Phys 1402 2015-11-03 Lec 20

Oscillations - any back-and-forth behavior.
- Voltage in AC
- Current in AC
- Magnetic field in coil w/ AC

- Spring oscillator (Simple Harmonic Osc)
- Pendulum
- String under tension is an oscillator formed from waves
- Air molecule in sound wave
- Ear drum

All Oscillations have timing related quantities
- Frequency (f) in hertz (Hz)
- Period (T) in seconds (s)
- Angular Freq (ω) in radians per second (s^{-1})

$$f = \frac{1}{T} \qquad \omega = 2\pi f$$

Ex: $f = 60\ Hz$ $\qquad T = \frac{1}{60\ \cancel{Hz}} = 0.0166\ s$

$$\omega = 2\pi f = 377\ s^{-1}$$

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Every osc has a quantity that varies.

The **Amplitude** is how far it varies from the **Equilibrium**.

What causes oscillations?
- Restoring Force
- Momentum or Inertia

Mass on a Spring (Lab 9)

$$F_s = -kx = ma \qquad a = -\frac{k}{m}x$$

If x is ⊕, a is ⊖, pulling the mass back to the middle.
If x is 0, a is 0, allowing the mass to keep going.

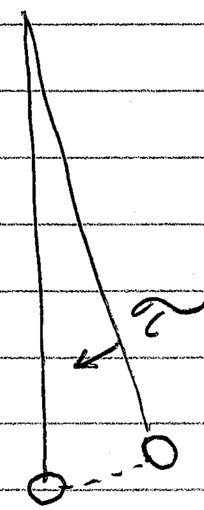
$$f = \frac{1}{2\pi}\sqrt{k/m}$$ Bigger = slower

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

③

Pendulum

For small amplitudes, the restoring force is approx proportional to the angle.



$$\tau \propto \theta$$

Spring $F_s \propto x$

$$f = \frac{1}{2\pi}\sqrt{g/L}$$

Bigger = slower

Ex: Want a period of 1.0 s.

$$f = \frac{1}{T} = 1.0 \text{ Hz}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}} \qquad 2\pi f = \sqrt{\frac{g}{L}}$$

$$(2\pi f)^2 = \frac{g}{L} \qquad L = \frac{g}{(2\pi f)^2} = \frac{9.81}{4\pi^2}$$

$$= 0.248 \text{ m}$$
$$= 24.8 \text{ cm}$$

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Energy in Oscillations

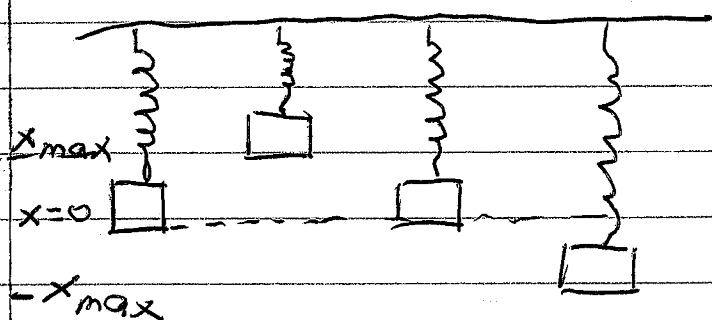
The energy of an oscillator is constant.

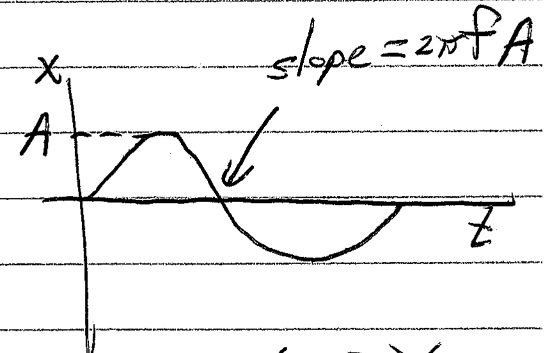
Spring Energy: $PE = \frac{1}{2}kx^2$

$$KE = \frac{1}{2}mv^2$$

$$\text{Total} = PE + KE = \text{const}$$

$$\frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \text{const}$$





$y = (-2\pi f A)(x - x_0)$

PE	0	$\frac{1}{2}kx_{max}^2$	0	$\frac{1}{2}kx_{max}^2$
KE	$\frac{1}{2}mV_{max}^2$	0	$\frac{1}{2}mV_{max}^2$	0

$$\text{Total} = \frac{1}{2}kX_{max}^2 = \frac{1}{2}mV_{max}^2$$

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

$$V_{max} = \sqrt{\frac{k}{m}}\,x_{max} = 2\pi f\,x_{max}$$

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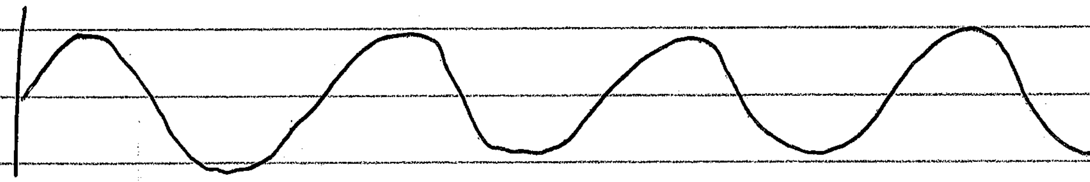
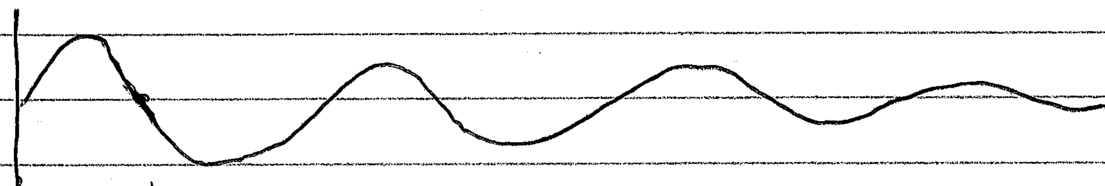
Damped Oscillations

Undamped: Amplitude = const

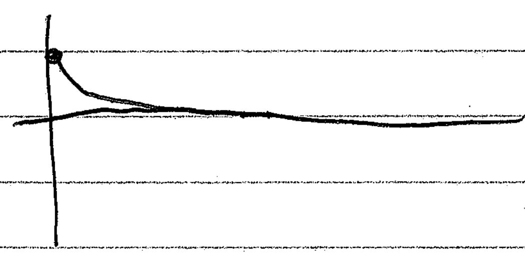


Damped: Decreasing Amplitude



This means energy is going away.

Overdamped: Amplitude decreases even before the "overshoot".



Looks exponential.