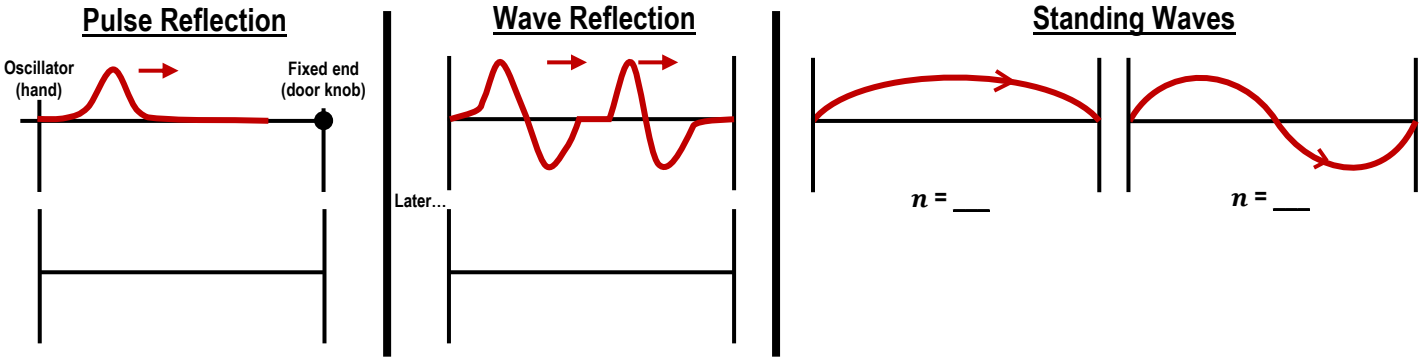
CONCEPT: INTRO TO TRANSVERSE STANDING WAVES

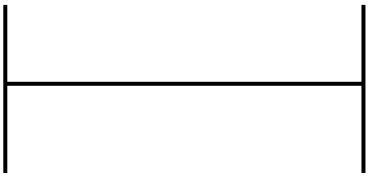
- When a traveling wave reaches a fixed endpoint, it creates a *reflected* wave that travels backwards, upside-down.
  - For *most frequencies*, these waves interfere randomly.
  - For *very special frequencies*, these waves interfere & make a wave that "looks" _____ → **Standing Wave**



[*You change the wave width by changing your frequency (wiggle faster/slower)*]

- There are infinite special frequencies which create standing waves, where n = # of loops.
  - "**Fundamental" Frequency** (f_1) ⇒ always when **n = ___**
  - **Harmonic Frequencies:** All other frequencies for n>1 standing waves are multiples of f_1: f_n = _____ (For n=1,2,3…)

EXAMPLE: A string between two supports vibrates in a standing-wave pattern of 3 loops with a frequency of 15Hz. **a)** Draw a sketch of the wave. **b)** What is the fundamental frequency? **c)** What is the frequency for standing wave with 5 loops?



PROBLEM**:** By whipping a string up and down, you determine the fundamental frequency to be 4 Hz**.** If you attached the string to a motorized oscillator and increased the frequency to 28Hz, how many loops would this standing wave have?

A) 14
B) 4
C) 28
D) 7

STANDING WAVES
$f_n = nf_1$

PROBLEM**:** One of the harmonic frequencies for a particular string under tension is 325 Hz**.** The next higher harmonic frequency is 390 Hz**.** What harmonic frequency is next higher after the harmonic frequency 195 Hz?

A) 130 Hz
B) 260 Hz
C) 196 Hz
D) 4 Hz

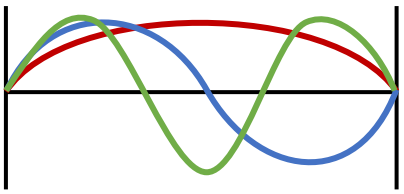
STANDING WAVES
$f_n = nf_1$

CONCEPT: EQUATIONS FOR TRANSVERSE STANDING WAVES

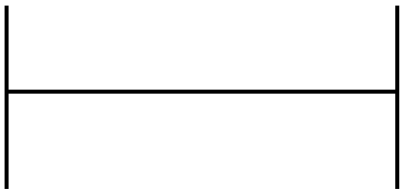
● **Standing Waves** can *ONLY* exist for special "Harmonic" frequencies, and have special values for wavelength:

- **"**Fundamental" (**n=1**) Frequency: $f_1 =$ ——
- Harmonic frequencies: $f_n = nf_1 =$ ——
- Wavelength: $\lambda_n =$ ——

For n = 1, 2, 3…



EXAMPLE: A 1.5m long string stretched between two supports with a Tension that makes the speed of transverse waves 48 m/s. What are the wavelength and frequency of the **a)** fundamental tone; **b)** first overtone?



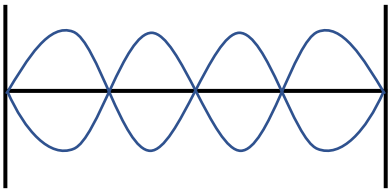
● "Harmonic" and "Overtone" are 2 words that *tell* you the value of n.

1st harmonic: n = 1; (fundamental)
2nd harmonic: n = 2; 1st overtone: n = 2;
3rd harmonic: n = 3; 2nd overtone: n = 3;

- In general, nth Overtone = n tones *over* fundamental frequency

PROBLEM: The figure below shows a standing wave on a 2.0-m-long string that has been fixed at both ends and tightened until the wave speed is 40 m/s. What is the frequency of this wave?

A) 20 Hz
B) 160 Hz
C) 40 Hz
D) 10 Hz



STANDING WAVES

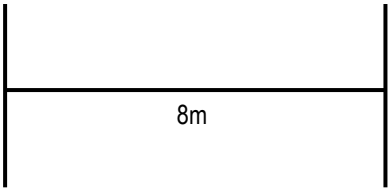
$f_1 = \frac{v}{2L}$

$f_n = nf_1 = \frac{nv}{2L}$

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

n^{th} Overtone = $(n+1)^{th}$ Harmonic

PROBLEM: A string fixed at both ends is 8 m long and has a mass of 0.20 kg. It is subjected to a tension of 100.0 N and set oscillating. **a)** What is the speed of waves on the string? **b)** What is the longest possible wavelength for a standing wave? **c)** Calculate the frequency of that wave.



STANDING WAVES

$v = \sqrt{\frac{F_T}{\mu}}$ (for *strings only*)

$f_1 = \frac{v}{2L}$

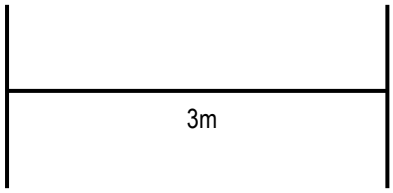
$f_n = nf_1 = \frac{nv}{2L}$

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

n^{th} Overtone = $(n+1)^{th}$ Harmonic

PROBLEM: A 3m-long rope is stretched between two supports with a tension that makes the speed of transverse waves 60 m/s. What are the wavelength and frequency of the second overtone?

A) λ **= 2 m ;** f **= 30 Hz**
B) λ **= 1 m ;** f **= 60 Hz**
C) λ **= 3 m ;** f **= 20 Hz**
D) λ **= 6 m ;** f **= 10 Hz**



STANDING WAVES

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