The Gravitational Acceleration

Name________________________________ ID________________________ TA________________

Partners____

Date______________________________________ Section____________________________________

---

1. Gravitational acceleration with a simple pendulum

The period of the simple pendulum:

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

where ℓ is the length of the pendulum. Solve for g (gravitational acceleration).

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

- **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.

ℓ	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:**

Location: (latitude) ϕ = _______________°N (elevation) H = _______________km

Theoretical value of g:

$g = 9.780356\cdot(1+0.0052885\cdot\sin^2\phi-0.0000059\cdot\sin^2 2\phi)-0.003086\cdot H$ = _________________________m/s^2

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

- **Error Analysis:**

$$\frac{|\text{Avg. of experimental data - theoretical value}|}{\text{theoretical value}}\times 100 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\%$$

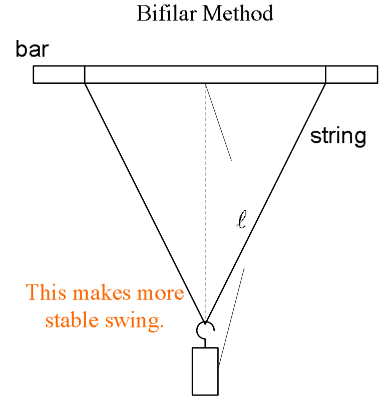
In your report, be sure to address following problems:

- How does the length affect the accuracy?
- What are the most significant sources of errors in determination of g in this lab?

Find the mass of the Earth.

From $g = \dfrac{GM_E}{r^2}$, solve for the mass. $M_E = \dfrac{gr^2}{G}$ = ____________________kg (ref. 5.98×10^{24} kg)

(Use the above experimental g to calculate. $r = 6.38\times10^6$ m.)



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:

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

Use a proper hanging mass, 50 or 100 g.

Fixed length: ℓ = ________________________ (m) g = ___________________________ (m/s^2)

(↑ This is from the theoretical g in the first part.)

Angle, θ_{deg} (degrees)	Convert into radians $\theta_{\text{rad}} = \frac{\pi}{180}\theta_{\text{deg}}$	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 ?