WAVES!

Basic wave parameters: $A$, $f$, $\lambda$, and $v_p$.

Waves are formed by coupled oscillators... in other words, a wave is a propagating disturbance in a medium of coupled oscillators. Note $v_p = \lambda/T = \lambda f$.

A wave can be described by any function whatsoever as long as the argument of the function is $x \mp v_p t$.

Transverse Waves: The standard wave function, for example for waves on a string, is

$$y(x, t) = A \cos[kx - \omega t]$$

where $k = 2\pi/\lambda$ and $\omega = 2\pi f$. A sin works just as well.

Notice that $v_p = \omega/k = \lambda f$.

The classical wave equation is

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v_p^2} \frac{\partial^2 y}{\partial t^2}.$$ 

Any function whatsoever will satisfy this equation if its argument is $x \mp v_p t$.

The phase speed of waves depends only on the mechanical properties of the material in which the wave
is propagating. For example for waves on a string, 
\[ v_p = \sqrt{T/\mu}. \]

Motion of the individual oscillators in a wave:
\[ v_y = \frac{\partial y}{\partial t}, \quad a_y = \frac{\partial v_y}{\partial t}. \]

Power carried by a wave:
\[ P_{\text{avg}} = \frac{1}{2} \mu \omega^2 A^2 v_p. \]

Intensity of 3-dimensional waves:
\[ I = \frac{P_{\text{avg}}}{4\pi r^2}. \]

Longitudinal Waves:
\[ s(x, t) = s_m \cos[kx - \omega t]. \]

Typically for sound waves, 
\[ v_p = \sqrt{B/\rho} = \sqrt{(\gamma p)/\rho}. \]

Sound level in decibels (dB):
\[ \beta = [10 \text{ dB}] \log \left( \frac{I}{I_0} \right). \]
Here $I_0$ is $10^{-12}$ W/m$^2$.

Characteristic Features of all waves:

$$y(x, t) = y_1(x, t) + y_2(x, t) + y_3(x, t) + \cdots$$

- Superposition, Interference, Dispersion (group velocity is $v_g = d\omega/dk$), beats ($f_B = |f_1 - f_2|$), reflection.

*Fixed end-reflection, phase change. Free end reflection, no phase change.*

**STANDING WAVES** are a consequence of reflection and interference (superposition). The secret to dealing with any displayed standing wave is to count the half wavelengths!

**Doppler Effect:**

$$f_D = f_S \frac{1 \pm (v_D/v_p)}{1 \mp (v_s/v_p)}.$$