P221, Spring 2001, Chapter 8 Summary

Work

− Work done by any force, $\vec{F}$, on a system of mass, *m*, is $W=\int_i^f \vec{F}\cdot d\vec{r}$ where the integral is along the path of the system from the initial to final point.

− The units of work are *N m* or Joules (*J*).

− If the force is constant (in both direction and magnitude) along the path, then $W=\vec{F}\cdot\Delta\vec{r}$ where $\Delta\vec{r}$ is the change in position vector from the initial to the final point $\Delta\vec{r}=\vec{r}_f-\vec{r}_i$.

− The work done by a force can be >0, <0, or = 0 depending upon the orientation of the $\vec{F}$ and $\Delta\vec{r}, d\vec{r}$ vectors.

− The work done by a *conservative* force (e.g. gravity, force from a spring) is independent of path.

− The work done by a *non−conservative* force (e.g. kinetic friction) depends upon the path.

− A zero−work force (e.g. static friction, normal force) always does zero−work regardless of path.

Potential and Kinetic Energy

− The work done by a conservative force is equal to the negative of the change of the potential energy function : $W_{conserv}\equiv-\Delta PE$.

− The potential energy function depends on a location in space and upon a choice for a zero−point of *PE*. The physics depends only upon the *change* in *PE*.

− Potential Energy Functions:

− gravity (near earth surface): $PE_{local}=mgy$ ($\hat{j}$ pointing up)

− gravity (general form): $PE_{grav}=\frac{-GMm}{r}$

− Hooke's Law Spring: $PE_{spring}=\frac{1}{2}kx^2$

− Kinetic Energy: $KE\equiv\frac{1}{2}mv^2$

CWE Theorem (Conservation of Energy)

− CWE Theorem: Work done by total force on system is equal to change in kinetic energy of system: $W_{total} = \Delta KE$

− The work done by non−conservative (other) forces on a system is equal to the change in total mechanical energy of the system:

$$W_{other} = \Delta E = \Delta(KE + PE)$$

− If all forces acting on system are conservative (or zero−work forces), energy is "conserved": $\Delta E = \Delta(KE + PE) = 0$ or $(KE + PE)_{initial} = (KE + PE)_{final}$

− The *escape speed* is the speed that gives a system sufficient energy to overcome the gravitational *binding energy*: $v_{escape} = \left(\frac{2GM}{R}\right)^{\frac{1}{2}}$

− A simple harmonic oscillator has total mechanical energy: $E = \frac{1}{2} k A^2 = \frac{1}{2} k x^2 + \frac{1}{2} m v^2$. The energy "oscillates" from potential to kinetic.

Power

− Power is the amount of work done in a given time and has units of J/s or Watts (*W*).

− The average power of a force on a system is defined: $P_{ave} = \frac{W}{\Delta t}$

− The instaneous power is defined: $P = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$

Energy Diagrams

− A plot of PE as a function of position for a system with $W_{other} = 0$ is an *energy diagram*. The total energy E is a constant and the KE may be read as the difference between PE and KE.

− The force associated with the PE is the negative of the slope of the PE on the energy diagram: $F_x = \frac{-d(PE)}{dx}$