Class 33
Simple Harmonic Motion
Announcements

• Monday/Wednesday next week
  I will be gone
Concepts overview

1. Oscillations
2. Simple harmonic motion
Problem Solving
Overview

• Exam questions as per webpage
• Homework problems
Oscillations and waves

- Oscillations are important: light and sound are oscillating electric fields/density waves
- Waves have special, mysterious properties of diffraction and interference (more on this later)
- Simple oscillations called “simple harmonic motion” are mathematically tractable
- Start with mechanical oscillations
Simple harmonic motion

• Read about it!
• \( x(t) = A \cos(2\pi ft) \)
• \( = A \cos(\omega t - \phi) \)

Know your cosine waves:
- \( \cos(0) = 1 \)
- \( \cos(\pi/2) = \cos(90^\circ) = 0 \)
- \( \cos(\pi) = \cos(180^\circ) = -1 \)

\( \phi \) is known as the “initial phase”. It tells you the “initial condition”, where the oscillator started.
- Pull a spring and release it (most common situation), \( \phi = 0 \)
- Pull a pendulum to the side and let it go (most common), \( \phi = 0 \)
SHM II

- $v(t) = -2\pi fA \sin(2\pi ft)$
- $= -\omega A \sin(\omega t - \phi)$

**Know your sine waves:**
- $\sin(0) = 0$
- $\sin(\pi/2) = \sin(90^\circ) = 1$
- $\sin(\pi) = \sin(180^\circ) = 0$
- $\sin(3\pi/2) = -1$
Frequency, period and angular frequency

- Period, T: how many seconds it takes to do one complete oscillation
  - \( F = 1/T \)
- Frequency, f: number of oscillations you do in one second (units=1/s)
  - \( F = 1/T \)
- Angular frequency, \( \omega \): the frequency expressed in units of radians/s
  - \( f = \# \text{ rev/s}, \ \omega = f \text{ in radians} \)
  - \( \omega = (\# \text{ rev/s})(2\pi \text{ rad/1 rev}) = 2\pi f \)
- **ALWAYS USE ANGULAR FREQUENCY IN EQUATIONS WITH \( \sin \) AND \( \cos \)**
Mechanical oscillators

• Mass on a spring
  – Period:
    \[ T = 2\pi \sqrt{\frac{m}{k}} \]
  – \( m \) is the mass, \( k \) is the spring constant
  – Remember, \( \omega = 2\pi f = 2\pi/T \)

• Pendulum
  – Period:
    \[ T = 2\pi \sqrt{\frac{L}{g}} \]
  – \( L \) is the length of the string, \( g \) is acceleration due to gravity
How to solve oscillation problems:

1) Find the period (T)

2) Convert it to angular frequency (\(\omega\))

3) Find the amplitude (maximum displacement)

4) Consider the initial condition. Usually the object is released from rest (\(\phi=0\)), it may be given a velocity (hit) from its equilibrium position (\(\phi=\pi/2\))

5) Plug into \(x(t) = A \cos(\omega t - \phi)\)

A. This is useful

B. This isn’t useful

C. Need more information