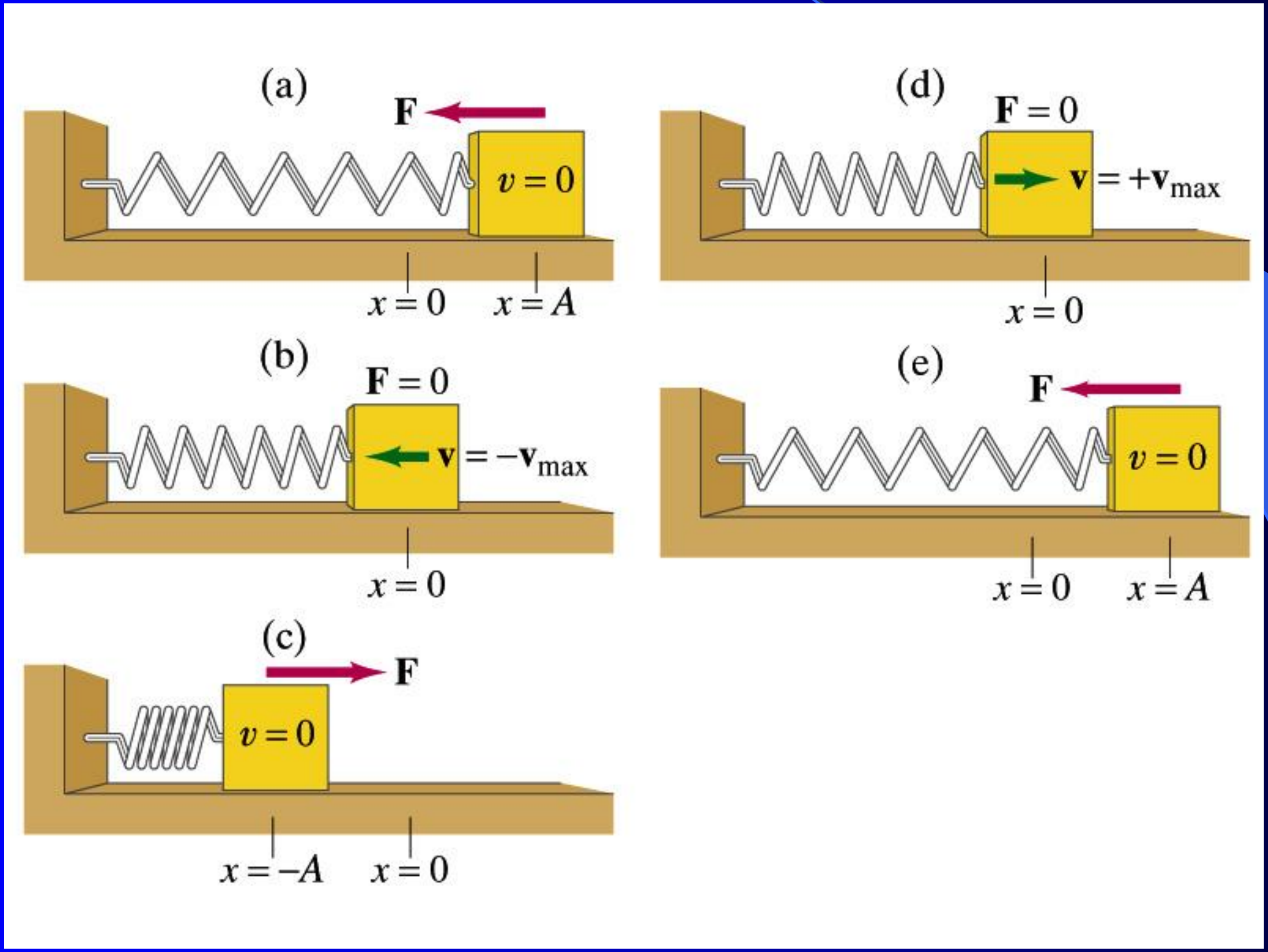
Stress and Strain

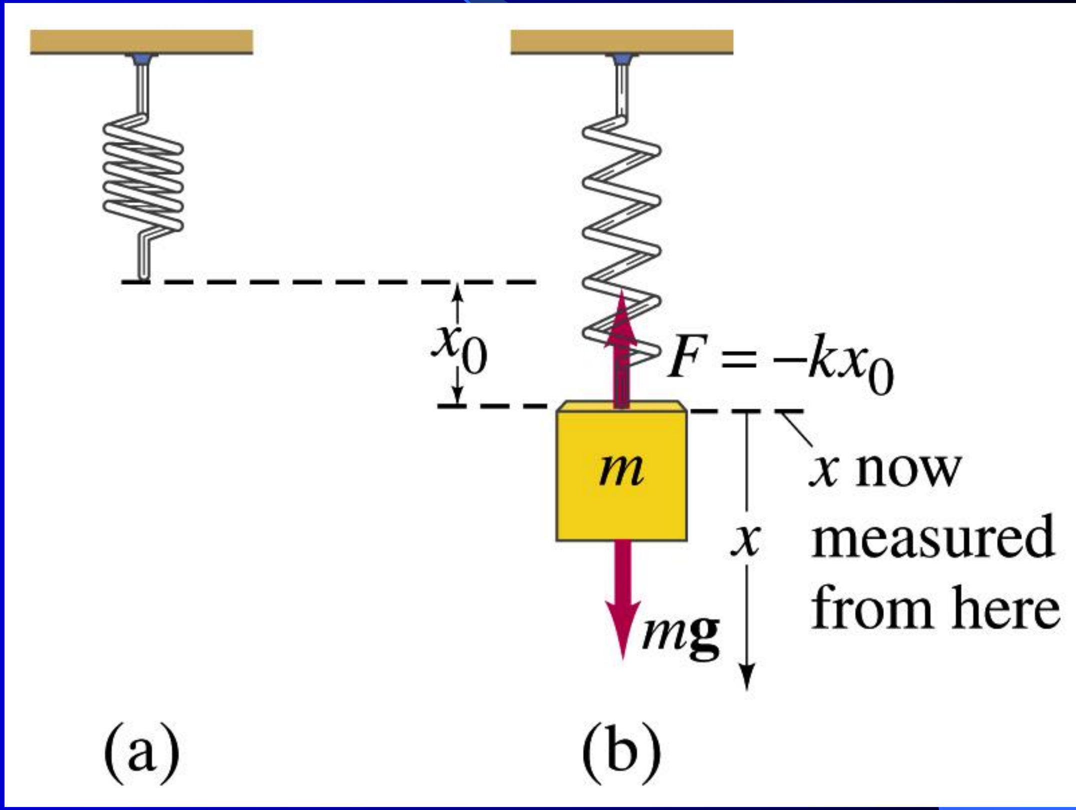
- Stress/Strain=Constant
- Tensile Stress = $F_{\perp}/A$ (Unit: N/m^2=Pa)
- Tensile Strain = $(l-l_0)/l_0$
- Young's modulus: Y=Stress/Strain= $l_0F_{\perp}/A(l-l_0)$
- $F_{\perp} = YA(l-l_0)/l_0 = k(l-l_0) = kx$

Oscillation of a Spring



Vertical Spring

- $\Sigma F=0=kx_0-mg$
- Any additional displacement x produces a force $F=-kx$

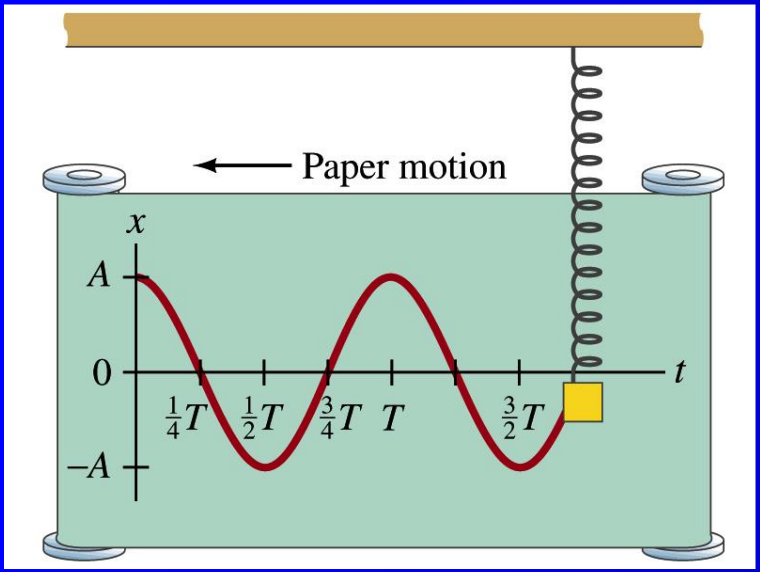


Simple Harmonic Motion

$$ma = \sum F$$

$$ma = -kx$$

$$a + \frac{k}{m}x = 0$$



- **Equation of Motion**
- How to solve?
- Guess an Ansatz

$$x = x_{max}\cos(\omega t + \phi)$$

Simple Harmonic Motion

$$x = x_{\max}\cos(\omega t + \phi)$$

$$a + \frac{k}{m}x = 0$$

$$v = -\omega x_{\max}\sin(\omega t + \phi)$$

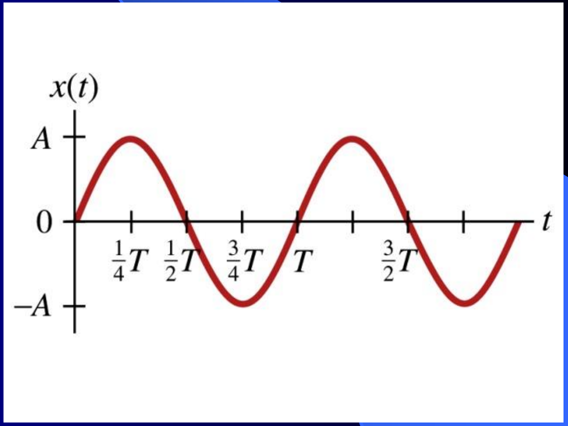
$$a = -\omega^2 x_{\max}\cos(\omega t + \phi)$$

$$-\omega^2 x_{\max}\cos(\omega t + \phi) + \frac{k}{m}x_{\max}\cos(\omega t + \phi) = 0$$

$$\left(\frac{k}{m} - \omega^2\right)x_{\max}\cos(\omega t + \phi) = 0$$

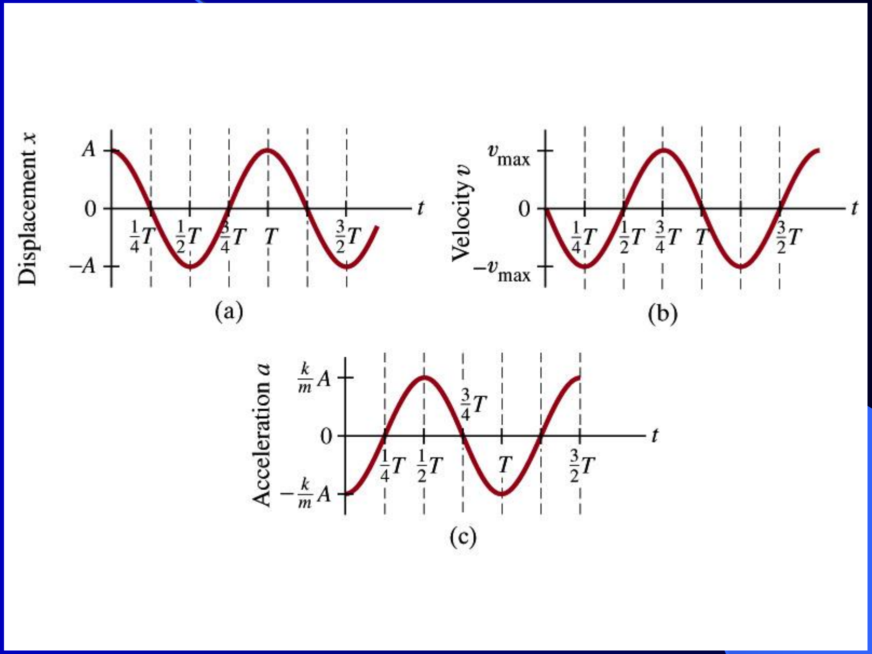
Simple Harmonic Motion

- When is $\left(\frac{k}{m}-\omega^2\right)x_{\max}\cos(\omega t+\phi)=0$ true for all t?
- Only if $\omega^2=\frac{k}{m}$
- x_{max} and ϕ are arbitrary!
- Determined through initial conditions
- cos function repeats itself after 2πrad
- $\cos(\omega T+\phi)=\cos(0+\phi)$ $\omega T=2\pi$



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

Summary



$$x = x_{max} \cos(\omega t + \phi)$$

$$v = -\omega x_{max} \sin(\omega t + \phi)$$

$$a = -\omega^2 x_{max} \cos(\omega t + \phi)$$

Energy in the SHO