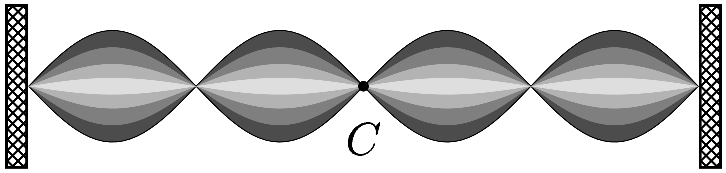
Consider a string of length L fixed at both ends. Its fundamental frequency gives a note A above middle C with frequency $f_A = 440$ Hz. Now consider a second string of the same length, again fixed at both ends. Its mass per unit length is one-half of that of the first string and its tension is twice as large.



The frequency of second harmonics of the second string is given by

A) $f_2' = \dfrac{1}{4}\, f_A\,.$

B) $f_2' = \dfrac{1}{2}\, f_A\,.$

C) $f_2' = f_A\,.$

D) $f_2' = 2\, f_A\,.$

E) $f_2' = 4\, f_A\,.$

$$f_A = \frac{1}{2\,L}\sqrt{\frac{F}{\mu}} \quad \text{and} \quad f_2' = 2\,f_1' \,.$$

$$f_1' = \frac{v'}{\lambda'} = \frac{1}{\lambda'}\sqrt{\frac{F'}{\mu'}} \,.$$

From the givens, both strings are fixed at both ends and have the same strength L.

The fundamental mode corresponds to half of a wavelength, or $\lambda_1' = 2\,L$.

Also from the givens, $F' = 2\,F$ and $\mu' = 0.5\,\mu$.

This leads to

$$f_1' = \frac{1}{\lambda'}\sqrt{\frac{F'}{\mu'}} = \frac{1}{2\,L}\sqrt{\frac{2\,F}{0.5\,\mu}} = 2\,\frac{1}{2\,L}\sqrt{\frac{F}{\mu}} = 2\,f_A \,.$$

$$f_2' = 2\,f_1' = 4\,f_A \,.$$

Answer **E**

18.03-01˙Standing˙Waves˙Fixed˙at˙Both˙Ends 2007-4-26