# Advanced Lab for the Simple Pendulum

Name_____ ID_____ TA_____

Partners_____

Date_____ Section_____

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### 1. Gravitational acceleration with a simple pendulum

From Lab Simple Pendulum, we learned that the period is:

$$T = 2\pi\sqrt{\ell/g}$$

where $\ell$ is the length of the pendulum (remember how to measure the length?). If you solve for $g$ (gravitational acceleration), we will obtain this formula

$$g = 4\pi^2\ell/T^2.$$

- **Experimental g:**

Use five different lengths. For each of them, let the pendulum swing for a number of cycles and record the average period of those cycles determined by the photogate. Find g for each length, and calculate the average. Use 50- or 100-gram mass.

| $\ell$ | T | $g = 4\pi^2\ell/T^2$ |
|---|---|---|
| (m) | (s) | (m/s$^2$) |
| (m) | (s) | (m/s$^2$) |
| (m) | (s) | (m/s$^2$) |
| (m) | (s) | (m/s$^2$) |
| (m) | (s) | (m/s$^2$) |
| Average gravitational acceleration g | | (m/s$^2$) |

- **Theoretical g:**

<u>Location:</u>    (latitude) $\phi$ = _____°N        (elevation) H = _____km

<u>Theoretical value of g:</u>
g = 9.780356·(1+0.0052885·sin$^2\phi$-0.0000059·sin$^2$2$\phi$)-0.003086·H = _____m/s$^2$

[Note: sin$^2\phi$ = (sin$\phi$)$^2$]

- **Error Analysis:**

$$\frac{|\text{Avg. of experimental data - theoretical value}|}{\text{theoretical value}} \times 100 = \underline{\hspace{3cm}}\%$$

**In your report, be sure to address following problems:**
- How does the length affect the accuracy?
- What are the most significant sources of errors in determination of g in this lab?
- Why can you get much more accurate result for g in this lab, compared with previous labs [lab 3 (Free fall) & lab 4 (Uniformly Accelerated Motion)] in which you also determined g?

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## 2. Amplitude dependence of the period

In the Simple Pendulum, the period is not supposed to depend upon the swinging amplitude. The main reason was that you used small angles for the lab. However, when the amplitude (angle) is large, the period becomes angle-dependent with the following equation:

string

$$T = 2\pi \sqrt{\frac{\ell}{g}} \left(1 + \frac{\theta_{rad}^2}{16}\right).$$

This makes more stable swing.

Use a proper hanging mass, 50 or 100 g.

Fixed length: $\ell =$ _____ (m)   $g =$ _____ (m/s$^2$)

(↑ This is from the theoretical g in the first part.)
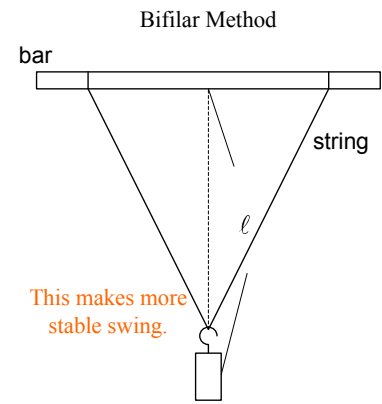
| Angle, $\theta_{deg}$ (degrees) | Convert into radians $\theta_{rad} = \frac{\pi}{180}\theta_{deg}$ | $T_{ex}$ experimental period (photo gate) | $T_{th}$ theoretical period | % difference $\frac{\lvert T_{ex} - T_{th}\rvert}{T_{th}} \times 100$ |
|---|---|---|---|---|
| 15° | | | | |
| 18° | | | | |
| 21° | | | | |
| 24° | | | | |
| 27° | | | | |
| 30° | | | | |
| 36° | | | | |
| 45° | | | | |

**In your report, be sure to address following problems:**
- Does the theoretical period accurately predict the experimental period?
- What are the most significant sources of errors in measuring $T$ ?