Phys 103

Chapter 8

Potential Energy

By

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LECTURE OUTLINE

- 8.1 Potential Energy of a System
- 8.2 The Isolated System—Conservation of Mechanical Energy
- 8.3 Conservative and Nonconservative Forces
- 8.4 Changes in Mechanical Energy for Nonconservative Forces
- 8.5 Relationship Between Conservative Forces and Potential Energy

8.3 Conservative and Nonconservative Forces

Conservative Forces

Conservative forces have these two equivalent properties:

1. The work done by a conservative force on a particle moving between any two points is independent of the path taken by the particle.

2. The work done by a conservative force on a particle moving through any closed path is zero. (A closed path is one in which the beginning and end points are identical.)

Examples of Conservative Forces:

- 1.gravitational force
- 2.Spring force

8.4 Changes in Mechanical Energy for Nonconservative Forces

A force is nonconservative if it does not satisfy properties 1 and 2 for conservative forces.

Nonconservative forces acting within a system cause a change in the *mechanical energy* Emechof the system.

As an example of the path dependence of the work, consider moving a book between two points on a table. If the book is moved in a straight line along the path between points A and B; a certain amount of work against the kinetic friction force must be spent to keep the book moving at a constant speed.

Now, imagine that the book was pushed along a semicircular path. More work must have been performed against friction along this longer path than along the straight path.

Hence, The work done depends on the path, so the friction force cannot

- be conservative force.

8.4 Changes in Mechanical Energy for Nonconservative Forces

Consider a body sliding across a surface. As the body moves through a distance *d,* the only force that does work on it is the force of kinetic friction. This force causes a decrease in the kinetic energy of the body. This decrease was calculated in Chapter 7, leading to Equation 7.20, which we repeat here:

$$\triangle K = -f_k d$$

If there is also a change in potential energy then:

$$E_{mech} = \triangle K + \triangle U_g$$

Or in general, for any potential:

$$E_{mech} = \triangle K + \triangle U = -f_k d$$

where ΔU is the change in all forms of potential energy.

8.5 Relationship Between Conservative Forces and Potential Energy

The work done by a cons. force F as a particle moves along the *x axis is:*

$$W_c = \int_{x_i}^{x_f} F_x \, dx = -\triangle U$$

$$Or \triangle U = U_f - U_i = -\int_{x_i}^{x_f} F_x \, dx$$

Therefore, ΔU is negative when F_x and dx are in the same direction, as when an object is lowered in a gravitational field or when a spring pushes an object toward equilibrium.

We can then define the potential energy function as:

$$U_f(x) = -\int_{x_i}^{x_f} F_x \, dx + U_i$$

8.5 Relationship Between Conservative Forces and Potential Energy

If the point of application of the force undergoes an infinitesimal displacement d_x, *we can express the infinitesimal change in the potential energy of the system dU as*

$$dU = -F_x\,dx$$

Therefore, the conservative force is related to the potential energy function through the relationship

$$F_x = -\frac{dU}{dx}$$

That is, the x component of a conservative force acting on an object within a system equals the negative derivative of the potential energy of the system with respect to x.

Lecture Summary

If a particle of mass *m is at a distance y above the Earth's surface, the gravitational potential* energy of the particle–Earth system is

$$U_g = mgy$$

The elastic potential energy stored in a spring of force constant *k is*

$$U_s = \frac{1}{2}kx^2$$

Total Energy of A system is:

$$K_f + U_f = K_i + U_f$$

Lecture Summary

- A force is conservative if the work it does on a particle moving between two points is independent of the path the particle takes between the two points, Or if the work it does on a particle is zero when the particle moves through an arbitrary closed path and returns to its initial position. A force that does not meet these criteria is said to be nonconservative.
- The total mechanical energy of a system is defined as the sum of the kinetic energy and the potential energy:

$$E_{mech} = K + U$$

- If a system is isolated and if no nonconservative forces are acting on objects inside the system, then the total mechanical energy of the system is constant:

$$K_f + U_f = K_i + U_f$$

Thank You


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