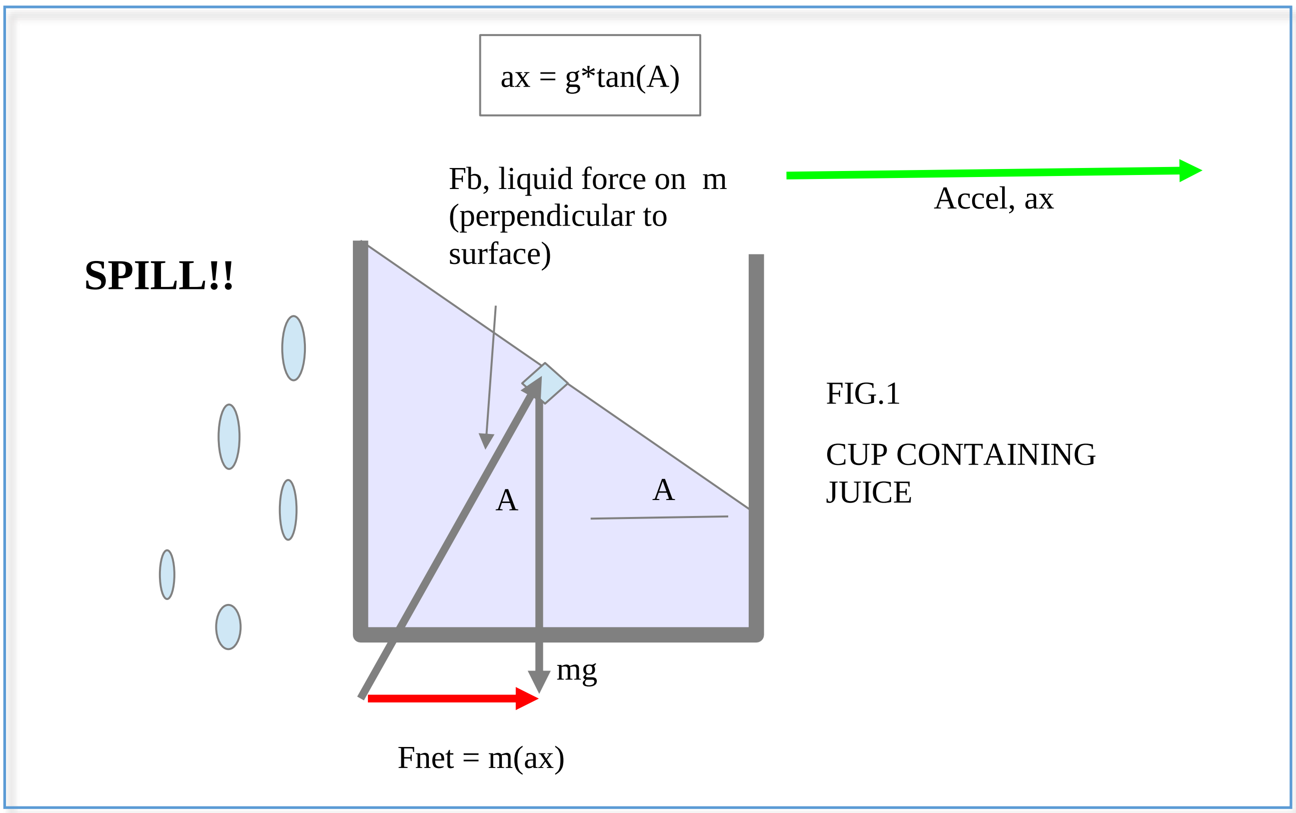

FIG.1

CUP CONTAINING JUICE

By contrast, the SpillNot automatically tips the cup so that its top stays parallel to the juice surface (see FIG.2 on the next page). For example, if the juice surface tips to 30 degrees but the cup stays horizontal, the juice could spill. But if the cup also tips to 30 degrees, we get no spill!

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Note that there are only two forces on each portion m of juice: the weight mg down, and the buoyancy force Fb of the juice pushing at a right angle to the surface. These two forces result in a horizontal accelerating force ma (in red).

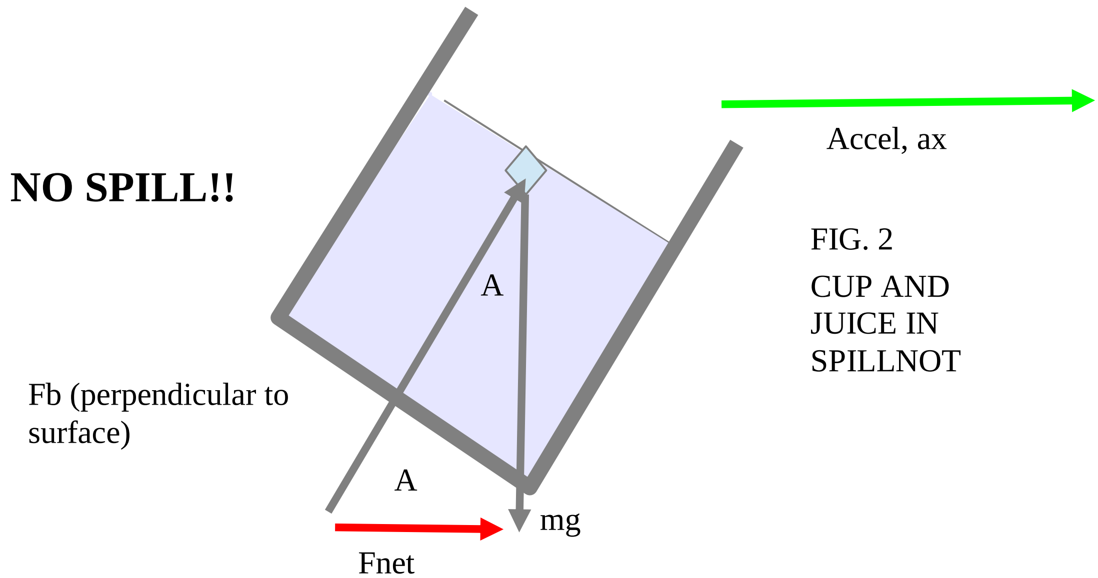
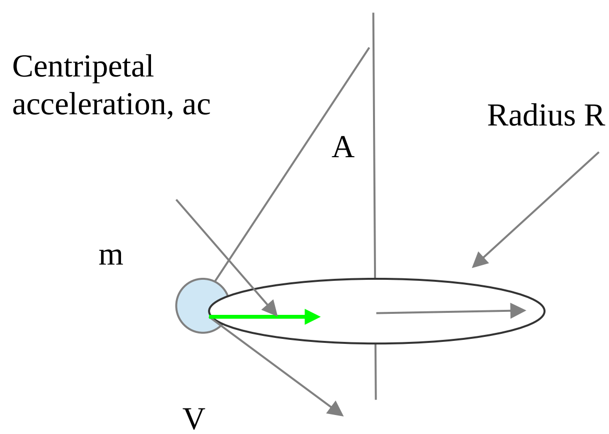


FIG. 2
CUP AND JUICE IN SPILLNOT

Experiment 1
Build a circular carnival ride

Hang the SpillNot on a string about 0.50 m long. Place a lump of molding clay on the pan—this will be your "rider." Swing the SpillNot around in front of you in a horizontal circle of about 0.20 m radius. With a smartphone, take a photo so angle A shows in its true size (see diag. below). From the photo, measure the angle A with a protractor. The forces on the rider are similar to those on a mass m of juice in FIG.2 above, and you can calculate the centripetal acceleration ac (ax) of the SpillNot "carnival rider" from ac = g*tan(A).

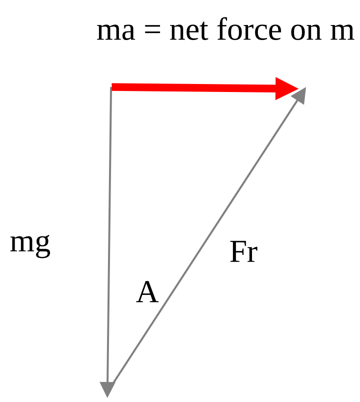
A = _____ degrees **ac = g*tan(A) = __________ m/s^2**

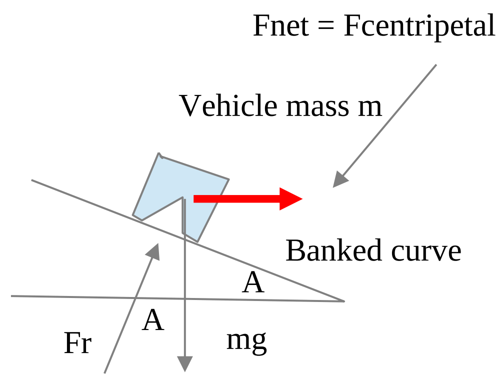


Experiment 2
Build a banked racetrack

Road curves may be banked for safety, so that at a certain speed no friction between tire and roadway is needed to prevent sliding up or down the bank. At this speed the force of the road Fr is at a right angle to the road surface. The SpillNot illustrates banking of curves to keep vehicles from sliding, because it "banks" at the correct angle A. The SpillNot, banked road turns, and banked airplane turns all obey a similar acceleration equation.
*NOTE: Refer to Experiment 1 (on page 2) for the experimental technique to find angle A. This time, use a radius of about 0.30 m; then calculate ax = g*tan(A).*

A =_____ degrees   ax = g*tan(A) = __________ m/s^2



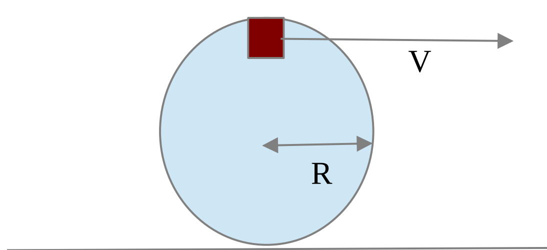


Experiment 3
Build a model loop-the-loop

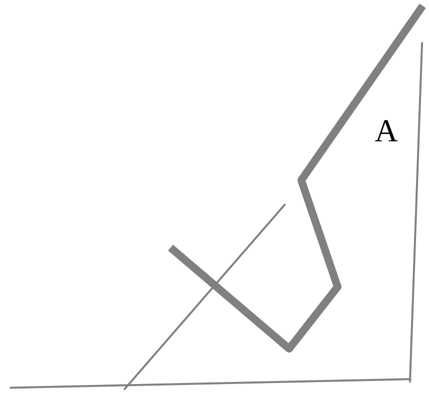
NOTE: To avoid messy accidents, perform this experiment with a penny, not water, on the pan of the SpillNot. You can rotate the SpillNot in a vertical circle, just as you may have experienced with some amusement park rides. Again, use the 0.5 m string extension, as in Experiment 1. Beyond a certain speed Vmin at the top, the penny can do a loop-the-loop without falling off the pan. Amaze your friends with this trick!

For your loop-the-loop, this minimum speed is Vmin = √ (g(R)).

R = _________ m   Vmin = _______ m/s



Experiment 4
Measure the acceleration of a car



In a car, suspend the SpillNot from the short cord provided. As the car accelerates, photograph the SpillNot so that you can measure the true size of the angle between the cord and the vertical. As the car accelerates forward, notice that the SpillNot is pulled forward, like a puppy being pulled forward on a leash. As the car brakes, the SpillNot is pulled backward, and the direction of the acceleration is backward. As the car turns right/left, the SpillNot is pulled to the right/left, and the direction of the acceleration is to the right/left. From the photo for each case, measure the angle A of the SpillNot. See diagram at right. ax = g*tan(A). This gives

For forward acceleration, Angle A=_______ ax = _________ m/s^2

For backward acceleration, Angle A=_______ ax = _________ m/s^2

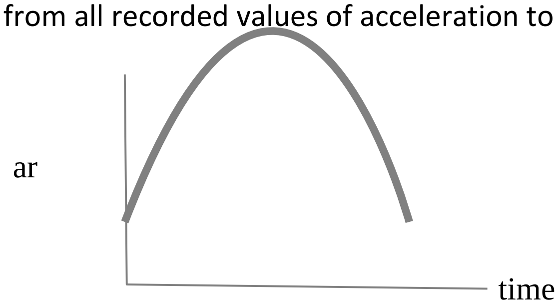
For radial (centripetal, sideways) acceleration, Angle A=_______ ax = _________ m/s^2

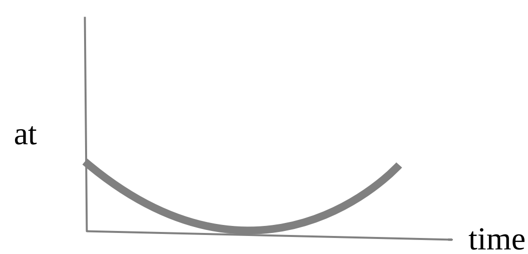
Experiment 5
Pendulum (more advanced)

NOTE: See The Physics Teacher magazine, vol. 52, Nov. 2014, pg. 502-503. Available at

www.teachersource.com/downloads/502_1.pdf

Use a smartphone with an accelerometer (such as the Android Samsung GT-19100 with Androsensor recorder). Securely attach a smartphone to the SpillNot so it lies flat on the SpillNot pan. Orient the smartphone so that an axis of its accelerometer is aligned with its motion. Using SpillNot as a simple pendulum, measure radial acceleration (ar). Plot (ar) and (at) vs. time for pendulum motion from 90 degrees (horizontal) through the lowest point at 0 degrees, and back to 90 degrees. Subtract off “g” from all recorded values of acceleration to obtain true values of acceleration.





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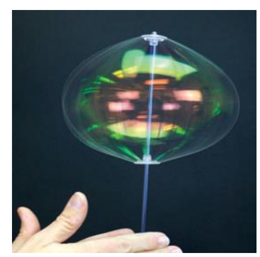
Centripetal Spinner (PHY-250)
The prettiest demonstration of centripetal force and inertia we've ever seen! This perky, iridescent device reflects a dazzling rainbow as it spins. Twirl the stick and the thin ribbons spread into a bubble shape. The faster you spin, the wider the bubble becomes! It can be gently twisted by hand to make a delicate "flower" that neatly tucks itself into a tight ball. Endlessly fascinating!



G-Ball (PHY-200)
Students can use this clever device to easily study the effects of gravity. A digital timer in the center of the G-Ball measures the amount of time the ball is in the air. The timer begins when the button on the display is released, and it stops when the ball is caught or it hits a surface (maximum 12 meters—about 3 stories—when dropped onto a fairly soft surface). Students can throw the ball straight up, horizontally, or let the ball drop to calculate the height, velocity, or magnitude of gravitational acceleration. This is a fun way for students to master the concepts of gravity.

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