General Physics 1
Quarter 2 - Module 4: Mechanical Waves and Sound

Name of Learner: _______________________
Grade & Section: _______________________
Name of School: _______________________
What I Need to Know

What is your favorite musical instrument? Whether it’s a guitar, a violin, a piano, or a flute, the same concepts in waves and in acoustics can explain how they work. In this module, you will see that the sound produced by musical instruments can be described using wave mechanics.

The module covers:

• Lesson 4 – Mechanical Waves and Sound

After going through this module, you are expected to:

1. Differentiate underdamped, overdamped, and critically damped motion (STEM_GP12PMld-28)
2. Define mechanical wave, longitudinal wave, transverse wave, periodic wave, and sinusoidal wave; (STEM_GP12PMld-31)
3. From a given sinusoidal wave function infer the speed, wavelength, frequency, period, direction, and wave number (STEM_GP12PMld-32)
4. Apply the inverse-square relation between the intensity of waves and the distance from the source (STEM_GP12MWSlle- 34)
Activity 1. Look, Connect and Match.

**Directions:** Look for word/s in the box (horizontal, vertical, or diagonal), draw a line that would connect the letters to form a word/s. Write the word/s on the space provided before each sentence that best describes them. Item 1 is already done for you. *(1pt each)*

| S | U | N | D | E | R | D | A | M | P | E | D | M | C | R | H | S | I | U | F | B | A | G | U | R | E | O | H | V | A |
| A | O | R | S | F | A | C | F | D | E | F | T | G | O | G | F | S | P | G | S | R | S | A | I | O | R | F | V | V | D | C |
| C | F | U | A | F | A | G | B | M | R | Y | K | D | I | O | T | E | E | D | S | E | G | D | F | R | S | F | E | A | S | C |
| A | F | G | N | V | E | L | O | C | I | T | Y | V | G | D | T | T | T | E | T | E | Q | S | F | H | U | G | D | R | A | C |
| C | S | F | H | D | A | F | A | E | O | H | F | S | E | F | D | G | D | D | S | U | A | R | V | F | S | S | D | S | V | L |
| S | I | M | P | L | E | E | P | E | N | D | U | L | U | M | A | D | E | F | S | A | E | C | D | S | W | E | R | A | R | D | E |
| C | D | F | R | W | E | E | F | R | W | Q | E | R | W | D | G | R | W | D | E | C | E | D | I | O | Y | G | P | R | F | A |
| F | M | E | C | H | A | N | I | C | A | L | W | A | V | E | V | G | E | T | H | Y | E | D | S | W | F | G | E | G | T | T |
| S | I | M | P | L | E | E | H | A | R | M | O | N | I | C | M | O | T | I | O | N | V | T | T | C | V | N | Y | D | S | E | I |
| C | R | T | G | H | Y | A | N | G | U | L | A | R | F | R | E | Q | U | N | C | Y | V | G | H | E | S | E | A | D | N |
| D | C | R | I | T | I | C | A | L | L | Y | D | A | M | P | E | D | P | I | N | K | W | A | R | E | D | F | D | O | L | L |

**Mechanical Wave**

1. wave that requires a medium for propagation
2. the distance between two successive crests or two troughs
3. the time taken to generate one complete wave. It is also the time taken for the crests, or any given point on the wave, to move a distance of one wavelength
4. the distance moved by a wave in one second
5. consists of a mass m hanging from a string of length L and fixed at a pivot point P
6. a vector measurement of the rate and direction of motion
7. the condition in which the damping of an oscillator causes it to return as quickly as possible to its equilibrium position without oscillating back and forth about this position
8. a special type of periodic motion where the restoring force on the moving object is directly proportional to the object's displacement magnitude and acts towards the object's equilibrium position
9. the condition in which damping of an oscillator causes it to return to equilibrium without oscillating
10. vibration that propagates as an acoustic wave, through a transmission medium such as a gas, liquid or solid
11. the condition in which damping of an oscillator causes it to return to equilibrium with the amplitude gradually decreasing to zero
12. the number of crests or troughs that pass a point per second
13. is a scalar measure of rotation rate
14. the rate of change of the velocity of an object with respect to time
15. the change in position of an object
Activity 2. Let’s Make Some Wave

Directions:

1. Get a piece of rope about 2 m long. Fix one end of a rope by tying it around a post or a rod.
2. Have a single disturbance in one end of the rope. What is formed? This time move that same end with a series of disturbances. What did you observe? The single disturbance made in a rope is called wave pulse while a series of disturbances are called wave trains.

Guide Questions: (3pts each)

1. How did you generate waves in a rope?

2. What is transferred by waves from one place to another?

3. What is necessary so that energy could be transferred by the waves produced by a rope?

What’s New

Types of Waves

There are two types of waves: the transverse waves and the longitudinal waves. These are mechanical waves that require a medium for propagation. Water waves and rope waves are examples of transverse waves. On the other hand, light wave is an example of electromagnetic wave, which does not require any medium for propagation. Rope waves travel in a direction perpendicular to the direction of wave motion. This kind of wave is what we call transverse wave as seen in Figure 1 below.

![Figure 1. Transverse Wave](https://www.google.com/search?q=rope%20wave&tbm=isch&hl=en&hl=en&tbs=rimg:YMhx4MIWADNYREjOJF_150U2Z&sa=X&ved=0CCUQuIIBahcKEwjo7_Wvdi7rAHHAAAAAHQAAAAAGGQ&biw=1519&bih=754#imgrc=62e8q7IS111Hm)
On the other hand, longitudinal waves are waves which travel in a direction parallel to the direction of wave motion or parallel to the direction of vibration (see Figure 2).

![Longitudinal Wave](https://cnx.org/contents/FFC6Ygl0@3.2:yzEWB8wD/Longitudinal-Waves)

**Figure 2. Longitudinal Wave**

**Characteristics of Waves**

Water waves are easily produced and observed. By touching one point on the surface you can see the peaks of the waves form circles and move outwards from the source of the disturbance.

Some of the characteristics used to describe transverse wave motion are enumerated below (see also Figure 3 on the next page):

- The high points are called **crests** or peaks while the low points are called **troughs**.

- The **amplitude** is the maximum displacement from the rest position. It is the height of the crest or depth of a trough measured from the normal undisturbed position.

- The **wavelength**, \( \lambda \), is the distance between two successive crests or two successive troughs. It is also equal to the distance between any two identical points on successive waves, for example points A and B, and points C and D.

- The **frequency**, \( f \), is the number of crests or troughs that pass a point per second. This is equivalent to the number of complete waves generated per second. Frequency is measured in terms of hertz (Hz).

- In a **periodic wave**, the motion of each point of the medium is periodic with frequency \( f \) and period \( T \).

- The **period**, \( T \), is the time taken to generate one complete wave. It is also the time taken for the crests, or any given point on the wave, to move a distance of one wavelength.

\[
T = \frac{1}{f}
\]
The speed, \( v \), of the wave is the distance moved by a wave in one second. Since the wave crest travels a distance of one wavelength in one period, the wave speed,

\[
v = \frac{\lambda}{T} \text{ or } v = f\lambda
\]

A sinusoidal wave is a special periodic wave in which each point moves in simple harmonic motion.

- A wave is an oscillation (of a physical quantity) that travels through a medium, accompanied by a transfer of energy. Energy transfers from one point to another in the direction of the wave motion. The particles of the medium oscillate up and down, back and forth, or both up and down and back and forth, around an equilibrium position.

- A snapshot of a sinusoidal wave at time \( t = 0.00s \) can be modeled as a function of position. Two examples of such functions are \( y(x) = A\sin(kx + \varphi) \) and \( y(x) = A\cos(kx + \varphi) \).

- Given a function of a wave that is a snapshot of the wave, and is only a function of the position \( x \), the motion of the pulse or wave moving at a constant velocity can be modeled with the function, replacing \( x \) with \( x \mp vt \). The minus sign is for motion in the positive direction and the plus sign for the negative direction.

- The wave function is given by \( y(x,t) = A\sin(kx - \omega t + \varphi) \) where \( k = \frac{2\pi}{\lambda} \) is defined as the wave number, \( \omega = \frac{2\pi}{T} \) is the angular frequency, and \( \varphi \) is the phase shift.

- The wave moves with a constant velocity \( v_w \), where the particles of the medium oscillate about an equilibrium position. The constant velocity of a wave can be found by \( v = \lambda T = \omega k \).

**Damp Harmonic Motion**

**critical damping:** the condition in which the damping of an oscillator causes it to return as quickly as possible to its equilibrium position without oscillating back and forth about this position (see Figure 4 in green color)
over damping: the condition in which damping of an oscillator causes it to return to equilibrium without oscillating; oscillator moves more slowly toward equilibrium than in the critically damped system (see Figure 4 in pink color)

under damping: the condition in which damping of an oscillator causes it to return to equilibrium with the amplitude gradually decreasing to zero; system returns to equilibrium faster but overshoots and crosses the equilibrium position one or more times (see Figure 4 in red color)

Sound
- Intensity is the same for a sound wave as was defined for all waves; it is
  \[ I = \frac{P}{A} \]
  where \( P \) is the power crossing area \( A \). The SI unit for \( I \) is watts per meter squared. The intensity of a sound wave is also related to the pressure amplitude \( \Delta p \),
  \[ I = \frac{(\Delta p)^2}{2\rho v_w} \]
  where \( \rho \) is the density of the medium in which the sound wave travels and \( v_w \) is the speed of sound in the medium.

- Sound intensity level in units of decibels (dB) is
  \[ \beta(\text{dB}) = 10\log_{10}(I/I_0) \]
  where \( I_0 = 10^{-12} \text{ W/m}^2 \) is the threshold intensity of hearing.
What’s More

Activity 3. Guess What?
A. Below is an illustration of a transverse wave. Identify the characteristic of the wave that is called for in the given item. Write your answer on the space provided below the figure. Refer to the description of each characteristic as mentioned in the early part of Lesson. (1 point each)

![Transverse Wave Illustration]

1. __________________
2. __________________
3. __________________
4. __________________

Source: https://home.apu.edu/~disaak/gp2/resources/16sampleHWproblem.pdf

B. How are the frequency, period and speed of a transverse wave related? (3pts)
___________________________________________________________________________
___________________________________________________________________________

Activity 4. Problem Solving

Sample Problem:
The frequency of some approaching ocean waves is 2 Hz and the length between two wave crests is 3 m. What is the speed of the ocean waves moving towards the shore?

Given:
\[ f = 2 \text{ Hz} \]
\[ \lambda = 3 \text{ m} \]

Formula:
\[ v = f \lambda \]
\[ = 2 \text{ Hz} \times 3 \text{ m} \]
\[ = 6 \text{ m/s} \]

Solve the following exercises. Show all necessary solution inside the box: (5 pts each problem)

1. A vibration of frequency 5 Hz sends a wave of wavelength 0.8 m down a rope. What is the speed of the wave?
2. A wave of wavelength 1.5 m travels down a rope at a speed of 6 m/s. What is the frequency of the wave?

What I Have Learned

Activity 5. You Can Do It!

A. Based on the figure below, identify the underdamped, overdamped, and critically damped motion. Explain how does it differ from one another. (3pts each)

![Graph showing underdamped, overdamped, and critically damped motion](https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQZm9Pq2bTJ6jxQcBwJXl7vGv9kYk5qU7wclw&usqp=CAU)

1. Green Wave

2. Pink Wave

3. Blue Wave

Source: [Critical Damping](https://www.google.com/search?q=critical+damping&tbm=isch&chips=q:critical+damping,g_1:rlc+circuit:UkB1r58L8Y%3D&hl=en&sa=X&ved=2ahUKEwjft-Df9d_rAhULAKYHTOWDxUQ4IYoAXoECAEQFw&biw=1519&bih=754#imgrc=g8W7hwrgg0ayYM)
B. Match the word in column A to the sentences in column B that best describes the word/s. Write the letter of your answer on the space provided before each number. (1pt each)

<table>
<thead>
<tr>
<th>COLUMN A</th>
<th>COLUMN B</th>
</tr>
</thead>
<tbody>
<tr>
<td>___1. Mechanical Waves</td>
<td>A. waves that require a medium for propagation</td>
</tr>
<tr>
<td>___2. Longitudinal Waves</td>
<td>B. the motion of each point of the medium is periodic with <em>frequency f and period T</em></td>
</tr>
<tr>
<td>___3. Periodic Waves</td>
<td>C. waves travel in a direction perpendicular to the direction of wave motion</td>
</tr>
<tr>
<td>___4. Sinusoidal Waves</td>
<td>D. waves which travel in a direction parallel to the direction of vibration</td>
</tr>
<tr>
<td>___5. Transverse Waves</td>
<td>E. vibration that propagates as an acoustic wave, through a transmission medium such as a gas, liquid or solid</td>
</tr>
</tbody>
</table>

C. Solve the following problems below showing all necessary solutions in the space provided below each question. (5pts each)

1. A wave is modeled by the wave function
   \[ y(x,t) = (0.30\text{m})\sin[2\pi/4.50\text{m}(x-18.00\text{m}/\text{st})]. \]
   What are the amplitude, wavelength, wave speed, period, and frequency of the wave?
2. What is the intensity in watts per meter squared of 85.0-dB sound?

What I Can Do

Activity 6. Feeling Sound

Directions:

1. Search for a rock music on your android phone and connect it to a speaker.
2. Place the speaker on a light table and start playing the rock music.
3. Place your hand gently on the table next to the speaker.
4. Increase the volume and note the level when the table begins to vibrate as the rock music plays.
5. Increase the reading on the volume control until it doubles.
6. Observe what happened to the vibrations.
7. Record your observation on the table below

Data Observed:

<table>
<thead>
<tr>
<th>Volume</th>
<th>Vibration (weak-strong) (2pts each)</th>
<th>Observation (shaking of the table) (3pts each)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very loud</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Assessment

Directions: Read the following questions and choose the letter of the best answer. Encircle the letter of your answer.

1. Which of the following CANNOT travel in empty space?
   a. Electromagnetic Wave
   b. Light
   c. Mechanical Wave
   d. All of the above

2. This type of wave has both a transverse and longitudinal wave and it separates the two different media the waves travel through.
   a. Transverse Wave
   b. Longitudinal Wave
   c. Surface Wave
   d. Tidal Wave

3. Which of the following describes the effect of water waves passing into shallow water?
   a. wavelength increases, frequency increases, velocity increases
   b. wavelength increases, frequency unchanged, velocity increases
   c. wavelength decreases, frequency increases, velocity unchanged
   d. wavelength decreases, frequency unchanged, velocity decreases

4. Which one of the following statements is true for both transverse and longitudinal wave?
   a. It can be refracted.
   b. It can travel through a vacuum.
   c. It can have similar wavelengths.
   d. It can travel with the same speed.

5. This type of wave occurs when the wave motion moves perpendicular to the material.
   a. Transverse Wave
   b. Surface Wave
   c. Longitudinal Wave
   d. Tidal Wave

6. An ocean wave is an example of a __________.
   a. standing waves.
   b. stationary wave.
   c. transverse wave.
   d. longitudinal wave.

7. This type of wave occurs when the wave motion moves parallel to the material.
   a. Transverse Wave
   b. Surface Wave
   c. Longitudinal Wave
   d. Tidal Wave

8. The maximum distance the molecules of a medium are displaced from their rest position is the __________.
   a. speed.
   b. frequency.
   c. amplitude.
   d. wavelength.

SCORE: ____/15
9. Which of the following is an example of longitudinal wave?
   a. blue light
   b. radio waves
   c. water ripples
   d. sound waves
10. A source of frequency 500 Hz emits waves of wavelength 0.2 m. How long does it take the waves to travel 600 m?
   a. 3 s
   b. 6 s
   c. 12 s
   d. 60 s
11. A large ripple tank with a vibrator working at a frequency of 30 Hz produces 25 complete waves in a distance of 50 cm. The velocity of the wave is __________.
   a. 60 cm/s.
   b. 5/3 cm/s.
   c. 750 cm/s.
   d. 1500 cm/s.

The figure below represents a sea-wave that causes a small cork (Z) to rise up and down through one complete oscillation every 4 seconds.

Refer to this figure for questions 12-15.

Source: https://home.apu.edu/~disaak/gp2/resources/16sampleHWproblem.pdf

12. The amplitude of the wave is __________.
   a. 0.5 m
   b. 1.0 m
   c. 1.5 m
   d. 3.0 m
13. The wavelength of the wave is __________.
   a. 0.5 m
   b. 1.0 m
   c. 1.5 m
   d. 3.0 m
14. The horizontal speed of the wave is __________.
   a. 4 m/s
   b. 12 m/s
   c. 0.25 m/s
   d. 0.75 m/s
15. If the wave is moving to the right, after 4 seconds the cork (Z) will be at position __________.
   a. P
   b. Q
   c. R
   d. S
**Additional Activity**

**Activity 7. Let’s Have Some Vlog**

**Directions:**

1. Look for at least two stringed and percussion instruments like in the figure below.
2. Record yourself through a video while making sounds from the different instruments.
3. Describe how tones and vibrations are produced by each instrument by stating it on your video presentation.
4. Refer the rubric in Table 1 for your guide.
5. Submit your output to your science teacher through his/her email.

![Stringed and Percussion Instruments](https://www.vectorstock.com/royalty-free-vector/cartoon-musical-instruments-vector-22524630)

*Figure 5. Stringed and Percussion Instruments*

<table>
<thead>
<tr>
<th>Category</th>
<th><strong>Excellent (10pts)</strong></th>
<th><strong>Very Satisfactory (8pts)</strong></th>
<th><strong>Satisfactory (6pts)</strong></th>
<th><strong>Needs Improvement (4pts)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td>The video clearly demonstrates a key concept.</td>
<td>The video demonstrates key concepts.</td>
<td>The video demonstrates a previous concept.</td>
<td>The video does not demonstrate a clear concept.</td>
</tr>
<tr>
<td>Design</td>
<td>The quality and materials in the video are very well organized and understandable.</td>
<td>The quality and materials in the video adequately organized and somewhat clear.</td>
<td>The quality and materials in the video lacked some organization and 50% clear.</td>
<td>The quality and materials in the video are not organized and lack clarity</td>
</tr>
<tr>
<td>Final Product</td>
<td>Final product looks professional and the concepts were visibly demonstrated.</td>
<td>Final product looks decent and the concepts were somewhat demonstrated.</td>
<td>Final product required more revisions and the concepts were not clearly demonstrated.</td>
<td>Final product looks unrefined and the concepts were not demonstrated.</td>
</tr>
</tbody>
</table>

Table 1. Rubric for Video Presentation
Answer Key

ASSESSMENT


ASSESSMENT

Activity 5.A
1. Green wave shows underdamped motion because an oscillator causes it to return to equilibrium with the amplitude gradually decreasing to zero.
2. Pink wave shows overdamped motion because an oscillator causes it to return to equilibrium without oscillating.
3. Blue wave shows critically damped motion because an oscillator causes it to return to equilibrium as quickly as possible with no oscillating.

Activity 5.B
1. A
2. C
3. B
4. F
5. D

Activity 5.C
1. A
2. C
3. A
4. D
5. Displacement
6. Acceleration
7. Angular Frequency
8. Simple Harmonic
9. Overdamped
10. Sound
11. Simple Pendulum
12. Critical
13. Damped
14. Speed
15. Pendulum

Activity 6
Soft - Weak
Medium - Strong
Loud - Strongest

Activity 3
1. Crest or peak
2. trough
3. amplitude
4. energy
5. speed
6. period
7. wave length
8. simple harmonic
9. sound
10. displacement
11. acceleration
12. frequency
13. critically damped
14. speed
15. pendulum

Activity 1
1. Mechanical Wave
2. Wave length
3. Speed
4. Frequency
5. Speed
6. Velocity
7. Critical
8. Simple Harmonic
9. Overdamped
10. Sound

Activity 2
1. By distinguishing one end of the rope
2. one wavelength
3. trough
4. amplitude
5. crest or peak

Activity 4
1. A
2. C
3. B
4. F
5. D

Activity 5
1. Crest or peak
2. trough
3. amplitude
4. energy
5. speed
6. period
7. wave length
8. simple harmonic
9. sound
10. displacement
11. acceleration
12. frequency
13. critically damped
14. speed
15. pendulum
Deja que el sol, ardiendo, las llamas evapore
Y al cielo tornen puras, con mi clamor en pos;
Deja que un ser amigo mi fin temprano llore
Y al cielo tornen sus últimas i

Y en el polvo de tu alfombra que vayan a formar.

Adiós, Patria adorada, región del sol querida,
Y en tu encantada tierra la eternidad dormir.

¡Salud te grita el alma que pronto va a partir!

Por nuestras pobres madres que gimen su amargura;
Por cuantos padecieron tormentos sin i

Y en las serenas tardes cuando por mí alguien ore,
Y sienta yo en mi frente bajo la tumba fría,

Por huérfanos y viudas, por presos en tortura
Y el polvo de tu alfombra que vayan a formar.

Tu atmósfera, tu espacio, tus valles cruzaré.

Y en las serenas tardes cuando por mí alguien ore,
Y sienta yo en mi frente bajo la tumba fría,

Adiós, Patria adorada, región del sol querida,
Y en tu encantada tierra la eternidad dormir.

¡Salud te grita el alma que pronto va a partir!

Por nuestras pobres madres que gimen su amargura;
Por cuantos padecieron tormentos sin i

Y en las serenas tardes cuando por mí alguien ore,
Y sienta yo en mi frente bajo la tumba fría,

Tu atmósfera, tu espacio, tus valles cruzaré.