# Information

- The Labs will be open on Friday at 2 pm.
- Car Testing will begin at 3 pm
- CW 6 is available at noon in front of the Physics offices
- There is a test next Tuesday at the same location as last time.

# Energy in SHM

*By the end of this lecture you should:*

Understand the notions of *natural frequency* of an oscillating system and the *driving frequency* of a system

Be able to define resonance

Give some real examples of resonance

Understand what is meant by *damping* and be able to give examples in which damping occurs

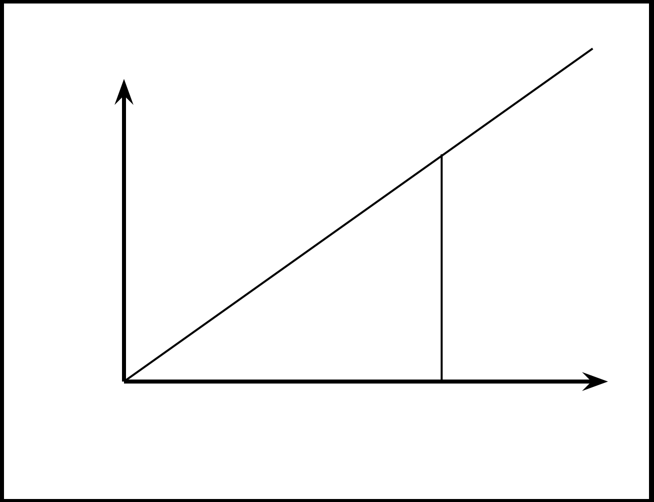
Have clear, useful notes from the material presented

# Energy in SHM

**Kinetic energy :**

**Potential energy:**

The energy required to extend the mass on a spring by a displacement x is stored in the spring and is called the potential energy



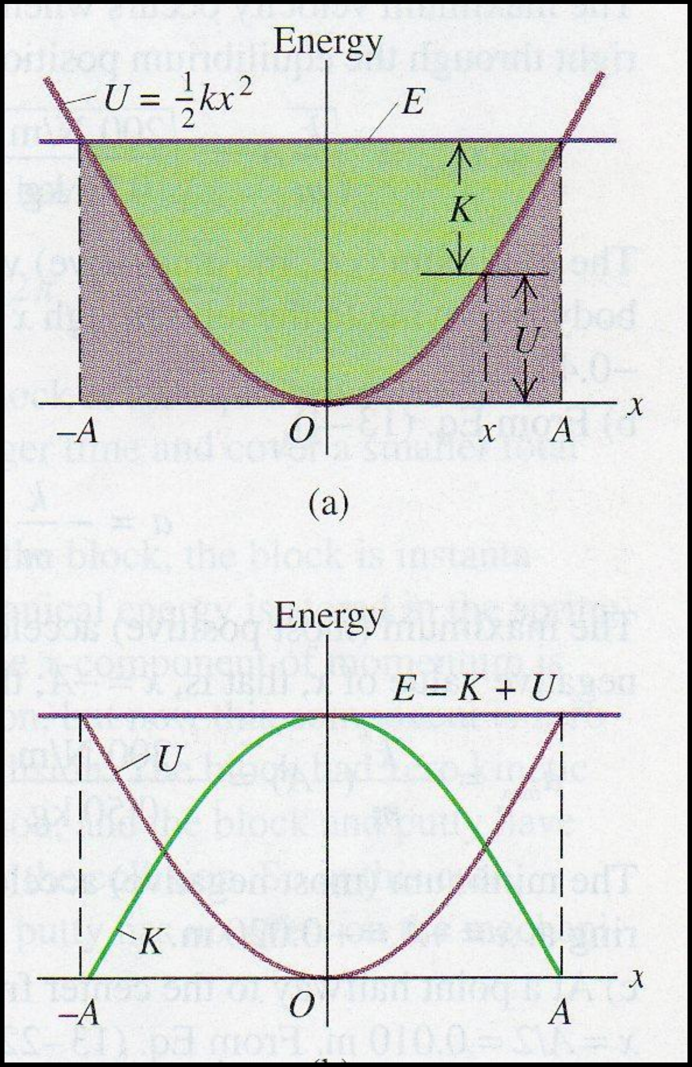
Hence the total energy is given by:

# How total energy, kinetic energy, and potential energy depend on the displacement x

Maximum KE is

Maximum PE is

So we can again show that:



## Example 1

A mass of 500 g is in equilibrium on the end of a vertical spring of force constant $k = 200\ \mathrm{N\ m^{-1}}$ .

It is then pulled downwards a distance $x = 2.00$ cm and released so that it oscillates with SHM.

Find the following at the point when the mass has travelled half-way towards the equilibrium position

a) the velocity

b) the acceleration

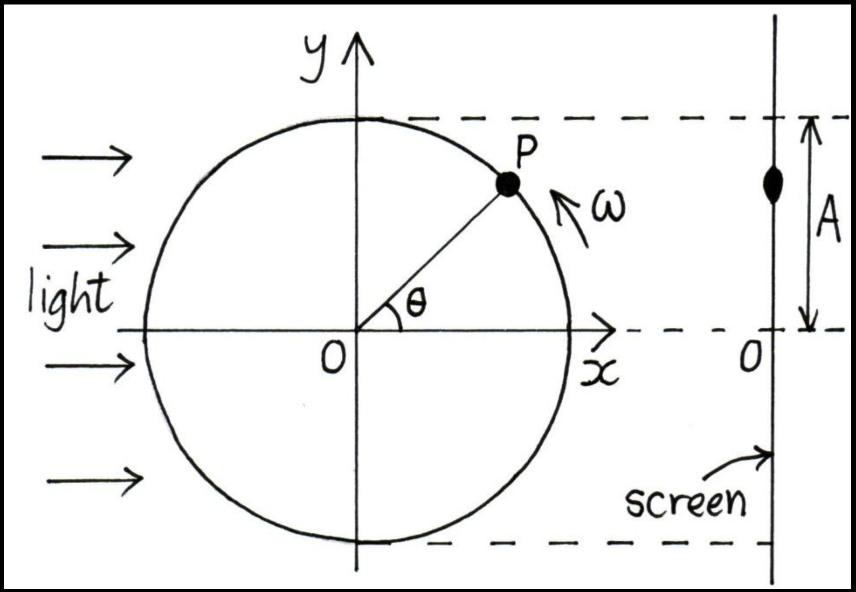
c) the total energy

d) the kinetic energy

e) the potential energy

# SHM and circular motion

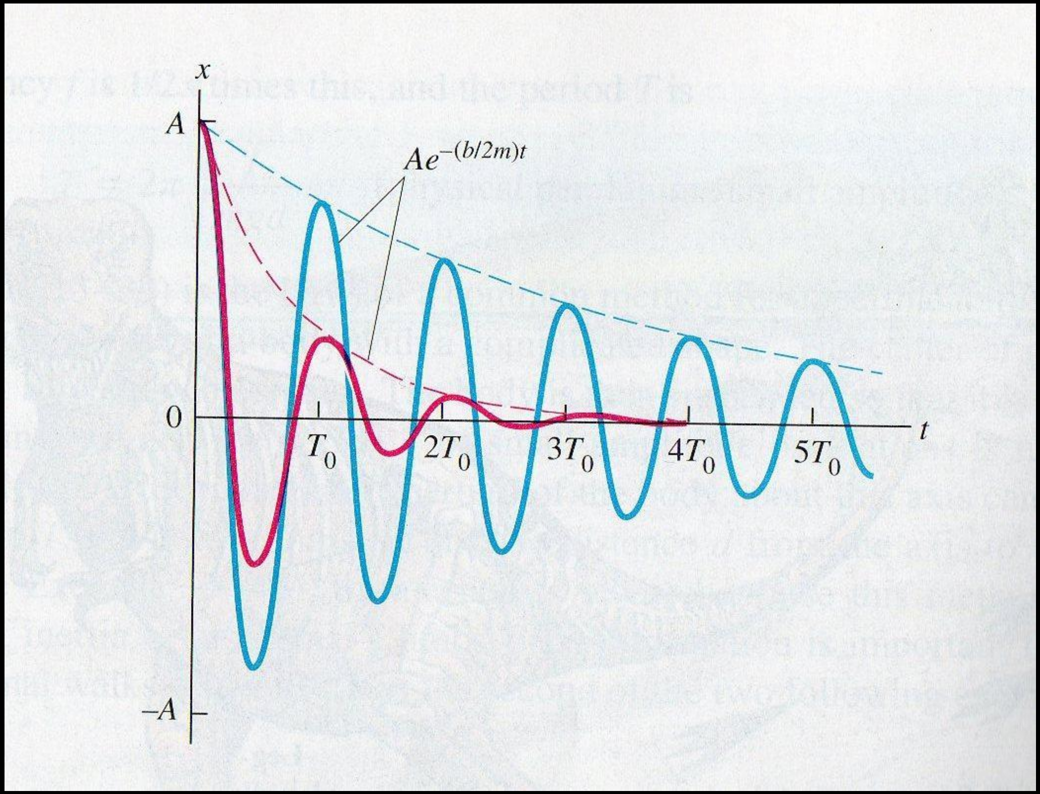
P moves in circular motion about O. If we illuminate this motion, P makes a shadow on the screen. As P rotates, the shadow of P on the screen moves with simple harmonic motion (SHM). We call this the projection of P on the y axis



# Let's make this more realistic.

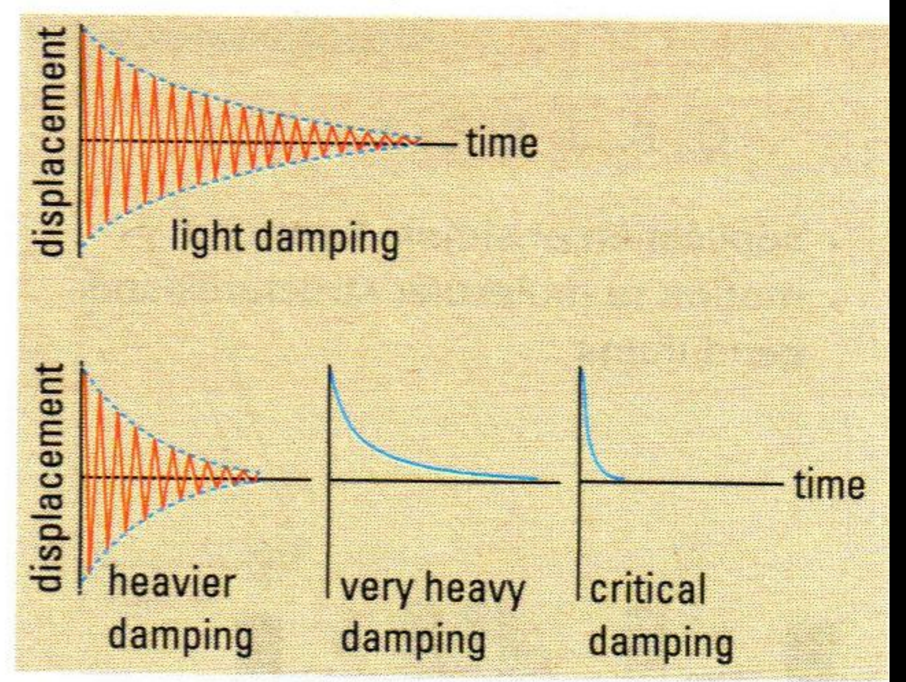
Add friction, air resistance etc **damping**

Mathematically our equation of motion becomes:

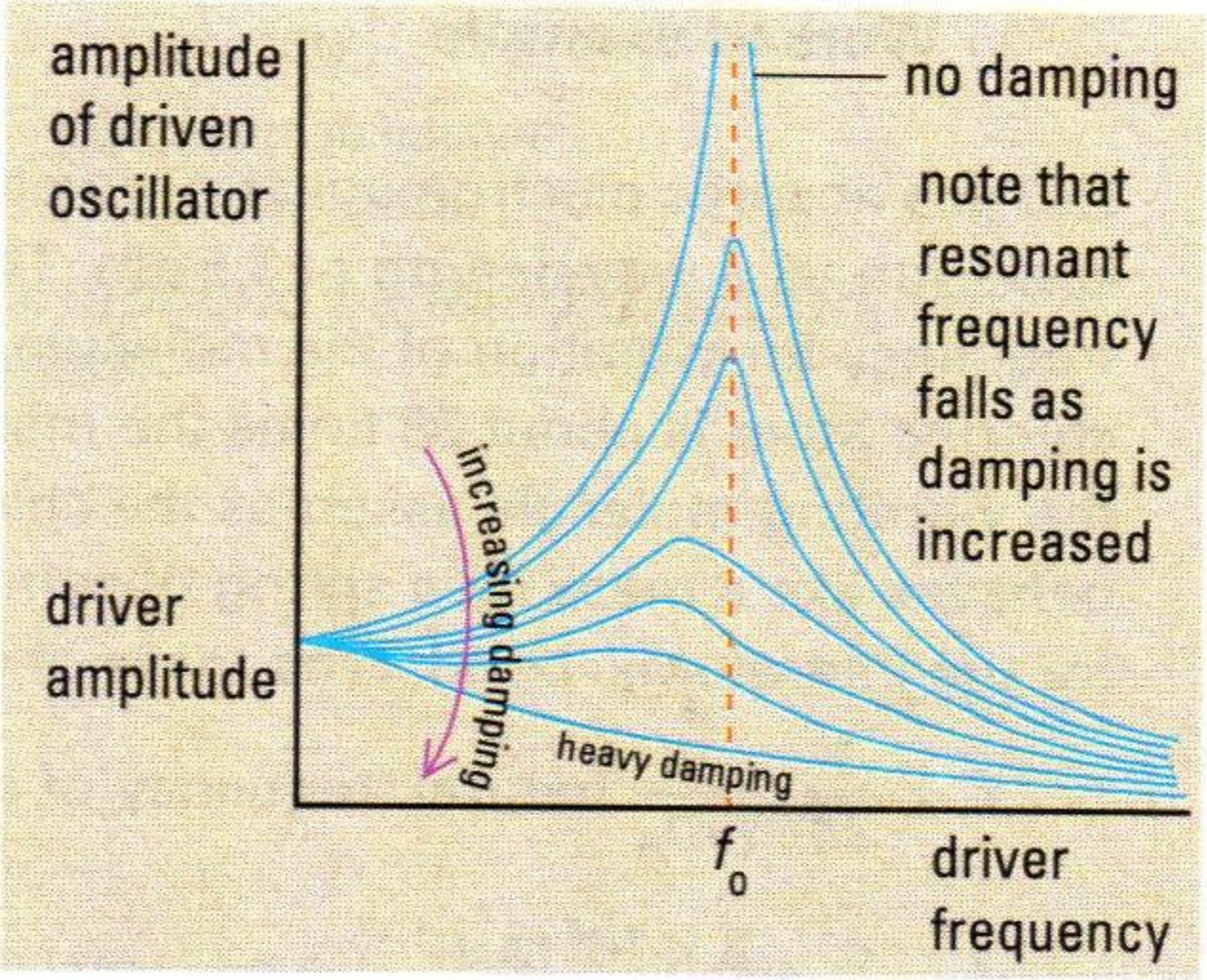


# Examples of damping

- A car's suspension system
- Shock absorbers on a mountain bike
- Air resistance slowing down a pendulum




*Damped oscillations. Critical damping stops the oscillations in the minimum time.*

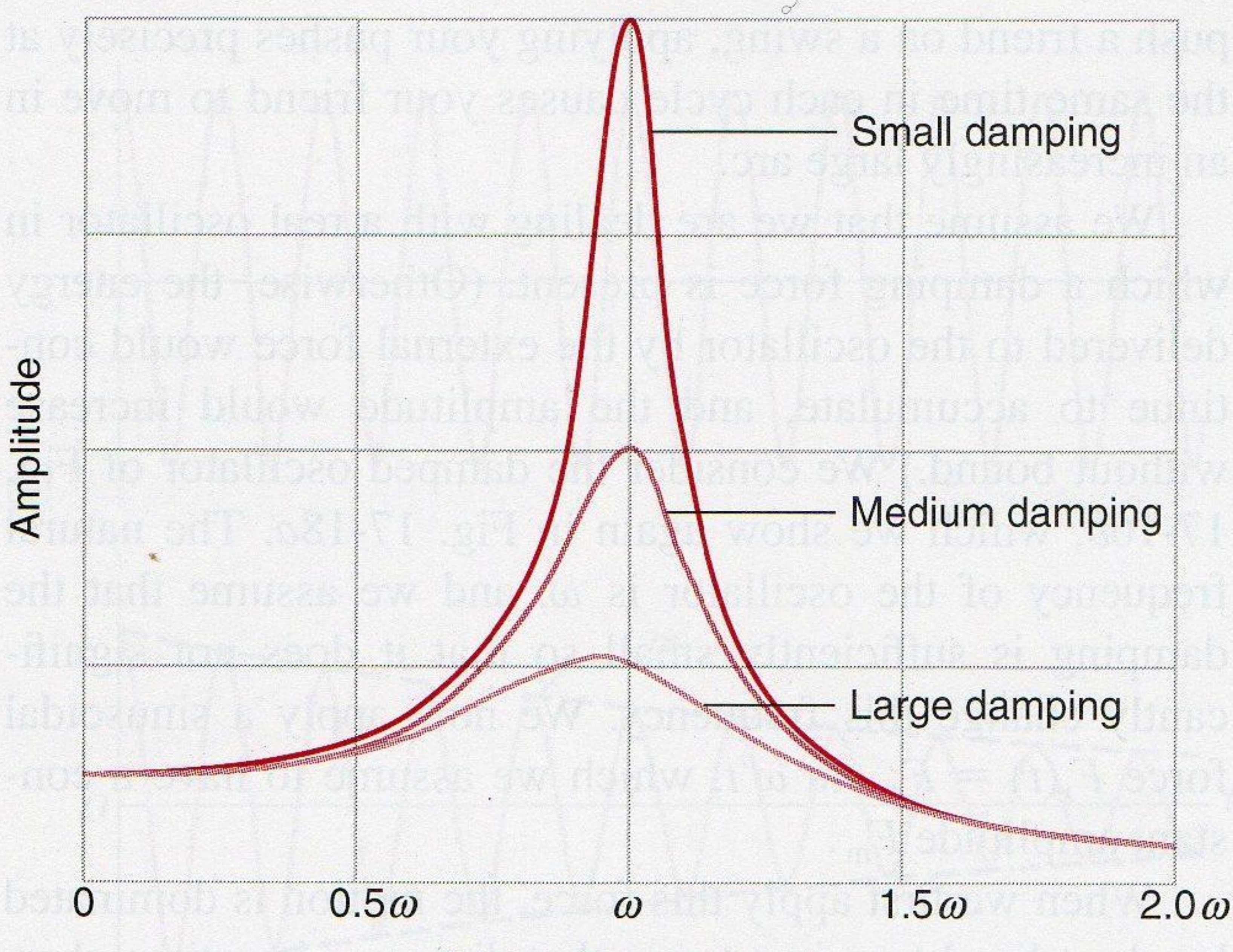

amplitude of driven oscillator
no damping
note that resonant frequency falls as damping is increased
increasing damping
driver amplitude
heavy damping
$f_0$
driver frequency

# Spring system with ‘driving force’

Apply a periodic force to a damped system that can oscillate with SHM of “natural” frequency.

The periodic force is given by

And the equation of motion becomes:


Small damping
Medium damping
Large damping
Amplitude
0
0.5ω
ω
1.5ω
2.0ω
Driving frequency ω″

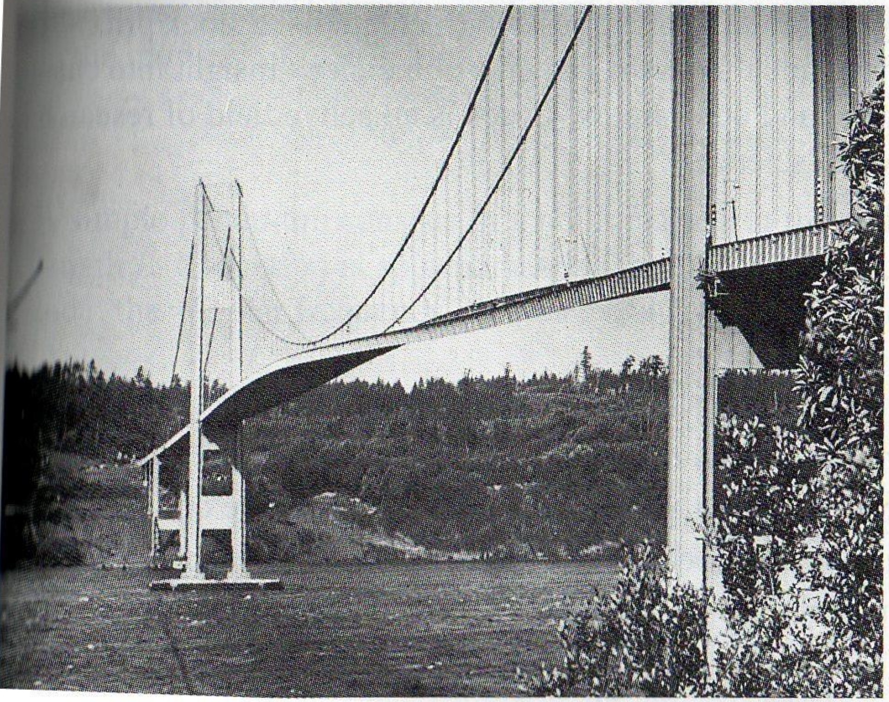
# Example 2

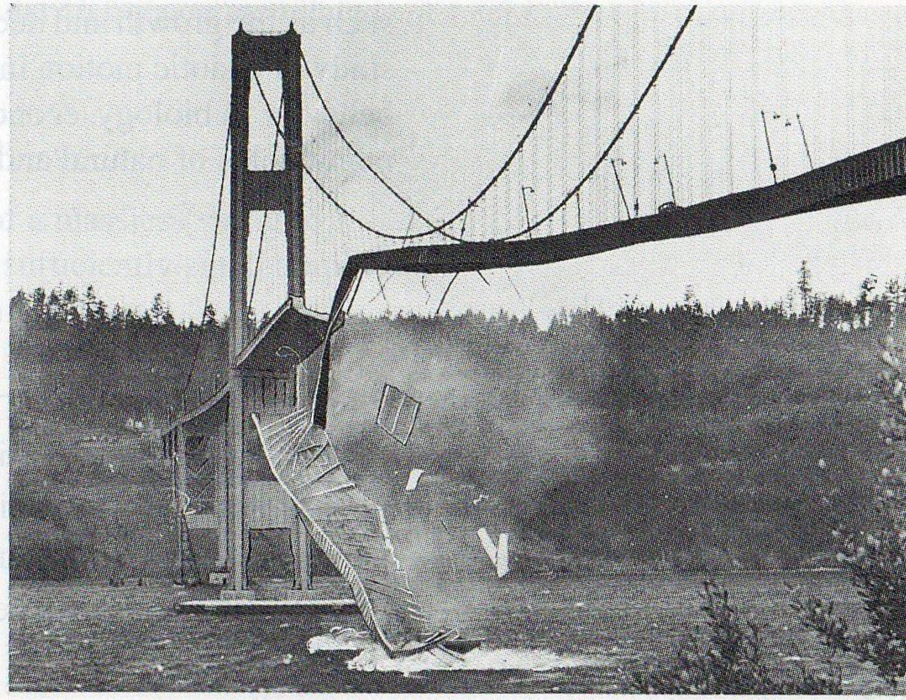
A free swing is a lightly damped system.

If a girl starts swinging from a amplitude of x= 50 cm with a frequency of 0.5Hz, calculate the maximum damping force if the damping coefficient is 58.3 $Nsm^{-1}$

# Examples of resonance

- Pushing a child on a swing
- Singing or playing a musical instrument
- Nuclear Magnetic Resonance
- Bridge subject to wind or earthquake





**LECTURE CHECK LIST**

Simple Harmonic Motion (SHM)

READING Adams and Allday: 3.32, 3.33, 3.34.

Understand PE and KE and total energy for SHM

Be able to perform calculations to find the *amplitude, period, frequency* and *angular frequency* of objects performing SHM in a variety of situations

Be able to perform calculations involving PE KE acceleration velocity displacement and energy.

Understand the links between SHM and circular motion

READING Adams and Allday: 3.35, 3.36

- Understand the notions of *natural frequency* of an oscillating system and the *driving frequency* of a system
- Be able to define resonance
- Give some real examples of resonance
- Understand what is meant by *damping* and be able to give examples in which damping occurs