Chapter 14 Problem 66 [†]

Given
$f = 440\ Hz$
$L = 38.9\ cm = 0.389\ m$
$F = 667\ N$

Solution
Find the mass of the string.

First the wavelength of the fundamental must be found. Since the string is clamped at both ends, its wavelength is just twice its length.

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

$$\lambda = \frac{2L}{n} = \frac{2(0.389\ m)}{1} = 0.778\ m$$

Next the velocity of the wave can be found.

$$v = f \cdot \lambda = (440\ Hz)(0.778\ m) = 342\ m/s$$

The velocity is related to the mass per length by

$$v = \sqrt{\frac{F}{\mu}}$$

Solving for the mass per length gives

$$\mu = \frac{F}{v^2} = \frac{(667\ N)}{(342\ m/s)^2} = 0.0057\ kg/m$$

The mass of the string is then

$$m = \mu \cdot L = (0.0057\ kg/m)(0.389\ m) = 0.00222\ kg$$

$$m = 2.22\ g$$

[†]Problem from Essential University Physics, Wolfson