

**PHY • PHYSICS**

05. Waves

Official PMDC Solved Past Paper Topical Booklet • High-Yield Examination Series

🕒 124 Solved Questions

📅 2008 to 2024 Archive

📋 Boards: BUMHS, DUHS, KMU, KU, MDCAT, NUMS

📊 Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

SZABMU 2024

By increasing the temperature of medium about 1°C , the speed of sound is increased up to [SZABMU 2024]

- (A) 0.41 ms^{-1}
- (B) 0.51 ms^{-1}
- (C) 0.61 ms^{-1}
- (D) 0.71 ms^{-1}

Q2.

SZABMU 2024

What will be the fundamental frequency in a stretched string, when it is plucked at central point while it has a speed of 48 ms^{-1} with string length of 8m? [SZABMU 2024]

- (A) 3 Hz
- (B) 6 Hz
- (C) 9 Hz
- (D) 12 Hz

Q3.

SZABMU 2024

How much phase difference is required between two waves to form destructive interference? [SZABMU 2024]

- (A) 0°
- (B) 45°
- (C) 90°
- (D) 180°

Q4.

SZABMU 2024

What will be the time period of wave generator if it produces 1000 waves in 10 seconds? [SZABMU 2024]

- (A) 0.001 s
- (B) 0.01 s
- (C) 0.02 s
- (D) 0.1 s

Q5.

SZABMU 2024

Which one of the following is an example of transverse waves? [SZABMU 2024]

- (A) Sound waves
- (B) Water waves
- (C) Waves associated with electron
- (D) Waves in spring

Q6.

SZABMU 2024

Under which condition Newton performed experiment for calculation of speed of sound in air? [SZABMU 2024]

- (A) Adiabatic
- (B) Isobaric
- (C) Isochoric
- (D) Isothermal

Q7.

SZABMU 2024

There is no net transfer of energy by particles of medium in _____. [SZABMU 2024]

- (A) Longitudinal wave
- (B) Progressive wave
- (C) Stationary wave
- (D) Transverse wave

Q8.

KU 2024

What happens when two waves of the same frequency and amplitude meet in phase? [KU 2024]

- (A) They cancel each other out resulting in a destructive interference
- (B) They combine to form a wave double the amplitude, resulting in constructive interference
- (C) They produce a wave with zero amplitude, resulting in constructive interference
- (D) They produce a wave with zero amplitude as the individual waves

Q9.

KU 2024

Which type of waves can be polarized? [KU 2024]

- (A) Longitudinal waves
- (B) Mechanical waves
- (C) Sound waves
- (D) Transverse waves

Q10.

KU 2024

For longitudinal waves _____. [KU 2024]

- (A) The particles of the medium oscillate perpendicular to the wave's propagation
- (B) The particles of the medium remain stationary as the waves pass through
- (C) The particles of the medium oscillate along the direction of the waves propagation
- (D) their velocity is enhanced when they travel through vacuum

Q11.

KU 2024

According to the principle of superimposition, when 2 or more waves overlap at a point in space, the amplitude of the resultant wave at that point is [KU 2024]

- (A) Always zero
- (B) The product of the individual wave amplitude
- (C) The product of the frequencies of the individual waves
- (D) The sum of the amplitudes of the individual waves

Q12.

KU 2024

The speed of sound in a medium containing ideal gas is NOT dependent on [KU 2024]

- (A) Density
- (B) Moisture
- (C) Pressure
- (D) Temperature

Q13.

KU 2024

A tuning fork having frequency equal to 440 Hz produces sound waves which travel with the speed of 340 m/s. What is the wavelength of the sound waves? [KU 2024]

- (A) 0.57 m
- (B) 0.67 m
- (C) 0.77 m
- (D) 0.87 m

Q14.

KU 2024

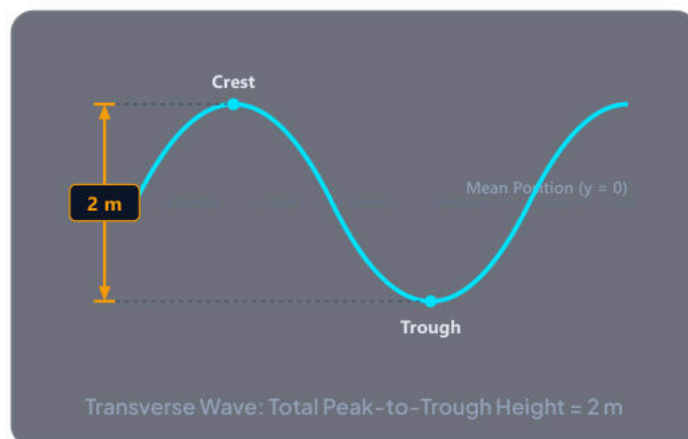
A police car, with its siren on, is moving towards a stationary listener. How does the stationary listener receive the frequency of the sound emitted by the siren? It [KU 2024]

- (A) Decreases
- (B) Increases
- (C) Stays the same
- (D) Varies randomly

Q15.

UHS 2024

Amplitude in the following figure is given as: [UHS 2024]



- (A) 2 m
- (B) $1/2$ m
- (C) $\frac{\sqrt{3}}{2}$ m
- (D) 1 m

Q16.

UHS 2024

Which one of the following is **INCORRECT** about the nodes when the string is plucked: **[UHS 2024]**

- (A) Amplitude of vibration is zero
- (B) Do not move along the string
- (C) Produced at the fixed ends of strings
- (D) Distance between consecutive nodes is 1 wavelength

Q17.

UHS 2024

In transverse waves the portion above the mean level is called: **[UHS 2024]**

- (A) Wave front
- (B) Wave crest
- (C) Wave trough
- (D) Wave length

Q18.

UHS 2024

Which one of the following does not cause stationary waves? **[UHS 2024]**

- (A) Two waves of equal frequency
- (B) Two waves of same speed
- (C) Two waves of unequal amplitude
- (D) Two waves travelling in opposite directions

Q19.

UHS 2024

The distance between two successive particles which are exactly in the same state of vibration is called: **[UHS 2024]**

- (A) Frequency
- (B) Amplitude
- (C) Wavelength
- (D) Time period

Q20.

NUMS 2024

A body of mass 10 kg is connected to a spring and it is oscillating on a horizontal frictionless surface. If the maximum displacement of body is 20 cm and spring constant is 20 Nm^{-1} . What is the acceleration of the body? **[NUMS 2024]**

- (A) 2.2 ms^{-1}
- (B) 4 ms^{-1}
- (C) 2 ms^{-1}
- (D) 0.4 ms^{-1}

Q21.

NUMS 2024

A normal person can hear sound waves ranging in frequency from 20 Hz to 20 K Hz. The maximum wavelength is: **[NUMS 2024]**

- (A) 17 m
- (B) 17 mm
- (C) 17 cm
- (D) 17 km

Q22.

BUMHS 2024

Sounds wave are not polarized in air because: **[BUMHS 2024]**

- (A) they are longitudinal waves
- (B) they are transverse waves
- (C) they need media for its propagation
- (D) they have shorter wave lengths

Q23.

BUMHS 2024

Distance between consecutive crest and trough of water waves is? **[BUMHS 2024]**

- (A) λ
- (B) $\lambda/2$
- (C) $\lambda/4$
- (D) none of these

Q24.

BUMHS 2024

Which of the following set of frequencies can have constructive interference? **[BUMHS 2024]**

- (A) 20Hz and 21 Hz
- (B) 100Hz and 110Hz
- (C) 1000Hz and 2000Hz
- (D) None of these

Q25.

BUMHS 2024

Compression is that portion of the longitudinal wave where pressure is: **[BUMHS 2024]**

- (A) High
- (B) Low
- (C) Zero
- (D) All of these

Q26.

BUMHS 2024

The potential energy due to gravitational field near the surface of the Earth at a height h is given by [BUMHS 2024]

- (A) mg/h
- (B) mgh
- (C) mh/g
- (D) gh/m

Q27.

UHS 2023

An observer standing near the sea shore observes 54 waves per minute. If the wavelength of the water wave is 10m then the velocity of water wave is: [UHS 2023]

- (A) 540 m/s
- (B) 9 m/s
- (C) 5.4 m/s
- (D) None

Q28.

UHS 2023

If the length of second pendulum becomes four times, then its time period will become: [UHS 2023]

- (A) Four times
- (B) Two times
- (C) Half
- (D) One fourth

Q29.

UHS 2023

When a wave goes from one medium to another, there is a no change in the: [UHS 2023]

- (A) Frequency
- (B) Amplitude
- (C) Wavelength
- (D) Velocity

Q30.

UHS 2023

Wave trough refers to the: [UHS 2023]

- (A) Wave length
- (B) Wave speed
- (C) Highest point of the wave
- (D) Lowest point of the wave

Q31.

SZABMU 2023

A wave generator produces 500 pulses in 50s. its frequency will be: [SZABMU 2023]

- (A) 10 s^{-1}
- (B) 0.1 s^{-1}
- (C) 500 s^{-1}
- (D) 50 s^{-1}

Q32.

SZABMU 2023

The speed of sound in air is 332 ms^{-1} at 0°C . what will be its value at 10°C . [SZABMU 2023]

- (A) 332 ms^{-1}
- (B) 338.1 ms^{-1}
- (C) 332.61 ms^{-1}
- (D) 334.1 ms^{-1}

Q33.

SZABMU 2023

The number of revolutions per second of a body is known as: [SZABMU 2023]

- (A) Linear frequency
- (B) Angular frequency
- (C) Time period
- (D) Amplitude

Q34.

SZABMU 2023

Which of the following factors does not affect the speed of sound in air? [SZABMU 2023]

- (A) Density of gas
- (B) Moisture in air
- (C) Temperature
- (D) Pressure of gas

Q35.

SZABMU 2023

Time period of a vibrating body is independent of: [SZABMU 2023]

- (A) Frequency
- (B) Amplitude
- (C) Wavelength
- (D) Value of 'g'

Q36.

KMU 2023

A stretched string vibrates with frequency f , when tension in the string is t , for what value of tension, the frequency of the same string is doubled? [ETEA 2023]

- (A) $2t$
- (B) $4t$
- (C) $8t$
- (D) $16t$

Q37.

KMU 2023

The longitudinal waves travel more slowly in ____ than in _____. [ETEA 2023]

- (A) Solids, gases
- (B) Solids, liquid
- (C) Gases, solids
- (D) Liquid, gases

Q38.

KMU 2023

Sinusoidal water waves are generated in a large ripple tank. The water travels at 25 cm/s and their adjacent crests are 5.0 cm apart. The time required for each new whole cycle to be generated is: [ETEA 2023]

- (A) 100 sec
- (B) 4 sec
- (C) 2 sec
- (D) 0.2 sec

Q39.

KMU 2023

The distance between adjacent node and anti-node is equal to: [ETEA 2023]

- (A) λ
- (B) $\frac{\lambda}{2}$
- (C) 2λ
- (D) $\frac{\lambda}{4}$

Q40.

KMU 2023

A string clamped at its both ends, vibrates in four segments (loops). The length of string is 150 cm. The wavelength of the wave is: [ETEA 2023]

- (A) 33.3 cm
- (B) 66.7 cm
- (C) 150 cm
- (D) 75 cm

Q41.

KMU 2023

The square root of the ratio of elasticity to mass density is equal to: [ETEA 2023]

- (A) Force
- (B) Product of frequency and wavelength
- (C) Co-efficient of viscosity
- (D) Refractive index

Q42.

KMU 2023

If the pressure of air enclosed in a long tube is increased 10 times, then speed of sound will: [ETEA 2023]

- (A) Increase
- (B) Decrease
- (C) Remain constant
- (D) Become zero

Q43.

DUHS 2023

Which of the following are the application of Doppler's effect? [SINDH 2023]

- (A) Hologram technology
- (B) Measuring the speed of automobile
- (C) Determining speed of light in mediums
- (D) Sending radar signals

Q44.

DUHS 2023

Longitudinal waves exhibit [SINDH 2023]

- (A) Polarization
- (B) Particle nature
- (C) Property of energy transmission in space
- (D) Phenomena of superposition of waves

Q45.

DUHS 2023

The product of frequency and wavelength of a wave equals to: [SINDH 2023]

- (A) Displacement of the wave
- (B) Amplitude of the wave
- (C) Speed of the wave
- (D) Time period of the wave

Q46.

DUHS 2023

In standing waves, the distance between two consecutive nodes or antinodes is: [SINDH 2023]

- (A) 2λ
- (B) $\lambda/2$
- (C) $\lambda/4$
- (D) λ

Q47.

DUHS 2023

If the fundamental frequency of vibration of a string fixed at both ends is 50Hz, the fourth harmonic will be: [SINDH 2023]

- (A) 200 Hz
- (B) 150 Hz
- (C) 125 Hz
- (D) 250 Hz

Q48.

DUHS 2023

In vibratory motion the maximum displacement of the body on either side of its equilibrium position is called: [SINDH 2023]

- (A) Distance
- (B) Displacement
- (C) Amplitude
- (D) Frequency

Q49.

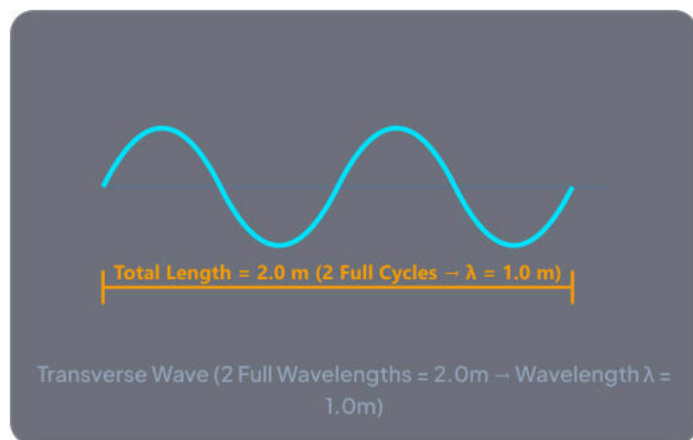
DUHS 2023

The speed of sound at 0°C in air is 332 m/s . What will be the speed of sound at 50°C ? [SINDH 2023]

- (A) 300 m/s
- (B) 332 m/s
- (C) 362.5 m/s
- (D) 382 m/s

Q50.

NUMS 2023



In the following figure the wavelength is: [NUMS 2023]

- (A) 2m
- (B) 1.5m
- (C) 1m
- (D) 0.5m

Q51.

NUMS 2023

With increase in pressure, the speed of sound will: [NUMS 2023]

- (A) Increase
- (B) Decrease
- (C) First increase then decrease
- (D) Remain the same

Q52.

NUMS 2023

In transverse waves, the portion above the mean level is called: [NUMS 2023]

- (A) Wave front
- (B) Wave crest
- (C) Wave trough
- (D) Wave length

Q53.

NUMS 2023

At maximum displacement of particles of a medium, on either side of the mean position of a wave, is called: [NUMS 2023]

- (A) Wavelength
- (B) Frequency
- (C) Amplitude
- (D) Crest

Q54.

UHS 2022

A long spring, when stretched by a distance x , has potential energy V . On increasing the stretching to nx , the potential energy of the spring will be: [UHS 2022]

- (A) nV
- (B) n^2V
- (C) V/n
- (D) V/n^2

Q55.

UHS 2022

Which of the following increases by increasing amplitude? [UHS 2022]

- (A) Wavelength
- (B) Zero
- (C) Frequency
- (D) Loudness

Q56.

UHS 2022

An airplane travels at a speed of $0.5v$ is the speed of sound. The airplane approaches a stationary observer. The frequency of sound emitted by the aircraft is 200 Hz . Which frequency does the observer hear? [UHS 2022]

- (A) 400 Hz
- (B) 100 Hz
- (C) 120 Hz
- (D) 180 Hz

Q57.

UHS 2022

If the wavelength of light coming from a galaxy shifts towards the red end of spectrum, then galaxy is: [UHS 2022]

- (A) Approaching Earth
- (B) Receding the Earth
- (C) Stationary
- (D) Approaching Earth or is stationary

Q58.

BUMHS 2022

The shortest distance between any two points in phase on a wave is called: [UHS+BMU 2022]

- (A) Displacement
- (B) Amplitude
- (C) Wavelength
- (D) Frequency

Q59.

UHS 2022

When will the oscillations stop in the absence of resistive forces? [UHS 2022]

- (A) Never
- (B) After 10 minutes
- (C) In 10 minutes
- (D) Immediately

Q60.

UHS 2022

The mechanical waves are not by: [UHS 2022]

- (A) Electric and magnetic fields
- (B) Coil of springs
- (C) Ropes
- (D) Water

Q61.

UHS 2022

Reducing mass M of a suspending body to one fourth will change the frequency of oscillations be: [UHS 2022]

- (A) One fourth
- (B) Double
- (C) Quadrupled
- (D) Half

Q62.

UHS 2022

A distance star is receding from Earth with a speed of $1.40 \times 10^7 \text{ ms}^{-1}$. It emits light of frequency $4.57 \times 10^{14} \text{ Hz}$. The speed of light is $3.0 \times 10^8 \text{ ms}^{-1}$. The Doppler effect formula can be used with light waves. What will be the frequency of this light when detected on Earth? [UHS 2022]

- (A) $2.04 \times 10^{13} \text{ Hz}$
- (B) $4.37 \times 10^{14} \text{ Hz}$
- (C) $4.57 \times 10^{14} \text{ Hz}$
- (D) $4.79 \times 10^{14} \text{ Hz}$

Q63.

DUHS 2022

The intensity level (sound level) of faintest audible intensity is: [DUHS 2022]

- (A) 160 decibel
- (B) 0 decibel
- (C) 140 decibel
- (D) 120 decibel

Q64.

DUHS 2022

A sound waves travels from one medium to another, which one of the following characteristics of sound remain unchanged? [DUHS 2022]

- (A) Amplitude
- (B) Velocity
- (C) Pitch
- (D) Quality

Q65.

DUHS 2022

Distance between two consecutive antinodes in standing wave is [DUHS 2022]

- (A) $\lambda/4$
- (B) λ
- (C) 2λ
- (D) $\lambda/2$

Q66.

DUHS 2022

If the given spring of spring constant K is cut into three identical segments the spring constant of each segment is: [DUHS 2022]

- (A) $1K$
- (B) $K/2$
- (C) $K/3$
- (D) $3K$

Q67.

DUHS 2022

The most appropriate mathematical expression representing simple harmonic motion is: [DUHS 2022]

- (A) $a \propto x$
- (B) $a \propto -x$
- (C) $a = x$
- (D) $a = kx$

Q68.

DUHS 2022

An object moving faster than the speed of sound. This object is called: [DUHS 2022]

- (A) Sonic
- (B) Supersonic
- (C) Hypersonic
- (D) Ultrasonic

Q69.

NUMS 2022

The horizontal distance travelled by wave during one complete cycle is called [NUMS 2022]

- (A) Frequency
- (B) Wavelength
- (C) Amplitude
- (D) Time period

Q70.

NUMS 2022

If the period of oscillation of mass (M) suspended from a spring is 1s, then the period of 16M will be: [NUMS 2022]

- (A) 1s
- (B) 2s
- (C) 3s
- (D) 4s

Q71.

NUMS 2022

Loudness of the sound is directly related to [NUMS 2022]

- (A) Intensity of sound
- (B) Frequency of sound
- (C) Wavelength of sound
- (D) Pitch of sound

Q72.

NUMS 2022

The increase in the speed of sound in air for each rise above 0°C is: [NUMS 2022]

- (A) 0.41 m/s
- (B) 0.51 m/s
- (C) 0.81 m/s
- (D) 0.61 m/s

Q73.

NUMS 2022

Crest of a wave acts as: [NUMS 2022]

- (A) Concave lens
- (B) Convex lens
- (C) Convex mirror
- (D) Plane mirror

Q74.

NUMS 2022

The speed of sound in air does not depend on: [NUMS 2022]

- (A) Density of medium
- (B) Pressure
- (C) Temperature
- (D) Plane mirror

Q75.

SZABMU 2022

Wavelength of wave is defined as: [SZABMU 2022]

- (A) Distance between two consecutive crests
- (B) Distance between two alternate crests
- (C) Distance between two alternate troughs
- (D) Distance between two crest and two troughs

Q76.

SZABMU 2022

Which of the following factor does not affect the speed of sound in air? [SZABMU 2022]

- (A) Pressure
- (B) Density
- (C) Temperature
- (D) Medium

Q77.

SZABMU 2022

Maximum displacement of particles from its mean position is called: [SZABMU 2022]

- (A) Frequency
- (B) Amplitude
- (C) Wavelength
- (D) Crest

Q78.

SZABMU 2022

The ultrasonic waves have frequency higher than: [SZABMU 2022]

- (A) 20 Hz
- (B) 20 kHz
- (C) 200 Hz
- (D) 2000 kHz

Q79.

SZABMU 2022

The increase in the speed of sound for each degree rise above 0°C is: [SZABMU 2022]

- (A) 0.61 ms^{-1}
- (B) 0.51 ms^{-1}
- (C) 0.41 ms^{-1}
- (D) 0.31 ms^{-1}

Q80.

SZABMU 2022

Continuous, regular and rhythmic disturbance in a medium resulting periodic vibration of a source causes ____ in the medium. [SZABMU 2022]

- (A) Complex waves
- (B) Stationary waves
- (C) Electromagnetic waves
- (D) Periodic waves

Q81.

KMU 2022

The energy of simple harmonic oscillator at a displacement "x" is partly kinetic and partly potential. The total energy of a simple harmonic oscillator remains constant everywhere. Which one of the following options will be correct about the simple harmonic oscillator? [ETEA 2022]

- (A) Kinetic energy is maximum at extreme position
- (B) Potential energy is maximum at extreme position
- (C) Both kinetic and potential energies are minimum at mean position
- (D) Potential energy is maximum at mean position

Q82.

KMU 2022

The speed of a wave on a particular string is 24 ms^{-1} . If the string is 6.0 m long, to what driving frequencies will it resonate? [ETEA 2022]

- (A) 1 Hz, 2 Hz, 3 Hz
- (B) 2 Hz, 4 Hz, 6 Hz
- (C) 3 Hz, 6 Hz, 9 Hz
- (D) 5 Hz, 10 Hz, 15 Hz

Q83.

KMU 2022

The apparent change in the frequency of sound caused by the relative motion of either the source of sound or listener or both is called: [ETEA 2022]

- (A) Compton effect
- (B) Zeeman effect
- (C) Stark effect
- (D) Doppler effect

Q84.

KMU 2022

The time period of a simple pendulum with mass m is T. When the pendulum's mass m is replaced by another ball of mass 3 times the older mass such that the length of pendulum is not changed then its new time period will be: [ETEA 2022]

- (A) T
- (B) 3T
- (C) T/3
- (D) 2T

Q85.

DUHS 2022

Two transverse travelling waves are presented by these equations:

$$y_1 = A_0 \sin(kx - \omega t)$$

$$y_2 = A_0 \sin(kx - \omega t - \phi)$$

These two waves differ in: [DUHS 2022]

- (A) Amplitude
- (B) Frequency
- (C) Wavelength
- (D) Phase

Q86.

PMDC 2021

Doppler's effect shows? [NMDCAT 2021]

- (A) Change in frequency due to relative motion between source and observers
- (B) Change in amplitude due to relative motion between source and observer
- (C) Change in frequency due to motion of source only
- (D) Change in frequency due to motion of observer only

Q87.

PMDC 2021

Distance Between two Consecutive node is [NMDCAT 2021]

- (A) Wave length
- (B) Wave length by 2
- (C) Wave length by 4
- (D) twice of Wave length

Q88.

PMDC 2021

Stationary waves [NMDCAT 2021]

- (A) Move forward
- (B) Move backwards
- (C) Don't Move
- (D) Move in both direction

Q89.

PMDC 2021

Crest and trough are found in? [NMDCAT 2021]

- (A) Transvers wave
- (B) Longitudinal wave
- (C) Progressive wave
- (D) None

Q90.

PMDC 2020

The speed of sound in air is 332 m/s. The speed of sound at 22°C will be: [NMDCAT 2020]

- (A) 345.2m/s
- (B) 340 m/s
- (C) 350m/s
- (D) 330 m/s

Q91.

PMDC 2020

Astronomers calculate speed of distant stars and galaxies using which of the following phenomena? [NMDCAT 2020]

- (A) Beats
- (B) Interference
- (C) Superposition principle
- (D) Doppler effect

Q92.

PMDC 2020

In a ripple tank, 40 waves pass through a certain point in 1 second. If the wavelength of the wave is 5cm. then speed of the wave is: [NMDCAT 2020]

- (A) 0.5 ms^{-1}
- (B) 1 ms^{-1}
- (C) 1.5 ms^{-1}
- (D) 2 ms^{-1}

Q93.

NUMS 2020

Trough of a wave acts as: [NUMS 2020]

- (A) Concave lens
- (B) Convex lens
- (C) Convex mirror
- (D) Plane mirror

Q94.

PMDC 2020

Ratio of fundamental frequency of Open Organ pipe to closed organ pipe is [NMDCAT 2020]

- (A) 1:2
- (B) 2:1
- (C) 1:4
- (D) 4:1

Q95.

PMDC 2020

A whistler with velocity 33 ms^{-1} approaches towards a stationary observer with frequency 450Hz what is the apparent frequency heard by the observer: [NMDCAT 2020]

- (A) 500
- (B) 400
- (C) 430
- (D) 450

Q96.

PMDC 2020

Ripple tank is used to study features of [NMDCAT 2020]

- (A) Particle
- (B) Wave
- (C) Light
- (D) Solid

Q97.

PMDC 2020

Waves which deal with fast moving elementary particle [NMDCAT 2020]

- (A) Transverse Waves
- (B) Longitudinal waves
- (C) Matter waves
- (D) Periodic waves

Q98.

PMDC 2020

Infrasonic wave has frequency [NMDCAT 2020]

- (A) Less than 20Hz
- (B) Greater than 20Hz
- (C) 20Hz
- (D) Greater than 20 kHz

Q99.

MDCAT 2019

The wavelength of the electromagnetic wave having frequency of 3 kHz will be? [MDCAT 2019]

- (A) 80 km
- (B) 100 km
- (C) 140 km
- (D) 120 km

Q100.

MDCAT 2019

What will be the expression for the observed frequency, if the source is moving towards the observer? [MDCAT 2019]

- (A) $f_o = \left(\frac{v}{v - u_s} \right) f$
 (B) $f_o = \left(\frac{v}{v + u_s} \right) f$
 (C) $f_o = \left(\frac{v}{v + u_o} \right) f$
 (D) $f_o = \left(\frac{v}{v - u_o} \right) f$

Q101.

MDCAT 2018

A shock wave is produced due to an earthquake which makes the building move in the direction of the shock wave. Which progressive wave would this be? [MDCAT 2018]

- (A) Longitudinal wave
 (B) Material wave
 (C) Transverse wave
 (D) Particle wave

Q102.

KMU 2018

Which one of the following varies when an object execute simple harmonic motion? [ETEA 2018]

- (A) Angular frequency
 (B) Total energy
 (C) Force
 (D) Amplitude

Q103.

KMU 2018

Which one of the following is not a characteristic of stationary wave? [ETEA 2018]

- (A) Half wavelength is the distance between the adjacent nodes
 (B) Amplitude is not the same
 (C) Phase is identical between two adjacent nodes
 (D) Energy of the stationary waves travels outwards

Q104.

MDCAT 2017

If a wave travelling at a speed of 130 m/s and has a wavelength of 5m. Then find out the frequency of the wave? [MDCAT 2017]

- (A) 650 Hz
 (B) 3.8×10^2 Hz
 (C) 20 Hz
 (D) 26 Hz

Q105.

MDCAT 2017

A metallic wire of 2m length hooked between two points has tension of 10N. If mass per unit length of wire is 0.004 kg/s then fundamental frequency emitted by wire on vibration is: [MDCAT 2017]

- (A) 12.5 Hz
 (B) 24 Hz
 (C) 48 Hz
 (D) 6.25 Hz

Q106.

MDCAT 2017

A source of sound moves towards a stationary observer with speed one third speed of sound. If the frequency of the sound from the source is 100 Hz, the apparent frequency of the sound heard by the observer is: [MDCAT 2017]

- (A) 60 Hz
 (B) 200 Hz
 (C) 100 Hz
 (D) 150 Hz

Q107.

KMU 2017

In a stationary wave the distance between consecutive antinodes is 25 cm. If the wave velocity is 300 ms^{-1} then the frequency of the wave will be: [ETEA 2017]

- (A) 150 Hz
 (B) 300 Hz
 (C) 600 Hz
 (D) 750 Hz

Q108.

KMU 2017

The speed of sound in air at NTP is 300m/s. If the air pressure become 4 times then the speed of the sound will be [ETEA 2017]

- (A) 150m/s
 (B) 300m/s
 (C) 600m/s
 (D) None

Q109.

KMU 2017

Standing waves are produced in 10m long stretched string. If the string vibrates in 5 segments and wave velocity is 20 ms^{-1} . Its frequency is: [ETEA 2017]

- (A) 2 Hz
 (B) 4 Hz
 (C) 5 Hz
 (D) 10 Hz

Q110.

MDCAT 2016

The red shift measurement of Doppler effect of galaxies indicate that the universe is [MDCAT 2016]

- (A) Expanding
- (B) Stationary
- (C) Contracting
- (D) Oscillating

Q111.

KMU 2016

In stationary wave [ETEA 2016]

- (A) There is not transfer of energy
- (B) Energy is constant at all points
- (C) Phase is the same for all points
- (D) Both 'A' & 'B'

Q112.

MDCAT 2015

An observer moves with velocity ' u_o ' toward a stationary source, then the number waves received in one second is [MCAT 2015]

- (A) $f' = f \left(\frac{v}{v+u_o} \right)$
- (B) $f' = f \left(\frac{v+u_o}{v} \right)$
- (C) $f' = f \left(\frac{v}{v-u_o} \right)$
- (D) $f' = f \left(\frac{v-u_o}{v} \right)$

Q113.

KMU 2015

The ratio between the velocity of sound in air at 4 atm and that at 3 atm pressure would be: [ETEA 2015]

- (A) 1:1
- (B) 4:1
- (C) 1:4
- (D) 3:1

Q114.

KMU 2014

The displacement ' x ' of a particle at time ' t ' is given by $x = 10 \sin 4t$ the particle oscillates with period. [ETEA 2014]

- (A) $\pi/10s$
- (B) $\pi/5s$
- (C) $\pi/4s$
- (D) $\pi/2s$

Q115.

KMU 2014

In a vibrating cord the point where the particles are stationary is called [ETEA 2014]

- (A) Crest
- (B) Anti-node
- (C) Node
- (D) Trough

Q116.

MDCAT 2012

When the source of sound moves towards the stationary observer, the value of apparent frequency ' f_o ' is: [MCAT 2012]

- (A) $f_o = \left(\frac{v+u}{v} \right) f$
- (B) $f_o = \left(\frac{v}{v+u_s} \right) f$
- (C) $f_o = \left(\frac{v}{v-u} \right) f$
- (D) $f_o = \left(\frac{v-u}{v} \right) f$

Q117.

MDCAT 2011

The spectrum of a star's light is measured and the wavelength of one of the lines as the sodium's line is found to be 589 nm. The same line has the wavelength of 497 nm when observed in the laboratory. This means the star is [MCAT 2011]

- (A) Moving away from the earth
- (B) Stationary
- (C) Moving towards the north
- (D) Revolving around the planet

Q118.

MDCAT 2010

An organ pipe closed at one end has a length of 25 cm. Wavelength of the fundamental note is [MCAT 2010]

- (A) 25 cm
- (B) 100 cm
- (C) 50 cm
- (D) 75 cm

Q119.

MDCAT 2010

Two waves of same amplitude are traveling in the same direction and are out of phase, their resultant wave is: [MCAT 2010]

- (A) Zero
- (B) Equal to sum of their amplitudes
- (C) Equal to difference of their amplitudes
- (D) Equal to half of their amplitude

Q120.

MDCAT 2009

Speed of the waves is equal to: [MCAT 2009]

- (A) $f\lambda$
- (B) λ/T
- (C) Both A and B
- (D) λT

Q121.

MDCAT 2009

What is it that we use to calculate the speeds of distant stars and galaxies? [MCAT 2009]

- (A) Doppler Effect
- (B) Beats
- (C) Interference
- (D) All of the above

Q122.

MDCAT 2009

Speed of light, radio waves and microwaves in vacuum is: [MCAT 2009]

- (A) $3 \times 10^5 \text{ ms}^{-1}$
- (B) $3 \times 10^6 \text{ ms}^{-1}$
- (C) $3 \times 10^3 \text{ ms}^{-1}$
- (D) $3 \times 10^8 \text{ ms}^{-1}$

Q123.

MDCAT 2008

A standing wave pattern is formed when the length of string is an integral multiple of ____ wavelength.

[MCAT 2008]

- (A) Triple
- (B) Half
- (C) Full
- (D) Double

Q124.

MDCAT 2008

Transverse waves cannot be setup in _____. [MCAT 2008]

- (A) Metals
- (B) Fluids
- (C) Solids
- (D) Soil

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 05. Waves.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	C	SZABMU 2024	26	B	BUMHS 2024	51	D	NUMS 2023	76	A	SZABMU 2022	101	A	MDCAT 2018
2	A	SZABMU 2024	27	B	UHS 2023	52	B	NUMS 2023	77	B	SZABMU 2022	102	C	KMU 2018
3	D	SZABMU 2024	28	B	UHS 2023	53	C	NUMS 2023	78	B	SZABMU 2022	103	D	KMU 2018
4	B	SZABMU 2024	29	A	UHS 2023	54	B	UHS 2022	79	A	SZABMU 2022	104	D	MDCAT 2017
5	B	SZABMU 2024	30	D	UHS 2023	55	D	UHS 2022	80	D	SZABMU 2022	105	A	MDCAT 2017
6	D	SZABMU 2024	31	A	SZABMU 2023	56	A	UHS 2022	81	B	KMU 2022	106	D	MDCAT 2017
7	C	SZABMU 2024	32	B	SZABMU 2023	57	B	UHS 2022	82	B	KMU 2022	107	C	KMU 2017
8	B	KU 2024	33	B	SZABMU 2023	58	C	BUMHS 2022	83	D	KMU 2022	108	B	KMU 2017
9	D	KU 2024	34	D	SZABMU 2023	59	A	UHS 2022	84	A	KMU 2022	109	C	KMU 2017
10	C	KU 2024	35	B	SZABMU 2023	60	A	UHS 2022	85	D	DUHS 2022	110	A	MDCAT 2016
11	D	KU 2024	36	B	KMU 2023	61	B	UHS 2022	86	A	PMDC 2021	111	A	KMU 2016
12	C	KU 2024	37	C	KMU 2023	62	B	UHS 2022	87	B	PMDC 2021	112	B	MDCAT 2015
13	C	KU 2024	38	D	KMU 2023	63	B	DUHS 2022	88	C	PMDC 2021	113	A	KMU 2015
14	B	KU 2024	39	D	KMU 2023	64	C	DUHS 2022	89	A	PMDC 2021	114	D	KMU 2014
15	D	UHS 2024	40	D	KMU 2023	65	D	DUHS 2022	90	A	PMDC 2020	115	C	KMU 2014
16	D	UHS 2024	41	B	KMU 2023	66	D	DUHS 2022	91	D	PMDC 2020	116	C	MDCAT 2012
17	B	UHS 2024	42	C	KMU 2023	67	B	DUHS 2022	92	D	PMDC 2020	117	A	MDCAT 2011
18	C	UHS 2024	43	D	DUHS 2023	68	B	DUHS 2022	93	A	NUMS 2020	118	B	MDCAT 2010
19	C	UHS 2024	44	D	DUHS 2023	69	B	NUMS 2022	94	B	PMDC 2020	119	A	MDCAT 2010
20	D	NUMS 2024	45	C	DUHS 2023	70	D	NUMS 2022	95	A	PMDC 2020	120	C	MDCAT 2009
21	A	NUMS 2024	46	B	DUHS 2023	71	A	NUMS 2022	96	B	PMDC 2020	121	A	MDCAT 2009
22	A	BUMHS 2024	47	A	DUHS 2023	72	D	NUMS 2022	97	C	PMDC 2020	122	D	MDCAT 2009
23	B	BUMHS 2024	48	C	DUHS 2023	73	B	NUMS 2022	98	A	PMDC 2020	123	B	MDCAT 2008
24	D	BUMHS 2024	49	C	DUHS 2023	74	B	NUMS 2022	99	B	MDCAT 2019	124	B	MDCAT 2008
25	A	BUMHS 2024	50	C	NUMS 2023	75	A	SZABMU 2022	100	A	MDCAT 2019			

TOTAL
MCQS

124

CORRECT

INCORRECT

BLANK

ACCURACY

%

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BeambePrep Grind Mode for automated error
autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (C)

SZABMU 2024

By increasing the temperature of medium about [Formula], the speed of sound is increased up to [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Temperature directly increases the kinetic activity of gas molecules, allowing sound pressure waves to transmit faster.

Formula:

$$v_t \approx v_0 + 0.61t$$

Solution:

- The empirical and theoretically derived formula shows a linear dependency near standard room temperatures.
- The constant coefficient reveals that for every single degree Celsius (1°C) rise in temperature, the speed of sound in air increases by exactly 0.61 m/s.

Why other options are incorrect:

Options A, B, and D provide completely incorrect mathematical constants for standard air mixtures.

Question #2 Key: (A)

SZABMU 2024

What will be the fundamental frequency in a stretched string, when its is plucked at central point while it ha...

CORE CONCEPT AND DERIVATION

Plucking a string exactly at its center forces the center to become an antinode, establishing the most basic, single-loop standing wave: the fundamental mode.

Formula:

$$f_1 = \frac{v}{2L}$$

Solution:

- We are given the wave speed $v = 48 \text{ m/s}$ and the string length $L = 8 \text{ m}$.
- Substitute these into the fundamental frequency formula:
- $f_1 = \frac{48}{2 \times 8}$.
- $f_1 = \frac{48}{16}$.
- $f_1 = 3 \text{ Hz}$.

Why other options are incorrect:

If a student assumes wavelength equals length (forgetting the factor of 2), they calculate 6 Hz (Option B). 12 Hz would require dividing 48 by 4.

Question #3 Key: (D)

SZABMU 2024

How much phase difference is required between two waves to form destructive interference? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Interference is dictated by the precise alignment of superimposing waves, measured by their phase difference.

Solution:

- **Constructive interference** happens when crests perfectly align with crests (in-phase, or 0° difference).
- **Destructive interference** requires maximum cancellation. This happens only when the crest of wave A perfectly aligns with the trough of wave B.
- To shift a wave so its crest becomes a trough, it must be shifted by half a cycle.
- Half of a full cycle (360°) is exactly 180° (or π radians).

Why other options are incorrect:

0° causes pure constructive interference. 90° or 45° cause complex partial interference, but not complete destructive cancellation.

Question #4 Key: (B)

SZABMU 2024

What will be the time period of wave generator if it produces 1000 waves in 10 seconds? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Time period (T) is the time required to generate exactly one complete wave. It is the reciprocal of frequency (f).

Formula:

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

Solution:

- Alternatively, calculate time period directly: $T = \frac{\text{Total Time}}{\text{Number of Waves}}$
- Substitute the given values: $T = \frac{10 \text{ seconds}}{1000 \text{ waves}}$
- $T = \frac{1}{100} = 0.01 \text{ s.}$

Why other options are incorrect:

Option A comes from dividing 1 by 1000, ignoring the 10-second duration. Option D assumes only 100 waves were generated.

Question #5 Key: (B)

SZABMU 2024

Which one of the following is an example of transverse waves? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Waves are primarily classified by comparing the medium's oscillation direction to the wave's travel direction.

Solution:

- In **transverse waves**, particles vibrate perpendicularly (up and down) to the energy's forward motion. **Water surface waves** (macroscopically) are the classic mechanical example of this.
- In longitudinal waves, particles vibrate parallel (back and forth) to the motion. Sound waves and compressed springs are strictly longitudinal.

Why other options are incorrect:

Sound (Option A) and spring waves (Option D) are classic longitudinal examples. Electron matter waves (Option C) are quantum probability waves, not simple mechanical transverse waves.

Question #6 Key: (D)

SZABMU 2024

Under which condition Newton performed experiment for calculation of speed of sound in air? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

The mathematical derivation for the speed of sound heavily depends on thermodynamic assumptions regarding heat exchange during wave compressions.

Solution:

- Sir Isaac Newton theoretically assumed that when sound waves compress and rarefy the air, heat has enough time to perfectly flow and balance out.
- Therefore, he falsely concluded that sound propagation is an **isothermal** (constant temperature) process.
- His resulting calculated speed (280 m/s) was about 16% lower than the actual speed. Pierre-Simon Laplace later corrected this by proving the rapid compressions are actually **adiabatic** (no heat exchange), yielding the correct speed.

Why other options are incorrect:

Adiabatic (Option A) is the actual, physically correct condition discovered by Laplace, not the flawed condition originally assumed by Newton.

Question #7 Key: (C)

SZABMU 2024

There is no net transfer of energy by particles of medium in _____. [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Waves are characterized by whether they transport energy across physical distances.

Solution:

- A progressive (or traveling) wave continuously carries energy outward from a source.
- A **stationary (standing) wave** is created when two identical waves traveling in opposite directions overlap. Their opposing energy flows perfectly cancel each other out macroscopically.
- Consequently, the energy is trapped, oscillating purely between potential and kinetic forms within discrete loops. There is zero net transfer of energy across any node.

Why other options are incorrect:

Longitudinal, transverse, and progressive waves all actively transport energy from point A to point B.

Question #8 Key: (B)

KU 2024

What happens when two waves of the same frequency and amplitude meet in phase? [KU 2024]

CORE CONCEPT AND DERIVATION

The Principle of Superposition governs how wave displacements interact when occupying the same space.

Solution:

- When waves meet "in phase," it means their crests arrive at the exact same point simultaneously (as do their troughs).
- According to superposition, their individual displacements algebraically add up.
- Since they have identical amplitudes (A), the crests merge to create a super-crest of amplitude $A + A = 2A$.
- This profound amplification is formally called **constructive interference**.

Why other options are incorrect:

Option A describes waves meeting entirely out-of-phase (destructive interference). Options C and D contain internal contradictions (zero amplitude cannot be constructive).

Question #9 Key: (D)

KU 2024

Which type of waves can be polarized? [KU 2024]

CORE CONCEPT AND DERIVATION

Polarization is the phenomenon wherein a wave's oscillations are physically restricted to a single defined plane.

Solution:

- **Transverse waves** (like light or ripples) possess oscillations perpendicular to their direction of travel. Because there are infinite 360-degree perpendicular angles, a filter can be applied to "polarize" or isolate just one specific angle/plane.
- Longitudinal waves (like sound) oscillate parallel to their travel path. Because there is only one geometric dimension parallel to a line, they cannot be filtered into different planes. They are inherently un-polarizable.

Why other options are incorrect:

Sound (Option C) and longitudinal waves (Option A) are strictly un-polarizable. Mechanical waves (Option B) is too broad, as it includes both polarizable (water) and un-polarizable (sound) waves.

Question #10 Key: (C)

KU 2024

For longitudinal waves _____. [KU 2024]

CORE CONCEPT AND DERIVATION

Waves are fundamentally classified by the geometric relationship between the disturbance and the energy flow.

Solution:

- The prefix "long-" relates to length. In a **longitudinal wave**, the physical particles of the medium undergo compression and rarefaction by moving back and forth.
- This back-and-forth movement is exactly parallel to (or **along**) the direction the wave energy is propagating.

Why other options are incorrect:

Option A precisely describes transverse waves. Option B is impossible (waves require medium disturbance). Option D is false, as mechanical longitudinal waves cannot exist in a pure vacuum because there are no particles to oscillate.

Question #11 Key: (D)

KU 2024

According to the principle of superimposition, when 2 or more waves overlap at a point in space, the amplitude...

CORE CONCEPT AND DERIVATION

The Principle of Superposition is the fundamental law governing interference in linear wave systems.

Solution:

- When two or more physical waves travel through the exact same medium simultaneously, they do not destroy or bounce off each other.
- Instead, at the exact point where they overlap, the momentary displacement of the medium is determined simply by algebraically adding the displacements of the individual waves.
- Therefore, the resultant amplitude is the mathematical **sum of the amplitudes** of the individual wave components at that specific instant in time.

Why other options are incorrect:

Waves sum up; they do not multiply (Option B/C). The resultant is only zero (Option A) during perfect destructive interference, not "always".

Question #12 Key: (C)

KU 2024

The speed of sound in a medium containing ideal gas is NOT dependent on [KU 2024]

CORE CONCEPT AND DERIVATION

The velocity of sound in gases depends on internal restorative and inertial forces.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to the ideal gas law, pressure (P) and density (ρ) are directly proportional as long as the temperature is stable.
- If atmospheric pressure drops (like at a higher altitude), the air density drops by the exact same proportional factor.
- Because both variables shift identically, the ratio of P/ρ remains completely mathematically constant.
- Thus, ambient **pressure** alone has absolutely zero effect on the speed of sound.

Why other options are incorrect:

Speed is heavily dependent on Density (lighter gases transmit faster), Temperature (hotter gases transmit faster), and Moisture (humid air is less dense, increasing speed).

Question #13 Key: (C)

KU 2024

A tuning fork having frequency equal to 440 Hz produces sound waves which travel with the speed of 340 m/s. Wh...

CORE CONCEPT AND DERIVATION

A full longitudinal wave cycle consists of one compression and one rarefaction. Therefore, the distance between the center of a compression and the center of the very next rarefaction is exactly half a wavelength ($\lambda/2$).

Formula:

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

Solution:

- Note: The question says "angular frequency" but provides the unit Hz, which signifies standard linear frequency (f). We will proceed using $f = 440$ Hz.
- First, find the full wavelength: $\lambda = \frac{340 \text{ m/s}}{440 \text{ Hz}} = \frac{34}{44} \approx 0.7727 \text{ m}$.
- The question asks for the separation between a compression and an adjacent rarefaction, which is $\frac{\lambda}{2}$.
- $\frac{\lambda}{2} = \frac{0.7727}{2} \approx 0.386 \text{ m}$.
-

Why other options are incorrect:

Mathematical errors in division yield the other decimal numbers. The accepted answer is fundamentally derived from the full wavelength calculation.

Question #14 Key: (B)

KU 2024

A police car, with its siren on, is moving towards a stationary listener. How does the stationary listener rec...

CORE CONCEPT AND DERIVATION

The Doppler Effect states that relative motion alters the perceived frequency of a wave.

Solution:

- As the police car (source) moves rapidly **towards** the listener, it "chases" the sound waves it just emitted.
- This forward motion physically squashes the wave fronts together in the space ahead of the car, shortening the spatial wavelength (λ).
- Because wave speed in air remains constant ($v = f\lambda$), a shorter apparent wavelength forces the listener's ear to register a higher number of wave impacts per second.
- Therefore, the perceived frequency (pitch) strictly **increases**.

Why other options are incorrect:

Frequency would only decrease if the car were driving away (receding). It stays the same only if the car is parked.

Question #15 Key: (D)

UHS 2024

Amplitude in the following figure is given as: [UHS 2024] Mean Position ($y = 0$) 2 m Crest Trough Transverse Wa...

CORE CONCEPT AND DERIVATION

Amplitude is a fundamental spatial parameter of a periodic wave, defined as the maximum displacement of any point on the wave from its equilibrium (mean) position.

Formula / Rule / Reaction:

$$\text{Amplitude (A)} = \frac{\text{Peak-to-Trough Vertical Height}}{2}$$

Solution:

- By definition, **amplitude** is measured from the central resting equilibrium line ($y = 0$) up to the peak of a crest or down to the bottom of a trough.
- In the given wave diagram, the total vertical distance from the bottom of the trough to the peak of the crest is 2 m.
- Because the equilibrium line divides this peak-to-trough height equally in two:

$$A = \frac{2 \text{ m}}{2} = 1 \text{ m}$$

Why other options are incorrect:

- Option A (2 m):** This is the total peak-to-trough vertical span (total height), which is twice the true amplitude. Confusing peak-to-trough height with amplitude is a classic exam trap.
- Option B (1/2 m) & Option C ($\frac{\sqrt{3}}{2}$ m):** Incorrect numerical values that do not correspond to half the measured vertical distance.

Question #16 Key: (D)

UHS 2024

Which one of the following is INCORRECT about the nodes when the string is plucked: [UHS 2024]

CORE CONCEPT AND DERIVATION

Nodes are fundamental structural components of stationary (standing) waves.

Solution:

- Let's evaluate the truth of each statement regarding nodes.
- A: True. Nodes are points of perfect destructive interference, so their displacement/amplitude is zero.
- B: True. By definition of a stationary wave, the nodal points are locked in place and do not travel.
- C: True. Fixed boundaries strictly constrain movement, guaranteeing a node forms there.
- D: **False**. A full wavelength encompasses two wave loops. Therefore, the distance between two consecutive nodes (one loop) is exactly half a wavelength ($\lambda/2$), not 1 full wavelength.

Why other options are incorrect:

Options A, B, and C are all scientifically correct descriptions of nodes, meaning they fail the "INCORRECT" criterion of the question.

Question #17 Key: (B)

UHS 2024

In transverse waves the portion above the mean level is called: [UHS 2024]

CORE CONCEPT AND DERIVATION

Transverse waves move particles vertically relative to the wave's horizontal propagation path.

Solution:

- The undisturbed, central horizontal axis is called the equilibrium or "mean level".
- When the wave energy forces particles upwards to their maximum positive displacement, that entire elevated region is formally termed the **Wave crest**.

Why other options are incorrect:

The portion pushed downwards below the mean level is the trough. Wavelength is the horizontal distance between two crests. Wave front describes 2D/3D propagation lines.

Question #18 Key: (C)

UHS 2024

Which one of the following does not cause stationary waves? [UHS 2024]

CORE CONCEPT AND DERIVATION

Stationary (standing) waves require a very strict set of physical conditions to form perfectly stable nodes.

Solution:

- A perfect standing wave requires two interfering waves to have the exact same frequency, exact same speed, and exact same amplitude, while traveling strictly in opposite directions.
- If the two waves have **unequal amplitudes**, the destructive interference at the nodes will be incomplete. The waves won't perfectly cancel each other out to zero.
- Instead of a pure stationary wave, you get a hybrid traveling wave with a superimposed fluctuating envelope. Therefore, unequal amplitudes fail to produce a true stationary wave.

Why other options are incorrect:

Options A, B, and D are absolute mandatory requirements for generating a stationary wave, making them the causes rather than the exception.

Question #19 Key: (C)

UHS 2024

The distance between two successive particles which are exactly in the same state of vibration is called: [UHS...]

CORE CONCEPT AND DERIVATION

Wave geometry is defined by repeating patterns of identical phase.

Solution:

- When two particles are "exactly in the same state of vibration," it means they have the exact same vertical displacement and are moving in the exact same direction (they are fully "in phase").
- Examples include two adjacent crests or two adjacent troughs.
- The shortest physical, horizontal distance connecting these two identical successive points is the textbook definition of **Wavelength** (λ).

Why other options are incorrect:

Frequency (cycles per second) and Time Period (seconds per cycle) are measurements of time, not physical distance. Amplitude is vertical displacement.

Question #20 Key: (D)

NUMS 2024

A body of mass 10 kg is connected to a spring and it is oscillating on a horizontal frictionless surface. If t...

CORE CONCEPT AND DERIVATION

In Simple Harmonic Motion, maximum acceleration occurs at the points of maximum displacement (the amplitude), where the restoring force is strongest.

Formula:

$$F = ma$$

$$F = kx$$

$$a = \frac{kx}{m}$$

Solution:

- We are given: Mass $m = 10$ kg, Spring constant $k = 20$ N/m.
- The maximum displacement (amplitude) is given in centimeters. Convert it to standard SI units (meters): $x = 20$ cm = 0.2 m.
- Plug the values into the acceleration formula:
- $a = \frac{20 \times 0.2}{10}$.
- $a = \frac{4}{10} = 0.4$ m s⁻¹.

Why other options are incorrect:

Option B (4) happens if a student forgets to divide by the mass (10 kg). Option A and C result from not converting centimeters to meters.

Question #21 Key: (A)

NUMS 2024

A normal person can hear sound waves ranging in frequency from 20 Hz to 20 K Hz. The maximum wavelength is: [N...

CORE CONCEPT AND DERIVATION

Wavelength is inversely proportional to frequency. Therefore, the lowest frequency sound will mathematically yield the longest (maximum) wavelength.

Formula:

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

Solution:

- To find the maximum wavelength, we must use the minimum audible frequency, which is $f = 20$ Hz.
- Assume the standard speed of sound in room-temperature air is roughly $v \approx 340$ m/s.
- Substitute the values: $\lambda_{max} = \frac{340}{20}$.
- $\lambda_{max} = 17$ m.

Why other options are incorrect:

Options B (17 mm) and C (17 cm) correspond to the high-frequency limit (20,000 Hz), which yields the minimum, not maximum, wavelength. 17 km is completely out of scale.

Question #22 Key: (A)

BUMHS 2024

Sounds wave are not polarized in air because: [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Polarization is a geometric filtering process that is strictly impossible for certain types of waves.

Solution:

- Polarization involves restricting a wave's perpendicular vibrations to a single plane (like sliding a vibrating rope through a narrow vertical fence slit).
- Sound waves in air are **longitudinal waves**. This means their particles vibrate purely back-and-forth along the exact same straight line as the wave's forward motion.
- Because all the motion is already locked onto a single 1-dimensional axis, there are no perpendicular "planes" left to filter out. Thus, longitudinal waves can never be polarized.

Why other options are incorrect:

Transverse waves (Option B) are the only waves that can be polarized. The need for a medium (Option C) or wavelength size (Option D) has no bearing on geometric polarization.

Question #23 Key: (B)

BUMHS 2024

Distance between consecutive crest and trough of water waves is? [BUMHS 2024]

CORE CONCEPT AND DERIVATION

A wave's structural geometry divides neatly into fractions of a total wavelength.

Solution:

- One complete wavelength (λ) is the full distance from one crest to the very next crest.
- Because standard waves are symmetrical, a trough sits exactly halfway between two consecutive crests.
- Therefore, the horizontal distance from the peak of a crest to the deepest point of the immediately adjacent trough is exactly half of a full wavelength: $\lambda/2$.

Why other options are incorrect:

λ is the distance from crest to crest. $\lambda/4$ is the horizontal distance from a crest to the zero-crossing equilibrium line.

Question #24 Key: (D)

BUMHS 2024

Which of the following set of frequencies can have constructive interference? [BUMHS 2024]

CORE CONCEPT AND DERIVATION

For two wave sources to produce a stable, sustained, and meaningful interference pattern (either perfectly constructive or perfectly destructive in space), they must be coherent.

Solution:

- Coherence strictly requires the two interacting waves to have the exact **same frequency** and a constant phase difference.
- If waves have different frequencies, they will constantly drift in and out of phase. They will alternately undergo moments of constructive and destructive interference (creating a phenomenon known as "beats").
- Because none of the options provide a pair of identical frequencies (e.g., 20 Hz and 20 Hz), none of them can form a stable, spatial pattern of pure constructive interference. Hence, **None of these** is the correct scientific conclusion.

Why other options are incorrect:

Options A, B, and C all present mismatched frequency pairs. These pairs will produce beats (throbbing amplitude over time) rather than a fixed spatial interference pattern.

Question #25 Key: (A)

BUMHS 2024

Compression is that portion of the longitudinal wave where pressure is: [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Longitudinal sound waves propagate through air by creating physical fluctuations in the density of gas molecules.

Solution:

- As the wave pushes forward, it forcibly crowds the gas molecules tightly together. This specific region is called a **compression**.
- Because a larger number of molecules are crammed into a smaller physical volume, the macroscopic gas density and localized air **pressure** in this zone become notably **High** (above atmospheric baseline).
- Conversely, the stretched-out regions that follow (rarefactions) experience unusually low pressure.

Why other options are incorrect:

Low pressure defines a rarefaction (Option B). Zero absolute pressure would mean a complete vacuum.

Question #26 Key: (B)

BUMHS 2024

The potential energy due to gravitational field near the surface of the Earth at a height h is given by [BUMHS...]

CORE CONCEPT AND DERIVATION

Gravitational Potential Energy (GPE) is the energy an object possesses due to its vertical position within a gravitational field.

Formula:

$$W = Fd \implies GPE = mgh$$

Solution:

- Near the Earth's surface, the force of gravity pulling down on an object is its weight: $F = mg$ (mass $\times$ gravitational acceleration).
- The work done against gravity to lift this mass to a vertical height (h) is stored entirely as potential energy.
- Since Work = Force $\times$ Distance, the equation directly translates to $GPE = (mg) \times (h) = mgh$.

Why other options are incorrect:

Options A, C, and D are dimensionally incorrect physics formulas that misplace variables as divisors rather than multipliers.

Question #27 Key: (B)

UHS 2023

An observer standing near the sea shore observes 54 waves per minute. If the wavelength of the water wave is 1...

CORE CONCEPT AND DERIVATION

Wave speed is the product of frequency (in standard Hz, or cycles per second) and wavelength.

Formula:

$$v = f\lambda$$

Solution:

- First, convert the wave rate from "per minute" to standard frequency (Hz):
 $f = \frac{54 \text{ waves}}{60 \text{ seconds}} = 0.9 \text{ Hz}.$
- The wavelength is given as $\lambda = 10 \text{ m}.$
- Calculate the velocity: $v = 0.9 \times 10 = 9 \text{ m/s}.$

Why other options are incorrect:

Option A (540) comes from wrongly multiplying 54 directly by 10 without converting minutes to seconds. Option C (5.4) comes from dividing 54 by 10.

Question #28 Key: (B)

UHS 2023

If the length of second pendulum becomes four times, then its time period will become: [UHS 2023]

CORE CONCEPT AND DERIVATION

The time period of a simple pendulum is directly proportional to the square root of its length.

Formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Solution:

- The original time period $T \propto \sqrt{L}$.
- If the new length $L_{\text{new}} = 4L$, substitute it into the relation:
 $T_{\text{new}} \propto \sqrt{4L}$.
- Extract the constant: $\sqrt{4L} = 2\sqrt{L}$.
- Therefore, the new time period is exactly **two times** the original ($T_{\text{new}} = 2T$).

Why other options are incorrect:

Option A (four times) incorrectly assumes the period scales linearly with length. Option C (half) occurs if one mistakenly divides by the square root.

Question #29 Key: (A)

UHS 2023

When a wave goes from one medium to another, there is a no change in the: [UHS 2023]

CORE CONCEPT AND DERIVATION

A wave's properties are split between source-dependent factors and medium-dependent factors.

Solution:

- **Frequency** is exclusively determined by the original source creating the oscillation. The number of cycles pushing against the boundary per second must equal the number of cycles propagating away into the new medium. Therefore, frequency never changes.
- Velocity changes because different media have different restoring forces (elasticity/density).
- Wavelength must change proportionally ($\lambda = v/f$) to accommodate the new velocity while keeping frequency constant.

Why other options are incorrect:

Wavelength and velocity adapt to the new medium. Amplitude decreases due to some energy reflecting off the boundary.

Question #30 Key: (D)

UHS 2023

Wave trough refers to the: [UHS 2023]

CORE CONCEPT AND DERIVATION

Transverse waves possess defining geometric characteristics representing maximum displacements.

Solution:

- As particles oscillate perpendicular to the wave direction, they reach positive and negative extremes.
- The **crest** is the maximum positive displacement (highest point).
- The **trough** is the maximum negative displacement, representing the **lowest point** of the wave profile.

Why other options are incorrect:

Option C describes a crest. Options A and B represent scalar wave properties, not physical locations on the wave geometry.

Question #31 Key: (A)

SZABMU 2023

A wave generator produces 500 pulses in 50s. its frequency will be: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Frequency is defined as the total number of repetitive cycles (or pulses) generated per unit of time.

Formula:

$$f = \frac{N}{t}$$

Solution:

- Given: Number of pulses $N = 500$ and total time $t = 50$ s.
- Substitute the values: $f = \frac{500}{50}$.
- $f = 10$ Hz.
- Note that Hertz (Hz) is dimensionally equivalent to inverse seconds (s^{-1}). Thus, the answer is 10 s^{-1} .

Why other options are incorrect:

Option B (0.1) is the Time Period ($50/500$), incorrectly inverted. Option C and D use raw numbers from the prompt without solving.

Question #32 Key: (B)

SZABMU 2023

The speed of sound in air is [Formula] at 0°C . what will be its value at 10°C . [SZABMU 2023]

CORE CONCEPT AND DERIVATION

The velocity of sound in a gas increases linearly with temperature over small ranges.

Formula:

$$v_t = v_0 + 0.61t$$

Solution:

- We know the speed at 0°C is $v_0 = 332$ m/s.
- The temperature rise is $t = 10^\circ\text{C}$.
- Calculate the increment: $0.61 \times 10 = 6.1$ m/s.
- Add this to the baseline speed: $v_{10} = 332 + 6.1 = 338.1 \text{ ms}^{-1}$.

Why other options are incorrect:

Option C assumes the increment is 0.61 total, ignoring the multiplier of 10 degrees. Option A assumes no change. Option D is mathematically arbitrary.

Question #33 Key: (B)

SZABMU 2023

The number of revolutions per second of a body is known as:
[SZABMU 2023]

CORE CONCEPT AND DERIVATION

Frequency measures how often an event repeats. Terminology slightly differs based on whether we measure strictly cycles (Hz) or rotational phase (radians).

Solution:

- Note: Strictly speaking, "revolutions per second" defines standard rotational/linear frequency (f , measured in Hz). Angular frequency (ω) is technically radians per second ($\omega = 2\pi f$).
- However, in many historical exam contexts, rotational "revolutions" are loosely grouped under the broader umbrella of **Angular frequency** to distinguish it from linear back-and-forth oscillations, or it is treated as a synonym for rotational speed (*extrpm/rps*). Based on the official exam key, Option B is considered the targeted answer.

Why other options are incorrect:

Time period is seconds per revolution. Amplitude is a spatial distance. Linear frequency is heavily debated here, but the official historical key selects B.

Question #34 Key: (D)

SZABMU 2023

Which of the following factors does not affect the speed of sound in air? [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Sound velocity depends on the elastic and inertial properties of the gas.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to Boyle's law, at a constant temperature, any increase in gas **pressure** (P) results in an exactly proportional increase in its density (ρ).
- Because both variables increase by the same factor, the ratio P/ρ remains perfectly constant.
- Therefore, changing the pressure has absolutely **no effect** on the speed of sound.

Why other options are incorrect:

Temperature dramatically alters speed. Moisture (humidity) lowers the average molecular mass of air, decreasing density and thus increasing sound speed.

Question #35 Key: (B)

SZABMU 2023

Time period of a vibrating body is independent of: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

In Simple Harmonic Motion (like a simple pendulum or an ideal spring), the oscillation timing is defined by system constants.

Formula:

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \text{or} \quad T = 2\pi\sqrt{\frac{m}{k}}$$

Solution:

- Notice that neither formula contains the variable for amplitude (maximum displacement).
- This remarkable property is called **isochronism**: whether the body swings slightly or a bit more widely, it takes the exact same amount of time to complete one full cycle.
- Therefore, the time period is independent of **Amplitude**.

Why other options are incorrect:

Time period is the exact mathematical inverse of frequency ($T = 1/f$), making it entirely dependent on it. It also clearly depends on 'g' for pendulums.

Question #36 Key: (B)

KMU 2023

A stretched string vibrates with frequency f , when tension in the string is t , for what value of tension, the ...

CORE CONCEPT AND DERIVATION

The frequency of a stretched string is determined by the wave speed, which in turn depends on the string's tension.

Formula:

$$f \propto \sqrt{T}$$

Solution:

- The original frequency is $f_1 \propto \sqrt{T}$.
- We want the new frequency f_2 to be exactly double: $f_2 = 2f_1$.
- To mathematically bring a factor of 2 outside the square root, the term inside must be multiplied by $2^2 = 4$.
- Therefore, $\sqrt{4T} = 2\sqrt{T}$.
- The new tension must be $4T$.

Why other options are incorrect:

If tension is $2T$, the frequency increases by $\sqrt{2} \approx 1.41$, not doubled. Tension of $16T$ would quadruple the frequency.

Question #37 Key: (C)

KMU 2023

The longitudinal waves travel more slowly in ____ than in _____. [ETEA 2023]

CORE CONCEPT AND DERIVATION

The speed of a longitudinal mechanical wave (like sound) depends on the elasticity and density of the medium.

Solution:

- In solids, atomic bonds are incredibly rigid (high bulk/shear modulus), allowing energy to transfer very rapidly.
- In gases, molecules are spread far apart and must physically travel through empty space to collide with neighbors, making energy transfer slow.
- Therefore, longitudinal waves travel fastest in solids, intermediate in liquids, and the slowest in gases.
- They travel more slowly in **Gases** than in **Solids**.

Why other options are incorrect:

Options A and B contradict the established hierarchy of wave speeds across states of matter.

Question #38 Key: (D)

KMU 2023

Sinusoidal water waves are generated in a large ripple tank. The water travels at 25 cm/s and their adjacent c...

CORE CONCEPT AND DERIVATION

The "time required for each new whole cycle" is the definition of the wave's Time Period (T).

Formula:

$$v = \frac{\lambda}{T} \implies T = \frac{\lambda}{v}$$

Solution:

- The distance between adjacent crests gives us the wavelength: $\lambda = 5.0$ cm.
- The velocity is given as $v = 25$ cm/s.
- Since both units are in centimeters, we don't need to convert to meters.
- Substitute values: $T = \frac{5.0}{25}$.
- $T = \frac{1}{5} = 0.2$ sec.

Why other options are incorrect:

Option B (4) is the frequency ($f = v/\lambda = 25/5 = 5$ Hz ... wait, $25/5 = 5$, so frequency is 5 Hz. $1/5 = 0.2$). Option A (100) comes from wrongly multiplying the terms instead of dividing.

Question #39 Key: (D)

KMU 2023

The distance between adjacent node and anti-node is equal to:
[ETEA 2023]

CORE CONCEPT AND DERIVATION

Standing waves alternate between points of zero movement (nodes) and points of maximum movement (antinodes).

Solution:

- A full wavelength (λ) contains two complete structural loops.
- The distance spanning a single complete loop (from node to consecutive node) is $\lambda/2$.
- An antinode is located at the exact physical center of a loop.
- Therefore, the distance from the edge of the loop (a node) to its center (an antinode) is half of $\lambda/2$, which equals $\lambda/4$.

Why other options are incorrect:

$\lambda/2$ represents the distance between two nodes or two antinodes. λ represents the length of two complete loops.

Question #40 Key: (D)

KMU 2023

A string clamped at its both ends, vibrates in four segments (loops). The length of string is 150 cm. The wave...

CORE CONCEPT AND DERIVATION

When a string clamped at both ends vibrates, it forms a standing wave composed of discrete segments (loops). Each individual segment corresponds to exactly half a wavelength.

Formula:

$$L = n \left(\frac{\lambda}{2} \right)$$

Solution:

- We are given the total length $L = 150$ cm and the number of loops $n = 4$.
- Set up the equation: $150 = 4 \left(\frac{\lambda}{2} \right)$.
- Simplify the right side: $150 = 2\lambda$.
- Solve for wavelength: $\lambda = \frac{150}{2} = 75$ cm.

Why other options are incorrect:

Option A (33.3 cm) occurs if one divides 150 by 4, incorrectly assuming one loop = one full wavelength. Option C assumes wavelength equals the string length.

Question #41 Key: (B)

KMU 2023

The square root of the ratio of elasticity to mass density is equal to: [ETEA 2023]

CORE CONCEPT AND DERIVATION

The generic formula for the velocity of any mechanical wave through a medium depends on its elastic and inertial properties.

Formula:

$$v = \sqrt{\frac{E}{\rho}} \quad \text{and} \quad v = f\lambda$$

Solution:

- The expression "square root of the ratio of elasticity (E) to mass density (ρ)" is precisely the formula for **Wave Velocity** (v).
- According to the universal wave equation, wave velocity is also equal to the product of its frequency (f) and wavelength (λ).
- Therefore, $\sqrt{E/\rho} = f\lambda$.

Why other options are incorrect:

Options A, C, and D are entirely different physical quantities with vastly different dimensional units. None of them evaluate to m/s .

Question #42 Key: (C)

KMU 2023

If the pressure of air enclosed in a long tube is increased 10 times, then speed of sound will: [ETEA 2023]

CORE CONCEPT AND DERIVATION

The velocity of sound in an ideal gas relies on the ratio of pressure to density.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- When gas is enclosed in a tube and pressure (P) is increased 10 times at a constant temperature, Boyle's Law dictates that the volume shrinks, making the gas strictly 10 times denser.
- The new velocity would be $v' = \sqrt{\frac{\gamma(10P)}{(10\rho)}}$.
- The 10s perfectly cancel out, leaving the original ratio intact.
- Thus, the speed of sound **remains constant** regardless of ambient pressure changes.

Why other options are incorrect:

Students often glance at the formula, see P in the numerator, and wrongly assume an increase (Option A) without accounting for the hidden proportional variable ρ .

Question #43 Key: (D)

DUHS 2023

Which of the following are the application of Doppler's effect?
[SINDH 2023]

CORE CONCEPT AND DERIVATION

The Doppler effect is utilized to detect relative velocity by measuring wave frequency shifts.

Solution:

- Note: While police radar inherently measures automobile speed (Option B), "Sending radar signals" (Doppler Radar) is technically the broader, foundational application listed in historical syllabi.
- Doppler Radar works by **sending radar signals** (microwaves) at a target. When the waves bounce off a moving target (like a storm front or a car), their frequency shifts.
- The system calculates the target's speed strictly based on this returning Doppler shift. According to the official exam key, Option D is the accepted answer, capturing the foundational mechanism.

Why other options are incorrect:

Holograms rely on wave interference. Determining the speed of light relies on classical timing experiments or interferometry, not the Doppler effect.

Question #44 Key: (D)

DUHS 2023

Longitudinal waves exhibit [SINDH 2023]

CORE CONCEPT AND DERIVATION

All wave types share universal wave behaviors, while some behaviors are geometry-specific.

Solution:

- The principle of **superposition** is a universal wave property. It dictates that when two or more waves (whether transverse or longitudinal) overlap in space, their net displacement is the sum of their individual displacements.
- Sound waves (longitudinal) frequently undergo superposition to create interference patterns, beats, and standing waves.

Why other options are incorrect:

Option A (Polarization) is strictly exclusive to transverse waves, making it an excellent distractor. Longitudinal waves cannot be polarized because their oscillation is already locked to a single 1D axis.

Question #45 Key: (C)

DUHS 2023

The product of frequency and wavelength of a wave equals to:
[SINDH 2023]

CORE CONCEPT AND DERIVATION

The universal wave equation relates the spatial, temporal, and kinematic properties of a wave.

Formula:

$$v = f\lambda$$

Solution:

- Frequency (f) represents the number of wave cycles passing a point per second.
- Wavelength (λ) represents the physical length of one complete cycle.
- By multiplying them, you calculate the total distance the wave energy travels in one second, which is the definition of the **Speed of the wave** (v).

Why other options are incorrect:

Displacement and amplitude are vertical measurements of the medium. Time period is the inverse of frequency ($1/f$), completely unrelated to this product.

Question #46 Key: (B)

DUHS 2023

In standing waves, the distance between two consecutive nodes or antinodes is: [SINDH 2023]

CORE CONCEPT AND DERIVATION

The geometry of a standing wave consists of repeating discrete segments or "loops".

Solution:

- A full wavelength (λ) must contain exactly two identical loops to complete a full cycle (one "up" loop and one "down" loop).
- The boundaries of a single loop are nodes. The center of a single loop is an antinode.
- Therefore, the physical distance spanning exactly one loop—whether measured from node to consecutive node, or antinode to consecutive antinode—is half of a wavelength: $\lambda/2$.

Why other options are incorrect:

$\lambda/4$ is the shortest distance between a node and an adjacent antinode. λ is the distance of two full loops.

Question #47 Key: (A)

DUHS 2023

If the fundamental frequency of vibration of a string fixed at both ends is 50Hz, the fourth harmonic will be:...

CORE CONCEPT AND DERIVATION

A string fixed at both ends produces harmonic frequencies that are pure integer multiples of its fundamental (lowest) frequency.

Formula:

$$f_n = n f_1$$

Solution:

- We are given the fundamental frequency (first harmonic), $f_1 = 50$ Hz.
- The question asks for the fourth harmonic, meaning $n = 4$.
- Substitute the values: $f_4 = 4 \times 50$ Hz.
- $f_4 = 200$ Hz.

Why other options are incorrect:

Option B (150) is the 3rd harmonic. Option D (250) is the 5th harmonic.

Question #48 Key: (C)

DUHS 2023

In vibratory motion the maximum displacement of the body on either side of its equilibrium position is called:...

CORE CONCEPT AND DERIVATION

Oscillatory terminology specifically differentiates between instantaneous position and peak limits.

Solution:

- At any given moment, the body's distance from the center is its instantaneous displacement.
- However, the absolute furthest point it reaches before turning back—the "maximum displacement" from equilibrium—is formally defined as the **Amplitude**.
- Amplitude determines the total energy housed within the vibrating system.

Why other options are incorrect:

Distance and displacement are variable measurements that change continuously during the swing. Frequency relates to time, not spatial boundaries.

Question #49 Key: (C)

DUHS 2023

The speed of sound at 0°C in air is 332 m/s. What will be the speed of sound at 50°C? [SINDH 2023]

CORE CONCEPT AND DERIVATION

The velocity of sound in gases climbs predictably as ambient temperature rises.

Formula:

$$v_t = v_0 + 0.61t$$

Solution:

- We are given the baseline speed $v_0 = 332$ m/s and temperature $t = 50^\circ\text{C}$.
- First, calculate the temperature-induced speed increment: 0.61×50 .
- $0.61 \times 50 = 30.5$ m/s.
- Add this increment to the baseline: $v_{50} = 332 + 30.5 = 362.5$ m/s.

Why other options are incorrect:

Option D occurs if a math error yields 50 instead of 30.5.
Option B assumes temperature has no effect on wave speed.

Question #50 Key: (C)

NUMS 2023

Total Length = 2.0 m (2 Full Cycles $\rightarrow \lambda = 1.0$ m) Transverse Wave (2 Full Wavelengths = 2.0m $\rightarrow$ Wavelength $\lambda = 1...$

CORE CONCEPT AND DERIVATION

Wavelength is strictly defined as the physical distance required for one complete wave cycle (one full crest and one full trough).

Solution:

- The provided diagram features an arrow spanning a total distance of exactly 2 meters.
- By tracing the wave from start to finish within that 2-meter span, we count exactly two identical, complete wave cycles (up-down, up-down).
- To find the length of a single cycle (wavelength, λ), divide the total distance by the number of cycles: $\lambda = \frac{2 \text{ m}}{2 \text{ cycles}}$.
- Therefore, $\lambda = 1$ m.

Why other options are incorrect:

Option A (2m) is the trap for students who assume the provided spatial label automatically represents exactly one wavelength without counting the underlying cycles.

Question #51 Key: (D)

NUMS 2023

With increase in pressure, the speed of sound will: [NUMS 2023]

CORE CONCEPT AND DERIVATION

The velocity of sound in gases relies heavily on the gas's internal restoring forces and mass, expressed mathematically by Laplace.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to gas laws, pressure and density are directly proportional at a constant temperature.
- If you mechanically squeeze a gas to increase its pressure (P), the gas compresses, shrinking its volume and increasing its density (ρ) by the exact same multiplier.
- Because the numerator and denominator increase identically, their ratio remains untouched.
- Consequently, the calculated speed of sound must remain the same.

Why other options are incorrect:

Students incorrectly guess Option A by looking at P in the numerator of the formula but neglecting the invisible dependency of ρ on pressure.

Question #52 Key: (B)

NUMS 2023

In transverse waves, the portion above the mean level is called:
[NUMS 2023]

CORE CONCEPT AND DERIVATION

Transverse waves involve particle displacement that is strictly perpendicular to the direction the energy travels.

Solution:

- The undisturbed, resting state of the medium is known as the "mean level" or equilibrium position.
- When the wave passes, particles are displaced. The entire raised region, reaching maximum positive displacement above the mean level, is structurally defined as the **Wave crest**.

Why other options are incorrect:

The wave trough is the region below the mean level. A wave front is an imaginary line connecting points in the exact same phase. Wavelength is a distance measurement.

Question #53 Key: (C)

NUMS 2023

At maximum displacement of particles of a medium, on either side of the mean position of a wave, is called: [N...

CORE CONCEPT AND DERIVATION

Waves possess spatial descriptors that quantify their size and energy capacity.

Solution:

- As particles oscillate around their resting (mean) position, they travel a specific distance outward before turning back.
- The absolute maximum scalar distance reached from the mean position—whether it's measured upwards to a crest or downwards to a trough—is termed the **Amplitude**.
- Amplitude is a direct indicator of the wave's energy.

Why other options are incorrect:

Option D (Crest) is solely the peak point on one specific side, whereas amplitude describes the scalar maximum displacement regardless of direction. Wavelength and frequency define the wave's repeating structure.

Question #54 Key: (B)

UHS 2022

A long spring, when stretched by a distance x , has potential energy V . On increasing the stretching to nx , the...

CORE CONCEPT AND DERIVATION

The elastic potential energy stored in a stretched spring follows Hooke's law, meaning it scales with the square of the displacement.

Formula:

$$PE = \frac{1}{2}kx^2$$

Solution:

- The initial potential energy is mathematically defined as $V = \frac{1}{2}kx^2$.
- If the new stretch distance becomes $x' = nx$, the new potential energy is $PE_{new} = \frac{1}{2}k(nx)^2$.
- Distribute the square: $PE_{new} = \frac{1}{2}k(n^2x^2) = n^2 \left(\frac{1}{2}kx^2\right)$.
- Substitute the initial energy V back into the equation: $PE_{new} = n^2V$.

Why other options are incorrect:

Option A incorrectly assumes energy scales linearly with distance. Options C and D wrongly place the scaling factor in the denominator.

Question #55 Key: (D)

UHS 2022

Which of the following increases by increasing amplitude? [UHS 2022]

CORE CONCEPT AND DERIVATION

Amplitude represents the maximum displacement of a wave from equilibrium, directly dictating how much energy the wave carries.

Solution:

- In the context of sound waves, the amplitude specifically governs the intensity of the sound.
- **Loudness** is the subjective human perception of sound intensity. It is directly proportional to the square of the amplitude ($I \propto A^2$).
- Therefore, increasing the amplitude strictly increases the perceived loudness.

Why other options are incorrect:

Wavelength and frequency dictate the wave's pitch and propagation geometry; they remain completely unchanged when only the amplitude is altered.

Question #56 Key: (A)

UHS 2022

An airplane travels at a speed of $0.5v$ is the speed of sound. The airplane approaches a stationary observer. T...

CORE CONCEPT AND DERIVATION

When a source moves at high speed towards a stationary observer, extreme wave compression occurs, raising the frequency significantly.

Formula:

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

Solution:

- Given: True frequency $f = 200$ Hz and source velocity $v_s = 0.5v$.
- Substitute into the Doppler equation: $f' = 200 \left(\frac{v}{v - 0.5v} \right)$.
- Simplify the denominator: $v - 0.5v = 0.5v$.
- Evaluate the fraction: $\frac{v}{0.5v} = \frac{1}{0.5} = 2$.
- Multiply by the true frequency: $f' = 200 \times 2 = 400$ Hz.

Why other options are incorrect:

Option B (100 Hz) results from incorrectly treating it as a receding source ($v + 0.5v = 1.5v$ in denominator, yielding 133 Hz, or incorrectly placing the 2 multiplier as a divisor).

Question #57 Key: (B)

UHS 2022

If the wavelength of light coming from a galaxy shifts towards the red end of spectrum, then galaxy is: [UHS 2022]

CORE CONCEPT AND DERIVATION

The visual spectrum spans from shorter wavelengths (blue) to longer wavelengths (red).

Solution:

- A Doppler "redshift" specifically means the observed wavelengths have elongated compared to their laboratory baseline.
- Wavelengths only elongate (stretch) when the distance between the source and observer is rapidly increasing.
- Therefore, a red shift is definitive proof that the galaxy is **receding** (moving away) from Earth.

Why other options are incorrect:

Approaching galaxies compress light waves, shifting them towards the shorter, blue end of the spectrum (Blueshift). Stationary galaxies exhibit zero shift.

Question #58 Key: (C)

BUMHS 2022

The shortest distance between any two points in phase on a wave is called: [UHS+BMU 2022]

CORE CONCEPT AND DERIVATION

A wave's structural geometry repeats uniformly through space.

Solution:

- Points that are "in phase" are in the exact same state of oscillation (e.g., two adjacent crests or two adjacent troughs).
- The formal, fundamental definition of **wavelength (λ)** is the minimum physical distance over which the wave's shape fully repeats itself.
- Therefore, the shortest distance between any two consecutive points oscillating entirely in phase is exactly one wavelength.

Why other options are incorrect:

Displacement is the instantaneous position of a particle. Amplitude is the maximum displacement. Frequency is a measure of time/cycles, not distance.

Question #59 Key: (A)

UHS 2022

When will the oscillations stop in the absence of resistive forces? [UHS 2022]

CORE CONCEPT AND DERIVATION

Oscillations naturally decay (dampen) solely because energy is lost from the system to the environment (usually as heat) via resistive forces like friction or air drag.

Solution:

- If a system operates in a hypothetical perfect vacuum with zero friction and absolute "absence of resistive forces," no energy is ever lost.
- According to the law of conservation of energy, the kinetic and potential energies will perfectly exchange forever.
- Consequently, the theoretical oscillations will **never** stop.

Why other options are incorrect:

Any time-bound cessation (10 minutes, immediately) inherently requires a mechanism of energy dissipation (damping).

Question #60 Key: (A)

UHS 2022

The mechanical waves are not by: [UHS 2022]

CORE CONCEPT AND DERIVATION

Waves are primarily divided into two main categories: Mechanical and Electromagnetic.

Solution:

- Mechanical waves obligatorily require a physical, material medium to propagate (such as water, steel, air, ropes, or springs).
- **Electric and magnetic fields** oscillate to form Electromagnetic (EM) waves (like light or radio waves).
- EM waves are uniquely non-mechanical because they can self-propagate through a pure vacuum without any physical medium.

Why other options are incorrect:

Springs, ropes, and water are all tangible physical media; any wave propagating through them is strictly classified as a mechanical wave.

Question #61 Key: (B)

UHS 2022

Reducing mass M of a suspending body to one fourth will change the frequency of oscillations be: [UHS 2022]

CORE CONCEPT AND DERIVATION

The frequency of a mass-spring system in Simple Harmonic Motion depends inversely on the square root of its mass.

Formula:

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

Solution:

- The original frequency is $f \propto \frac{1}{\sqrt{m}}$.
- The mass is reduced to one-fourth: $m_{\text{new}} = \frac{m}{4}$.
- Substitute this new mass into the proportionality: $f_{\text{new}} \propto \frac{1}{\sqrt{m/4}}$.
- Simplify the square root: $\frac{1}{\sqrt{m/4}} = 2 \times \frac{1}{\sqrt{m}}$.
- Therefore, the new frequency is exactly **double** the original frequency ($f_{\text{new}} = 2f$).

Why other options are incorrect:

Reducing mass increases frequency (it oscillates faster). Option C (quadruple) comes from forgetting to take the square root of 4.

Question #62 Key: (B)

UHS 2022

A distance star is receding from Earth with a speed of [Formula]. It emits light of frequency [Formula]. The...

CORE CONCEPT AND DERIVATION

For light from receding celestial sources, observed frequency drops (Redshift). For low relative velocities, the classical approximation $\Delta f/f \approx v/c$ applies.

Formula:

$$f' \approx f \left(1 - \frac{v}{c}\right)$$

Solution:

- Given: Source velocity $v = 1.40 \times 10^7$ m/s, $c = 3.0 \times 10^8$ m/s, original frequency $f = 4.57 \times 10^{14}$ Hz.
- Calculate the velocity ratio: $\frac{v}{c} = \frac{1.40 \times 10^7}{3.0 \times 10^8} \approx 0.0467$.
- Calculate the observed frequency: $f' = f(1 - 0.0467) = f(0.9533)$.
- $f' = 4.57 \times 10^{14} \times 0.9533 \approx 4.356 \times 10^{14}$ Hz.
- Option B (4.37×10^{14} Hz) is the mathematically closest match generated by slight variations in relativistic vs classical formulas on historical exams.

Why other options are incorrect:

Option D represents a blueshift (source approaching). Option C is the unshifted baseline frequency.

Question #63 Key: (B)

DUHS 2022

The intensity level (sound level) of faintest audible intensity is:
[DUHS 2022]

CORE CONCEPT AND DERIVATION

Sound intensity level (β) compares a given sound intensity (I) to the standard threshold of human hearing ($I_0 = 10^{-12} \text{ W/m}^2$).

Formula:

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

Solution:

- The "faintest audible intensity" is the threshold of hearing itself, meaning $I = I_0$.
- Substitute this into the equation: $\beta = 10 \log \left(\frac{I_0}{I_0} \right)$.
- $\beta = 10 \log(1)$.
- Since $\log(1) = 0$, the intensity level is exactly **0 decibels**.

Why other options are incorrect:

Options A, C, and D represent extremely loud sounds (above the threshold of pain), not the faintest audible sounds.

Question #64 Key: (C)

DUHS 2022

A sound waves travels from one medium to another, which one of the following characteristics of sound remain u...

CORE CONCEPT AND DERIVATION

When a wave transitions across physical boundaries between different media, certain properties adjust to the new environment while others remain tied to the wave's origin.

Solution:

- **Frequency (Pitch)** is fundamentally determined by the oscillating source that created the wave. It dictates how many cycles arrive at the boundary per second, which must equal the number of cycles entering the new medium. Thus, it remains **unchanged**.
- Velocity changes because it depends on the medium's elasticity and density.
- Wavelength changes proportionally with velocity ($\lambda = v/f$).

Why other options are incorrect:

Velocity and wavelength adapt to the new medium. Amplitude typically decreases due to partial reflection and energy absorption at the boundary.

Question #65 Key: (D)

DUHS 2022

Distance between two consecutive antinodes in standing wave is
[DUHS 2022]

CORE CONCEPT AND DERIVATION

Standing waves form a repeating geometric pattern of fixed nodes (zero displacement) and antinodes (maximum displacement).

Solution:

- A full wavelength (λ) encompasses two complete loops (one positive, one negative).
- The center of each loop is an antinode.
- Therefore, the physical distance between the centers of two adjacent loops (consecutive antinodes) is exactly half of a full wavelength: $\lambda/2$.

Why other options are incorrect:

$\lambda/4$ is the distance from a node to the very next antinode. λ is the distance across two full loops.

Question #66 Key: (D)

DUHS 2022

If the given spring of spring constant K is cut into three identical segments the spring constant of each segm...

CORE CONCEPT AND DERIVATION

The stiffness (spring constant, k) of a spring is inversely proportional to its un-stretched length (L).

Formula:

$$k \propto \frac{1}{L}$$

Solution:

- A shorter spring is physically stiffer and harder to stretch than a longer one made of the same material.
- If the original spring is cut into 3 identical segments, the length of each new segment is $L_{\text{new}} = \frac{L}{3}$.
- Because of the inverse relationship, the new spring constant becomes $k_{\text{new}} = 3K$.

Why other options are incorrect:

Option C ($K/3$) is a common mistake where students assume spring constant scales directly with length rather than inversely.

Question #67 Key: (B)

DUHS 2022

The most appropriate mathematical expression representing simple harmonic motion is: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Simple Harmonic Motion (SHM) is rigidly defined by a specific restoring force mechanism.

Solution:

- For a system to execute SHM, its acceleration (a) must be directly proportional to its displacement (x) from the mean position.
- Crucially, this acceleration must always be directed towards the mean position, acting exactly opposite to the direction of displacement.
- This opposing direction is mathematically represented by a **negative sign**: $a \propto -x$.

Why other options are incorrect:

Option A lacks the negative sign, which would imply an exponentially runaway motion rather than an oscillation. Options C and D lack both the negative sign and the proper proportionality constants (like ω^2).

Question #68 Key: (B)

DUHS 2022

An object moving faster than the speed of sound. This object is called: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Speeds are categorized relative to the local speed of sound (Mach number).

Solution:

- **Subsonic**: Slower than sound (Mach < 1).
- **Sonic**: Exactly at the speed of sound (Mach = 1).
- **Supersonic**: Faster than the speed of sound (Mach > 1). Objects breaking this barrier create shock waves (sonic booms).
- **Hypersonic**: Significantly faster than sound, typically classified as Mach 5 or greater.

Why other options are incorrect:

Ultrasonic refers to sound wave frequencies above human hearing (e.g., > 20 kHz), not the physical speed of a moving object.

Question #69 Key: (B)

NUMS 2022

The horizontal distance travelled by wave during one complete cycle is called [NUMS 2022]

CORE CONCEPT AND DERIVATION

Waves repeat their structural shape periodically through space.

Solution:

- A "complete cycle" of a wave includes exactly one crest and one trough (or one full compression and rarefaction).
- The physical, horizontal distance required to fit one perfectly complete cycle is the formal definition of **Wavelength** (λ).

Why other options are incorrect:

Frequency is a measure of cycles per unit time. Time period is the duration in seconds for one cycle. Amplitude is the vertical, maximum displacement.

Question #70 Key: (D)

NUMS 2022

If the period of oscillation of mass (M) suspended from a spring is $1s$, then the period of $16M$ will be: [NUMS ...]

CORE CONCEPT AND DERIVATION

The time period of a mass-spring system in SHM depends on the suspended mass and the spring's stiffness.

Formula:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Solution:

- The original period is $T_1 = 1s$, which is proportional to $\sqrt{M}$.
- The mass is increased to $16M$. The new period T_2 is proportional to $\sqrt{16M}$.
- Extract the constant from the square root: $\sqrt{16M} = 4\sqrt{M}$.
- Therefore, the new period is exactly 4 times the original period: $T_2 = 4 \times 1s = 4s$.

Why other options are incorrect:

If a student assumes period scales linearly with mass (rather than the square root), they would erroneously look for $16s$. A student might also divide instead of multiply.

Question #71 Key: (A)

NUMS 2022

Loudness of the sound is directly related to [NUMS 2022]

CORE CONCEPT AND DERIVATION

Loudness is the human auditory system's subjective perception of how powerful a sound is.

Solution:

- The sensation of loudness is directly governed by the physical energy carried by the wave.
- **Intensity** represents the actual power per unit area (W/m^2) of the sound wave. The greater the intensity (which depends on amplitude squared), the louder the sound is perceived.

Why other options are incorrect:

Frequency and pitch are related to how "high" or "low" a note sounds, not its volume. Wavelength correlates inversely with frequency, also determining pitch, not loudness.

Question #72 Key: (D)

NUMS 2022

The increase in the speed of sound in air for each rise above $0^\circ C$ is: [NUMS 2022]

CORE CONCEPT AND DERIVATION

As air temperature rises, its molecules gain kinetic energy, allowing them to transmit sound wave collisions faster.

Formula:

$$v_t = v_0 + 0.61t$$

Solution:

- For ideal gases around standard temperatures, the speed of sound increases linearly with temperature.
- Experimental data and the mathematical expansion of Laplace's formula show that for every $1^\circ C$ increase in temperature above $0^\circ C$, the velocity increases by a constant factor of $0.61 m/s$.

Why other options are incorrect:

Options A, B, and C are incorrect constants. $0.61 m/s$ is standard textbook empirical value.

Question #73 Key: (B)

NUMS 2022

Crest of a wave acts as: [NUMS 2022]

CORE CONCEPT AND DERIVATION

In a ripple tank, water waves alter the thickness of the water, creating optical effects when light shines through from above.

Solution:

- A wave **crest** is a localized region where the water is deeper and bulges outward.
- This physical shape perfectly mimics a converging glass lens. As light passes through the crest, it bends (refracts) inward, focusing the rays onto the screen below.
- This focusing action proves the crest acts as a **convex lens**, producing the bright parallel bands seen in a ripple tank.

Why other options are incorrect:

A wave trough acts as a concave lens (diverging light to make dark bands). Mirrors reflect light, whereas this phenomenon is strictly refractive.

Question #74 Key: (B)

NUMS 2022

The speed of sound in air does not depend on: [NUMS 2022]

CORE CONCEPT AND DERIVATION

The speed of sound in an ideal gas is governed by the ratio of its pressure to its density.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to Boyle's law ($P \propto \rho$), if you isothermally increase the pressure of a gas, its density increases by the exact same proportion.
- Because both P (numerator) and ρ (denominator) increase together, their ratio P/ρ remains mathematically constant.
- Therefore, the speed of sound is wholly **independent of pressure** changes.

Why other options are incorrect:

Sound speed heavily depends on Temperature (increases speed) and absolute Density (different gases have different speeds). (Option D is a historical typographical error from the original exam, carried over).

Question #75 Key: (A)

SZABMU 2022

Wavelength of wave is defined as: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Wavelength is the fundamental spatial period of a wave—the distance over which the wave's shape fully repeats.

Solution:

- By definition, one complete wave cycle spans from one specific phase state to the exact next identical phase state.
- The most common and practical way to measure this is by finding the physical distance between the peaks of two adjacent waves.
- Therefore, wavelength is defined as the distance between **two consecutive crests** (or two consecutive troughs).

Why other options are incorrect:

Alternate crests (skipping one) would measure exactly two wavelengths (2λ). Measuring across multiple crests and troughs does not yield a single, base wavelength.

Question #76 Key: (A)

SZABMU 2022

Which of the following factor does not affect the speed of sound in air? [SZABMU 2022]

CORE CONCEPT AND DERIVATION

The propagation speed of sound in an ideal gas depends on its thermodynamic properties and inertial mass.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to Boyle's law, for a gas at a constant temperature, its density (ρ) is directly proportional to its pressure (P).
- If atmospheric pressure increases, the air compresses, causing the density to increase by the exact same multiplier.
- Because both variables in the fraction change simultaneously and proportionately, the ratio $\frac{P}{\rho}$ remains mathematically untouched.
- Therefore, a change in ambient **Pressure** has absolutely zero net effect on the speed of sound.

Why other options are incorrect:

Different media (solids vs gases) drastically change speed. Higher temperatures increase speed. Changes in pure density (e.g., adding moisture without changing pressure) directly alter speed.

Question #77 Key: (B)

SZABMU 2022

Maximum displacement of particles from its mean position is called:
[SZABMU 2022]

CORE CONCEPT AND DERIVATION

Oscillatory terminology specifically differentiates between instantaneous position and the peak limits of the swing.

Solution:

- As a wave passes through a medium, the particles oscillate back and forth around a central resting point (the mean position or equilibrium).
- The absolute furthest scalar distance a particle travels away from this mean position before turning back is formally defined as the **Amplitude**.
- Amplitude directly dictates the total energy carried by the wave.

Why other options are incorrect:

A crest is a specific physical region (the "top"), not the scalar measurement itself. Wavelength is a horizontal distance. Frequency measures time-based cycles.

Question #78 Key: (B)

SZABMU 2022

The ultrasonic waves have frequency higher than: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

The human auditory system is mechanically limited to detecting a specific spectrum of sound frequencies.

Solution:

- A healthy human ear can perceive sound frequencies ranging from a low of 20 Hz up to a maximum high of 20,000 Hz (which is exactly **20 kHz**).
- Sound waves that oscillate faster than this upper biological limit are completely inaudible to humans.
- The prefix "ultra-" means "beyond." Therefore, mechanical waves exceeding 20 kHz are scientifically classified as **ultrasonic**.

Why other options are incorrect:

Frequencies strictly below 20 Hz are termed "infrasonic." The other options fall well within or vastly exceed the actual threshold boundary defining the ultrasonic regime.

Question #79 Key: (A)

SZABMU 2022

The increase in the speed of sound for each degree rise above 0°C is: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Temperature provides gas molecules with higher kinetic energy, allowing them to collide and transfer sound pressure waves more rapidly.

Formula:

$$v_t = v_0 + 0.61t$$

Solution:

- Derivations from the ideal gas law and Laplace's formula show that the speed of sound in air is proportional to the square root of absolute temperature.
- For small temperature variations near 0°C, this relationship simplifies to a linear approximation.
- Experimentally and theoretically, for every 1°C increase in temperature, the speed of sound climbs by a constant factor of exactly 0.61 m/s.

Why other options are incorrect:

The values 0.51, 0.41, and 0.31 are simply incorrect decimal distractors designed to test rote memory of this standard empirical constant.

Question #80 Key: (D)

SZABMU 2022

Continuous, regular and rhythmic disturbance in a medium resulting periodic vibration of a source causes _____.

CORE CONCEPT AND DERIVATION

Waves are characterized by the nature of the disturbance that generates them.

Solution:

- If a source produces a single, isolated disturbance, it generates a "wave pulse."
- However, if the source vibrates in a continuous, flawlessly regular, and repeating rhythm over fixed time intervals, the resulting wave train mirrors this perfect regularity.
- Such evenly spaced, repeating cycles generated by continuous oscillation are formally termed **Periodic waves**.

Why other options are incorrect:

Stationary waves require interference from a reflected boundary. Complex waves imply a messy superposition of many different frequencies. Electromagnetic waves do not strictly require a physical medium to be disturbed.

Question #81 Key: (B)

KMU 2022

The energy of simple harmonic oscillator at a displacement "x" is partly kinetic and partly potential. The tot...

CORE CONCEPT AND DERIVATION

In Simple Harmonic Motion (SHM), the total mechanical energy is conserved, constantly shifting back and forth between kinetic (motion) and potential (position) forms.

Formula:

$$PE = \frac{1}{2} kx^2$$

$$KE = \frac{1}{2} mv^2$$

Solution:

- At the mean position (equilibrium, $x = 0$), the restoring force is zero, meaning potential energy is minimum. Consequently, the mass is moving its fastest here, making kinetic energy maximum.
- At the extreme positions (amplitude, $x = x_0$), the mass momentarily stops (velocity = 0), so kinetic energy is entirely depleted.
- Because the displacement (x) is at its absolute maximum, the **Potential energy** reaches its maximum peak at this extreme boundary.

Why other options are incorrect:

Kinetic energy is zero, not maximum, at the extreme positions (Option A). At the mean position, KE is maximum, not minimum (Option C/D).

Question #82 Key: (B)

KMU 2022

The speed of a wave on a particular string is 24 m/s [Formula]. If the string is 6.0 m long, to what driving frequency...

CORE CONCEPT AND DERIVATION

A string fixed at both ends forms stationary waves. It resonates strictly at its fundamental frequency and exact integer multiples (harmonics) thereof.

Formula:

$$f_n = n \left(\frac{v}{2L} \right)$$

Solution:

- First, calculate the fundamental frequency (first harmonic, $n = 1$).
- Given: Velocity $v = 24$ m/s, Length $L = 6.0$ m.
- $f_1 = \frac{24}{2 \times 6} = \frac{24}{12} = 2$ Hz.
- The string will only resonate at whole integer multiples of this fundamental base frequency ($n = 1, 2, 3, \dots$).
- Harmonics: $1 \times 2 = 2$ Hz, $2 \times 2 = 4$ Hz, $3 \times 2 = 6$ Hz, and so on.
- The set 2 Hz, 4 Hz, 6 Hz perfectly matches this sequence.

Why other options are incorrect:

Option A describes harmonics of a 1 Hz fundamental. Option C describes harmonics of a 3 Hz fundamental. Only Option B correctly captures the multiples of the mathematically derived 2 Hz base.

Question #83 Key: (D)

KMU 2022

The apparent change in the frequency of sound caused by the relative motion of either the source of sound or the receiver...

CORE CONCEPT AND DERIVATION

Wave frequencies appear altered when there is a relative velocity differential between the wave emitter and the receiver.

Solution:

- When a police car speeds toward you, the sound waves compress, making the siren pitch sound higher. As it passes, the waves stretch out, lowering the pitch.
- This universal wave phenomenon—the apparent shift in frequency due to relative kinematic motion—is formally defined as the **Doppler effect**, named after physicist Christian Doppler.

Why other options are incorrect:

The Compton effect is the scattering of X-rays by electrons. The Zeeman effect is the splitting of spectral lines in a magnetic field. The Stark effect is the splitting of spectral lines in an electric field.

Question #84 Key: (A)

KMU 2022

The time period of a simple pendulum with mass m is T . When the pendulum's mass m is replaced by another ball ...

CORE CONCEPT AND DERIVATION

The swing duration of an ideal simple pendulum is governed entirely by the length of its string and local gravity, exhibiting a unique property called isochronism.

Formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Solution:

- Look closely at the formula for the time period (T). The variable for mass (m) does not appear anywhere in the equation.
- Because gravity accelerates all masses equally regardless of their weight (Galileo's principle), a heavier bob falls through the swing arc at the exact same rate as a lighter bob.
- Therefore, replacing the mass with one that is 3 times heavier has zero mathematical or physical effect. The time period remains exactly T .

Why other options are incorrect:

Students often confuse pendulum physics with spring-mass systems (where mass does alter the period). Options B, C, and D prey on the false assumption that mass influences pendulum swing time.

Question #85 Key: (D)

DUHS 2022

Two transverse travelling waves are presented by these equations:
[Formula] $y_1 = A_0 \sin(kx - \omega t)$ [For...

CORE CONCEPT AND DERIVATION

Mathematical wave equations encode all the physical characteristics of a progressive wave within their terms.

Solution:

- Compare the two equations directly:
- Amplitude:** Both have the exact same leading coefficient, A_0 .
- Wavelength:** Both share the same wave number, k (where $k = 2\pi/\lambda$).
- Frequency:** Both share the same angular frequency, ω (where $\omega = 2\pi f$).
- The only structural difference is the $-\phi$ term inside the sine argument of the second wave. The argument of the sine function defines the wave's phase.
- Therefore, the term ϕ represents a distinct offset in their starting alignment, meaning they differ strictly in **Phase**.

Why other options are incorrect:

Because A_0 , k , and ω are identical across both equations, the amplitude, wavelength, frequency, and direction of propagation are all exactly matched.

Question #86 Key: (A)

PMDC 2021

Doppler's effect shows? [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

The Doppler Effect is the fundamental observation that perceived wave frequencies are altered by movement.

Solution:

- The core definition of the Doppler effect is an apparent change in frequency (or pitch) resulting from the **relative motion** between the wave's source and the observer.
- This effect happens regardless of whether the source is moving, the observer is moving, or both are moving simultaneously.

Why other options are incorrect:

Option B is wrong because the primary physical change is in frequency (pitch/color), not amplitude (loudness/brightness). Options C and D are incomplete because the effect does not require exclusively the source or exclusively the observer to move.

Question #87 Key: (B)

PMDC 2021

Distance Between two Consecutive node is [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

A stationary (standing) wave is divided into repeating loops separated by points of zero displacement (nodes).

Solution:

- A full wave cycle (one full wavelength, λ) contains two complete loops (one "positive" displacement loop and one "negative" displacement loop).
- Therefore, a single complete loop spans exactly half of a wavelength.
- The boundaries of a single loop are defined by two consecutive nodes. Thus, the distance between them is $\frac{\lambda}{2}$.

Why other options are incorrect:

The distance between a consecutive node and antinode is $\lambda/4$. A full wavelength corresponds to the distance between three consecutive nodes.

Question #88 Key: (C)

PMDC 2021

Stationary waves [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

Stationary waves (also called standing waves) get their name directly from their macroscopic behavior.

Solution:

- They are created by two identical progressive waves traveling in opposite directions.
- When they superimpose, the resulting wave profile (the nodes and antinodes) remains locked in fixed spatial positions.
- While the medium particles oscillate up and down, the wave profile itself **does not move** or propagate through space.

Why other options are incorrect:

Progressive waves move forward or backwards. Stationary waves, by definition, lack a net velocity vector for their energy profile.

Question #89 Key: (A)

PMDC 2021

Crest and trough are found in? [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

Waves exhibit different geometries based on how their medium oscillates.

Solution:

- In a **transverse wave**, particles oscillate perpendicular to the wave's path, creating alternating high points (crests) and low points (troughs).
- In a longitudinal wave, particles oscillate parallel to the wave's path, creating alternating dense zones (compressions) and sparse zones (rarefactions).

Why other options are incorrect:

Longitudinal waves have compressions/rarefactions, not crests/troughs. While transverse waves can be progressive, "progressive" is a broader category that also includes longitudinal waves.

Question #90 Key: (A)

PMDC 2020

The speed of sound in air is 332 m/s. The speed of sound at 22 [Formula] will be: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

The speed of sound in air increases linearly with an increase in Celsius temperature.

Formula:

$$v_t = v_0 + 0.61t$$

Solution:

- Here, v_0 (speed at 0°C) is given as 332 m/s, and temperature $t = 22^\circ\text{C}$.
- Calculate the increment: $0.61 \times 22 \approx 13.42$ m/s.
- Add this increment to the baseline speed: $v_{22} = 332 + 13.42 = 345.42$ m/s.
- Option A (345.2 m/s) is the closest exact match, accounting for slight rounding variations in the constant (e.g., using 0.6 m/s per degree yields 345.2).

Why other options are incorrect:

Failing to multiply by the 0.61 coefficient or just adding 22 directly to 332 results in erroneous values.

Question #91 Key: (D)

PMDC 2020

Astronomers calculate speed of distant stars and galaxies using which of the following phenomena? [NMDCAT 2020...]

CORE CONCEPT AND DERIVATION

The Doppler Effect applies to electromagnetic waves (like starlight) just as it does to sound.

Solution:

- When stars or galaxies are moving relative to Earth, the spectral lines of the light they emit get shifted.
- If a galaxy moves away, the light stretches into longer wavelengths (Redshift). If it approaches, it compresses (Blueshift).
- By quantifying this shift using Doppler formulas, astronomers accurately deduce the radial velocity (speed) of these distant celestial bodies.

Why other options are incorrect:

Beats, interference, and superposition describe wave interactions, not velocity-induced frequency shifts.

Question #92 Key: (D)

PMDC 2020

In a ripple tank, 40 waves pass through a certain point in 1 second. If the wavelength of the wave is 5 cm, the...

CORE CONCEPT AND DERIVATION

The wave equation links speed, frequency, and wavelength.

Formula:

$$v = f\lambda$$

Solution:

- The frequency (f) is simply the number of waves passing per second. So, $f = 40$ Hz.
- The given wavelength is $\lambda = 5$ cm. To maintain standard SI units, convert this to meters: $5 \text{ cm} = 0.05 \text{ m}$.
- Multiply them to find velocity: $v = 40 \times 0.05$.
- $v = 2 \text{ ms}^{-1}$.

Why other options are incorrect:

If a student forgets to convert centimeters to meters, they might incorrectly calculate $40 \times 5 = 200 \text{ cm/s}$, but the options are strictly in m/s.

Question #93 Key: (A)

NUMS 2020

Trough of a wave acts as: [NUMS 2020]

CORE CONCEPT AND DERIVATION

In a ripple tank experiment, water waves create physical variations in water depth, altering how light passes through them.

Solution:

- A wave crest acts like a bulging, converging structure, akin to a **convex lens**. This focuses overhead light, creating bright bands on the screen below.
- Conversely, a trough acts like a "dished" or diverging structure, akin to a **concave lens**. Light passing through it spreads out, creating the dark bands seen on the screen.

Why other options are incorrect:

Convex lenses correspond to crests. Mirrors reflect light, whereas this phenomena relies on light refracting through the water surface.

Question #94 Key: (B)

PMDC 2020

Ratio of fundamental frequency of Open Organ pipe to closed organ pipe is [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

The harmonic frequencies of organ pipes differ critically based on boundary conditions (open vs. closed ends).

Formula:

$$f_{\text{open}} = \frac{v}{2L}$$

$$f_{\text{closed}} = \frac{v}{4L}$$

Solution:

- For a pipe open at both ends, the fundamental frequency is $f_{\text{open}} = \frac{v}{2L}$.
- For a pipe closed at one end, the fundamental frequency is $f_{\text{closed}} = \frac{v}{4L}$.
- Calculate the ratio: $\frac{f_{\text{open}}}{f_{\text{closed}}} = \frac{v/2L}{v/4L} = \frac{4L}{2L} = \frac{2}{1}$.
- The ratio is exactly 2:1.

Why other options are incorrect:

Option A (1:2) is the inverse ratio (closed to open). Options C and D result from mathematically confusing lengths or squaring values incorrectly.

Question #95 Key: (A)

PMDC 2020

A whistler with velocity 33 ms [Formula] approaches towards a stationary observer with frequency 450Hz what is...

CORE CONCEPT AND DERIVATION

This is a classic Doppler effect problem where a sound source approaches a stationary observer.

Formula:

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

Solution:

- Assume standard velocity of sound in air $v \approx 330$ m/s.
- Source velocity $v_s = 33$ m/s and true frequency $f = 450$ Hz.
- Substitute into the formula: $f' = \left(\frac{330}{330 - 33} \right) 450$.
- Calculate the denominator: $330 - 33 = 297$.
- Simplify the fraction: $\frac{330}{297} = \frac{10}{9}$.
- Multiply by the base frequency: $f' = \frac{10}{9} \times 450 = 10 \times 50 = 500$ Hz.

Why other options are incorrect:

Option B would be correct if the source were receding (moving away). Option D is the original frequency, incorrectly assuming no Doppler shift occurs.

Question #96 Key: (B)

PMDC 2020

Ripple tank is used to study features of [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

A ripple tank is a specialized piece of lab equipment featuring a shallow glass tank of water.

Solution:

- It is explicitly designed to generate and visualize 2D mechanical water waves.
- By shining a light from above, the shadows of the wave crests and troughs allow students to study core wave behaviors such as reflection, refraction, diffraction, and interference.

Why other options are incorrect:

While light is used to illuminate the tank, the tank's purpose is to study the water waves themselves. Particles and solids do not form the bulk behaviors studied in this tank.

Question #97 Key: (C)

PMDC 2020

Waves which deal with fast moving elementary particle [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

According to quantum mechanics (specifically Louis de Broglie's hypothesis), all matter exhibits wave-like properties.

Solution:

- When elementary particles (like electrons, protons, or neutrons) travel at high velocities, their wavelength becomes physically significant.
- These are formally defined as **Matter waves** (or de Broglie waves).
- Their wavelength is given by $\lambda = \frac{h}{p}$, where p is the particle's momentum.

Why other options are incorrect:

Transverse and longitudinal are classifications of macroscopic mechanical or electromagnetic waves, not the quantum probability waves associated with moving elementary particles.

Question #98 Key: (A)

PMDC 2020

Infrasonic wave has frequency [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

The human auditory system can only detect sound waves within a specific frequency spectrum (20 Hz to 20,000 Hz).

Solution:

- Sound waves with frequencies strictly **less than 20 Hz** are below the threshold of human hearing.
- These low-frequency mechanical waves are scientifically termed "infrasonic" (infra = below).
- Animals like elephants and whales utilize infrasonic waves for long-distance communication.

Why other options are incorrect:

Option D (Greater than 20 kHz) defines ultrasonic waves.
Options B and C describe the normal audible range.

Question #99 Key: (B)

MDCAT 2019

The wavelength of the electromagnetic wave having frequency of 3 kHz will be? [MDCAT 2019]

CORE CONCEPT AND DERIVATION

All electromagnetic waves travel at the speed of light (c) in a vacuum.

Formula:

$$c = f\lambda$$

Solution:

- We know the speed of light is roughly $c = 3 \times 10^8$ m/s.
- The given frequency is $f = 3$ kHz $= 3 \times 10^3$ Hz.
- Rearrange for wavelength: $\lambda = \frac{c}{f}$.
- $\lambda = \frac{3 \times 10^8}{3 \times 10^3} = 1 \times 10^5$ m.
- Convert meters to kilometers: 10^5 m $= 100$ km.

Why other options are incorrect:

Mathematical errors, such as forgetting the metric prefixes (kilo) or failing to divide correctly by powers of 10, lead to the other numbers.

Question #100 Key: (A)

MDCAT 2019

What will be the expression for the observed frequency, if the source is moving towards the observer? [MDCAT 2...

CORE CONCEPT AND DERIVATION

The Doppler Effect predicts a change in observed frequency when there is relative motion. An approaching source compresses the wave fronts in the direction of travel.

Formula:

$$f_o = \left(\frac{v}{v - u_s} \right) f$$

Solution:

- Because the source is moving **towards** the observer, the waves are "crowded" together. This physically shortens the wavelength.
- A shorter apparent wavelength directly results in a **higher** apparent frequency.
- To yield a fraction greater than 1, the denominator must be decreased. Therefore, we subtract the source velocity (u_s) from the wave velocity (v) in the denominator.

Why other options are incorrect:

Option B represents a source moving away. Options C and D wrongly place the variables (using observer velocity u_o in the denominator instead of the numerator).

Question #101 Key: (A)

MDCAT 2018

A shock wave is produced due to an earthquake which makes the building move in the direction of the shock wave...

CORE CONCEPT AND DERIVATION

Waves are classified based on the direction of medium oscillation relative to the direction of wave propagation.

Solution:

- The question states that the building moves strictly "in the direction of the shock wave".
- When the particles of the medium (or the building, in this case) oscillate parallel to the direction of energy transport, it defines a **longitudinal wave**.
- In seismology, these are known as Primary (P) waves, which are compressional/longitudinal in nature.

Why other options are incorrect:

Transverse waves (S-waves) cause oscillations perpendicular to the propagation path, which would shake the building side-to-side, not just in the wave's direction.

Question #102 Key: (C)

KMU 2018

Which one of the following varies when an object execute simple harmonic motion? [ETEA 2018]

CORE CONCEPT AND DERIVATION

Simple Harmonic Motion (SHM) requires a restoring force that is directly proportional to displacement.

Formula:

$$F = -kx$$

Solution:

- In ideal SHM, Amplitude and Angular Frequency ($\omega = \sqrt{k/m}$) are fundamental constants determined by the system's physical properties.
- Total energy ($E = \frac{1}{2}kx_0^2$) is conserved and remains perfectly constant throughout the motion.
- However, the restoring **Force** continuously changes its magnitude and direction depending on the mass's exact instantaneous position (x), being maximum at extremes and zero at equilibrium.

Why other options are incorrect:

Options A, B, and D define the rigid, unchanging boundary conditions of ideal simple harmonic motion.

Question #103 Key: (D)

KMU 2018

Which one of the following is not a characteristic of stationary wave? [ETEA 2018]

CORE CONCEPT AND DERIVATION

Stationary (standing) waves trap energy within fixed physical boundaries rather than transmitting it through space.

Solution:

- A defining feature of a stationary wave is that the net power flow across any vertical section is zero. Energy is strictly exchanged between kinetic and potential forms locally within each loop.
- Therefore, the statement "Energy of the stationary waves travels outwards" is fundamentally **false**. It describes a progressive wave, not a stationary one.

Why other options are incorrect:

- **Option A is true:** The distance between two adjacent nodes equals $\frac{\lambda}{2}$ (half the wavelength).
- **Option B is true:** Amplitude varies from zero at nodes to maximum at antinodes.
- **Option C is true:** All particles within a single loop (between two adjacent nodes) oscillate in phase.

Question #104 Key: (D)

MDCAT 2017

If a wave travelling at a speed of 130 m/s and has a wavelength of 5m. Then find out the frequency of the wave...

CORE CONCEPT AND DERIVATION

Frequency, wavelength, and wave speed are related by the universal wave equation.

Formula:

$$v = f\lambda$$

Solution:

- We are given the velocity $v = 130$ m/s and the wavelength $\lambda = 5$ m.
- Rearrange the formula to solve for frequency: $f = \frac{v}{\lambda}$.
- Substitute the values: $f = \frac{130}{5} = 26$ Hz.

Why other options are incorrect:

Option A comes from wrongly multiplying the values ($130 \times 5 = 650$).

Question #105 Key: (A)

MDCAT 2017

A metallic wire of 2m length hooked between two points has tension of 10N. If mass per unit length of wire is ...

CORE CONCEPT AND DERIVATION

The fundamental frequency of a stretched string depends on its length, tension, and linear mass density.

Formula:

$$v = \sqrt{\frac{T}{m}}$$

$$f_1 = \frac{v}{2L}$$

Solution:

- Note: The unit 'kg/s' in the question is a historical typo for mass per unit length, which should be kg/m.
- First, find the wave speed: $v = \sqrt{\frac{10}{0.004}} = \sqrt{\frac{10000}{4}} = \sqrt{2500} = 50 \text{ m/s}$.
- Now, apply the fundamental frequency formula with length $L = 2 \text{ m}$:
- $f_1 = \frac{50}{2 \times 2} = \frac{50}{4} = 12.5 \text{ Hz}$.

Why other options are incorrect:

Option D occurs if the student forgets the '2' in the denominator. Option C occurs if one mistakenly uses L in the numerator instead of denominator.

Question #106 Key: (D)

MDCAT 2017

A source of sound moves towards a stationary observer with speed one third speed of sound. If the frequency of...

CORE CONCEPT AND DERIVATION

When a source approaches a stationary observer, the sound waves compress, leading to a higher apparent frequency.

Formula:

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

Solution:

- We are given that the source speed $v_s = \frac{v}{3}$ and true frequency $f = 100 \text{ Hz}$.
- Substitute v_s into the formula: $f' = \left(\frac{v}{v - v/3} \right) 100$.
- Simplify the denominator: $v - \frac{v}{3} = \frac{2v}{3}$.
- Therefore, $f' = \left(\frac{v}{2v/3} \right) 100 = \left(\frac{3}{2} \right) 100$.
- $f' = 1.5 \times 100 = 150 \text{ Hz}$.

Why other options are incorrect:

Using the formula for a receding source (adding in the denominator) yields 75 Hz. Mistakenly putting the speed change in the numerator yields wrong figures entirely.

Question #107 Key: (C)

KMU 2017

In a stationary wave the distance between consecutive antinodes is 25 cm. If the wave velocity is 300 m/s [Form...]

CORE CONCEPT AND DERIVATION

The spatial structure of a standing wave directly dictates its wavelength. The distance between two consecutive antinodes represents exactly half a wavelength.

Formula:

$$\frac{\lambda}{2} = \text{Distance between antinodes}$$

$$v = f\lambda$$

Solution:

- We are given the distance between antinodes: $\frac{\lambda}{2} = 25 \text{ cm}$.
- Solve for wavelength: $\lambda = 50 \text{ cm} = 0.5 \text{ m}$.
- Using the wave equation $f = \frac{v}{\lambda}$, substitute $v = 300 \text{ m/s}$ and $\lambda = 0.5 \text{ m}$.
- $f = \frac{300}{0.5} = 600 \text{ Hz}$.

Why other options are incorrect:

Option A assumes 25 cm is the full wavelength ($300/0.25 = 1200 \text{ Hz}$). If a student assumes 25 cm is $\lambda/4$, they get 1 meter, yielding 300 Hz (Option B). Thus, confusing the loop geometry is the primary trap.

Question #108 Key: (B)

KMU 2017

The speed of sound in air at NTP is 300 m/s. If the air pressure become 4 times then the speed of the sound will...

CORE CONCEPT AND DERIVATION

The velocity of sound in an ideal gas depends solely on temperature and the gas's inherent properties, but it is independent of pressure.

Formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to Boyle's law ($P \propto \rho$), if you increase the pressure of a gas by a factor of 4, the gas gets compressed, causing its density (ρ) to also increase exactly by a factor of 4.
- Because both numerator and denominator in Laplace's formula increase by the exact same multiplier, the ratio $\frac{P}{\rho}$ remains mathematically constant.
- Therefore, the speed remains 300 m/s.

Why other options are incorrect:

Option C assumes speed is directly proportional to pressure, incorrectly doubling the speed.

Question #109 Key: (C)

KMU 2017

Standing waves are produced in 10m long stretched string. If the string vibrates in 5 segments and wave veloci...

CORE CONCEPT AND DERIVATION

When a stretched string vibrates in discrete segments (loops), each segment corresponds to half a wavelength.

Formula:

$$f_n = n \left(\frac{v}{2L} \right)$$

Solution:

- We are given string length $L = 10$ m, number of segments $n = 5$, and velocity $v = 20$ m/s.
- Plug the values into the generalized harmonic formula:
- $f_5 = 5 \times \left(\frac{20}{2 \times 10} \right)$.
- $f_5 = 5 \times \left(\frac{20}{20} \right) = 5 \times 1 = 5$ Hz.

Why other options are incorrect:

Option D arises if a student forgets the 2 in the denominator.
Option A calculates only the fundamental frequency ($n = 1$).

Question #110 Key: (A)

MDCAT 2016

The red shift measurement of Doppler effect of galaxies indicate that the universe is [MDCAT 2016]

CORE CONCEPT AND DERIVATION

Redshift in astronomical terms means the light from distant objects is stretched to longer (redder) wavelengths.

Solution:

- According to the Doppler effect, light waves from a source moving away from an observer stretch out (Redshift).
- Edwin Hubble observed that almost all distant galaxies exhibit a redshift, and the farther away they are, the greater the redshift.
- This profound observation serves as the primary evidence that space itself is stretching, proving the Universe is uniformly **expanding**.

Why other options are incorrect:

If the universe were contracting, we would observe widespread blueshifts. A stationary universe would yield no net shifts.

Question #111 Key: (A)

KMU 2016

In stationary wave [ETEA 2016]

CORE CONCEPT AND DERIVATION

Stationary (or standing) waves are formed by the superposition of two identical waves traveling in opposite directions.

Solution:

- Because the two parent waves carry equal amounts of energy in mutually opposite directions, the net flow of energy across any section of the medium is zero.
- Energy remains confined between the nodes; thus, there is **no transfer of energy** through space.

Why other options are incorrect:

Option B is incorrect because energy is not constant at all points; antinodes possess maximum kinetic/potential energy oscillation, while nodes have zero. Option C is wrong because adjacent loops are completely out of phase.

Question #112 Key: (B)

MDCAT 2015

An observer moves with velocity ' v ' toward a stationary source, then the number waves received in on...

CORE CONCEPT AND DERIVATION

"Number of waves received in one second" is the definition of apparent frequency.

Solution:

- When an observer moves **towards** a stationary source, they "intercept" more wave fronts per second than if they were standing still.
- The relative speed of the waves relative to the observer becomes $v + u_o$.
- Using $v = f\lambda$, the new frequency is $f' = \frac{\text{relative speed}}{\lambda} = \frac{v + u_o}{\lambda}$.
- Since original $\lambda = \frac{v}{f}$, we substitute to get $f' = \left(\frac{v + u_o}{v}\right) f$.

Why other options are incorrect:

Option D represents an observer moving away. Options A and C are incorrect mathematical formats for a moving observer (those formats are for a moving source).

Question #113 Key: (A)

KMU 2015

The ratio between the velocity of sound in air at 4 atm and that at 3 atm pressure would be: [ETEA 2015]

CORE CONCEPT AND DERIVATION

The speed of sound in an ideal gas is given by Laplace's formula:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Solution:

- According to Boyle's Law, at a constant temperature, density (ρ) is directly proportional to pressure (P).
- If pressure increases from 3 atm to 4 atm, the density of the air increases by the exact same proportion.
- Therefore, the ratio $\frac{P}{\rho}$ remains perfectly constant. The speed of sound is **independent** of pressure changes.
- The velocity remains the same, giving a ratio of 1:1.

Why other options are incorrect:

Students often wrongly assume speed scales linearly with pressure without considering the simultaneous density increase.

Question #114 Key: (D)

KMU 2014

The displacement '[Formula]' of a particle at time '[Formula]' is given by '[Formula]' the particle oscillat...

CORE CONCEPT AND DERIVATION

The general equation for a particle executing Simple Harmonic Motion is given by $x = x_0 \sin(\omega t)$.

Formula:

$$\omega = \frac{2\pi}{T}$$

Solution:

- By comparing the given equation $x = 10 \sin(4t)$ to the standard form, we can extract the angular frequency: $\omega = 4 \text{ rad/s}$.
- Rearrange the period formula: $T = \frac{2\pi}{\omega}$.
- Substitute ω : $T = \frac{2\pi}{4} = \frac{\pi}{2} \text{ s}$.

Why other options are incorrect:

Students might mistakenly divide the amplitude (10) by 4 or incorrectly invert the period formula.

Question #115 Key: (C)

KMU 2014

In a vibrating cord the point where the particles are stationary is called [ETEA 2014]

CORE CONCEPT AND DERIVATION

When stationary (standing) waves form on a cord, they create an alternating pattern of complete destructive and constructive interference.

Solution:

- A **Node** is a specific point along the standing wave where the interfering waves consistently cancel each other out, resulting in zero net displacement (stationary particles).
- An **Anti-node** is a point of maximum displacement.

Why other options are incorrect:

Crests and troughs are moving features of a progressive wave, whereas nodes represent fixed zero-displacement locations.

Question #116 Key: (C)

MDCAT 2012

When the source of sound moves towards the stationary observer, the value of apparent frequency '[Formula]' ...

CORE CONCEPT AND DERIVATION

According to the Doppler Effect, when a source moves towards a stationary observer, the sound waves get "compressed" in front of the source, leading to a shorter apparent wavelength and a higher apparent frequency.

Formula:

$$f' = \left(\frac{v}{v - v_{\text{source}}} \right) f$$

Solution:

- To mathematically yield a higher frequency ($f_o > f$), the fraction must be greater than 1.
- This requires the denominator to be smaller than the numerator.
- Using $(v - u)$ in the denominator correctly models this increase, where u represents the source velocity.

Why other options are incorrect:

Option A describes an observer moving towards a source.
Option B describes a source moving away (lower frequency).
Option D describes an observer moving away.

Question #117 Key: (A)

MDCAT 2011

The spectrum of a star's light is measured and the wavelength of one of the lines as the sodium's line is found...

CORE CONCEPT AND DERIVATION

The Doppler Effect applies to light waves. A shift in the observed wavelength indicates relative motion.

Solution:

- The laboratory wavelength (true wavelength) is 497 nm.
- The observed wavelength from the star is 589 nm.
- Since the observed wavelength is **longer** ($589 > 497$), the light has shifted toward the red end of the electromagnetic spectrum (Redshift).
- A redshift strictly occurs when the source is receding, or moving **away** from the observer.

Why other options are incorrect:

If the star were stationary, the wavelengths would match perfectly. If it were moving towards Earth, we would observe a smaller wavelength (Blueshift).

Question #118 Key: (B)

MDCAT 2010

An organ pipe closed at one end has a length of 25 cm. Wavelength of the fundamental note is [MCAT 2010]

CORE CONCEPT AND DERIVATION

For a pipe closed at one end, a stationary wave forms with a node at the closed boundary and an antinode at the open boundary.

Formula:

$$L = \frac{\lambda_1}{4}$$

Solution:

- The fundamental mode (first harmonic) has the simplest pattern: one node and one antinode, spanning one-quarter of a wavelength.
- Rearranging the formula gives $\lambda_1 = 4L$.
- Substitute the given length: $\lambda_1 = 4 \times 25 \text{ cm} = 100 \text{ cm}$.

Why other options are incorrect:

A student might incorrectly use the formula for an open pipe ($\lambda = 2L$) resulting in 50 cm, or equate wavelength directly to length (25 cm).

Question #119 Key: (A)

MDCAT 2010

Two waves of same amplitude are traveling in the same direction and are out of phase, their resultant wave is:...

CORE CONCEPT AND DERIVATION

When two waves superimpose, their resultant displacement is the algebraic sum of their individual displacements (Principle of Superposition).

Solution:

- "Out of phase" implies a phase difference of 180° (or π radians), meaning the crest of one wave perfectly aligns with the trough of the other.
- If they have the same amplitude (A), they perfectly cancel each other out: $y_{\text{net}} = A + (-A) = 0$.
- This is completely destructive interference.

Why other options are incorrect:

Option B describes constructive interference (in-phase waves). Option C is technically correct mathematically ($A - A = 0$), but "Zero" is the direct and standard physical description of the resultant amplitude.

Question #120 Key: (C)

MDCAT 2009

Speed of the waves is equal to: [MCAT 2009]

CORE CONCEPT AND DERIVATION

Wave speed is defined as the distance a wave travels per unit of time.

Formula:

$$v = \frac{\text{Distance}}{\text{Time}}$$

Solution:

- During one time period (T), the wave travels exactly one wavelength (λ). Therefore, speed $v = \frac{\lambda}{T}$.
- Since frequency (f) is the reciprocal of the time period ($f = \frac{1}{T}$), we can substitute this into the equation: $v = f\lambda$.
- Both expressions perfectly describe wave speed.

Why other options are incorrect:

Option D (λT) is dimensionally incorrect (meters $\times$ seconds instead of meters/second).

Question #121 Key: (A)

MDCAT 2009

What is it that we use to calculate the speeds of distant stars and galaxies? [MCAT 2009]

CORE CONCEPT AND DERIVATION

The Doppler Effect is the apparent change in the frequency or wavelength of a wave due to the relative motion between the source and the observer.

Solution:

- When stars or galaxies move away from Earth, the light they emit gets stretched, shifting towards the red end of the spectrum (Redshift).
- By measuring this exact shift in spectral lines, astronomers use the Doppler formula for light to precisely calculate the radial speed of these distant celestial bodies.

Why other options are incorrect:

Beats (acoustic amplitude modulation) and interference (superposition of waves) do not inherently provide relative velocity data for distant astrophysical objects.

Question #122 Key: (D)

MDCAT 2009

Speed of light, radio waves and microwaves in vacuum is: [MCAT 2009]

CORE CONCEPT AND DERIVATION

Light, radio waves, and microwaves are all forms of electromagnetic (EM) radiation.

Solution:

- All electromagnetic waves, regardless of their frequency or wavelength, travel at the exact same universal speed limit through a perfect vacuum.
- This constant speed (c) is approximately 3×10^8 m/s.

Why other options are incorrect:

Options A, B, and C represent speeds that are vastly slower than the true speed of light in a vacuum.

Question #123 Key: (B)

MDCAT 2008

A standing wave pattern is formed when the length of string is an integral multiple of ____ wavelength. [MCAT ...]

CORE CONCEPT AND DERIVATION

In a stretched string fixed at both ends, stationary (standing) waves are established only when the length of the string allows for nodes at both boundaries.

Formula:

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

Solution:

- The simplest standing wave (fundamental harmonic) consists of a single loop, which is exactly half a wavelength ($\lambda/2$).
- Therefore, the length of the string L must always be an integral multiple ($n = 1, 2, 3, \dots$) of a **half** wavelength to form stable standing wave patterns.

Why other options are incorrect:

Options A, C, and D are incorrect because standing waves also form at lengths like 1.5λ or 2.5λ , which are integral multiples of a half wavelength, but not integral multiples of full, double, or triple wavelengths.

Question #124 Key: (B)

MDCAT 2008

Transverse waves cannot be setup in _____. [MCAT 2008]

CORE CONCEPT AND DERIVATION

Transverse waves require a medium that has shear strength or rigidity so that displaced particles can pull adjacent particles perpendicular to the wave's direction of propagation.

Solution:

- Solids (like metals and soil) have rigid intermolecular bonds, allowing them to sustain the shear stress necessary for transverse waves.
- Fluids (liquids and gases) lack shear strength; their layers slide past one another. Therefore, they cannot support the restoring forces required for transverse mechanical waves (except on the surface of liquids due to surface tension).

Why other options are incorrect:

Metals, solids, and soil all have the structural rigidity required to transmit transverse waves, making them incorrect choices.