a vector with magnitude (speed) constant, $v \cong 29$ cm/s (Table I) and direction variable. Since the acceleration is the rate of change of velocity with time, we have a non-zero component of the acceleration (the centripetal acceleration) $a_c \cong$ 121 cm/s^2 due to the change in direction of velocity with the time. Thus, for circular movement the velocity is tangential to the path and the centripetal acceleration is toward the center of the circle at each instant of time.

Table I shows typical quantities of uniform circular movement (UCM) estimated in this activity.

The values will vary depending upon the form that the wind-up train is powered.

Toys[1] have been used as a teaching tool in the physics classroom. They provide a richer opportunity for students to understand situations of daily life and physical behavior of everyday objects. Of course, other model trains with circular tracks can be used for this activity, provided the motion is nearly constant in speed. This setup, using a very inexpensive toy, is helpful in the better understanding of uniform circular motion.

References

1. Jodi and Roy McCullough, *The Role of Toys in Teaching Physics* (American Association of Physics Teachers, College Park, MD, 2000).
2. Mini Wind-Up Train Set ***[AU: can you provide a source for obtaining set?]***

Trick of the Trade

A very inexpensive Magnus force demonstrator

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In any professional baseball game you can watch pitchers fool batters with their magic. The magic is done by the Magnus force caused by the spin the pitcher imparts to the ball.[1,2] The Magnus force is exerted perpendicular to the plane defined by the axis of spin and the axis of the velocity of the air flow over the ball.

A very elegant apparatus made by PASCO (ME-9481) allows for careful measurement of the force, but shown below is a very inexpensive demonstration for your students to see the qualitative behavior of the Magnus force. It consists of a top made from a plastic practice golf ball and a short dowel. The top is set spinning in a trough made from half a ¾-in PVC pipe. Blowing across the trough creates a Magnus force along the trough one way or the other, depending upon which direction the top is spinning.

You can follow up this demonstration by showing off your curve ball to the class. I can still break off an excellent "12-6" ... if I use a Styrofoam ball instead of a real baseball.

References

1. Lyman Briggs, "Effect of spin and speed on the lateral deflection (curve) of a baseball; and the Magnus effect for smooth spheres," *Am. J. Phys.* **27,** 589–596 (Nov. 1959).
2. Alan M. Nathan, "The effect of spin on the flight of a baseball," *Am. J. Phys.* **76,** 119–124 (Feb. 2008).