

## Simple Pendulum

Just how simple is a “simple pendulum?” The usual expression for the period:

$$T = 2\pi \sqrt{\frac{l}{g}}$$

involves some approximations. One approximation is that the amplitude of the swing is small. Another is the assumption that air resistance is negligible. If these approximations are valid, the relationship among the pendulum’s length ( $l$ ) its period ( $T$ ), and the acceleration of gravity ( $g$ ) is indeed simple. In that case a pendulum might provide a reasonable method for determining  $g$ .

In this lab we will approach the simple pendulum from two distinct points of view. First we will use it to measure  $g$ ; then we will investigate the validity of the equation above. (Strictly speaking, we should investigate the equation’s validity before using it, but the backwards approach is more practical in the lab.)

- I. Measure  $g$  using a pendulum. Before you begin, think about how the length of the string and the number of periods observed affect the uncertainty in the measured value of  $g$ . Determine  $g$  as accurately as you can, and estimate the uncertainty in your result! Also compare your result with the “accepted” value of  $g$  and the values you have obtained in previous experiments.
- II. Use pendula of different lengths to investigate the dependence of  $T$  on  $l$ . Plot your data in a way which makes the relationship clear. (Don’t just plot  $T$  vs.  $l$ !). Use Excel for plotting.
- III. The equation above does not contain the mass of the bob because air resistance has been neglected. Investigate the validity of this assumption by using pendulum bobs of different masses.
- IV. The simple equation above is valid if the amplitude of the pendulum’s swing is “small.” The expression:

$$T = 2\pi \sqrt{\frac{l}{g}} \left(1 + \frac{1}{4} \sin^2 \frac{\theta}{2} + \dots\right),$$

where  $\theta$  is the angular amplitude of the oscillation, is more accurate for larger amplitudes. Try to measure the dependence of  $T$  on  $\theta$ . Are your results consistent with the “simple” expression? Are they consistent with the “improved” expression?