Course code : AS 410
Experiment No. : 02

Ultrasound

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Date : 2023/08/26

Introduction

Ultrasound is high frequency sound wave that has frequency greater than 20Kz. These waves are above the range of human hearing. Therefore, it is called ultrasound. Ultrasound is versatile and important tool in medical field. This wave create image of inside the body that supports to monitor fetal development, asses heart and examine the organ, such as liver, bladder and kidneys. This experiment focus on determination the velocity ultra sound in air and the relationship of ultra sound intensity with distance between transmitter and reviser. The velocity can be calculated by measuring time it takes for ultra sound waves to travel a none distance.

Aim

A. To determine the velocity of ultrasound in air
B. The relationship of ultrasound intensity with distance between transmitter and receiver

Material and Apparatus

A fixed transmitter, a movable receiver, a signal generator, a two-probe cathode ray oscilloscope, a meter ruler, a wooden board with a rectangular slit, a Vernier calliper, a wooden block with two piezoelectric plates, an amplifier circuit, a wooden platform with marked angles and connecting wires**.**

Theory

Ultrasound is any sound wave having a frequency greater than the upper frequency limit of human hearing (20kHz).

Speed of Sound (υ)

Two fundamentally different sound velocities can be distinguished. Phase velocity corresponds to the propagation velocity of a given phase (a single frequency component of a periodic wave). A propagating medium is said to be dispersive if the phase velocity is a function of frequency or wavelength (e.g. in all attenuating media) Group velocity corresponds physically to the velocity at which energy or information is conveyed along the direction of propagation. In the case of a dispersive medium, the group velocity may differ from the phase velocity. In the linear propagation regime (tiny perturbation or small wave amplitude) speed of sound is a characteristic of the medium. It is independent from the wave amplitude and can be determined from the material and geometrical properties of the medium.

By introducing the generalized concept of an effective elastic modulus (Me) and an effective mass density (ρe)

$$v = \sqrt{\frac{M_e}{\rho_e}}$$

A common correction in realistic systems is that speed of sound can also depend on the amplitude of the wave, leading to nonlinear wave propagation.

Intensity

Sound energy causes particle displacements and variations in local pressure in the propagation medium. Pressure variations are most often described as pressure amplitude (p). Pressure amplitude is defined as the peak maximum or peak minimum value from the average pressure on the medium in the absence of a sound wave.

Intensity is the amount of power per unit area and is proportional to the square of the pressure amplitude;

$I \ \alpha \ P^2$

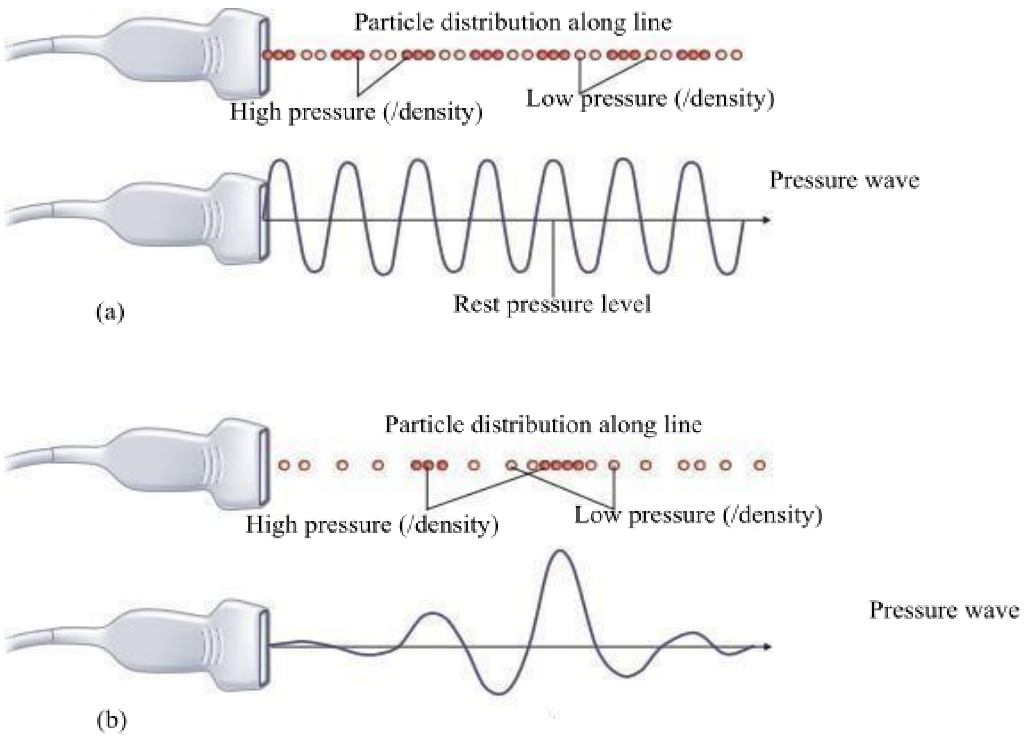


Figure 1: The waveform description of ultrasound pressure fluctuations (a) continuous wave (b) pulsed wave

Attenuation

A plane wave of sound propagating through a medium is attenuated: there is a decrease in intensity because of dissipative factors such as viscosity and heat conduction.

The amplitude attenuation coefficient (α)

$\alpha \ = \frac{-1dp}{p \ dx}$

Where the x distance is the wave travels in the medium

The sound pressure amplitude decay exponentially

$$P(x) = P(0)e^{-ax}$$

Since the intensity is proportional to P^2

$$I(x) = I(0)e^{-2ax}$$

Acoustic impedance (*Z*)

When an ultrasound wave is incident on the boundary between two different substances, some of the ultrasound will be reflected and some will be refracted. The amount of refraction depends on the acoustic impedance (Z) of each of the substances.

$$Z = \frac{P}{U}$$

Where,

P = Acoustic pressure

U = Acoustic volume flow

Diffraction

Historically, it has meant optical phenomena. More generally, it has come to mean phenomena that can be caused by an interaction of wave fronts. The classic case is monochromatic light passing through two pinholes. Sound wave diffraction usually used to refer to the ‘leakage’ of sound into ‘shadow zones’. The sound waves ‘bend’ around the corners more than light waves do as they have a much longer wavelength.

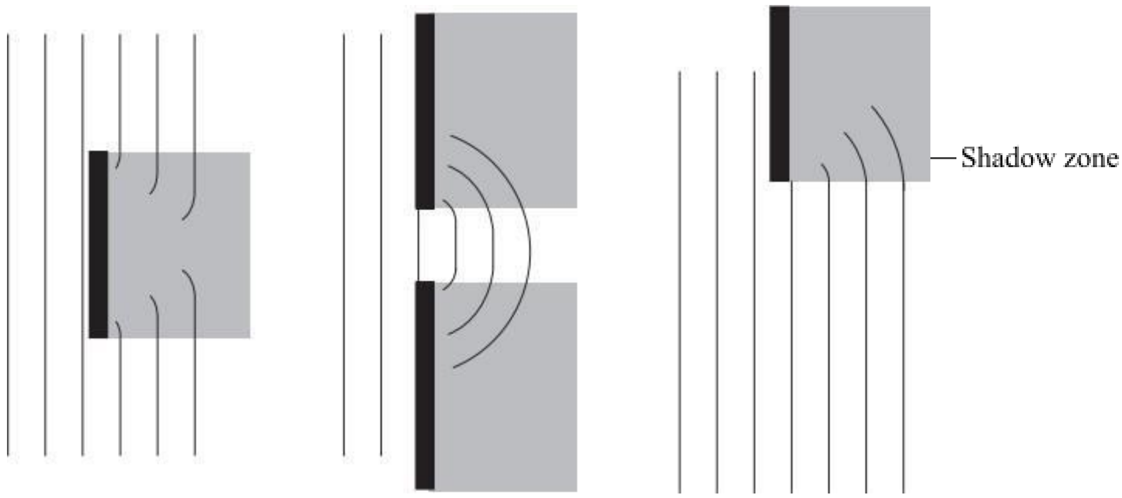


Figure 2: Three examples of diffraction, past an obstacle, through an aperture, and at a corner

The shadow zones, into which the sound waves would not reach if they followed purely geometric, ‘ray’, trajectories. The sound waves moving into these shadow zones are one of the main characteristics of diffraction.

Procedure
Part A

First, ultrasound resonance frequency (F) was found for given transducers by keeping the receiver (R) and transmitter (T) as closed as possible (facing each other) and varying the frequency of the signal generator. Then, T was fed with a F KHz sine wave and R was kept as closed as possible to T. Next, the output wave was observed from using a CRO. After that, distance of R was adjusted to make peaks of output wave form pass a fixed position on the screen. Next, the procedure was repeated by varying and finding the corresponding values for d. Finally, velocity of ultrasound in air was calculated using $d = \lambda n$.

Where,

d - integer

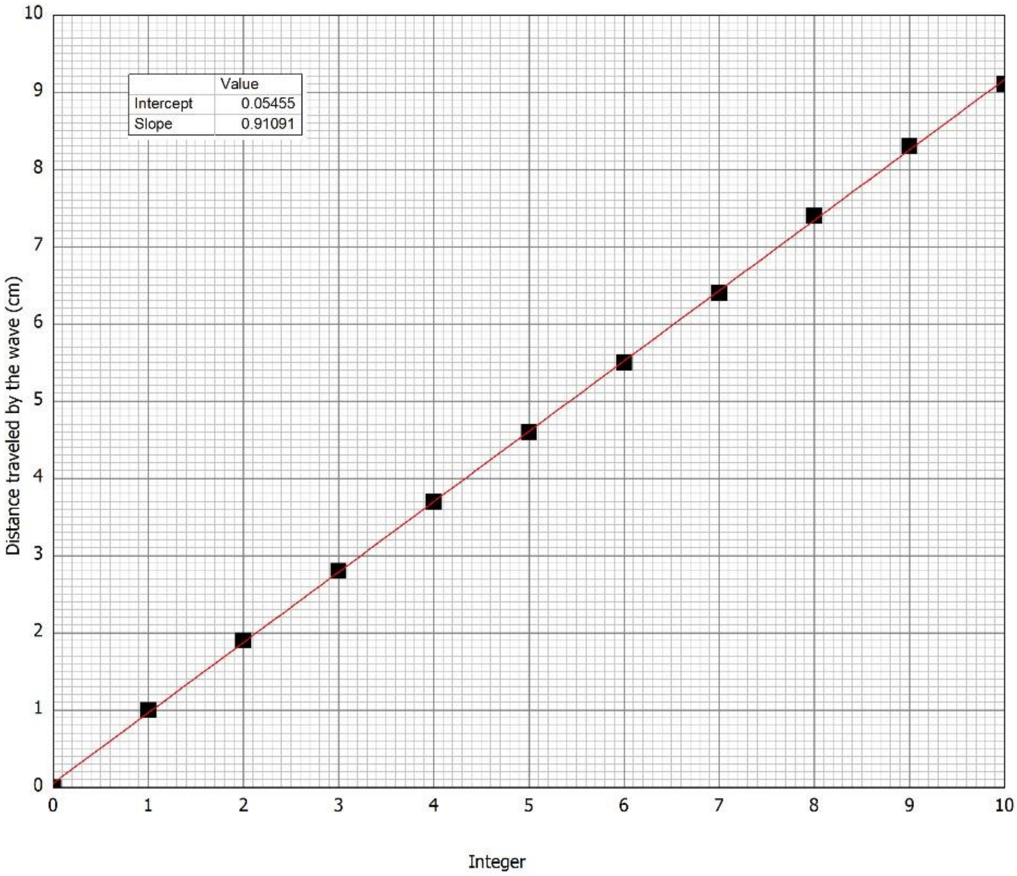
λ – wave length of the ultrasound

n – distance travelled by the wave

Part 2

First, transmitter was fed with the resonance frequency sine wave input. Then, the amplitude (A) of the received signal was noted down at receiver for different distances (d) between transmitter and receiver. Finally, the graph of A vs d was plotted.

Graph 1: The graph of peaks of the output wave passed a fixed position on the screen



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