Pendular Motion

Name:	Teammates:

Pendulum

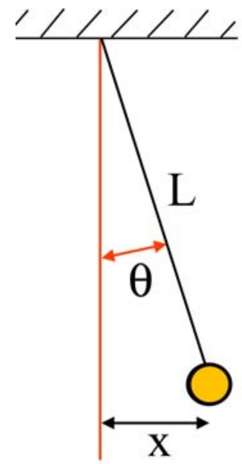

Fig. 1: Pendulum

Pendulums have been used for millennia as a tool for mankind. One use for which they have proven extremely useful is for keeping time. The reason for this is because their frequency is dependent upon only one variable. To see this, let us consider a pendulum in which we neglect the actions of friction or drag. The only two forces on the pendulum mass are the tension in the support and gravity. If the pendulum is pulled back from equilibrium to an angle θ, then setting the forces along the support (that is along the radial direction L) equal to zero gives us that the tension in the support is equal to mg cos θ. In the direction perpendicular to the support, there is only one force, which is mg sin θ. This is the lone force that will drive the motion of the pendulum mass, which means that

$$F_{net} = ma = -mg \sin\theta$$

This force is not constant; it gets larger for larger values of θ (sin θ gets larger as θ increases from 0), and it always points back to the equilibrium position. Note that the direction of the force is always changing direction; it is always perpendicular to the pendulum support or tangential to the circle made by the pendulum mass. Secondly, the force is not linear in θ; it varies as a sine function. However, if we restrict our attentions to values for which θ is very small, we can then use the approximation that in radians sin θ is approximately equal to θ. Noting that the acceleration is tangential, we get:

$$m\, a_T = -mg\,\theta$$

which leads to:

$$\alpha L = -g\,\theta$$

where α is the angular acceleration and L, the length of the pendulum (which is also the radius of the circle the mass is constrained to.) This last equation is a differential equation. Its solution is:

$$\theta = \theta_{max} \sin\left(\frac{2\pi t}{T} + \psi\right)$$

where T is the period of oscillations and the focus of this lab activity, θ_{max} the maximum angular displacement from equilibrium and ψ is what is called the phase angle.

Activity

For this activity, you will need a set of small cylindrical masses, a long piece of string, one table stand (with a pendulum attachment), and a timer.

1. Determine three possible factors that might affect the value of the period of a pendulum:

Factor 1:______________________ Factor 2:______________________ Factor 3:_______________________

2. Discuss how you would test the effect of "Factor 1" on the period of the pendulum.

3. Discuss your idea with the instructor before proceeding.

4. Using the provided supplies, run the experiment to test you hypothesis. Collect data (making sure to take the average of several measurements), graph it.

Factor 1						
Period (T)						

5. If your graph does not result in a linear relationship, try to identify the relationship by graphing alternative relationships like T vs. $(\text{factor } 1)^2$, T vs. $(\text{factor } 1)^{0.5}$, T vs. 1/(factor 1), or T vs. $1/(\text{factor } 1)^2$
6. What is then the relationship between "factor 1" and the period T?

7. Discuss how you would test the effect of "Factor 2" on the period of the pendulum.

8. Using the provided supplies, run the experiment to test you hypothesis. Collect data (making sure to take the average of several measurements), graph it.

Factor 2						
Period (T)						

9. If your graph does not result in a linear relationship, graph alternative relationships.
10. What is then the relationship between "factor 2" and the period T?

11. Discuss how you would test the effect of "Factor 3" on the period of the pendulum.

12. Using the provided supplies, run the experiment to test you hypothesis. Collect data (making sure to take the average of several measurements), graph it.

Factor 3						
Period (T)						

13. If your graph does not result in a linear relationship, try to identify the relationship by graphing alternative relationships like T vs. $(\text{factor } 3)^2$, T vs. $(\text{factor } 3)^{0.5}$, T vs. 1/(factor 3), or T vs. $1/(\text{factor } 3)^2$
14. What is then the relationship between "factor 3" and the period T?

A. What do you conclude, what are the factors that affect the period of a pendulum?

B. What are the sources of error in this experiment?