MODULE :03

ACOUSTICS

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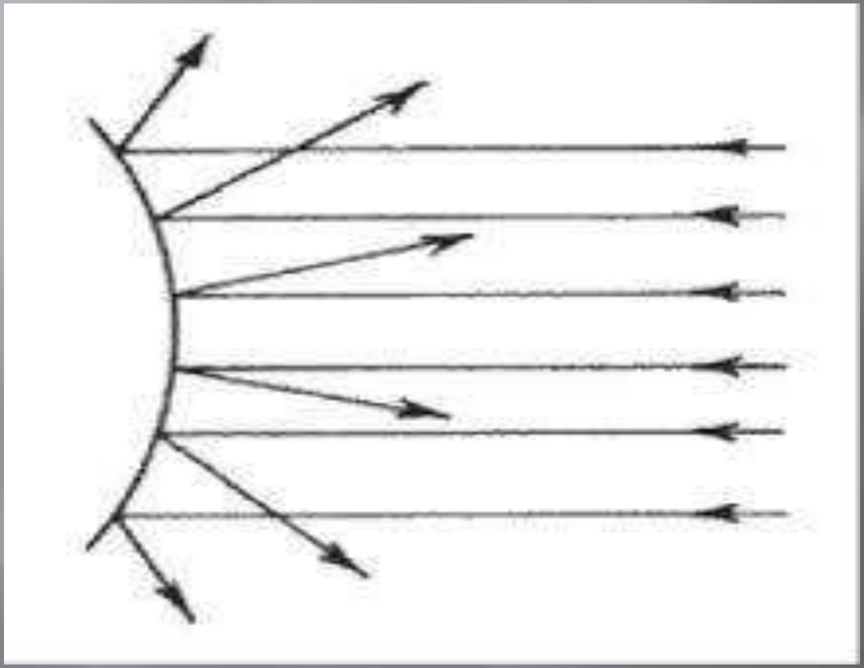
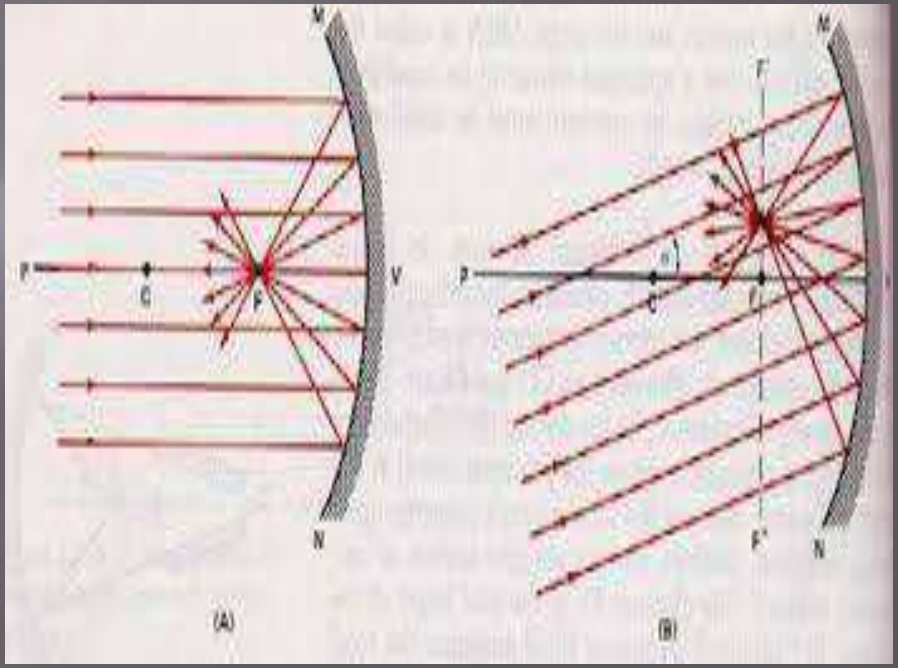
Outlines:

- Acoustic Reflectors and absorbers
- Reflection of sound causes two effects
- Reverberation and Reverberation-time

Acoustic Reflectors and absorbers

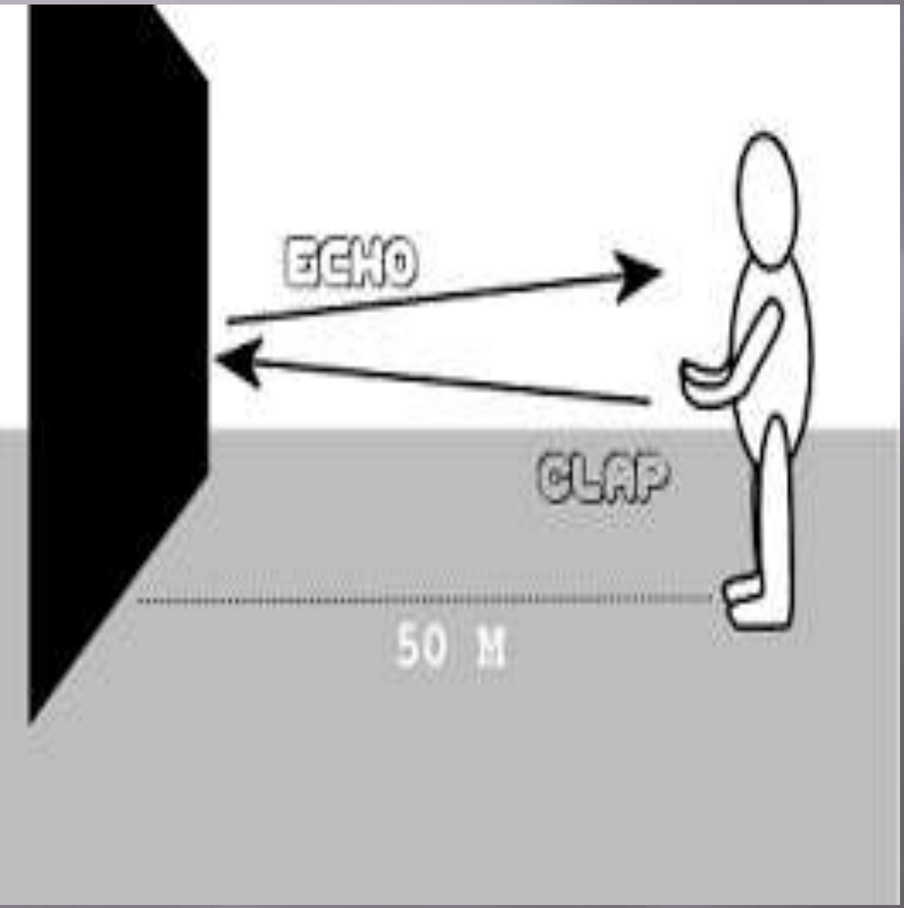
- Sound waves undergo reflection & obey laws of reflection.
- Convex surface scatters sound.
- Concave surface focuses it.

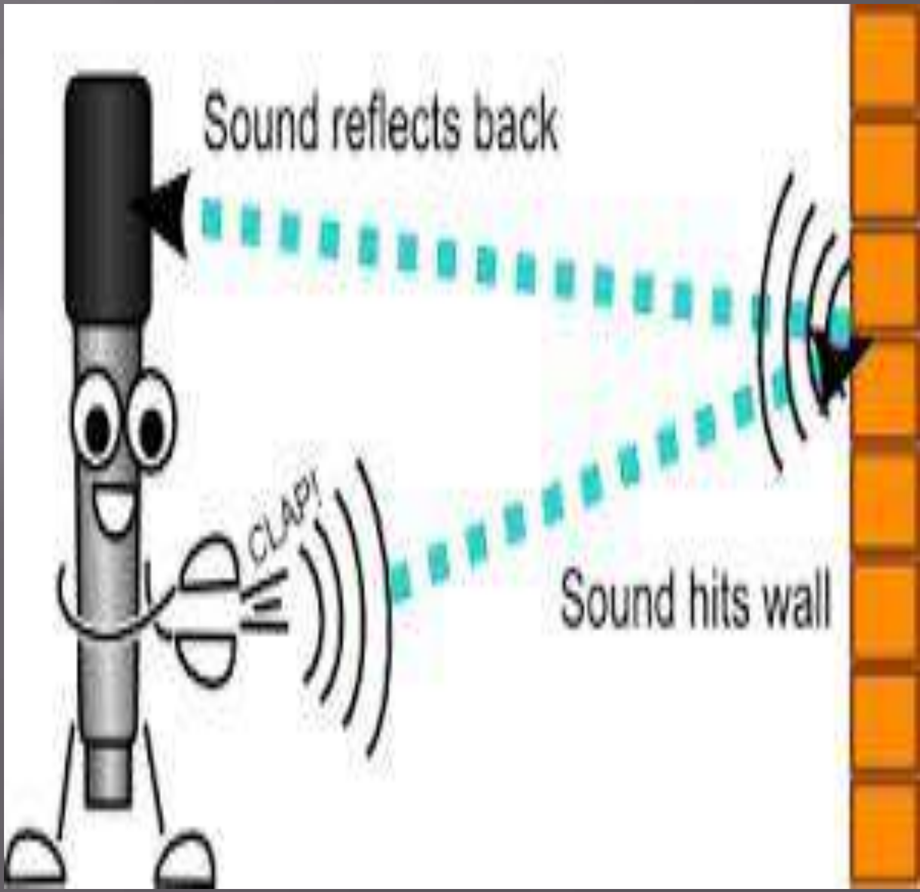



M
P
C
F
V
N
(A)
(B)

Reflection of sound causes two effects

- 1. Echoes
- 2. Reverberation
- **Echo: Reflection of sound when the time interval between the original sound & its reflection is long enough. Both(original & reflected)are heard distinctly.**
- **Echo results when we have multiple reflective surfaces Ex: Thunder (Mountains, clouds, buildings, land)**


ECHO
CLAP
50 M


Sound reflects back
CLAP!
Sound hits wall

Reverberation and Reverberation-time

Reverberation

Persistence of sound in a room due to multiple reflections, even when the source stops emitting the sound.

Large no of echoes which are closely spaced causes reverberation.

Ex: large hall without furniture /audience,New house

Reverberation time

The time taken by the sound in a room to fall from its average intensity to inaudibility

The time interval during which the sound intensity falls from its steady state value to one millionth value after the source is shut off.

13.9.1 Reflection of Sound Waves

Sound waves are reflected just as light waves and obey the similar laws. Flat surfaces reflect sound waves in such a way that the angle of incidence equals to angle of reflection (Fig. 13.5). Sound waves are reflected when the dimensions of the obstacle are large in comparison to the wavelength.

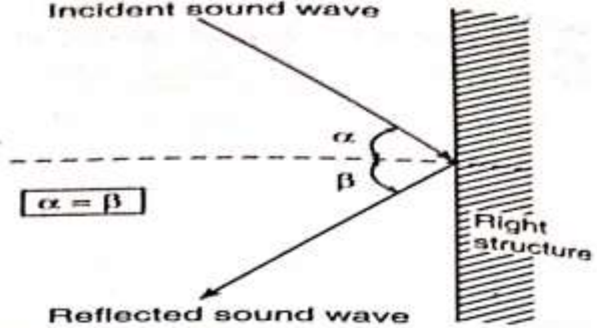


Fig. 13.5: Reflection of Sound Waves.

Generally, in enclosed spaces such as rooms, halls etc, sound reflects from all the surfaces such as side walls, floors, ceiling etc. The sound that reaches the listener's ear directly from the sound source is called the ***direct sound.*** This sound reaches the listener's ears first. The reflection of sound in the enclosed space leads to some important phenomena, namely *echo* and *reverberation*.

Sound waves that bounce off something like a wall or the ceiling and arrive at the listener's ear at almost precisely the same time as the direct sound are called "***early reflections***" (Fig. 13.6). As early reflections travel a longer path, they arrive later than the direct sound, often in a range from 5 to 100 ms.

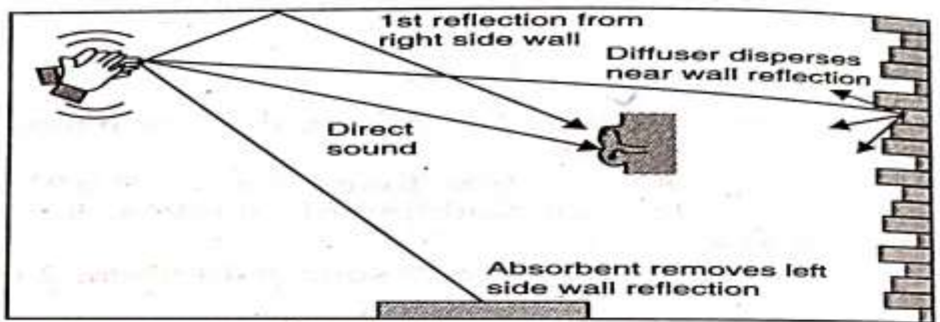


Fig. 13.6: Early reflections-travel a longer path

When there are numerous reflections in the room, some reflections will be added together. These reflections gain in strength and produce ***echoes***. The rate of build-up of echo density is proportional to the square root of the volume of the room. The stream of continuing sound is called ***reverberation*** (Fig. 13.7). Sounds that arrive at the listener's ears after multiple reflections are termed as "***late reflections***." The speaker and room contribute to late reflected sounds. Therefore, sound reflection plays a very important role in the study of acoustics of enclosed spaces.

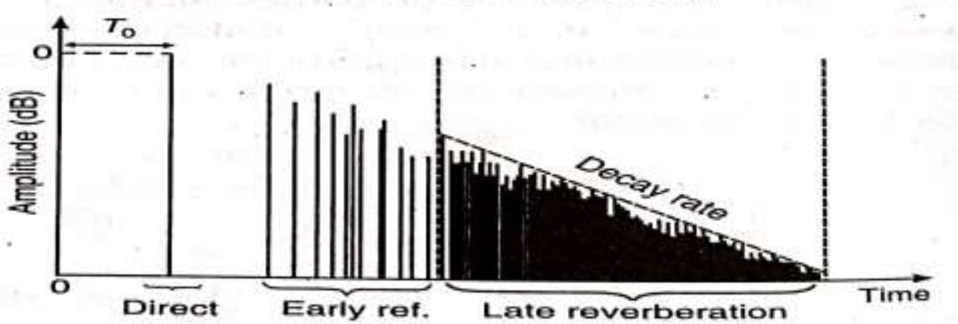


Fig. 13.7: Reverberation-Stream of continuing sound.

13.9.1.1 Reverberation

A sound stays in memory of human brain for 0.1s. A sound is termed as *prolonged* if the reflected sound wave reaches the ear within 0.1 s of the initial sound. Multiple reflections from the walls and ceilings within 0.1 s of each other give reverberations. As the sound velocity is 340 m/s at room temperature, it will take about 0.1 s for a sound to travel the length of a 17 m room and back, thus causing a reverberation. So, only reverberations are common in rooms with dimensions of approximately 17 m or less. A person in a hall continues to receive successive reflections of sound from the walls, floor and ceiling etc whose intensity progressively diminishes (Fig. 13.8). The prolongation of sound before it falls off to a negligible intensity is called *reverberation*.

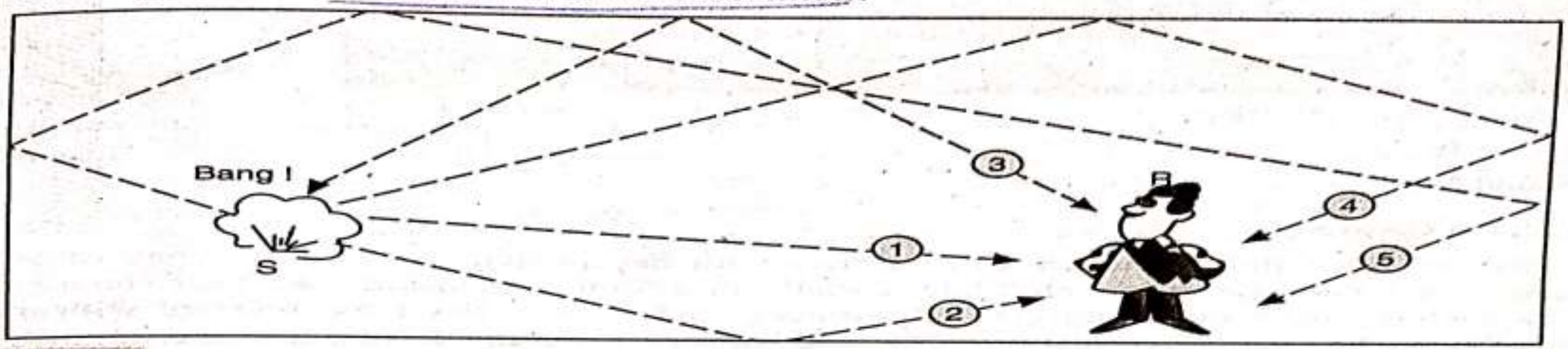


Fig. 13.8:

Successive reflections of sound waves.

In auditoriums and concert halls, reverberations occasionally occur. The auditorium would not seem to be as lively and full of sound. Reverberation in auditoriums and concert halls do not give disturbing results if the reflections are properly *designed*. Rough walls diffuse the sound by reflecting it in all directions. So that a spectator feels the sounds from every part of the room, making it seem lively and full.

Some reverberation is desirable, especially in a hall used for musical performance. A small amount of reverberation improves the original sound. However, too much reverberation causes boomy sound quality in a musical performance. Speeches given in such a hall would be unintelligible. Note that *the reverberation of sound pertains to enclosed spaces only*. In open air the sound spreads out in all directions without repeated reflections.

13.9.1.2 Sound foci

Reflection of sound waves is affected by the shape of the surface. Curved surfaces with a parabolic shape focus sound waves to a single point in space; at that point, the sound is amplified. Fig. 13.9 and Fig. 13.10 show sound reflection from concave surface -'*s*' is sound source and '*f*' is the sound focus. At the focal point even the faintest whisper can be heard.

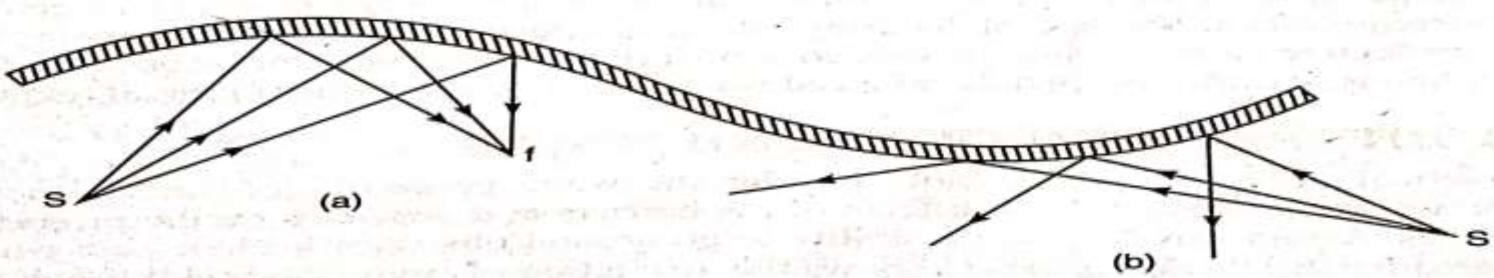


Fig. 13.9:

Sound reflection from concave surface.

Thanks