Nov 30: Standing Wave on a string

$L = 1.75\ m, \quad \mu = 3.76 \times 10^{-3}\ \frac{kg}{m}$

hanging mass of 250 g, so $F_T = mg = 2.45\ N$

$$v = \sqrt{\frac{F_T}{\mu}} = \sqrt{\frac{2.45\ kg\,m/s^2}{3.76\times 10^{-3}\ \frac{kg}{m}}} = 25.5\ m/s$$

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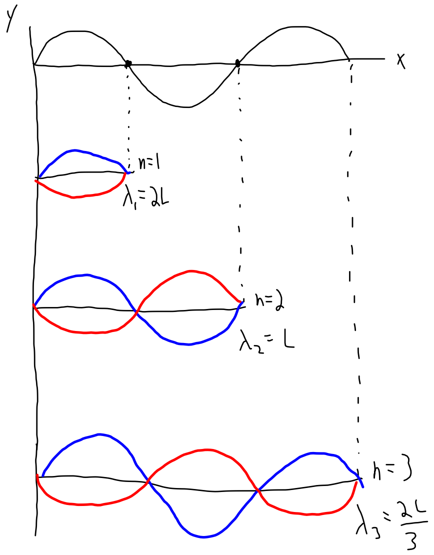

pattern is $\lambda_n = \frac{2L}{n}$

$$f_n = \frac{v}{\lambda_n} = n\frac{v}{2L}$$

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For this example, $v = 25.5\ \text{m/s}$, $L = 1.75\ \text{m}$

$$\lambda_1 = 2L = 3.5\ \text{m}$$

$$f_1 = n\frac{v}{2L} = \frac{25.5\ \text{m/s}}{3.5\ \text{m}} = 7.3\ \text{Hz} \quad (\text{measured } 7.4)$$

⋮

$$f_4 = 4\,\frac{25.5}{3.5} = 29.2\ \text{Hz} \quad (\text{measured } 29)$$

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Derivation

$y_R = y_1 + y_2$ ← right-ward travelling wave, left ward travelling wave

$$= A\sin(kx-\omega t) + A\sin(kx+\omega t)$$

$$= A\left[\sin(kx-\omega t) + \sin(kx+\omega t)\right]$$

Let $\alpha = kx$, $\beta = \omega t$

$$\sin(\alpha \mp \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$$

$$y_R = A\left[\sin(kx)\cos(\omega t) - \cos(kx)\sin(\omega t) + \sin(kx)\cos(\omega t) + \cos(kx)\sin(\omega t)\right]$$

$$\boxed{y_R = \left[2A\sin(kx)\right]\cos\omega t}$$

standing wave equation for $\sin(kx) = 0$

at $x = 0$

$x = L$

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