I. WAVES AND THE SPEED OF SOUND

1. The displacement of a wave is given by
   \[ y(x, t) = A \cos \left[ \frac{2\pi}{\lambda} x + \frac{2\pi t}{\tau} \right] \]
   What direction does it move in and what is its speed?

2. A wire is under tension \( T = 50 \text{ N} \). If the fundamental frequency is to be increased an octave (factor of two), what must the tension be increased to?

3. The longitudinal speed of sound in a certain metal is \( 2000 \text{ m/s} \). The metal has a density \( \rho = 2.5 \times 10^3 \text{ kg/m}^3 \). Find Young's modulus.

II. RESONANCES - HELMHOLTZ RESONATOR, SPRINGS

4. If all linear sizes in a Helmholtz resonator are increased by a factor of 2, find the factor by which the resonances change to.

5. A spring with spring constant \( k = 500 \text{ N/m} \) has attached to it a mass \( m = 0.2 \text{ kg} \). The spring mass system is subject to a frictional force \(-12\pi\text{ N} \cdot \text{m/s}\) where \( \omega \) is the speed. Find the new frequency.

6. Two pendulums of length \( L = 2.5 \text{ m} \) are coupled with a spring with spring constant \( k = 0.5 \text{ N/m} \). As shown, the masses are each \( m = 0.2 \text{ kg} \). Use \( g = 10 \text{ m/s}^2 \). Draw a picture showing the two natural modes of oscillation and their associated angular frequencies \( \omega \).

III. VIBRATIONS IN PIPES

7. Draw a picture of the acoustic pressure in a pipe closed by at one end and open at the other end for the fundamental and first overtone. Draw a picture for the displacement in a pipe open at both ends for the fundamental and first overtone.
3. A musical instrument consists of a set of musical bars, below them are tubes open at both ends that are constructed to resonate with the apex, one bar resonates at 688 Hz. What should the length of the tube resonator be?

4. A tube open at one end and closed at the other end resonates at 425 Hz. Take the speed of sound to be 340 m/s. The 425 Hz is the fundamental, find its length. A second similar tube has a fundamental frequency of 480 Hz. When played together, what is heard?

IV. Vibration in Drums, Metals

10. A rectangular drumhead has the nodal pattern shown. Boundaries are fixed nodes.

The pattern suggests that the length of the drumhead is $L = \frac{1}{4} m$. What are the components of the wavenumber? $k = (k_x, k_y)$. How is $\omega$ related to this $k_x, k_y$?

11. A circular drumhead has a nodal pattern shown. Describe how you find the frequency of vibration.

12. A metal bar is pivoted at both ends. The bar is $\frac{1}{2}$ m long. What is the fundamental $\lambda$ and next two $\lambda$'s. Draw a picture of the results. If a similar bar is 3 times as thick, what is the ratio of frequencies of this bar with the original one? Show the expression you used.
A single slit diffraction pattern is shown.

What happens to the position of the width if
A) \( w \) (the width of the slit) is decreased by 2
B) \( \lambda \) (the wavelength) is increased by 2
C) \( L \) (screen to slit distance) is increased by 2

Consider 8 slits each separate by distance \( d \). The wavelength is \( \lambda \). The phase between each successive opening is \( \delta \). At what phase angles is the interference pattern zero?

Draw a vector diagram for 8 vectors adding to zero for the 3 smallest cases and draw a picture of the interference pattern.

A plane wave of wavelength \( \lambda \) encounters two slits which are separated by \( d \).

\[ \frac{\lambda}{D} = \frac{1}{2} (\sqrt{5} - 1) = 0.618 \]

At what position does the angle of the first minimum in the interference pattern occur?
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I

1. \( k = 3 \), \( \omega = 300 \), \( \omega = k \nu \) \( \nu = \frac{\omega}{k} = \frac{300}{3} = 100 \) m/s.

2. \( f = \frac{\omega}{2\pi} = \frac{1}{2\pi} \sqrt{\frac{T}{M/L}} \) \( T = 2.94 \) T

3. \( v = \sqrt{\frac{Y}{\rho}} \) \( Y = \frac{v^2}{g} = 4 \times 10^6 \times 2.5 \times 10^3 = 10^{10} \) kg/s

II

4. \( A \sim \sqrt{\frac{V}{A}} \) \( S \sim \sqrt{\frac{A}{V}} \) \( A \rightarrow 2 L^2 \rightarrow 4 \)

5. \( V \rightarrow 2 \sqrt{3} \rightarrow 2.8 \)

6. \( \frac{V}{2} \rightarrow 2 \sqrt{8} \rightarrow \sqrt{2} = \frac{1}{2} \) goes down and out

7. \( \omega_0 = \sqrt{\frac{k}{m}} = \sqrt{\frac{5000}{.2}} = \sqrt{25000} = 50 \)

\( x = \frac{b}{m} = \frac{12}{.2} = 60 \) \( y = 80 \)

\( \omega = \sqrt{\omega_0^2 - y^2} = \sqrt{50^2 - 30^2} = 40 \)

III

8. \( \omega_1 = \sqrt{\frac{\omega_0^2}{12}} = \sqrt{25} = 5 \)

\( \omega_2 = \sqrt{\frac{\omega_0^2 - 2k \omega}{12}} = \sqrt{4 + \frac{1}{12}} = \sqrt{4 + \frac{1}{12}} \)

\( \omega_1 = \frac{3740}{8} \) \( \omega_2 = 3740 \)

PRESSURE

DISPLACEMENT

9. \( s = 688 = \frac{Tl}{2} = \frac{344}{2} \) \( 2l = 344 \) \( l = \frac{344}{2} = 172 \)
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19  λ/4 = L  λ = 4L  λ = 4L  λ = 3L
1/4 = 2m  λ2 = 2m  λ2 = 2m  λ2 = 2m

λ2 = 430  f = 427.5 Hz  f2 = 5 Hz

ω = 2π√(kx + ky) = 2π√(kx) = 1077.65

10  k = 3  LINES  USE J3(x)

k = 2  CIRCLES  FIND 2ND ZERO  x3  0  J3

x3  = rπλ  λ  = rπλ  λ  = rπλ

ω = kx  v/λ  = v/λ  = v/λ

ω  3π/4  = 3  for  each  mode

11  MIN  λ  = λ/2  sin θ  = λ/2  sin θ

M  = 4λ/3

R  = 5/8  cos ω/2  9 = 3π/2

12  λ/2 = L  λ = L  λ = L

ω = 2π/λ  υ = thickness  L = 2π/λ

ω  3π/2  = 3  for  each  mode

13  MIN  N = 8

sin θ  = λ/2  sin θ  = λ/2

L = 4L

14  R  = 4  λ = 2π/λ = 3π/2  N = 8

PRINCIPAL MAX  b  = 2π  3π  5π

2π/2  = 2π  3π  3π  5π

S = 45°  S = 45°  S = 45°  S = 45°

15  D  = 1  S = D  = D  

S = D

χ/2  sin θ = (χ/2)

NOTE  √(15) - 1 = φ