

Newton's Laws: $\vec{F} = m\vec{a}$

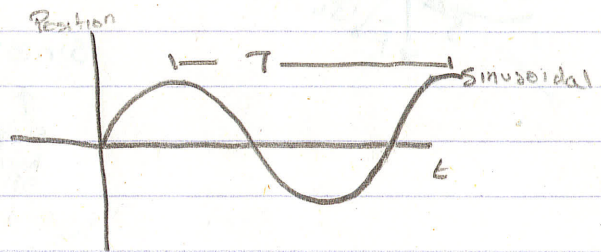
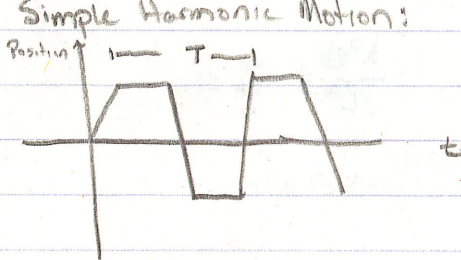
Energy, momentum, conservation

Coulomb's Law for Electrical Force

9/12 Lectures:

Oscillations:

Simple Harmonic Motion:



Mass on a spring

$$F = ma \quad a = \frac{d^2x}{dt^2}$$
$$F = -kx \quad k(N/m)$$

$$m \frac{d^2x}{dt^2} = -kx$$

$$\ddot{x} = -\left(\frac{k}{m}\right)x$$

$$x(t) = A \cos(\omega t + \phi)$$

↑
amplitude

↑
phase shift

$$\omega = \omega_0 \quad \omega_0^2 = k/m$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

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

$$\omega = 2\pi f$$

$$v(t) = \frac{dx}{dt}$$

$$= -v_{max} \sin(\omega_0 t + \phi)$$

$$v_{max} = \omega_0 A$$

$$x = A \cos \phi = 0 \quad v(t) = 0$$

$$v(t) = -\omega_0 A \sin \phi = 0$$

$$x(t) = A \cos \phi = A$$

$$\left. \begin{array}{l} \\ \end{array} \right\} \phi = 0$$

Energy:

Kinetic: $K = \frac{1}{2}mv^2$

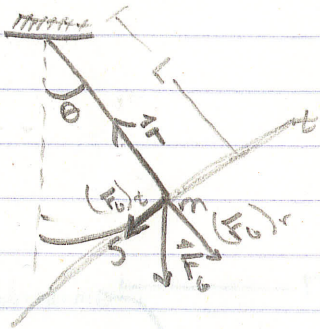
$$K + U = \text{const.}$$

Potential: $U = \frac{1}{2}kx^2$

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

$$v(x)^2 = \frac{k}{m}(A^2 - x^2)$$

Pendulum



$$F_{\text{tang}} = -mg \sin \theta$$

$$s = L\theta$$

$$\frac{d^2 \theta}{dt^2} = -\frac{g}{L} \sin \theta$$

$$\sin \theta \approx \theta$$

$$\frac{d^2 \theta}{dt^2} = -\frac{g}{L} \theta$$

↑
simple

harmonic motion
assumption → small oscillations

$$\omega_0^2 = g/L$$

9/7 Lecture:

Simple Harmonic Motion

$$x(t) = A \cos \omega t$$

$$v(t) = -\omega A \sin \omega t = -v_{\text{max}} \sin \omega t$$

$$a(t) =$$

Initial conditions:

① give mass an initial displacement x_0

② $v_0 = 0$, force to initiate motion

$$F = -kx$$

$$m \frac{d^2 x}{dt^2} = -kx \Rightarrow \frac{d^2 x}{dt^2} = -\frac{k}{m} x$$

$$\text{When } \omega_0^2 = \frac{k}{m}$$

$$\omega_0 = \frac{2\pi}{T}$$

$$x(t) = A \cos(\omega t + \phi)$$

$$v(t) = -\omega A \sin(\omega t + \phi)$$

Dimensions

$$\frac{1}{t^2} \sim \frac{N}{m \cdot kg} \frac{kg \cdot k}{t^2 \cdot kg \cdot k} = \frac{1}{t^2}$$

$$x = A \text{ @ } t=0, v=0$$

$$x(t) = A \cos \omega t$$

$$v(t) = -v_{\text{max}} \sin \omega t$$