Schedule for the Rest of the Semester

• Today: Chapter 13, Part 1
• Thursday Nov. 30th: Chapter 13, Part 2
• Tuesday December 5th: Final Exam Review
• No lecture on December 7th (Reading day)
• Final exam is Monday, Dec. 11th, 1-3PM
• We will skip Chapter 15
Next Semester

Many of you have asked about next semester:

• I am **NOT** teaching 208

• However I am planning on teaching a new course: “**Big Bang, Black Holes, No Math**”
  – Introduction to Cosmology
  – Based on “**A Brief History of Time**” by Stephen Hawking
  – If you can’t take it, you might pass this info along
Chapter 13: Periodic Motion

**This time:**
- Oscillations and vibrations
- Why do we care?
- Equations of motion
- Our spherical cow: Springs
- Simple Harmonic Motion

**Next time:**
- Energy
- Uniform Circular Motion
- Pendulums
What is an Oscillation?

• The good news is that this is just a fancy term for stuff you already know. It’s an extension of rotational motion.

Stuff that just goes back and forth over and over again

“Stuff that goes around and around”

• Anything which is Periodic
• Same as vibration
• No new physics… just a combination of chapters 4/5 and 9/10
Examples

Lots of stuff *Vibrates* or *Oscillates*:

– Radio Waves
– Guitar Strings
– Atoms
– Clocks, etc...

In some sense, the Moon *oscillates* around the Earth
Why do we care?

Lots of engineering problems are oscillation problems

– Buildings vibrating in the wind
– Motors vibrating when running
– Solids vibrating when struck
– Earthquakes

→ Moving towards setting up our spherical cow
What’s Next

1. First we’ll “model” oscillations with a mass on a spring
   • You’ll see why we do this later

2. Then we’ll talk about what happens as a function of time

3. Then we’ll calculate the equation of motion using the math
Simplest Example: **Springs**

What happens if we attach a mass to a spring sitting on a table at it’s equilibrium point (I.e., \( x = 0 \)) and let go?

What happens if we attach a mass, then stretch the spring, and then let go?
Questions

• What are the forces?

  Hooke’s Law: $F = -kx$

• Does this equation describe our motion?

  $x = x_0 + v_0 t + \frac{1}{2} a t^2$
The forces

No force

Force in $-x$ direction

Force in $+x$ direction
More Detail

Time

(a) $F \rightarrow v = 0$

$x = 0 \quad x = A$

(b) $F = 0 \quad v = -v_{\text{max}}$

$x = 0$

(c) $v = 0 \quad F$

$x = -A \quad x = 0$

(d) $F = 0 \quad v = +v_{\text{max}}$

$x = 0$

(e) $F \rightarrow v = 0$

$x = 0 \quad x = A$
Some Terms

Amplitude: Max distance

Period: Time it takes to get back to here
Overview of the Motion

• It will move back and forth on the table as the spring stretches and contracts

• At the end points its velocity is zero

• At the center its speed is a maximum
Simple Harmonic Motion

Call this type of motion

Simple Harmonic Motion
(Kinda looks like a sine wave)

Next: The equations of motion:

Use $\Sigma F = ma = -kx$

(Here comes the math. It’s important that you know how to reproduce what I’m going to do next)
Equation of Motion

A block of mass $m$ is attached to a spring of constant $k$ on a flat, frictionless surface

Find the equation of motion
Mass $m$ on a spring with spring constant $k$:

$$x = A \sin(\omega t + \phi)$$

Where

$$\omega^2 = k/m$$

$A$ is the **Amplitude**

$\phi$ is the **“phase”**

(phase just allows us to set $t=0$ when we want)
At some level sinusoidal motion is the definition of Simple Harmonic Motion

A system that undergoes *simple harmonic motion* is called a *simple harmonic oscillator*
A block with mass $m$ is attached to the end of a spring, with spring constant $k$. The spring is stretched a distance $D$ and let go at $t=0$

- Find the position of the mass at all times
- Where does the maximum speed occur?
- What is the maximum speed?
Check:

This looks like a cosine. Makes sense…

Spring and Mass Paper which tells us what happens as a function of time
Example: Spring with a Push

We have a spring system

– Spring constant: $K$
– Mass: $M$
– Initial position: $X_0$
– Initial Velocity: $V_0$

Find the position at all times
Simple Harmonic Motion

\[ x = A \sin(\omega t + \phi) \]

- What is the amplitude?
- What is the phase?
- What is the angular frequency?
- What is the velocity at the end points?
- What is the velocity at the middle?
Challenge Exam

• Announcement of this semester’s 218 Challenge Exam: *Monday December 4th at 6:00PM*
  – Not required (just for fun)
  – Does not (will not!!) count as part of your final grade

• Test your skills against the best Aggies from all the Physics 218 sections (not just this lecture) on Physics 218 material

• Students who perform well will be recognized as *Mechanics Scholars*, and honored at a banquet in their honor. Other prizes, including *cash*.

• Handout information on my WebSite
Exams

• Overall exam 3 Mean is an 69/100

• 3 Exam grades for semester (approx) have an average of 75%. Straight scale for A’s & B’s so far… (ballpark…)

  - >90% (247/275) A
  - >80% (220/275) B
  - >60% (152/275) C
  - >50% (138/275) D
  - <50% (138/275) F
Next Week

• Wednesday: Chapter 12 HW and HWq due
• Recitation: Will cover Chapter 13
• Thursday:
  – Rest of Chapter 13
  – Energy, Uniform Circular Motion, Pendulums
• Next Tuesday:
  – Last day of class, Review for the final
• Monday December 11th, 1-3PM: Final exam
  – HW for Chapter 13 due
  – Chapters 12 and 13 will be on the final and I guarantee a problem from each
End of Lecture Notes