SOUND

SPEED OF SOUND IN VARIOUS MEDIUM

Speed of sound in different media

We have seen above that sound can travel through solids, liquids and gases. The question which comes to mind is how fast does sound travel? Sound travels at different speeds in different media. The speed of sound depends on the following factors:

The properties (or nature) of the medium. The order of the speed of sound is

SOLIDS > LIQUIDS > GASES

Temperature

Pressure

In any medium, the speed of sound is increases with a rise in temperature

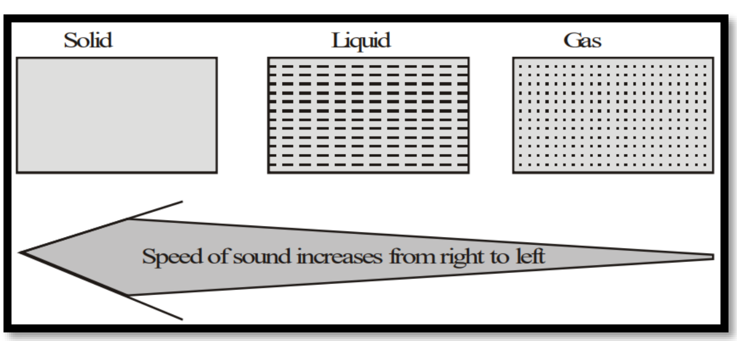
As per definition,

$$Speed\ of\ sound = \frac{Distance\ travelled\ by\ the\ sound}{Time\ taken}$$

The speed of light in the air (or more correctly in vacuum) is 3×10^8 m/ s, (3lakh kilometre per second).

Conclusion

Speed of sound in solids is greater than the speed of sound in liquids and the speed of sound in liquids is greater than the speed of sound in gases.



SPEED OF SOUND IN VARIOUS MEDIA

GASES	
Air (0°C)	331
Air (20°C)	343
Oxygen (0°C)	317
Helium (0°C)	972
Hydrogen (0°C)	1286
LIQUIDS	
Water (25°C)	1493
Sea water (25°C)	1533
Methyl alcohol(25°C)	1143
Blood (37°C)	1570
SOLIDS	
Aluminum (20ºC)	5100
Copper (20ºC)	3560
Iron (20ºC)	5130
Vulcanized rubber	54
Glass (20ºC)	5170
Granite (20ºC)	6000

Newton's Thought

Why speed of sound is fastest in solids and slowest in gases?

Explanation

Speed of sound waves depends on the nature of material (or medium). As a sound wave travels through a material, the particles in the material collide with each other. In a solid, molecules are closer together than in liquids or gases, so collisions between molecules occur more rapidly than in liquids or gases. Thus, the speed of sound is fastest in solids, where molecules are closest together, and slowest in gases, where molecules are farthest apart

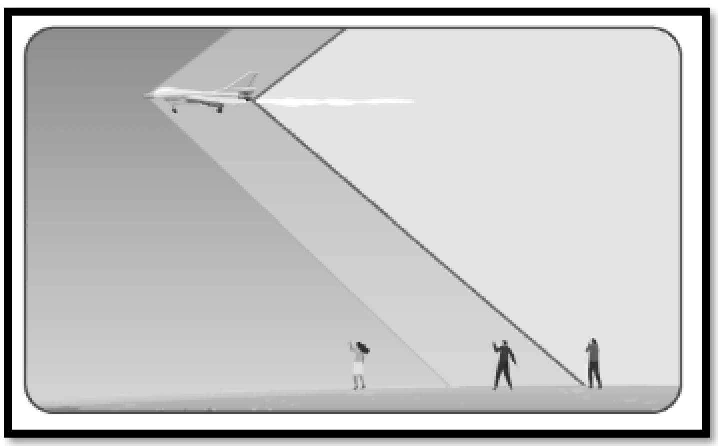
Sonic Boom

A sonic boom is a thunderous noise caused by compressed moving sound waves. It is generated by an object moving faster than the speed of sound (about 335m/s at sea level).

When an aircraft breaks the sound speed, pressure waves merge and form shock waves that move forward from the generation or "release" area.

A sonic boom is very powerful, but it cannot be heard or detected in all directions. A sonic boom can be heard in the area of an imaginary three-dimensional cone at the back of the moving object. The sonic boom can be heard inside that geometrical zone as the object passes you. On the other hand, the sonic boom will be inaudible outside the imaginary zone.

In fact, the imaginary conical region also moves with the vehicle. As the object passes nearby, the observer experiences the boom for a very brief period.



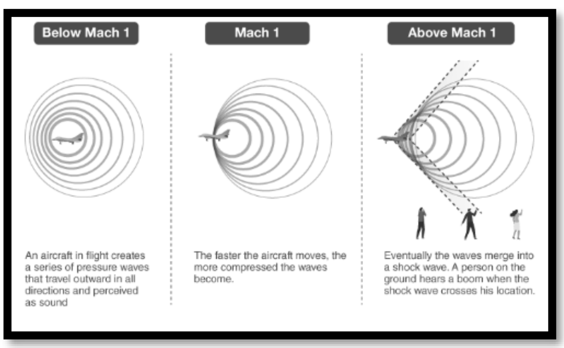
Sonic Boom Principle

The basic physical principle behind the sonic boom is the superposition of pressure waves induced by extreme speed.

Throw a pebble in a pond, small waves will be created in concentric circles, and move away from the point of contact. If a boat moves on a water body at 2m/s to 3m/s, small waves will travel in the same manner, both front and behind the boat.

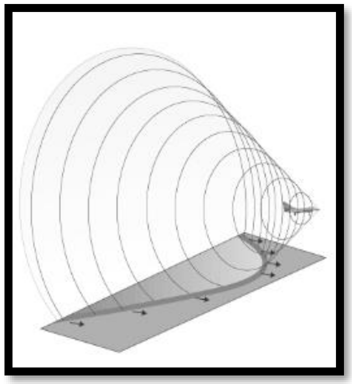
When the boat moves faster than the speed of the waves, the waves will not be able to get out of the trajectory of the boat, and they will form a wake. A wake is a single big wave. It is created out of all the small waves that would have moved in front of the moving object, but failed to.

Air acts like a fluid to supersonic objects. Whenever an object travels through the air, sound waves are produced. In the case of fast-moving aircraft, air disturbance will be large and powerful. As speed increases, the characteristics of the created sound waves also change. If the aircraft is moving less than the speed of sound, then sound waves can travel ahead of the aircraft. When the aircraft crosses the sound threshold and travels faster than the sound speed, it creates a sonic boom. 'Wake' of the sound wave is the sonic boom. Every sound wave that might have usually travelled ahead of the aircraft is superimposed together; within a fraction of seconds, you will hear the thunderous boom.



Factors that Control Sonic Boom

Many variables can influence sonic booms: weight, size, and shape of the aircraft or object. Besides physical attributes, the nature of the trajectory of the movement is also very crucial. Factors like weather conditions, altitude, flight path and attitude play vital roles in generating a sonic boom.



Sonic Boom Measurement

Sonic booms are calculated in pounds per square foot (overpressure). It is the amount of the increase over the usual atmospheric pressure (2,116 psf/14.7 psi).

Generally, the pressure caused by a sonic boom is around a few pounds per square foot.

With higher altitudes, there will be less pressure on the ground. The shock wave's strength diminishes as it spreads away from the aircraft.

Effects of Sonic Booms

A sonic boom creates a tremendous amount of noise and pressure variations.

Anything in the path of its trajectory will surely experience the sonic boom. After-effects are strictly dependent on the source's height (from the receiver) and other atmosphere variables.

A mighty sonic boom might damage delicate building parts with large surface areas and low tensile strength.

No structural damage is caused by one pound overpressure.

Minor damage might be generated with 2 to 5 pounds of overpressure.

Good condition structures can easily withstand overpressures up to 11 pounds.

Sonic boom generating overpressures around 20-144 pounds have not caused human injuries.

When overpressure hits 720 pounds, eardrums can be damaged.Lung damage is expected above 2160 pounds of overpressures.

Sonic booms have caused serious effects on human behaviour and living experience, as noted by abnormal reactions and feelings of fear. It can disrupt sleep and relaxation.

Unique cases such as insomniacs and people sensitive to noise should be given special consideration.

In other cases, complaints to sonic booms are due to the belief that property has or can be damaged by such disturbances.