Physics 218
Lecture 21
Dr. David Toback
Schedule for the Rest of the Semester

• Today: Chapter 12
• Tuesday Nov 21st: Exam 3
• Thursday Nov 23rd: No class, Thanksgiving
• Tuesday November 28th: Chapter 13, Part 1
• Thursday November 30th: Chapter 13, Part 2
• Tuesday December 5th: Final Exam Review
• No lecture on December 7th (Reading day)
• Final exam is Monday, December 11th, 1-3PM
• We will skip Chapter 15
Chapter 12: Overview

• Newton’s gravitational law
• Dynamics and Gravity
• Gravity and Uniform Circular Motion
• Escape Velocity
Gravitation

Newton’s law of Universal Gravitation

“Every particle in the universe attracts every other particle”
Large number of scales

Kinda amazing!

Gravity covers the attraction between

- An apple near the earth
- The earth and the moon
- The earth and the sun
- The sun and our galaxy
- Our galaxy and the universe
- Every particle in the universe and an apple
- The Earth and you
- Bevo and Reveille
Newton’s Law

“Every particle in the universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them. This force acts along the line joining the particles”

• Gravity has a magnitude and direction

⇒ Gravity is a force
The Force of Gravity

\[ \vec{F}_{\text{gravity}} = G \frac{m_1 m_2}{r^2} \hat{r} \]

Distance between the masses

Direction of the force

Gravitational force exerted on Moon by Earth

Gravitational force exerted on Earth by the Moon

\[ G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2 \]
The motion of the moon and the planets

• One of the great achievements of physics is that it explains the motion of planets

• It took awhile, but they eventually figured out that the motion of the planets made much more sense if one assumed that the Sun was the center of motion rather than the Earth

• Newton was able to use his gravitational law and Uniform Circular Motion to “Predict” these observations
Gravity and Circular Motion

• Use the force of gravity along with other forces in force diagrams

• Circular motion is motion with the acceleration pointed towards the center of the circle

• The Earth is a good “center” acceleration for *Satellites* and *Moons*
Binary System

Two equal mass stars maintain a constant distance $R_s$ apart and rotate about a point, midway between them, at a revolution rate of once per time $T$.

What must be the mass of each star?
Gravitational Potential Energy

How much potential energy does a ball of mass $m$ have in outer space?

Assuming you know $M_E$ and $G$, calculate how much work you would have to do move a ball from the surface of the earth to some distance $R$. 

Physics 218, Lecture XXI
Escape Velocity

• What happens if I throw a ball up in the air? Will it fall down?

• What if I throw it up really fast?

• What if I throw it up REALLY fast?

• Can I throw it up so fast that it will never come down? How fast would that be?
Example: Geosynchronous Satellite

A satellite is in orbit around the Earth and its speed is such that it always stays above the same point on the earth throughout the day.

Assuming a spherical Earth with mass $M_E$, determine the height of the satellite (from the center of the Earth) in terms of the period, $M_E$ and $G$. 
Next Week

• Monday: Chapter 11 HW due

• Tuesday: Exam 3
  – Covers Chapter 8 through 11
    • Only sections listed on the syllabus
      – Mini-practice exam is open and available for people who are caught up. Usual 5 points

• Thursday: Thanksgiving, no class

• Following Tuesday: Lecture on Chapter 13
  – Periodic Motion