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

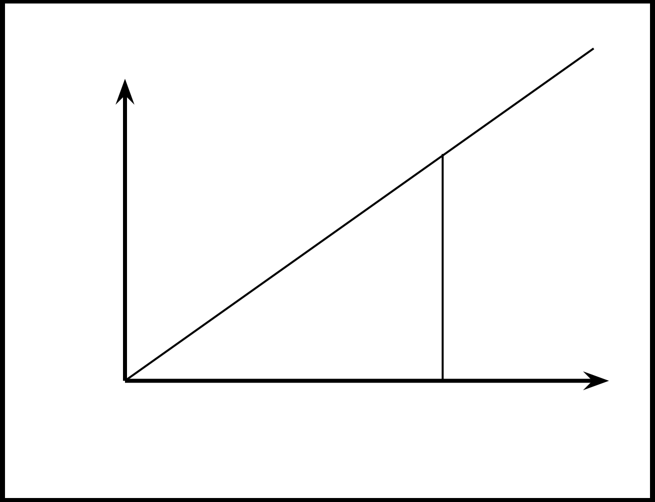
Have clear, useful notes from the material presented

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



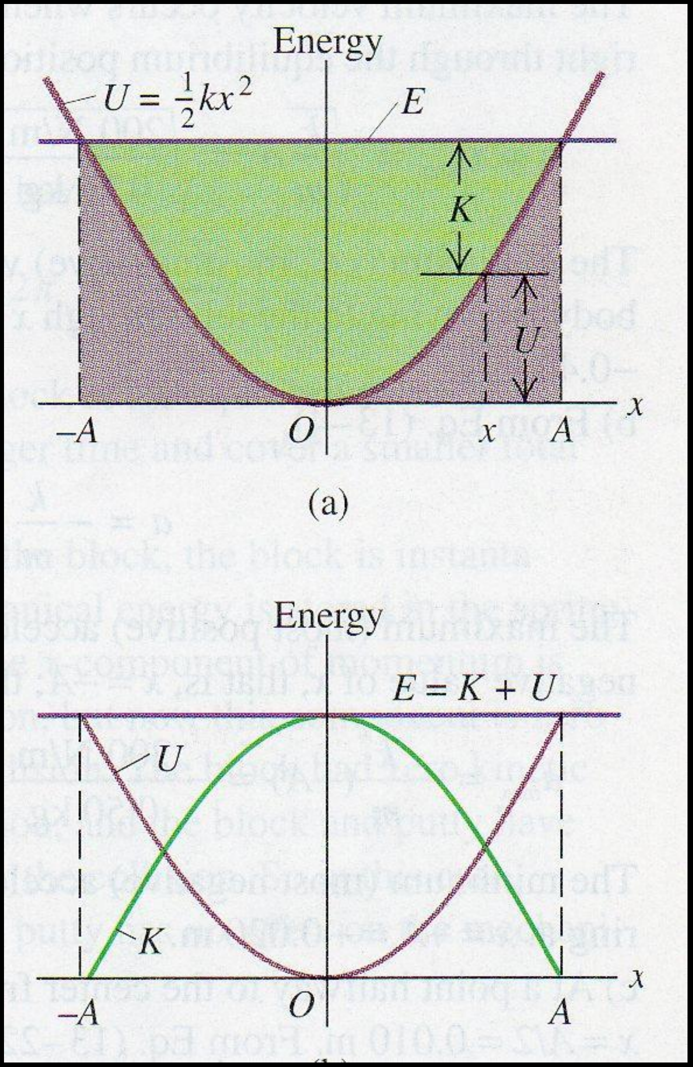
Hence the total energy is given by:

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 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

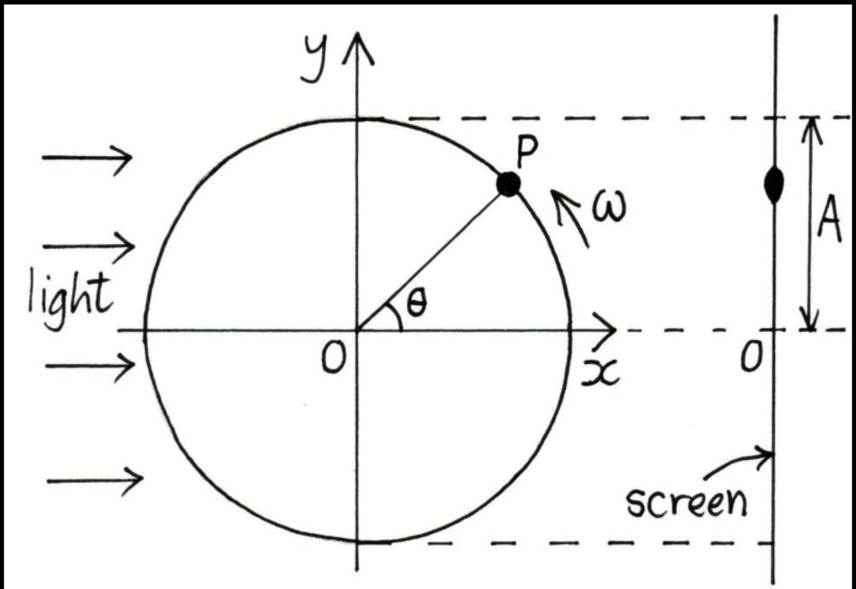
c) the total energy

d) the kinetic energy

e) the potential energy

SHM and circular motion

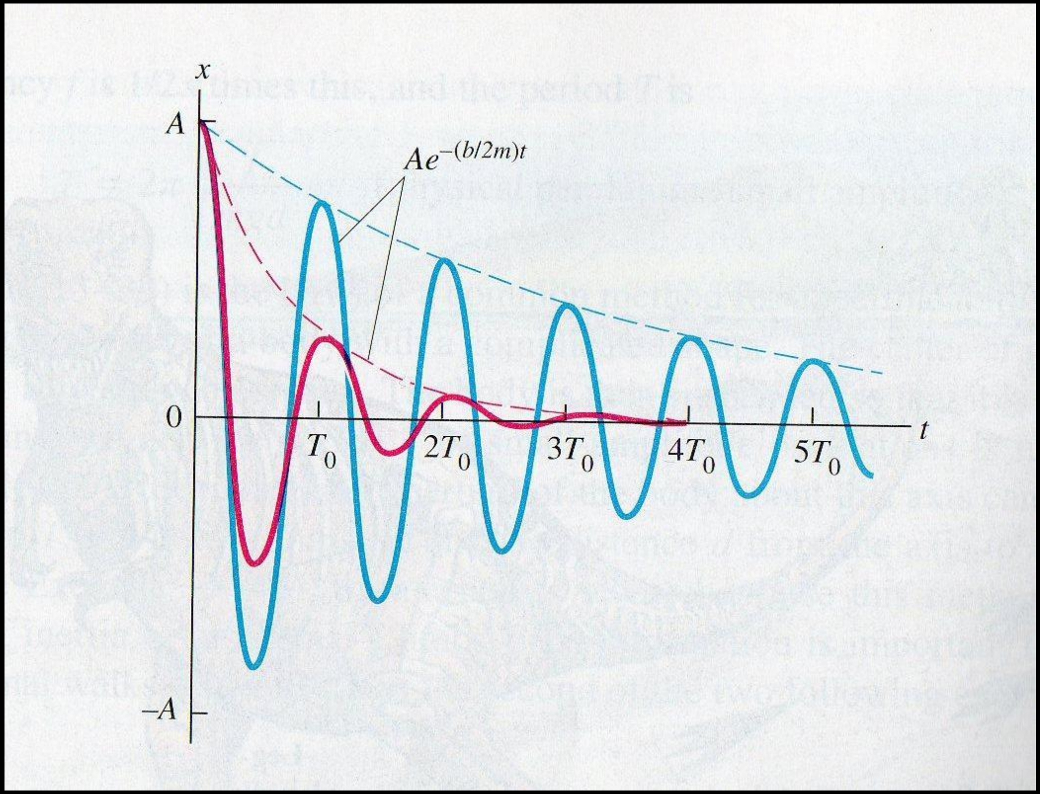
P moves in circular motion about O. If we illuminate this motion, P makes a shadow on the screen. As P rotates, the shadow of P on the screen moves with simple harmonic motion (SHM). We call this the projection of P on the y axis



Let’s make this more realistic.

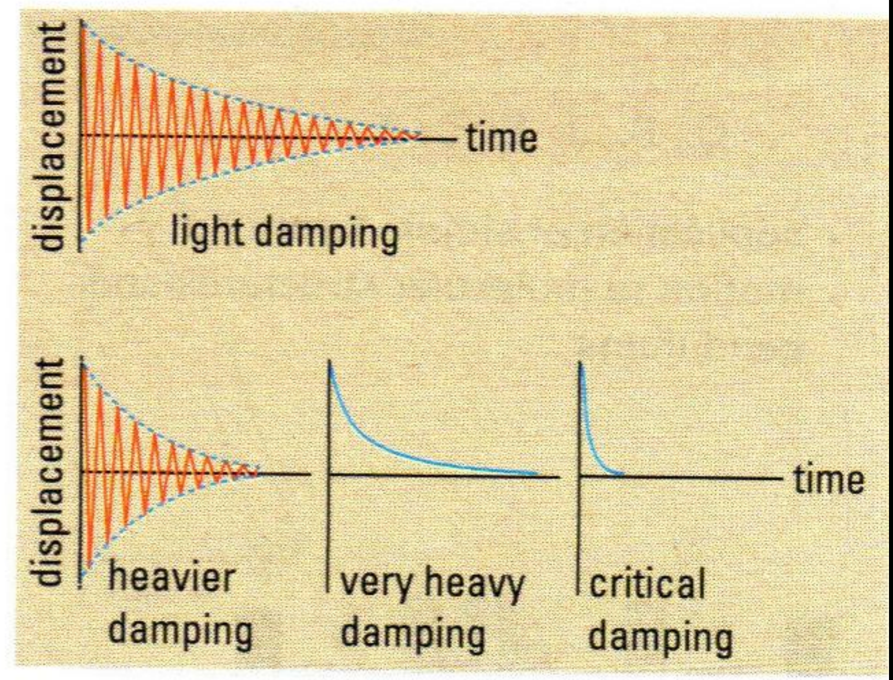
Add friction, air resistance etc **damping**

Mathematically our equation of motion becomes:

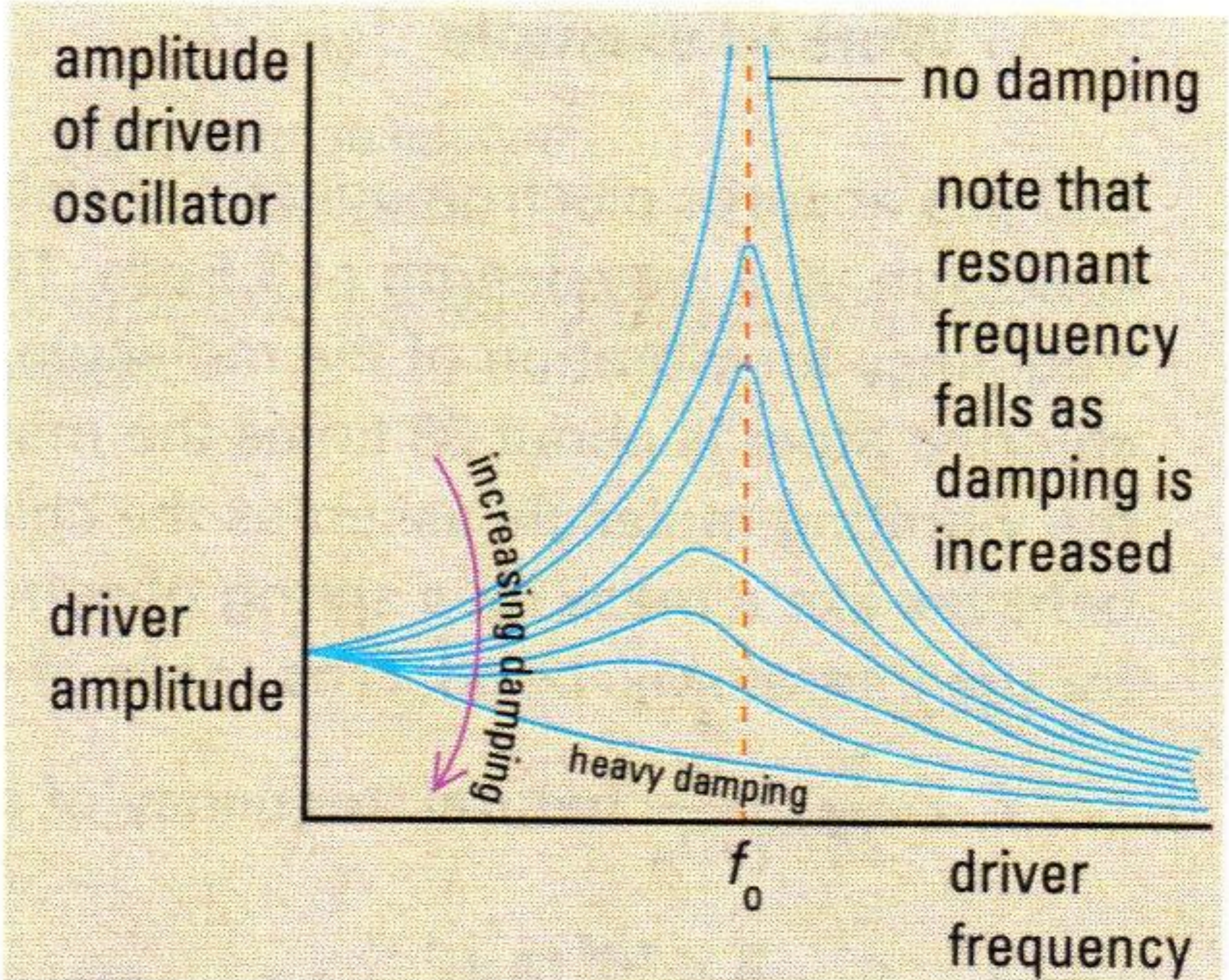


Examples of damping

- 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.

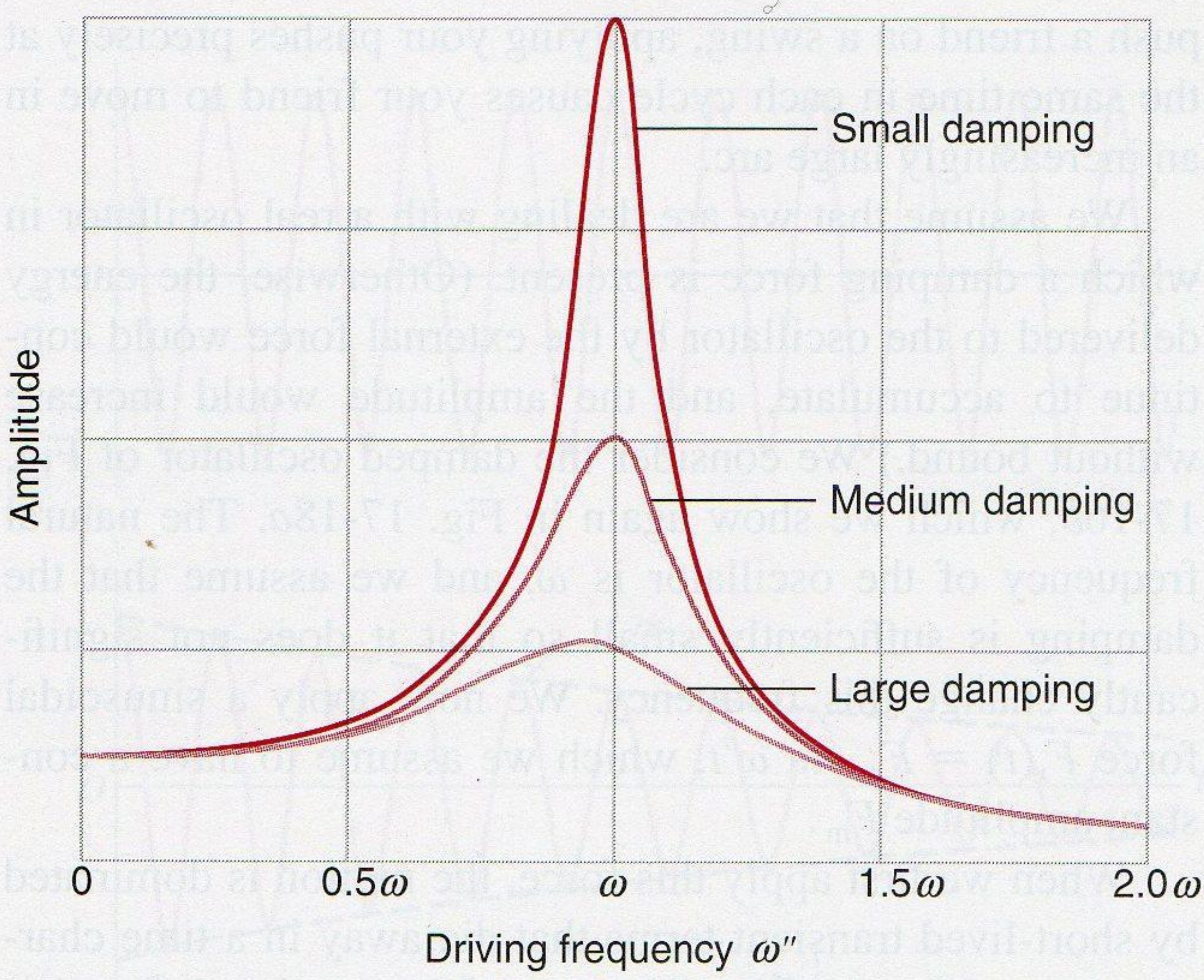

amplitude of driven oscillator
no damping
note that resonant frequency falls as damping is increased
increasing damping
driver amplitude
heavy damping
f_0
driver frequency

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″

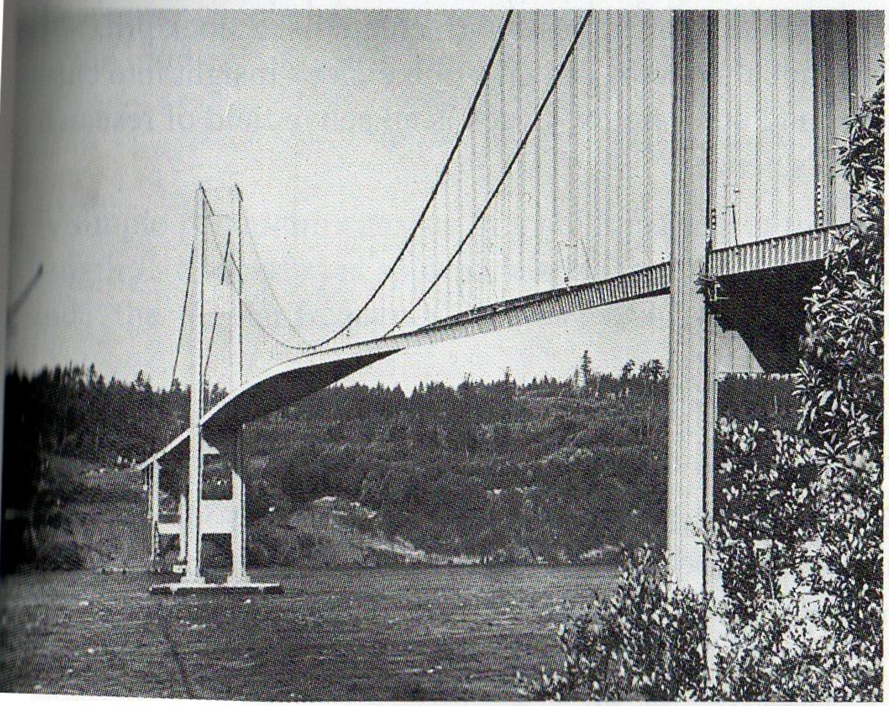
Example 2

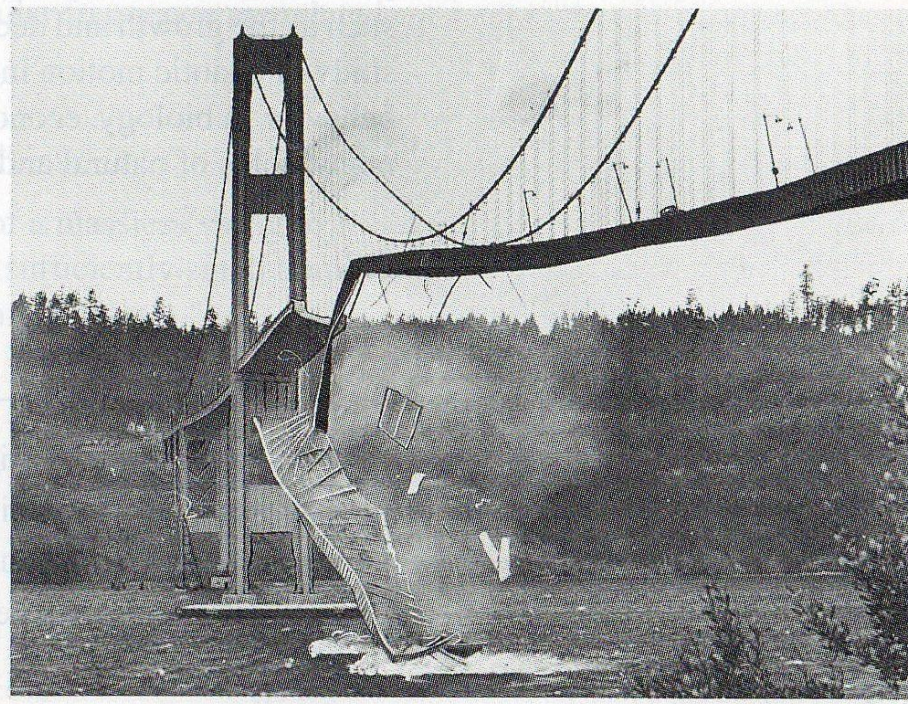
A free swing is a lightly damped system.

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