

مراجعة نهاية الفصل الدراسي الثالث



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف التاسع المتقدم ← فيزياء ← الفصل الثالث ← ملفات متنوعة ← الملف

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المزيد من مادة
فيزياء:

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التواصل الاجتماعي بحسب الصف التاسع المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف التاسع المتقدم والمادة فيزياء في الفصل الثالث

مراجعة نهائية مرفقة بالإجابة

1

مراجعة نهائية وشاملة

2

حقيقتي التدريبية كراسة تدريبية

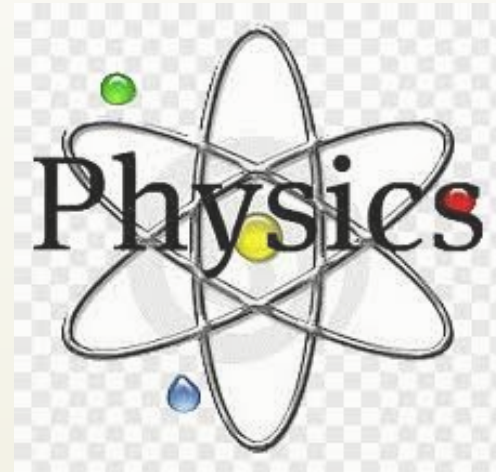
3

أسئلة تدريبية في الفيزياء والضوء

4

مراجعة هيكل الامتحان 2026م

5



BE READY

END OF TERM 3 REVISION PHYSICS GRADE 09 ADV

COMPILED BY
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جلال عبدالرحمن صالح
حمدة العامري

1	Differentiate between transverse, longitudinal, and surface waves and give examples	St. textbook	115-116
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Type of Wave	Particles movement	Direction Compared to Wave Motion	Example
Transverse Wave	Particles move up and down	Perpendicular to wave direction	Light waves, waves on a rope
Longitudinal Wave	Particles move back and forth	Parallel to wave direction	Sound waves, slinky spring compression
Surface Wave	Particles move in a circular or rolling motion	Combination of transverse and longitudinal motion	Ocean water waves

1. In which type of wave do particles move perpendicular to the direction of wave motion?

- A. Longitudinal wave
- B. Surface wave
- C. Transverse wave
- D. Sound wave

2. Which wave contains compressions and rarefactions?

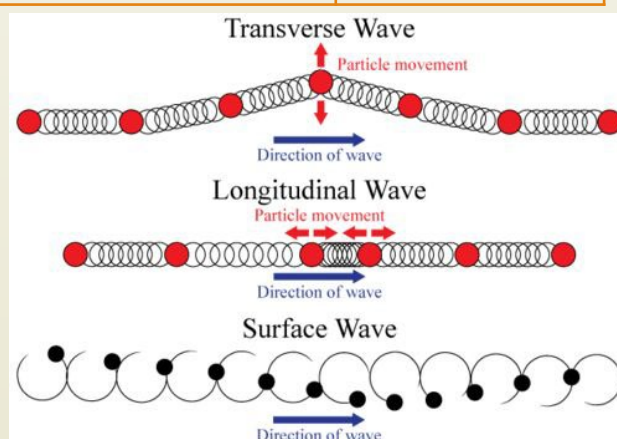
- A. Surface wave
- B. Transverse wave
- C. Water wave
- D. Longitudinal wave

3. Ocean waves are best described as:

- A. Only transverse
- B. Only longitudinal
- C. Surface waves
- D. Electromagnetic waves

4. Which of the following is an example of a longitudinal wave?

- A. Light wave
- B. Sound wave
- C. Water ripple
- D. Rope wave



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

Frequency of a Wave

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

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

Wavelength

The wavelength of a wave is equal to the velocity divided by the frequency.

$$\lambda = \frac{v}{f}$$

$$v = \frac{d}{t} = \frac{\lambda}{T} = \lambda f$$

EXAMPLE Problem 3

CHARACTERISTICS OF A WAVE A sound wave has a frequency of 192 Hz and travels the length of a football field, 91.4 m, in 0.271 s.

- What is the speed of the wave?
- What is the wavelength of the wave?
- What is the period of the wave?
- If the frequency were changed to 442 Hz, what would be the new wavelength and period?

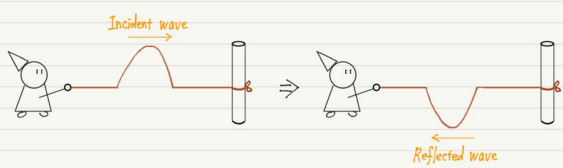
- A sound wave produced by a clock chime is heard 515 m away 1.50 s later.
 - Based on these measurements, what is the speed of sound in air?
 - The sound wave has a frequency of 436 Hz. What is the period of the wave?
 - What is its wavelength?
- How are the wavelength, frequency, and speed of a wave related? How do they depend on the medium through which the wave is passing and the type of wave?
- What is the speed of a periodic wave disturbance that has a frequency of 3.50 Hz and a wavelength of 0.700 m?
- How does increasing the wavelength by 50 percent affect the frequency of a wave on a rope?
- The speed of a transverse wave in a string is 15.0 m/s. If a source produces a disturbance that has a frequency of 6.00 Hz, what is its wavelength?
- Five wavelengths are generated every 0.100 s in a tank of water. What is the speed of the wave if the wavelength of the surface wave is 1.20 cm?
- A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coiled spring toy. If the distance between successive compressions is 0.600 m, what is the speed of the wave?
- How does the frequency of a wave change when the period of the wave is doubled?
- Describe the change in the wavelength of a wave when the period is reduced by one-half.
- If the speed of a wave increases to 1.5 times its original speed while the frequency remains constant, how does the wavelength change?

Figure 11



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
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• Fixed - end reflection



1. Fixed End Reflection (Inversion)

- A fixed end does not move (like a wave on a string tied to a wall).
- When the wave reaches the fixed end, it is reflected **upside down** (inverted).
- This happens because the end must remain at zero displacement, so the wave flips to cancel the motion.

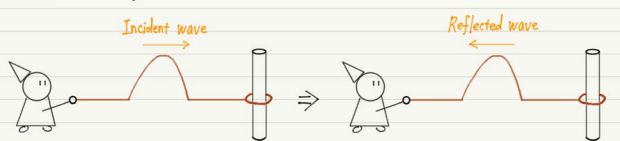
Result: Incident pulse → reflected pulse is **inverted** (crest becomes trough).

2. Free End Reflection (No Inversion)

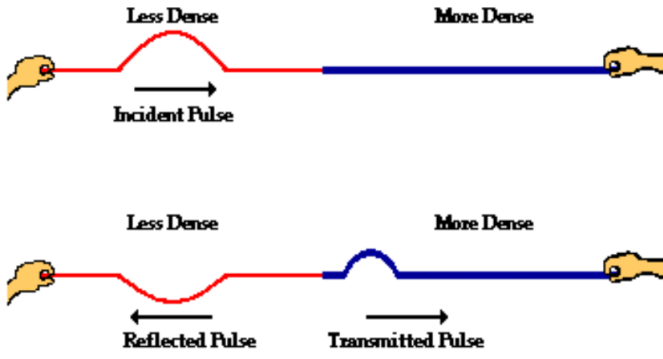
- A free end can move freely (like a string attached to a ring that can slide).
- When the wave reaches the free end, it is reflected **upright** (not inverted).
- The end can move, so it does not force the wave to flip.

Result: Incident pulse → reflected pulse remains **upright** (crest stays crest).

• Free - end reflection

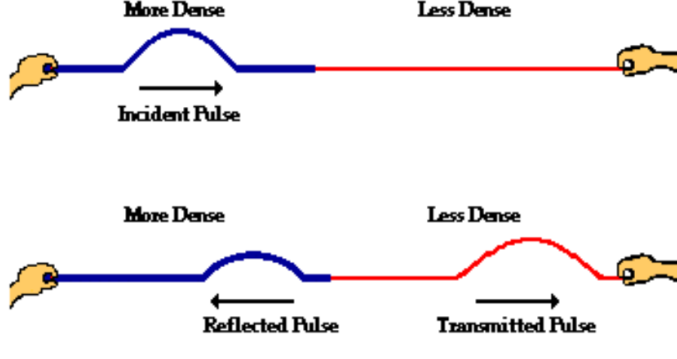


A wave traveling from a less dense to a more dense medium ...



...will be reflected off the boundary and transmitted across the boundary into the new medium. The reflected pulse is inverted.

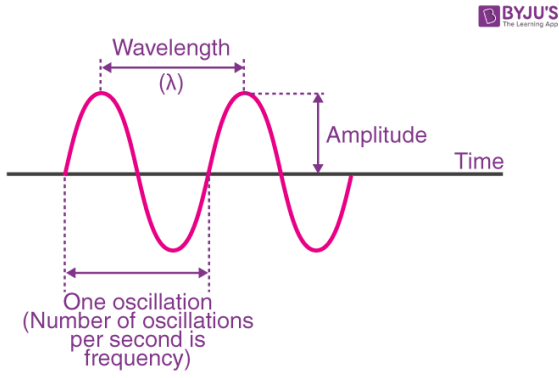
A wave traveling from a more dense to a less dense medium ...



...will be reflected off the boundary and transmitted across the boundary into the new medium. There is no inversion.

- 1. What happens to a wave reflected from a fixed end?**
 - A. It disappears
 - B. It becomes faster
 - C. It is inverted
 - D. It doubles in size
- 2. What happens to a wave reflected from a free end?**
 - A. It is inverted
 - B. It remains upright
 - C. It stops moving
 - D. It changes frequency
- 3. Why does a wave invert at a fixed end?**
 - A. The wave gains energy
 - B. The boundary must stay at zero displacement
 - C. The wave changes medium
 - D. Gravity acts on it
- 4. Which situation shows no inversion of a reflected wave?**
 - A. String fixed to a wall
 - B. Rope tied tightly
 - C. Wave on a string attached to a rigid support
 - D. Wave reflecting from a free-moving end

4	Describe wave properties like amplitude, energy of a wave, wavelength, speed, phase, period and frequency	St. textbook	116-118
Property	Description		
Amplitude	The maximum displacement of a wave from its rest position. Larger amplitude means more energy. ($A \propto \sqrt{E}$)		
Energy of a Wave	The energy carried by a wave increases with amplitude. Bigger amplitude $\rightarrow$ more energy. ($E \propto A^2$)		
Wavelength (λ)	The distance between two identical points on consecutive waves, such as crest to crest.		
Wave Speed	The distance a wave travels per second. Wave speed depends on the medium.		
Phase	The position of a point in the wave cycle. Points in the same phase move together.		
Period (T)	The time taken for one complete wave cycle. Measured in seconds.		
Frequency (f)	The number of waves passing a point each second. Measured in hertz (Hz).		



Wavelength (λ)

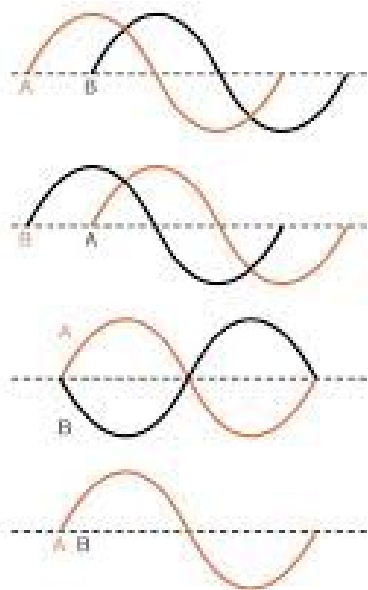
Amplitude

Time

One oscillation (Number of oscillations per second is frequency)

Two waves having the same amplitude and frequency are traveling in the same medium. Maximum destructive interference will occur when the phase difference between the waves is

1. 0°
2. 90°
3. 180°
4. 270°



Phase shift = 90° degrees
A is ahead of B
(A "leads" B)

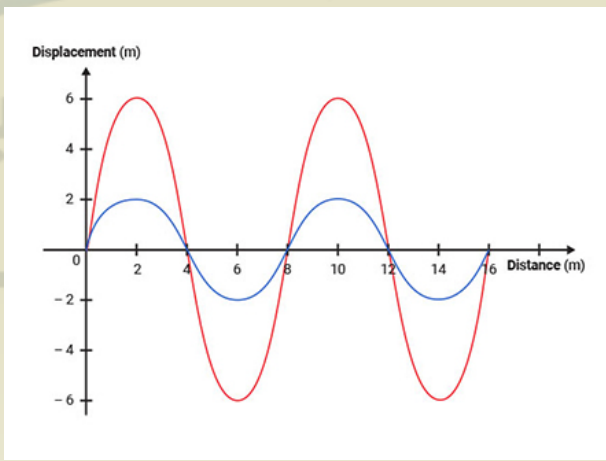
Phase shift = 90° degrees
B is ahead of A
(B "leads" A)

Phase shift = 180° degrees
A and B waveforms are mirror-images of each other

Phase shift = 0° degrees
A and B waveforms are in perfect step with each other

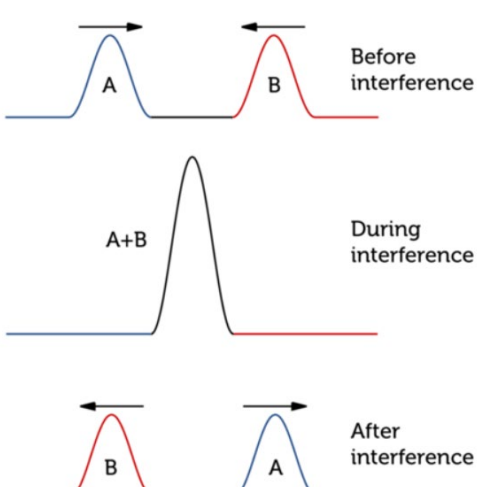
In the figure, you have two waves (red, blue).

1. Find the amplitude for each wave
2. Compare the energy of the two waves
3. Find the wavelength for each wave
4. Are the two waves in phase or out of phase? If they are out, how many degrees is the shift?
5. If the red wave made the number of the oscillations as shown in 1 second, what is the frequency, period and speed of the red wave?



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
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Constructive Interference

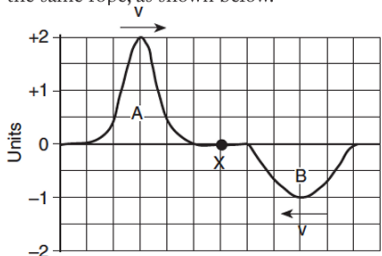


Before interference

During interference

After interference

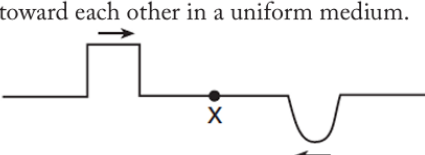
Two pulses, A and B, travel toward each other along the same rope, as shown below.



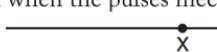
When the centers of the two pulses meet at point X, the amplitude at the center of the resultant pulse will be

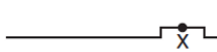
- +1 unit
- +2 units
- 0
- 1 unit

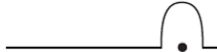
The diagram below shows two pulses traveling toward each other in a uniform medium.



Which diagram best represents the medium when the pulses meet at point X?

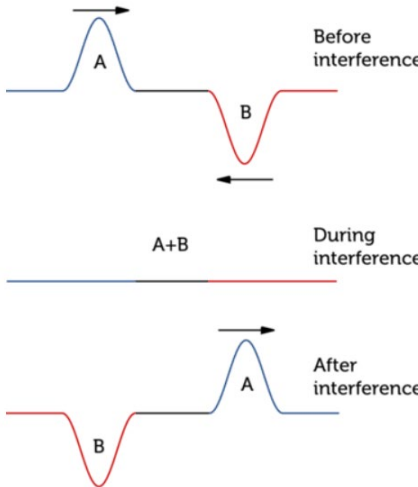
(1) 

(2) 

(3) 

(4) 

Destructive Interference

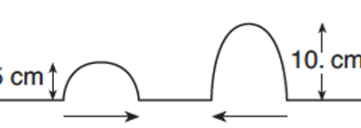


Before interference

During interference

After interference

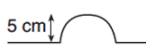
The diagram below shows two pulses approaching each other in a uniform medium.



Which diagram best represents the superposition of the two pulses?

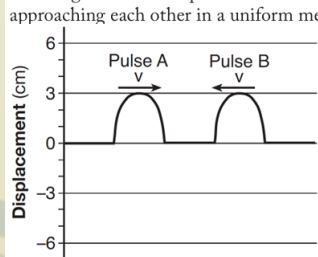
(1) 

(2) 

(3) 

(4) 

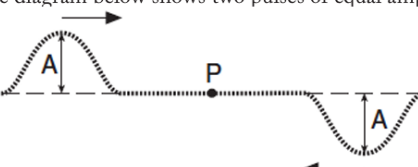
The diagram below represents two identical pulses approaching each other in a uniform medium.



As the pulses meet and are superposed, the maximum displacement of the medium is

- 6 cm
- 0 cm
- 3 cm
- 6 cm

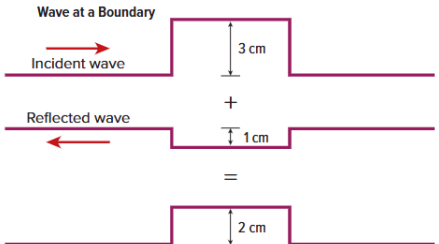
The diagram below shows two pulses of equal amplitude, A, approaching point P along a uniform string.



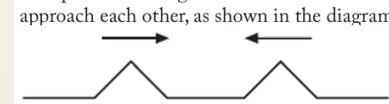
When the two pulses meet at P, the vertical displacement of the string at P will be

- A
- 2A
- 0
- A/2

Wave at a Boundary



Two pulses traveling in the same uniform medium approach each other, as shown in the diagram below.



Which diagram best represents the superposition of the two pulses?

(1) 

(2) 

(3) 

(4) 

The diagram below represents two pulses approaching each other from opposite directions in the same medium.



Which diagram best represents the medium after the pulses have passed through each other?

(1) 

(2) 

(3) 

(4) 

6	Define nodes and antinodes and describe how they are formed.	St. textbook	123
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Node
 A **node** is a point in a standing wave where the displacement is always zero.

The particles at a node do not move.

How Nodes Are Formed

Nodes are formed when two waves interfere destructively.

This happens when the crest of one wave meets the trough of another wave with equal amplitude.

Antinode

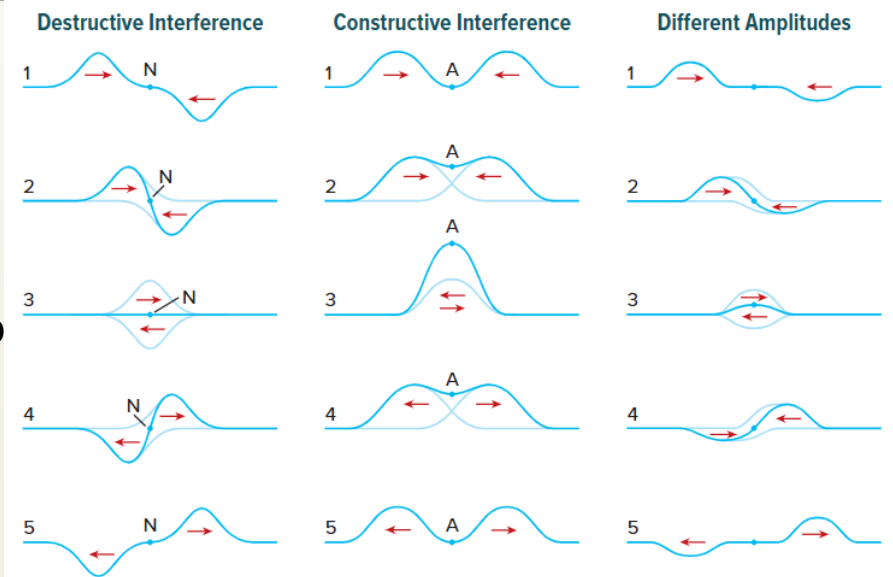
An **antinode** is a point in a standing wave where the displacement is maximum.

The particles at an antinode vibrate with the greatest amplitude.

How Antinodes Are Formed

Antinodes are formed when two waves interfere constructively.

This happens when two crests or two troughs meet together.



The diagram below represents a standing wave.



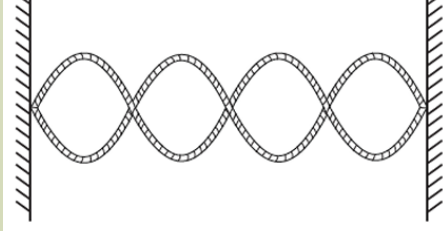
The number of nodes and antinodes shown in the diagram is

1. 4 nodes and 5 antinodes
2. 5 nodes and 6 antinodes
3. 6 nodes and 5 antinodes
4. 6 nodes and 10 antinodes

One of your classmate dreamed of a standing wave but he can't remember its description, can you suggest of of these choices to might be correct?

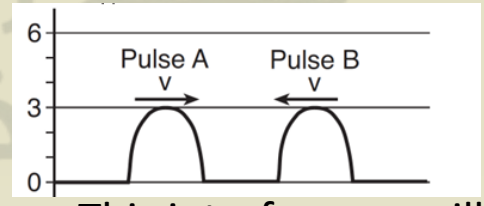
- A) 5 nodes and 6 antinodes
- B) 4 nodes and 5 antinodes
- C) 6 nodes and 5 antinodes
- D) 2 nodes and 3 antinodes

The diagram below shows a standing wave in a string clamped at each end.



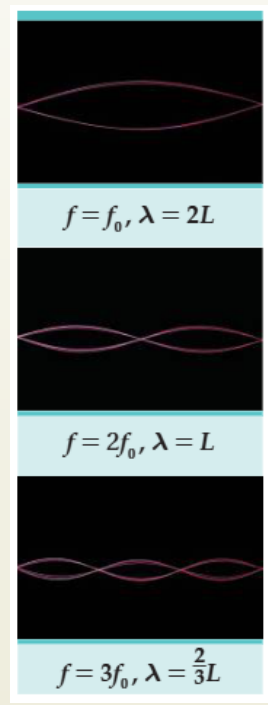
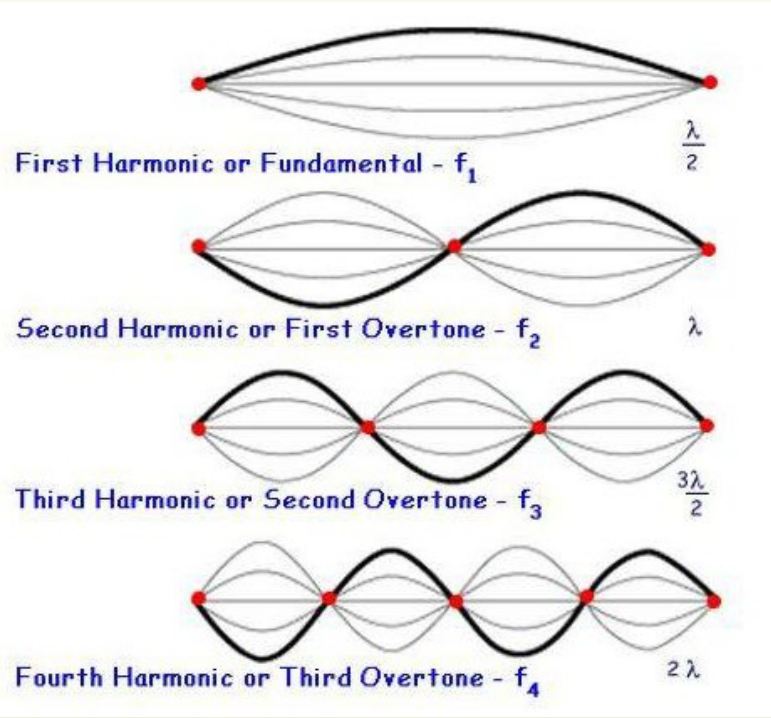
What is the total number of nodes and antinodes in the standing wave?

1. 3 nodes and 2 antinodes
2. 2 nodes and 3 antinodes
3. 5 nodes and 4 antinodes
4. 4 nodes and 5 antinodes



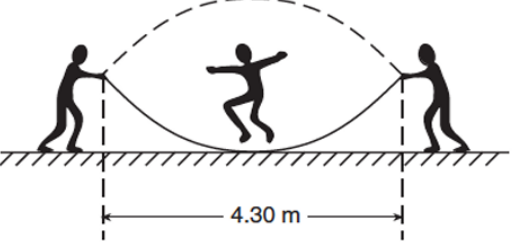
This interference will create a node or an antinode?

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
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$$\lambda = \frac{2L}{n} = \frac{v}{f} = vT$$

While playing, two children create a standing wave in a rope, as shown in the diagram below. A third child participates by jumping the rope.



- What is the wavelength of this standing wave?
- 2.15 m
 - 4.30 m
 - 6.45 m
 - 8.60 m

The string length, L , relates to wavelength, λ , by the equation: $L = \frac{n\lambda}{2}$

where n is the number of antinodes. The frequency, f , is calculated as: $f = nf_0$

The speed of the waves in a string is 240 m/s. A 1.5 m string vibrates at 240 Hz.

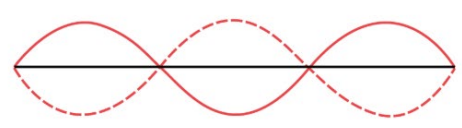
Find its wavelength and antinodes.

Select the correct answer.

☐ $\lambda = 1.0$ m and $n = 3$	☐ $\lambda = 2.0$ m and $n = 2$
☐ $\lambda = 1.0$ m and $n = 2$	☐ $\lambda = 2.0$ m and $n = 3$

Select the correct answers.

A standing wave is created in a toy guitar string having a length of 9 cm as shown in the figure. What is the wavelength and speed of the wave knowing that the frequency of vibration is 5 Hz?



Select 2 choice(s)

- | | |
|---|---|
| ☐ $\lambda = 3$ cm | ☐ $v = 0.45$ m / s |
| ☐ $v = 0.3$ m / s | ☐ $v = 0.15$ m / s |
| ☐ $\lambda = 6$ cm | ☐ $\lambda = 9$ cm |

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
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Definition of Sound

Sound is a **pressure oscillation** that travels through matter such as solids, liquids, and gases.
It is produced when vibrating objects cause particles in the medium to vibrate back and forth.

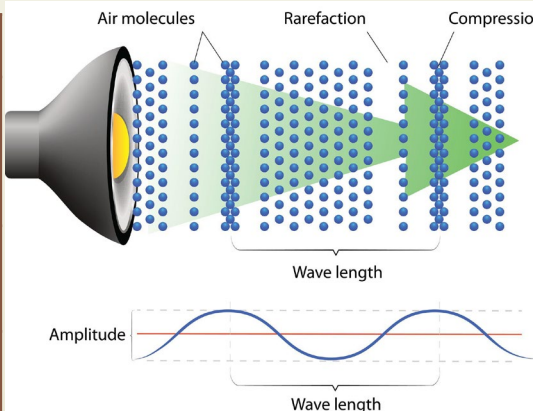
Sound as a Longitudinal Wave

Sound is a **longitudinal wave** because the particles of the medium vibrate **parallel** to the direction of wave travel.

Sound waves consist of:

- Compressions** → regions where particles are close together
- Rarefactions** → regions where particles are spread apart

Property	Description
Frequency (f)	Number of vibrations per second. Determines the pitch of sound. Measured in hertz (Hz).
Wavelength (λ)	Distance between two consecutive compressions or rarefactions.
Speed (v)	Distance traveled by the sound wave each second. Depends on the medium.



1. Sound is best described as:

- A. A transverse electromagnetic wave
- B. A pressure oscillation transmitted through matter
- C. A wave that travels in a vacuum
- D. A stationary wave

2. Why is sound considered a longitudinal wave?

- A. Particles move perpendicular to the wave direction
- B. It does not require a medium
- C. Particles vibrate parallel to the direction of wave travel
- D. It travels only in solids

3. Which property of sound determines its pitch?

- A. Wavelength
- B. Speed
- C. Frequency
- D. Amplitude

9	Explain that the speed of sound varies with different mediums and temperatures.	St. textbook	133-134
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Sound travels as vibrations of particles.
The closer the particles are, the faster sound can move through them.

SOLID	LIQUID	GAS	VACUUM
			
Particles are very close together. Sound travels.	Particles are close but can move around. Sound is slower than in solids.	Particles are far apart. Sound travels the slowest.	No particles at all. Sound cannot travel.

Medium	Speed (m/s)
Air (0°C)	331
Air (20°C)	343
Helium (0°C)	965
Water (25°C)	1497
Seawater (25°C)	1535
Copper (20°C)	4760
Iron (20°C)	4994

Change in **Velocity** of Sound Wave in Air
For 1°C Increase in Temperature



1. A student places one ear on a long metal rail while another student hits the rail with a hammer far away. The student hears the sound through the rail after 1 second. How long will it take to hear the sound through the air?
- A. Less than 1 second
B. Exactly 1 second
C. More than 1 second
D. Sound cannot travel through air
2. The speed of sound in air is 343 m/s at a certain temperature. If the temperature decreases by 2°C, what happens to the speed of sound?
- A. Increases to 341.8 m/s
B. Decreases to 341 m/s
C. Remains 343 m/s
D. Decreases by 1.2 m/s
3. If the temperature of air increases by 3°C, what will happen to the speed of sound if it was originally 343 m/s?
- A. 344.8 m/s
B. 344 m/s
C. 346 m/s
D. 349 m/s
4. The speed of sound changes from 343 m/s to 345.4 m/s. By how much did the temperature of the medium change?
- A. Increased by 1°C
B. Increased by 2°C
C. Increased by 3°C
D. Increased by 4°C

10	Define sound pitch and relate it to the frequency of a sound wave.	St. textbook	135
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SOUND PITCH AND FREQUENCY

PITCH is how high or low a sound appears to the human ear.
It depends on the **FREQUENCY** of the sound wave.

RELATIONSHIP BETWEEN PITCH AND FREQUENCY

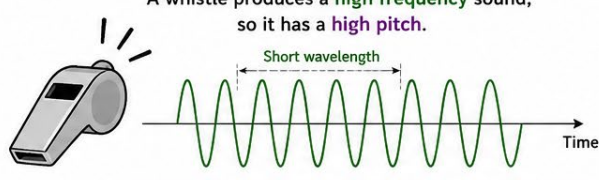
High frequency → High pitch $f \uparrow \Rightarrow \text{Pitch} \uparrow$ Low frequency → Low pitch

This means: when frequency **increases**, pitch **increases**. When frequency decreases, pitch **decreases**.

EXAMPLES

High Frequency – High Pitch

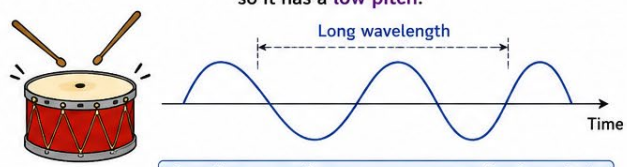
A whistle produces a **high frequency** sound,
so it has a **high pitch**.



High frequency (many waves per second) = High pitch

Low Frequency – Low Pitch

A drum produces a **low frequency** sound,
so it has a **low pitch**.



Low frequency (few waves per second) = Low pitch

KEY RELATIONSHIP

Pitch is directly related to **frequency**, not **amplitude**.

- Frequency determines how high or low a sound is (pitch).
- Amplitude determines how loud or soft a sound is (**loudness**).

Frequency	Pitch	Example	Wave Diagram
High frequency	High pitch	Whistle	
Low frequency	Low pitch	Drum	

★ In summary: **Higher the frequency, higher the pitch. Lower the frequency, lower the pitch.**

1. What is pitch?

- A. The loudness of sound
- B. The speed of sound
- C. How high or low a sound appears
- D. The distance between waves

2. A sound with a high frequency will have:

- A. Low pitch
- B. High pitch
- C. Low energy
- D. Long wavelength only

3. Which property determines the pitch of a sound wave?

- A. Amplitude
- B. Speed
- C. Frequency
- D. Energy

11	Define loudness and relate it to the amplitude of a sound wave.	St. textbook	135
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LOUDNESS OF SOUND

Loudness is how loud or soft a sound appears to the human ear.
Loudness depends on the **AMPLITUDE** of the sound wave, **not** the frequency.

RELATIONSHIP BETWEEN LOUDNESS AND AMPLITUDE

Large amplitude → **Loud sound**
(more energy)

Small amplitude → **Soft sound**
(less energy)

When amplitude increases, loudness **increases**.
When amplitude decreases, loudness **decreases**.

EXAMPLES

A shout has **large amplitude** and sounds **loud**.

A whisper has **small amplitude** and sounds **soft**.

IMPORTANT DIFFERENCE		
Property	Frequency	Amplitude
Determines	Pitch (high or low)	Loudness (loud or soft)
What it depends on	Number of vibrations per second (Hz)	Size or height of the wave
If it increases	Pitch increases (sound is higher)	Loudness increases (sound is louder)
If it decreases	Pitch decreases (sound is lower)	Loudness decreases (sound is softer)

KEY POINT

Frequency affects how **HIGH** or **LOW** a sound is (pitch).

Amplitude affects how **LOUD** or **SOFT** a sound is (loudness).

A sound can have high pitch and be loud, high pitch and be soft, low pitch and be loud, or low pitch and be soft.

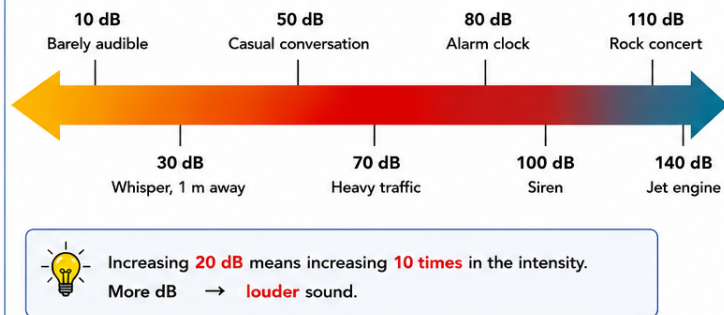
- 1. Loudness of a sound depends mainly on:**
- A. Frequency
 - B. Amplitude
 - C. Wavelength
 - D. Speed
- 2. If the amplitude of a sound wave increases, the sound becomes:**
- A. Softer
 - B. Lower in pitch
 - C. Louder
 - D. Slower
- 3. A sound wave has a very high frequency but a small amplitude. How will the sound most likely be heard?**
- A. High pitch and soft
 - B. Low pitch and loud
 - C. High pitch and loud
 - D. Low pitch and soft
- 4. Which statement is correct?**
- A. Frequency determines loudness
 - B. Amplitude determines pitch
 - C. Amplitude determines loudness while frequency determines pitch
 - D. Both pitch and loudness depend only on amplitude

12	Describe the sound level and define the decibel (dB) as a unit of measuring sound level.	St. textbook	135
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SOUND LEVEL AND DECIBEL (dB)

Sound level describes how loud or soft a sound is.
It is measured in **decibels (dB)**, a unit on a **logarithmic scale**.

1. DECIBEL SCALE: EXAMPLES



WHAT DOES THE SCALE MEAN?

The decibel (dB) scale is **logarithmic**.
A 20 dB increase means the sound is 10 times more intense.

Examples:

- 0 dB = threshold of hearing (faintest sound humans can detect)
- 20 dB = 10 times more intense than 0 dB
- 40 dB = 100 times more intense than 0 dB
- 60 dB = 1,000 times more intense than 0 dB
- 80 dB = 10,000 times more intense than 0 dB

Sound Level (dB)	Relative Intensity Compared to 0 dB (faintest sound)
0 dB	1× (reference)
20 dB	10× more intense
40 dB	100× more intense
60 dB	1,000× more intense
80 dB	10,000× more intense
100 dB	100,000× more intense
120 dB	1,000,000× more intense
140 dB	10,000,000× (10 ⁷ times) more intense

SUMMARY

- Sound level describes how loud or soft a sound is.
- It is measured in **decibels (dB)** on a **logarithmic scale**.
- Increasing 20 dB means increasing 10 times in the intensity.
- The human ear can detect a very wide range of sound intensities.

2. HOW THE HUMAN EAR DETECTS SOUND



- The ear detects pressure-wave variations (changes in air pressure) at certain frequencies.
- Normal air pressure: 1 atmosphere = 1.01×10^5 Pa
- The ear can detect extremely small pressure amplitudes: less than one-billionth of an atmosphere, or 2×10^{-5} Pa.
- At the other end, pressure variations of about 20 Pa or greater cause pain.
- Changes in pressure that do not occur at audible frequencies (e.g., driving over a mountain pass) are not heard.

KEY IDEA

Humans can detect a very wide range of intensities. Therefore, we use a **logarithmic scale (sound level in dB)** to measure them conveniently.

QUICK RULE (Using school scale)

If intensity changes by 10ⁿ times:

Change in dB = **20n**

Examples:

- 10× increase (n = 1) → +20 dB
- 100× increase (n = 2) → +40 dB
- 1,000× increase (n = 3) → +60 dB
- 10,000× increase (n = 4) → +80 dB



Tip:

Count the zeros in the intensity increase and multiply by 20.

1. What unit is used to measure sound level?

- A. Hertz B. Joule C. Decibel D. Watt

2. A sound that increases from 20 dB to 80 dB becomes:

- A. 3 times more intense
B. 60 times more intense
C. 10 times more intense
D. 10³ times more intense

3. Which sound has the highest sound level?

- A. Whisper
B. Conversation
C. Heavy traffic
D. Jet engine

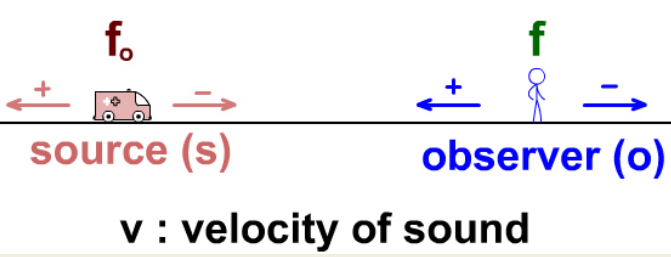
4. According to the simplified decibel scale in your textbook, a sound becomes 100 (10²) times more intense. If its original sound level was 40 dB, what is the new sound level?

- A. 50 dB
B. 60 dB
C. 80 dB
D. 100 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 Problem1 Practice problems	138
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+ observer toward source
 - observer away from source

$$f = f_o \left(\frac{v \pm v_o}{v \mp v_s} \right)$$
 - source toward observer
 + source away from observer



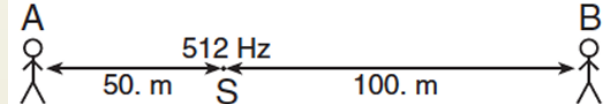
Sound waves are produced by the horn of a truck that is approaching a stationary observer. Compared to the sound waves detected by the driver of the truck, the sound waves detected by the observer have a greater

1. wavelength
2. frequency
3. period
4. speed



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

In the diagram below, a stationary source located at point S produces sound having a constant frequency of 512 hertz. Observer A, 50 meters to the left of S, hears a frequency of 512 hertz. Observer B, 100 meters to the right of S, hears a frequency lower than 512 hertz.

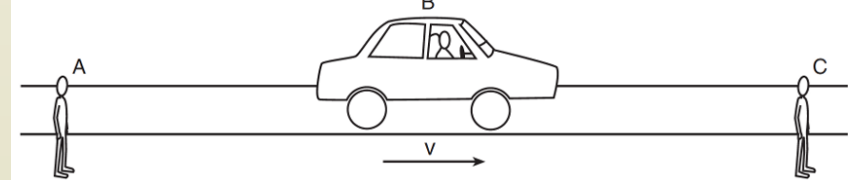


Which statement best describes the motion of the observers?

1. Observer A is moving toward point S, and observer B is stationary.
2. Observer A is moving away from point S, and observer B is stationary.
3. Observer A is stationary and observer B is moving toward point S.
4. Observer A is stationary, and observer B is moving away from point S.

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.

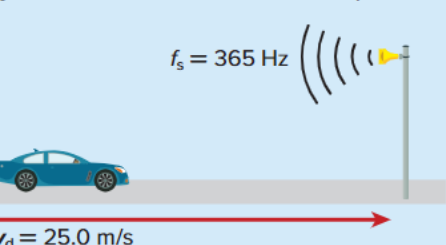
The horn of a moving vehicle produces a sound of constant frequency. Two stationary observers, A and C, and the vehicle's driver, B, positioned as represented in the diagram below, hear the sound of the horn.



Compared to the frequency of the sound of the horn heard by driver B, the frequency heard by observer A is

1. lower and the frequency heard by observer C is lower
2. lower and the frequency heard by observer C is higher
3. higher and the frequency heard by observer C is lower
4. higher and the frequency heard by observer C is higher

You are in an automobile, like the one in Figure 7, traveling toward a pole-mounted warning siren. If the siren's frequency is 365 Hz, what frequency do you hear? Use 343 m/s as the speed of sound.



3. You are in an automobile traveling at 55 mph (24.6 m/s). A second automobile is moving toward you at the same speed. Its horn is sounding at 475 Hz. What frequency do you hear? Use 343 m/s as the speed of sound.

An ambulance emits a sound wave with a wavelength of 0.40 m while moving toward a stationary observer at 20 m/s. The speed of sound in air is 340 m/s. What frequency does the observer hear?

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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Resonance is the **increase in the amplitude** of vibration that occurs when an external periodic force vibrates at the same frequency as the system's **natural frequency**.

★ **KEY IDEA**
Driving Frequency = Natural Frequency

RESULT: Larger amplitude → Louder sound

4. OTHER SOURCES OF SOUND (VIBRATING OBJECTS)

STRING INSTRUMENTS
Strings are plucked, struck, or bowed and vibrate. The vibrating strings transfer energy to a sounding board, which vibrates and produces sound.

Examples: Guitar, Violin, Piano

PERCUSSION INSTRUMENTS
A surface is struck, causing it to vibrate and produce sound waves.

Examples: Drums, Cymbals, Gongs

LOUDSPEAKER
An electric current vibrates the cone. The vibrating surface creates sound waves that travel to our ears.

Example: Speaker

HUMAN VOICE
Vocal cords in the throat vibrate as air from the lungs passes through.
• More tension → faster vibration → higher pitch
• Less tension → slower vibration → lower pitch

Examples: Speaking, Singing

SUMMARY
Resonance increases the amplitude of vibration.

 It makes the sound much louder.

 Standing waves are formed in the air column.

 Many musical instruments use this to produce music!

When air is blown across the top of an open water bottle, air molecules in the bottle vibrate at a particular frequency and sound is produced. This phenomenon is called

1. diffraction
2. refraction
3. resonance
4. the Doppler effect

A girl on a swing may increase the amplitude of the swing's oscillations if she moves her legs at the natural frequency of the swing. This is an example of

1. the Doppler effect
2. destructive interference
3. wave transmission
4. resonance

Wind blowing across suspended power lines may cause the power lines to vibrate at their natural frequency. This often produces audible sound waves. This phenomenon, often called an Aeolian harp, is an example of

1. diffraction
2. the Doppler effect
3. refraction
4. resonance



Which phenomenon occurs when an object absorbs wave energy that matches the object's natural frequency?

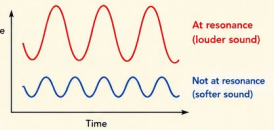
1. reflection
2. diffraction
3. resonance
4. interference

A student in a band notices that a drum vibrates when another instrument emits a certain frequency note. This phenomenon illustrates

1. reflection
2. resonance
3. refraction
4. diffraction

SUMMARY

- ✓ Resonance occurs when the **driving frequency** equals the **natural frequency**.
- ✓ The air column vibrates with a large amplitude.
- ✓ Standing waves are formed in the tube.
- ✓ The sound becomes much louder.



At resonance (louder sound)
Not at resonance (softer sound)

3. AIR COLUMNS IN MUSICAL INSTRUMENTS

Many musical instruments produce sound because the air column inside them resonates, which increases the amplitude and produces a clear note (pitch).

BRASS INSTRUMENTS
(lips vibrate)

Examples: Trumpet, Trombone, Tuba, Bugle
The musician's lips vibrate in the mouthpiece. This vibration sets the air column in the tube into resonance.
Air column: Acts like a closed pipe (one end closed by the lips, other open).

WOODWIND INSTRUMENTS
(reed vibrates)

Examples: Clarinet, Saxophone
A thin reed vibrates as air is blown across it, setting the air column into resonance.
Air column: Acts like a closed pipe.

FLUTES
(open at both ends)

Example: Flute
Air is blown across the opening, causing the air column in the tube to resonate.
Air column: Acts like an open pipe (both ends open).

ORGAN PIPES
(air from source)

Example: Organ pipes
Air from a blower enters the pipes. The air column inside each pipe resonates and produces a note.
Some pipes are open, some are closed.

1. Resonance occurs when:
 - A. The driving frequency is greater than the natural frequency.
 - B. The driving frequency is less than the natural frequency.
 - C. The driving frequency equals the natural frequency.
 - D. The amplitude becomes zero.
2. Which of the following best explains the resonance in an air column?
 - A. The air column absorbs all sound waves and stops vibrating.
 - B. The air column vibrates strongly when the sound source frequency matches one of its natural frequencies, producing a louder sound.
 - C. The speed of sound increases inside the tube.
 - D. The wavelength becomes zero inside the tube.
3. An open pipe and a closed pipe have the same length and are both resonating at their fundamental frequencies. Which statement is correct?
 - A. They have the same pitch and loudness.
 - B. The open pipe has a higher pitch, while both become louder during resonance.
 - C. The closed pipe has a higher pitch.
 - D. Resonance affects pitch but not loudness.

Playing a certain musical note on a trumpet causes the spring on the bottom of a nearby snare drum to vibrate. This phenomenon is an example of

1. resonance
2. refraction
3. reflection
4. diffraction

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
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1. LUMINOUS AND NON-LUMINOUS SOURCES OF LIGHT

A luminous source emits its own light. A non-luminous source does not emit light; it is visible because it reflects light from a luminous source.

LUMINOUS SOURCES

- These objects produce their own light.
- They are also called self-luminous objects.

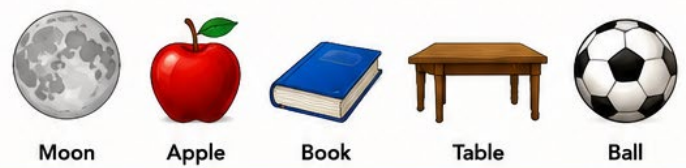
Examples:



NON-LUMINOUS SOURCES

- These objects do not produce their own light.
- They are seen when light from a luminous source falls on them and gets reflected.

Examples:

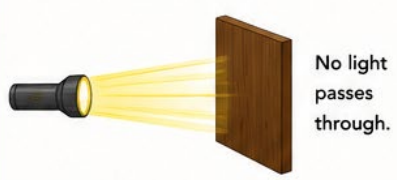


2. OPAQUE, TRANSLUCENT AND TRANSPARENT MEDIUMS

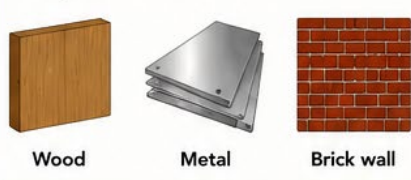
When light passes through different materials, they can be classified based on how much light they allow to pass.

OPAQUE MEDIUMS

- Do not allow light to pass through.
- We cannot see through them.

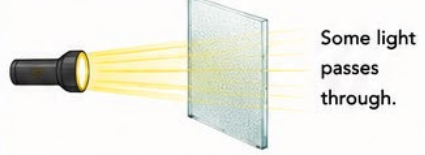


Examples:



TRANSLUCENT MEDIUMS

- Allow some light to pass through.
- Objects behind them can be seen blurred or not clearly.



Examples:



TRANSPARENT MEDIUMS

- Allow most or all light to pass through.
- Objects behind them can be seen clearly.



Examples:



1. Which material is translucent?
A. Air B. Butter paper C. Metal D. Clear glass
2. A student shines a flashlight at three materials: a wooden board, frosted glass, and clear glass. Through which material will the student see an object most clearly?
A. Wooden board
B. Frosted glass
C. Clear glass
D. All three materials equally
3. Which statement is correct about opaque, translucent, and transparent materials?
A. Transparent materials transmit all light and do not absorb or reflect any light.
B. Opaque materials reflect all light and do not absorb any light.
C. All materials absorb some light and reflect some light, but they differ in how much light they transmit.
D. Translucent materials transmit all light without scattering it.
4. Why can we see a transparent glass window even though most light passes through it?
A. It produces its own light.
B. It absorbs all the light that reaches it.
C. It reflects some light into our eyes.
D. It blocks all light from passing through.

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
18	Define quantities of light like luminous flux and illuminance, specifying their SI units.	St. textbook	158-161

QUANTITIES OF LIGHT

Light can be measured using different quantities. The three fundamental photometric quantities are **luminous flux (Φ)**, **luminous intensity (I)** and **illuminance (E)**.

1. LUMINOUS FLUX (P)

Luminous flux is the total amount of visible light emitted by a source per unit time.



Total light emitted in all directions

Formula	$P = E 4\pi r^2 = 4\pi I$
---------	---------------------------

Symbol	P (capital P)
--------	---------------

SI Unit	lumen (lm)
---------	-------------------

From Formula	$P = E 4\pi r^2 \Rightarrow \text{lm} = \text{lx} \times \text{m}^2$
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From Formula	$P = 4\pi I \Rightarrow \text{lm} = \text{cd}$
--------------	--

Equivalent Units

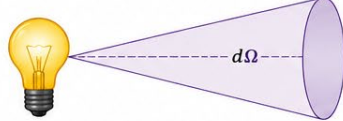
$$1 \text{ lumen (lm)} = 1 \text{ lx} \cdot \text{m}^2 = 1 \text{ candela (cd)}$$

KEY POINTS

- ✓ All surfaces absorb some light and reflect some light. The remainder (if any) is transmitted.
- ✓ The way light is absorbed, reflected and transmitted by a material determines whether it is **opaque**, **translucent** or **transparent**.
- ✓ These quantities help us measure and compare the production and distribution of visible light.

2. LUMINOUS INTENSITY (I)

Luminous intensity is the luminous flux emitted by a source in a particular direction per unit solid angle.



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

Symbol	I (capital I)
--------	---------------

SI Unit	candela (cd)
---------	---------------------

From Formula	$I = \frac{P}{4\pi} \Rightarrow \text{cd} = \text{lm}$ (since 4π is dimensionless)
--------------	---

Equivalent Units

$$1 \text{ candela (cd)} = 1 \text{ lumen (lm)}$$

(for uniform radiation over 4π steradians)

RELATION BETWEEN THE QUANTITIES

For a source that emits uniformly in all directions (isotropically):

$$P = 4\pi I$$

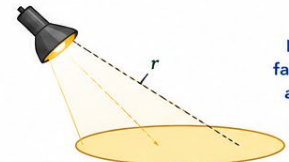
For a surface at distance r from such a source:

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

(These relations apply when the area is perpendicular to the direction of light.)

3. ILLUMINANCE (E)

Illuminance is the luminous flux received on a surface per unit area.



Flux P falling on area A

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

Symbol	E (capital E)
--------	---------------

SI Unit	lux (lx)
---------	-----------------

From Formula	$E = \frac{P}{4\pi r^2} \Rightarrow \text{lx} = \frac{\text{lm}}{\text{m}^2}$
--------------	---

Equivalent Units

$$1 \text{ lux (lx)} = 1 \text{ lumen per square metre (lm/m}^2\text{)}$$

UNITS AT A GLANCE

Quantity	Symbol	SI Unit	Equivalent Unit(s)
Luminous flux	P	lumen (lm)	$1 \text{ lm} = 1 \text{ lx} \cdot \text{m}^2 = 1 \text{ cd}$
Luminous intensity	I	candela (cd)	$1 \text{ cd} = 1 \text{ lm}$ (for uniform radiation over 4π sr)
Illuminance	E	lux (lx)	$1 \text{ lx} = 1 \text{ lm/m}^2$

Where: r = distance from source (m), A = area of surface (m^2), P = luminous flux (lm), I = luminous intensity (cd), E = illuminance (lx)

Note: 4π steradian (sr) is the total solid angle around a point.

1. What is the SI unit of luminous flux (P)?

- A. Candela (cd)
- B. Lux (lx)
- C. Lumen (lm)
- D. Watt (W)

2. Luminous intensity (I) is defined as:

- A. The luminous flux received per unit area
- B. The total visible light emitted by a source
- C. The luminous flux emitted in a particular direction
- D. The distance light travels per second

3. Which formula is used to calculate illuminance (E)?

- A. $P = 4\pi I$
- B. $I = \frac{P}{4\pi}$
- C. $E = \frac{P}{4\pi r^2}$
- D. $P = E(4\pi r^2)$

4. Which of the following correctly matches the quantity with its SI unit?

- A. Luminous Flux $\rightarrow$ lux (lx)
- B. Illuminance $\rightarrow$ candela (cd)
- C. Luminous Intensity $\rightarrow$ lumen (lm)
- D. Illuminance $\rightarrow$ lux (lx)

17	Apply the equation for illuminance of a point source to numerical problems	Example Problem1 Practice problems	162
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

QUANTITIES OF LIGHT – FORMULAS, UNITS & RATIO RELATIONS SUMMARY

The three fundamental photometric quantities used to measure visible light are:
LUMINOUS FLUX (P), LUMINOUS INTENSITY (I) and **ILLUMINANCE (E)**.

$$\pi = 22/7$$

1. LUMINOUS FLUX (P)

Total amount of visible light emitted by a source per unit time.

FORMULAS

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

or

$$P = 4\pi I$$

Where,
 P = luminous flux (lumen, lm)
 E = illuminance (lux, lx)
 r = distance from source (metre, m)
 I = luminous intensity (candela, cd)

UNITS

SI Unit	lumen (lm)
Equivalent Unit	1 lm = 1 cd·sr

 1 lumen is the luminous flux emitted by a source of 1 candela uniformly in all directions into a solid angle of 1 steradian.

2. LUMINOUS INTENSITY (I)

Luminous flux emitted by a source in a particular direction per unit solid angle.

FORMULA

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

Where,
 P = luminous flux (lumen, lm)
 I = luminous intensity (candela, cd)
 $\pi = \frac{22}{7}$ (dimensionless)

UNITS

SI Unit	candela (cd)
Equivalent Unit	1 cd = 1 lm/sr

 1 candela is the luminous intensity of a source that emits 1 lumen of luminous flux uniformly into a solid angle of 1 steradian.

3. ILLUMINANCE (E)

Luminous flux received on a surface per unit area.

FORMULA

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

Where,
 P = luminous flux (lumen, lm)
 E = illuminance (lux, lx)
 r = distance from source (metre, m)
 $\pi = \frac{22}{7}$ (dimensionless)
 A = area of surface (square metre, m²)

UNITS

SI Unit	lux (lx)
Equivalent Unit	1 lx = 1 lm/m ²

 1 lux is the illuminance produced when 1 lumen of luminous flux is uniformly distributed over an area of 1 square metre.

RATIO RELATIONS (Useful for Problem Solving)

At constant P (luminous flux)
(P same for both cases)
From $E = \frac{P}{4\pi r^2}$

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

Illuminance is inversely proportional to r^2 .

At constant P (luminous flux)
(P same for both cases)
From $I = \frac{P}{4\pi}$

$$\frac{I_1}{I_2} = 1$$

Intensity is independent of distance.

At constant E (illuminance)
(E same for both cases)
From $E = \frac{P}{4\pi r^2} = \frac{I}{r^2}$

$$\frac{I_1}{I_2} = \frac{r_1^2}{r_2^2}$$

Intensity is directly proportional to r^2 .

At constant E (illuminance)
(E same for both cases)
From $E = \frac{P}{4\pi r^2}$

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

Flux is directly proportional to r^2 .

At constant r (distance)
(r same for both cases)
From $E = \frac{P}{4\pi r^2}$

$$\frac{E_1}{E_2} = \frac{P_1}{P_2}$$

Illuminance is directly proportional to flux.

WHERE:

- P = luminous flux (lumen, lm)
- I = luminous intensity (candela, cd)
- E = illuminance (lux, lx)
- r = distance from source (metre, m)
- A = area of surface (square metre, m²)
- $\pi = \frac{22}{7}$ (dimensionless)
- Ω = solid angle (steradian, sr)
- 1 sr = 1 steradian

AT A GLANCE

Quantity	Symbol	Formula	SI Unit	Equivalent Unit
Luminous Flux	P	$P = E 4\pi r^2$ or $P = 4\pi I$	lumen (lm)	1 lm = 1 cd·sr
Luminous Intensity	I	$I = \frac{P}{4\pi}$	candela (cd)	1 cd = 1 lm/sr
Illuminance	E	$E = \frac{P}{4\pi r^2}$	lux (lx)	1 lx = 1 lm/m ²

 **KEY POINT**
All surfaces absorb some light and reflect some light. The remainder (if any) is transmitted.

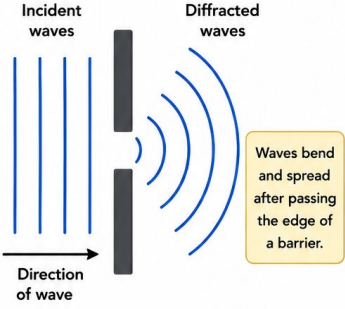
EXAMPLE Problem 1

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?

1. A lamp emits 352 lm of luminous flux uniformly in all directions. A screen is placed 2 m away from the lamp. What is the illuminance on the screen?
- A. 7 lx
B. 14 lx
C. 21 lx
D. 28 lx
2. A light source emits 176 lm of luminous flux uniformly in all directions. What is its luminous intensity?
- A. 7 cd
B. 14 cd
C. 21 cd
D. 28 cd
3. A surface located 1 m from a light source receives an illuminance of 35 lx. What is the luminous flux emitted by the source?
- A. 220 lm
B. 440 lm
C. 660 lm
D. 880 lm
1. A lamp is moved from 30 cm to 90 cm above the pages of a book. Compare the illumination on the book before and after the lamp is moved.

20	Define diffraction as the bending of a wave as it passes the edge of a barrier	St. textbook	165
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Diffraction is the bending or spreading of a wave as it passes around the edge of a barrier or through an opening.



Key Points

- Diffraction occurs with all types of waves (sound, water, light, etc.).
- The effect is more noticeable when the size of the opening or obstacle is similar to the wavelength of the wave.
- Greater diffraction means greater bending and spreading of the wave.

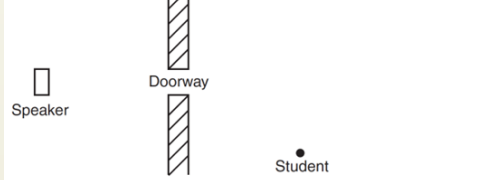
Examples

Sound Waves: You can hear someone speaking around a corner because sound waves diffract around obstacles.

Water Waves: Water waves spread out after passing through a narrow gap in a barrier.

Light Waves: Light can bend slightly around very small openings, producing diffraction patterns.

A student listens to music from a speaker in an adjoining room, as represented in the diagram below.



She notices that she does not have to be directly in front of the doorway to hear the music. This spreading of sound waves beyond the doorway is an example of

1. the Doppler effect
2. resonance
3. refraction
4. diffraction

- 1. What is diffraction?**
- A. The reflection of a wave from a surface
- B. The bending or spreading of a wave around an obstacle or through an opening
- C. The absorption of a wave by a material
- D. The increase in wave speed
- 2. Diffraction is most noticeable when:**
- A. The wavelength is much smaller than the opening
- B. The opening is much larger than the wavelength
- C. The size of the opening or obstacle is similar to the wavelength
- D. The wave amplitude is zero
- 3. Which of the following is an example of diffraction?**
- A. Seeing your image in a mirror
- B. Hearing someone speaking around a corner
- C. A pencil appearing bent in water
- D. A solar panel absorbing sunlight
- 4. Two water waves pass through different gaps. Wave X passes through a narrow gap, while Wave Y passes through a much wider gap. Which statement is correct?**
- A. Wave X shows greater diffraction than Wave Y.
- B. Wave Y shows greater diffraction than Wave X.
- C. Both waves show the same amount of diffraction.
- D. Neither wave undergoes diffraction.

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

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COLOR OF LIGHT, WAVELENGTH, AND FREQUENCY

The color of visible light is determined by its **wavelength** and **frequency**.

- Different colors have different wavelengths and frequencies.
- Longer wavelengths correspond to lower frequencies.
- Shorter wavelengths correspond to higher frequencies.

Relationship between speed, wavelength, and frequency:

$$c = f\lambda$$

c = speed of light (3.0×10^8 m/s)

f = frequency (Hz)

λ = wavelength (m)

VISIBLE LIGHT SPECTRUM (400 nm to 700 nm)

Color	VIOLET	BLUE	GREEN	YELLOW	ORANGE	RED
						
Wavelength (nm)	400 – 450 nm	450 – 495 nm	495 – 570 nm	570 – 590 nm	590 – 620 nm	620 – 700 nm
Frequency (Hz)	7.50×10^{14} – 6.67×10^{14} Hz	6.67×10^{14} – 6.06×10^{14} Hz	6.06×10^{14} – 5.26×10^{14} Hz	5.26×10^{14} – 5.08×10^{14} Hz	5.08×10^{14} – 4.84×10^{14} Hz	4.84×10^{14} – 4.29×10^{14} Hz
Relative Frequency	Highest	High	Medium	Medium	Low	Lowest



KEY POINTS

- ✓ Visible light ranges from 400 nm to 700 nm.
- ✓ As wavelength increases, frequency decreases.
- ✓ As wavelength decreases, frequency increases.

EXTREMES OF THE VISIBLE SPECTRUM

VIOLET LIGHT



Shortest wavelength
(~400 nm)
Highest frequency

RED LIGHT



Longest wavelength
(~700 nm)
Lowest frequency

SUMMARY



The color of light depends on its wavelength and frequency.



Red light has the longest wavelength and lowest frequency.
Violet light has the shortest wavelength and highest frequency.

1. Which color of visible light has the highest frequency?
A. Red B. Orange C. Green D. Violet
2. Which color of visible light has the longest wavelength?
A. Violet B. Blue C. Yellow D. Red
3. As the wavelength of visible light increases from 400 nm to 700 nm, the frequency:
A. Increases
B. Decreases
C. Remains constant
D. Becomes zero
4. A student compares a beam of blue light and a beam of red light. Which statement is correct?
A. Blue light has a longer wavelength than red light.
B. Blue light has a lower frequency than red light.
C. Blue light has a shorter wavelength and a higher frequency than red light.
D. Blue light and red light have the same wavelength but different frequencies.
5. Two light waves travel through a vacuum. Wave X has a wavelength of 450 nm, and Wave Y has a wavelength of 650 nm. Which statement is correct?
A. Wave X has a lower frequency than Wave Y.
B. Wave Y has a higher frequency than Wave X.
C. Wave X and Wave Y have the same frequency.
D. Wave X has a higher frequency than Wave Y.

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.

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1. Which pair represents the **primary colors of light**?

- A. Red, Yellow, Blue
- B. Red, Green, Blue
- C. Green, Yellow, Blue
- D. Red, Green, Yellow

2. Which pair of colors combines to produce **cyan light**?

- A. Red + Green
- B. Red + Blue
- C. Green + Blue
- D. Red + Yellow

3. A **green leaf** is illuminated with **red light only**. What color will the leaf appear?

- A. Green
- B. Yellow
- C. Red
- D. Black (or very dark)

4. A **white shirt** is illuminated with **blue light only**. What color will the shirt appear?

- A. White
- B. Blue
- C. Black
- D. Green

5. A **red apple** is illuminated by **cyan light** (cyan = green + blue). What color will the apple appear?

- A. Red
- B. Cyan
- C. White
- D. Black (or very dark)

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. PRIMARY COLORS OF LIGHT (RGB)

The primary colors of light are **Red, Green, and Blue**. They cannot be produced by mixing other colors of light.



MIXING PRIMARY COLORS

$R + G = Y$ Yellow
 $R + B = M$ Magenta
 $G + B = C$ Cyan
 $R + G + B = W$ White

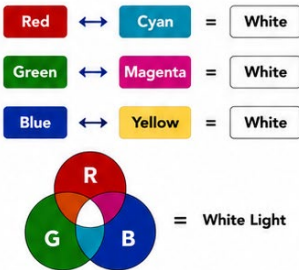
2. SECONDARY COLORS OF LIGHT

Secondary colors are produced by mixing two primary colors.

$R + G = Y$ Yellow
 $G + B = C$ Cyan
 $R + B = M$ Magenta

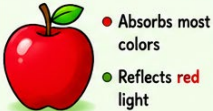
3. COMPLEMENTARY COLORS OF LIGHT

Complementary colors are pairs of colors that combine to produce white light.



EFFECTS OF DIFFERENT LIGHT ON OBJECTS

1. Red apple under **white light**



APPEARS RED

2. Red apple under **blue light**



APPEARS BLACK (or very dark)

3. White shirt under **green light**



APPEARS GREEN

4. Black object under **white light**



APPEARS BLACK

5. SIMPLE RULE: RELATING INCIDENT LIGHT TO APPEARING COLOR



An object appears the **color of the light it reflects**. It **absorbs** the other colors in the incident light.

Incident Light (Color)	Object Appears	Reflects	Absorbs
Red	Red	Red	Green, Blue
Green	Green	Green	Red, Blue
Blue	Blue	Blue	Red, Green
White (all colors)	Depends on object	The colors it reflects	The colors it absorbs
No Light (darkness)	Black (cannot be seen)	None	None

Examples:

- A red object under blue light appears **black**.
- A white object under green light appears **green**.
- A green object under red light appears **black**.



23	Describe primary and secondary pigments and the effects of mixing pigments or dyes	St. textbook	168
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Pigments: What They Absorb and Reflect

Primary Pigments (CYM)

CYAN  Absorbs: Red Reflects: Green and Blue	MAGENTA  Absorbs: Green Reflects: Red and Blue	YELLOW  Absorbs: Blue Reflects: Red and Green
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Each primary pigment absorbs one primary color and reflects the other two.

Secondary Pigments

(Made by mixing two primary pigments)

CYAN + YELLOW  ↓ GREEN Absorbs: Red, Blue Reflects: Green	CYAN + MAGENTA  ↓ BLUE Absorbs: Red, Green Reflects: Blue	MAGENTA + YELLOW  ↓ RED Absorbs: Green, Blue Reflects: Red
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Each secondary pigment absorbs two primary colors and reflects the third.

PIGMENTS vs DYES

PIGMENTS  - Insoluble colored materials. - Usually made from crushed minerals or synthetic materials. - Used in paints, inks, and coatings.	DYES  - Soluble colored substances. - Often obtained from plants, flowers, roots, or insects. - Used for coloring fabrics, food, and liquids.
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3. EFFECTS OF MIXING PIGMENTS (SUBTRACTIVE MIXING)

When pigments are mixed, more wavelengths of light are **absorbed**.

Pigments Mixed	Result
 +  = 	Green
 +  = 	Blue
 +  = 	Red
 +  +  = 	Black (or very dark color)

Statement: Primary colors of **light** are the secondary colors of **pigments**, and primary **pigments** are the secondary colors of **light**.

Light (Additive Mixing)	Pigments (Subtractive Mixing)
Primary: Red, Green, Blue	Secondary: Red, Green, Blue
Secondary: Cyan, Magenta, Yellow	Primary: Cyan, Magenta, Yellow

● ● ● Primary Light ↔ Secondary Pigment
● ● ● Secondary Light ↔ Primary Pigment

- Which of the following is a **primary pigment**?
A. Green
B. Blue
C. Cyan
D. Red
- Mixing **cyan** and **magenta** pigments produces:
A. Green
B. Blue
C. Yellow
D. White
- A **yellow pigment** is illuminated with white light. Which primary color of light is mainly absorbed by the pigment?
A. Red
B. Green
C. Blue
D. Yellow
- A pigment reflects **red light** and absorbs **green and blue light**. This pigment is:
A. Cyan
B. Magenta
C. Yellow
D. Red (secondary pigment)

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

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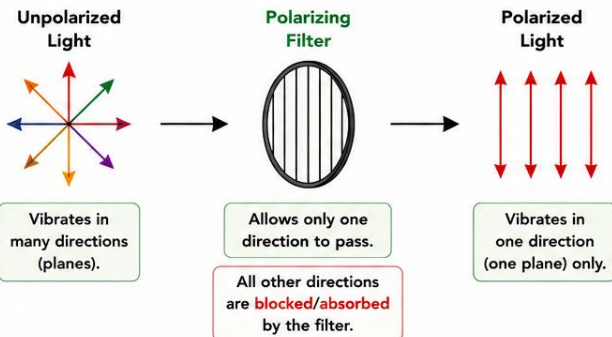
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POLARIZATION OF LIGHT – SUMMARY

Polarization is the process of restricting light vibrations to one plane (**one direction**).

1. POLARIZATION BY FILTERING

A polarizing filter allows only **one** vibration direction to pass.



Applications:

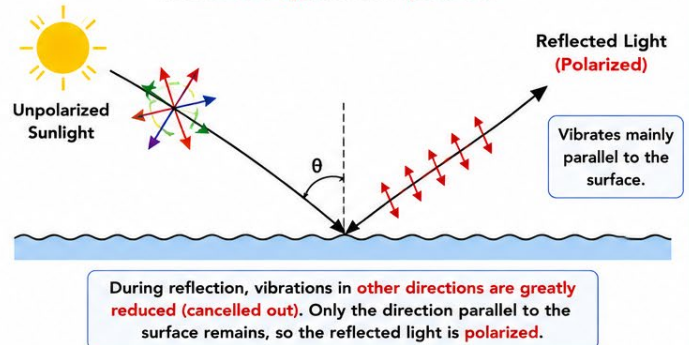
- Polarized sunglasses reduce glare.
- Camera filters improve image quality.
- LCD screens use polarizing filters.



Because the other directions are blocked, the intensity (brightness) of light **decreases**.

2. POLARIZATION BY REFLECTION

When unpolarized light reflects from a non-metallic surface, the **reflected light** becomes **polarized**.



Examples:

- Sunlight reflected from water, glass, or roads becomes polarized.
- Polarized sunglasses block this polarized light, reducing glare.



The other vibration directions are **greatly reduced**, so the reflected light is partially dimmer.

COMPARISON

Point	By Filtering	By Reflection
Method	Uses a polarizing filter	Uses reflection from a surface
What happens to other rays?	Other directions are blocked (absorbed) by the filter.	Other directions are greatly reduced (cancelled out).
Result	Polarized light (one direction)	Polarized reflected light
Use / Effect	Used in sunglasses, cameras, LCD screens, etc.	Causes glare from shiny surfaces; sunglasses reduce it.

KEY TAKEAWAY

- ✓ Unpolarized light vibrates in many directions.
- ✓ Polarization makes light vibrate in one direction only.
- ✓ In filtering, other directions are blocked by the filter.
- ✓ In reflection, other directions are greatly reduced.
- ✓ Polarized sunglasses reduce glare by blocking polarized reflected light.

REMEMBER



Polarized sunglasses work because they block polarized reflected light.



Glare from water, glass, or roads is polarized light.

1. What is polarization of light?
 - A. The bending of light around obstacles
 - B. The reflection of light from a mirror
 - C. Restricting light vibrations to one plane (one direction)
 - D. Splitting light into different colors
2. What is the function of a polarizing filter?
 - A. It increases the speed of light.
 - B. It allows only one vibration direction of light to pass.
 - C. It changes the color of light.
 - D. It reflects all incoming light.
3. Unpolarized light passes through a polarizing filter. What happens to the vibrations in the other directions?
 - A. They become stronger.
 - B. They change color.
 - C. They pass through unchanged.
 - D. They are blocked (absorbed) by the filter.
4. Why do polarized sunglasses reduce glare from water, roads, and glass?
 - A. They make light travel slower.
 - B. They block the polarized reflected light causing the glare.
 - C. They absorb all visible light.
 - D. They convert reflected light into sound.

MALUS’S LAW

Malus’s Law gives the intensity of plane-polarized light after it passes through an analyzer when the light is first polarized by a polarizer.

DESCRIPTION

When plane-polarized light of intensity I_1 is passed through an analyzer, the transmitted intensity I_2 depends on the angle θ between the transmission axes of the polarizer and the analyzer.

FORMULA

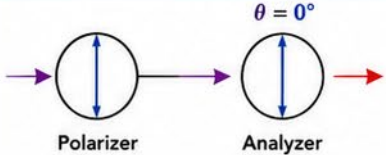
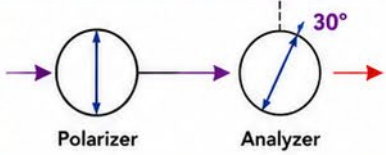
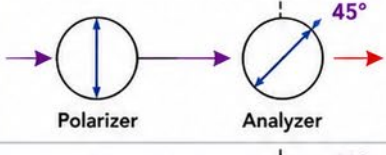
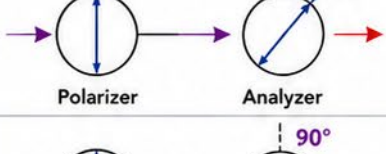
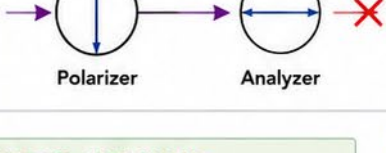
$$I_2 = I_1 \cos^2 \theta$$

Where,
 I_2 = Intensity after analyzer
 I_1 = Intensity before analyzer
 θ = Angle between transmission axes of polarizer and analyzer

UNIT

The unit of intensity (I_1 and I_2) is the same.

SI Unit: watt per square meter (W/m^2)
(Also written as W m^{-2})

DIFFERENT ANGLES BETWEEN POLARIZER AND ANALYZER				
Angle (θ)	Diagram	$\cos^2 \theta$	Result ($I_2 = I_1 \cos^2 \theta$)	Explanation
0° (Parallel)		1	$I_2 = I_1$ (Maximum intensity)	Axes are in the same direction. All the light passes through. 
30°		0.75	$I_2 = 0.75 I_1$ (75% of I_1)	Some light passes through. Intensity is 75% of I_1 . 
45°		0.50	$I_2 = 0.50 I_1$ (50% of I_1)	Half of the light passes through. 
60°		0.25	$I_2 = 0.25 I_1$ (25% of I_1)	Only a small amount passes through. 
90° (Perpendicular)		0	$I_2 = 0$ (No light passes)	Axes are perpendicular. No light passes through. (Perfect darkness) 

SYMBOLS MEANING	
I_1	→ Intensity of polarized light before analyzer
I_2	→ Intensity of light after analyzer
θ	→ Angle between transmission axes of polarizer and analyzer

KEY TAKEAWAYS

- I_2 is maximum when $\theta = 0^\circ$.
- I_2 decreases as θ increases.
- I_2 becomes zero when $\theta = 90^\circ$ (crossed polarizers).
- This law is used in sunglasses, camera filters, LCD screens, and many optical instruments.



Two polarizing filters are placed so that the angle between the polarizing axes is 45°. Find the ratio of the intensity of the light exiting the second filter to the intensity of the light exiting the first filter.