Shantilal Shah Engineering College, Bhavnagar

General Department

Physics (Practical)-3110011

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Shantilal Shah Engineering College, Bhavnagar

Physics Laboratory Manual

Experiment-1 (P_1)

- **Objective:** Determination of the velocity of ultrasonic waves in a non-electrolytic liquid by ultrasonic interferometer.

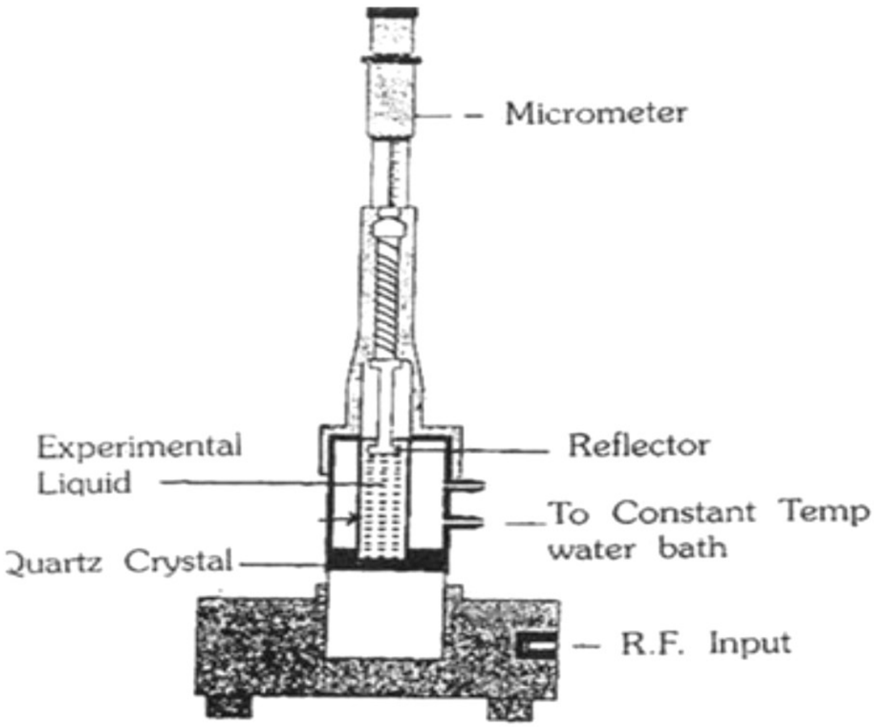
- **Item Required:** Ultrasonic Measurement Lab Trainer, Liquid cell**,** Mains Cord**,** Co-axial cable

- **Procedure:**

1. Connect the mains cord to the Trainer.
2. Insert the cell in the base and clamp it with the help of a screw provided on one of its side.
3. Unscrew the knurled cap of cell and lift it away from double walled construction of the cell. In the middle portion of it pour experimental liquid (water) and screw the knurled caps as shown in figure 1.
4. Two chutes in double wall construction are provided for water circulation to maintain desired temperature.

    Note: Make sure the power switch should be 'Off' at the time of connection.
5. Connect co-axial cable between liquid cell and receiver terminal of Nvis 6109 Ultrasonic Measurement Lab Trainer.

    Note: Set the gain knob at fully anticlockwise, before switch 'On' the trainer.
6. Switch 'On' the power of trainer.
7. Wait for 2-3 minutes until display shows a constant value of current (because for better interference, some time is needed).
8. Adjust the gain knob for maximum constant value of current.
9. Move the micrometer slowly (by increments of 0.01mm) in either clockwise or anticlockwise direction till the current shows minimum reading on meter.
10. Note the readings of micrometer corresponding to the value of current. Now again rotate the micrometer in same direction until the second minimum value of current occurred.
11. Note the readings of micrometer in the table below.
12. Repeat the same procedure for number of consecutive minima value of current and tabulate them.



[Figure: **Ultrasonic interferometer**]

❖ Observation Table:

Sr No.	Current (µA) Min	Micrometer Reading N(mm)			Difference between consecutive Max/Min $\lambda/2 = N_{n+1} - N_n$
		M.S.R	C.S.R.	T.R.=M.S.R.+ (C.S.R.*L.C.)	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

- Mean λ/2 =………………

  ∴ Wavelength λ = ………….. mm = ……….. × 10^{-3} m

❖ Calculations:

- Frequency f = 2MHz = 2 × 10^{6} Hz

- Therefore velocity of Ultrasonic wave in experimental liquid,
  v = λ × f = ……………………………….. m/s

❖ Result:

The velocity of Ultrasonic wave in experimental liquid v = …………….. m/s.

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Experiment-2 (P_2)

❖ **Aim:** To determine the frequency of an electrically maintained tuning fork by,

1. Transverse mode of vibration
2. Longitudinal mode of vibration

❖ **Apparatus:** Electrically maintained tuning fork, fine thread, scale pan, weights and meter scale.

❖ **Transverse drive mode :**

- In this arrangement the vibrations of the prongs of the tuning fork are in the direction perpendicular to the length of the string.
- The time, during which the tuning fork completes one vibration, the string also completes one vibration. In this mode, frequency of the string is equal to the frequency of the tuning fork.

$$\text{Frequency } f = \sqrt{\frac{gM}{4\mu l^2}}$$

Where the total mass M is equal to the mass M' of the weight in the scale pan plus the mass M_0 of the scale pane, M = M' + M_0.

Linear density of string, $\mu = 1.17 \times 10^{-4} \frac{Kg}{m}$

Mass of the scale pan M_0 = 0.5 gm

Longitudinal drive mode:

- In this arrangement the tuning fork is set in such a manner that the vibrations of the prongs are parallel to the length of the string.
- The time, during which the tuning fork completes one vibration, the string completes half of its vibration. In this mode, frequency of the fork is twice the frequency of the string.

$$\text{Frequency } f = \sqrt{\frac{gM}{\mu l^2}}$$

Performing Simulator

Combo Box:

Longitudinal mode- In this arrangement the tuning fork is set in such a manner that the vibrations of the prongs are parallel to the length of the string.

Transverse mode - In this arrangement the vibration of the prongs of the tuning fork are in the direction perpendicular to the length of the string.

Selecting Tuning fork - There are five tuning forks with different frequencies. One can choose any one of the tuning forks to carry out the experiment.

Select Environment- Use only earth's environment.

Sliders:

Mass in the pan M'- This slider is used for adding mass in the scale pan.

Transformer Voltage- This is used to change the voltage of the step down transformer.
Note: At 8V, we get well defined loops.

Scale Position- This is used to change the position of the meter scale and one can calculate the length of one loop.

Power On - This is used to start the experiment.

Pointer movement- The pointer can be moved by using the arrow keys on either side of the zoomed part of the loop image in the simulator.

Reset- One can repeat the whole experiment by using this button.

Procedure for simulation

1. Select the mode of Vibration.
2. Select a particular tuning fork to carry out the experiment.
3. Choose the environment for doing the experiment.
4. The transformer voltage is adjusted to 8V.
5. Mass is suspended in the scale pan.
6. Power on the button and loops will be formed.
7. Length l for one loop is measured by adjusting the scale position.
8. Using equations for mode of vibration, calculate the frequency of particular tuning fork.
9. Repeat the experiment by changing the parameters.

❖ ***Observation Table***

Mode of Vibration: Transverse

Mass of the pan M_0 = 0.5 gm

Tuning fork	Mass Suspended M Kg	Total mass M in Kg ($M+M_0$)	Number of Loops N	Length of Loops (Total) L	Length of one Loop $l = L/N$	Frequency in Hz f
1						
2						
3						
4						
5						

- **Calculation of frequency:** $f = \sqrt{\dfrac{gM}{4\mu l^2}}$

Mode of Vibration: <u>Longitudinal</u>

Mass of the pan M_0 = 0.5 gm

Tuning fork	Mass Suspended M Kg	Total mass M in Kg ($M+M_0$)	Number of Loops N	Length of Loops (Total) L	Length of one Loop $l = L/N$	Frequency in Hz f
1						
2						
3						
4						
5						

- **Calculation of frequency:** $f = \sqrt{\frac{gM}{\mu l^2}}$

❖ **Result:** (1) Frequency of tuning fork in transverse mode is = ...Hz

(2) Frequency of tuning fork in longitudinal mode is = ...Hz

Experiment-3 (P_3)

- **Objective:** To find reverberation time using sabin's formula.

- **Item Required:** Measurement tap.

- **Procedure:**

1. Measure length, width and height in meter for given room.
2. Find volume of hall using $V = l \times W \times h$
3. Find area of each wall of the room.
4. Calculate reverberation time using following formula:

$$T = \frac{0.167\ V}{\sum aS}$$

5. Repeat the same by considering all windows of room.
6. Repeat the same by considering all windows of room and carpet flooring and gypsum ceiling.

- **Observations:**
  - Length of room/hall, l = ... m
  - Width of room/hall, W = ... m
  - Height of room/hall, h = ... m
  - Area of window, S_w = ... m^2
  - Volume of the room/hall, V = ...m^3
  - Absorption coefficient of flooring tiles = 0.02 O.W.U m^2
  - Absorption coefficient of concrete wall = 0.05 O.W.U m^2
  - Absorption coefficient of wood = 0.08 O.W.U m^2
  - Absorption coefficient of thick carpet = 0.65 O.W.U m^2
  - Absorption coefficient of perforated Gypsum = 0.84 O.W.U m^2

❖ Observation Table:

Without Windows				
Absorption of walls, a_lS_1 (O.W.U m^2)	**Absorption of floor, a_2S_2 (O.W.U m^2)**	**Absorption of Ceiling, a_3S_3 (O.W.U m^2)**	**Total Absorption, ΣaS (O.W.U m^2)**	**Reverberation Time, T_1 (s)**

With wooden windows					
Absorption of walls, a_lS_1 (O.W.U m^2)	**Absorption of floor, a_2S_2 (O.W.U m^2)**	**Absorption of Ceiling, a_3S_3 (O.W.U m^2)**	**Absorption of Windows, a_wS_w (O.W.U m^2)**	**Total Absorption, ΣaS (O.W.U m^2)**	**Reverberation Time, T_2 (s)**

Floor with carpet, Ceiling with perforated gypsum and wooden windows					
Absorption of walls, a_lS_1 (O.W.U m^2)	**Absorption of floor, a_2S_2 (O.W.U m^2)**	**Absorption of Ceiling, a_3S_3 (O.W.U m^2)**	**Absorption of Windows, a_wS_w (O.W.U m^2)**	**Total Absorption, ΣaS (O.W.U m^2)**	**Reverberation Time, T_3 (s)**

❖ Calculations:

(1) <u>Without windows:</u>

- Total Absorption, $\Sigma aS = a_1S_1 + a_2S_2 + a_3S_3 =$ ……………….. O.W.U. m^2

- Reverberation Time, $T = \dfrac{0.167\,V}{\sum aS}$

(2) With windows:

- Total Absorption, $\Sigma aS = a_1 S_1$(without walls) + $a_2 S_2 + a_3 S_3 + a_W S_W$ = ...O.W.U. m^2

- Reverberation Time, $T = \dfrac{0.167\,V}{\sum aS}$

(3) Floor with carpet, ceiling with perforated gypsum and wooden windows:

- Total Absorption, $\Sigma aS = a_1 S_1$(without walls) + $a_2' S_2' + a_3' S_3' + a_W S_W$ = ... O.W.U. m^2

- Reverberation Time, $T = \dfrac{0.167\,V}{\sum aS}$

❖ Result:

1. The Reverberation time of given room/hall, T_1 = ... s.
2. The Reverberation time of given room/hall with wooden window, T_2 = ... s
3. The Reverberation time of given room/hall with wooden window and floor covered with carpet and gypsum ceiling, T_3 = ... s

Experiment-4 (P_4)

- **Aim:** To determine the wavelength of the given source using Newton's ring.

- **Components:** Start button, Light source, Filter, Microscope, Lens, Medium and Glass plate.

- **Equation:** The wavelength of monochromatic light can be determined as

$$\lambda = \frac{D_{m+p}^2 - D_m^2}{4\ p\ R}$$

Where, D_{m+p} is the diameter of the $(m+p)^{th}$ dark ring and D_m is the diameter of the m^{th} dark ring.
R is radius of lens used

- **Variable region:**
  - Choose Medium Combo box helps you to choose the type of medium that the simulation have to perform.
  - Radius Slider helps to change the radius of curvature of lens.
  - The wavelength slider helps to change the wavelength of light used.

- **Measurement region:**
  - The start button will help to play the simulation.
  - The variation in the rings can be seen when the medium, wavelength of light or the radius of the lens changes.

- **Procedure:**
  - Click on the "light on" button.
  - Select the lens of desirable radius.
  - Adjust the microscope position to view the Newton rings.
  - Focus the microscope to view the rings clearly.
  - Fix the cross-wire on 20^{th} ring either from right or left of the centre dark ring and take the readings.
  - Move the crosswire and take the reading of 18^{th}, 16^{th}...........2^{nd} ring.
  - You have to take the reading of rings on either side of the centre dark ring.
  - Enter the readings in the tabular column.
  - Calculate the wavelength of the source by using the given formula.

❖ Observations:

➢ **To find Least Count**

1. One main scale division= .... cm
2. Number of divisions on Vernier = ...
3. L.C = One main scale division/ Number of division on vernier

   =................................
4. R= radius of lens = ...

❖ Observation Table:

Sr. No.	Order of ring	Microscopic Reading (cm)		Diameter D (cm)	D^2 (cm^2)	D^2_{m+p} -D^2_m (cm^2)
		Left	Right			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

❖ Calculation:

➢ Mean value of D^2_{m+p} - D^2_m =.......cm^2

➢ Wavelength of light $\lambda = \frac{D^2_{m+p} - D^2_m}{4pR}$

$\lambda =$............................nm

❖ Result:

Wavelength of light from the given source is found to be = ... nm

Experiment-5 (P_5)

❖ **Aim:** Understand the function of CRO and measure the *rms* voltage ns frequency of AC signal using CRO.

❖ **Components:** CRO, Function Generator

❖ Procedure:

- Switch on the CRO and Function Generator.
- Study and understand the function of every knob on CRO and function generator.
- Set function generator to any frequency with a particular peak to peak voltage (V_P)
- Connect the output of function generator to any channel of CRO.
- Adjust CRO so that stable and full signal is viewed.
- Measure V_P using formula-(1). Determine V_P & V_{rms}.
- Determine the frequency of the same signal.
- Repeat for different signals.

❖ Observation Table:

1. Measurement of AC voltage:

Sr. No.	Signal no.	Division on Y-axis	Volt/div.	V_P	V_{rms}
1	Signal-1				
2	Signal-2				
3	Signal-3				

2. Measurement of AC frequency:

Sr. No.	Signal no.	Division on X-axis	Time/div.	Time Period (T)	Frequency (f)
1	Signal-1				
2	Signal-2				
3	Signal-3				

❖ Calculation:

1. Signal-1

- Voltage (V_P) = (Division on Y-axis) (volt/division) = ...
- V_{rms} = 0.707 V_P =.....................
- Time period (T) = (Division on X-axis) (time/division) = ...
- Frequency (f) =....................

2. Signal-1

- Voltage (V_P) = (Division on Y-axis) (volt/division) = ...
- V_{rms} = 0.707 V_P =.....................
- Time period (T) = (Division on X-axis) (time/division) = ...
- Frequency (f) =....................

3. Signal-1

- Voltage (V_P) = (Division on Y-axis) (volt/division) = ...
- V_{rms} = 0.707 V_P =.....................
- Time period (T) = (Division on X-axis) (time/division) = ...
- Frequency (f) =...................

❖ Result:

With the help of CRO one can determine the *rms* voltage and frequency of AC signal.

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Experiment-6 (P_6)

❖ **Aim:** To determine the moment of inertia of the given disc using Torsion pendulum, with identical masses.

❖ **Components:** The given torsion pendulum, two identical cylindrical masses, stop watch, metre scale, etc.

❖ **Procedure:**

1. The radius of the suspension wire is measured using a screw gauge.
2. The length of the suspension wire is adjusted to suitable values like 0.3 m, 0.4 m, 0.5 m, ...0.9 m, 1 m etc.
3. The disc is set in oscillation. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_0 '.
4. The two identical masses are placed symmetrically on either side of the suspension wire as close as possible to the centre of the disc, and measure d_1 which is the distance between the centres of the disc and one of the identical masses.
5. Find the time for 20 oscillations twice and determine the mean period of oscillation T_1.
6. The two identical masses are placed symmetrically on either side of the suspension wire as far as possible to the centre of the disc, and measure d_2 which is the distance between the centres of the disc and one of the identical masses.
7. Find the time for 20 oscillations twice and determine the mean period of oscillation T_2.
8. Find the moment of inertia of the disc using the given formulae.

❖ Observations:

1. Length of the suspension wire = ...m
2. Radius of the suspension wire = ...m
3. Mass of each identical masses = ...kg
4. d_1 =...........m
5. d_2 =...........m

❖ Observation Table:

Length of the suspension wire *l* (*m*)	**Time for 20 oscillations (in seconds)**									**Period of oscillations (in seconds)**			$\frac{T_0^2}{(T_2^2 - T_1^2)}$
	Without mass			**With masses at d_1**			**With masses at d_2**			T_0	T_1	T_2	
	1	**2**	**Mean (T_0)**	**1**	**2**	**Mean (T_1)**	**1**	**2**	**Mean (T_2)**				

❖ Calculations:

Moment of inertia of the given disc, $I_0 = 2\, m\, (d_2^2 - d_1^2) \frac{T_0^2}{(T_2^2 - T_1^2)}$

❖ Result:

The moment of inertia of the given disc is .... kg-m^2

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Experiment-7 (P_7)

❖ **Objective:** Measurement of the distance using ultrasonic sensors

❖ **Procedure:**

1. Connect the mains cord to the Trainer.
2. Switch 'On' the power supply.
3. Now select Clock Generator for frequency of 40 kHz at mode '2'.
4. Select second switch at "Distance Measurement" mode.
5. Adjust the Threshold Voltage such that the display shows exact reading of distance.
6. Take the reflector plate from the accessories box and hold it with the hands in the Ultrasonic range.
7. Move the reflector plat up and down parallel to the ultrasonic sensors (Transmitter and Receiver)
8. Observe the display as it shows the distance (in cm) between the ultrasonic sensors and the object.
9. Note the reading of distance and compare it by taking a meter scale.

   Note: Object should be placed more than 28cm far from the Ultrasonic sensors.

❖ **Result:** The distance measured by ultrasonic sensors is ………………. m.