Engineering Physics Laboratory (Course Code : PHY119)

Experiment Number: 5

AIM: Determination of the velocity of Ultrasonic waves using Ultrasonic interferometer. Hence find the compressibility of the given liquid.

Learning Objectives

a. To understand about standing waves in liquid column.

b. To perform the simulated version of the actual ultrasonic interferometer experiment.

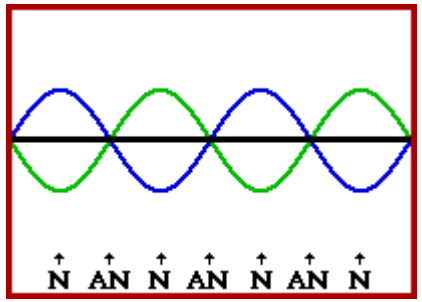
c. To enhance the knowledge of production of ultrasonic waves.

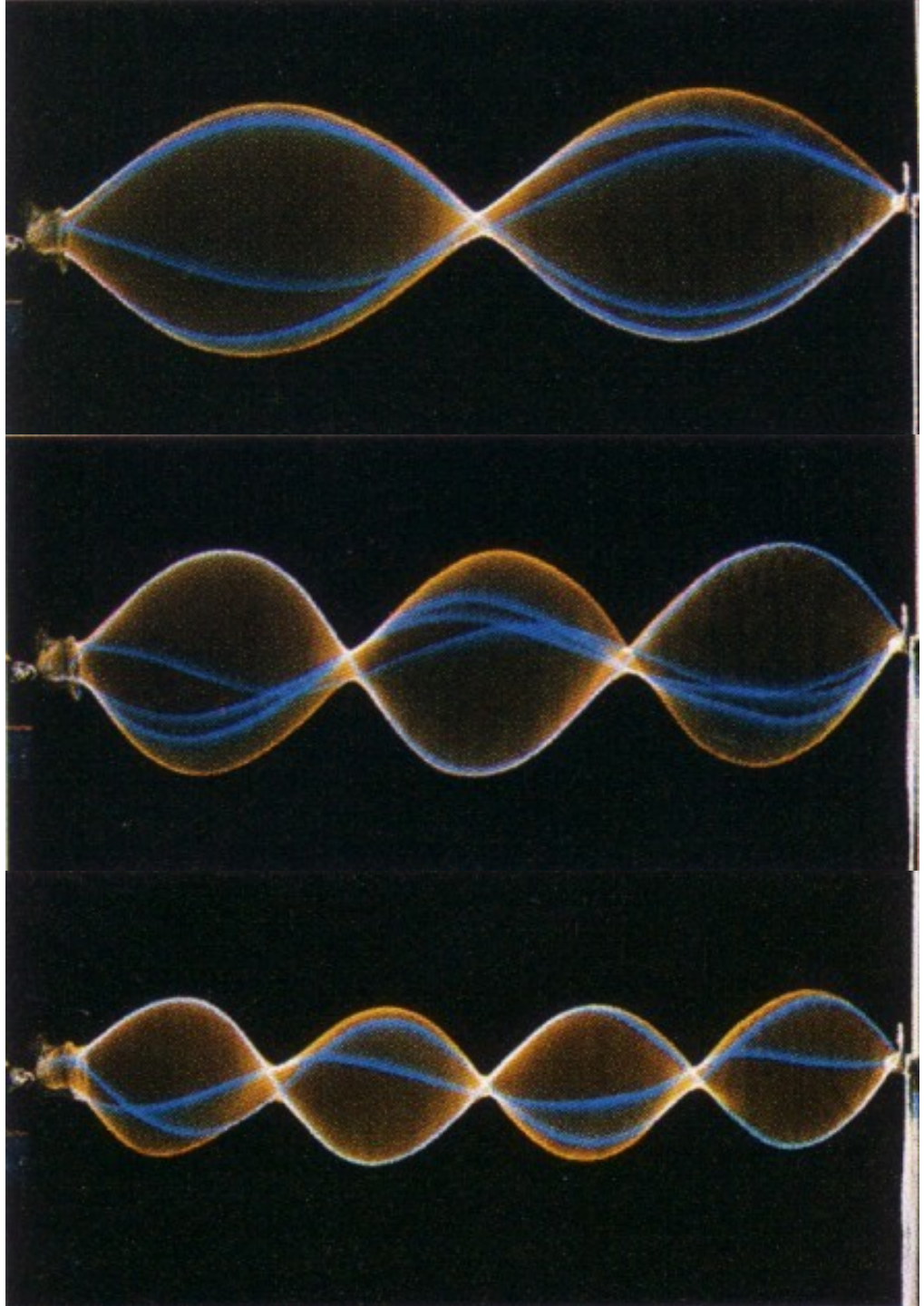
d. To understand the dependence of the velocity of ultrasonic waves on the density of the medium.

Pre-requisite Understanding

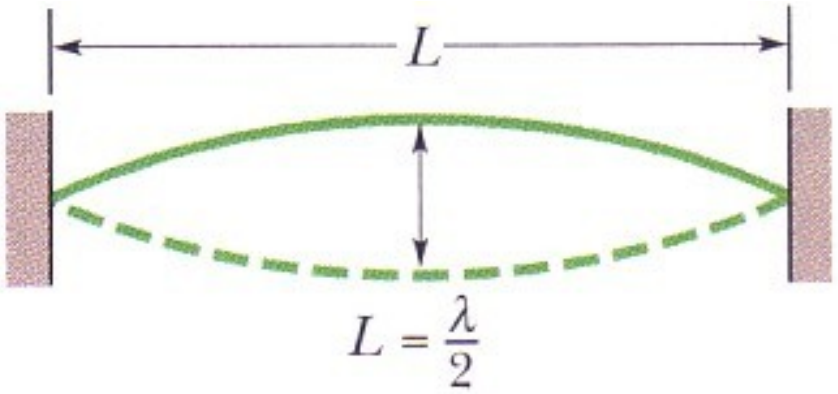
Standing waves and resonance

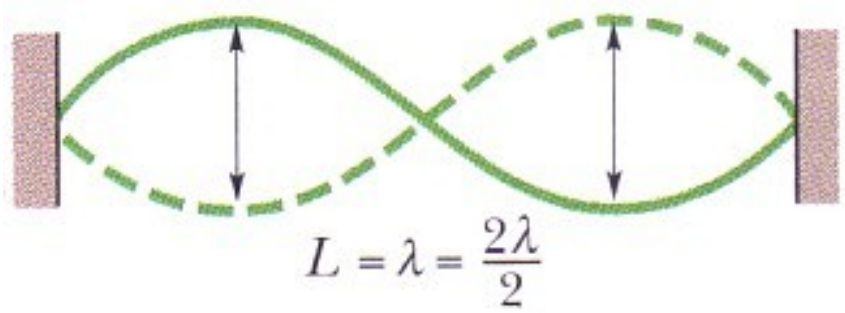
- At ordinary frequencies, waves travel backwards and forwards along the string or any media/vacuum.
- Each new reflected wave has a new phase.

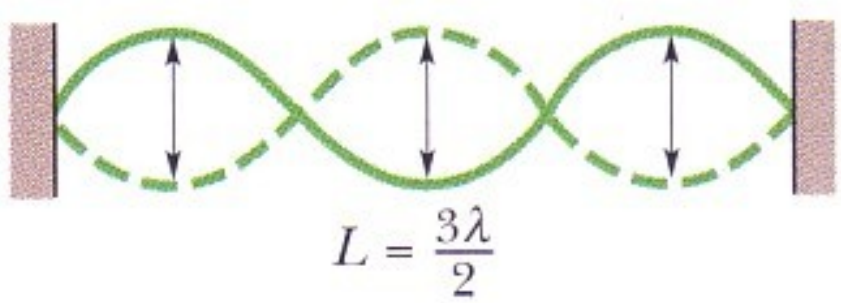




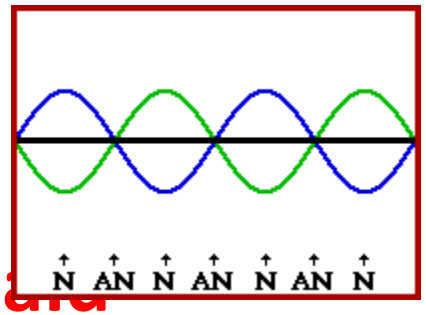
Standing waves and resonance





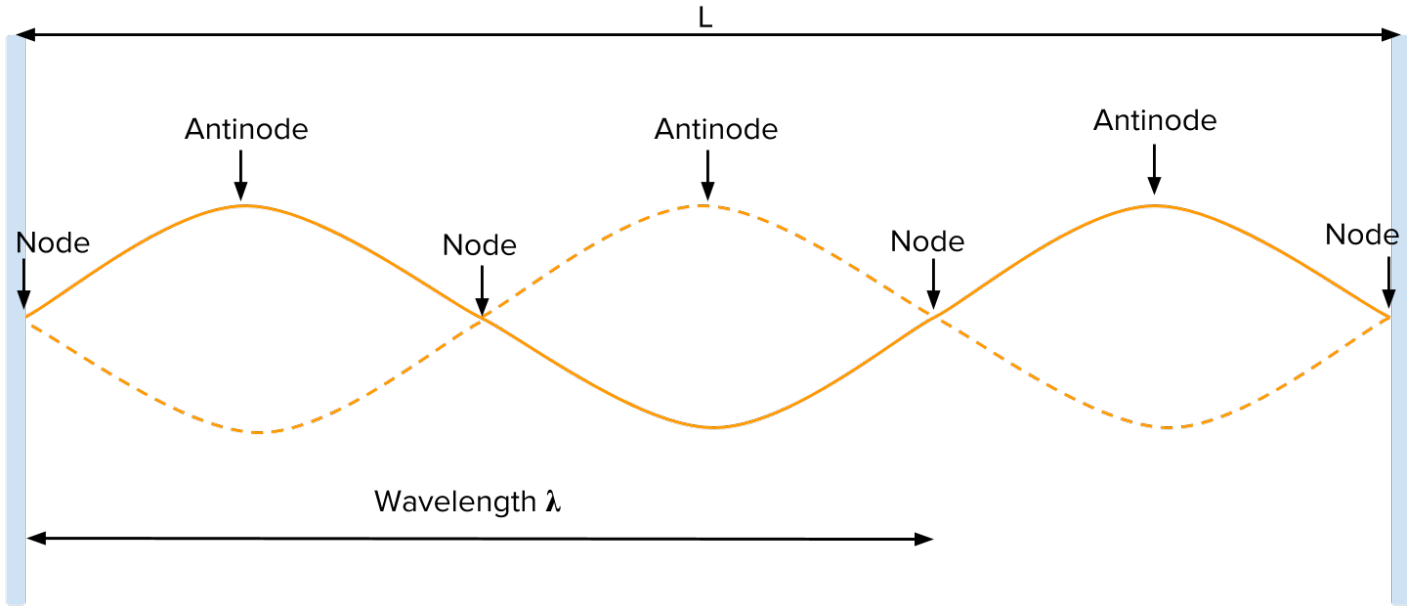


- However, at certain special frequencies, the interference produces strong standing wave patterns.



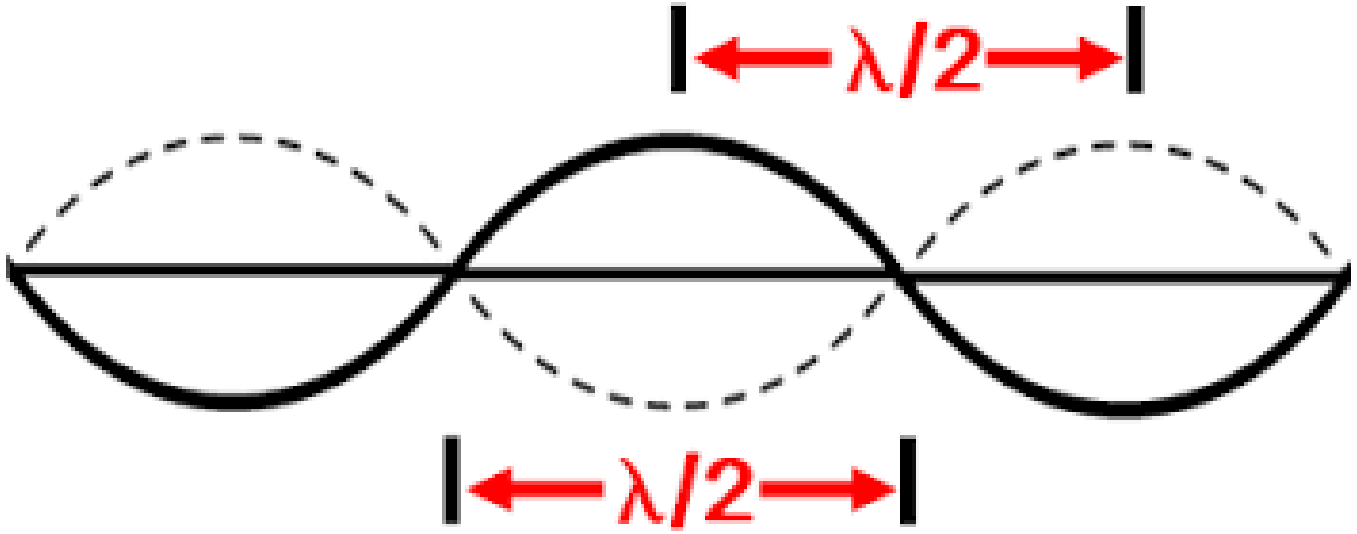
- Such a standing wave is said to be produced at resonance.
- These certain frequencies are called resonant frequencies.

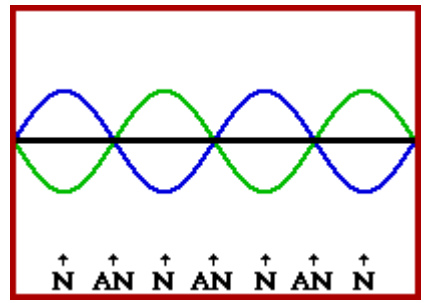
Node and anti-node in a standing wave



Anti-node: Region of maximum amplitude in a standing wave

Node: Region of minimum amplitude in a standing wave





Classified of Sound Waves:

- Depends upon Frequency
- Divided into 3 groups.

Description	Frequency range Hz	Example
Infrasound	0 – 20	Earth quake
Audible	20 – 20,000	Speech, music
Ultrasonic	> 20,000 to 5M	Bat, Quartz crystal

Production of ultrasonic waves by inverse Piezo-electric effect

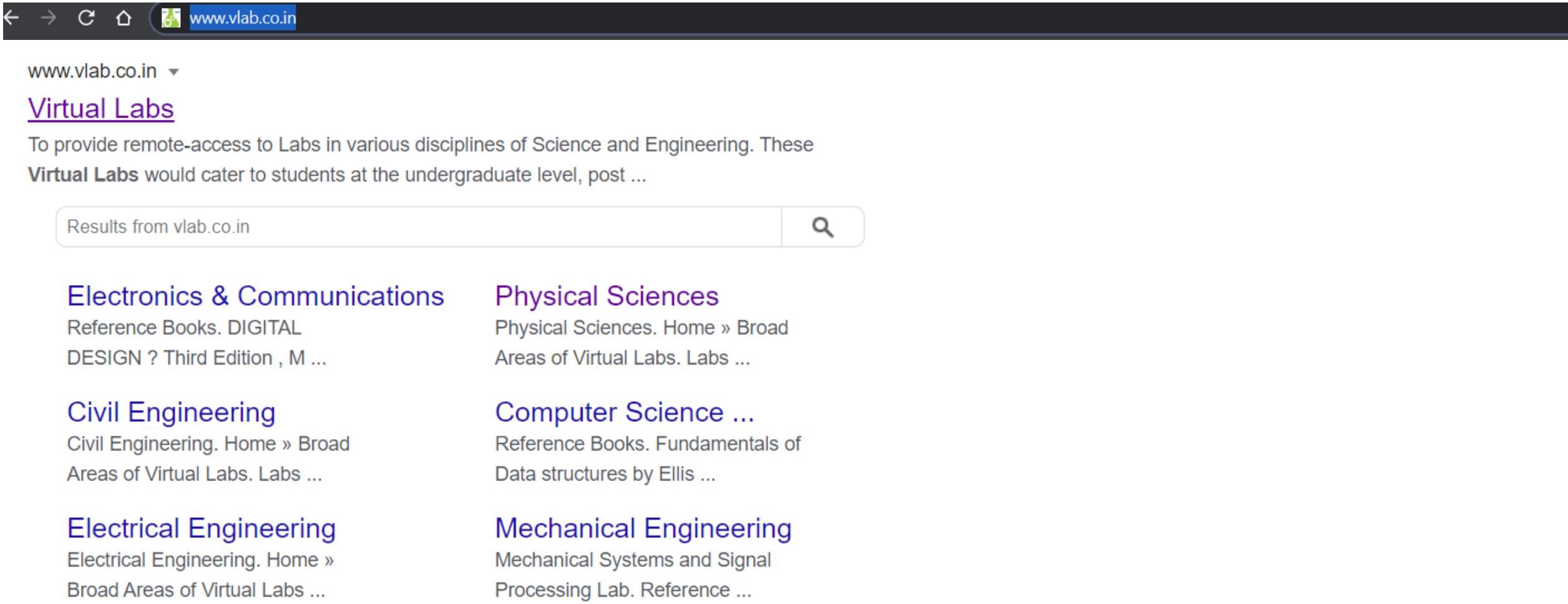
Principle : Inverse piezo electric effect

- If mechanical pressure is applied to one pair of opposite faces of certain crystals like quartz, equal and opposite electrical charges appear across its other faces. This is called as piezo-electric effect.
- The converse of piezo electric effect is also true.
- If an electric field is applied to one pair of faces, the corresponding changes in the dimensions of the other pair of faces of the crystal are produced. This is known as *inverse piezo electric* effect or *electrostriction*.

Step by Step guide to perform the experiment in Virtual lab

(1) Follow the slides below.
(2) Click on the YouTube video link: http://www.youtube.com/v/MD_zkNzF3eA&hl=en&fs=1&rel=0&hd=1&autoplay=1

Type this link on the address bar or Click on this link : https://www.vlab.co.in/



This page will open. Scroll down the page end click on Physical sciences

Scroll down the page end click on Physical sciences

Broad Areas of Virtual Labs

- Electronics & Communications
- Computer Science & Engineering
- Electrical Engineering
- Mechanical Engineering
- Chemical Engineering
- Biotechnology and Biomedical Engineering
- Civil Engineering
- Physical Sciences
- Chemical Sciences

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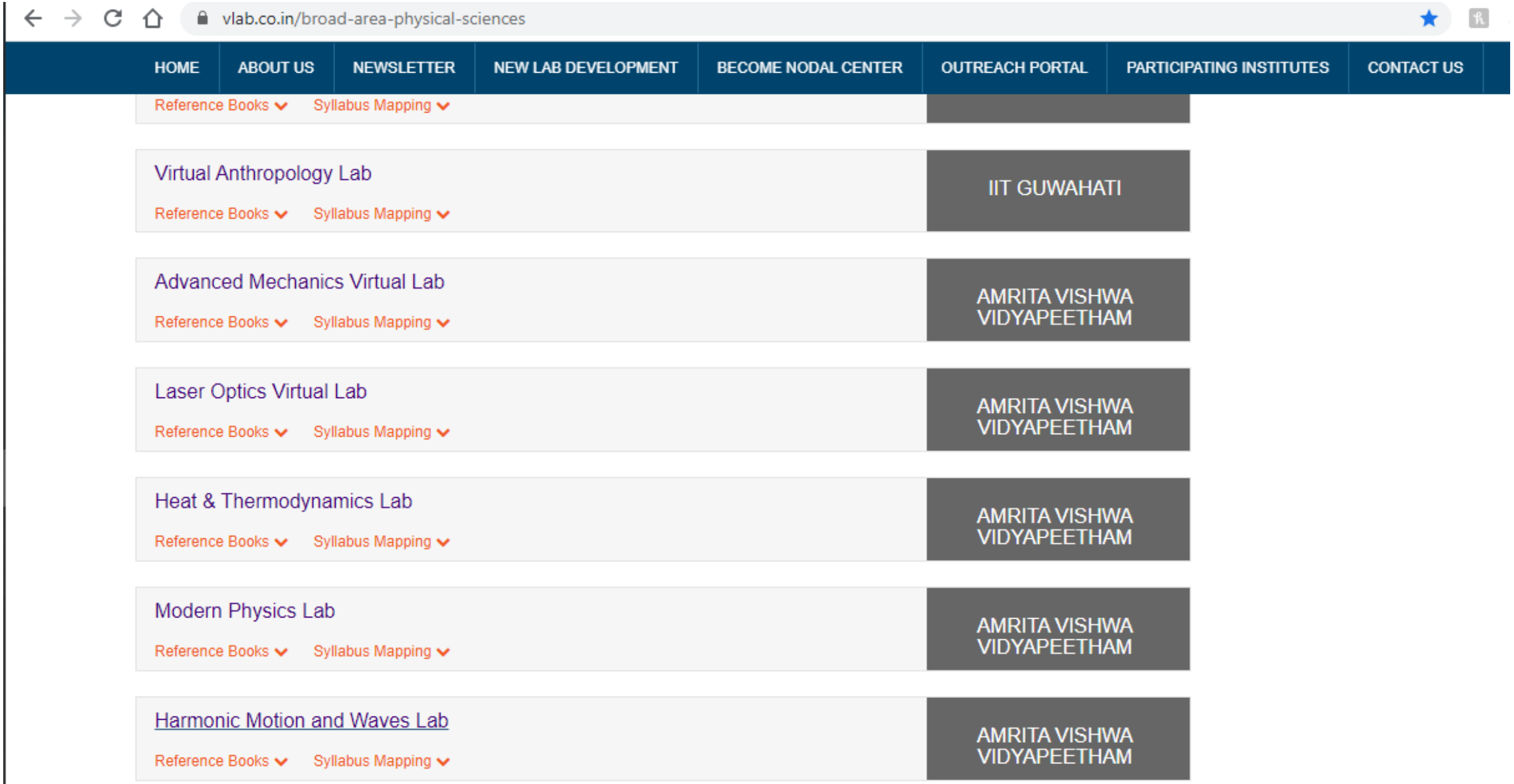
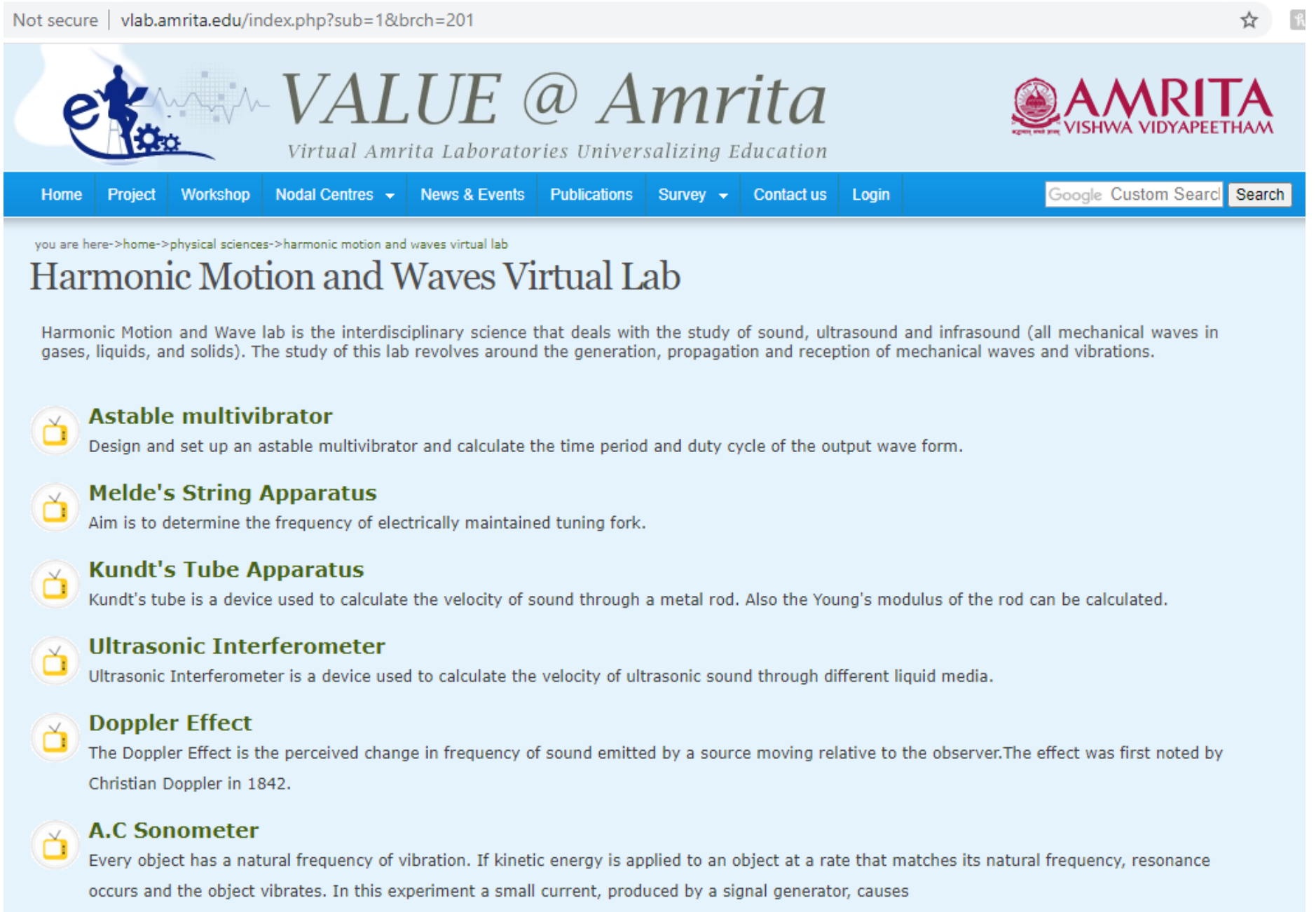
Then click on – Harmonic motion and waves lab



Then click on – Ultrasonic Interferometer



Details of the experiment will be available to you . You may login also.

- **Read the theory**
- **Procedure**
- **Complete the self evaluation to check your understanding**
- **Then click on the simulator**

Ultrasonic Interferometer

Theory | Procedure | Self Evaluation | Simulator | Assignment | Reference | Feedback

Aim:

To calculate the velocity of ultrasonic sound through different liquid media.
To calculate the adiabatic compressibility of the given liquid.

Apparatus:

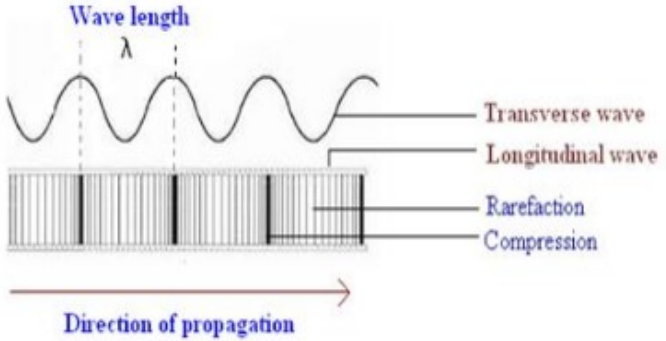
Ultrasonic interferometer, sample liquids, high frequency generator etc.

Theory:

Ultrasonic interferometer is a simple device which yields accurate and consistent data, from which one can determine the velocity of ultrasonic sound in a liquid medium.

Ultrasonics:

Ultrasonic sound refers to sound pressure with a frequency greater than the human audible range (20Hz to 20 KHz). When an ultrasonic wave propagates through a medium, the molecules in that medium vibrate over very short distance in a direction parallel to the longitudinal wave. During this vibration, momentum is transferred among molecules. This causes the wave to pass through the medium.



Generation of ultrasound:

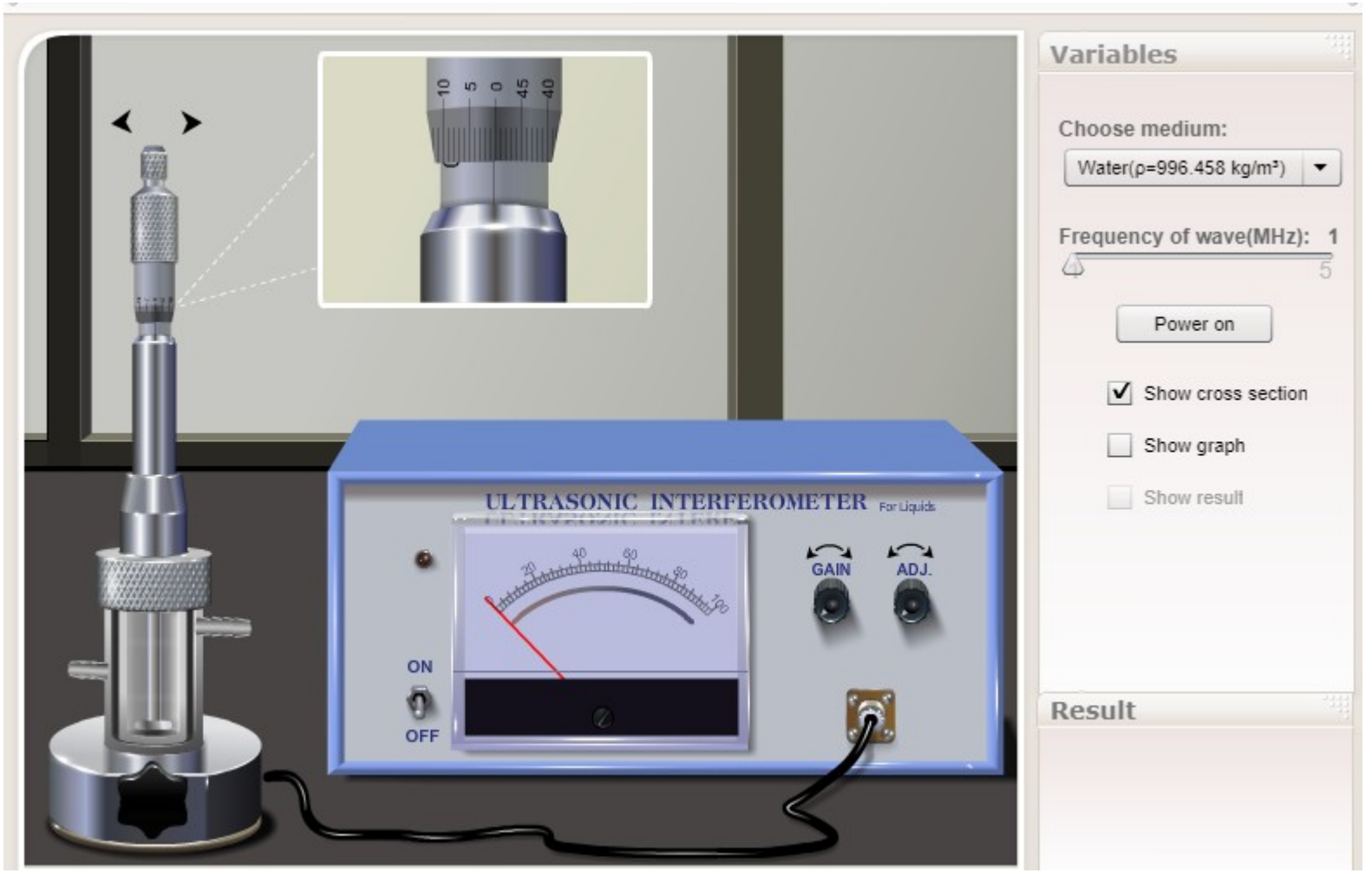
Ultrasonic can be produced by different methods. The most common methods include:

Click on the simulator

Alternative link, if adobe flash is not supported by your browser. It works in html.

http://hmw-au.vlabs.ac.in/harmonic-motion-waves/Ultrasonic_Interferometer/experiment.html

Click on the cross section icon to see the interferometer cell and switch on the frequency generator by clicking ‘Power on’ icon.

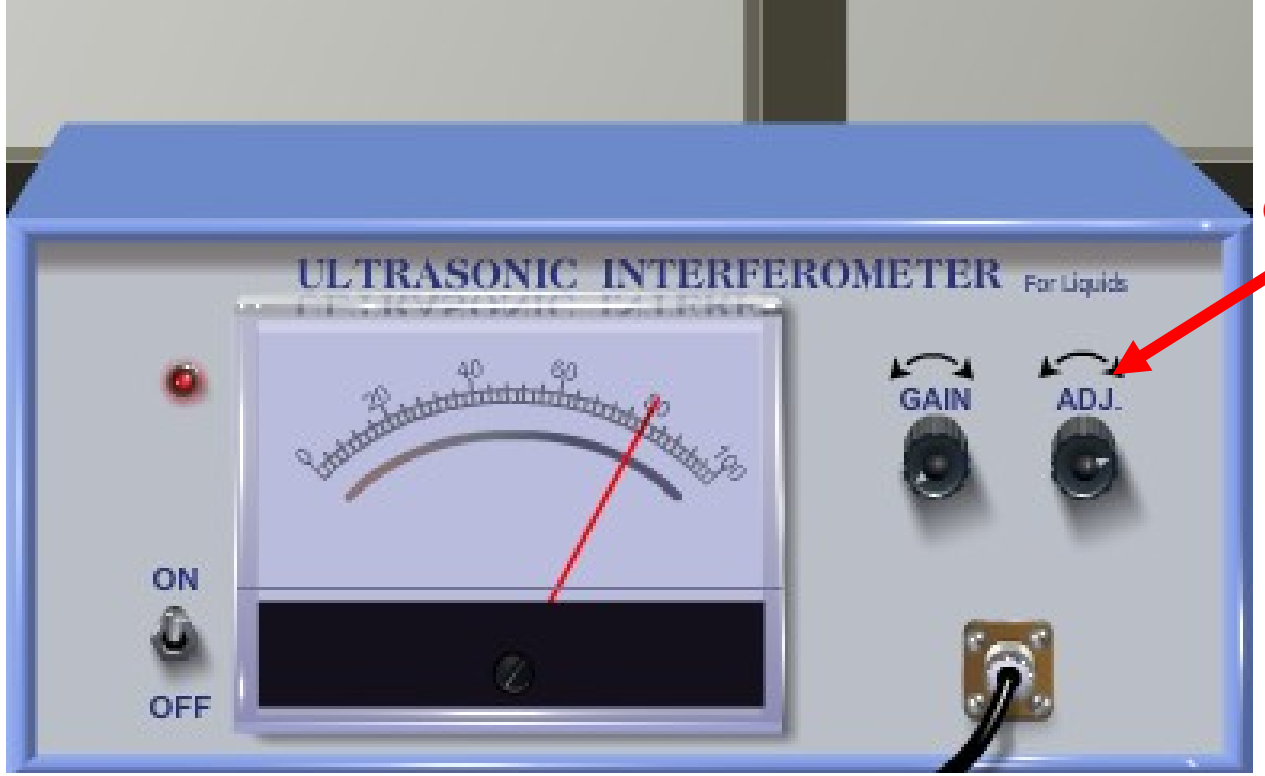


Selection of medium and frequency

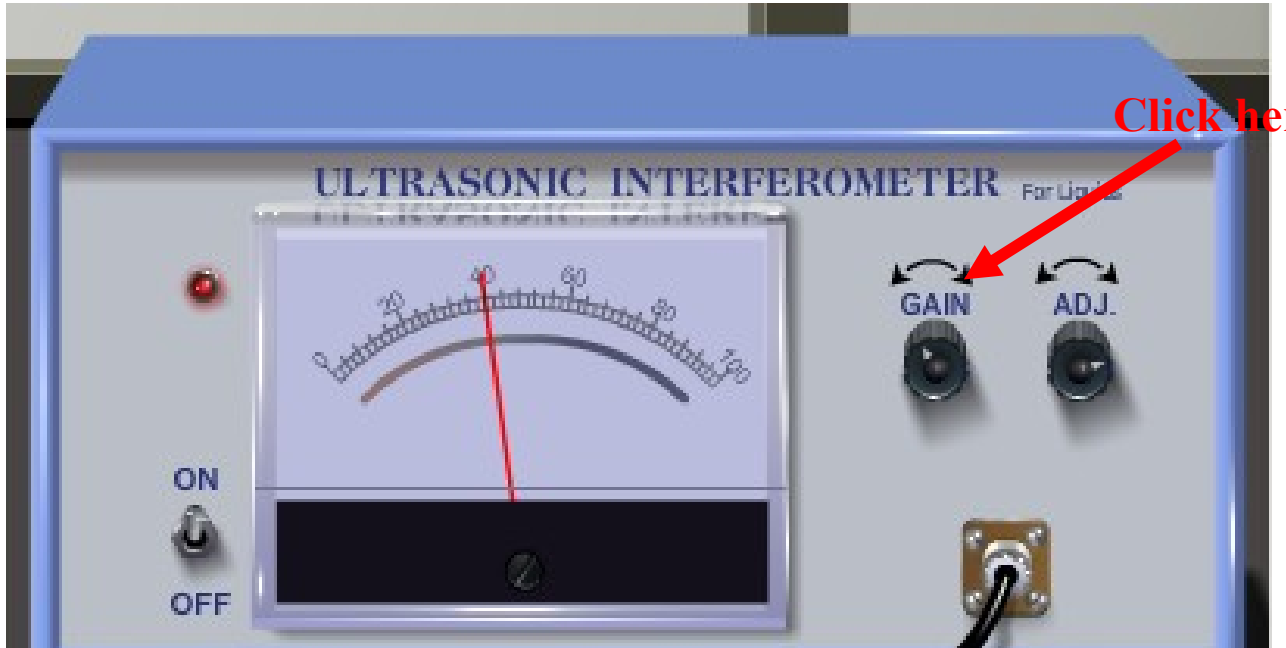
Select the medium from the 'choose medium' drop down menu to 'Water'.

Move the frequency sliding bar to 2 MHZ

Selection of ‘Gain’ and ‘ADJ’ knob



Keep clicking the right arrow of the ‘ADJ’ knob until the ammeter reading reaches a higher value (80 in figure) from it’s ‘zero’ position.

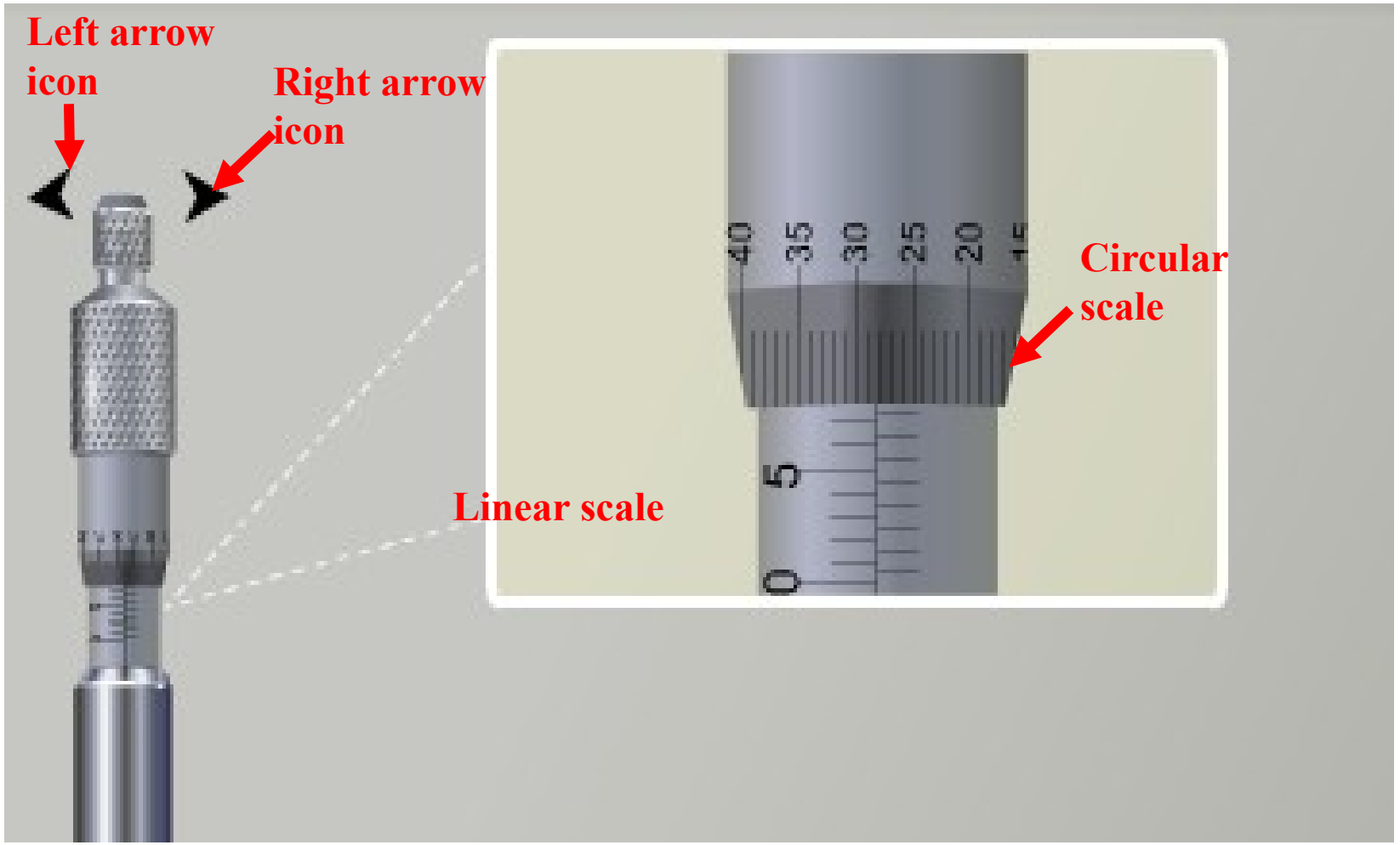


Keep clicking the right arrow of the ‘GAIN’ knob until the ammeter reading reaches a higher value (40 in figure) from it’s ‘zero’ position. Make sure the ‘GAIN’ reading is less than that of ‘ADJ’ reading.

Selection of graph option

Pop-up window to observe the graph.

Click the 'Show graph' option to see the graph of the ammeter readings. A small pop up window will open.

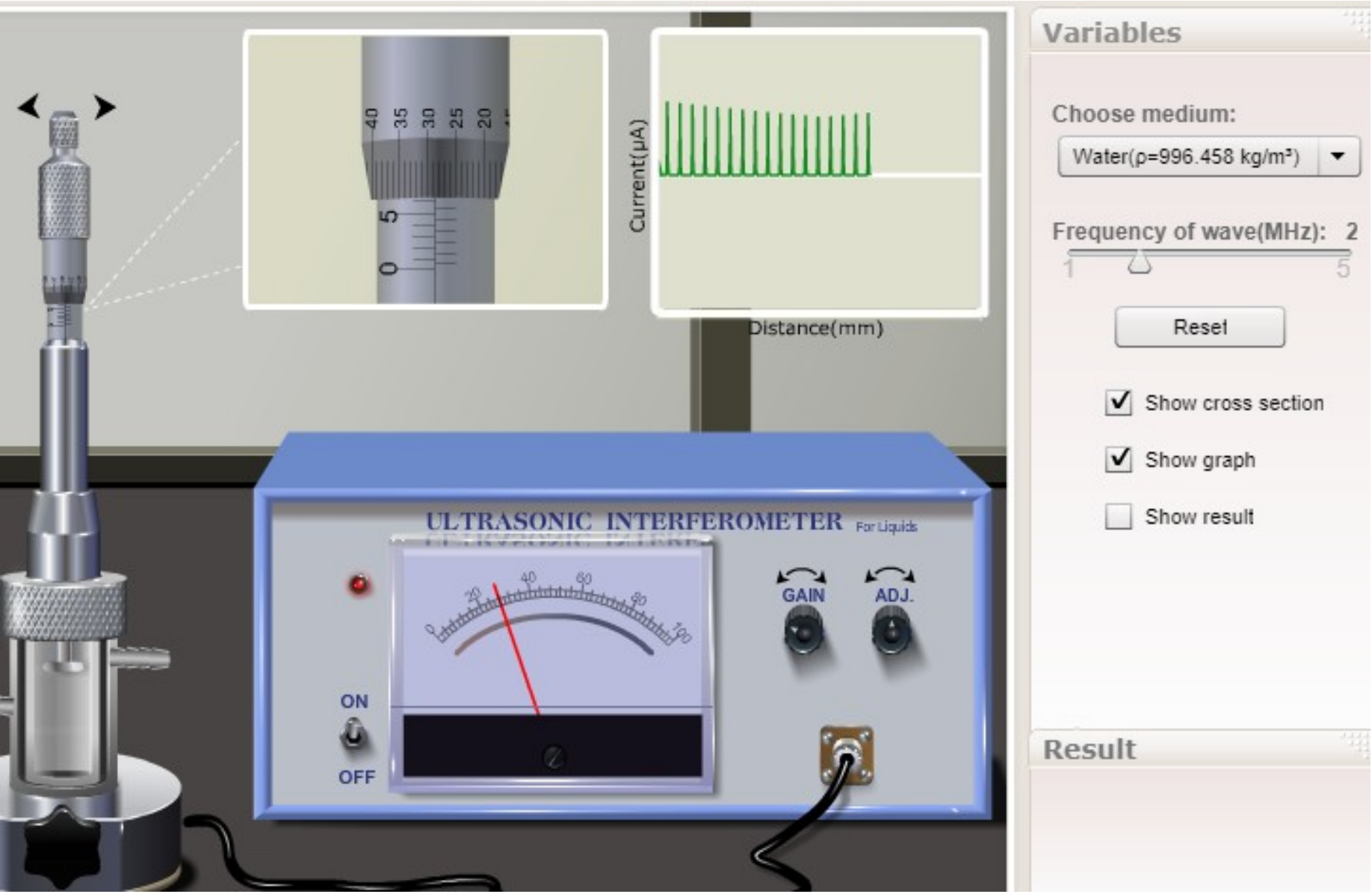


Mico-meter scale

The micro-meter scale, as shown, consists of two parts. Linear scale and circular scale, just like any screw gauge. The circular scale moves upward by clicking the right arrow icon and it moves downward by clicking the left arrow icon, as shown the figure. The least count of this scale is 0.01 mm and all readings are in mm scale.

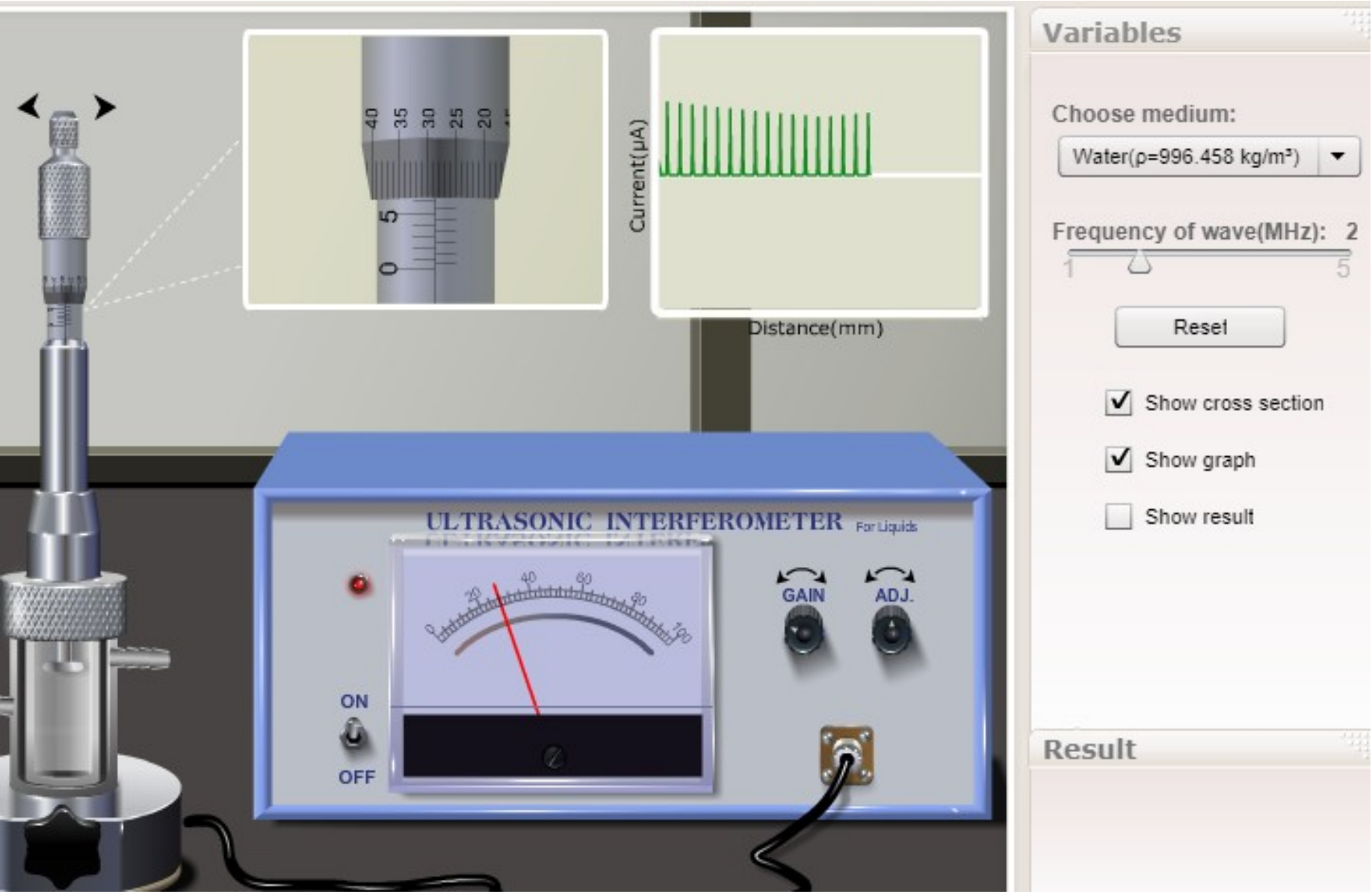
Initially the circular scale is at the ‘zero’ position of the linear scale reading. You need to click the right arrow icon to move the circular scale upward.

Tabulation of Micro-meter readings



- In the simulator, right and left arrows are provided to move the circular scale upward and downward across the linear scale respectively. Increase the micrometer setting till the anode current in the ammeter shows a new maximum. (After the first few clicks, if you click and hold the arrow, the micrometer setting will increase continuously. A single click increases it by a small increment.) Note down the micrometer reading at the new maximum.

Tabulation of Micro-meter readings



- **Micro-meter reading= Linear scale reading + Circular scale reading X Least count**
- **Example : Linear scale reading = 1.2 mm, Circular scale reading = 35.**

Micro-meter reading = 1.2 + (35 X 0.01) = 1.55 mm

- **Note down the micrometer readings for each peak position of the current in the graph.**
- **These readings are the at the current readings at each anti-nodes inside the water column and distance between two anti-nodes is half of the wavelength.**

Tabulation of Micro-meter readings

Order of Maxima (n)	Micrometer reading for maximum			$\frac{\lambda}{2} = x_{n+1} - x_n$	λ
	MSR (mm)	CSD	MSR + (CSD x LC) mm		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

x_{n+1} and x_n are the micro-meter readings for two consecutive maxima current values when moving the circular scale in a particular direction. And the difference between them is the half of the wavelength, multiplying that value by 2, we get the wavelength of ultrasonic wave in mm. One need to calculate the average value of the wavelength and write that down in the table.

scale in a particular direction. And the difference between them is the half of the wavelength, multiplying that value by 2, we get the wavelength of ultrasonic wave in mm. One need to calculate the average value of the wavelength and write that down in the table.

Necessary Formulae

Frequency of the ultrasonic wave (f)

Wavelength of the ultrasonic wave (λ)

Velocity of the ultrasonic waves in the given liquid (v) = λ × f

Compressibility $=1/\rho v^2$

Reading of adobe flash interface

Order of maxima (n)	MSR	CS
1	0.85	
2	1.2	
3	1.6	
4	2.1	
5	2.5	
6	2.8	

Velocity of sound wave: 1498 m/sec

Reading of adobe flash interface

Order of maxima (n)	MSR	CSI					
1	0.5						
2	0.8						
3	1.2						
4	1.7						
5	2.2						

Velocity of sound wave: 1680 m/sec

Reading of adobe flash interface

Order of maxima (n)	MSR	C:					
1	0.4						
2	0.65						
3	1.1						
4	1.5						
5	1.9						
6	2.4						

Velocity of sound wave: 1472 m/sec

Reading of adobe flash interface

Order of maxima (n)	MSR	C:					
1	0.4						
2	0.8						
3	1.2						
4	1.6						
5	2						
6	2.5						

Velocity of sound wave: 1560 m/sec

Reading of adobe html interface

Order of maxima (n)	MSR	C
1	1.1	
2	1.4	
3	1.7	
4	2.2	
5	2.8	
6	3.1	

Velocity of sound wave: 1777 m/sec

Reading of adobe html interface

Order of maxima (n)	MSR	C					
1	1.1						
2	1.4						
3	1.7						
4	2.2						
5	2.7						
6	3.2						

Velocity of sound wave: 1808 m/sec

Reading of adobe html interface

Order of maxima (n)	MSR	C:					
1	1						
2	1.4						
3	1.8						
4	2.2						
5	2.7						
6	3.2						

Velocity of sound wave: 2040 m/sec

Theory based questions

Q: 5.1 The human audible range is

A. 20Hz - 20KHz
B. 15KHz- 2MHz
C. Above 2MHz
D. None of the above

Q: 5.2 Ultrasonic waves have frequency is,

A. Less than that of human audible range
B. In between human audible range
C. Greater than the upper human audible range
D. None of the above

Q: 5.3 The velocity(v) of a wave is related to its wavelength(λ) by the relation,

A. $v = f\lambda$

B. $f = v\lambda$

C. $v = f/\lambda$

D. $\lambda = vf$

Theory based question

Q: 5.4 Among the following, which is the unit of adiabatic compressibility?

A. N/m^2
B. m^2/N
C. Kg/Nm^2
D. None of these

Q: 5.5 Compressibility of a medium is defined as the reciprocal of

A. Young’s modulus Rigidity modulus Density Young’s modulus
B. Rigidity modulus
C. Density
D. Bulk modulus

Q: 5.6 Ultra-Sound waves are

(A) Longitudinal
(B) Transverse
(C) Electromagnetic
(D) Only magnetic

Q: 5.7 Ultra-Sound waves cannot pass through

(A) Air
(B) Vacuum
(C) Solid
(D) Liquid

Theory based question

Q: 5.8

The distance between an Anti-node and the next Anti-node of a transverse wave is _____.

(A) $\frac{\lambda}{4}$

$\frac{\lambda}{2}$

$\frac{\lambda}{8}$

Q: 5.9 In magnetostriction method,

(A) Length of an object change in presence of a magnetic field.
(B) Color of an object changes in presence of a magnetic field.
(C) Resistance of a metal becomes zero in presence of a magnetic field.
(D) A paramagnetic material becomes a ferromagnetic material in presence of a magnetic field.

Q: 5. 10 Which of the following materials could be used for the production of Ultrasonic wave,

(A) Iron
(B) Nickel
(C) Quartz Crystal
(D) All of the above

Q: 5.11 Speed of stationary waves is,

(A) 1 m s-1
(B) 2 m s-1
(C) 3 m s-1
(D) Zero

Q: 5.12 In a stationary wave, nodes are at,

(A) Fixed points
(B) Movable points
(C) There are no nodes
(D) Random points

Activity based questions

A: 5.1 Which liquid you used during the Experiment?

A.Water
B.Sulphuric Acid
C.Petrol
D.Mercury

Activity based question

A: 5.2 If you rotate the micrometer screw anti-clock wise, which direction the circler scale will move?

A.Upward
B.Downward
C.Right side
D.Left Side

A: 5.3 If you keep the ‘adj’ value less than that of ‘Gain’ Value, can you perform the experiment?

A.Yes

B.No

A: 5.4 Which parameter does get recorded in the graph when we rotate the micrometer scale?

A. Density of water
B. Frequency of the ultra-sonic wave
C. Ammeter reading
D. Voltage of the external power supply

A: 5.5 How many different types of liquid you can choose in this experiment?

A.3

B.4

C.5

D.7

Activity based question

A: 5.6 What is the range of frequency of the interferometer you can change in the simulator?

A.3 MHZ-10 MHz

B.1 MHZ- 5 MHz

C.1 MHz-4 MHz

D.3 MHz-6 MHz

A: 5.7 How do you turn on the interferometer in the simulator?

A. It gets automatically turned on once run.
B. It is not needed.
C. One need to click ‘Power on’ icon in the simulator.
D. It has to be done by your PHY 119 teacher remotely.

Activity based question

A: 5.8 What is the distance between two consecutive graduation on the linear scale, as available in the simulator?

A.0.5 mm

B.1 mm

C.1.5 mm

D.2 mm