PHYSICS 332
MECHANICS LABORATORY
LARGE AMPLITUDE OSCILLATIONS OF A PENDULUM

***Purpose**:* You will both design and perform an experiment to measure the amplitude dependence of the period of a physical pendulum and to investigate the theory described below.

Apparatus: You should use one of the two coaxially mounted plexiglass discs equipped with moveable weights. When shifted to off-center mounting holes, these weights allow you to change the moment of inertia of the disc. Your first measurements should be with both weights mounted at their center holes. Handle the discs with care as their low friction support bearings are delicate.

***Theory**:* While for small amplitude oscillations, the period of a pendulum is nearly independent of the oscillation amplitude, at larger amplitudes there is a measurable change in the period. Texts such as Mechanics by Symon and Analytical Mechanics by Fowles and Cassiday show that the period for larger amplitude oscillations of any physical pendulum can be approximated as

$$\tau_L \approx \tau_S \left(1 - \frac{\theta_o^2}{8}\right)^{-1/2} \approx \tau_S \left(1 + \frac{\theta_o^2}{16}\right) \qquad (1)$$

where τ_L is the period measured at amplitude θ_o (in rad). As can be seen from taking the zero amplitude limit of this equation, τ_S represents the small amplitude limit of the period. In arriving at this equation, damping has been neglected and the amplitude is still assumed to be moderately small.

***Procedure**:* As indicated above, the procedure is self-designed. One of the two discs has a degree scale attached to it. Note that $\theta=0^o$ does not necessarily correspond to the equilibrium position. You may either use this disc (without altering the scale) or make your own scale and tape it to the other disc. If you make your own scale, please remove it when through. τ_s is to be determined experimentally (not by weighing the plexiglass disc). You can, for instance, extrapolate it from the zero amplitude limit of your data or you can just use the period measured at a small amplitude (such as 5^o).

Among the questions you should ask yourself in designing your experiment are:

a. Is the equation you are trying to investigate expected to be valid for all amplitudes?
b. How many data points should be used to verify the equation?
c. Can the pendulum be changed to generate more than one curve? That is, can τ_s be changed so that equation (1) can be checked for more than one pendulum?

d. How accurately can the amplitude be determined?

Your experiment should give you sufficient information to provide estimates of sources of error in your measurements. In particular, you should devise a way to estimate the influence of damping on your data. You should also determine the limits of applicability of the above equation and interpret them in light of its derivation. (Your report, however, need not include a complete derivation of that equation, just a description of how it is arrived at. Understanding the limitations of the derivation is essential to analyzing the data in this experiment.)

What is due: As in the previous experiment, you need to hand in a full report on this one. However, the Procedure section is weighted more heavily in this report, so make sure you include sufficient detail in that section. For instance, discuss how you make time measurements, how many times you repeat the measurements, etc. Part of your grade is based on the quality of your experimental design.