Problem 14.39

A stretched string fixed at both ends has mass .040 kg and length 8.0 meters. The tension in the string is 49.0 newtons.

a.) Determine the position of the nodes and antinodes for the third harmonic.

b.) What is the vibration frequency for this harmonic?

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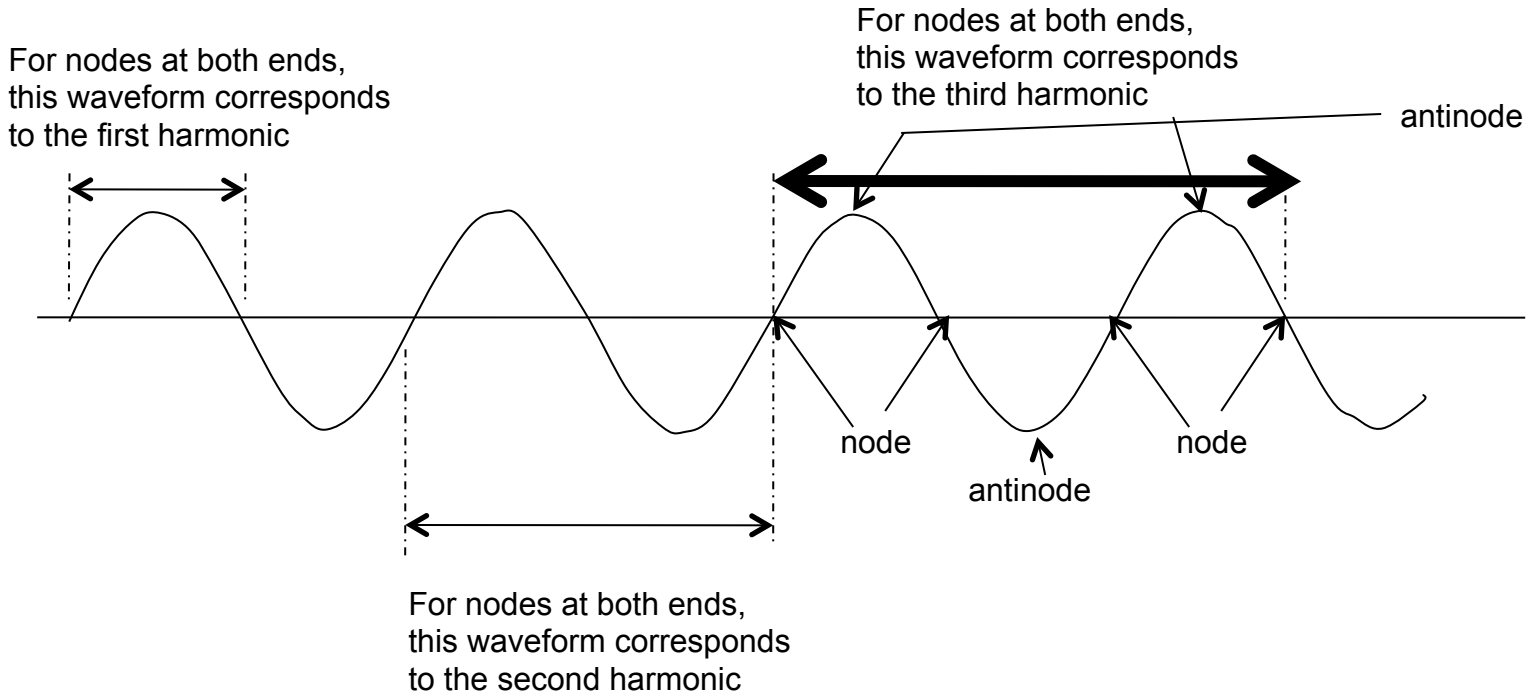
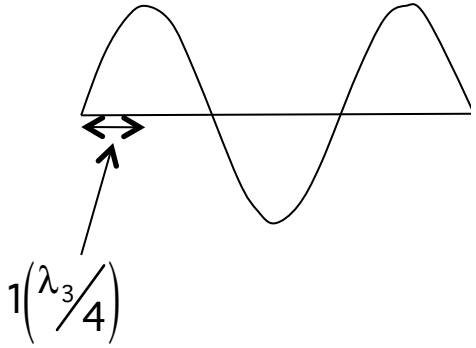


b.) What is the vibration frequency for this harmonic?

We need to use the relationship:

$$v = \lambda \nu$$

To get lambda, we have to ask the question: "How many quarter-wavelengths are there in the waveform?" Looking at the sketch, we can write:



$$?\left(\lambda_3/4\right) = L$$

$$\Rightarrow \quad 6\left(\lambda_3/4\right) = L$$

$$\Rightarrow \quad \lambda_3 = 2/3 L = 2/3 (8\,\text{m}) = 5.33\,\text{m}$$

To get the wave velocity, we need the tension in the line and the linear weight density of the string. That is:

b.) What is the vibration frequency for this harmonic?

The mass per unit length is: $\mu = \text{mass per unit length}$

$$= \frac{.040\ \text{kg}}{8.0\ \text{m}}$$

$$= .005\ \text{kg/m}$$

The tension is: $T = \text{tension in line}$

$$= 49\ \text{N}$$

So the wave velocity (courtesy of your book for the formula) is: $v = \sqrt{\frac{T}{\mu}}$

$$= \sqrt{\frac{49\ \text{N}}{.005\ \text{kg/m}}}$$

$$= 99\ \text{m/s}$$

Putting it all together, we get: $v = \lambda_3 \nu_3$

$$\Rightarrow \quad \nu_3 = \frac{v}{\lambda_3}$$

$$\Rightarrow \quad \nu_3 = \frac{99\ \text{m/s}}{5.33\ \text{m}}$$

$$\Rightarrow \quad \nu_3 = 18.7\ \text{cycles/sec}$$