KEY

Physics 11 – Standing Waves Practice Quiz

1. A stretched string has a length of L = 50.0 cm long, and stretched to a tension such that the speed of waves in the string is 2.50 m/s. The string is fixed (held tight) at both ends (for example, it could be a guitar string). Follow the steps listed below to determine the first 3 natural frequencies of the string (resonant frequencies).

   a. First natural (resonant) frequency) = f_1

      i. Draw a sketch of the resonating string, labeling the parts.

      ii. State the known values:

         1. v = 2.50 m/s
         2. L = 1/2 × λ
         3. λ = 2× 50 cm = 1.00 m

         $\lambda = 2L$

      iii. Calculate the value of the first natural frequency:

         1. Equation in symbols: $v = f_1\lambda_1$
         2. Substitute expression for λ in terms of L

            $v = f_1(2L)$

         3. Use algebra to rearrange the equation to solve for f (do not yet enter measured number for length – keep the symbols "L" and "λ" in the equation)

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

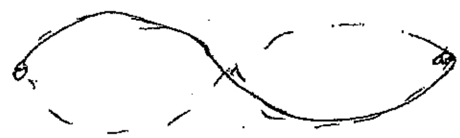
         4. Enter measured value for length and solve the equation. State the answer with appropriate significant digits and appropriate units.

            $f_1 = \dfrac{2.50\ m/s}{2(0.50\ m)}$

            f_1 = 2.50 Hz

b. Second natural (resonant) frequency) = f_2

i. Draw a sketch of the resonating string, labeling the parts.



ii. State the known values:

1. $v =$ 2.50 m/s
2. $L =$ 1 $\times \lambda_2$
3. $\lambda_2 =$ 50.0 cm = 1.00 m

iii. Calculate the value of the second natural frequency :

1. Equation in symbols: $v = f_2\lambda_2$
2. Substitute expression for λ_2 in terms of L

$$v = f_2(L)$$

3. Use algebra to rearrange the equation to solve for f (do not yet enter measured number for length – keep the symbol "L" in the equation)

$$f_2 = \frac{v}{L}$$

4. Enter measured value for length and solve the equation. State the answer with appropriate significant digits and appropriate units.

$$f_2 = \frac{2.50\,m/s}{0.50\,m}$$

$f_2 =$ 5.00 Hz

c. Third natural (resonant) frequency) = f_3

i. Draw a sketch of the resonating string, labeling the parts.

ii. State the known values:

1. v = 2.50 m/s
2. L = 1.5 × λ_3 $= \frac{3}{2}\lambda_3$
3. $\lambda_3 = \frac{2}{3}(50)$ cm = ~~0.333~~ m

$\therefore \lambda_3 = \frac{2L}{3}$

iii. Calculate the value of the third natural frequency :

1. Equation in symbols: $v = f_3\lambda_3$
2. Substitute expression for λ_3 in terms of L

$$v = f_3\left(\frac{2}{3}L\right)$$

3. Use algebra to rearrange the equation to solve for f (do not yet enter measured number for length – keep the symbol "L" in the equation)

$$f_3 = \frac{3v}{2L}$$

4. Enter measured value for length and solve the equation. State the answer with appropriate significant digits and appropriate units.

$$f_3 = \frac{3(2.50\,m/s)}{2(0.50\,m)}$$

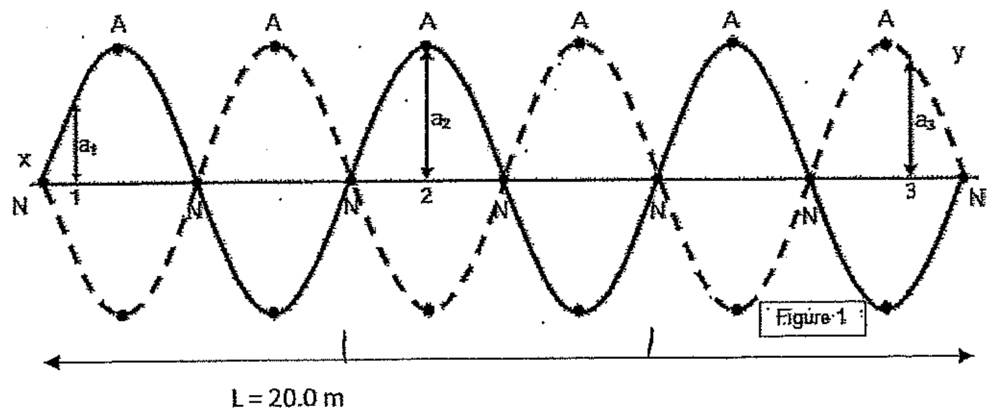
f_3 = 7.50 Hz

d. Refer to the expressions you developed in each of the questions above (a, iii, 3; b, iii, 3; c, iii, 3). Look for a pattern, and develop a general expression that will work for any resonant frequency "n" in a stretched string fixed at both ends (as in this question). Include L and λ_n in the expression.

~~f_1 =~~

$$f_n = \frac{nv}{2L}$$

2. Refer to the diagram of a standing wave on a stretched string. The length of the string is L = 20.0 m, and the frequency of the vibration shaking it is f = 20.0 Hz. Determine the speed of waves on the string.



$L = 3\lambda$

$\therefore \lambda = \frac{L}{3} = \frac{20.0\,m}{3}$

$v = f\lambda = (20.0\,Hz)\left(\frac{20.0\,m}{3}\right)$

$V = 133\,m/s$

$V = 1.33 \times 10^{2}\,m/s$