

CHAPTER 8: Potential Energy and Conservation of Energy

Potential Energy:

- A force is Conservative when the net work done to a particle moving it along a closed path, and back to point zero, is Zero
- Potential Energy: When a conservative force acts does work W on a particle, the change ΔU in potential energy is :
$$\Delta U = -W$$
- Gravitational Potential Energy: If a particle moves from height y_i to height y_f , the change ΔU in gravitational potential energy is :
$$\Delta U = mg(y_f - y_i) = mg \Delta y$$

If $y_i = 0$ and the initial Potential Energy $U_i = 0$ then gravitational potential energy U when the particle is at height y is:
$$U = mgy$$
- Elastic Potential Energy is the energy associated with state of compression or extension of an elastic object. If a spring exerts a force $F = -kx$ then elastic potential energy U at position x is:

$$U(x) = kx^2$$

Mechanical Energy:

- Mechanical Energy E is the sum of kinetic energy K and potential energy U
$$E = K + U$$
- Conservation of Mechanical Energy: mechanical energy is always constant if the work done to a system is only done by conservative forces: $\Delta E = \Delta K + \Delta U = 0$

Reading a Potential Energy Curve:

- Finding the force analytically

Given the change in potential energy we can solve for the force by:
 $U(x) = -W \implies -F(x)dx = -W \implies F(x) = -W/dx \implies \mathbf{F(x) = -dU(x)/dx}$.

- The potential energy curve

Given the graph of the potential energy curve, taking the slope at various points gives you the curve of the **force** that acts on that particle.

- Turning points

The turning points on a potential energy curve occurs when the potential energy is equal to the total energy.(in other words, the kinetic energy is zero so the particle is momentarily at rest.)

- Equilibrium points
 - **Neutral** equilibrium: $K=0$, the sum of the forces =0.
(ex. a marble on a table)
 - **Unstable** equilibrium: $K=0$. If the sum of the forces is not zero then the particle will continue to move in the direction of the applied force.
(ex. a marble on a bowling ball)
 - **Stable** equilibrium:
(ex. a marble in a bowl)

***This section is pretty straightforward, the hardest parts of these problems is understanding what they are asking you for. So when doing the problems look in section 8-5 and see if there is another way of stating the problem so that it is obvious to you what they are asking for.

Work Done By Nonconservative Forces:

When a **nonconservative** force does work on an object, the mechanical energy of the system **changes**. We will examine two types of nonconservative forces: **an applied force**, and a **kinetic frictional force**.

Work Done by an Applied Force

If we have a body with only two forces acting on it, those being an applied force, and the other being its weight, then from the Work-Kinetic Energy theorem we can say that

$$W_{\text{app}} + W_g = \Delta K$$

$$W_g = -\Delta U \quad \text{thus:} \quad W_{\text{app}} = \Delta E$$

Work is then an energy transferred to or from a system via a force.

Work Done by a Kinetic Frictional Force

Let's say we have a block sliding a distance **d** down a non-frictionless surface. We know that in this case all of its **kinetic energy is dissipated by kinetic frictional force (f_k)**. We know that $\Delta K = \mathbf{F} \cdot \mathbf{d} = Fd \cos \theta$, in this case frictional force is acting in the direction opposite to the displacement thus

$$\Delta E = -f_k d \quad (\text{dissipated mechanical energy})$$

- Without additional information we cannot determine W_f since it equals the **portion** of the dissipated energy that was transferred from the block to the floor.

Conservation of Energy:

- In an Isolated System, energy can be transferred from one type to another, but the total energy of the system remains the same.

$$\Delta E_{\text{TOT}} = \Delta K + \Delta U + \Delta E_{\text{INT}} = 0$$

- Energy can not magically appear or disappear
- New Average Power Formula $P = \Delta E / \Delta T$

Tips and Tricks when Solving Kinetic and Potential energy problems:

- If energy is conserved within a system, that means the total energy within the system is always the same.
- When the object is not moving, there is no kinetic energy. For example, in a problem where an object is dropped onto a spring, the potential energy stored in the spring once the object stops moving is equal to the potential energy of the object before it is dropped.
- In Non-conservative systems, the work done due to outside forces is equal to the total energy change. Friction is an example of one of these forces.
- Sometimes you'll find problems that have a combination of both frictionless surfaces and

surfaces that have friction. It helps to envision these as two separate problems, one of a system where energy is conserved, and one of a system where energy is not conserved.

Links:

- <http://zebu.uoregon.edu/1998/ph101/15.html>
This link gives a VERY simple definition / example of a conservation of energy problem.
- <http://photon.iyte.edu.tr/PhysicsNet/Topics/Energy/PEandForces.html>
This link shows the different Potential Energy Equations and for they are related to specific conservative forces (litte messy)
- <http://schutz.ucsc.edu/~josh/5A/book/work/node17.html>
Very good definition of Conservation of Mechanical Energy. Also has 4 sample problems