Measuring *g* with a Joystick Pendulum

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Most of our students are familiar with using a joystick to play video games. The control stick protrudes upwards from a base and can be moved up, down, left, and right to control anything on the computer screen from a race car to a spaceship. Tell the computer to report precisely on the moving joystick's position, and the game software will respond accordingly. With this readily available equipment, we have developed an activity that can be a high school or undergraduate lab or a lecture demonstration for measuring *g*, the acceleration due to gravity.

Choose a joystick that does not self-center, or a model with a switch that deactivates the self-centering mode. Turn the joystick upside down and attach a long rod to the stick with duct tape. We've used anything from a broomstick to PVC and copper pipe. The model shown in Fig. 1 uses an aluminum pipe of length 1.65 m and mass 0.313 kg. Once assembled, you've created a physical pendulum. The setup is a bit simpler than previously described computerized pendulum experiments in which the rod is attached to the shaft of a helipot.[1,2]

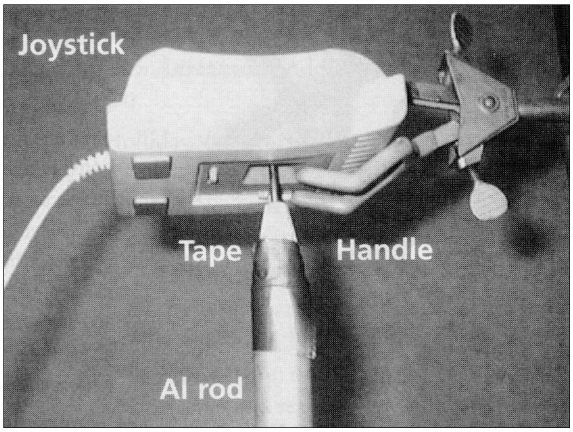

Fig. 1. Model of physical pendulum.

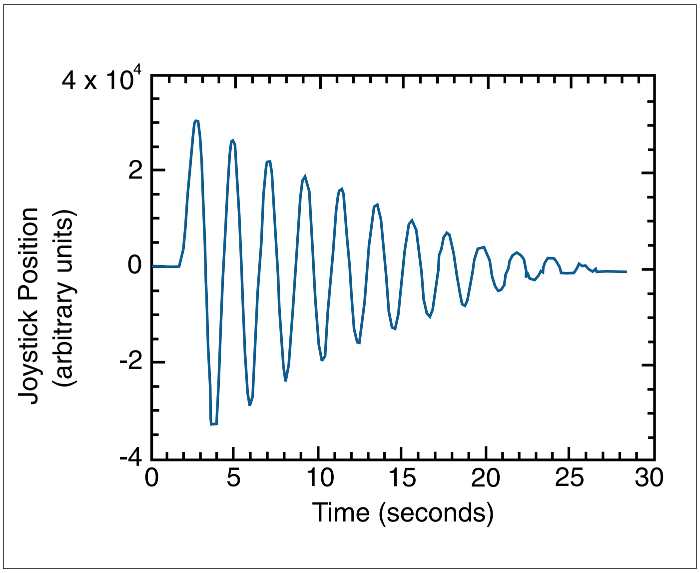

Fig. 2. Position-vs-time data for joystick.

Swing the joystick and let it oscillate back and forth. Instruct the computer to keep careful track of the joystick's position as it swings. To do this, download the free software from my website at *http://haywire.csuhayward.edu/~tbensky/joystick.html*.[3] A typical data set retrieved by such a procedure is shown in Fig. 2. Here the ordinate is the joystick's position (in arbitrary units) and the abscissa is time. The critical parameter is the period of the pendulum—the time between successive peaks (or valleys) in such a data plot. For our joystick pendulum, the peak-to-peak time is 2.10 s for a rod of length 1.65 m. The period, T, of such a physical pendulum is[4]

$$T = 2\pi\sqrt{\frac{2L}{3g}}, \tag{1}$$

where L is the length of the rod. Solving for g gives

$$g = \frac{8\pi^2 L}{}. \qquad (2)$$

Inserting our values for T and L into Eq. (2) gives $g = 9.85\ \text{m/s}^2$, in excellent agreement with g at the surface of Earth.

Since the joystick pendulum eventually stops swinging, this is also a damped system. More advanced analysis to determine the damping coefficient of the system is possible.[5] The damping can also be varied by attaching a flat piece of cardboard to the end of the pendulum, thereby increasing air resistance.

References

1. Joseph Priest and Larry Potts, "Computer analysis of a physical pendulum," *Phys. Teach.* **28**, 413-415 (Sept. 1990).
2. R.C. Nicklin and J.B. Rafert, "The digital pendulum," *Am. J. Phys.* **52,** 632-639 (July 1984).
3. The software works with any Windows 95/98 /NT/2000 computer equipped with a joystick port (most are). Contact the author by e-mail or phone, 510-885-3488, for further information.
4. R.A. Serway, *Physics for Scientists and Engineers,* 4th ed. (Saunders, New York, 1996), p. 374.
5. Ibid., pp. 377-378.