A violin string 0.700 m long is clamped at both ends. The mass of the string is 12.0 gram.

(a) Find the tension necessary so that the fundamental mode will be at a frequency of 440 Hz.

(b) Set the origin of your coordinate system (x = 0) at the midpoint of the string, as shown. Write, as completely as possible, the function describing the waves on this string for the fundamental and the first two overtones. [Hint: Draw pictures of the waves for these three situations, and use these pictures to determine the appropriate functions.]

\( v = \lambda f = \left( \frac{T}{m} \right)^{\frac{1}{2}} = \left( \frac{T}{m} \right)^{\frac{1}{2}} \)

\( \lambda = n \left( \frac{2\pi}{k} \right) \)

\( \frac{T}{m} = \left( \frac{n}{2} \right)^{2} \frac{4l^{2}f^{2}}{n^{2}} \)

\( T = 4 \left( \frac{1000}{9} \right) (440s^{-1})^{2} (0.12 kg) \)

\( T = 6.50 \times 10^{2} N \)

\( \gamma_{1}(x,t) = A_{1} \cos (k_{1}x) \cos (\omega_{1}t) \)

\( \gamma_{2}(x,t) = A_{2} \sin (k_{2}x) \cos (\omega_{2}t) \)

\( \gamma_{3}(x,t) = A_{3} \cos (k_{3}x) \cos (\omega_{3}t) \)

\( \gamma_{1}(x,t) = A_{1} \cos \left( \frac{2\pi}{L} x \right) \cos \left( \frac{2\pi}{L} \cdot 440 t \right) \)

\( \gamma_{2}(x,t) = A_{2} \sin \left( \frac{4\pi}{L} x \right) \cos \left( 4\pi \cdot 440 t \right) \)

\( \gamma_{3}(x,t) = A_{3} \cos \left( \frac{6\pi}{L} x \right) \cos \left( 6\pi \cdot 400 t \right) \)