

**EVALUATING
ACADEMIC READINESS
FOR APPRENTICESHIP TRAINING**
Revised for
ACCESS TO APPRENTICESHIP

**SCIENCE SKILLS
SOUND**

**AN ACADEMIC SKILLS MANUAL
for
Industrial Maintenance Mechanic Trades**

This trade group includes the following trades:
Boiler Maker,
Facilities Maintenance Mechanic & Technician, and,
Industrial Mechanic (Millwright)

*Workplace Support Services Branch
Ontario Ministry of Education and Training*

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In preparing these Academic Skills Manuals we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

This trade related material is not intended to instruct you in your trade. It is used only to demonstrate how understanding an academic skill will help you find and use the information you need.

SCIENCE SKILLS

SOUND

*An academic skill required for the study of the
Industrial Maintenance Mechanic Trades*

INTRODUCTION

Industrial machines are a source of noise. Working around loud equipment can damage the eardrum and lead to deafness. Knowing how sound impacts your hearing can help you recognize why and when to wear ear protection. Loud noise sometimes indicates that there is too much friction occurring in a machine. It can be a sign that parts are rubbing or that bearings need lubricating. When you are trying to find the source of a problem in a machine, an unusual noise is sometimes a clue as to what is not working right.

An understanding of what sound is and how it is transmitted can help you recognize the impact of sound in an industrial setting. This skills manual looks at the following aspects of sound:

- ◆ Source of sound
- ◆ Transmitting medium
- ◆ Receiving sound

SOURCE OF SOUND

There are three requirements for sound to occur: *a source of the sound, a medium for transmitting the sound and an ear to receive the sound.*

The source of the disturbance that produces sound is a vibrating object. When an object vibrates, it moves back and forth. If it vibrates strongly enough, the gas molecules in the air on one side of the object become **compressed** as the object pushes against them. When the object then moves in the other direction, it causes the space that the gas molecules occupy to expand. We say they become **rarefied**.

Vibrations

A vibration becomes a *longitudinal wave* when the energy produced by this back and forth motion travels out through another substance such as air, water, or a board – a medium. **Sound** is *a type of vibration that travels as a longitudinal wave*. See Figure 1 below. Waves travel at different speeds through different mediums. A sound wave travels through air at about 300 meters per second but it travels much faster through steel.

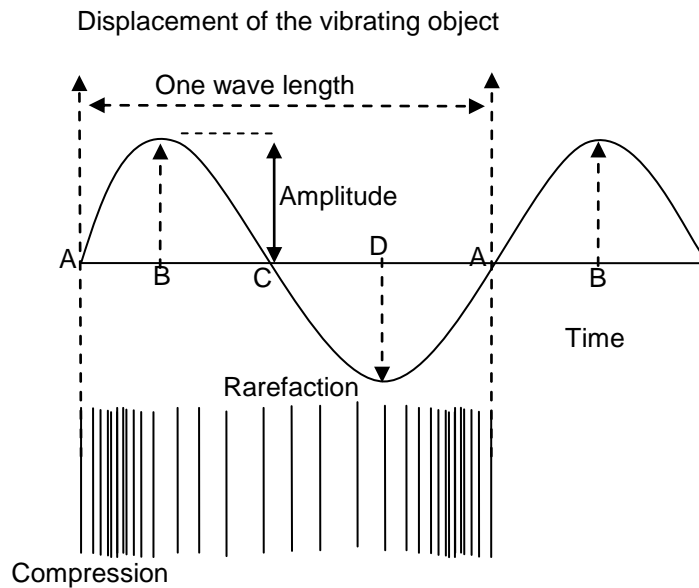


FIGURE 1: Longitudinal Sound Waves

Each time an object vibrates, the vibrations transfer energy to the gas molecules next to the object. These vibrations create a pattern of compression and expansion as the molecules contract and expand into nearby gas molecules, transferring energy to them. In this way, gas molecules spread the waves of compression and rarefaction away from the source of the sound. If this vibrating air comes in contact with your eardrum and causes it to vibrate, your brain interprets the vibrations as sound. The brain also enables you to recognize what sound you are hearing.

Example: When you operate a power saw, the movement of the turning parts causes them to vibrate. Continuous sound waves are created by this vibration. As the sound waves travel through a medium such as air or the walls of a building, the particles transmitting the sound all vibrate in an identical manner.

The number of sound waves that pass through a certain point in the medium in one second can be measured. *This number of waves that pass through in one second*

When a wave is generated, the wave source (the vibrating object) can vibrate in such a way that continuous waves are created. *The **frequency** of a wave is the number of waves that pass through a certain point in the medium in one second.* The unit used to measure frequency is called the **hertz**.

When the vibrating medium moves through a complete phase of the sound wave's up and down motion, it moves the distance of one **wavelength**. A wavelength is the distance over which the wave forms one complete phase (or one complete shape on a graph) before repeating itself. It is also the distance between one point in a wave phase and the same point in the phase of the next wave.

The maximum displacement of the molecules of the transmitting medium either upwards or downwards of a passing wave is the **amplitude** of the wave. In a graph of a wave, the amplitude is shown as the maximum vertical distance of the wave, either upwards or downwards. The distance is measured from the center line in the graph as in Figure 1. The amplitude depends on the amount of energy being transmitted by the source of the sound.

TRANSMITTING MEDIUM

Longitudinal waves need a medium to transmit their vibrations. They cannot travel through a vacuum, where there is nothing for them to compress. The most common medium for sound waves is the air. Although most of the sound we hear is transmitted through air, liquids and solids are actually better transmitters of sound than gases are.

Sound can pass from one medium to another, such as from the air to a wall. When this happens, the speed, wavelength and direction of the wave can change, lessening the energy of the sound. This causes the intensity of the sound being transmitted to diminish. Some of the sound is transmitted through, some is reflected and some is absorbed.

Sound can be **transmitted** through a wall; it travels through the new medium and out into the next room. The sound may be **reflected**; it bounces back from the surface it contacts. Sound can also be **absorbed**; it is trapped in soft materials and converted to heat energy.

To reduce noise levels in a building, you can use materials in walls and ceilings that reflect sound back into the room where it is generated. You want to prevent as much sound transmission as possible without creating unpleasant sound reverberations within a room. Reverberation occurs when sound is reflected around a room for too long, causing the old sound waves to interfere with newly created sounds.

The denser the material in a wall, the less sound it will transmit. Sound energy is absorbed into the solid materials, especially when they are filled with soft material such as insulation. Insulating materials absorb sound waves, causing them to dissipate or vanish.

RECEIVING SOUND

Hearing can only occur if your ear receives the vibrations and your brain interprets them. The sounds we hear have different characteristics. A power saw has a loud, high sound; a humming fan has a quiet, low sound. Sounds can be loud or quiet. They can be high or low in pitch.

Loudness depends on the intensity of the sound wave or the amount of energy it has. Intensity of sound can be measured accurately, while loudness depends on the opinion of the person listening. Music that is too loud for one person might be considered just right for someone else.

Intensity

Intensity is measured in *decibels*. Ordinary conversation is about 65 decibels. Sound begins to feel painful at around 120 decibels. Noise that is too intense is not only painful, it can damage our ears, leading to deafness. For this reason, it is important to wear ear protectors when working close to sounds of high intensity.

Here is a list of the decibel level of some familiar sounds:

Type of Sound	Decibels
Whisper	10 - 20
Soft music	30
Average home	40 - 50
Conversation	60 - 70
Street noise	70 -80
Thunder	110
Threshold of pain	120

Since the amount of energy of a sound wave is measured by its amplitude, loudness is determined by the amplitude of the sound wave on our ears. If the intensity of a sound of a fixed frequency is increased, a listener standing in the same spot will hear the sound get louder.

As a sound wave travels further from its source, the frequency (the speed) and the wavelength remain the same but the intensity of the wave diminishes. Its amplitude becomes less. The further away from the source of the vibration, the lower the intensity of the sound becomes.

Pitch

We describe some sounds such as the squeal of car tires as high and others such as a growling dog as low. Pitch depends on the frequency of the sound waves reaching the ear. (Remember: frequency is the number of waves or cycles per second.) Humans can only hear frequencies between 20 cycles per second and 20 000 cycles per second. Other animals such as dogs can hear higher frequencies than we can. Sounds with frequencies above 20 000 cycles per second are called ultrasound.

Doppler effect

There is an unusual effect that happens when the source of a sound is moving relative to your ear. Say a train is moving towards you and sounding its whistle. As the train passes by, you hear the pitch of the whistle change. As the whistle vibrates, it sends out sound waves at a certain frequency. If the train is not moving, you hear the same number of vibrations per second that the whistle is producing.

But if the train is moving towards you, the whistle is getting closer to your ear. Because the source of the sound is always getting closer to you, you hear the later vibrations at a higher frequency (pitch) than they are actually being produced. Each vibration is traveling at the same speed but the closer the vibration is to your ear, the less distance it has to travel before you hear it. The later sound waves arrive more quickly than sound waves produced earlier and you hear them as having a higher pitch. Then as the train travels away from you, each vibration must travel further to reach your ear and so it gives a lower sound.

If the frequency of sound waves remains the same but the distance traveled by them becomes smaller, the velocity of the wave actually increases. This causes the wavelength to get smaller as the compressions and rarefactions get closer together. The wavelengths of the sound get compacted as they travel to your ear when the source of sound is approaching and they get stretched when the source of the sound (the train) gets farther away.

CONCLUSION

An understanding of what sound waves are and how they travel is important in finding ways to control the amount of sound generated by industrial machines. For a sound to occur, there are three requirements: a source of the sound, a medium to transmit the sound and a receptor such as the ear to receive the sound.

When sound in the air comes to a barrier such as a wall, some of the sound is transmitted, some is reflected and some is absorbed. Sound at too high an intensity or decibel level can damage the eardrum and cause hearing problems. Wearing ear protectors when working around loud equipment will safeguard your hearing.

**Answer the following questions about sound by putting the correct word in the blank.
Answers are on the last page.**

1. The source of the disturbance that produces sound is a _____ object.
2. When the gas molecules next to a vibrating object become pushed close together, they are _____ .
3. When the object moves back and the space between the air molecules becomes expanded, we say they are _____ .
4. A cycle of a compression and a rarefaction forms one complete _____ .
5. Sound needs a _____ to travel through. It cannot travel in a vacuum.
6. Longitudinal waves transmit _____ through matter.
7. _____ can only occur if your ear receives the sound vibrations.
8. The _____ of sound is the number of waves that pass through a certain point in the medium in one second.
9. The _____ of a sound wave is the maximum displacement in one direction of the air molecules carrying the sound.
10. Sound intensity is measured in _____ .
11. A sound above 120 decibels is painful and can lead to _____ .
12. When sound is _____ , it bounces back toward the source.
13. _____ is caused by sound being reflected for too long within a room.
14. Building material such as insulation can prevent the transmission of sound by _____ some of the energy in the sound waves.

Answer page

1. vibrating
2. compressed
3. rarefied
4. wavelength
5. medium
6. energy
7. Hearing
8. frequency
9. amplitude
10. decibels
11. hearing loss or deafness
12. reflected
13. Reverberation
14. absorbing