Physics 1

Lecture 16

Sahraei

Physics Department,
Razi University

http://www.razi.ac.ir/sahraei

Kinetic Energy

In this lecture we will concentrate only on the first type of energy: *Kinetic*

Kinetic energy is the *energy of motion* – it is associated with the *state of motion* of an object

The faster an object is moving, the greater it's kinetic energy; an object at rest has zero kinetic energy

Kinetic Energy

For an object of mass *m* (whose speed is well below the speed of light), we will define kinetic energy as:

$$K = \frac{1}{2} m v^2$$

The SI unit of kinetic energy (and of every other kind of energy) is the joule (J) and Scalar quantity

1 joule = 1 J = 1 kg · m^2/s^2

Work-Kinetic Energy Theorem

When work is done by a net force on an object and the only change in the object is its speed, the work done is equal to the change in the object's kinetic energy

Speed will increase if work is positive

Speed will decrease if work is negative

Work-Energy Theorem

$$W_{net} = F_{net}(x - x_0) = ma(x - x_0)$$

Recall, $v^2 = v_0^2 + 2\,a\,(x - x_0)$

multiply by m, divide by 2

$\frac{1}{2} mv^2 = \frac{1}{2} mv_0^2 + F_{net}\,(x - x_0)$

$\frac{1}{2} mv^2 - \frac{1}{2} mv_0^2 = W_{net}$

So, $K - K_0 = W_{net}$

$\Delta K = W_{net}$

Kinetic Energy

Work-Kinetic Energy Theorem

Change in KE ≡ work done by all forces

$$\Delta K \equiv W_{net}$$

Work Energy Theorem

W_{net} is the work done by

F_{net} the net force acting on a body.

$$W_{net} = \int_{x_i}^{x_f} F_{net}(x)dx$$

$$= \int_{x_i}^{x_f} madx = m\int_{x_i}^{x_f} \frac{dv}{dt}dx$$

$$= m\int_{v_i}^{v_f} \frac{dx}{dt}dv = m\int_{v_i}^{v_f} vdv$$

$$W_{net} = m\int_{v_i}^{v_f} v\,dv$$

$$= m\left[\frac{v^2}{2}\right]_{v_i}^{v_f} = \tfrac{1}{2}m(v_f^2 - v_i^2)$$

$$W_{net} = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

$$W_{net} = K_f - K_i$$

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

Work done by net force = change in KE

مثال: جسمی به جرم m=4.5 g از ارتفاع h=10.5 m بالاتر از سطح زمین ، از حالت سکون سقوط می کند، سرعت این جسم درست پیش از برخورد به زمین چقدر است؟

$$W_g = \vec{F}.\vec{S} = mgh$$

$$\Delta K = \frac{1}{2}mv^2 - \frac{1}{2}m{v_0}^2$$

$$W = \Delta K \rightarrow mgh = \frac{1}{2}mv^2$$

$$v = \sqrt{2gh} = 14.3 m/s$$

مثال: جسمی به جرم m=3.63kg با سرعت v=1.22 m/s روی میز افقی بدون اصطکاک می لغزد. این جسم به فنری برخورد می کند و آن را می فشارد تا به حالت سکون برسد. فنر در این حالت چقدر فشرده شده است؟ (k=135 N/m)

$$\Delta K = K_f - K_i = 0 - \frac{1}{2}mv^2$$

$$W = -\frac{1}{2}kd^2 \quad spring \quad work\ on\ the\ body$$

$$W = \Delta K \rightarrow -\frac{1}{2}kd^2 = -\frac{1}{2}mv^2$$

$$d = v\sqrt{\frac{m}{k}} = 0.200m$$

Power

So far we have talked about the amount of work done by an applied force

But we have not talked about <u>how long</u> it may take to do that work

The time rate at which work is done by a force is said to be the power due to the force

As we have done before, we can define the *average power* as the *amount of work done by a force during some time interval*, e.g.:

$$P_{\mathrm{avg}} = \frac{W}{\Delta t}$$

and the *instantaneous power* as:

$$P = \frac{dW}{dt}$$

The SI units for power is the joule per second – but it has a special name (*watt*)

In the British system the unit of power is the foot-pound per second

Another common unit for power is *horsepower*

Here are some common power conversions:

$$1\ \text{watt} = 1\ \text{W} = 1\ \text{J/s} = 0.738\ \text{ft}\cdot\text{lb/s}$$

$$1\ \text{horsepower} = 1\ \text{hp} = 550\ \text{ft}\cdot\text{lb/s} = 746\ \text{W}$$

Often also interested in the *rate* at which the energy transfer takes place

Power **is defined as this rate of energy transfer**

$$P = \frac{dW}{dt} = \frac{\vec{F}.d\vec{s}}{dt} = \vec{F}.\frac{ds}{dt} = \vec{F}.\vec{v}$$

$$P = Fv$$