PHC-103: Waves & Oscillations | **NEP-DSC3 : List of Practicals**
Teacher : Savinder Kaur | Date: 16 August, 2023

SYLLABUS for Practical laboratory : **Waves & Oscillations.**

Experiment DSC3- Waves & Oscillations

1. Experiments using **Bar pendulum**:
   - Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM.
   - Determine the value of g using bar pendulum.
   - To study damped oscillations using bar pendulum
   - Study the effect of area of the damper on damped oscillations. Plot amplitude as a function of time and determine the damping coefficient and Q factor for different dampers
2. To determine the value of acceleration due to gravity using **Kater's pendulum** for both the cases
   (a) $T_1 \sim T_2$ and (b) $T_1 \neq T_2$
   Discuss the relative merits of both cases by estimation of error in the two cases.
3. Understand the **applications of CRO** by
   - measuring voltage and time period of a periodic waveform using CRO.
   - study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures)
4. Experiments with **spring and mass system**
   - To calculate g, spring constant and mass of a spring using static and dynamic methods.
   - To calculate spring constant of series and parallel combination of two springs.
5. To study normal modes and beats in **coupled pendulums or coupled springs**.
6. To determine the frequency of an electrically maintained tuning fork by **Melde's experiment** and to verify $\lambda^2 - T$ Law.
7. To determine the current amplitude and phase response of a driven **series LCR circuit** with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping

Reference Books for Laboratory Work: Waves and Oscillations Lab

1.*Advanced Practical Physics for students*, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.

2. *Engineering Practical Physics*, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.

3. *Practical Physics*, G. L. Squires, 2015, 4/e, Cambridge University Press.

4. *A Text Book of Practical Physics*, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.

5. *An Introduction to Error Analysis: The study of uncertainties in Physical Measurements*, J. R. Taylor, 1997, University Science Books List of experiment

Instructions for Practical laboratory Waves & Oscillations.

1. **For Class Work (In Auxillary copy)** :
   (a) Students will prepare an auxillary copy.
   (b) All readings will be noted in the laboratory.
   (c) Note practical aim, formulas with units, and relevant tables in this auxillary.
   (d) Complete calculations, graphs, and results before filing (in FILE), **post-signature of teacher ONLY** in the auxillary file
2. **Filing (in FILE): ON RHS ruled pages**
   (a) Aim of Practical
   (b) Apparatus and Accessories
   (c) Formula used with units (with short explanation of the origin of the formula)
   (d) Least Count of instruments used
   (e) Result
   (f) Precautions taken
   (g) Applications of the Practical
3. **Filing (in FILE): ON LHS blank pages**
   (a) Diagram
   (b) Observation Tables
   (c) Calculations
   (d) Paste the signed Graphs
   (e) Errors as discussed in class
4. *Students will be organized into batches and given a practical assignment to present and be assessed on the blackboard.*
5. Kindly ensure consistent attendance and uphold your record. Arrive punctually, stay attentive, and make the most of the learning opportunities we offer.

PHC-103 (DSC-3): Practical Lab | **NEP- Sem 1: Waves & oscillations**

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Experiment 1a : The Compound Pendulum: *Graduated Bar*

- **Determine the value of acceleration due to gravity g and radius of gyration k using bar pendulum.**
- Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM.

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1. **SETUP & FORMULAE:** The compound pendulum is a graduated bar pendulum which is reversible. If the distance of the point of suspension (knife edge) from the CG is $l_1 = l$ and that of the point of oscillation $l_2 = k^2/l$ (to be determined from graph of T vs l_1) then the following formula is employed to determine the value of acceleration due to gravity (g) and radius of gyration (k) of the bar pendulum

$$g = \frac{4\pi^2(l_1 + l_2)}{T^2} = \frac{4\pi^2 L}{T^2}$$

where $L = l_1 + l_2$ is the equivalent length of pendulum and T is the measured time period. Another formula which is applicable when the time period is minimum is

$$g = \frac{8\pi^2 k}{T_{min}^2} = \frac{4\pi^2 L}{T_{min}^2}$$

where $k = \frac{k_1+k_2}{2}$ where $k_1 + k_2$ is the distance between the minimas on the T versus l_1 graph. Also $k = \sqrt{l_1 l_2}$. In the Ferguson method we plot l_1^2 versus $l_1 T^2$ and the slope predicts the value of g

2. **Tables: Observations and Graphs** Make a

   (a) Table for l_1 & T and l_2 & T. Plot time period T versus (l_1, l_2) and extract L value for different T. From this graph also find at T_{min} the $k_1 + k_2$ value.

   (b) Plot l_1^2 versus $l_1 T^2$.

3. **Calculations from Table and Graphs**

   - From Table 2(a) evaluate g and k. Corresponding to T_{min} evaluate the g value
   - From graph 2(b) report the slope and intercept and evaluate g and k

4. **APPLICATIONS**

   (a) Estimate limits on angular displacement for SHM by measuring the time period **at different angular displacements and compare it with the expected value of time period for SHM**.

   (b) Any other

Experiment 1b : Compound Pendulum: *Damped Bar*

- To study damped oscillations using bar pendulum
- Study the effect of area of the damper on damped oscillations.

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1. **SETUP & FORMULAE:** The graduated bar pendulum is mounted with a rectangular damper of area a at the bottom. The knife edge is placed at one of the graduated marking and the system is made to undergo damped oscillations. The amplitude A decays as

$$A_n = A_0 e^{-\lambda t_n}$$

where λ is the decay constant, A_0 is the initial displacement, A_n are the amplitudes observed for respective oscillation time t_n. The initial energy of the system is $E = I\omega^2\theta_0^2$ where $\theta_0 = A_o/L$ is the initial angular displacement, $\omega = 2\pi/T$ is the angular velocity with T as the time period of oscillation and I is the moment of inertia about the point of suspension. For the n^{th} oscillation

$$E_n = I\omega_n^2\theta_n^2 = \left(\frac{I\omega_n^2}{L^2}\right) A_n^2 \propto A_n^2$$

The Quality factor $Q_n = E_n/\Delta E_n$ where $\Delta E_n = E_n - E_{n-1}$.

2. **Tables: Observations and Graphs**

   - Table for time t_n and amplitude A_n for fixed area a of the damper. Plot for each area, $\ln A_n$ Vs t_n and determine the damping coefficient λ_a .
   - Repeat for six other areas and tabulate a_i and λ_{a_i}. Plot area a_i versus λ_{a_i}

3. **Calculations**

   - Calculate from Table in 2 above to calculate the energy E_n and the Quality factor Q_{a_i} for different dampers

4. **APPLICATIONS**

   (a) Mount the bar pendulum at a different groove and repeat the whole experiment. What is your inference ?

   (b) Check the Damping Effects Induced by a Mass Moving along a Pendulum.

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Experiment 2 : Compound Pendulum: *Kater's Reversible*

- To determine the value of acceleration due to gravity using **Kater's pendulum** revesible pendulum for both the cases (a) $T_1 \sim T_2$ and (b) $T_1 \neq T_2$
- Discuss the relative merits of both cases by estimation of error in the two cases.

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1. **SETUP & FORMULAE:** The Kater's pendulum is a compound of bar pendulum with two knife edge support and with two geometrically similar wooden and steel blocks placed at the opposite ends of the bar. These two objects are used to control the position of the CG so as to make the pendulum have almost same time period (T_1 and T_2) of oscillations in reverse modes. -The value of acceleration due to gravity (g) can be found from the equation

$$g = \frac{8\pi^2}{\left[\frac{T_1^2+T_2^2}{l_1+l_2} + \frac{T_1^2-T_2^2}{l_1-l_2}\right]} \xrightarrow{T_1 \sim T_2} \frac{8\pi^2}{\left[\frac{T_1^2+T_2^2}{l_1+l_2}\right]}$$

where l_1 and l_2 are the distance of the point of suspension from the CG.

2. **Tables: Observations and Calculations**

   - (Preliminary Step) Adjust the positions of the weights and record of times of oscillations during for (a) $T_1 \sim T_2$ and (b) $T_1 \neq T_2$.
   - (Final Step) Tabulate time periods T_1 and T_2 for 50 oscillations. Repeat for 100 oscillations.
   - Also tabulate the corresponding distances l_1 and l_2
   - Discuss the relative merits of both cases ($T_1 \sim T_2$ and $T_1 \neq T_2$) by estimation of error in the two cases.

3. **APPLICATIONS**

   (a) Any of say (i) Analyzing Rotational Motion, (ii) Period and Frequency Determination (iii) Moment of Inertia Calculation (iv) Structural Engineering (v) Biomechanics (vi)Architectural Design