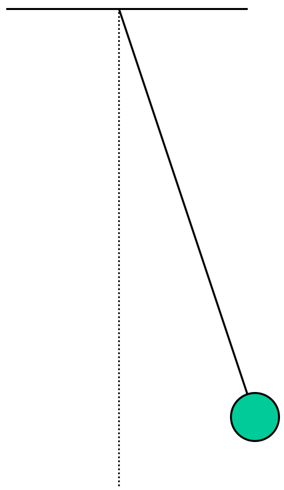
11-4. The Simple Pendulum



Small object suspended from the end of a light weight cord

Assume: Cord doesn't stretch
Cord mass negligible

Resemblance to SHM:

- Oscillates
- Equal A on both sides of e.p.
- Max speed as it pass through e.p.
- Potential + Kinetic Energy conserved

Period

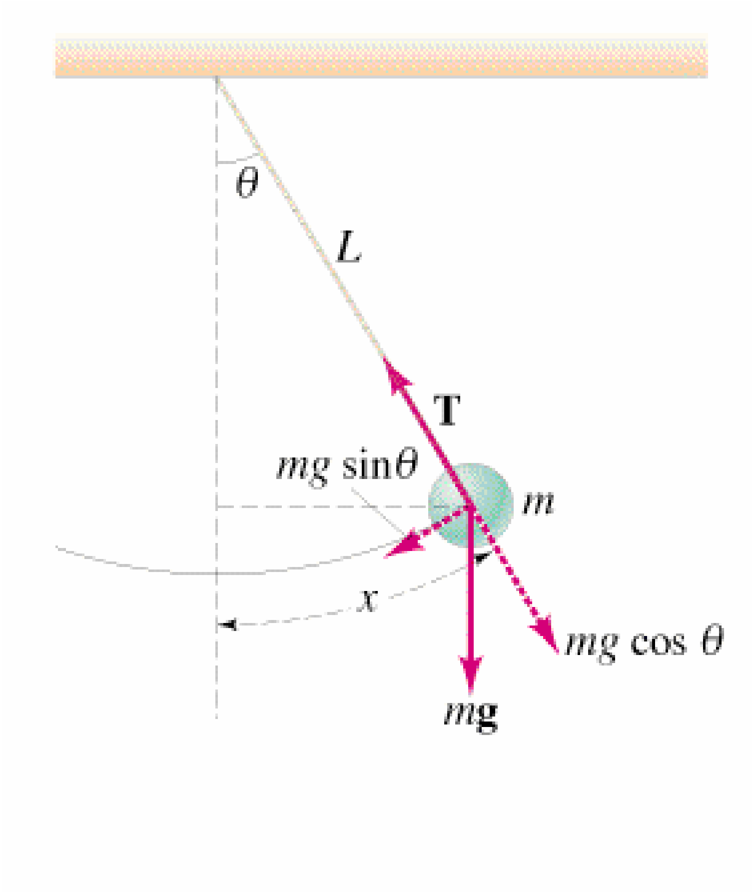
Does it depend on

Mass? NO!

Amplitude? Essentially NO

Cord length? YES!
Longer *l*, longer T

Pendulum Motion



Is it a SHO? $\vec{F} = -k\vec{x}$

Displacement, along arc

$x = L\theta$

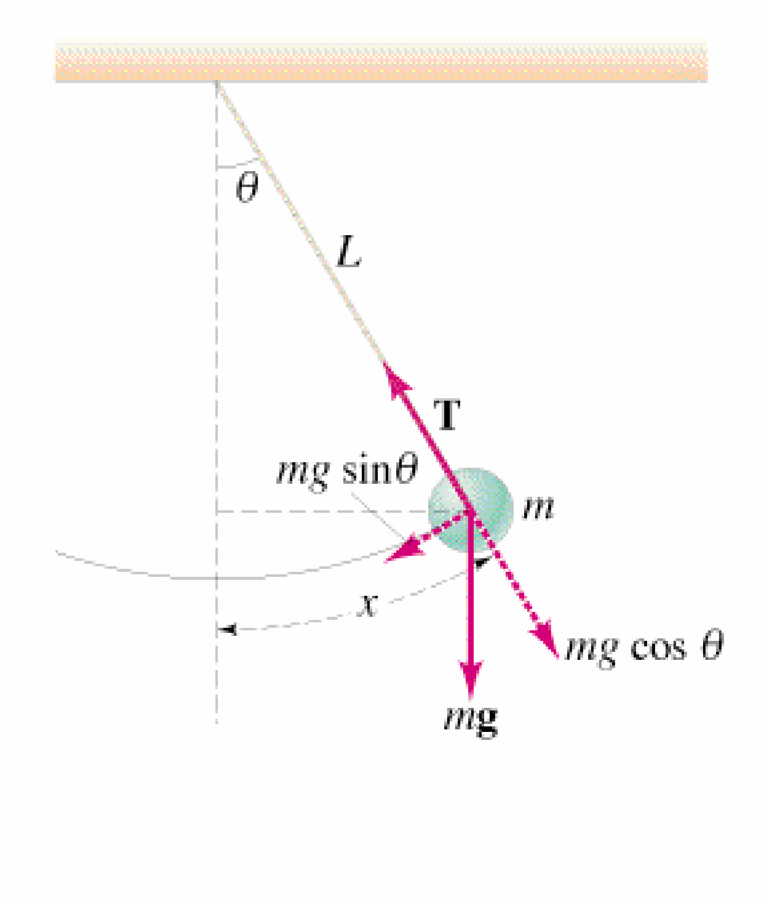
(θ in radians, $57.3^o = 1$ radian)

Restoring force

$F = -mg\sin\theta$

NOT SHM!

Pendulum Motion



Special case: θ is small

$\sin\theta \approx \theta$ *(in radians)*
(θ<*15*°, difference <1%)

$\theta = 10^{\circ} = 0.1745$ radians
$\sin\theta = 0.1736$

Restoring force

$F = -mg\sin\theta$
$\approx -mg\theta$

Since $x = L\theta$

$F \approx -(mg/L)x$

For small displacements, the motion is essentially SHM, $k=mg/L$

Pendulum Period

Period for SHM:

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

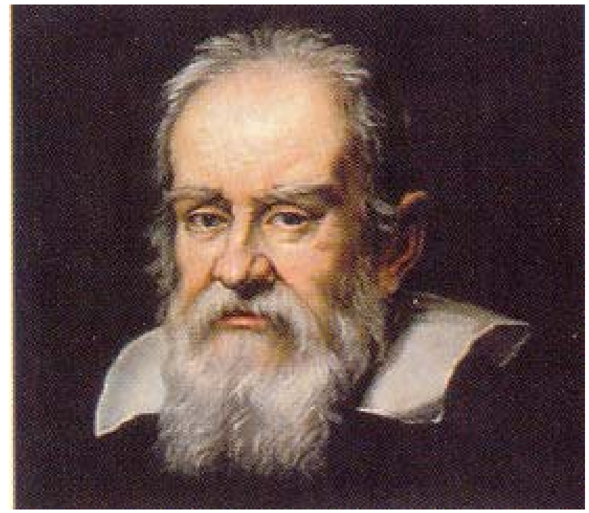
For pendulum, *k=mg/L*

$$T = 2\pi\sqrt{\frac{L}{g}}$$

θ small (Amplitude small)
No dependence on m

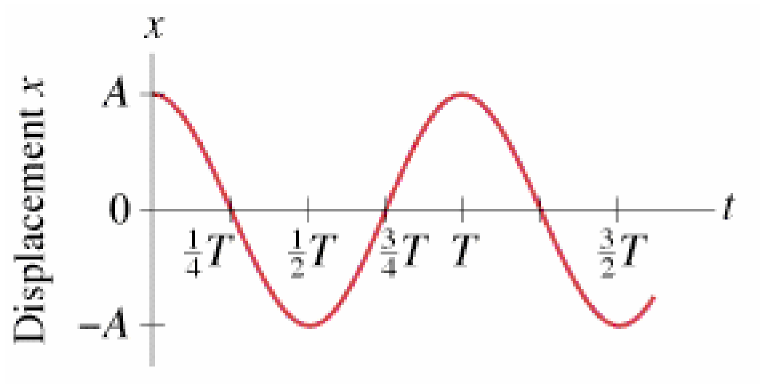
$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

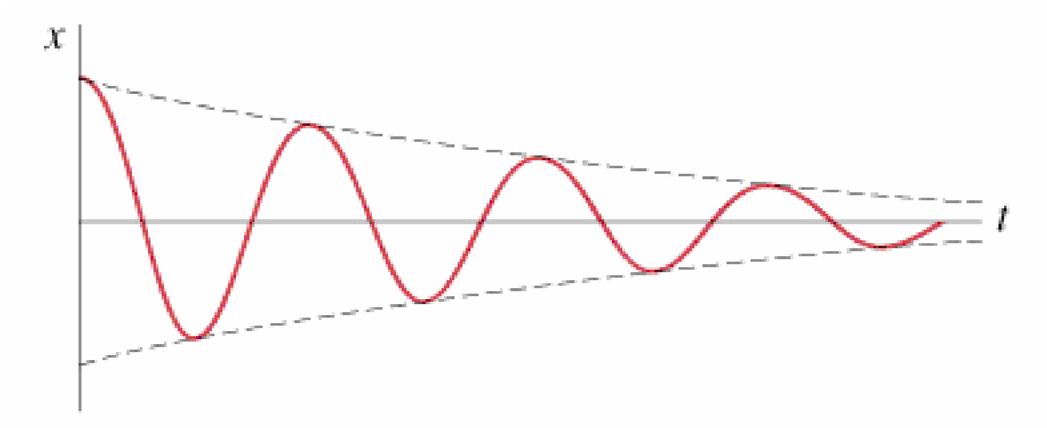
Pendulum Clock



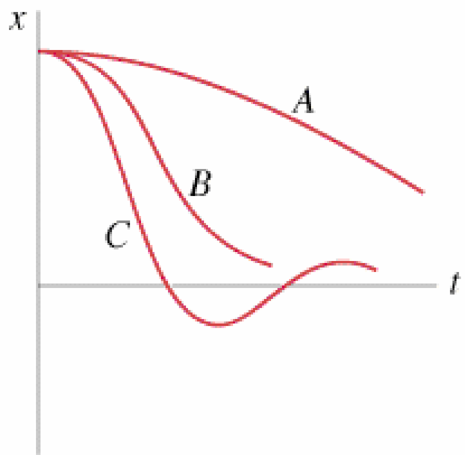
Grandfather clock:
1) If ticks once/sec, cord length?
2) If it's a 1-m long cord, Period?

11-5. Damped Harmonic Motion





Types of Damping

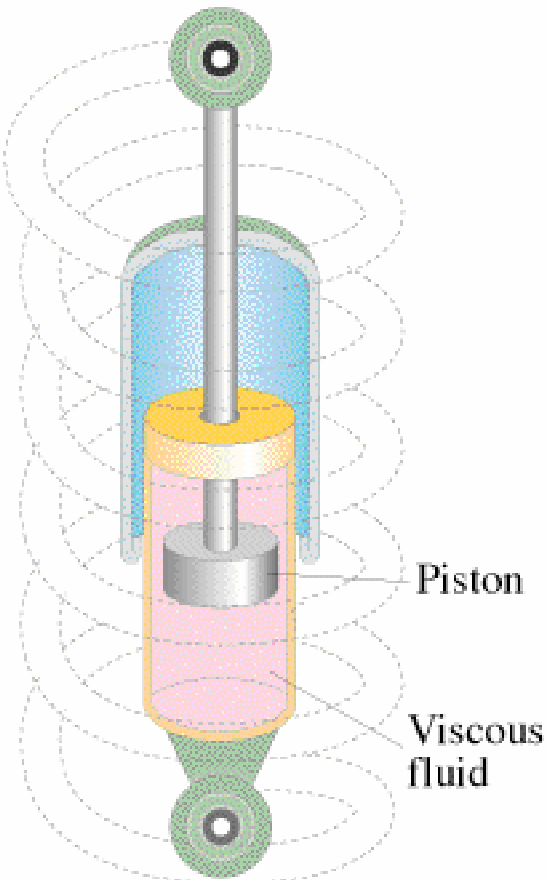


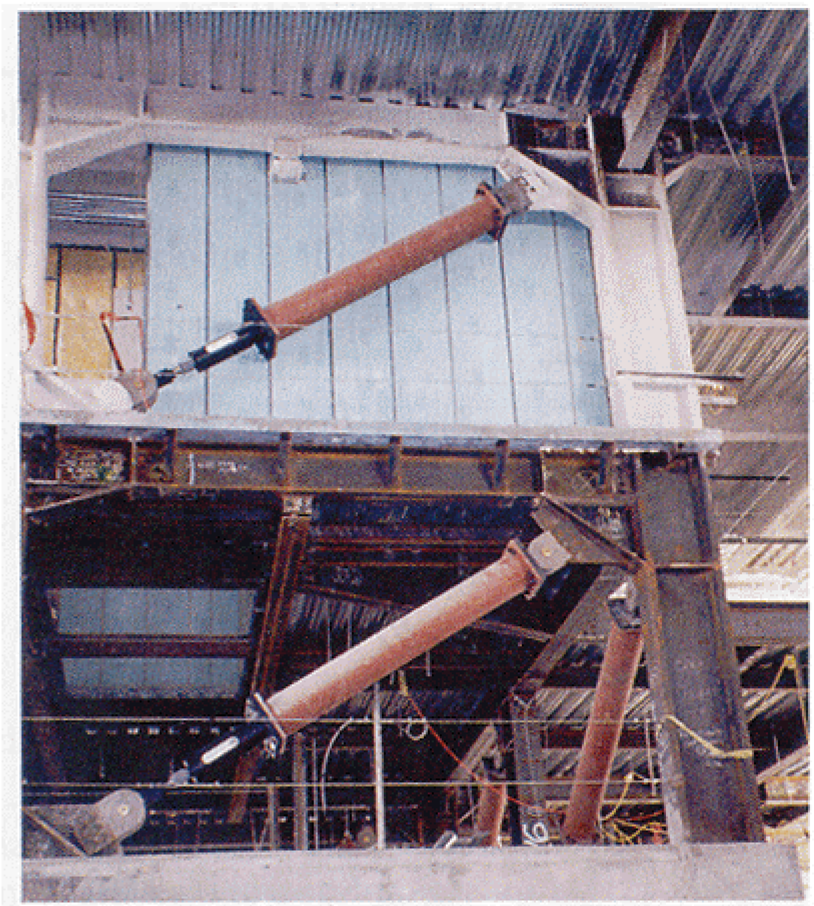
A: Overdamped

C: Underdamped

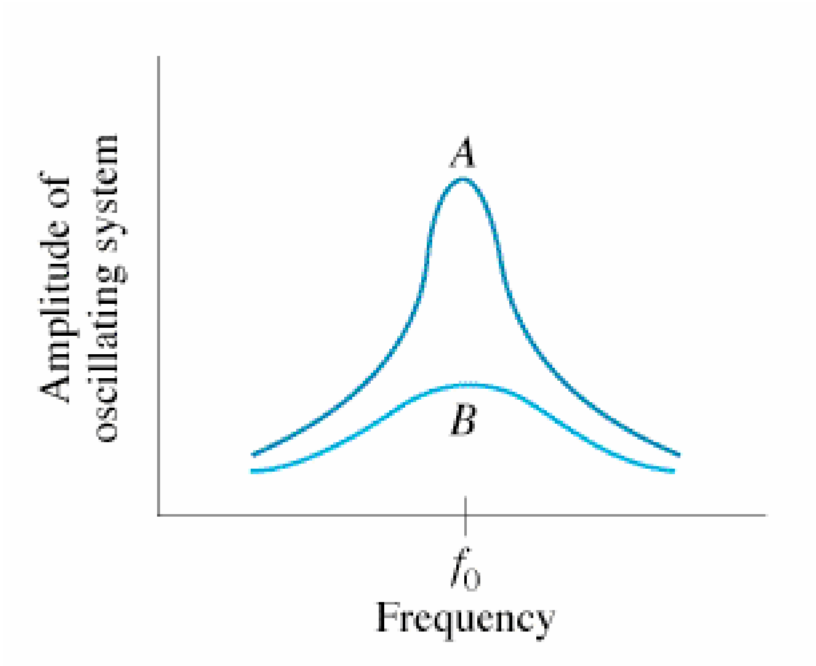
B: Critically damped

Shock Absorber





11-6. Forced Vibrations & Resonance



Natural frequency

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

Intrinsic

Resonance:

Very large increase in oscillation amplitude when $f=f_0$

Examples