

## EXPERIMENT NO. 01

### To determine and verify the time period of a cantilever.

Name of Experiment - To determine and verify the time period of a cantilever.

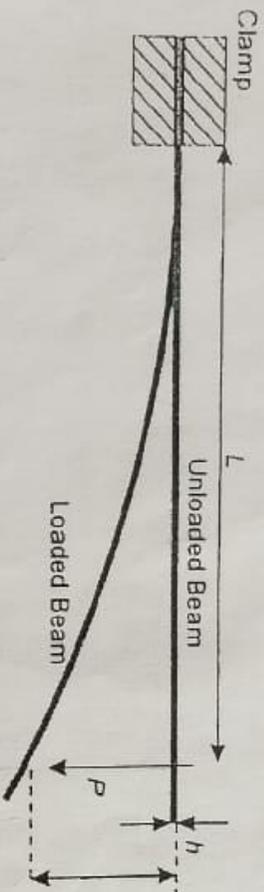
Apparatus Required - 2 meter sticks, weights, stop watch, tape, scissor.

Theory -

What is a cantilever beam?

A rigid structural element that extends horizontally and is supported at only one end Example- balcony supported at one end and unsupported at the other end, road direction signs supported at one end and free at the other, parking shades, swimming pool diving boards. Some cantilevers can be supported throughout their lengths by the cables. When a load is applied to the cantilever, it is transferred to the fixed end by bending.

$$T = 2\pi \sqrt{\frac{\text{Depression}}{g}}$$



#### Procedure

1. Set up the apparatus as shown in the graph. Make sure that the meter stick is attached stably to the stand and the meter stick measuring the amplitude is attached vertically on the ground for higher accuracy of measurement.
2. Lay a mass of 50 gm. at the end of meter stick stable it with plastic tapes
3. Pull the end of the meter stick downwards with one finger of amplitude 8cm, measured by a meter stick. The oscillation or the experiments should start with the same maximum displacements for all trials throughout the experiment.
4. Release the meter stick to allow the meter stick to oscillate. Start the stop watch simultaneously when released.
5. Stop the stop watch after 10 complete rotations.
6. Note the time taken for 10 rotations and calculate the time period for 1 rotation.
7. Also calculate the time period of a cantilever using the following formula:

$$T = 2\pi \sqrt{\frac{P}{g}}$$

Where P = depression

G = acceleration due to gravity

8. Compare the time period calculated experimentally and using the formula

Observation

S. no.	Load (w) gm	Initial Position of the tip of cantilever	Final Position of the tip of cantilever	(Initial - Final) Position Depression (P) in Cm	Time period $T = 2\pi \sqrt{\frac{P}{g}}$
1.	0	0.87 m	0.87 m	0	0.39
2.	50 gm	0.85	0.85 m	0.04 m	0.56
3.	100 gm	0.87	0.81 m	0.08 m	0.68
4.	150 gm	0.87	0.791 m	0.12 m	

**Result**

The time period of the cantilever beam is .....

For 150 gm

Time period for 20 osc. - 14 Sec.

1 osc. -

$$\frac{14}{20} = 0.7 \text{ Sec}$$

## EXPERIMENT NO. 02

**To determine velocity of ultrasonic in different liquids using ultrasonic interferometer.**

**Name of Experiment** - To determine velocity of ultrasonic in different liquids using ultrasonic interferometer.

**Apparatus:-** A measuring cell containing quartz crystal suitable to the frequency of the R.F. oscillator, A High frequency (H.F.) generator of fixed frequency (2 MHz or 4 MHz).

**Theory:-** The working of the cell is just like the resonance column used for the determination of the velocity of sound in air. The quartz crystal produces ultrasonic waves of known frequency ( $n$ ) in the liquid taken. These waves move upward and are reflected back by a metallic reflector arranged parallel to the surface of the crystal. Standing waves are formed in the liquid if the separation between the crystal and the reflector is a whole multiple of a wavelength. This is the state of resonance which gives rise to electrical reaction on the generator which excites the crystal and is manifested by the crystal current and hence the anode current of the generator becoming maximum, indicated by the maximum deflection of the micrometre needle.

In moving the reflector of the cell downward or upward one passes through a series of indications of maximum currents (Fig. 29.3) the separation between two successive maximum is one half wavelength ( $\lambda/2$ ) from which  $\lambda$  is known. Hence the velocity ( $v$ ) of the ultrasonic wave =  $n\lambda$ .

**Procedure :-** At first, the H.F. generator should not be switched on. The base part of the cell system is connected to the output terminal of the H.F. generator with the help of a shielded cable going into the R.F. input socket.

The cell is inserted in the square base socket and is clamped with the help of a screw provided to the base.

The cell-cap is unscrewed and is lifted away. Now the given liquid is poured in the middle portion of the cell and the cap is screwed back to the cell.

Now, the H.F. oscillator is switched on and is allowed to warm up for about one minute.

The micrometre head is rotated to move the reflector of the cell to a position at which the micrometre needle shows a maximum deflection. The "ADJ" and "GAIN" controls are used to make this deflection quite large but within the scale.

The micrometre head is rotated to shift the reflector at a fairly good distance from the quartz crystal. Now it is moved downward and the micrometre reading is set to an exact mark (say 20.00) with cap reading at zero (or 50).

The reflector is shifted very slowly through cap rotation further downward from this position until maximum current is indicated by the micro Ammeter. For this position, the cap reading is noted. This position is called as the 'first maximum position of the standing wave'.

The reflector is shifted further downward very slowly, until the second maximum is reached. For this position the cap reading is noted. In this way, the positions of ten or twenty maxima are noted. All the readings are inserted in tabular form as shown in the table.

Similarly, the positions of ten or twenty maxima are noted for the shift of the reflector in upward direction. Backlash error should be avoided.

The distance between the selected pairs of maxima is found for finding out the value of  $5\frac{\lambda}{2}$  (or  $10\frac{\lambda}{2}$ ). Both sets of observations should be tabulated Separately.

From this observations, the value of  $5\frac{\lambda}{2}$  or  $10\frac{\lambda}{2}$  is found out and from this the value of  $\lambda$  is known. Hence from  $v = n\lambda$ . The velocity can be calculated.

#### Observations and Calculations: -

Liquid used-K. oil

Frequency of the R.F. oscillator  $n = 4 \text{ MHz}$

Pitch of the micrometre screw = 0.5 mm

L.C. of the micrometre screw = 0.01 mm

**Downward movement of the reflector:** Starting position of the reflector as read on the micrometre scale = 20.00 mm.

Designation of maximum	Position of reflector for maximum micrometre deflection. (Reference Point at 20.00mm)					$5\frac{\lambda}{2}$ (mm)
	Initial cap reading(I)	Final cap reading(F)	Difference (F-I)	Diff. X L.C. (mm)	Position (mm)	
1 <sup>st</sup>	50	41	-9	-0.09	20.00-0.09=19.91	
2 <sup>nd</sup>	41	23	-18	-0.18	19.91-0.18=19.73	
3 <sup>rd</sup>	23	04	-19	-0.19	19.54	
4 <sup>th</sup>	54	37	-17	-0.17	19.37	
5 <sup>th</sup>	37	20	-17	-0.17	19.20	
6 <sup>th</sup>	20	02	-18	-0.18	19.02	0.89(1 <sup>st</sup> -6 <sup>th</sup> )
7 <sup>th</sup>	52	33	-19	-0.19	18.83	0.90(2 <sup>nd</sup> -7 <sup>th</sup> )
8 <sup>th</sup>	33	15	-18	-0.18	18.65	0.89(3 <sup>rd</sup> -8 <sup>th</sup> )
9 <sup>th</sup>	65	46	-19	-0.19	18.46	0.91(4 <sup>th</sup> -9 <sup>th</sup> )
10 <sup>th</sup>	46	29	-17	-0.17	18.29	0.91(5 <sup>th</sup> -10 <sup>th</sup> )

$$\text{Mean } 5\frac{\lambda}{2} = \frac{0.89+0.90+0.89+0.91+0.91}{5} = 0.90$$

$$\frac{\lambda}{2} = 0.18\text{mm}$$

$$\lambda = 0.36\text{mm} = 0.36 \times 10^{-3}\text{m} = 360 \times 10^{-6}\text{m}$$

$$n = 4\text{MHz} = 4 \times 10^6\text{Hz}$$

$$v = n\lambda = 4 \times 10^6 \times 360 \times 10^{-6} = 1440\text{m/s}$$

Velocity of ultrasonic waves in K.Oil = 1440m/s

**Precautions:**

- (i) The liquid should be filtered two or three times before filling into the glass cell. The walls of the cell should be perfectly clean.
- (ii) The crystal should touch the walls of the glass cell. Hence it is preferable to mount it in a cover carrying a hole and screws for adjusting the pressure on the crystal to obtain the best result. It should be immersed completely in the liquid.
- (iii) R.F generator should not be switched on without filling the liquid in the cell, otherwise the quartz crystal may be damaged.
- (iv) Before starting observations, one minute warming time should be allowed to the R.F. generator.

### EXPERIMENT NO. 03

#### To verify laws of reflection from a plane mirror/interface.

**Name of experiment** - To verify laws of reflection from a plane mirror/interface.

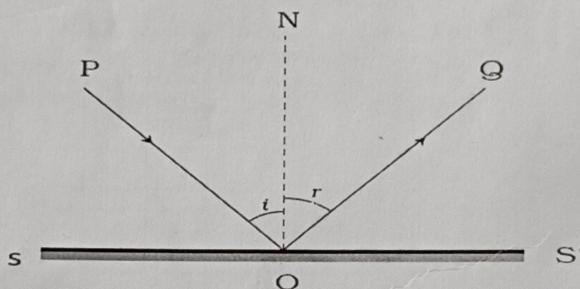
**Apparatus** - A plane mirror with a support to hold it vertical, a drawing board, sheet of white paper, protractor, measuring scale, pins, drawing pins or adhesive tape.

#### Theory -

When light falls on a smooth polished surface, it gets reflected in a definite direction. Fig. 1 shows a ray of light PO, incident on a plane polished surface (plane mirror) SS'. Line OQ shows the changed path of the incident ray after reflection at the point O. The ray PO is called incident ray and ray OQ is called reflected ray. The point O where the incident ray strikes the polished surface is called point of incidence. If ON be the normal to the polished surface SS' at point O, then the angle PON and the angle NOQ are called the angle of incidence (i) and the angle of reflection (r) respectively. The plane containing the incident ray and normal is called plane of incidence.

The principle when the light rays fall on the smooth surface, the angle of reflection is equal to the angle of incidence, also the incident ray, the reflected ray, and the normal to the surface all lie in the same plane.

$$\angle i = \angle r$$



#### Procedure

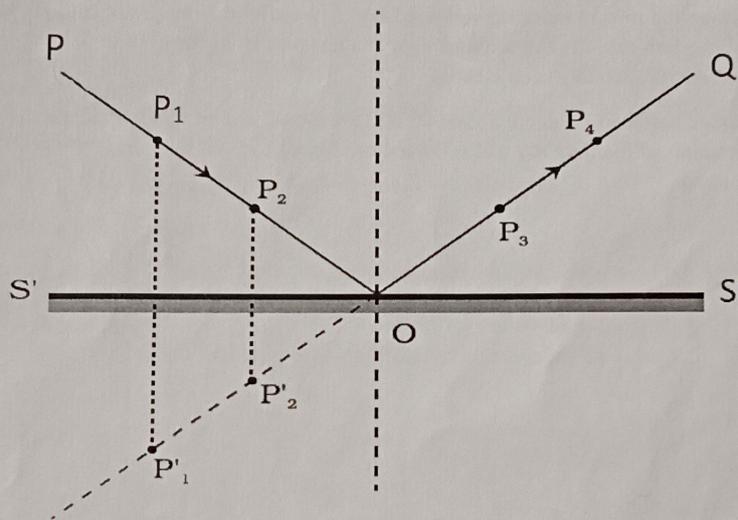
1. Fix a white sheet of paper on the drawing board using either adhesive tape or drawing pins.
2. Draw a thin line SS' in the middle of the paper. Also draw a normal ON to the line SS' at point O as shown in Fig.2.
3. Draw a thin line PO at any angle to the line SS'. Place the mirror vertically on line SS' with the help of a support so that its polished surface faces line PO.
4. Vertically fix two pins P1 and P2 with their tips, separated by a suitable distance of about 5 to 6 cm at two points on line PO. Look at the images P'1 and P'2 of pins P1 and P2 respectively from the same side of the plane mirror.
5. Fix two pins P3 and P4, vertically such that their feet appear to be in the same straight line as that of images P'1 and P'2. Look through the feet of pins P1 and P2, whether the feet of

images (not shown in the Fig.2 of pins P3 and P4 , as seen in the mirror appear to be on the same straight line. If it is so, you have correctly fixed the pins P3 and P4 .

6. Remove all the pins and the mirror. Mark the positions of feet of pins P3 and P4 . Draw a thin line OQ joining the points that mark the position of feet of pins P3 and P4 . Also extend this line till it meets the line SS'. This extended line should meet the surface SS' at the point O. The line OQ shows the path of the reflected ray corresponding to the incident ray along the line PO, at the point of incidence.

7. Measure angles PON ( $\angle i$ ) and NOQ ( $\angle r$ ) and record the values in observation table.

8. Repeat the experiment for two more angles of incidence.



#### OBSERVATIONS AND CALCULATIONS

S. no.	Angle of Incidence $\angle i = \angle PON$	Angle of reflection $\angle r = \angle NOQ$	Difference $\angle i - \angle r$
1.			
2.			
3.			

#### RESULTS AND DISCUSSION

- the reflected ray meet the point of incidence for all angles of incidence.
- As  $\angle i = \angle r$ , and the incident ray, normal and the reflected ray lie in the same plane, laws of reflection are verified.

### PRECAUTIONS

Plane mirror must be placed vertically on the plane of paper.

- Mirror should be made of thin glass with a smooth surface (Why? Otherwise many images may be formed due to multiple reflections). It should be of good quality with good reflecting surface.
- The pins P1 , P2 , P3 . and P4 fixed on the paper may not be exactly perpendicular (or vertical) to the plane of paper, Thus, if their feet are collinear, their heads may not appear to be collinear. Therefore while marking the position of the pins on paper, the positions of their feet should be considered for drawing the lines to show the path of incident and the reflected rays. It is done by marking the position of the holes made by the pins.
- While fixing the pins to mark the reflected ray by viewing the images of pins fixed on the path of the incident ray, the eye must be kept at a distance from the pins so that feet of all of them can be simultaneously seen clearly.
- The distance between P1 and P2 ; and P3 and P4 should not be less than about 5 to 6 cm so that the direction of incident ray and reflected ray can be located with a greater accuracy.

## EXPERIMENT NO. 04

### To verify laws of refraction (Snell's law) using a glass slab.

**Name of Experiment** - To verify laws of refraction (Snell's law) using a glass slab.

**Apparatus** - Drawing board, sheet of paper, board pins, rectangular glass slab.

#### Theory:

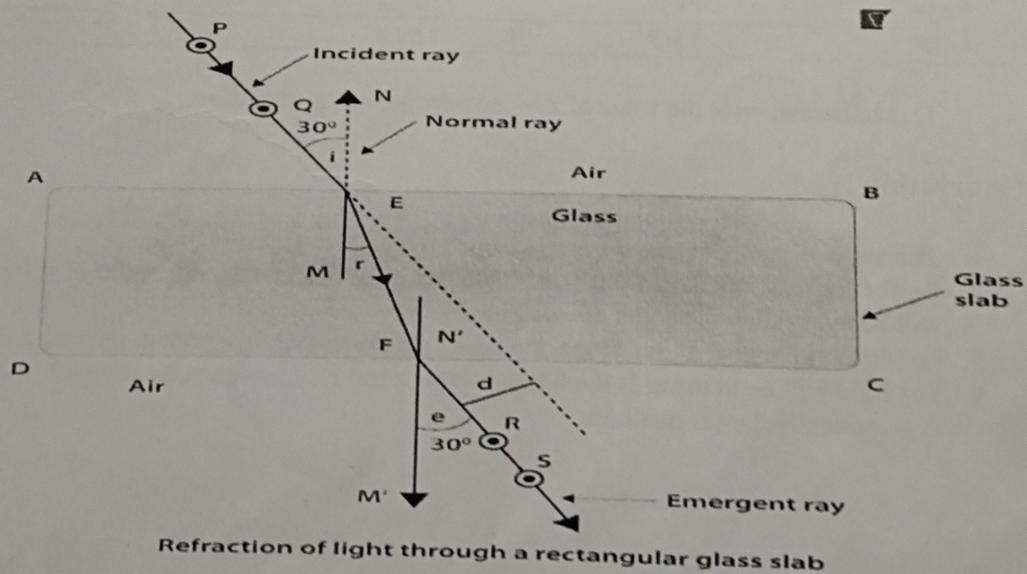
When a light ray incident on air to glass interface through a glass slab obliquely has the following characteristics:

1. When a light ray travels from air to glass, the ray bends towards the normal at the surface of the air-glass boundary.
2. When a light ray travels from glass to air, the angle of refraction is greater than the angle of incidence of glass-air interfaces as the ray of light bends away from the normal.
3. If the angle of incidence is zero, i.e. the incident ray is normal to the interface, the ray of light continues to travel in the same direction after refraction. displacement.
4. The angle of emergence and the angle of incidence will be equal.

#### Refractive index of a medium

When a ray of light passes from air or vacuum to the given medium, the ratio between the sine of the angle of incidence and the sine of the angle of refraction is called the refractive index of the given medium. If 'i' is the angle of incidence and 'r' is the angle of refraction, Refractive index of the medium

$$\mu = \frac{\sin i}{\sin r}$$



### PROCEDURE:

1. Fix a white sheet on the soft drawing board using thumb pins.
2. Place the glass slab at the centre of the white paper and draw its outline boundary using a sharp pencil.
3. Let ABCD be the rectangular figure obtained by drawing.
4. Mark a point E on AB and draw a perpendicular EN and label it as a normal ray.
5. Draw one angle of  $30^\circ$  with the help of protractor with EN. Fix pins at P and Q at 4-5 cm on the ray that is obtained by the angle.
6. Place the glass slab on the rectangular figure ABCD.
7. To fix R and S, see through the glass slab from side CD, such that when seen through the glass slab, all the pins P, Q, R, and S should lie in a straight line.
8. Draw small circles around the pins P, Q, R and S and remove the pins.
9. Remove the glass slab.
10. Join points R and S such that it meets CD at point F. Draw a perpendicular N'M' to CD at point F.
11. Using a pencil, join the points E and F.
12. Measure the angles formed at AB and CD, i.e, the incident angle, refracted angle, and emergent angle.
13. The lateral displacement is obtained by extending the ray PQ in a dotted line which is parallel to ray FRS.
14. Measure the lateral displacement.
15. Repeat the same procedure for angles  $45^\circ$  and  $60^\circ$ .

### Observation Table

Sl. No.	Angle of incidence $\angle i = \angle PEN$	Angle of refraction $\angle r = \angle MEF$	Angle of emergence $\angle e = \angle SFM'$	$\angle i - \angle e$ $\angle PEN - \angle SFM'$
1	$30^\circ$	$28^\circ$	$30^\circ$	$0^\circ$
2	$45^\circ$	$43^\circ$	$44.8^\circ$	$0.2^\circ$
3	$60^\circ$	$56^\circ$	$59.8^\circ$	$0.2^\circ$

Due to human error the value of  $\angle i - \angle e$  may not be equal to zero.

### Conclusion

1. The angle of incidence and the angle of emergence are almost equal.
2. As the light is traveling from rarer to denser optical medium, the angle of refraction will be lesser than the angle of incidence.
3. For different angles of incidence, the lateral displacement will remain the same.
4. The light will bend towards the normal when it travels from an optically rarer medium to an optically denser medium.

### Precautions

1. The rectangular glass slab used should have perfectly smooth faces.
2. The drawing board should be soft so that pins can be easily fixed on it.
3. The angle of incidence should lie between  $30^\circ$  and  $60^\circ$ .
4. All pins base should be in a straight line.
5. The distance between the pins P and Q or the pins R and S, about 5 cm gap should be maintained.
6. Using a sharp pencil, draw thin lines.
7. The quality of the protractor should be good.
8. The placement of the protractor should be correct to get correct measurements.
9. The perpendiculars should be drawn with care.

### Sources of Error

1. There shouldn't be any air bubbles in the glass slab.
2. The measurements done by the protractor should be accurate.