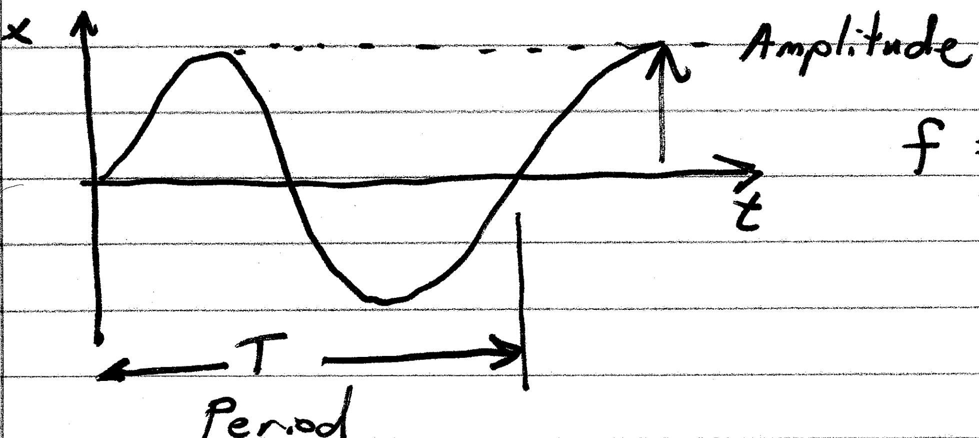
(1) Phys 1402 2014-11-04

Oscillations & Waves

Oscillations - any back-and-forth variation of an object.

- Measured quantity
  - Displacement (m)
  - Angle (° or rad)
  - Pressure (Pa)
  - Elec Field (V/m)
  - Magnetic Field (T)
- Equilibrium Value
- Restoring Force
  - makes system go back to equilibrium.
- Momentum
  - System "overshoots" the equilib.

Graph of oscillation



$$f = \frac{1}{T}$$

Spring Oscillator

Spring Force $F_s = -k x_s$

Force on mass $F_{net} = m a$

Frequency $f = \frac{1}{2\pi}\sqrt{k/m}$

Period $T = \frac{1}{f} = 2\pi\sqrt{m/k}$

Ex: 200 g mass oscillates at 5 HZ

$$f = \frac{1}{2\pi}\sqrt{k/m}$$

$$(2\pi f)^2 = k/m$$

$$k = (2\pi f)^2 m = (2\pi(5\,Hz))^2 (0.2\,kg)$$
$$= 197\ N/m$$

Energy Spring: $PE = \frac{1}{2} k x_s^2$

Mass: $KE = \frac{1}{2} m v^2$

When spring is stretched: Energy $= \frac{1}{2} k x^2 + 0$
At equilibrium: Energy $= 0 + \frac{1}{2} m v^2$

(3)

Energy of oscillator is constant, so

$$\frac{1}{2} k x_{max}^2 = \frac{1}{2} m V_{max}^2$$

$$\frac{k}{m} x_{max}^2 = V_{max}^2$$

$$V_{max} = \sqrt{\frac{k}{m}}\, x_{max}$$

$$= (2\pi f)\, x_{max}$$

$2\pi f = \omega$ (Greek omega) = angular frequency. measured in rad/s

Analytical Form: $x = x_{max} \sin(2\pi f t)$
Note sin() uses radians here!

Ex: $x = (4\,cm) \sin(0.6\pi t)$

Can say amplitude $x_{max} = 4$ cm

$2\pi f = 0.6\pi$ $\quad f = 0.3$ Hz

Waves - Formed from many connected oscillations

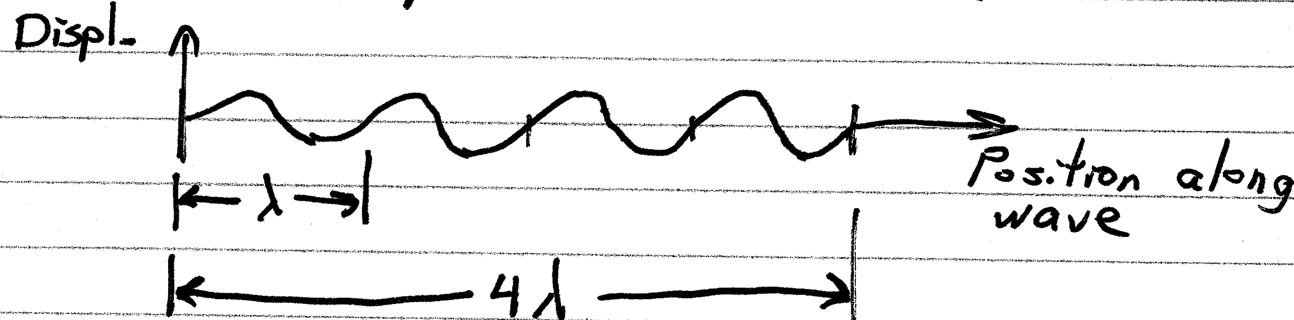
New ideas:

Speed of the wave v in m/s

Even though the wave propagates over long distances, the individual oscillators stay near their equilibrium positions.

Repeating Pattern has a length

Wavelength λ is the length of one cycle of the wave.



This wave is 4 wavelengths long.

$$v = \frac{\text{Dist}}{\text{Time}} = \frac{\lambda}{T} \qquad v = f\lambda$$

Ex: Sound Waves $V_{sound} \approx 340\ m/s$

Frequency range $v = f\lambda$

$f_{low} = 20\ Hz$ $\lambda = \frac{v}{f} = \frac{340\ m/s}{20\ Hz} = 17\ m$

$f_{high} = 20\ kHz$ $\lambda = \frac{340\ m/s}{20000\ Hz} = 0.017\ m$

$= 1.7\ cm$