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Astronomy Resources

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Understanding why an orbiting satellite neither travels in a straight line away from the body about which it is revolving, nor falls inward toward it, is an important concept in both astronomy and physics. Demonstrating an orbit in a classroom is made difficult by the Earth's gravity. The Earth's gravity can be used, along with simple kitchenware, to create a model of a planetary or satellite orbit.

The principle tool is a concave vessel. A salad serving bowl is ideal because it is extremely large and because hemispherically-shaped bowls are commercially available. The bowl is tipped slightly from the horizontal so that a seated class may see within it. A small ball is placed inside the bowl near the rim and given an initial velocity, tangential to the circumference of the bowl, with a snap of the index finger and thumb. A normal force is exerted on the ball by the bowl's surface. Because of the spherical shape of the bowl, a component of this force is directed radially toward the center; thus, the radial gravitational force between a pair of orbiting bodies is mimicked. The ball indeed "orbits" the center of the bowl.

An aluminum bowl works well because of its low coefficient of friction. (Any dents, however, would cause problems.) For a similar reason, a glass marble is used for the ball. A dark colored marble contrasts nicely with the aluminum to increase visibility, even though the marble is relatively small. Friction will eventually remove energy from the system, and the ball will settle into the center of the bowl, but only after ten or more revolutions. It is also useful to mark the center of the bowl or to permanently fix another (perhaps slightly larger) ball at that point to represent the primary body in the orbital system. (Strictly speaking, both bodies should be orbiting a common center of mass; this aspect is ignored in the model as the frame of reference is the bowl.)

After demonstrating the orbital situation, the teacher may ask students to identify the effects of giving the marble too great or too small an initial velocity; then demonstrate these cases. A marble traveling too fast will leap from the bowl, thereby escaping the "gravity" of the center of the bowl. A marble with little or no initial tangential velocity will quickly roll into the center. By experimenting with slightly non-tangential initial velocities, the instructor may create a simulated orbit with appreciable eccentricity.

Advanced students may be asked to estimate the velocity of the ball and actually calculate the dynamics of the system, in terms of either forces or energy, based on physical measurements made on the ball and bowl. Bear in mind, however, that this model is not a quantitative analogy because the inward radial force on the ball does not vary according to an inverse square law but rather does so according to a trigonometric function.

This exercise has been presented as a demonstration in which the class has the opportunity to watch its instructor play with marbles on the floor. An obvious hands-on approach for a small class would be to provide marbles and bowls to the individual students (or groups of students) and let them try to create their own orbiting models as an exploratory activity.

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