In this section of *Resonance*, we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. “Classroom” is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.

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**Motion of a Tiny Tool Thrown by an Astronaut Inside a Spinning Space Vehicle in a State of Free Fall**

One of two astronauts, while conducting an experiment inside a spinning space vehicle in a state of free fall neglecting all gravitational effects, throws a tiny tool at the other with a velocity perpendicular to its axis of rotation. Considering the motion of the tool with respect to the rotating frame rigidly fixed to the vehicle, we can obtain the position of the tool at a subsequent time by use of rotational kinematics and geometry without involving the concepts of coriolis and centripetal forces.

**Introduction**

P Chaitanya Das and his coauthors tackled projectile motion of a particle, viz, a tiny tool thrown by an astronaut at another astronaut in a space vehicle in a state of free fall and rotating with a uniform angular velocity about an axis through it. They formulated the differential equations of motion of the tool with reference to a rotating frame rigidly fixed to the space vehicle called non-inertial frame, i.e., relative to an observer in the vehicle, obviously taking into account the coriolis and...
centripetal forces in the absence of any gravitational effects because of weightlessness due to free fall of the vehicle. The axis of rotation of the vehicle is taken as \( Z \) axis (OZ); OX and OY are perpendicular to the Z-axis; hence OXYZ is a rotating frame, consisting of X-, Y- and Z-axes mutually at right angles to each other.

One astronaut throws a tiny tool from a point \((0, -R, 0)\) on the Y-axis with a velocity whose components along the \( X' \)- and \( Y' \)-axes of the rotating frame \( OX'Y'Z' \) are \( V_{0,x} \) and \( V_{0,y} \). They solved the differential equations with these initial conditions of projection and found the position of the tool at any instant of time \( t \) with reference to the rotating frame. Thereafter they analyzed its trajectory with some numerical examples.

In this article, we solve the same problem applying simple kinematics and geometry without involving any coriolis and centrepetal forces and without any differential equations of motion.

**Solution to the Problem**

Let OXYZ be an inertial frame fixed in space, and OXYZ' the noninertial frame fixed to the space vehicle rotating with a uniform angular velocity \( \omega \) about its Z-axis, OZ (= \( OZ' \)). The two frames are coincident at time \( t = 0 \), when the tiny tool is thrown by one astronaut with velocity having components \( V_{0,x} \) and \( V_{0,y} \) along the axes \( OX' \) and \( OY' \), from a point \((0, -R, 0)\) lying on \( OY_1 \equiv OY \). At a subsequent time \( t \), the righthanded frame is rotated through an angle \( \omega t \) and becomes \( OX'Y'Z' \) as illustrated in *Figure 1*.

Because of rotation of the frame, the tool will gain a linear velocity \( R\omega \) perpendicular to the Y-axis, i.e., along the X-axis at \( t = 0 \), on being released by the astronaut. Hence its true velocity component in space along \( OX \) is

\[
V_1 = V_{0,x} + R\omega, \quad (1)
\]