Portable Oscilloscope & Microphone

Demonstration

This demonstration includes using an oscilloscope to visualize sound signals! Here we will measure the electrical signals of a microphone to show people their own voices.

Figure 1. Image of demonstration materials

Number of Participants: 3-5
Audience: All ages
Duration: 25-30 Minutes
Difficulty: Level 3
Materials Required:

- Portable oscilloscope – Battery or wall powered (found on the internet inexpensively)
- Alligator to BNC Cable (often comes with oscilloscope)
- 9V battery or a 9V DC power cord
- Dynamic Microphone with standard output
  - Analog
  - 3-pin XLR or Audio jack output
  - Impedance ~500 Ω works well

Note: All materials are found in the 2020 SOCK.
https://www.spsnational.org/programs/outreach/science-outreach-catalyst-kits

Setup:

1. Utilizing the detailed setup for the portable oscilloscope and microphone in Appendix A or the instrument instructions.
2. Begin to experiment with the microphone by creating different sounds. Vary intensity, pitch, and distance from mouth.
3. Practice being able to see a constant sound, such as singing “Ah”. Observe what happens when you change pitch (how high or low you sing). This illustrates changes in frequency.
4. Practice with different sounds to observe different patterns. Observe the output of the microphone on the oscilloscope for sounds that change with time (such as words or lyrics). Find the ideal volume for your settings.
5. Attempt to recreate the signals in Appendix B (fig. 10-13).
6. Produce loud and quiet sounds into the microphone while comparing their signals on the oscilloscope screen. This illustrates intensity (volume).

Presenter Brief:

Be familiar with the features of the portable oscilloscope in your SOCK by referencing the instruction manual included with the oscilloscope. Test the functionality of the oscilloscope using the detailed setup in Appendix A. Understand the functionality of a microphone and how it converts pressure waves into electrical signals. Know that the oscilloscope measures electrical signals in real-time, and the y-axis and x-axis of the graph on the oscilloscope represent voltage and time, respectively. Be familiar with the safety tips below and be prepared to present and implement the safety tips during the demonstration.

Vocabulary:

Oscilloscope – a device used to view oscillations or waves, like voltage or electrical currents
Sound waves – vibrations or disturbances that travel through the air or other medium in the form of waves, and can be heard upon reaching the ear
Medium – a synonym for substance or material
Electric current – the flow of electric charge(s), like protons and electrons
Microphone – a device that measures sound waves by making contact with objects and feeling vibrations
Voltage – the electrical potential difference between two points, such as the two-wire attached to the microphone
Transducer – a device that turns a mechanical phenomenon into an electrical one
Frequency – the number of occurrences of a repeated event per unit of time
Pitch – describes how high or low something sounds when you hear it
Sound Intensity – a measurable amount relative to the power carried by a sound wave

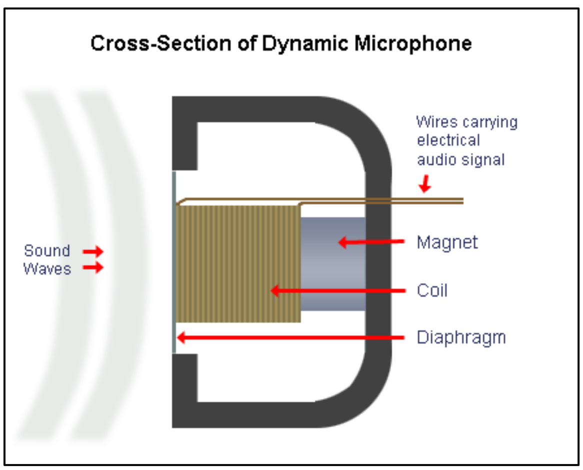


Figure 2. Microphone diagram from MediaCollege.com

Physics and Explanation:

Elementary:

While setting up the oscilloscope ask participants the following questions: What is sound? What is a microphone? Can we see sound waves?

Sound is just vibrations of air that travel from something that is vibrating! Air is made up of molecules like Oxygen and Nitrogen. When sound waves are created, they make the air molecules vibrate and travel, just like waves on a slinky. Sound waves travel into the ear and vibrate tiny hairs in the inner ear. These hairs are what allow us to hear sound. The ear also magnifies quiet sounds and even has safety mechanisms that prevent loud sound from hurting us. A diagram of the human ear can be found in Appendix C.

Microphones act much like our ears and respond to sound waves. Sound wave vibrations move parts of a microphone (often a membrane) and turns them into small electrical signals. Using an oscilloscope and a microphone, sound waves or vibrations traveling through the air can be measured and viewed on an oscilloscope screen. The oscilloscope screen shows on the vertical axis the loudness of a sound (intensity) and on the horizontal x-axis time (how intensity changes with time). Oscilloscopes can also identify the pitch of a sound signal by measuring the time between two peaks, which is called frequency.

When the microphone is connected to the oscilloscope leads, ask participants to speak into the microphone to see the signal on the oscilloscope change on the screen (fig. 4). Stress that people are seeing their own voices!

Different sound waves will appear differently on the oscilloscope screen because the vibrations effect the microphone differently. Attempt to recreate the sounds waves in Appendix B to see a similar signal on the oscilloscope. Compare soft and medium sounds into the microphone and observe what happens to the signal. Louder sounds will vibrate the microphone membrane more and make the signal on the oscilloscope larger. Quieter sounds will vibrate the microphone membrane less and make the signal on the oscilloscope smaller.

Ask participants whether their sounds compare to the sound waves in appendix B. Are your sounds similar or different? Do your loud sounds appear larger and quiet sounds appear smaller on the oscilloscope screen?

- Sound waves are just vibrations and we can see these vibrations using microphones and oscilloscope. We can measure these sound waves or vibrations on an oscilloscope to view them on the oscilloscope screen.
- Loud and quiet sounds will create large and small signals on the oscilloscope because the microphone will vibrate differently with each.

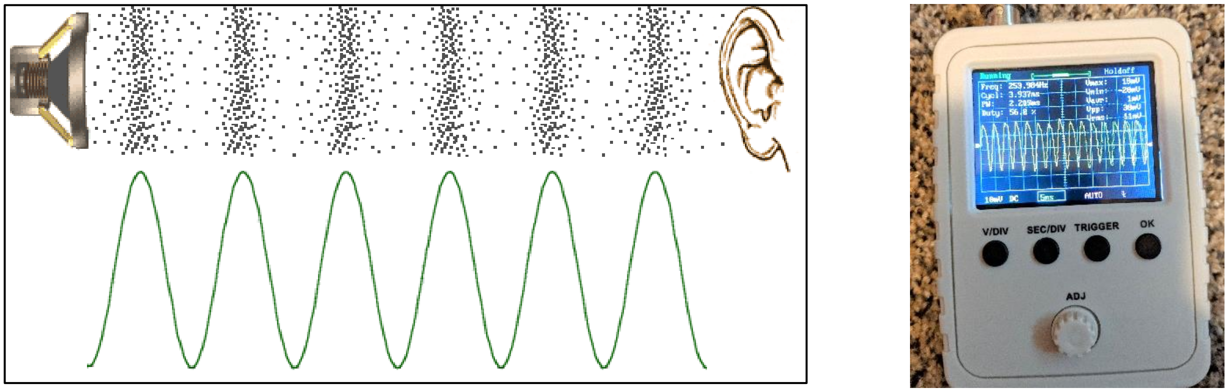


Figure 3-4. Diagram of vibrations in the form of sound waves traveling towards the ear, and a signal on the portable oscilloscope

Middle School and General Public:

While setting up the oscilloscope, ask participants the following questions: what is sound? How can we use microphones to see sound?

Sound is vibrations or disturbances in air or other medium. Air, for example, is made up of molecules like Oxygen and Nitrogen molecules. When sound waves are created, air molecules are disturbed and travel in waves as seen in Fig. 3. People hear sound waves as they travel into the ear, a very complex part of the body. All sound waves travel into the ear and vibrate the ear drum and eventually tiny hairs in the inner ear (cochlea). Each hair is designed to pick up a certain frequency or pitch for us to hear. A diagram of the human ear can be found in Appendix C.

Microphones act much like our ears and respond to sound waves. Sound wave vibrations move parts of a microphone (often a membrane) and get turned into small electrical signals. Using an oscilloscope and a microphone, sound waves or vibrations traveling through the air can be measured and viewed on an oscilloscope screen. The graph on the oscilloscope screen shows the intensity or amplitude of a sound on the vertical axis, and time (how intensity changes with time) on the horizontal x-axis. Oscilloscopes can also identify characteristics of a sound signal such as frequency by measuring the time between two peaks.

When the microphone is connected to the oscilloscope leads, ask participants to speak into the microphone to see the signal on the oscilloscope change on the screen (fig. 4). Stress that people are seeing their own voices!

Different sounds produce a unique electrical signal on the oscilloscope. Attempt to recreate the sounds waves in Appendix B to view similar signals on the oscilloscope. Compare soft and medium sounds into the microphone and observe what happens to the signal. Louder sounds will vibrate the microphone membrane more and produce a signal with greater amplitude. Quieter sounds will vibrate the microphone membrane less and produce a signal with a smaller amplitude.

Ask participants whether their sounds compare to the sound waves in Appendix B. Are your sounds similar or different?

- Sound waves are just vibrations and we can see these vibrations using microphones and oscilloscope. We can measure these sound waves or vibrations on an oscilloscope to view them on the oscilloscope screen.
- Loud and quiet sounds will produce signals with large and small amplitudes on the oscilloscope as the microphone membrane vibrates different with each.
- We hear sound as sound waves travel into the outer ear to vibrate the ear drum and eventually the hairs in the cochlea.

High School:

While setting up the oscilloscope, ask participants the following questions: what is sound? How does a microphone function? What is an oscilloscope?

Sound is vibrations or disturbances in air or other medium. Air, for example, is made up of molecules like Oxygen and Nitrogen. When sound waves are created, air molecules are disturbed and travel through space in waves as seen in figure 3. People hear sound waves as they travel into the ear, a very complex part of the body. All sound waves that travel into the outer ear, through the ear canal and to the ear drum, which will vibrate from the sound waves. Eventually, the sound waves vibrating the ear drum will travel into the inner ear and vibrate the tiny hairs inside the cochlea. Each hair in the cochlea is designed to pick up a unique pitch or frequency of sound. The farther the hair is located in the snail shell shaped cochlea, the higher the frequency the hair picks up. Overtime, the hairs that pick up higher frequencies of sound will die off. This explains why, as people age, they tend to become hard of hearing and eventually need the assistance of hearing aids. A diagram of the human ear can be found in Appendix C for reference.

Microphones are transducers that act much like our ears and respond to sound waves. Sound waves or pressure waves move certain parts in a microphone, such as a membrane, and the microphone converts the sound into a small electrical signal. In other words, the amplitude or voltage of a sound signal from a microphone is very small. There are many different types of microphones that allow one to measure sound in the air or even underwater.

Using an oscilloscope and a microphone, sound waves can be measured and viewed on an oscilloscope screen. The graph on the oscilloscope screen displays voltage or sound intensity over time. We can use the oscilloscope graph to measure characteristics of a signal such a frequency, wavelength, amplitude and more.

When the microphone is connected to the oscilloscope leads, ask participants to speak into the microphone to see the signal on the oscilloscope change on the screen (fig. 4).

Different sounds produce a unique electrical signal on the oscilloscope. Attempt to recreate the sounds waves in Appendix B to view similar signals on the oscilloscope. Compare soft and medium sounds into the microphone and observe what happens to the signal. Louder sounds will vibrate the microphone membrane more and produce a signal with a larger voltage or amplitude. Quieter sounds do just the opposite, vibrating the microphone membrane less and producing signals with a lower voltage or amplitude.

Ask participants whether their sounds compare to the sound waves in Appendix B. Are your sounds similar or different?

- Sound waves are pressure waves created by disturbances in air particles or other medium. We can measure these sound waves or vibrations on an oscilloscope to view them on the oscilloscope screen.
- A microphone converts sounds waves into electrical signals of voltage over time that can be measured and observed on an oscilloscope.
- Different sounds produce electrical signals on an oscilloscope with unique characteristics (frequency, wavelength, amplitude) that can be measured.

References:

1. Rossing, Thomas D., et al. The Science of Sound. Pearson Education, 2014.

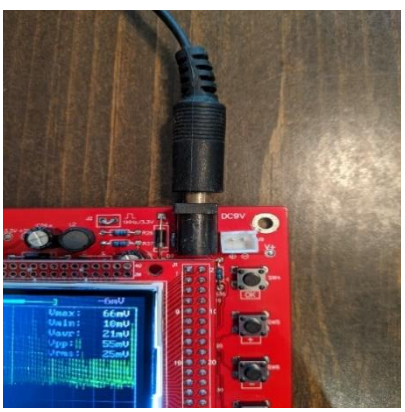
Additional Resources:

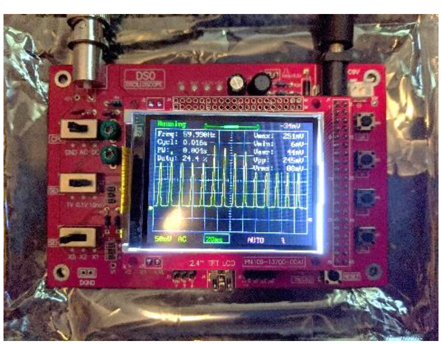
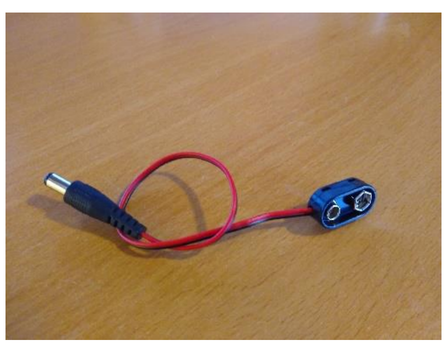
- Microphones: http://hyperphysics.phy-astr.gsu.edu/hbase/Audio/mic.html#c1
- “Introduction to Sound” diagram
- “How Do We ‘See’ Sound?” diagram

Appendix A:

Setup (Red Oscilloscope):

1. Locate the portable oscilloscope, cable, casing, casing hardware, and instructions. Locate the instructions and verify you have all the materials included in the portable oscilloscope kit.
2. Connect the 9V power cord (fig. 9) to the 9V battery and plug the power cord into the portable oscilloscope as seen in figure 5. Verify the oscilloscope powers on.
3. Remove the power cord from the oscilloscope and use the instructions included in the oscilloscope kit to build the casing for the oscilloscope if desired.
    - **Note: Building the included case for the oscilloscope is recommended for young participants.**
4. Connect the oscilloscope cable to the BNC port as seen in figure 6.
5. As seen in figure 7, connect the red and black alligator clips to the microphone cable.
6. Adjust the left-hand side switched on the oscilloscope to the following:
    - CPL: AC
    - SEN1: 10mV
    - SEN2: X1
7. Adjust the oscilloscope settings further with the right-hand side buttons:
    - “+” and “-“ buttons increase and decrease oscilloscope settings, respectively
    - “SEL” button switches adjustable settings
    - “OK” button freezes the signal on the screen for easier viewing
8. Test the microphone with sound or vibrations to verify that a signal appears on the oscilloscope like in figure 8.

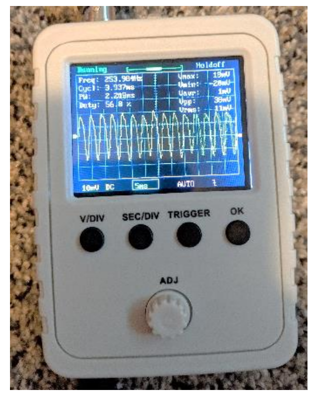


Figures 5-9. Red oscilloscope and microphone set up

Setup (White Oscilloscope):

1. Locate the portable oscilloscope, cable, casing, casing hardware, and instructions. Locate the instructions and verify you have all the materials included in the portable oscilloscope kit.
2. Connect the 9V power cord to the 9V battery and the 9V power port on the oscilloscope as seen in figure 10. Flip oscilloscope power switch to “on.”
3. Connect the oscilloscope cable to the oscilloscope BNC port as seen in figure 11.
4. As seen in figure 7, connect the red alligator clip on the cable to the red microphone wire and the black alligator clip to the black microphone wire.
5. Adjust the settings on the oscilloscope to a low voltage reading (5mV-20mV) and low second divider (0.1s-0.5s). These settings will produce a better view of the microphone’s signal on the oscilloscope screen.
6. Test the contact microphone with sound or vibrations to verify that a signal appears on the oscilloscope screen like in figure 12. Adjust oscilloscope settings further if necessary.



Figures 10-12. White oscilloscope setup

Appendix B:

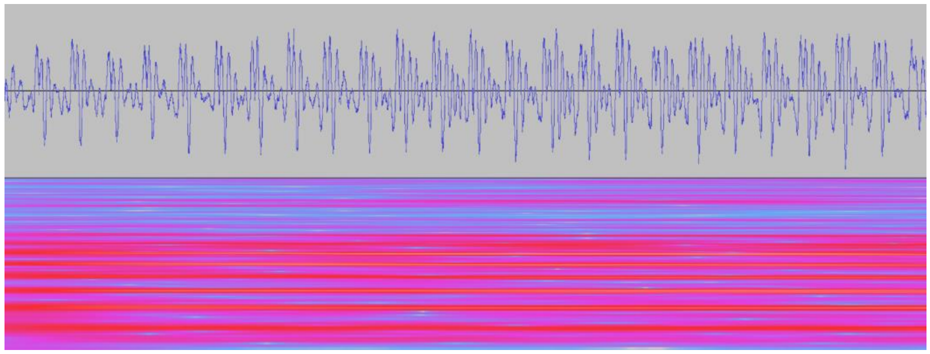


Figure 13. Recording of the vowel sound “AH” using the *Audacity* software

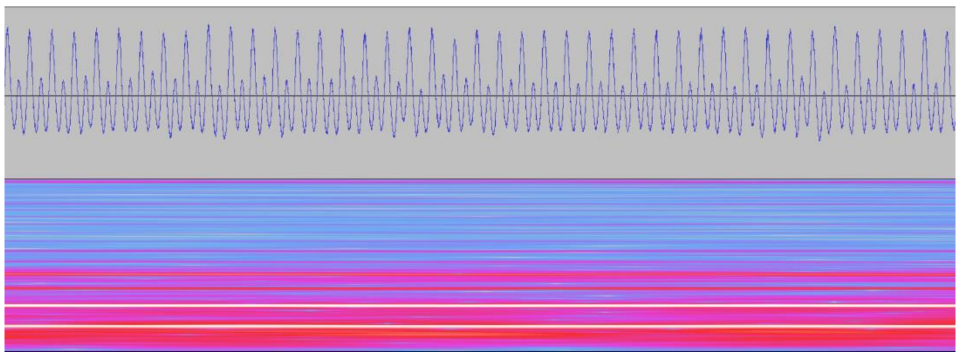


Figure 14. Recording of the vowel sound “OO” using the *Audacity* software

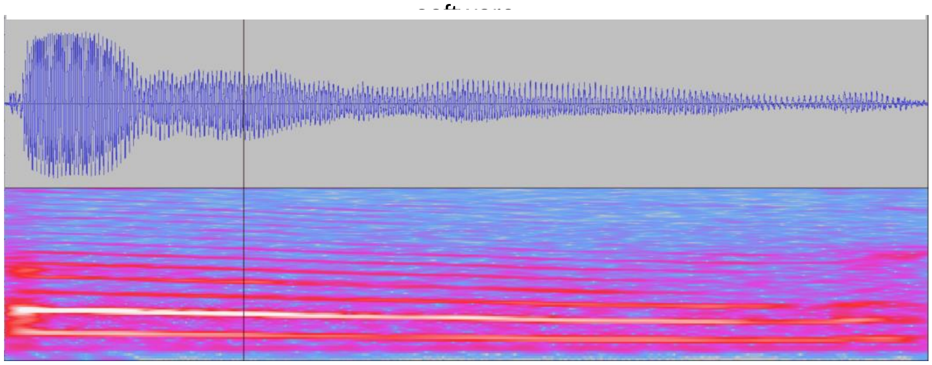


Figure 15. Recording of the word “boom” made in the *Audacity* software

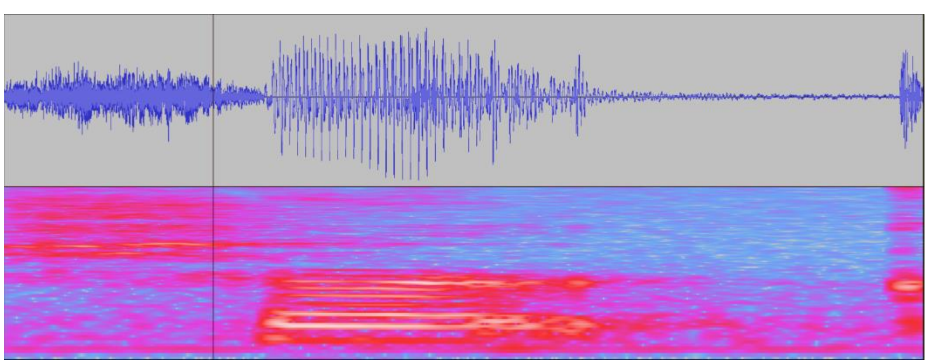


Figure 16. Recording of the word “shark” made in the *Audacity* software

Appendix C:

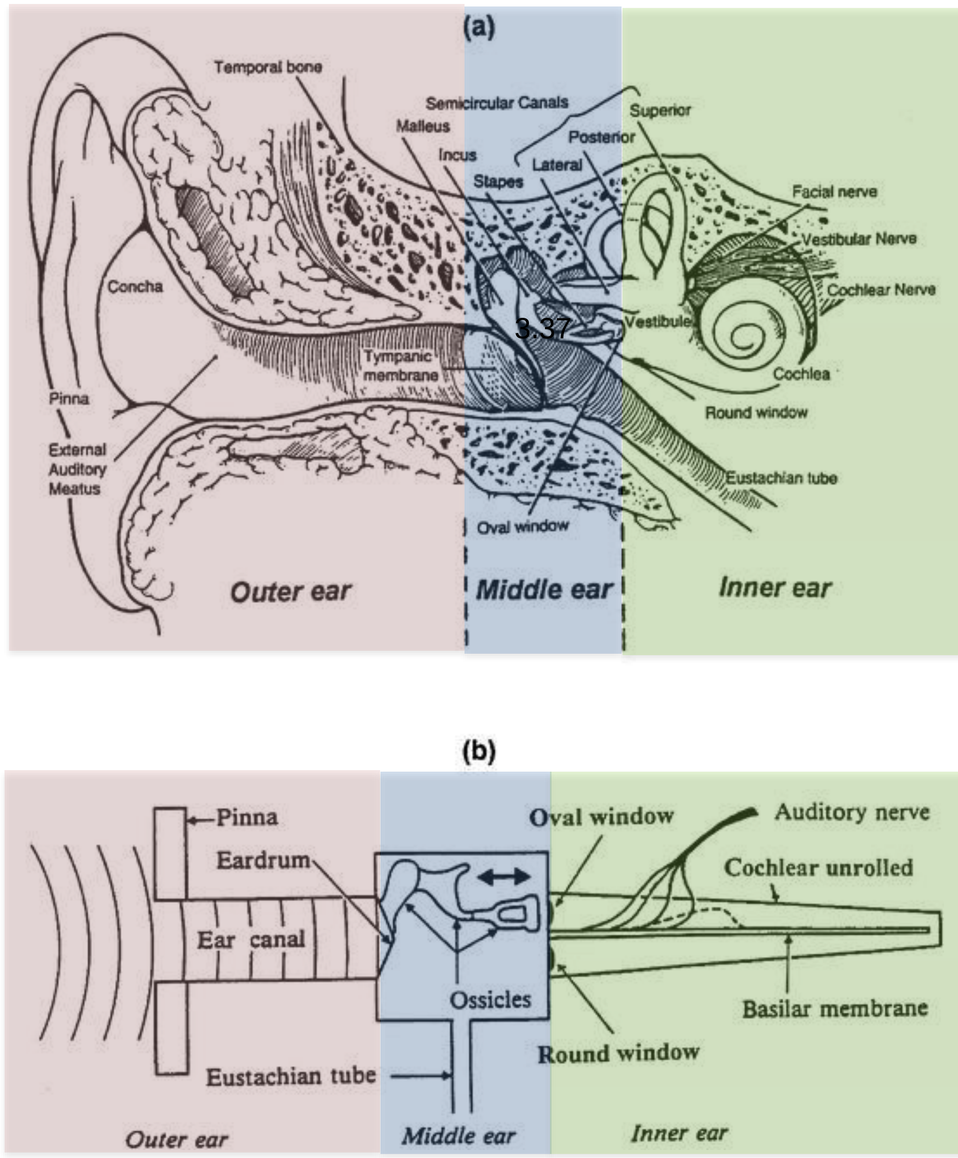


Figure 16. Diagram of the human ear from “The Science of Sound” by Rossing, Moore, and Miller