Physics 113 - October 11, 2012

- Exam 1 graded – Will return papers + Discuss at end of class
- Workshop cycle for now runs Wed → Tuesday
- Midterm Survey for TA’s
Energy is Conserved ... not always useful for you

\[ W_{nc} = \Delta KE + \Delta PE \]

Think your way through the energy flow

Two conservative systems considered so far:

- gravity
- springs

\[ \vec{F} = -k(x - x_0) \]

We looked at \( dw = F \cdot ds \) to stretch spring

\[ PE_{spring} = \frac{1}{2} k(x - x_0)^2 = \frac{1}{2} k x^2 \] if \( x_0 = 0 \)
As we change $x \rightarrow PE$ in system changes

$PE = \frac{1}{2}kx^2$  \quad (let \ x_0 = 0)$

I stretch spring $\Rightarrow$ \text{d}W \sim F \text{d}x$

$\text{d}U \sim \Delta PE$

$\frac{\text{d}U}{\text{d}x} = F_x$

Better to ask what is force of spring on something + how that is related to $U$ $\Rightarrow$ ps sign on work

$-\frac{\text{d}U}{\text{d}x} = F_x$
In general \[ F_s = - \frac{dU}{ds} \] along coordinate \( s \)

**Example**

\[ PE_{spring} = \frac{1}{2} k x^2 \]

\[ F_{spring} = - \frac{d(PE)}{dx} = -kx \]

Let's look at gravitation + come back to this ...

yeah, yeah ... \( F = mg \) \( \Delta PE = mgh \) Boing!!

What's the big deal ...
Demo and clicker exercise

Simple pendulum

Post

Swings around

Stops here

A

B

C
Newton's law of universal gravitation, and why it was a BFD.

Pythagorean theory
Early Greek view of the universe

Pythagoras of Samos
~ 500 BC
Plato ~400 BC ~ multiple spheres

Aristarchus ~310-230 BC
(Greek)

Proposed sun-centered universe
⇒ rejected

Fix the theory
The Heliocentric universe

Nicolaus Copernicus
1473-1543
(Poland)

On the Revolutions of the Heavenly Spheres
Galileo Galilei
(1564 - 1642)

observed phases of Venus

heliocentric expectation

Ptolemy's expectation

VS.

Earth
Sun
Venus epicycle
Tycho Brahe
1546 - 1601
(Danish)
Careful observations
of positions
of Sun, Moon, planets

Brahe's data did not fit perfectly
with Copernicus' theory

Johannes Kepler
1571 - 1630
(German)

Elliptical orbits
fits the data!

Determined 3 laws
that mathematically
describe orbits seen -
relate periods, areas, axes...
Sir Isaac Newton
1643–1727
(England)

universal law of gravitation
\[ F = \frac{GMm}{r^2} \]

Laws of Motion

\[ \Rightarrow \] derived Kepler's
3 laws of planetary motion

In your text section 6.5 not covered here

Same law that governs motion on Earth
\[ \vec{F} = -\frac{GMm}{r^2} \hat{r} \]

For spherically symmetric bodies, "r" measured from center

\[ \vec{F} = \frac{GM_1m}{r_1^2} \hat{y} + \frac{GM_2m}{r_2^2} \hat{x} \]
How much work done to move \( m \) from \( r_1 \rightarrow r_2 \) (along radial line)

\[
dW = \vec{F} \cdot d\vec{s} = \vec{F} \cdot d\vec{r} = F \, dr
\]

\[
W = \int_{r_1}^{r_2} F \, dr = \int_{r_1}^{r_2} \frac{GMm}{r^2} \, dr = -GMm \left( \frac{1}{r} \right) \bigg|_{r_1}^{r_2}
\]

\[
W = -GMm \left( \frac{1}{r_2} - \frac{1}{r_1} \right) = -\frac{6MMm}{r_2} + \frac{6MMm}{r_1}
\]
Define \( \text{grav. PE} = -\frac{Gmm}{r} \).

Gravitational PE \( \sim mg \).

WTF?
\[ \Delta P E \text{ go from } R_E \rightarrow R_E + \Delta r = r \]

\[ \Delta P E = -\frac{G M_E m}{r} + \frac{G M_E m}{R_E} \]

\[ = -\frac{G M_E m R_E + G M_E m r}{R_E r} = \frac{G M_E m (r - R_E)}{R_E r} \]
\[ F = \frac{GM_m (R_E + \Delta r - R_E)}{R_E (R_E + \Delta r)} \approx \frac{GM_m h}{R_E^2} \]

\[ \approx g \]

\[ \text{gravitational field} \]

\[ \vec{g} \]

\[ \vec{F}_g \]

\[ \frac{GM}{r^2} \]

\[ \text{at each point} \]
Visualizing the gravitational field

discussion on the concept of gravitation in Einstein's general Theory of Relativity
Mean ~ 74 ... Note long low tail
   median ~ 79

Don't ask me to translate this into letter grades.

Study Solutions
Regrade Policy
Troubleshooting guide

Syllabus allows for a drop 😊

Something is broken w/ respect to you + this course/exam 😞
Now is the time to figure it out and make changes.

Doing okay
Room for improvement
Examine scores ... See if you can identify issues to tighten up.

Things going well. Keep it up. Don't get cocky.
Problem 6 an Exam:

unfortunately a cancels out in final equation for θ. Still it is explicitly incorrect to set a = 0 in solution to problem.