Simple Pendulum Experiment

Prepared By: Hanan A. Issa
Objective:
To determine the acceleration due to gravity.

Apparatus:
Simple pendulum, meter stick, and stopwatch.

Theory:
A simple pendulum consists of a small, dense mass (called a bob) suspended by a nearly weightless cord from a point about which it can swing freely. Such a pendulum is shown in Figure (1).

The point about which the pendulum swings, S, is called the center of suspension. When the pendulum swings from a point and back again, to the same point this is called a complete vibration or cycle. The time required for a cycle is the periodic time of the pendulum.
When displaced from its equilibrium point, the restoring force, which brings it back to the center, is given by:

\[ F_{net} = -mg \sin \Theta \]  
\[ \text{............... (1)} \]

For small angles \( \Theta \), we can use the approximation \( \sin(\Theta) \approx \Theta \), in which case Newton’s 2nd law takes the form:

\[ F = ma = -mg\Theta = -mg \frac{x}{L} \]  
\[ \text{............... (2)} \]

In this approximate case, the solution of the equation uses calculus and differential equations, the differential equation is

\[ \frac{d^2x}{dt^2} + \frac{g}{L} x = 0 \]  
\[ \text{............... (3)} \]
The standard form of the equation for a particle is given by:

\[ T^2 = 4\pi^2 \frac{L}{g} \]  

\[ \text{Figure (1): Simple pendulum.} \]
Procedure:

**PART ONE: FIXED LENGTH, VARIABLE MASS.**

1. take a string of length L, say, L=70 cm.

2. Displace the mass from equilibrium to small angle $\theta = 10^\circ$.

3. Measure and record the time $t$ for 10 oscillations. Repeat the measurement one more time and find the $t_{av}$. Then $T = t_{av}/10$.

4. Tabulate your data in table (1).
PART TWO: FIXED MASS, VARIABLE LENGTH.

1. Measure the length of the string (L) from the center of suspension to the center of the bob. Record the data.

2. Give a small displacement to the bob (Keep the amplitude in all trials between 10 and 15°) and using the stopwatch to measure the time in seconds required for 10 oscillations of the pendulum bob. Record the time elapsed in the table.

3. Repeat the last step three times, and record the average $t_{av}$ in table (2). Then $T = \frac{t_{av}}{10}$.

4. Increase the length of the string, and repeat step 2 and 3.

5. Plot graph between $T2$ versus $L$, and draw the best straight line. Then find the slope $4\pi^2/g$.

6. From the obtained slope, calculate the acceleration due to gravity (g).

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Data and results:

Table (1):

<table>
<thead>
<tr>
<th>Object</th>
<th>M ( )</th>
<th>$t_1$ ( )</th>
<th>$t_2$ ( )</th>
<th>$t_{av}$ ( )</th>
<th>T ( )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td></td>
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<tr>
<td>brass</td>
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<td>lead</td>
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<tr>
<td>plastic</td>
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$L = \underline{\text{______ ( m )}}$

1- **Question:** Examine your results. Does your data support the statement that the period is independent of the mass?
Table (2):

<table>
<thead>
<tr>
<th>L</th>
<th>t₁</th>
<th>t₂</th>
<th>t₃</th>
<th>t_{av}</th>
<th>T</th>
<th>T²</th>
</tr>
</thead>
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</table>

M=______________ (   )

2- Find the slope:___________________ (   )
3- From the slope calculate g_{exp}.
4- **Question**: What is the relationship between the length of a pendulum and its period?