Physics-1 Lab SM203P 14 / 17 September 2021

Experiment 2: Experiments with simple and double pendulums

This involves an exercise involving taking both experimental measurements of your own, as well as running simulations at https://www.myphysicslab.com/

1. Find g using your phone as a simple pendulum – using the "pendulum" option in the PhyPhox app. If you do not have this option active in your smartphone, try this by measuring the time-period of oscillation of a pendulum you can make using a string and weight.

2a. Run the simulation for a simple pendulum without dissipation and see how the phase portrait ($d\theta/dt$ vs θ) looks like, for 3 different initial amplitudes – plot these phase-portraits.

2b. Obtain a representative phase portrait for your smartphone-pendulum too. This can be done by everyone. Use the Inclination option in PhyPhox which gives inclination as a function of time. You can use this to obtain $d\theta/dt$ (by finding difference in θ values over a period of time) vs θ, and get the phase-portrait.

2c. Plot the time series θ vs t obtained in 2b.

3. In the presence of dissipation (air drag, other local frictional effects), energy is lost. To quantify the energy lost per cycle, look at a phase portrait of the pendulum with drag in the simulation, and quantify the percent decrease per cycle by finding out the %-decrease in area per cycle. You are free to choose any non-zero value for the drag. Keep in mind that in the absence of dissipation, the phase portrait would be a uniform ellipse.

4. Look at the simulation for the double pendulum.
(a) For l = l2 / l1 = 1, choose n different values for m= m2/(m1 + m2), one for each of n group members. See how the phase portraits & time-series change. (Plot both $d\theta_1/dt$ vs θ_1 as well as $d\theta_2/dt$ vs θ_2 for each case).
What conclusions, if any, can you draw from your observations?

(b) Keep m constant at some value. Choose n different l values (one for each of n group members), such that values of l <1, l=1, l >1 are all covered. See how the phase portraits & time-series change. What conclusions, if any, can you draw from your observations? (Plot both $d\theta_1/dt$ vs θ_1 as well as $d\theta_2/dt$ vs θ_2 for each case).

- Note down the least-counts for all your measurements.
- Mention sources of errors.

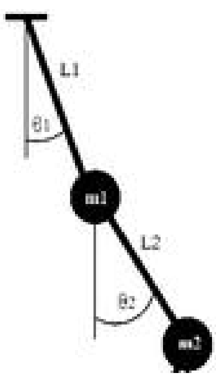
The report for each group should be a pdf file uploaded by any one member and should have:

1st (title) page: name of experiment, group number & group-members.
2nd page: Aim, equipment used, short summarized theory & procedure (common for the whole report)
3rd pages onwards:

- **Observation tables for the readings taken, from each individual group member**
- **Calculations & results with error-analysis, from each group-member**
- **Sources of error (summarized for the whole group)**

Reports should be neatly and systematically presented.

Due date for submission: no later than 26 September 2021, 12:00 noon.



$$x_1 = L_1 \sin(\theta_1),$$

$$y_1 = L_1 \cos(\theta_1),$$

$$x_2 = L_1 \sin(\theta_1) + L_2 \sin(\theta_2),$$

$$y_2 = L_1 \cos(\theta_1) + L_2 \cos(\theta_2).$$

The resulting equations of motion are

$$(m_1+m_2)L_1^2\theta_1''+m_2L_1L_2\theta_2''\cos(\theta_1-\theta_2)+m_2L_1L_2\theta_1'\theta_2'\sin(\theta_1-\theta_2)+gL_1\sin\theta_1(m_1+m_2)=0$$

$$m_2L_2^2\theta_2''+m_2L_1L_2\theta_1''\cos(\theta_1-\theta_2)-m_2L_1L_2\theta_1'^2\sin(\theta_1-\theta_2)+gm_2L_2\sin\theta_2=0.$$

In the above eqns time-derivatives are indicated by primes.
(from https://www.math.ucla.edu/~mason/research/exp2.pdf)