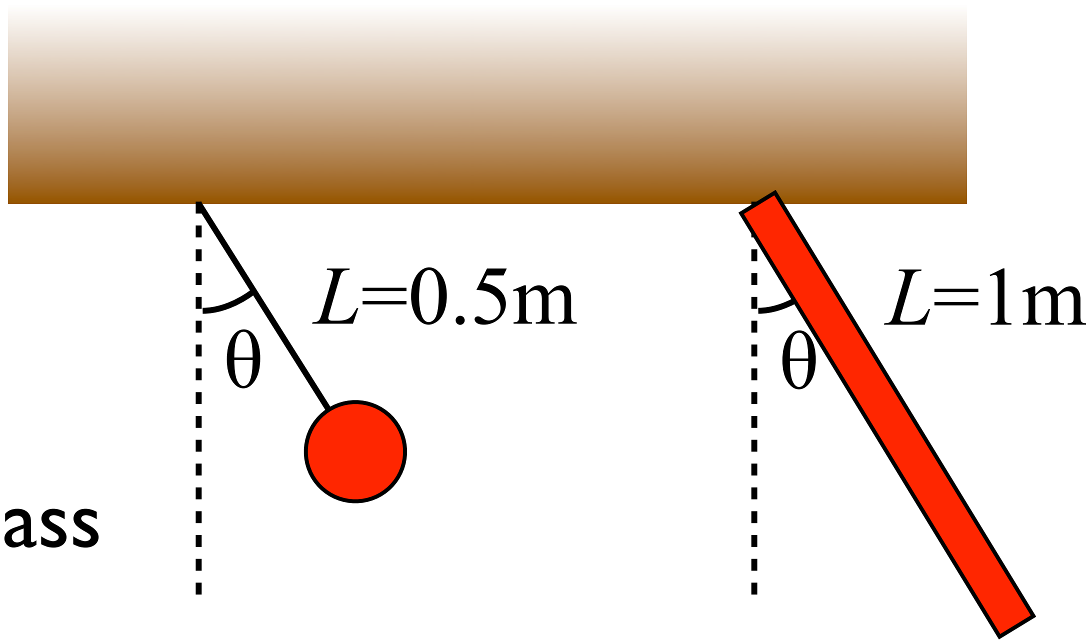
Which has a **shorter** period? A solid bar or a simple pendulum having the same distance to the center of mass?

A. Simple pendulum

B. Solid bar

C. They will have the same period

D. Depends on the mass



Text your answer to 22333

$I = ML^2/3$

Pendula

Simple pendulum

$$\omega = \sqrt{\frac{g}{L}}$$

Physical pendulum

$$\omega = \sqrt{\frac{mgd}{I}}$$

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

Ch 14.7-8
Damped Oscillations

PHYS 1210 -- Prof. Jang-Condell

Goals for Chapter 14

- To describe oscillations in terms of amplitude, period, frequency and angular frequency
- To do calculations with simple harmonic motion
- To analyze simple harmonic motion using energy
- To apply the ideas of simple harmonic motion to different physical situations
- To analyze the motion of a simple pendulum
- To examine the characteristics of a physical pendulum
- To explore how oscillations die out
- To learn how a driving force can cause resonance

Damped oscillations

- Real-world systems have some dissipative forces that decrease the amplitude.
- The decrease in amplitude is called *damping* and the motion is called *damped oscillation*.

Spring force

$$\sum F_x = -kx - bv_x$$

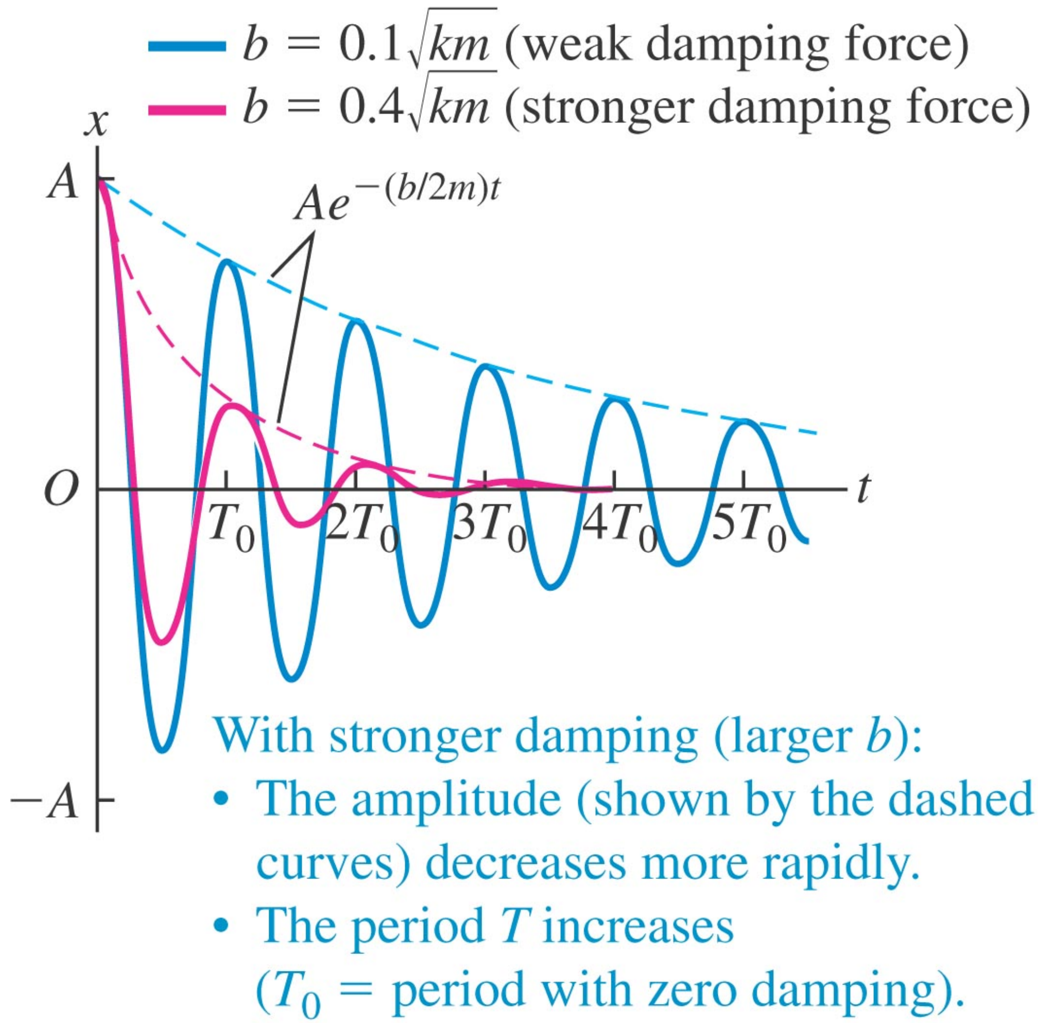
Damping force

$$x = Ae^{-(b/2m)t}\cos(\omega' t + \phi) \quad \text{(oscillator with little damping)} \qquad (14.42)$$

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}} \quad \text{(oscillator with little damping)} \qquad (14.43)$$

Damped oscillations

- Real-world systems have some dissipative forces that decrease the amplitude.
- The decrease in amplitude is called *damping* and the motion is called *damped oscillation*.
- Figure 14.26 at the right illustrates an oscillator with a small amount of damping.
- The mechanical energy of a damped oscillator decreases continuously.



Demo

Underdamping

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

- When $b^2/4m^2 < k/m$, then ω' is real.

Critical Damping

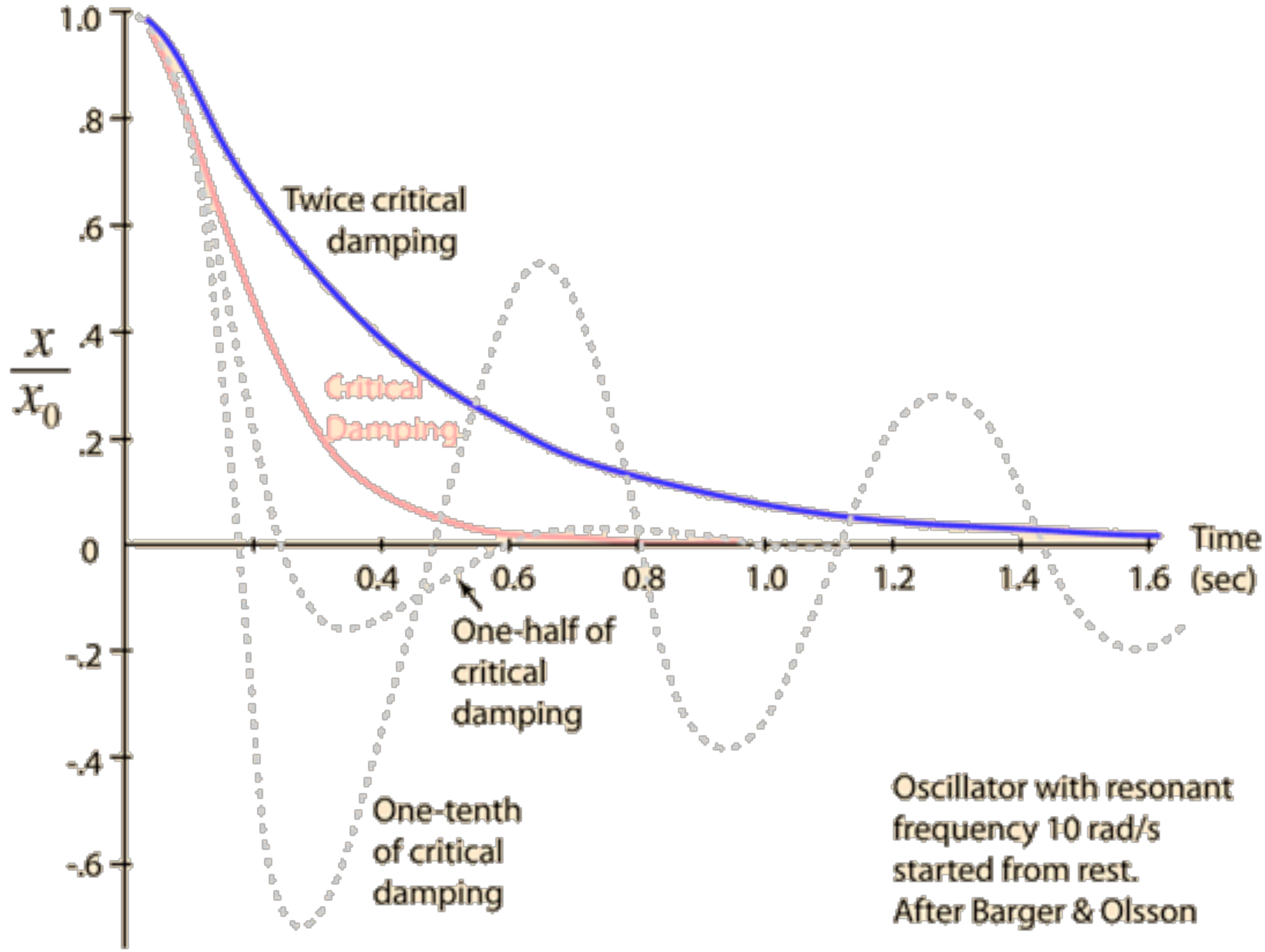
$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

- What if $b^2/4m^2 = k/m$?
- Then $\omega'=0$. **Critical damping**
- $x=(C_1 + C_2 t)\, e^{-at}$
- No oscillation, simply returns to equilibrium.

Overdamping

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

- What if $b^2/4m^2 > k/m$?
- Then ω' is imaginary. **Overdamping**
- $x = C_1 e^{-a_1 t} + C_2 e^{-a_2 t}$
- No oscillation, returns slowly to equilibrium.


1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
$\frac{x}{x_0}$
Twice critical
damping
Critical
Damping
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Time
(sec)
One-half of
critical
damping
One-tenth
of critical
damping
Oscillator with resonant
frequency 10 rad/s
started from rest.
After Barger & Olsson

Forced Oscillations

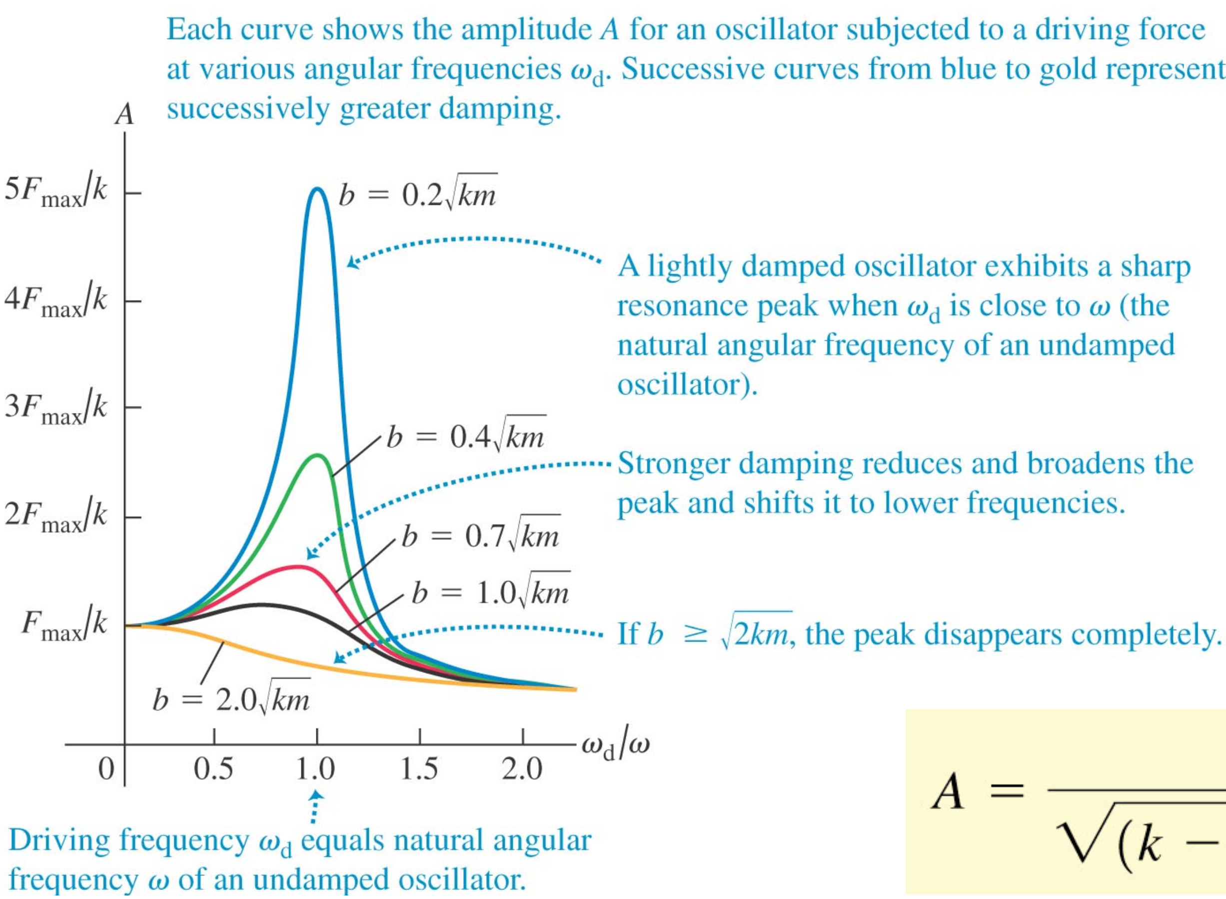
- When you periodically apply a force to an oscillator, this results in **forced oscillations**, or **driven oscillations**.

$$A = \frac{F_{\text{max}}}{\sqrt{(k - m\omega_{\text{d}}^2)^2 + b^2\omega_{\text{d}}^2}} \quad \text{(amplitude of a driven oscillator)} \quad (14.46)$$

ω_d = angular frequency of driver

Forced oscillations and resonance

- A *forced oscillation* occurs if a *driving force* acts on an oscillator.
- *Resonance* occurs if the frequency of the driving force is near the *natural frequency* of the system. (See Figure 14.28 below.)



$$A = \frac{F_{max}}{\sqrt{(k - m\omega_d^2)^2 + b^2\omega_d^2}}$$

Demo

Slinky© Drop

I hold a Slinky vertically so that it is all stretched out by gravity and not moving. What happens when I let go?

F. The slinky falls to the ground together.

G. The bottom of the Slinky stays where it is until the top catches up to it.

H. The bottom of the Slinky rises to meet the top, then it all falls together.

I. Something else.

Text 'PHYSJC' and your answer to 22333

Slinky Demo

Types of mechanical waves

- A *mechanical wave* is a disturbance traveling through a *medium*.
- Figure 15.1 below illustrates *transverse waves* and *longitudinal waves*.