Physics

Lecture 11
Work and Potential Energy

Today's Contents

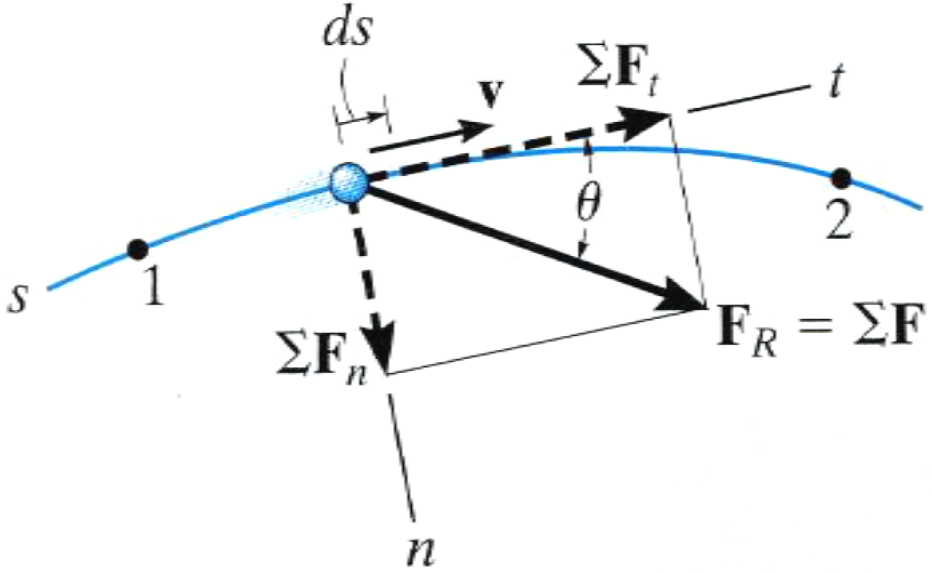
- **Principle of work and energy (review)**
- **Conservative forces and potential energy**
- **Conservation of mechanical energy**

Principle of Work and Energy

Statement

$$\sum U_{1-2} = \frac{1}{2} m(v_2^2 - v_1^2)$$

$$= T_2 - T_1$$



- **Only forces that DO work need be considered !**

Few Important Points Related to Work Energy Method

- **Work of a force is a scalar quantity (positive, negative or zero) that is associated with the change in the position of the point of application**

- **Sometimes (for some specific forces) work can be calculated without integration; But in general integration of elementary work along a given path (*line integral*) is required**

- **Kinetic energy is a scalar quantity (always positive) associated with the speed of a particle at a given instant of time.**

Conservative Force and Potential Energy

Conservative force

A force is said to be conservative if its work is a function of the initial and final positions of its point of application

In other words, the work done by a conservative force *does not depend on the path* (along which work is calculated)

Potential energy (V)

Capacity of conservative force to do work

- **Positive work diminishes the potential for further work, and negative work increases the potential**

Characteristic of Conservative Force

- **Work of a conservative force**
  = Decrease in potential energy

$$U_{1-2} = \int_{r_1}^{r_2} \mathbf{F} \bullet d\mathbf{r} = -\nabla V$$

- **Conservative force is a negative gradient of its potential function (V)**

$$F_x = -\frac{\partial V}{\partial x}, \quad F_y = -\frac{\partial V}{\partial y}, \quad F_z = -\frac{\partial V}{\partial z}.$$

Conservative Force Test

- **Given a force**

$$\boldsymbol{F} = F_x\,\boldsymbol{i} + F_y\,\boldsymbol{j} + F_z\,\boldsymbol{k}$$

- **with components**

$$F_x = F_x(x, y, z), \quad F_y = F_y(x, y, z), \quad F_z = F_z(x, y, z)$$

- **the force F is conservative if and only if**

$$\frac{\partial F_x}{\partial y} = \frac{\partial F_y}{\partial x}, \quad \frac{\partial F_x}{\partial z} = \frac{\partial F_z}{\partial x}, \quad \frac{\partial F_y}{\partial z} = \frac{\partial F_z}{\partial y}.$$

Energy Principles

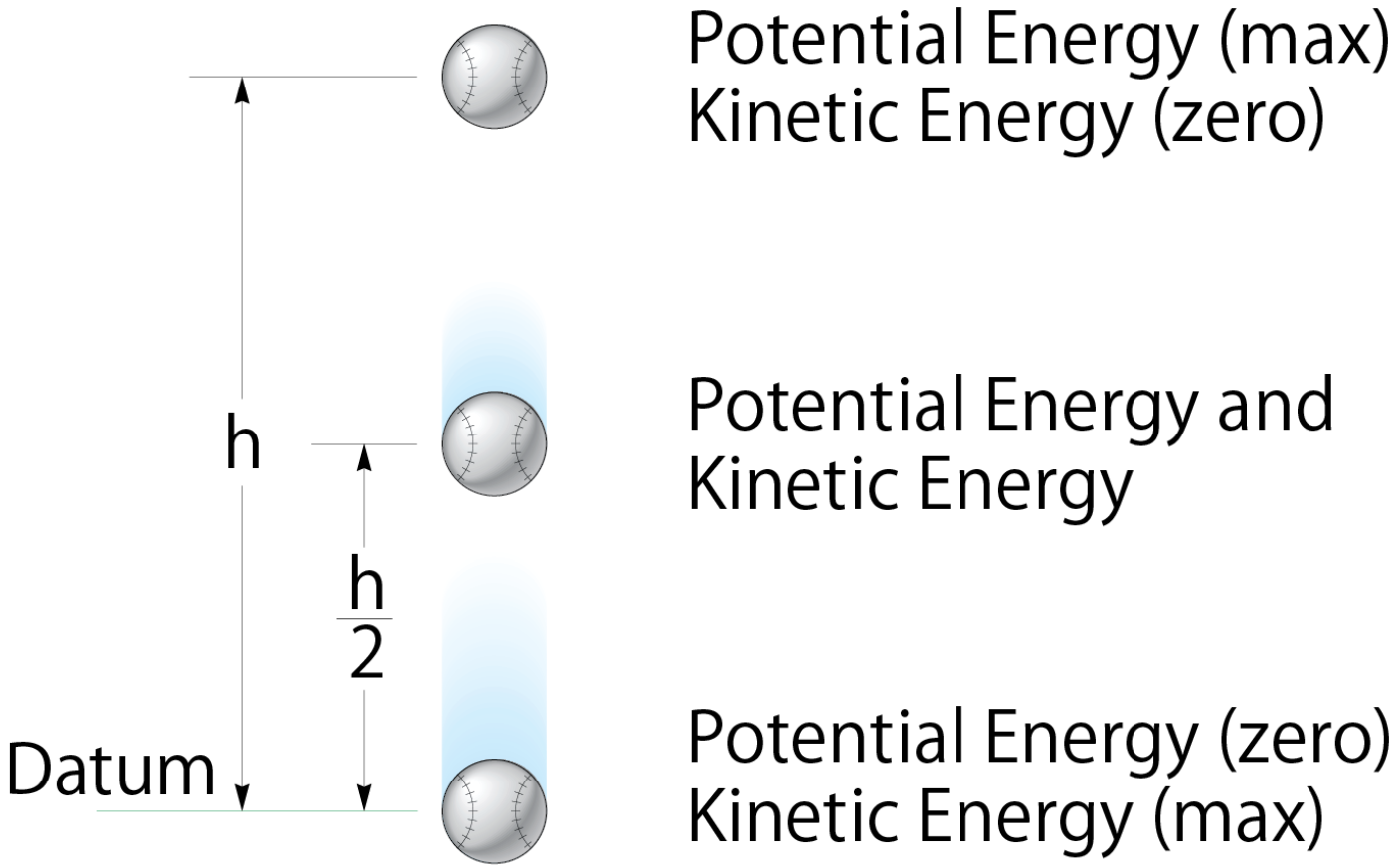
Principle of conservation of energy

For a closed system sum of all forms of energy remains constant

Principle of conservation of mechanical energy

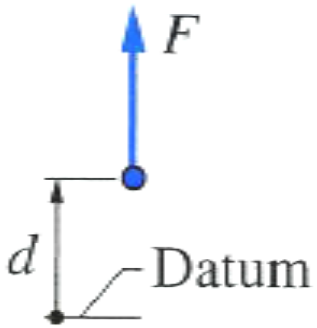
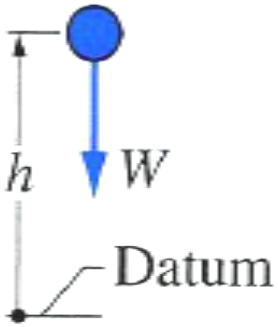
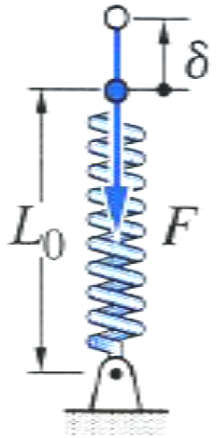
If all forces acting on a particle, body, or closed system of bodies are conservative, mechanical energy (E) is conserved

Example of Conservation of Mechanical Energy



Computation of Potential Energy

Potential energies of conservative forces

1. Constant force	2. Weight	3. Spring	4. Gravity
			
$V_f = -Fd$	$V_g = Wh$	$V_e = \frac{1}{2}k\delta^2$	$V_g = -\frac{Gm_Am_B}{R}$