

Physics Inspire - Mechanical Waves



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التواصل الاجتماعي بحسب الصف التاسع المتقدم



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ملف أسئلة Inspire وفق الهيكل

1

EOT Solution Term 3 Physics Grade 9 Advanced

2

ملزمة الوحدة 13 الاهتزازات

3

ورقة عمل عن خصائص و سلوك الموجات مع الحل

4

أسئلة اختبار الدرس الأول خصائص الموجات من الوحدة 13 الاهتزازات والموجات

5

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Physics

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PHYSICS

Inspire

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Academic Year العام الدراسي	2025-2026
Term/الفصل	T3
Subject الموضوع	Physics (Inspire)
Grade الصف	9
Stream. المسار	Advanced المتقدم
Number Of MCQ عدد الأسئلة الموضوعية	25



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عزيزي الطالب / عزيزتي الطالبة

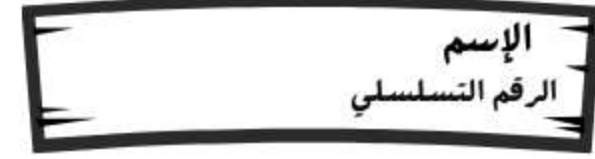


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- Part 1: Learning Outcomes 1-7

ملف الشرح

Type	Question	Learning Outcome/Performance Criteria** معايير الأداء	المرجع في كتاب الطالب (النسخة الإنجليزية) Reference(s) in the Student Book (English Version)	
			Example/Exercise مثال/تمرين	Page. صفحة
1	1	Differentiate between transverse, longitudinal, and surface waves and give examples	St. textbook	115-116
	2	Calculate the frequency of a wave from its period and vice-versa ($f = \frac{1}{T}$) Apply the relation ($v = \lambda f$) to calculate the speed, wavelength, or frequency of a wave	St. textbook Example problem 3 Practice problem(14 to 23)	118 119 120
	3	Describe that a mechanical wave is inverted if reflected from a fixed end and remains upright if reflected from a free end	St. textbook	122-121
	4	Describe wave properties like amplitude, energy of a wave, wavelength, speed, phase, period and frequency	St. textbook	116-118
	5	Sketch snapshots for the superposition of two overlapping wave pulses (same wavelength) traveling in opposite directions showing the resultant wave. Find the amplitude of the resultant wave in terms of the individual wave amplitude, for two overlapping waves (same wavelength) traveling in opposite directions	St. textbook	122-123
	6	Define nodes and antinodes and describe how they are formed.	St. textbook	123
	7	Determine the wavelengths required for the first several harmonics on a string under tension in terms of string length ($\lambda_n = \frac{2L}{n}$).	St. textbook	124

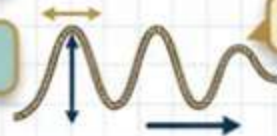




Mechanical Waves

Types of Waves

1. Transverse



$$y(x,t) = A \sin(kx - \omega t)$$

2. Longitudinal



$$\text{Speed } v = f\lambda$$

3. Surface



Wave Properties

1. Amplitude

A = Maximum Displacement

2. Wavelength (λ)

λ = Distance Between Cycles



3. Period (T)

T = Time for One Cycle

4. Frequency (f)

$$f = \frac{1}{T} \quad f = \frac{\text{Cycles}}{\text{Time}}$$

5. Speed (v)

$$v = f\lambda \quad v = \frac{\text{Distance}}{\text{Time}}$$

A wave is a disturbance that carries energy through matter or space without transferring matter.



Mechanical Wave

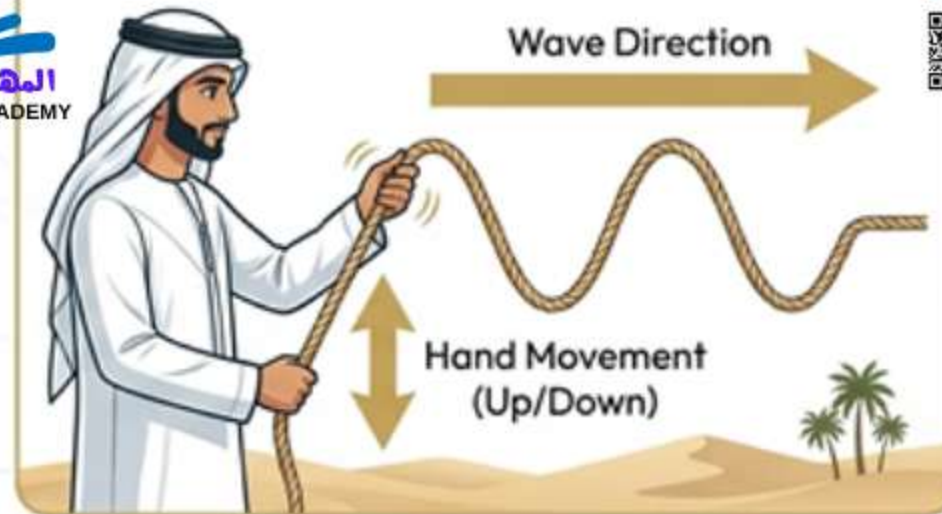
Waves that require a physical medium (water, air, or a rope) to travel. They are governed by Newton's laws of motion.



Comparing Mechanical Waves

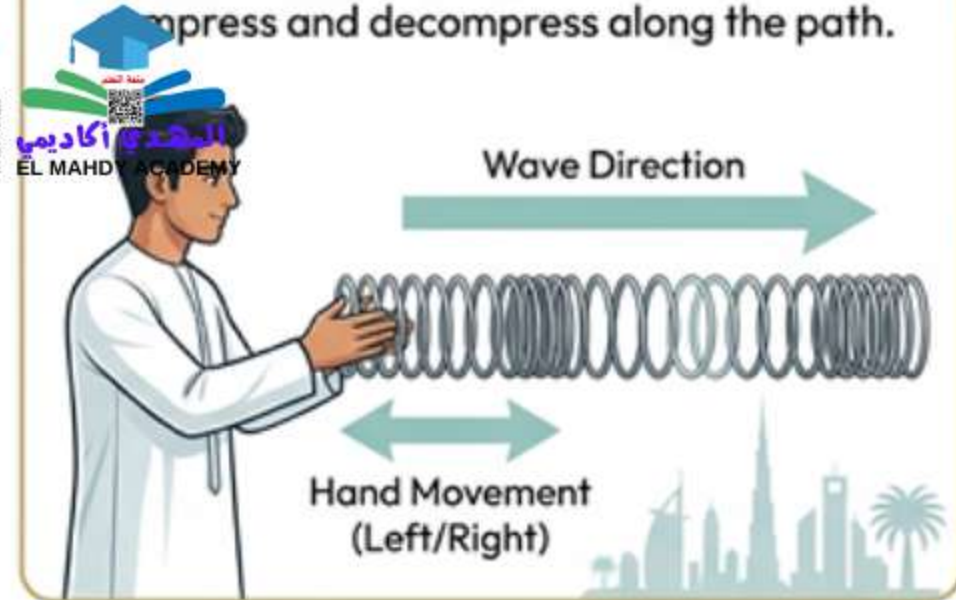
Transverse Waves

The disturbance is perpendicular to the direction of the wave's travel.

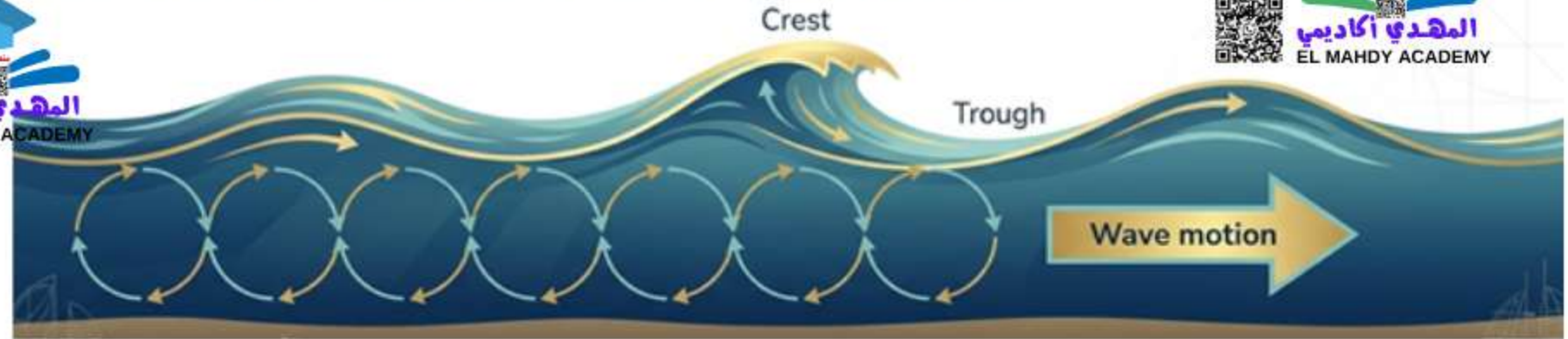


Longitudinal Waves

The disturbance is parallel to the direction of the wave's travel. Molecules alternately compress and decompress along the path.



Surface Waves & Tsunamis



Surface Waves

Found deep in lakes or oceans. Particles follow a circular path, moving both parallel and perpendicular to the wave's direction.



Real-World Physics: Tsunamis

A series of ocean waves generated by massive disturbances.

- Wavelengths: Over 100 km
- Wave Speeds: 500–1000 km/h



1

Differentiate between transverse, longitudinal, and surface waves and give examples

St. textbook

115-116

Transverse Waves



The particles in the medium move perpendicular to the direction of the wave's travel.

An example shown is shaking a rope up and down to create a wave that travels horizontally, Sea Wave



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Longitudinal Waves

The particles in the medium move parallel to the direction of the wave's travel.

An example shown is squeezing and releasing a coiled spring to create a wave that travels in the same direction as the disturbance.

Sound waves are also an example of longitudinal waves.

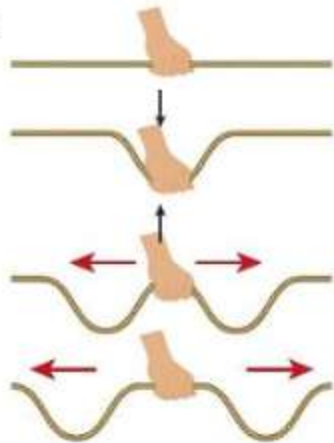


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Surface Waves

Particles in a surface wave move in a circular path, which is both parallel and perpendicular to the direction of wave motion. The circular motion is disrupted when the wave reaches the shore, causing it to break.

Transverse Wave



Longitudinal Wave

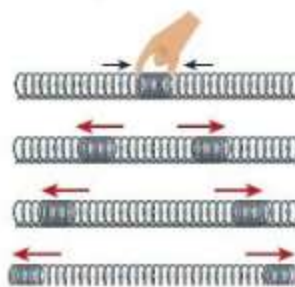


Figure 6 Shaking a rope up and down produces transverse wave pulses traveling in both directions. Squeezing and releasing the coils of a spring produces longitudinal wave pulses in both directions.

Explain the difference between transverse and longitudinal waves.

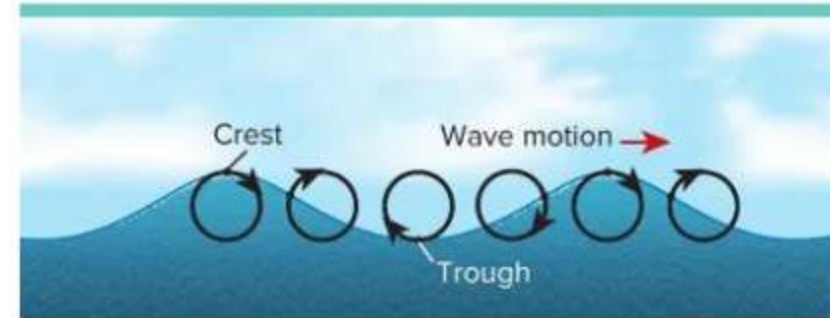


Figure 7 Surface waves in water cause movement both parallel and perpendicular to the direction of wave motion. When these waves interact with the shore, the regular, circular motion is disrupted and the waves break on the beach.





2	Calculate the frequency of a wave from its period and vice-versa ($f = \frac{1}{T}$)	St. textbook	118
	Apply the relation ($v = \lambda f$) to calculate the speed, wavelength, or frequency of a wave	Example problem 3	119
		Practice problem(14 to 23)	120

Period Or periodic Time (T)

: The time required for one full cycle of the motion / or one **wave**



$$T = \frac{\text{Total Time } t}{\text{Number of Cycles } n}$$

Frequency f

The number of cycles (**wave**) that a body makes in one second $f = \frac{\text{Number of cycles}}{\text{Total time}}$

Unit of Measurement: oscillation/second or cycle/second or vibration/second

All are equivalent to Hertz HZ or $\frac{1}{\text{second}}$ or S^{-1}

Period & Frequency

Definition Frame

Period (T): The time it takes for the motion to complete one cycle.

Formula Callout Box

$$f = \frac{1}{T}$$

(Frequency is the reciprocal of the period)

Definition Frame

Frequency (f): The number of complete oscillations a point makes each second. Measured in Hertz (Hz).
1 Hz = 1 oscillation/second.





The Relationship between Frequency and Period:

Each is the reciprocal of the other.

$$(\text{Period}) T = \frac{1}{f}$$



$$(\text{Frequency}) f = \frac{1}{T}$$

Frequency of a Wave

The frequency of a wave is equal to the reciprocal of the period.

$$f = \frac{1}{T}$$



Both the period and the frequency of a wave depend only on the wave's source. They do not depend on the wave's speed or the medium.

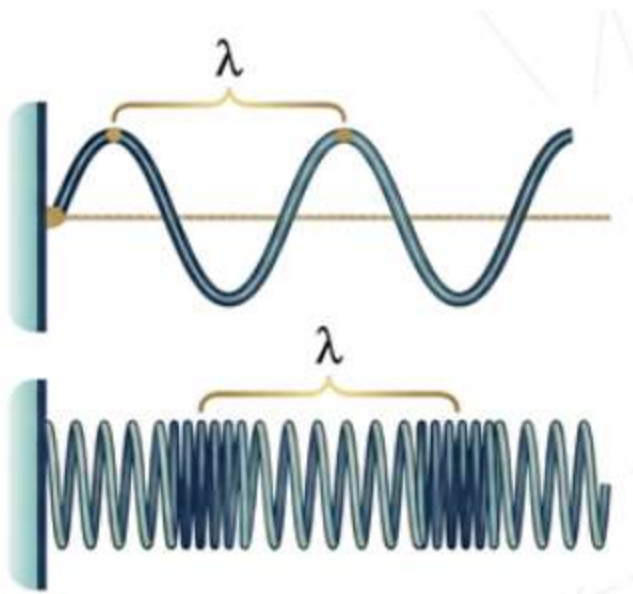




Wavelength λ

The shortest distance between repeating points on a wave.

The high points of a transverse wave are called crests, and the low points are called troughs in transverse, longitudinal compressions and rarefactions,

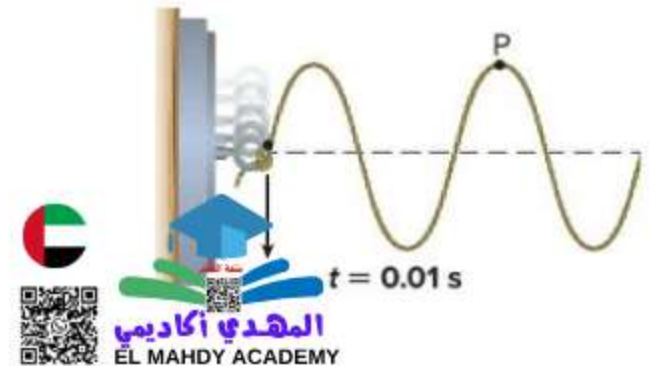
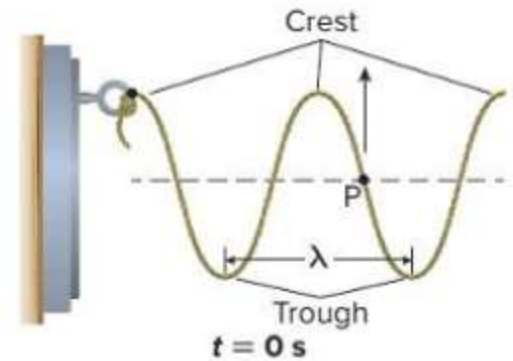


$$\lambda = \frac{L}{n}$$

L: The total distance traveled by the wave.

n: The number of complete waves in that distance, sometimes a whole number or a decimal.

Mechanical Wave



4 Describe wave properties like amplitude, energy of a wave, wavelength, speed, phase, period and frequency

St. textbook

116-118

Amplitude

The maximum displacement or distance of a wave from its equilibrium position. It is always a positive value. The text uses the example of shaking a rope to show how the force of the shake affects the amplitude.

Energy of a wave

The energy a wave transfers is related to its amplitude. Waves with a greater amplitude transfer more energy. the energy transferred is **proportional to the square of the amplitude**, meaning doubling the amplitude increases the energy transfer by a factor of four.

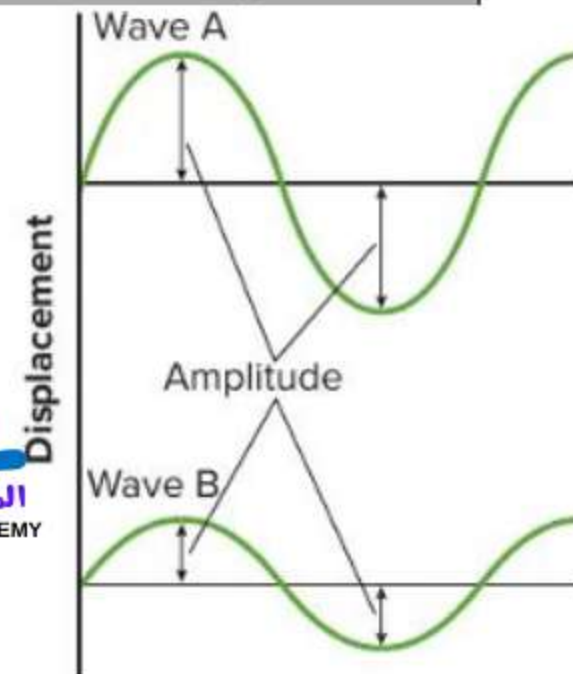


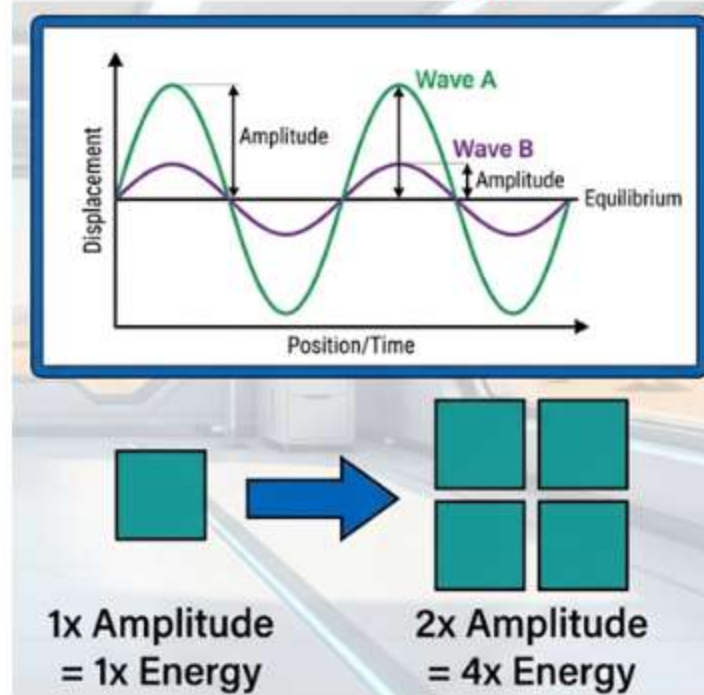
Figure 8 A wave's amplitude is measured from the equilibrium position to the highest or lowest point on the wave.



If the wave amplitude triples, the wave energy increases. to



If the wave energy doubles, the wave amplitude increase to





4 Describe wave properties like amplitude, energy of a wave, wavelength, speed, phase, period and frequency

St. textbook

116-118

Speed and velocity

The speed of a wave is determined by the displacement of a crest or compression divided by the time interval

$$v = \frac{\Delta d}{\Delta t}$$



$$v = \lambda f$$

mechanical waves, speed depends on the **medium** and not on amplitude, frequency, or wavelength.



the speed depends on two main factors:

1-The medium through which the waves are traveling. **2**-The type of wave. The temperature of the medium also affects wave speed, as demonstrated by sound waves traveling faster in warm, dry air compared to cool, dry air.



Get It?

Summarize how changing a wave's amplitude, frequency, or wavelength affects the wave's speed.





Phase

Two points on a wave are "in phase" if they are separated by one or more full wavelengths and have the same displacement and velocity.

Points with opposite displacements and velocities are "180° out of phase."

" The phase difference between two particles in a wave can range from 0° to 360°.

The period T is the time it takes for a periodic wave to complete one full cycle

لا تقلق الدكتور يوضحها في الشرح

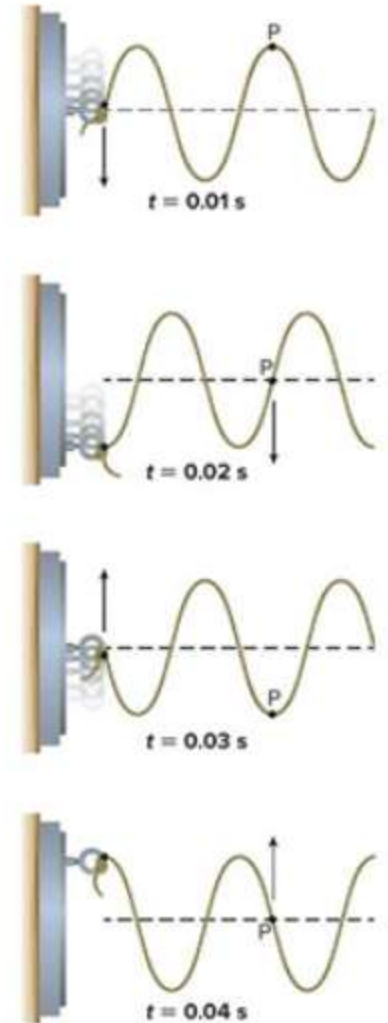


Figure 9 A mechanical oscillator moves the left end of the rope up and down, completing the cycle in 0.04 s.

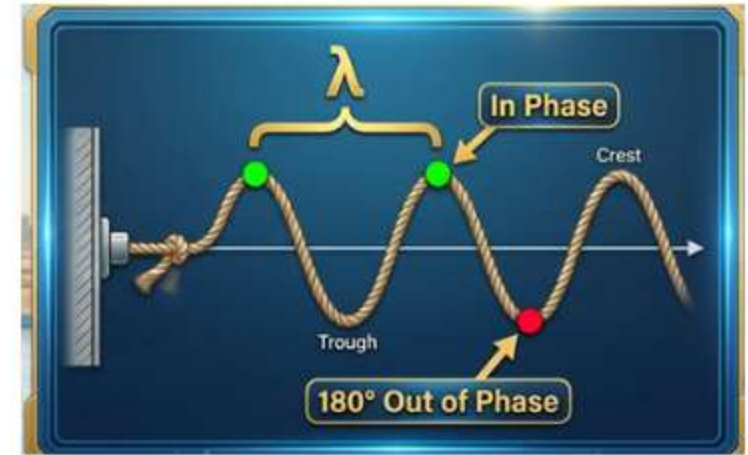


Phase , wave lenght , Periodic

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Two points separated by 360 degrees have a wavelength... a Period... i.e., a complete wave.

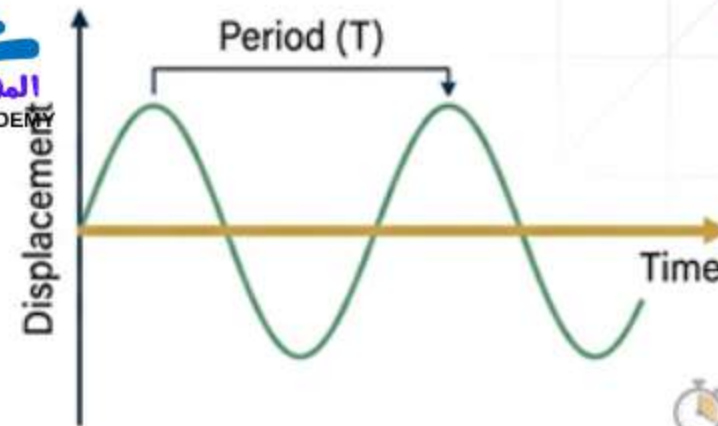
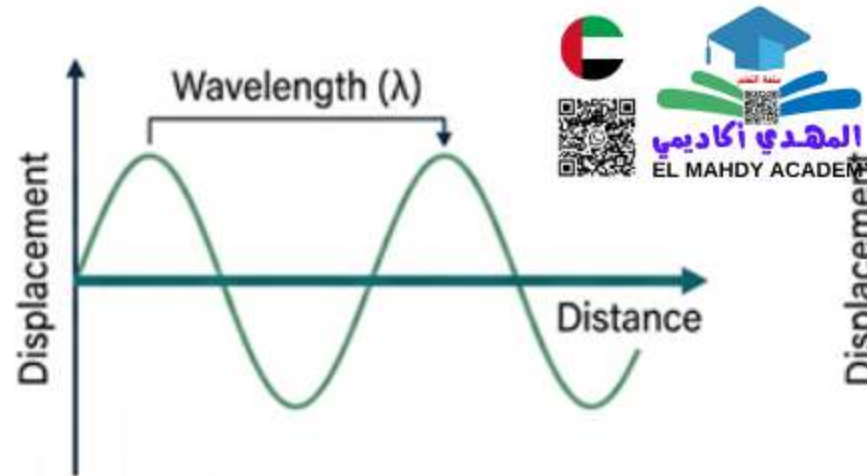


Wavelength : distance between two points in same phase

Period: time between two points in same phase



Graphing Waves: One Wave, Two Perspectives



Displacement vs. Distance

A snapshot in space. Measuring peak-to-peak reveals the Wavelength (λ).

Displacement vs. Time

The motion of a single particle over time. Measuring peak-to-peak reveals the Period (T).



Emirati Scholars
Blueprint





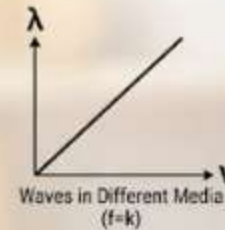
CHANGE OF MEDIUM (CONSTANT FREQUENCY)

When a wave transitions between two different media (e.g., from Air to Water):

The Frequency (f) remains Constant (f)

The Speed (v) and Wavelength (λ) change and remain Directly Proportional.

$$v \uparrow = \lambda \uparrow * f_{\text{same}}$$



Waves in Media:
Air to Water:
 v INCREASES
 f remains CONSTANT
 λ INCREASES

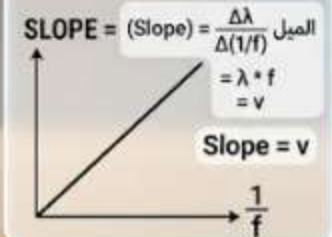
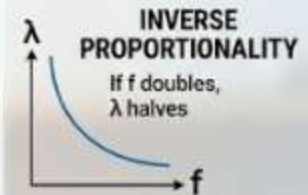
SAME MEDIUM (CONSTANT SPEED)

In the same medium, the wave speed is Constant (v).

The Wavelength (λ) and Frequency (f) become Inversely Proportional.

f INCREASE λ DECREASE

$$v_{\text{same}} = \lambda \downarrow * f \uparrow$$

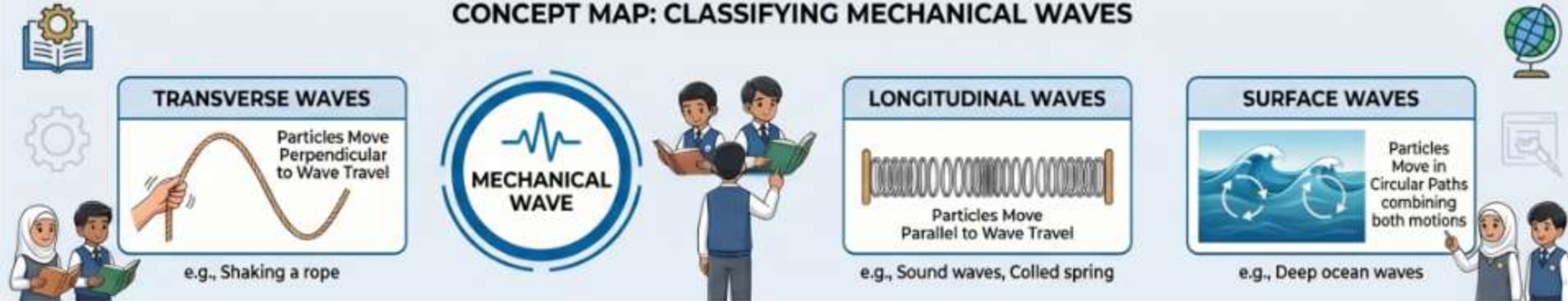




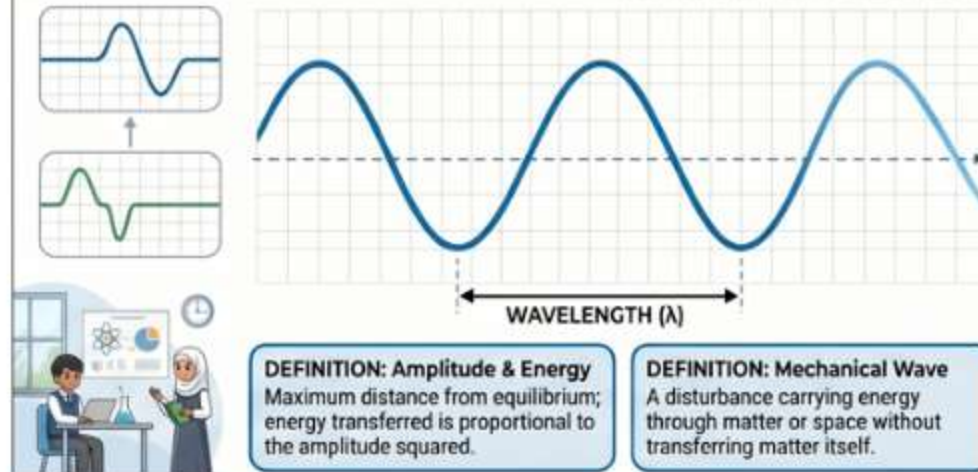
Summary

This guide breaks down the fundamental nature of mechanical waves, categorizing them by particle motion and detailing the physical properties and mathematical laws essential for UAE physics students.

CONCEPT MAP: CLASSIFYING MECHANICAL WAVES



THE ANATOMY AND MATHEMATICS OF WAVES



KEY FORMULAS (CHEAT SHEET)

Property	Formula	Units
Wave Speed	$v = \Delta d / \Delta t$	m/s
Frequency (f)	$f = 1 / T$ Reciprocal of Period (T)	Hz (1/s)
Wavelength (λ)	$\lambda = v / f$ Wavelength equals velocity divided by frequency	meters (m)



3

Describe that a mechanical wave is inverted if reflected from a fixed end and remains upright if reflected from a free end

St. textbook

122-121

Wave speed: The speed of a mechanical wave depends on the properties of the medium it travels through, such as the tension and mass per unit length of a spring. It does not depend on the wave's amplitude or frequency

Incident and reflected waves: When a wave pulse, called the "incident wave," strikes a boundary between two mediums, part of its energy is reflected back as a "reflected wave."

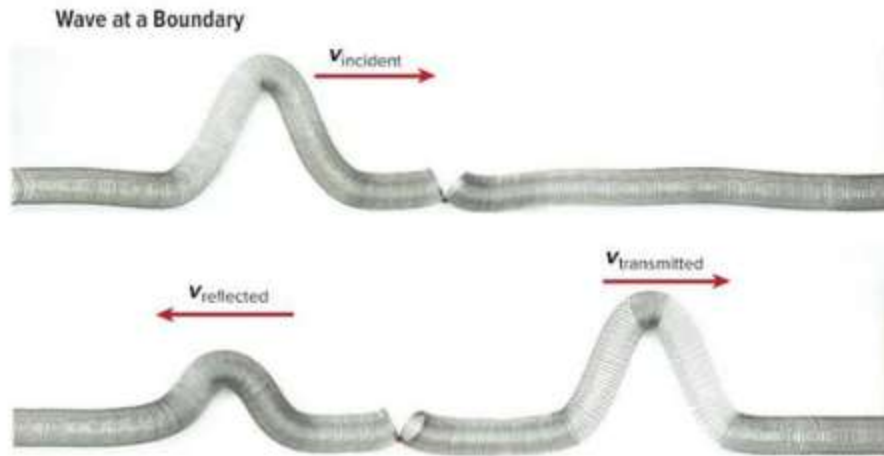


Figure 12 When the wave pulse meets the boundary between the two springs, a transmitted wave pulse and a reflected wave form.

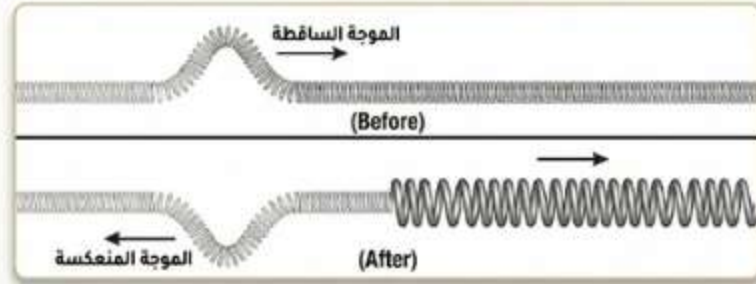
Compare the energy of the incident wave to the energy of the reflected wave.

Reflected wave orientation: The reflected wave can be either upright or inverted. If the wave travels into a medium where its speed is greater (e.g., a stiffer spring), the reflected wave will be inverted.

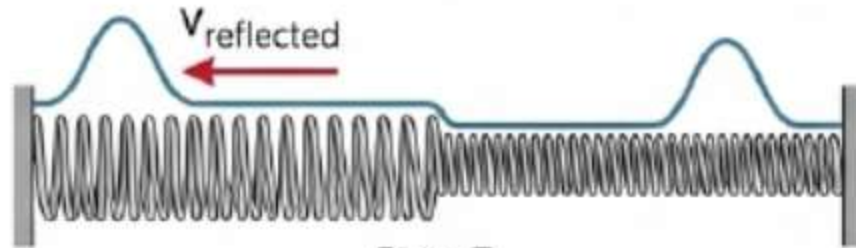


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غير مؤكد عليها الهيكل



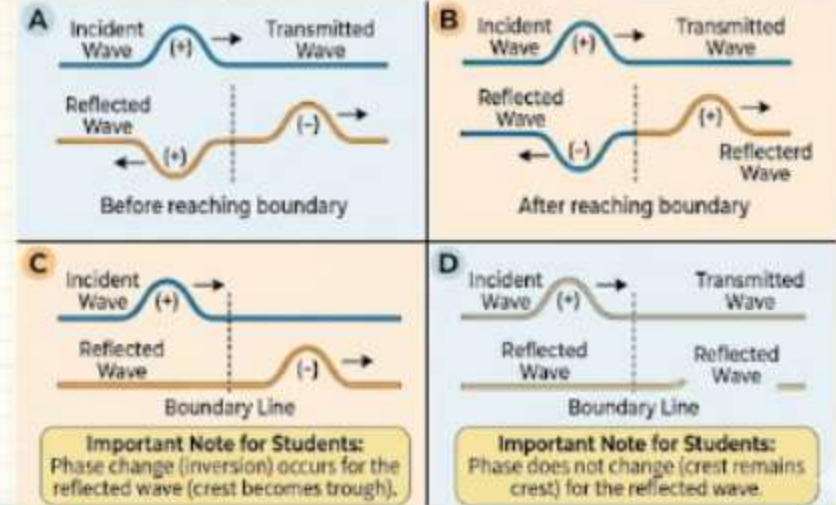
! الموجة المنعكسة تنقلب إذا كانت سرعة الموجات في الزنبرك الأقل سماكة أكبر (الزنبرك الأكثر صلابة).



Step 3.



Case 2: Specific Scenarios (Rope / Rope Boundary)



When a wave pulse encounters a rigid boundary, or free ended

Reflected Wave: Fixed and Free Ends

Fixed End Boundary

Incident Pulse (Wave) → Reflection → Fixed Wall

Peak amplitude inverts to a trough amplitude

Reflected Pulse

Wave inverts: Peak becomes trough

Inverted

Inverted phase shift 180° Result:

Free End Boundary

Incident Pulse → Reflection → Free Ring

Reflected Pulse

Wave reflection process

Free Ring Point

Upright

Result: Upright phase shift 0° (None)

COMPARISON TABLE

FIXED END BOUNDARY	FREE END BOUNDARY	ASPECTS
Inverted Wave	Upright Wave	Reflected Wave Form
180° (π radians) π	0° (0 radians / None)	Boundary Reaction
Wall exerts equal and opposite force	Free end moves freely, no reaction force	Speed, Frequency, Wavelength
Zero (Nodal Point) ✓	Maximized (Anti-nodal Point) ✓	Rope Displacement at Boundary



When a wave pulse encounters a rigid boundary, the following occurs:

reflected and inverted.

- The wave's energy is reflected back.
- The reflected pulse has almost the same amplitude as the incident wave.
- Almost all of the wave's energy is reflected, with very little being transmitted.
- The reflected pulse is inverted.



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Figure 13 When a wave encounters a rigid boundary, the reflected wave is inverted. Note that the amplitude is not affected by the rigid boundary.



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Reflection from a free end:

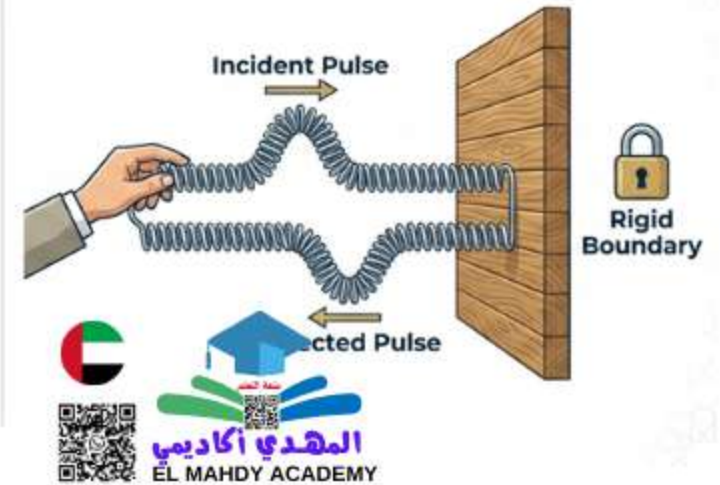
When a wave reaches a free end, there is no opposing force from the barrier. Therefore, the wave continues its motion and reflects without inverting, meaning its phase remains the same

Comparison Aspect	Free End (Movable)	Fixed End (Rigid)
Pulse Behavior	Reflects Only	Reflects and Inverts
Reflection Shape	Crest returns as Crest	Crest returns as Trough
Phase Change	No Phase Change (0°)	Phase Change of 180°



Key Concept Checklist

- ✓ 1. Almost all wave energy is reflected back.
- ✓ 2. Very little energy is transmitted into the wall.
- ✓ 3. The reflected pulse is INVERTED (flips upside down).



5

Sketch snapshots for the superposition of two overlapping wave pulses (same wavelength) traveling in opposite directions showing the resultant wave. Find the amplitude of the resultant wave in terms of the individual wave amplitude, for two overlapping waves (same wavelength) traveling in opposite directions

St. textbook

122-123



Incident wave

+



Reflected wave

=



Interference: The result of the superposition of two or more waves.

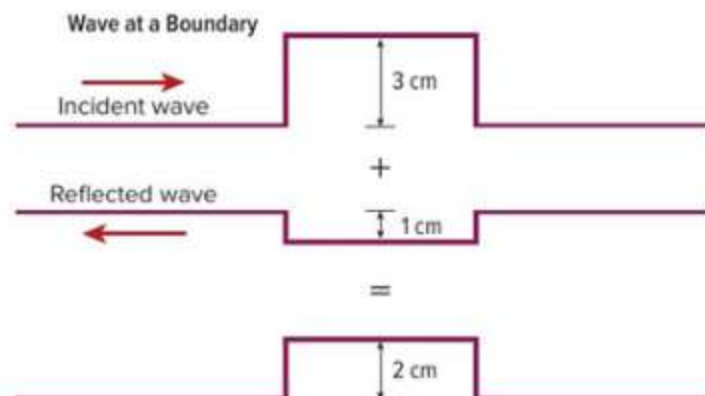


Figure 14 Waves add algebraically during superposition.

Interference: The result of the superposition of two or more waves is called interference.



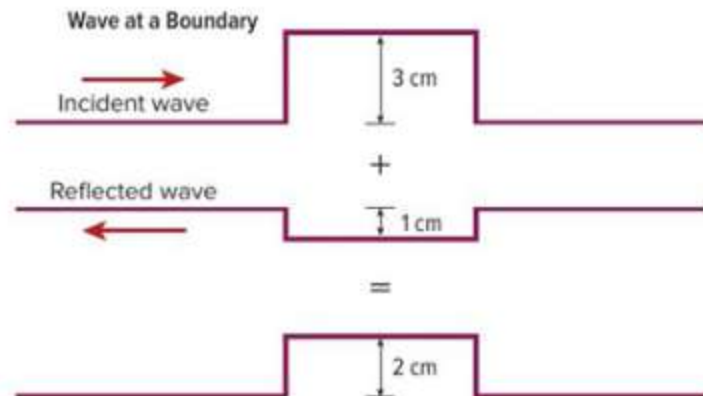


Principle of Superposition: This principle states that when two or more waves exist in the same medium at the same time, the resulting displacement of the medium is the algebraic sum of the displacements caused by each individual wave.

Combination of Waves: The individual waves combine to form a new wave.



Amplitude Change: The new wave can have a lesser or greater amplitude, depending on whether the individual waves cancel, add, or subtract from each other.



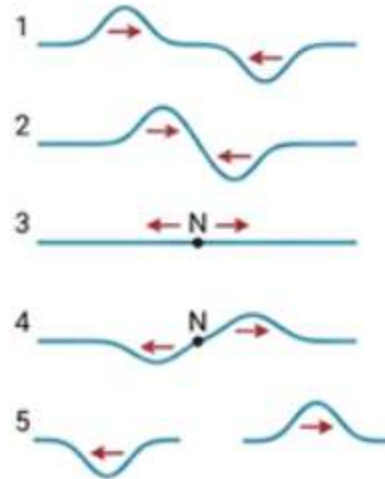
Interference: The result of the superposition of two or more waves is called interference.

Figure 14 Waves add algebraically during superposition.





Destructive Interference



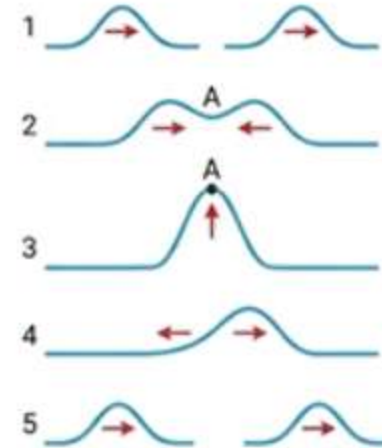
Pulses have **opposite** displacements.
They cancel each other out.

Definition Box

Node (N): A point that does not move at all during interference (displacement is zero).



Constructive Interference



Wave displacements are in the **same** direction, creating a larger amplitude.

Definition Box

Antinode (A): The point with the largest displacement when waves meet.



6 Define nodes and antinodes and describe how they are formed.

St. textbook

123

Constructive Interference

Occurs when wave displacements are in the same direction. The resulting wave has a greater amplitude than the individual waves. A point with the largest displacement is called an **antinode**. The resultant pulse is the algebraic sum of the two pulses

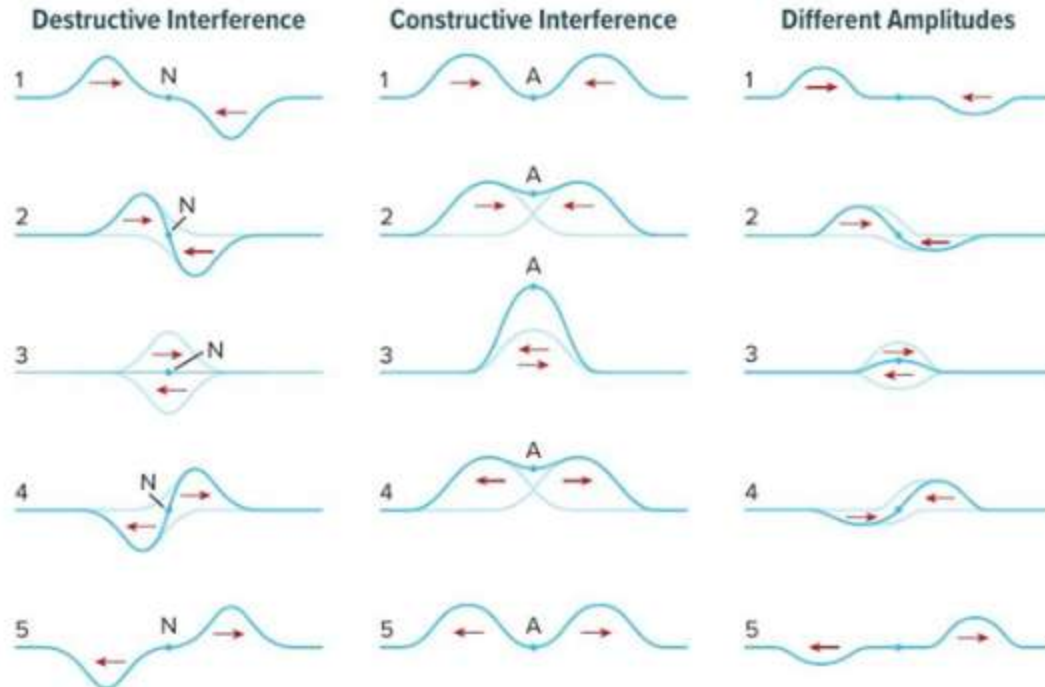


Figure 15 When waves add algebraically, the resulting combined waves can be quite different from the individual waves. Summarize how waves behave during and after superposition.

Destructive Interference:

Occurs when waves with equal but opposite displacements superimpose. The displacement at the point where the pulses meet is zero. A point that does not move is called a **node**.



Get It?

Compare the wave medium's displacement at a node and at an antinode.

A **node** is a point in a standing wave where the displacement is zero. This occurs due to destructive

An **antinode** is a point in a standing wave where the displacement is at its maximum. This occurs due to constructive interference,





7

Determine the wavelengths required for the first several harmonics on a string under tension in terms of string length ($\lambda_n = \frac{2L}{n}$).

St. textbook

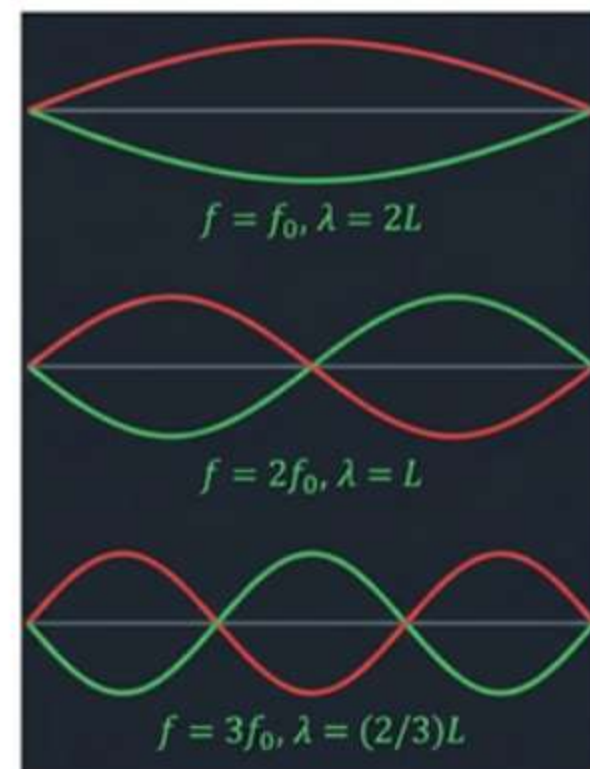
124

Standing Wave: The **interference** of waves traveling in opposite directions, producing stationary nodes and oscillating antinodes.



Figure 16 Interference produces standing waves only at certain frequencies.

Predict the wavelength if the frequency is four times the lowest frequency.





Standing waves

- A wave traveling along a rope attached to a fixed point is reflected and inverted at that point.
- When the reflected wave returns to the hand, it is inverted again and travels back down the rope.
- As a result, the displacement of the wave leaving the hand a second time is in the same direction as the first time.

Standing waves are formed by the interference of waves traveling in opposite directions.

The key features of a standing wave are nodes (points of no displacement, such as the ends of a rope) and antinodes (points of maximum displacement, such as the middle of a rope).

Increasing the frequency of vibration produces more nodes and antinodes, causing the wave to vibrate in multiple segments.

Figure 16 Interference produces standing waves only at certain frequencies.

Predict the wavelength if the frequency is four times the lowest frequency.



Wavelength Formula for Harmonics (n):

$$\lambda_n = \frac{2L}{n}$$



Where:

- λ_n : The wavelength of the n^{th} harmonic (measured in meters, m).
- L : The length of the stretched string (measured in meters, m).
- n : The harmonic number ($n = 1, 2, 3, 4, \dots$).



- **Number of Antinodes:** Always equals the harmonic number (n).
- **Inverse Relationship:** As the harmonic number (n) increases, the wavelength (λ_n) generated in the same string length decreases.



UNDERSTANDING STANDING WAVES ON STRINGS



Pluck the guitar string to see harmonic patterns.

- **NODE:** Point of zero vibration
- **ANTINODE:** Point of maximum vibration
- Another Node definition if space: Boundary points in this case

THE MATHEMATICAL LAW

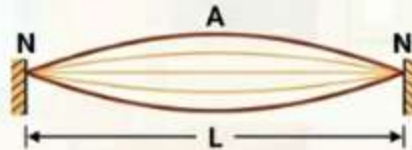
THE MATHEMATICAL LAW

$$\text{Wavelength } (\lambda_n) = 2 \frac{\text{String Length (L)}}{\text{Harmonic Number (n)}}$$



L: String Length
n: Harmonic Number
 λ_n : Wavelength

1ST HARMONIC (n = 1) FUNDAMENTAL HARMONIC



Single loop model

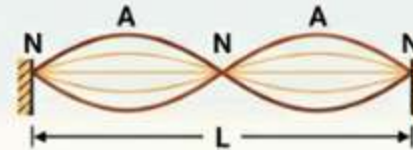
$$\lambda_1 = 2L$$



1 Antinode (A)
2 Nodes (N)



2ND HARMONIC (n = 2)



2 loop model

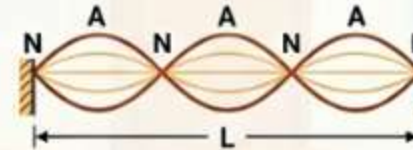
$$\lambda_2 = L$$



2 Antinodes (A)
3 Nodes (N)



3RD HARMONIC (n = 3)



3 loop model

$$\lambda_3 \approx 0.67L$$



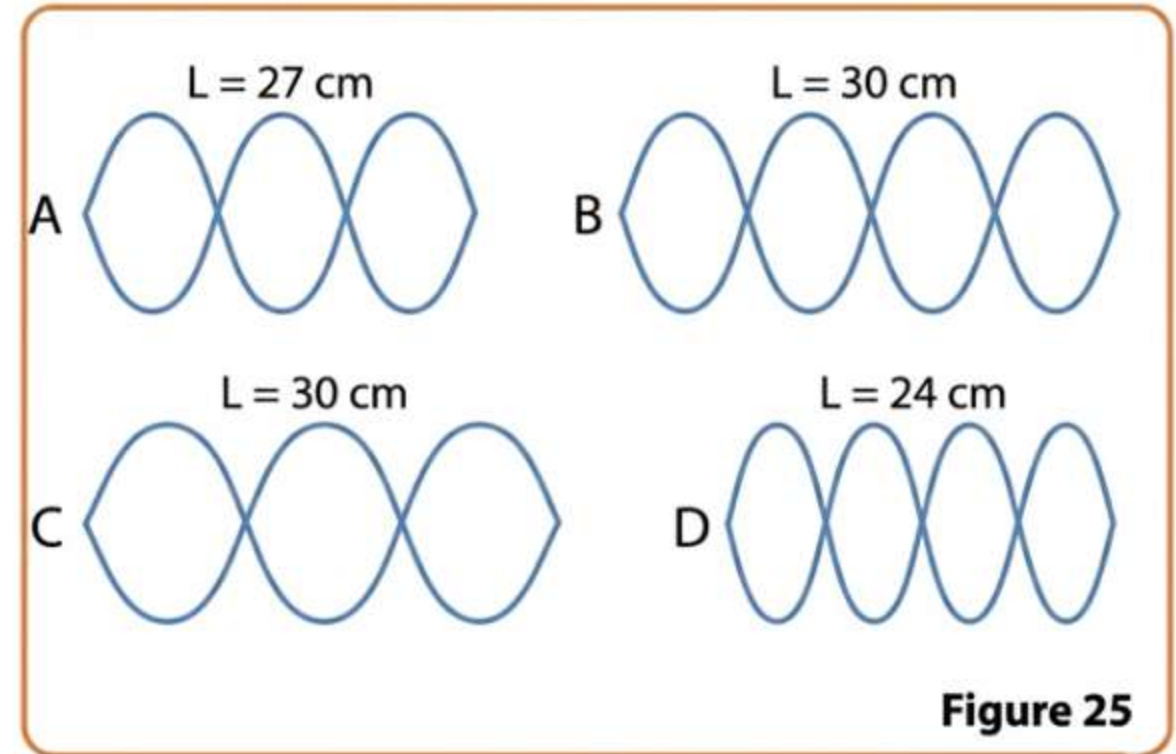
3 Antinodes (A)
4 Nodes (N)

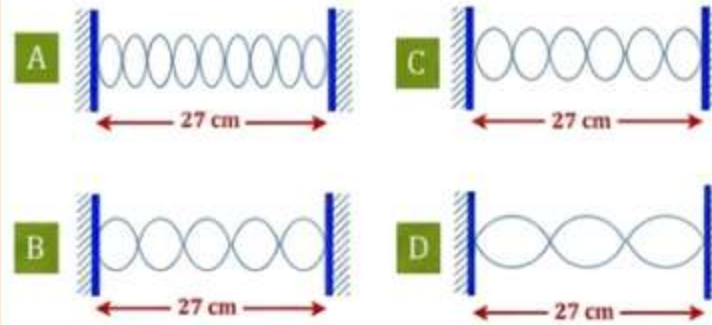




Standing waves are produced in the four strings shown in Figure 25. All the strings have the same mass per unit length and are subject to the same tension force. **78**

Given the lengths of the strings (L), rank the frequencies of the waves from highest to lowest.





تتكون موجات مستقرة في أربعة أوتار متماثلة لها نفس الطول (l) كما هو مبين بالشكل .
أي مما يلي يمثل الترتيب الصحيح لمقدار تردد الموجات الناتجة في الأوتار الأربعة؟

Standing waves are created in four identical strings, as shown in the figure. The strings are of length (l).
Which of the following is the **correct** ranking of the frequency produced in the four strings?

$$f_A > f_C > f_B > f_D$$

$$f_A < f_C < f_B < f_D$$

$$f_A \leq f_C > f_B \geq f_D$$

$$f_D > (f_A = f_B) > f_D$$



Part 2: Learning Outcomes: 8 -14

ملف الشرح

8	Define sound as pressure oscillation that is transmitted through matter. Explain that sound is a longitudinal wave that has frequency, wavelength, and speed	St. textbook	132
9	Explain that the speed of sound varies with different mediums and temperatures.	St. textbook	133-134
10	Define sound pitch and relate it to the frequency of a sound wave.	St. textbook	135
11	Define loudness and relate it to the amplitude of a sound wave.	St. textbook	135
12	Describe the sound level and define the decibel (dB) as a unit of measuring sound level.	St. textbook	135
13	Apply the Doppler effect equation ($f_d = f_s \left[\frac{v - v_d}{v - v_s} \right]$) to calculate different frequencies and velocities.	Example Problem1 Practice problems	138
14	Recall resonance as the increase in the amplitude of vibration that occurs when a system (or an object) is driven by an external periodic force, vibrating at the system's (or object's) own natural frequency. Explain resonance in air columns and give examples on different instruments.	St. textbook	141



8

Define sound as pressure oscillation that is transmitted through matter.
Explain that sound is a longitudinal wave that has frequency, wavelength, and speed

St. textbook

132

Sound Wave:

A pressure oscillation that is transmitted through matter.

Longitudinal Wave:

A wave where the motion of the particles is parallel to the direction of the wave's motion.

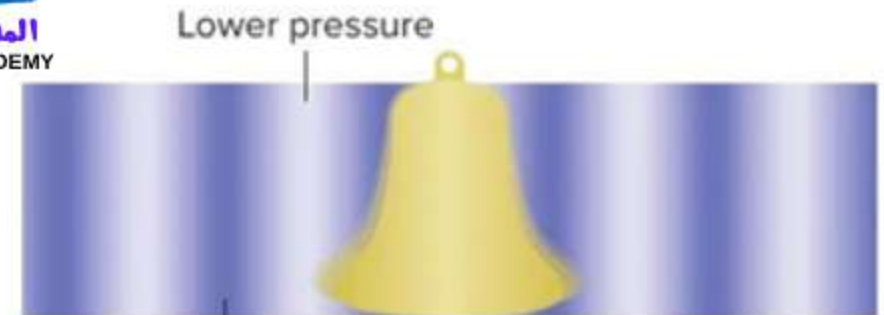
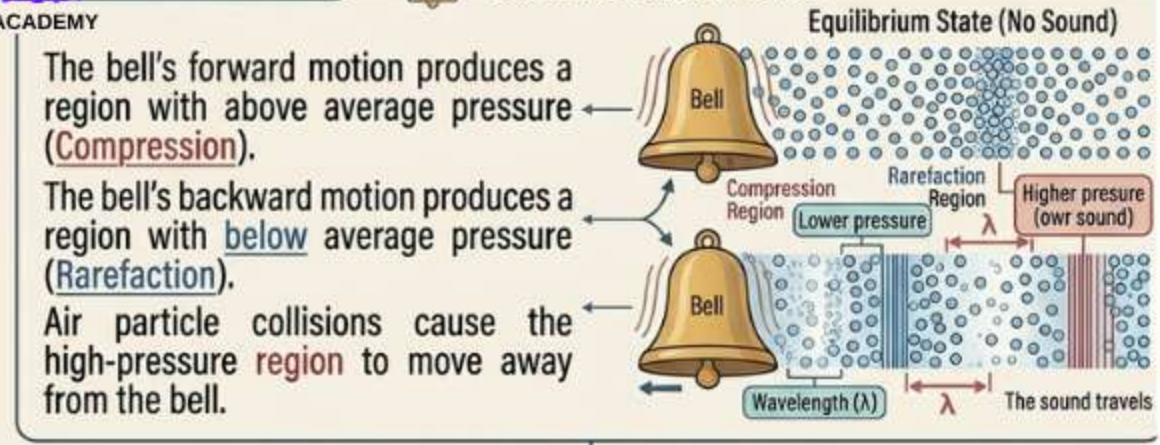
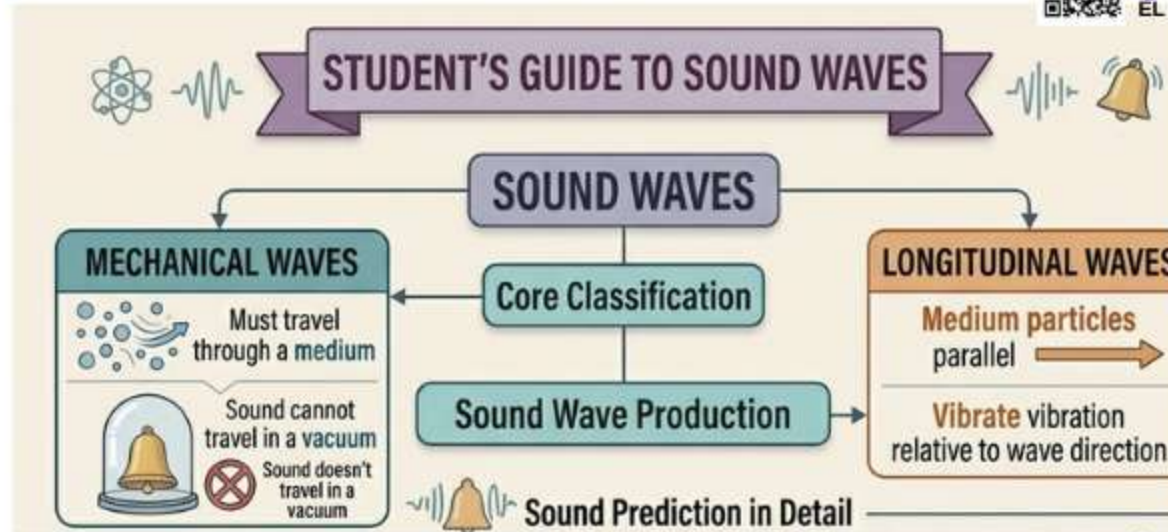


Figure 1 When the bell is at rest (top), the surrounding air is at average pressure. When the bell is struck (bottom), the vibrating edge creates regions of high and low pressure. Although the diagram shows the pressure regions moving in one direction, the waves move out in all directions.





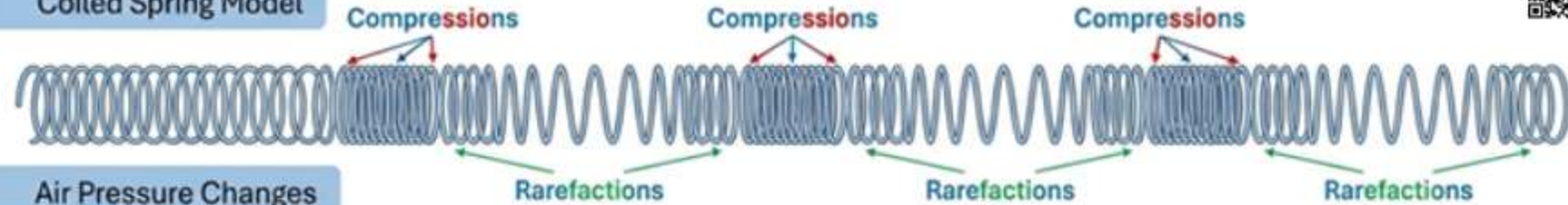
Sound is a change in pressure.

The **speed** of sound in a given medium is **constant** and is **not affected by frequency** or **wavelength**, but rather by **the properties of the medium**, such as its **temperature**.



SOUND WAVES & ACOUSTICS: MASTER-CLASS NOTES

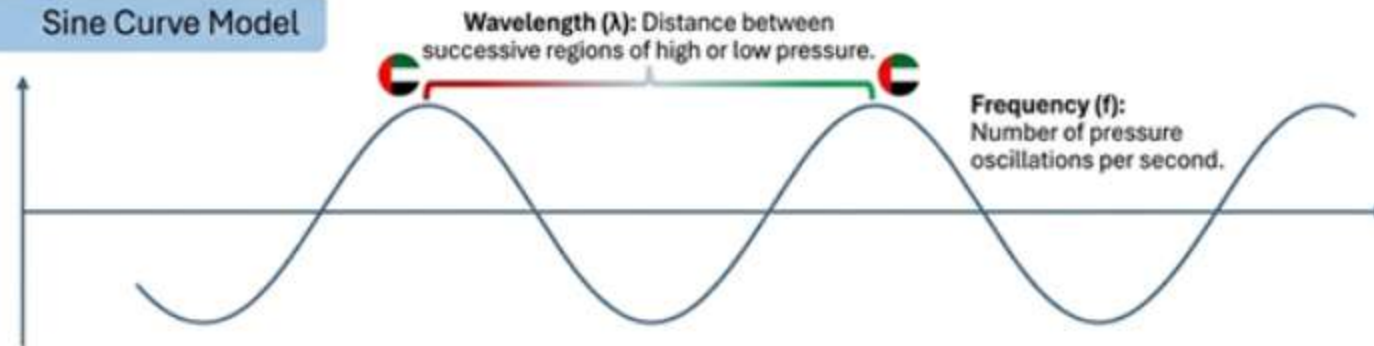
Coiled Spring Model



Air Pressure Changes



Sine Curve Model



A sound wave is a pressure oscillation transmitted through matter, caused by a vibrating source that produces regular variations in air pressure.

Wave Type: Sound is a **longitudinal wave**, meaning the motion of the particles is **parallel** to the direction of the wave's motion.

Frequency: The number of pressure oscillations per second.

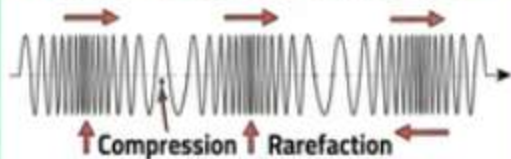
Wavelength: The distance between successive high or low-pressure regions.



BASICS OF WAVES

SOUND WAVES

Sound waves are pressure oscillations that are transmitted through matter.



Sound waves are pressure oscillations that are transmitted through matter.

The frequency is the number of oscillations in pressure each second, in regions of high or low pressure.

FREQUENCY (f)

FREQUENCY

$$f = \frac{n}{t} = \frac{1}{T}$$

WAVELENGTH

SPEED OF SOUND (v)

$$v = \frac{d}{t}$$



$$v = \frac{2d}{t}$$

Echo / Sonar
Used to measure ocean depth

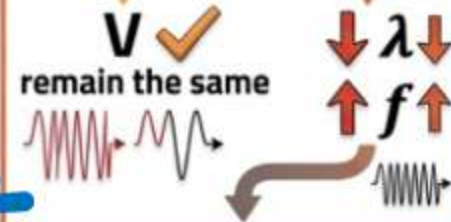


$$v = \lambda \cdot f$$

MEDIUM EFFECT

Solid:	Liquid:	Gas:
Air (20°C): 343 m/s	Water (25°C): 1493 m/s	Steel: 5960 m/s

SAME MEDIUM



INVERSELY PROPORTIONAL

$$y = \frac{1}{x}$$

FACTORS AFFECTING v



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What happens when waves travel from one medium to another
(frequency - period - speed - wavelength - amplitude)

لا تقلق الدكتور يوضحها في
الشرح



What happens when **the wavelength** changes the same medium? Speed - Frequency - Law

لا تقلق الدكتور يوضحها في
الشرح



9

Explain that the speed of sound varies with different mediums and temperatures.

St. textbook

133-134

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

Speed of Sound: The speed of sound depends on the medium and, in air, is affected by temperature. At room temperature (20 C) and sea level, the speed of sound is 343 m/s.

The speed increases by approximately 0.6 m/s for every (1C degree) increase in air temperature.

The speed of sound at 0 degrees Celsius is 331 m/s.

$$v = 331 + 0.6T$$

where v is the speed of sound in m/s and T is the temperature in degrees Celsius



10

Define sound pitch and relate it to the frequency of a sound wave.

St. textbook

135

Pitch: is the highness or lowness of a sound, which is determined by the frequency of the sound wave.

fr the human ear can typically hear sounds between 20 Hz and 16,000 Hz



Loudness: Loudness is the intensity of a sound as perceived by the ear, which is primarily determined by the **amplitude** of the **pressure wave**

Sound intensity is measured on a logarithmic scale called the sound level, with the unit being the decibel (dB).





Feature	Pitch	Loudness
Physical Characteristic	Frequency of vibration	Amplitude of the pressure wave
Description	The highness or lowness of a sound.	The intensity of a sound as perceived by the ear.
Measurement	Given a name on the musical scale (e.g., middle C).	Measured on a logarithmic scale in decibels (dB).



Get It?

Identify What characteristic of waves is pitch most closely linked to?



PITCH vs VS LOUDNESS

Two different qualities of sound that help us hear and understand the world.



PITCH (How High or Low a Sound Is)

Pitch depends on the frequency of the sound wave. Frequency is the number of vibrations (cycles) per second.

- High frequency = High pitch (high sound)
- Low frequency = Low pitch (low sound)
- Measured in Hertz (Hz)
- Humans can hear sounds from 20 Hz to 20,000 Hz
- Many animals can hear outside this range!

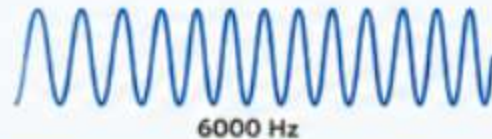


PITCH: Frequency (Hz) — Number of Vibrations per Second

Low Frequency = Low Pitch



High Frequency = High Pitch



LOUDNESS (How Strong or Soft a Sound Is)

Loudness depends on the **amplitude** of the sound wave. Amplitude is the height of the wave.

- Large amplitude = Loud sound
- Small amplitude = Soft sound
- Related to the energy of the sound wave
- Measured in decibels (dB)

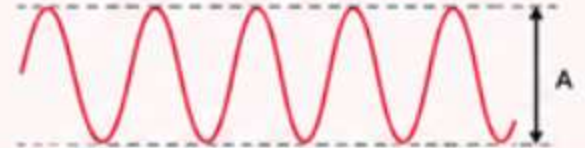


LOUDNESS: Amplitude — Height of the Wave

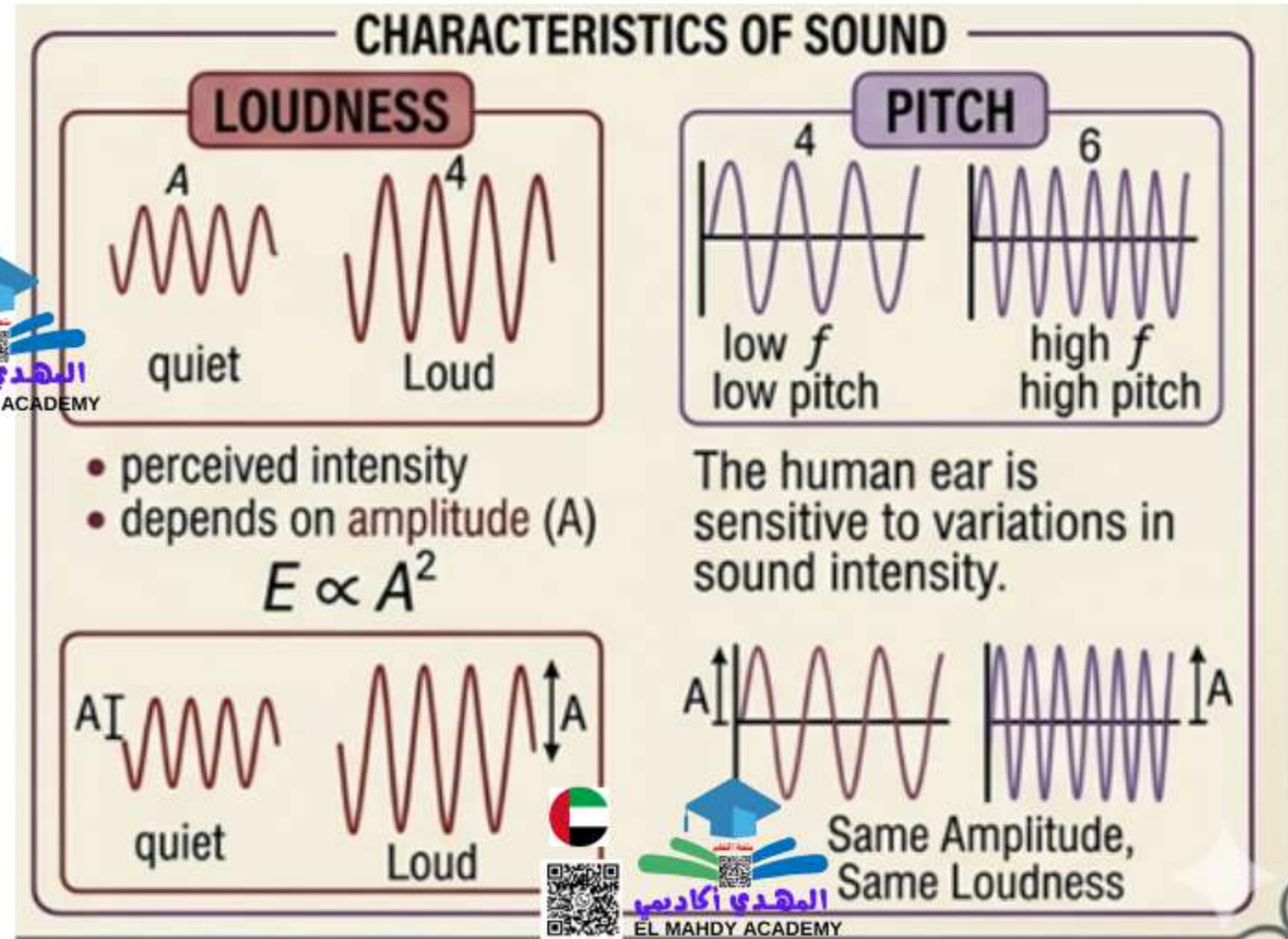
Small Amplitude = Soft Sound



Large Amplitude = Loud Sound



$$E \propto A^2$$



12

Describe the sound level and define the decibel (dB) as a unit of measuring sound level.

St. textbook

135

[DEFINITION FRAME]

Sound Level: A logarithmic scale used to measure **sound intensities**, measured in **decibels (dB)**.

Decibel (dB) is the unit used to measure sound level.

The higher the decibel value, the louder the sound.



Key Idea

The sound level depends on the **ratio** of the intensity of a given sound wave to that of the most faintly heard sound.

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FORMULA

$$\beta = 10 \log \left(\frac{I}{I_0} \right)$$

in terms of intensity

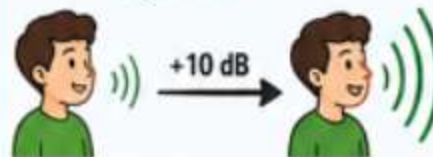
Where:

 β = sound level (dB) I = intensity of sound I_0 = reference intensity

HOW SOUND LEVEL CHANGES

10 dB increase

Sound level increases as about **twice as loud** as the original level.



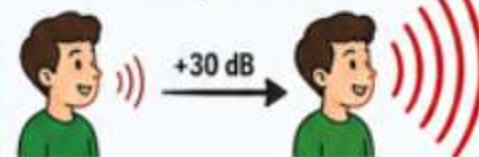
20 dB increase

Sound level increases as about **4 times as loud** as the original level.



30 dB increase

Sound level increases as about **8 times as loud** as the original level.



Get It?

Compare How much more intense is a sound that registers 80 dB than one of 40 dB?



13

Apply the Doppler effect equation ($f_d = f_s \left[\frac{v - v_d}{v - v_s} \right]$) to calculate different frequencies and velocities.

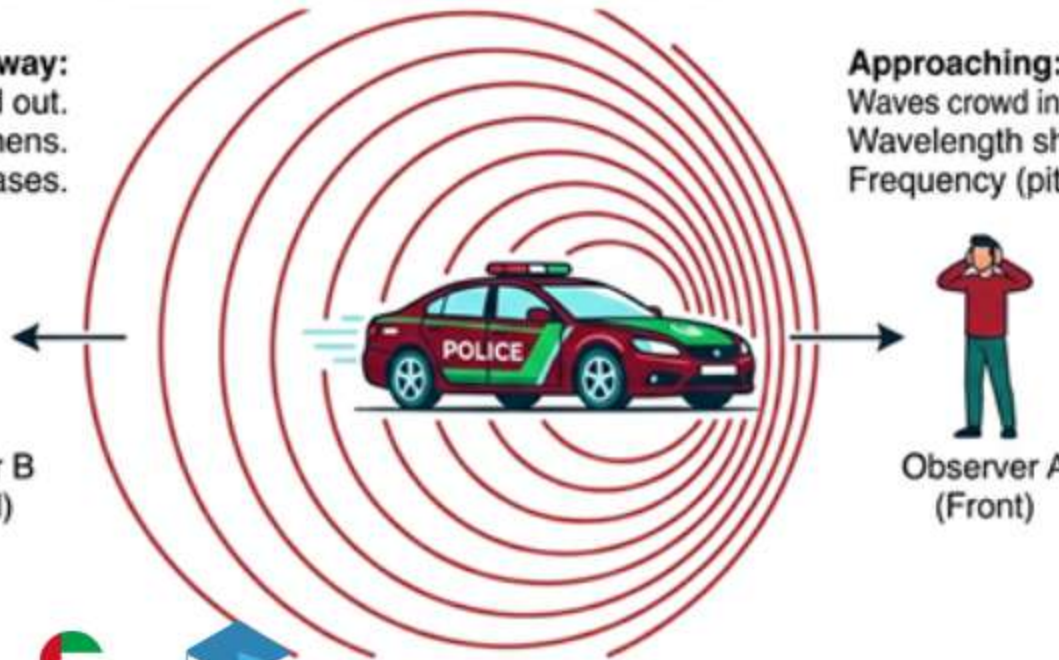
Example Problem 1
Practice problems

138

The Doppler Effect: The change in the frequency of sound caused by the movement of either the source, the detector, or both.

Moving Away:
Waves spread out.
Wavelength lengthens.
Frequency (pitch) decreases.

Observer B
(Behind)



Approaching:
Waves crowd into the space ahead.
Wavelength shortens.
Frequency (pitch) increases.

Observer A
(Front)



The Doppler effect is the change in the frequency of sound caused by the movement of the sound source, the detector, or both. A common example is the change in pitch of a fast car as it passes by, with the pitch being higher as it approaches and lower as it moves away.



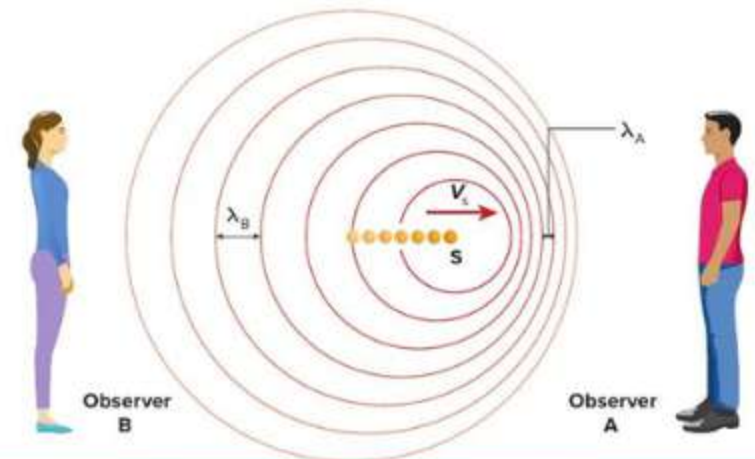
Doppler Effect

The frequency perceived by a detector is equal to the velocity of the detector relative to the velocity of the wave, divided by the velocity of the source relative to the velocity of the wave, multiplied by the wave's frequency.

$$f_d = f_s \frac{v - v_d}{v - v_s}$$

Figure 6 As a sound producing source moves toward observer A, the wavelength is shortened to λ_A . As the source moves away from observer B, the wavelength is lengthened to λ_B .

Describe What is the relative difference in the frequency of the detected sound for each observer?



The Doppler effect is the **change in the observed frequency (or pitch)** of a sound when there is relative motion between the source and the observer.

HOW IT HAPPENS

When the source moves, the wavefronts get compressed in front and stretched behind.

Approaching

Wavefronts compressed



Higher observed frequency (higher pitch)

Receding

Wavefronts stretched



Lower observed frequency (lower pitch)



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DOPPLER FORMULA (for sound)

Observed frequency (f')

$$f' = f \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

Where:

f' = observed frequency (Hz)

f = source frequency (Hz)

v = speed of sound in medium (m/s)

v_o = speed of observer (m/s)

v_s = speed of source (m/s)

+ in the numerator when the observer moves toward the source

- in the numerator when the observer moves away from the source

- in the denominator when the source moves toward the observer

+ in the denominator when the source moves away from the observer



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APPROACHING VS RECEDING

APPROACHING (moves toward each other)

Wavefronts are compressed.
Observed frequency increases.
Pitch sounds **higher**.



$$f' = f \left(\frac{v + v_o}{v - v_s} \right)$$

RECEDING (moves away from each other)

Wavefronts are stretched.
Observed frequency decreases.
Pitch sounds **lower**.



$$f' = f \left(\frac{v - v_o}{v + v_s} \right)$$

POSITIVE AND NEGATIVE CHANGE IN FREQUENCY

POSITIVE CHANGE (+Δf)

The observed frequency is **higher** than the source frequency.

$$f' > f$$

This happens when:

- Source and observer move toward each other.
- Or the observer moves toward the source.
- Or the source moves toward the observer.



Higher pitch

NEGATIVE CHANGE (-Δf)

The observed frequency is **lower** than the source frequency.

$$f' < f$$

This happens when:

- Source and observer move away from each other.
- Or the observer moves away from the source.
- Or the source moves away from the observer.



Lower pitch

EXAMPLES IN REAL LIFE

Approaching Source

Sirens of an ambulance sound **higher** pitched as it comes toward you.



Receding Source

Sirens sound **lower** pitched as it moves away from you.



Approaching Observer

You move toward a stationary source, you hear a **higher** pitch.



Receding Observer

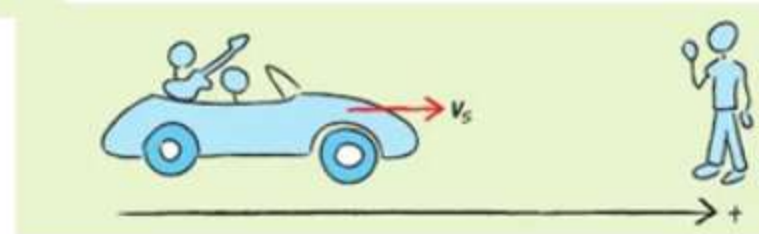
You move away from a stationary source, you hear a **lower** pitch.



EXAMPLE Problem 1

THE DOPPLER EFFECT A guitar player sounds C above middle C (523 Hz) while traveling in a convertible at 24.6 m/s. If the car is coming toward you, what frequency would you hear? Assume that the temperature is 20°C.

Ex.1 p.138



14

Recall resonance as the increase in the amplitude of vibration that occurs when a system (or an object) is driven by an external periodic force, vibrating at the system's (or object's) own natural frequency.

Explain resonance in air columns and give examples on different instruments.

St. textbook

141

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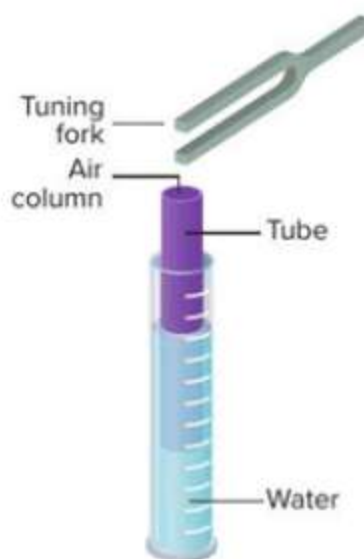


Figure 10 As the tube is raised or lowered, the length of the air column changes, which causes the sound's volume to change.



1. Definition of Resonance

It is a **phenomenon** that occurs when a system **vibrates in response** to a repeating **external** equal to its **natural frequency**.

Leads to **amplification** of the **vibration amplitude** and increase in **sound intensity**.



2. Conditions for Resonance in Columns

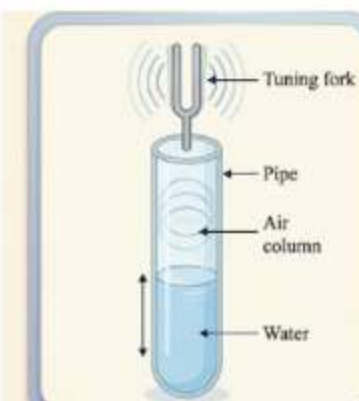
a) Presence of a **vibration source** (e.g., a **tuning fork**).



b) **Frequency** of the **vibration source** = **natural frequency** of the **air column**.



c) Adjusting the **length** of the **air column** to match the **frequency**.



CLOSED-ENDED RESONANCE PIPE:

A pipe that is open at the top and closed at the bottom (by the water surface).

When the tuning fork's frequency matches the natural frequency of the air column inside the pipe, the amplitude of vibration increases, leading to a significant amplification of the sound (the resonance state).

Definition of resonance: Resonance increases the amplitude of a vibration by repeatedly applying a small external force at the natural frequency of the air column.

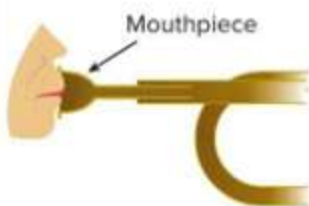




COMPARISON OF MUSICAL INSTRUMENTS



Brass Instrument



Woodwind Instrument

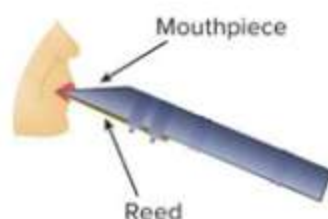


Figure 9 The sound produced by an instrument is partly determined by the structure of the mouthpiece.

	BRASS INSTRUMENTS	WOODWIND INSTRUMENTS	STRING INSTRUMENTS
How Sound is Produced 	Sound is produced when the player buzzes their lips (vibrates) into the mouthpiece. The vibration makes the air inside the instrument vibrate.	Sound is produced when air is blown across a reed or into an opening . The moving air sets the column of air inside the instrument into vibration.	Sound is produced when strings are set into vibration. The vibrating strings make the soundboard vibrate, which sends sound waves into the air.
How it Works (in the Air) 	Vibrating lips → vibration of air inside the instrument → pressure oscillations in the air → sound waves travel to our ears.	Air blown across a reed or through an opening → air column vibrates → pressure oscillations in the air → sound waves travel to our ears.	Vibrating strings → soundboard vibrates → pressure oscillations in the air → sound waves travel to our ears.
Examples 	Examples of Brass Instruments: Trumpet Tuba Bugle	Examples of Woodwind Instruments: Clarinet Saxophone Flute	Examples of String Instruments: Piano Guitar Violin
What Controls the Pitch? 	Changing the tension of the lips and the length of the air column (using valves or slides) changes the pitch.	Changing the length of the air column (covering holes or using keys) changes the pitch.	Changing the tension, length, or thickness of the strings changes the pitch.
Key Point 	Buzzing lips → vibrating air → sound waves	Blown air + reed or opening → vibrating air column → sound waves	Vibrating strings → vibrating soundboard → sound waves



Remember: All musical instruments create **vibrations**. These vibrations travel through the air to our ears as **sound**!



Part 2: Learning Outcomes: 15-19

ملف الشرح

15	Differentiate between luminous and non-luminous sources of light, giving examples. Differentiate between opaque, translucent and transparent mediums, giving examples	St. textbook	157-158
16	Define quantities of light like luminous flux and illuminance, specifying their SI units. Define luminous intensity, specifying its SI units	St. textbook	158-161
17	Apply the equation for illuminance of a point source to numerical problems	Example Problem1 Practice problems	162
18	Define quantities of light like luminous flux and illuminance, specifying their SI units.	St. textbook	158-161
19	Show that the illuminance provided by a point source of light has an inverse-square relationship with distance (r) from the source and a direct relationship with luminous flux.	St. textbook	159



15

Differentiate between luminous and non-luminous sources of light, giving examples.
Differentiate between opaque, translucent and transparent mediums, giving examples

St. textbook

157-158



Sources of Light

Luminous Source

A body that emits its own light.



The sun, light bulbs, stars, fireflies, and a burning match.

Illuminated Source

A body that reflects light from another source.



The moon, books, the wall.

Transparent	Translucent	Opaque
Transmits most light. Objects are seen clearly through it (e.g., air, clear glass).	Transmits some light, reflects the rest. Objects cannot be seen clearly (e.g., frosted glass, lampshades).	Absorbs or reflects all light. No transmission. (e.g., books, backpacks, people).
Transparent	Translucent	Opaque



Concept Check

Why can you see a fish in a bowl, and the bowl itself?

Answer: The water/glass transmits light, but also reflects a small amount.



16

Define quantities of light like luminous flux and illuminance, specifying their SI units.

Define luminous intensity, specifying its SI units

St. textbook

158-161

The Source: Luminous Flux (P)



Definition Frame

Luminous Flux (P) is the rate at which light energy is emitted from a luminous source.

- ✓ Measured in Lumens (lm).
- ✓ Represents the total output of the bulb, independent of where the light goes.
- ✓ A 100W bulb produces more luminous flux than a 60W bulb, sending more rays in all directions.



The Direction: Luminous Intensity (I)

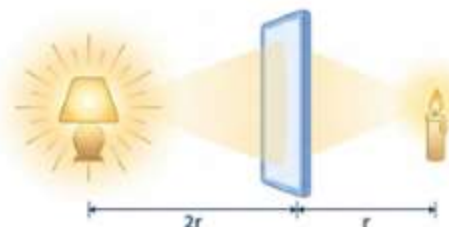


Figure 7



Definition Frame

Luminous Intensity (I) is the luminous flux that falls on 1 m^2 of the inside of a 1-m-radius sphere.

- Measured in Candelas (cd).

• Formula: $I = \frac{P}{4\pi}$

- In the diagram: To provide the same illuminance to the screen from twice the distance ($2r$), the lamp's luminous intensity must be four times that of the candle.

The Surface: Illuminance (E)



Definition Frame

Illuminance (E) is the luminous flux falling on a given surface area at any instant.

- Measured in Lux (lx), which equals lumens per square meter (lm/m^2).
- This is the amount of illumination an object (like a book) actually receives.
- Depends on both the Luminous Flux of the source and the distance to the object.



LUMINOUS FLUX (Φ)

Depends **ONLY** on the light source.



LUMINOUS INTENSITY (I)

Depends **ONLY** on the light **source**.

$$I = \frac{P}{4\pi}$$

ILLUMINANCE (E)

Depends on the **source** and the **distance** between the source and the surface.

$$E = \frac{P}{4\pi r^2}$$

$$E = \frac{I}{r^2}$$

هذا القانون هام جدا

Unit

Lumen (lm)

Unit

Candela (cd)

Unit

Lux (lx)

Illuminance (E)

Lux (lx) = lm/m²

Concept	Symbol	Definition	Unit	Key Equation
Luminous Flux	P	Total light energy emitted by the source	Lumens (lm)	Numerator
Illuminance	E	Light falling on a given surface area	Lux (lx) or lm/m ²	$E = \frac{P}{4\pi r^2}$
Luminous Intensity	I	Light falling on 1m ² of a 1m-radius sphere	Candelas (cd)	$I = \frac{P}{4\pi}$



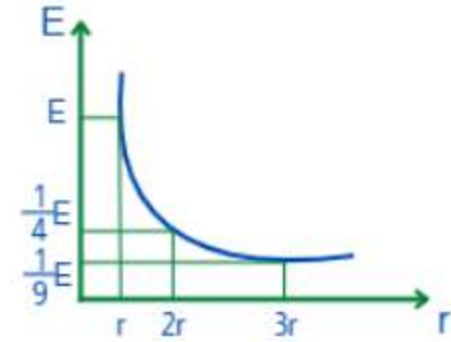
19

Show that the illuminance provided by a point source of light has an inverse-square relationship with distance (r) from the source and a direct relationship with luminous flux.

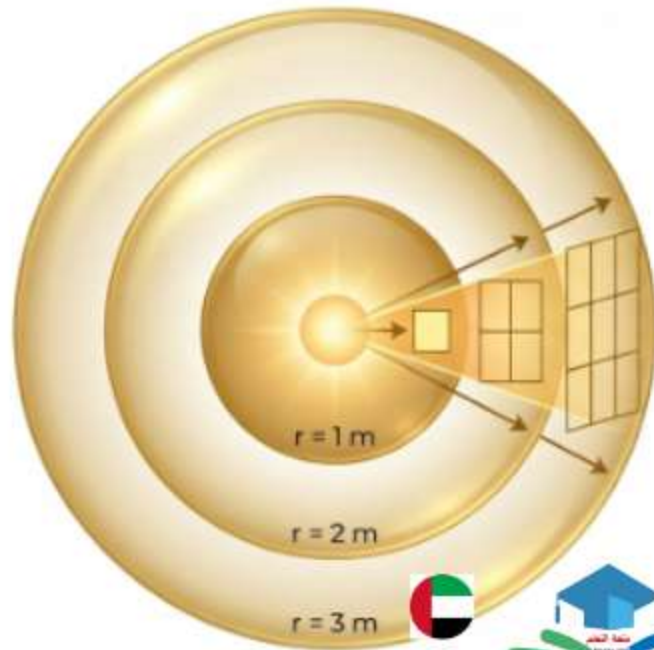
St. textbook

159

$$E = \frac{P}{4\pi r^2}$$



The Inverse-Square Relationship

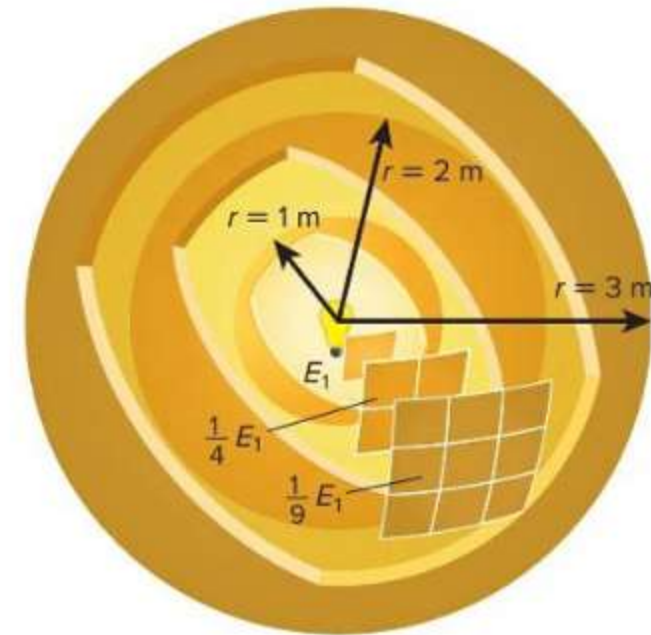


Step 1 ($r = 1\text{m}$): Light hits a 1m^2 area.
Illuminance = E_1

Step 2 ($r = 2\text{m}$): The exact same light spreads over 4m^2 (2^2). Illuminance = $\frac{1}{4} E_1$

Step 3 ($r = 3\text{m}$): The exact same light spreads over 9m^2 (3^2). Illuminance = $\frac{1}{9} E_1$

Core takeaway: As distance **increases**, light spreads out. Illuminance **decreases** as the **inverse of r squared ($1/r^2$)**.



$$\begin{aligned} \text{Illuminance} \\ E_1 &= \frac{1750}{4\pi} \text{ lx} \\ E_2 &= \frac{1750}{4\pi 2^2} \text{ lx} \\ E_3 &= \frac{1750}{4\pi 3^2} \text{ lx} \end{aligned}$$

Figure 6 Illuminance (E) is the quantity of light that strikes a surface. As the distance from the luminous source (r) increases, E decreases. E depends on the inverse of r squared.



17

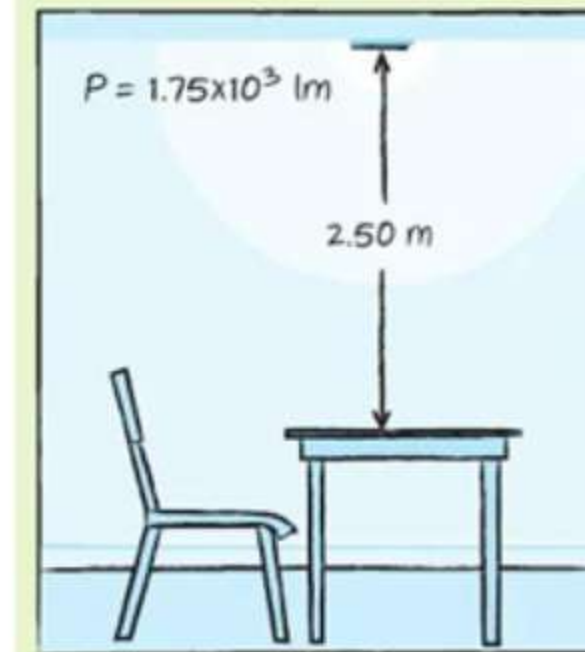
Apply the equation for illuminance of a point source to numerical problems

Example Problem1
Practice problems

162

EXAMPLE Problem 1

ILLUMINATION OF A SURFACE What is the illuminance on your desktop if it is lit by a 1750-lm lamp that is 2.50 m above your desk?



$$I = \frac{P}{4\pi}$$

للتحويل من Cd كاندिला إلى اللومن أو العكس



EQUAL ILLUMINANCE (E)

ILLUMINANCE E IS EQUAL ($E_1 = E_2$)

$$P = E \cdot 4\pi \cdot r^2$$

$$\frac{P}{4\pi \cdot r^2} = E, \quad E_1 = E_2$$

$$\frac{P_1}{4\pi r_1^2} = \frac{P_2}{4\pi r_2^2}$$

⇒ DIRECT RELATIONSHIP: $P \propto r^2$

$$\frac{P_1}{P_2} = \frac{r_1^2}{r_2^2}$$

EQUAL LUMINOUS FLUX (P)

LUMINOUS FLUX P IS EQUAL

$$P_1 = P_2$$

$$E = \frac{P}{4\pi \cdot r^2}$$

(SAME LIGHT SOURCE OR TWO IDENTICAL SOURCES)

$$E_1 = \frac{P_1}{4\pi r_1^2}, \quad E_2 = \frac{P_2}{4\pi r_2^2}$$

$$E_1 r_1^2 = E_2 r_2^2$$

⇒ INVERSE RELATIONSHIP: $E \propto \frac{1}{r^2}$

$$\frac{E_1}{E_2} = \frac{r_2^2}{r_1^2}$$



Part 3: Learning Outcomes: 20-25

ملف الشرح

20	Define diffraction as the bending of a wave as it passes the edge of a barrier	St. textbook	165
21	Describe that the color of light is related to its wavelength and frequency.	St. textbook	166
22	Describe primary, secondary, and complementary colors of light and the effects of corresponding combinations. Explain that the color of an object depends on the wavelengths present in incident light and on which wavelengths are absorbed or reflected by the object.	St. textbook	167
23	Describe primary and secondary pigments and the effects of mixing pigments or dyes	St. textbook	168
24	Explain the polarization of light by filtering using a polarizing filter. Describe the polarization of light by reflection	St. textbook	169
25	Apply Malus's law to light filtered by polarizer and analyzer filters	St. textbook	170



20

Define diffraction as the bending of a wave as it passes the edge of a barrier

St. textbook

165

Diffraction is the **bending** of waves around the **edges** of an opening or **obstacle**.

Diffraction: the bending of light when it passes the edge of a barrier the edges of shadows are not perfectly sharp



5.

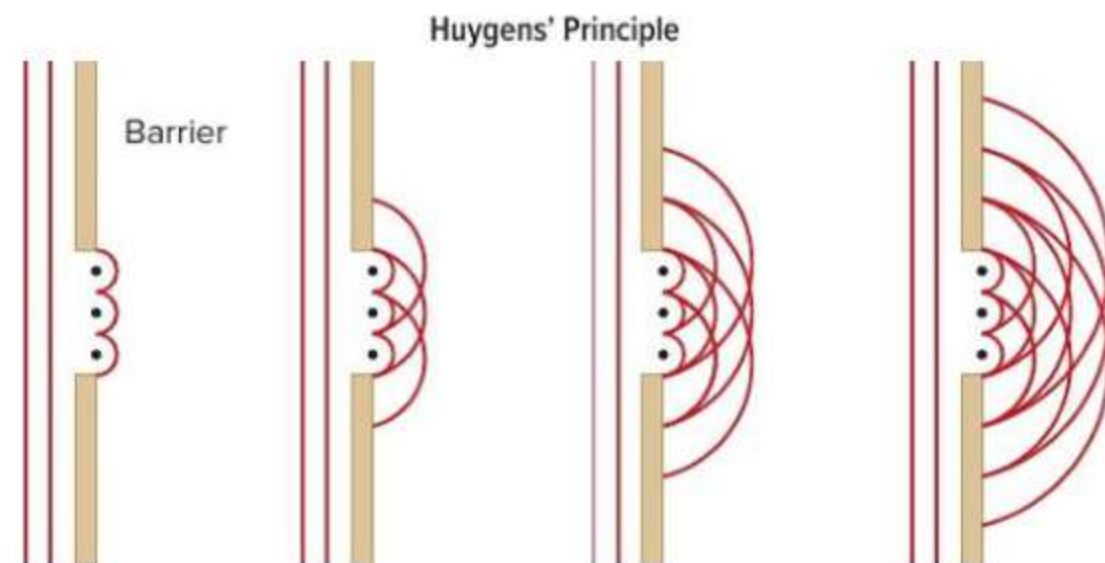
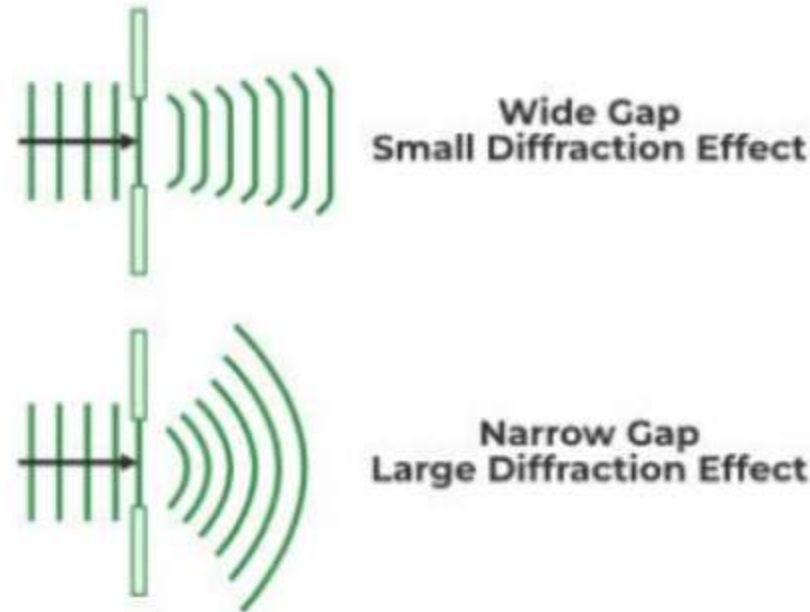


Figure 12 Huygens' wavelets combine to form a straight wavefront, except at the edges of the wave. The wavelets spread out in a circular manner when a barrier creates an edge.



Sound diffraction is clearer and easily observed than light diffraction ,
Sound waves have **longer wavelength than light**

The new wave front is the common **tangent** (or envelope) to all of **these secondary wavelets** in the forward direction.



21

Describe that the color of light is related to its wavelength and frequency.

St. textbook

166



Newton's Experiments: used a prism to separate white light into a spectrum of colors. He concluded that white light is composed of various colors, a property of the glass causing the separation



When the spectrum was projected onto a second prism, the second prism reflected the colors and recomposed them to form white, leading Newton to conclude that white is composed of several colors.

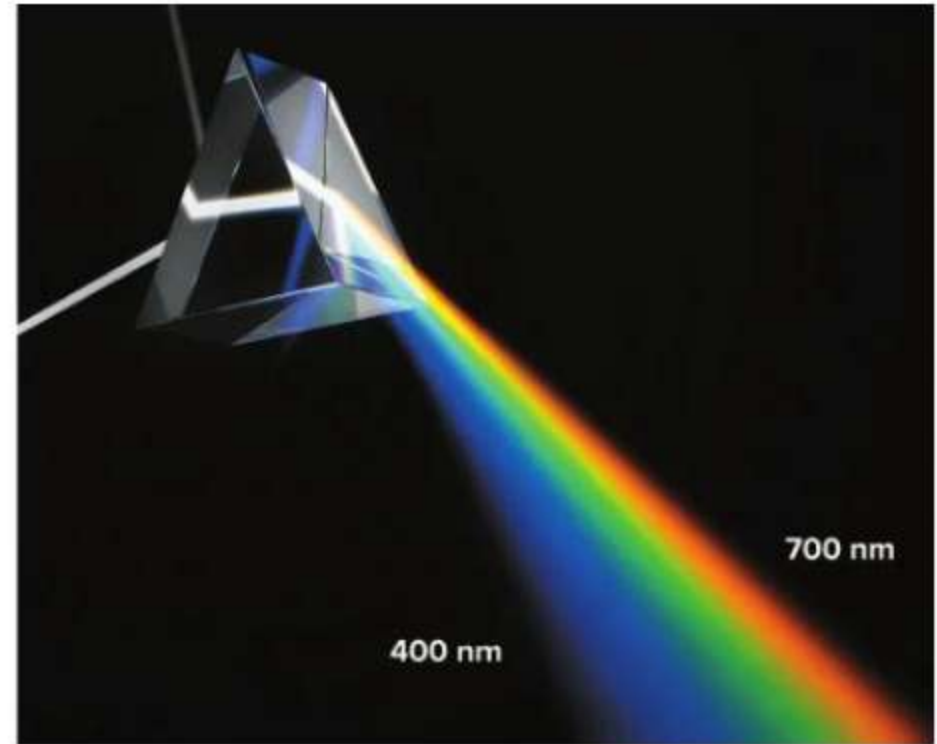
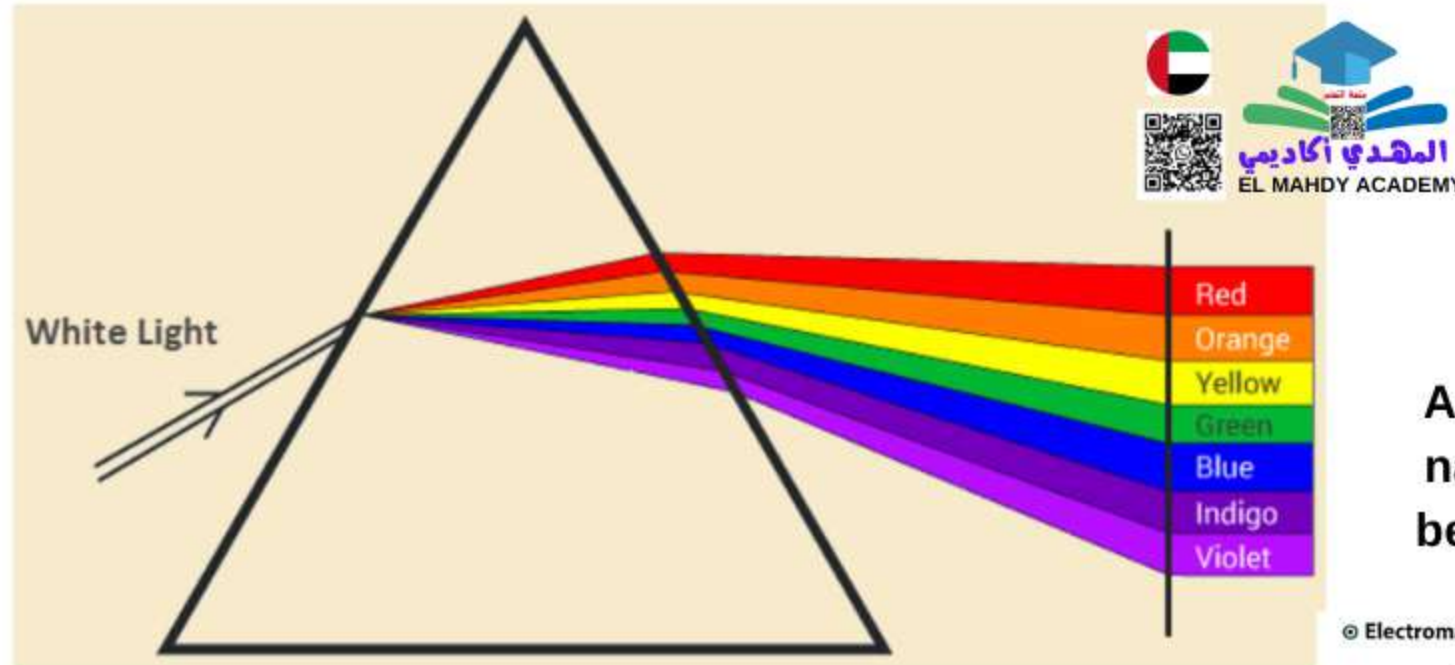


Figure 13 White light is separated into bands of color by a prism. Each color has a different wavelength.



Wavelength and Color: The color of light is related to its wavelength..

Visible light ranges from approximately 400 nm (violet, shortest wavelength) to 700 nm (red, longest wavelength)

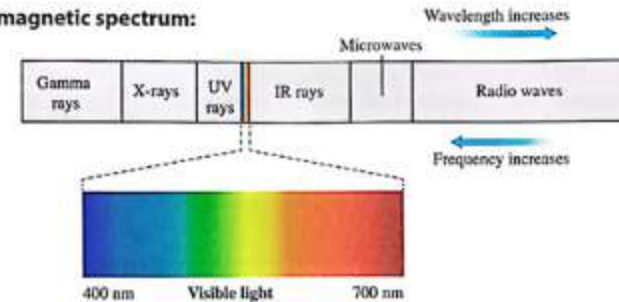


shortest wavelength -- frequency
longest wavelength --- frequency



As white light passes through a prism, its wave nature causes different colors (wavelengths) to bend at different angles, creating the spectrum.

© Electromagnetic spectrum:



Describe primary, secondary, and complementary colors of light and the effects of corresponding combinations.

Explain that the color of an object depends on the wavelengths present in incident light and on which wavelengths are absorbed or reflected by the object.

THE COLORS OF LIGHT

Light combines to make colors!

PRIMARY LIGHTS

The three primary colors of light cannot be made by mixing other colors.



HOW THEY MIX

When primary lights are mixed, they make secondary colors.



ALL THREE TOGETHER

When red, green, and blue light are combined, they make **WHITE** light.



COMPLEMENTARY LIGHTS

Two colors of light that combine to make white light are complementary.



Remember:

Light uses **ADDITIVE** mixing.
More light = Brighter colors!

THE COLORS OF PIGMENTS

Pigments mix by **subtraction**!

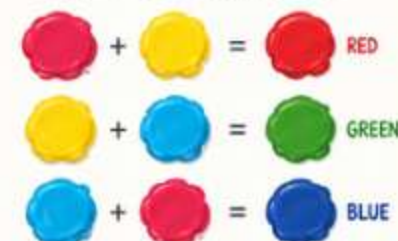
PRIMARY PIGMENTS

The three primary pigments cannot be made by mixing other colors.



HOW THEY MIX

When primary pigments are mixed, they make secondary pigments.



ALL THREE TOGETHER

When magenta, yellow, and cyan pigments are mixed, they make **BLACK**.



COMPLEMENTARY PIGMENTS

Two pigments that combine to make black are complementary.



Remember:

Pigments use **SUBTRACTIVE** mixing.
More pigment = Darker colors!



المهدي أكاديمي
EL MAHDY ACADEMY





WHY DO WE SEE COLORS?



The color of an object depends on the wavelengths present in incident light and on which wavelengths are **absorbed** or **reflected** by the object.

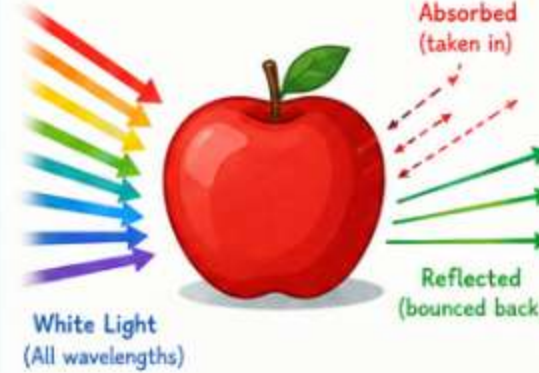
1. INCIDENT LIGHT

White light from the Sun or a lamp contains all the colors of the visible spectrum (wavelengths).



2. THE OBJECT

When white light hits an object, some wavelengths are **absorbed**, and some are **reflected**.



3. WHAT WE SEE

We see the color of the wavelengths that are reflected into our eyes.



KEY IDEA



Color of an object depends on = Wavelengths in incident light + Which wavelengths are **absorbed** or **reflected** by the object

EXAMPLES TO REMEMBER

- A red object reflects **red** light and absorbs other colors.
- A green object reflects **green** light and absorbs other colors.
- A black object absorbs almost all light (no color reflected).
- A white object reflects all colors.



Color by Subtraction (Objects & Dyes)

Under white light, a red object absorbs mostly blue and green, reflecting only red.

White Light



Under pure blue light, it reflects almost nothing and appears almost black.

Blue Light



Red Light



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The Master Matrix: Addition vs. Subtraction



	Light (Addition)	Pigments (Subtraction)
Mechanism	Emitted directly to the eye.	Absorbs light, reflects the rest.
Primary Colors	Red, Green, Blue (RGB).	Cyan, Magenta, Yellow (CMY).
Secondary Colors	Cyan, Magenta, Yellow.	Red, Green, Blue.
Mix All Three	Creates WHITE .	Creates BLACK .



24

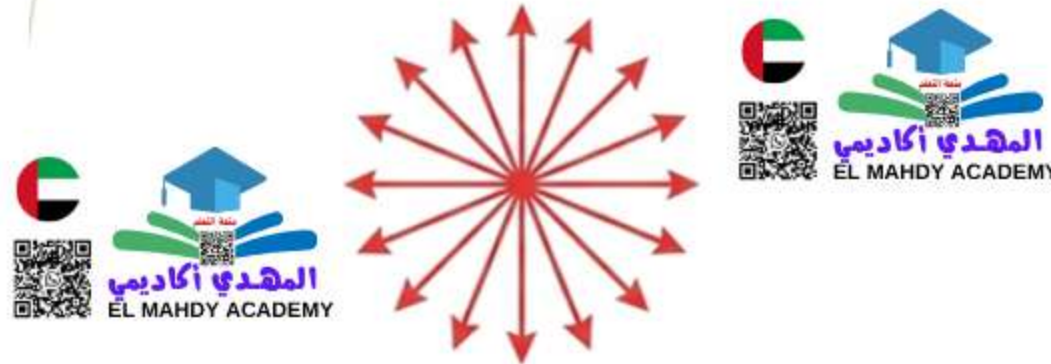
Explain the polarization of light by filtering using a polarizing filter.
Describe the polarization of light by reflection

St. textbook

169

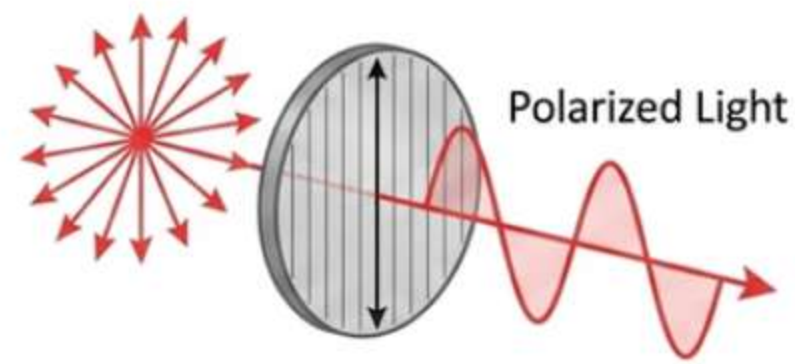
The Nature of Light Waves: Random vs. Ordered

Unpolarized Light



Nonpolarized Light: Electric fields oscillate in random directions.
Example: Normal lamp light.

Polarization by Filtering



Polarization: The production of light with a specific pattern of oscillation.



Using a Polarizing Filter

Light waves vibrate in many directions perpendicular to the direction of travel. This is called **unpolarized light**.

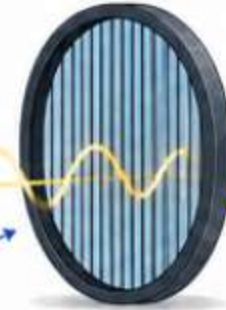


1. UNPOLARIZED LIGHT

The electric field vibrates in all directions perpendicular to the direction of travel.



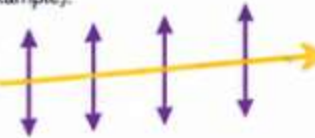
2. POLARIZING FILTER



The polarizing filter allows only the vibrations in one particular direction to pass.

3. POLARIZED LIGHT

After the filter, light vibrates only in one plane (vertical in this example).



The transmitted light is **plane-polarized**.



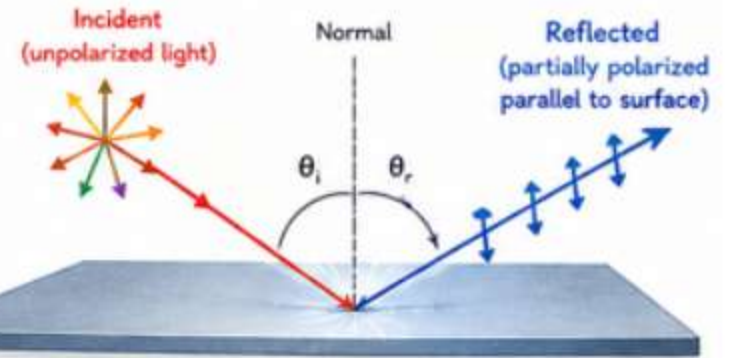
POLARIZATION OF LIGHT BY REFLECTION

When light reflects from a surface, it becomes partially or fully polarized.



HOW IT HAPPENS

Light from the sun (unpolarized) strikes a flat surface. The reflected light is partially polarized—mainly vibrating parallel to the surface.



25

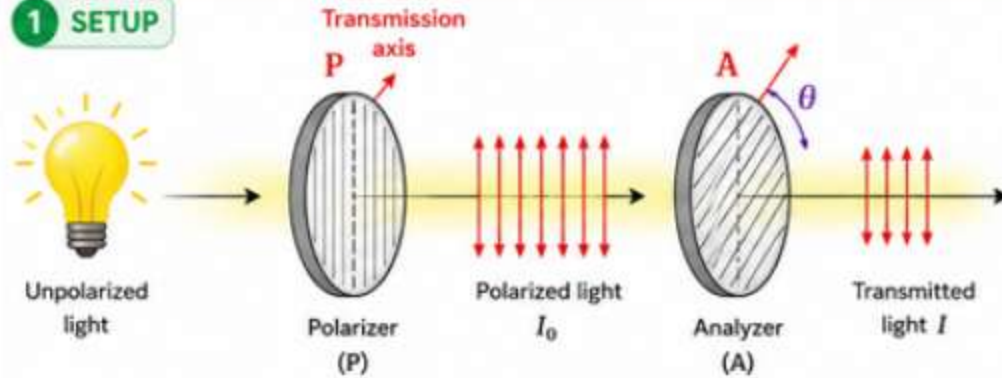
Apply Malus's law to light filtered by polarizer and analyzer filters

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170

When **plane-polarized light** passes through an analyzer, the transmitted intensity depends on the **angle (θ)** between the transmission directions of the polarizer and the analyzer.

1 SETUP



2 MALUS'S LAW

Where:

 I_0 = Intensity of light after the polarizer I = Intensity of light after the analyzer θ = Angle between transmission axes of polarizer (P) and analyzer (A)

$$I = I_0 \cos^2 \theta$$

Malus's law shows that the transmitted intensity varies with the square of the cosine of the angle between the two axes.





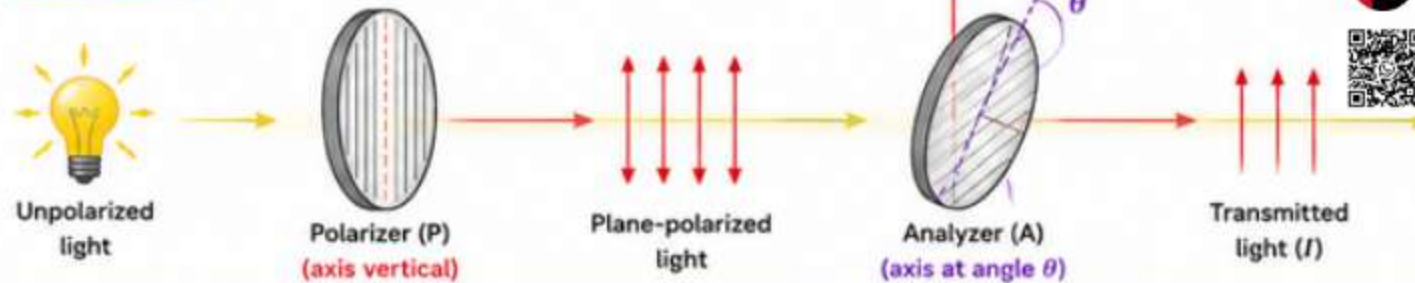
Figure 20 Polarizing filters with their axes parallel will allow the light with the same orientation to pass. With the polarizing axes at a 45° angle, the filters allow some light to pass. If the axes of the filters are perpendicular, the second filter will block the light that has passed through the first filter.





When **plane-polarized light** passes through an analyzer, the transmitted intensity depends on the **angle (θ)** between the transmission directions of the polarizer and the analyzer.

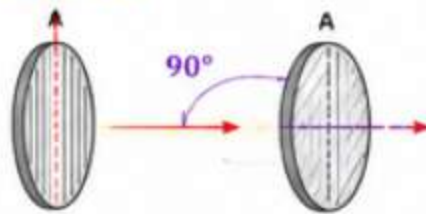
BASIC SETUP



MALUS'S LAW

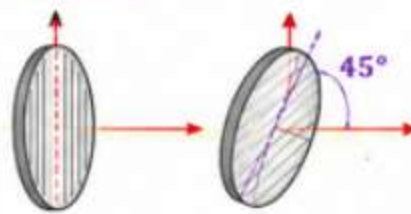
$$I = I_0 \cos^2 \theta$$

Where:

 I_0 = Intensity after the polarizer I = Intensity after the analyzer θ = Angle between transmission axes of polarizer (P) and analyzer (A)EFFECT OF ANGLE (θ) BETWEEN POLARIZER AND ANALYZER1) $\theta = 90^\circ$ 

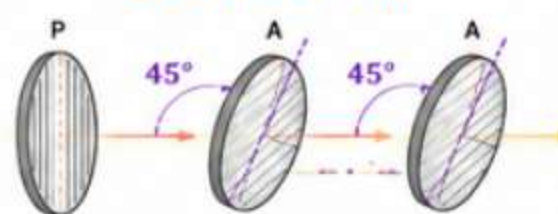
$$I = I_0 \cos^2 90^\circ = 0$$

No light transmitted
(Axes are perpendicular)

2) $\theta = 45^\circ$ 

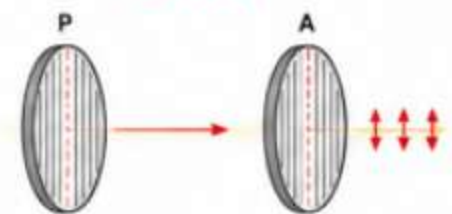
$$I = I_0 \cos^2 45^\circ = \frac{1}{2} I_0$$

Half of the intensity
is transmitted

3) $\theta = 45^\circ + 45^\circ = 90^\circ$ 

$$I = I_0 \cos^2 45^\circ \cos^2 45^\circ = \frac{1}{4} I_0$$

One quarter of the
initial intensity is transmitted

4) $\theta = 0^\circ$ 

$$I = I_0 \cos^2 0^\circ = I_0$$

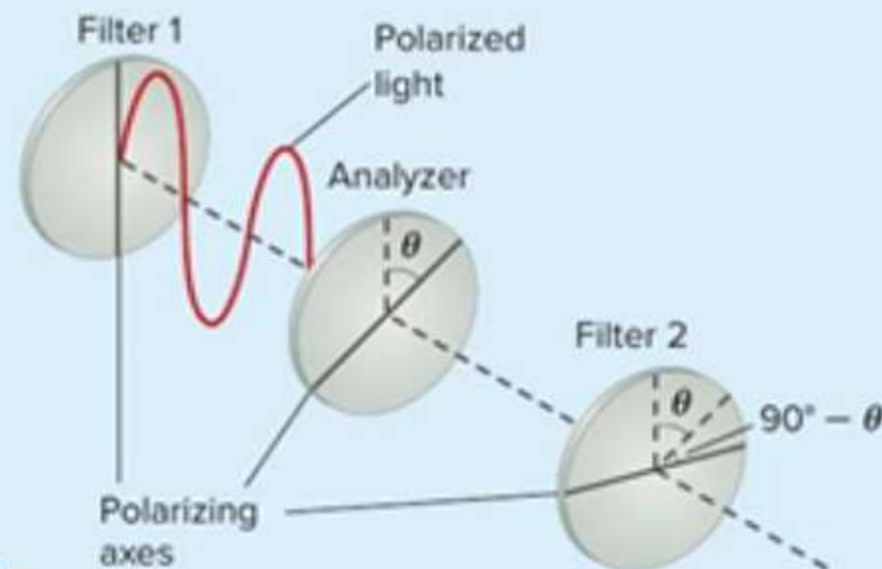
Maximum transmission
(Axes are parallel)



PHYSICS Challenge

You place an analyzer filter between the two cross-polarized filters, such that its polarizing axis is not parallel to either of the two filters, as shown in the figure to the right.

1. You observe that some light passes through filter 2, though no light passed through filter 2 before you inserted the analyzer filter. Why does this happen?
2. The analyzer filter is placed at an angle of θ relative to the polarizing axis of filter 1. Derive an equation for the intensity of light coming out of filter 2 compared to the intensity of light coming out of filter 1.





عزيزي الطالب / عزيزتي الطالبة

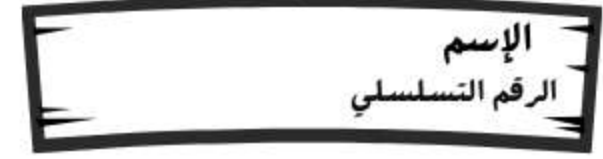


نحن لا نجمع الهيكل في أسئلة فقط
ولكن نقوم بالشرح الجزئيات المطلوبة
في الهيكل ثم نقوم بجمع الأسئلة عليها من الكتاب

هذا الجزء الأول من ملف الشرح على اليوتيوب

هناك ملف آخر للأسئلة... يجب الحل منه

لحجز الأجزاء الأخرى تواصل معنا



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