Answer on Question 66795, Physics, Molecular Physics, Thermodynamics

Question:

A stretched string of mass $20\ g$ vibrates with a frequency of $30\ Hz$ in its fundamental mode and the supports are $40\ cm$ apart. The amplitude of vibrations at the antinode is $4\ cm$. Calculate the velocity of propagation of the wave in the string as well as the tension in it.

Solution:

a) We can find the velocity of propagation of the wave in the string from the wave speed formula:

$$v = f\lambda,$$

here, v is the velocity of propagation of the wave in the string, f is the frequency, λ is the wavelength.

If the length of the string is L, the fundamental mode is the one produced by the vibration whose nodes are the two ends of the string, so L is half of the wavelength of the fundamental mode. Then, the wavelength of the fundamental mode will be equal to $\lambda = 2L$ and we can calculate the velocity of propagation of the wave in the string:

$$v = f\lambda = f2L = 30\ Hz \cdot 2 \cdot 0.4\ m = 24\ \frac{m}{s}.$$

b) We can find the tension in the string from the formula:

$$v = \sqrt{\frac{T}{\mu}},$$

here, v is the velocity of propagation of the wave in the string, T is the tension in the string, $\mu = M/L$ is the mass per unit length of the string.

Then, from this formula we can calculate the tension in the string:

$$v^2 = \frac{T}{\mu},$$

$$T = v^2\mu = v^2\frac{M}{L} = \left(24\ \frac{m}{s}\right)^2 \cdot \frac{0.02\ kg}{0.4\ m} = 28.8\ N.$$

Answer:

a) $v = 24\ \frac{m}{s}$.

b) $T = 28.8\ N$.