# PhysicsTutor

Standing wave mode on a string. Young & Freedman, 15.47

# Problem:

- A guitar string of length 63.5 cm is tuned to play the B3 note (245 Hz) as a fundamental.
- What is the speed of transverse waves on the string?
- The tension is increased by 1%. Which frequency is obtained?

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- Standing wave on a string of length L.
- First harmonic: n=1.
- Propagation speed depends on tension and on linear mass density.
- Tension force change implies propagation speed change. Wavelength remains the same, but frequency changes.

Equations associated with ideas:  

$$\begin{aligned}
& v_{W} = \lambda_{s} \cdot f & \lambda_{n} = \frac{2L}{n} & \text{with } n = 1 \\
& v_{W} = \sqrt{\frac{F_{E}}{M}} & \mu = \frac{M}{L} \\
& \overset{\Delta F_{L}}{\overset{}}_{F_{E}} = \frac{1\%}{n} & \overset{\Delta v_{W}}{\overset{}}_{T_{W}} = 0.5\%^{(*)} & \text{solution} \\
& \text{ideas} & \text{for part (b)} \\
& \ddots & \overset{\Delta f}{\overset{}}_{f} & \sim \frac{\Delta v_{W}}{v_{W}} & \sim 0.5\% \\
& (*) & \sqrt{x + \Delta x} = \sqrt{x} & \sqrt{1 + \frac{\Delta x}{x}} & = \sqrt{x} & (1 + \frac{1}{2} \frac{\Delta x}{x} + ...) = \sqrt{x} + \frac{1}{2} \frac{\Delta x}{\sqrt{x}} + ... \\
\end{aligned}$$

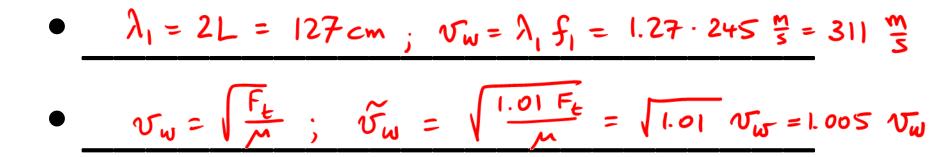
• Given L, n=1 we find the wavelength  $\frac{\lambda_1 = 2L}{L}$ 

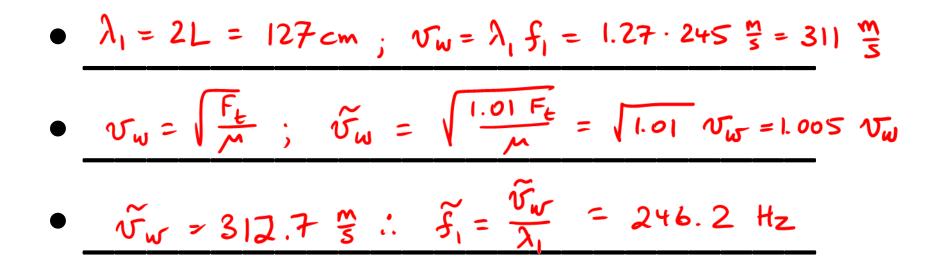
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- From wavelength and frequency we find the propagation speed  $\underbrace{\mathcal{V}_{w}}_{\mathcal{W}} = \lambda_{\mathcal{V}} \cdot f_{\mathcal{V}}$

- Given L, n=1 we find the wavelength
- From wavelength and frequency we find the propagation speed \_\_\_\_\_\_
- The tension force increase results in an increase of the propagation speed <u>𝕶̄𝑥 = √𝑎ψ</u>, not linear, but <u>~ √𝑎ψ</u>

- Given L, n=1 we find the wavelength
- From wavelength and frequency we find the propagation speed \_\_\_\_\_\_
- The frequency change is proportional to the propagation speed change, since  $f_1 = v_w / \lambda_1$

#### • $\lambda_1 = 2L = 127 \text{ cm}$ ; $\nabla_w = \lambda_1 f_1 = 1.27 \cdot 245 \frac{M}{2} = 311 \frac{M}{2}$





•	$\lambda_1 = 2L = 127 \text{ cm}$ ; $v_w = \lambda_1 f_1 = 1.27 \cdot 245 \frac{M}{3} = 311 \frac{M}{3}$
•	$\mathcal{T}_{W} = \sqrt{\frac{F_{L}}{M}};  \widetilde{\mathcal{T}}_{W} = \sqrt{\frac{1.01}{M}} = \sqrt{1.01}  \mathcal{T}_{W} = 1.005  \mathcal{T}_{W}$
•	$\tilde{v}_{w} = 312.7 \ ;  \tilde{f}_{i} = \frac{\tilde{v}_{w}}{\lambda_{i}} = 246.2 \ Hz = 246 \ Hz$
	$\frac{\Delta f}{f} = \frac{1.2}{245} = 5 \times 10^{-3} = 0.5\%$
	This confirms a result known from error analysis: errors in formulae involving powers of the measured quantity: $y = (x + \Delta x)^n$