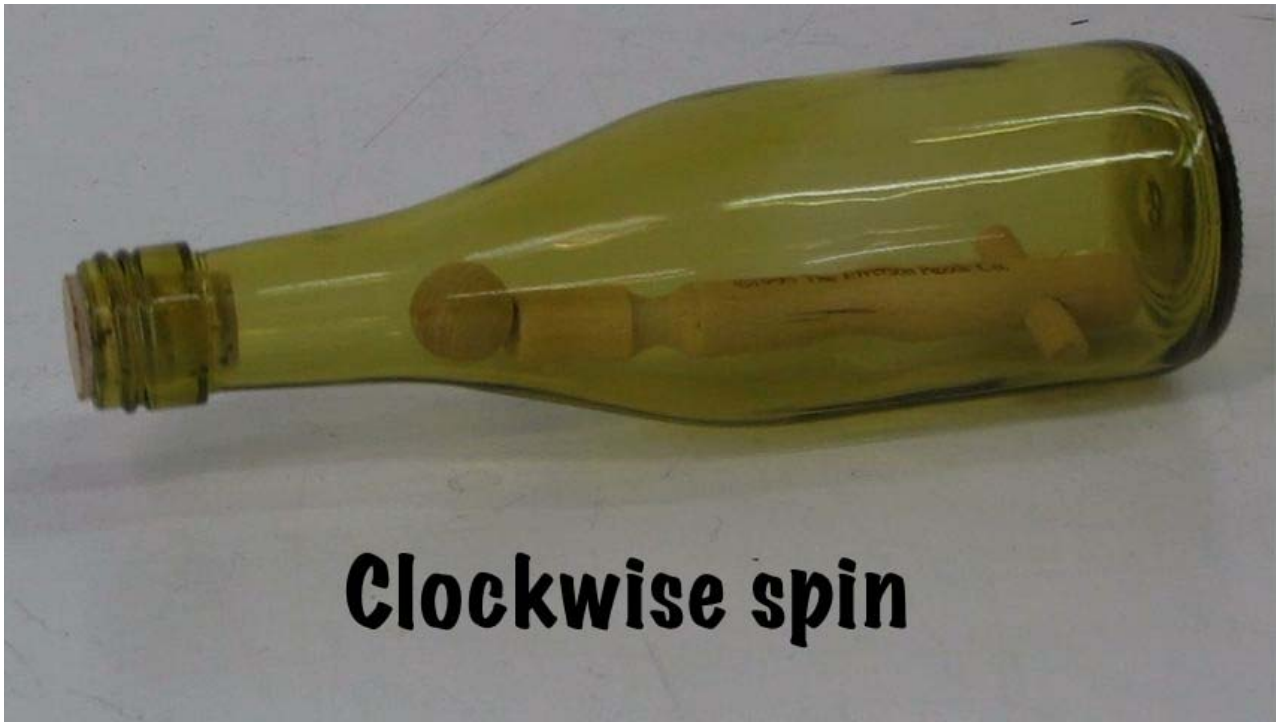
Answer #365

The answer is (e): the ball actually moves into the neck of the bottle whichever way it is spun! See both videos of the whirling wonder by clicking on the images below.

Alternate low-res version.



Alternate low-res version.

This little "trick" -- spinning an object so that its contents fly out to the sides -- is commonly used in centrifuges (e.g. in biology with DNA, nuclear physics with isotope separation, etc.)!

Technically speaking, the bottle rotates around its center of mass (COM), and the objects inside -- being in the *non-inertial reference frame* of the bottle -- are pushed outwards. The COM remains stationary -- at least to the extent I only spin the bottle, and not push it any!

Once the bottle is spinning, the ball is pushed towards the neck of the bottle, and the rod is pushed towards the bottom, because the center of mass of the ball and the center of mass of the rod are on opposite sides of the center of mass of the bottle. But now, since it was the *rod* sitting in the neck of the bottle that was preventing the ball from rolling into the neck in the first place (!), with it out the way, the ball is free to roll in!

One note of caution that might be worth mentioning: though we used the concept of the COM heavily in this explanation, one should realize the COM doesn't actually exist! What do we mean? By geometry we can clearly see the COM must be some point inside the bottle, and consist of some considerable mass -- but as we can clearly see, the bottle is hollow and no such point particle actually exists! The COM is only an abstraction, designed for convenience of describing motion of rotating bodies.

Well you might counter by saying "no point particle exists either," and that true -- but the COM is more abstract, because usually point particles are abstractions of actual masses. So perhaps the COM is more of a "2nd order" abstraction!

Question of the Week

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