PROBLEM OF THE WEEK
Solution of Problem No. 3 (Fall 2003 Series)

Problem: How long (in minutes) should the Earth day be so that persons at latitude 42° will experience zero gravity?
(Consider the Earth as a sphere of radius $6371km$ and gravity $981cm/sec^2$ at 42°.)

Solution (by Troy Siemers, Asst. Prof. of Math., Va. Military Inst., Lexington, VA)

Zero gravity will be achieved if the force due to gravity $F_g = mg$ is balanced against the component of centrifugal force in the direction toward the center of the earth $F_c = \frac{mv^2}{r} \cdot \cos(42°)$ where $v = \frac{2\pi r}{T}$, where T is length of one day and r is the distance from the surface of the Earth to the axis of rotation (at 42° latitude). Note that $r = r_e \cos(42°)$ where $r_e = 6371km$. We compute:

$$\begin{aligned} F_g &= F_c, \\ mg &= \frac{mv^2}{r} \cdot \cos(42°), \\ g &= \frac{4\pi^2 r_e \cos^2(42°)}{T^2}, \end{aligned}$$

so that

$$T = 2\pi \cos(42°)\sqrt{\frac{r_e}{g}}.$$

If $r_e = 637,100,000cm$ and $g = 981cm/s^2$ then $T \approx 3763s$ or 62.7 minutes.

Also solved by:

Undergraduates: Akira Matsudaira (ECE), Neel Mehta (So. AAE),

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Others: Greg Nelson (U.C. Santa Cruz), Taryn Quattrocchi (Gr. 12 Warren Central HS)

Seven incorrect solutions were received.