15.40. A piano tuner stretches a steel piano wire with a tension of 800 N. The steel wire is 0.400 m long and has a mass of 3.00 g. (a) What is the frequency of its fundamental mode of vibration? (b) What is the number of the highest harmonic that could be heard by a person who is capable of hearing frequencies up to 10,000Hz?

**Identify:** The fundamental frequency depends on the wave speed, and that in turn depends on the tension.

\[ v = \sqrt{\frac{F}{\mu}} \] where \( \mu = \frac{m}{L} \). The nth harmonic has frequency \( f_n = nf_i \).

**Set Up:**

\[ f_i = \frac{v}{2L} \]

\( f_i = \frac{327 \text{ m/s}}{2(0.400 \text{ m})} = 409 \text{ Hz} \)

\( n = \frac{10,000 \text{ Hz}}{f_i} = 24.4 \)

(b) The 24th harmonic is the highest that could be heard.

**Evaluate:** In part (b) we use the fact that a standing wave on the wire produces a sound wave in air of the same frequency.