Physics 2111
Unit 7

Today’s Concepts:

Work & Kinetic Energy
Power
The work done by force $F$ as it acts on an object that moves between positions $r_1$ and $r_2$ is equal to the change in the object’s kinetic energy:

$$W = \Delta K$$

$$W = \int_{r_1}^{r_2} \vec{F} \cdot d\vec{l}$$

$$K = \frac{1}{2} mv^2$$

Units for both are Joules: 1 Newton X 1 meter
\[ W = \int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{l} \]

Or how much of the distance the object moves is in the direction of the force.

\[ \vec{A} \cdot \vec{B} = AB \]  
(Parallel Vectors)

\[ \vec{A} \cdot \vec{B} = 0 \]  
(Perpendicular Vectors)

\[ \vec{A} \cdot \vec{B} = -AB \]  
(Anti-Parallel Vectors)
Example 7.1 (Work on cart)

A 2kg frictionless lab cart is pushed with a force of 5N for a distance of 1m. The force is horizontal.

What is the kinetic energy of the cart after the push?

What is the cart’s velocity after the push?
A 2kg frictionless lab cart is pushed with a force of 5N for a distance of 1m. The force has an angle of 30° to the horizontal.

What is the kinetic energy of the cart after the push?

What is the cart’s velocity after the push?
the whole pre-lecture was confusing. the apple has zero kinetic energy and thus 0 work because it started and stopped at rest; however a ball that is dropped does have work, when it too starts and stops at rest?? makes no sense

The fact that work can be zero after something moves can be confusing.
A box sits on the horizontal bed of a moving truck. Static friction between the box and the truck keeps the box from sliding around as the truck drives forward.

The work done on the box by the static frictional force as the truck moves a distance $D$ to the left is:

A) Positive  B) Zero  C) Negative
A force pushing over some distance will change the kinetic energy.
Example 7.3 (Block on Ramp)

A 5kg block is pulled up a distance of 2m along a frictionless ramp by a 20N force.

How much work did force do on the block?

How much work did gravity do?

If it starts from rest, what is the velocity of the box after the 2m?
Can break any path into tiny pieces (calculus!)

\[ W_{TOT} = W_1 + W_2 + \ldots + W_N \]
\[ = m\vec{g} \cdot d\vec{l}_1 + m\vec{g} \cdot d\vec{l}_2 + \ldots + m\vec{g} \cdot d\vec{l}_N \]
\[ = -mgdy_1 - mgdy_2 \ldots - mgdy_N \]
\[ = -mg\Delta y \]

\[ W_g = -mg\Delta y \]
If there are several forces acting then $W$ is the work done by the net (total) force:

$$W_{NET} = \Delta K$$

$$= W_1 + W_2 + \ldots$$

You can just add up the work done by each force

$$W_{NET} = W_{TOT}$$
Three objects having the same mass begin at the same height, and all move down the same vertical distance $H$. One falls straight down, one slides down a frictionless inclined plane, and one swings on the end of a string.

In which case does the object have the biggest net work done on it by all forces during its motion?

A) Free Fall  
B) Incline  
C) String  
D) All the same
A car drives up a hill with constant speed. Which statement best describes the total work $W_{TOT}$ done on the car by all forces as it moves up the hill?

A) $W_{TOT} > 0$
B) $W_{TOT} = 0$
C) $W_{TOT} < 0$

Let’s ask this in a different way.........
Work done by a Spring

\[ W_{1\to2} = -\frac{1}{2}k(x_2^2 - x_1^2) \]

Diagram showing the force \( F(x) \) and the area under the curve representing the work done by the spring. The area \( W_{spring} \) is equal to the work done. The force \( F_{spring} = -kx \) is also shown.
Example 7.4 (Box on Spring)

A 20kg box is placed gently on a vertical spring which compresses it 10cm. I then compress the spring an additional 40cm with my hand.

When I release the box and spring, how high will the box fly?
A proton with a mass of $1.67 \times 10^{-27}$ kg is heading directly towards a fixed nucleus. It starts 4 meters away at a speed of $8 \times 10^4$ m/sec. The nucleus repulses the proton with a force equal to $\alpha/r^2$, where $\alpha$ is a constant with a value of $1.82 \times 10^{-26}$ Nm$^2$.

What is the speed of the proton when its $8 \times 10^{-9}$ meters from the nucleus?
Power

Power = Energy/Time

1 Joule/1 sec = 1 Watt

Example:
60 Watt light bulb uses 60 Joules of electrical energy every second.

Note:

kilowatt is power
kilowatt–hour is energy
1HP = 745.7 Watts
Example 7.6 (Motorcycle Power)

A motorcycle and rider are going down the road at a constant velocity of 15m/sec. At this velocity, the wind drag is 160N. Their combined mass is 260kg.

What is the power produced by the engine?

How much power would be needed for him to go up a 15° incline at this same speed?