ATOMIC ENERGY CENTRAL SCHOOL,ANUPURAM

CH-6 Work Power and Energy(module3/6)

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PGT PHYSICS,AECS ANUPURAM

What is Potential Energy?

As we know, an object can store energy as a result of its position. In the case of a bow and an arrow, when the bow is drawn, it stores some amount of energy, which is responsible for the kinetic energy it gains, when released.

Potential energy is the energy held by an object because of its position relative to other objects, stresses within itself, its electric charge, or other factors.

Similarly, in the case of a spring, when it is displaced from its equilibrium position, it gains some amount of energy which we observe in the form of stress we feel in our hand upon stretching it. We can define potential energy as a form of energy that results from the alteration of its position or state.

Potential Energy Formula

- The formula for potential energy depends on the force acting on the two objects. For the gravitational force the formula is:

$W = m \times g \times h = mgh$

Where,m is the mass in kilograms

g is the acceleration due to gravity

h is the height in meters

Unit: Gravitational potential energy has the same units as kinetic energy: **$Kg\ m^2 / s^2$**

Note**:** All energy has the same units – $kg\ m^2 / s^2$, and is measured using the unit Joule (J).

TYPES OF POTENTIAL ENERGY

- What are the different types of potential energy?
- Potential energy is one of the two main forms of energy, along with kinetic energy. There are two main types of potential energy and they are:
- Gravitational Potential Energy
- Elastic Potential Energy
- **Gravitational Potential Energy**

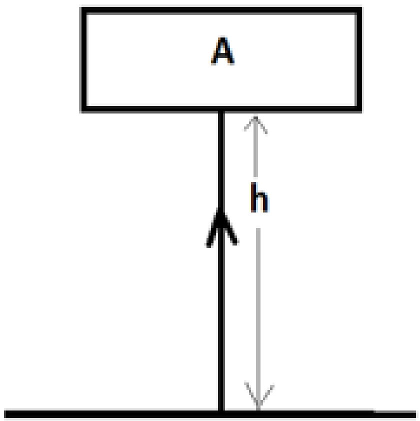
The gravitational potential energy of an object is defined as the energy possessed by an object rose to a certain height against gravity. We shall formulate gravitational energy with the following example.

Consider an object of mass = m.

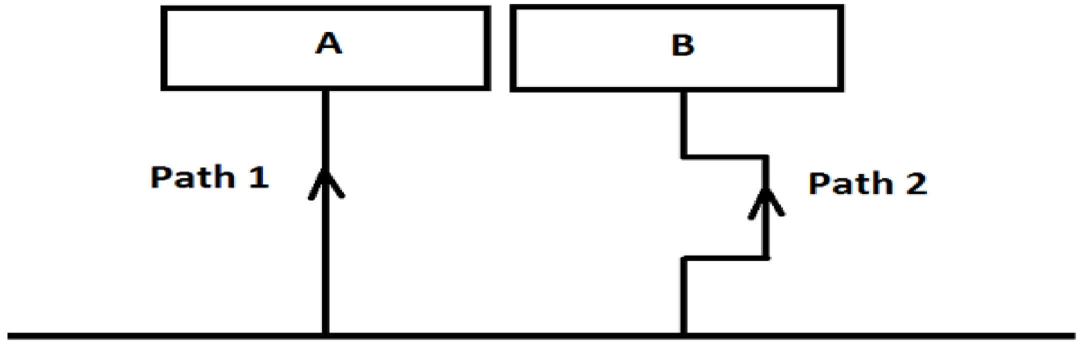
Placed at a height h from the ground, as shown in the figure.

Now, as we know, the force required to raise the object is equal to $m \times g$ of the object.

- As the object is raised against the force of gravity, some amount of work (W) is done on it.
- Work done on the object = force × displaceme



- So,
- W = m×g×h = mgh
- ***above is the potential energy formula.***
- As per the law of conservation of energy, since the work done on the object is equal to m×g×h, the energy gained by the object = m×g×h, which in this case is the potential energy E.
- **E** of an object raised to a height h above the ground = **m×g×h**



It is important to note that, the gravitational energy does not depend upon the distance travelled by the object, but the displacement i.e., the difference between the initial and the final height of the object. Hence, the path along which the object has reached the height is not taken into consideration. In the example shown above, the gravitational potential energy for both the blocks A and B will be the same.

Elastic Potential Energy

- Elastic potential energy is the energy stored in objects that can be compressed or stretched such as rubber bands, trampoline and bungee cords. The more an object can stretch, the more elastic potential energy it has. Many objects are specifically designed to store elastic potential energy such as the following:
- A twisted rubber band that powers a toy plane
- An archer's stretched bow
- A bent diver's board just before a diver dives in
- Coil spring of a wind-up clock
- An object that stores elastic potential energy will typically have a high elastic limit, however, all elastic objects have a threshold to the load they can sustain. When deformed beyond the elastic limit, the object will no longer return to its original shape.
- Elastic potential energy can be calculated using the following formula: $U=1/2kx^2$
- Where, *U* is the elastic potential energy

  k is the spring force constant

  x is the string stretch length in m

- Consider an electric spring of negligibly small mass .One end of the spring is attached to the rigid wall and another end of spring is attached to a block of mass m which can move on smooth frictionless horizontal surface

- Consider the figure given below

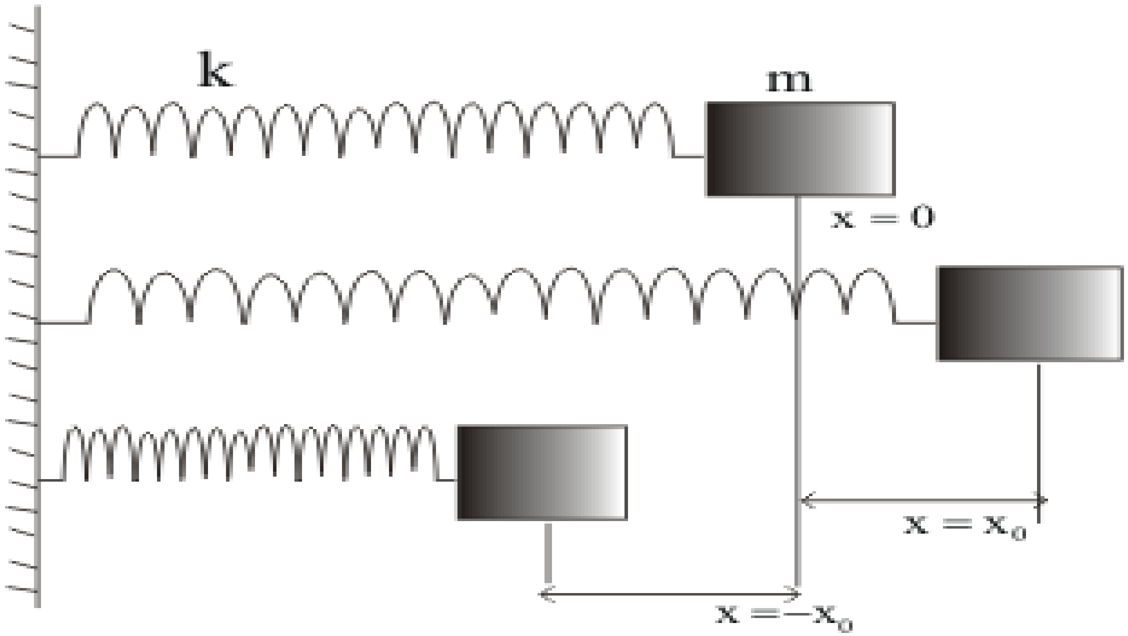


Figure 6. PE of a spring

Here un-stretched or un-compressed position of the spring is taken at $x=0$

We now take the block from its un-stretched position to a point P by stretching the spring

At this point P restoring force is exerted by the spring on the block trying it bring it back to the equilibrium position.
Similar restoring force developed in the spring when we try to compress it

For an ideal spring ,this restoring force F is proportional to displacement x and direction of restoring force is opposite to that displacement

Thus force and displacement are related as
$F \alpha x$
or $F= - kx$ --------------------------(1)

where K is called the spring constant and this equation (1) is known as Hook's law. negative sign indicates that force oppose the motion of the block along x

To stretch a spring we need to apply the external force which should be equal in magnitude and opposite to the direction of the restoring force mentioned above i.e for stretching the spring

$F_{ext}=Kx$ Similarly for compressing the spring

$-F_{ext}=-Kx$

or $F_{ext}=Kx$ (both F and x are being negative)

Work done in both elongation and compression of spring is stored in the spring as its PE which can be easily calculated

If the spring is stretched through a distance x from its equilibrium position x=0 then

$W=\int F_{ext}dx$

Since both F_{ext} and dx have same direction Now

$W=\int Kxdx$

x=x

We have

$W=Kx^2/2$ ………………………………………….. (2)

•This work done is positive as force is towards the right and spring also moves towards the right same amount of external

•On integrating with in the limits x=0 to l is done on the spring when it is compressed through a distance x

•Work done as calculated in equation (1) is stored as Potential Energy of the spring. Therefore

$U=Kx^2/2$ …………………………………………….. (3)

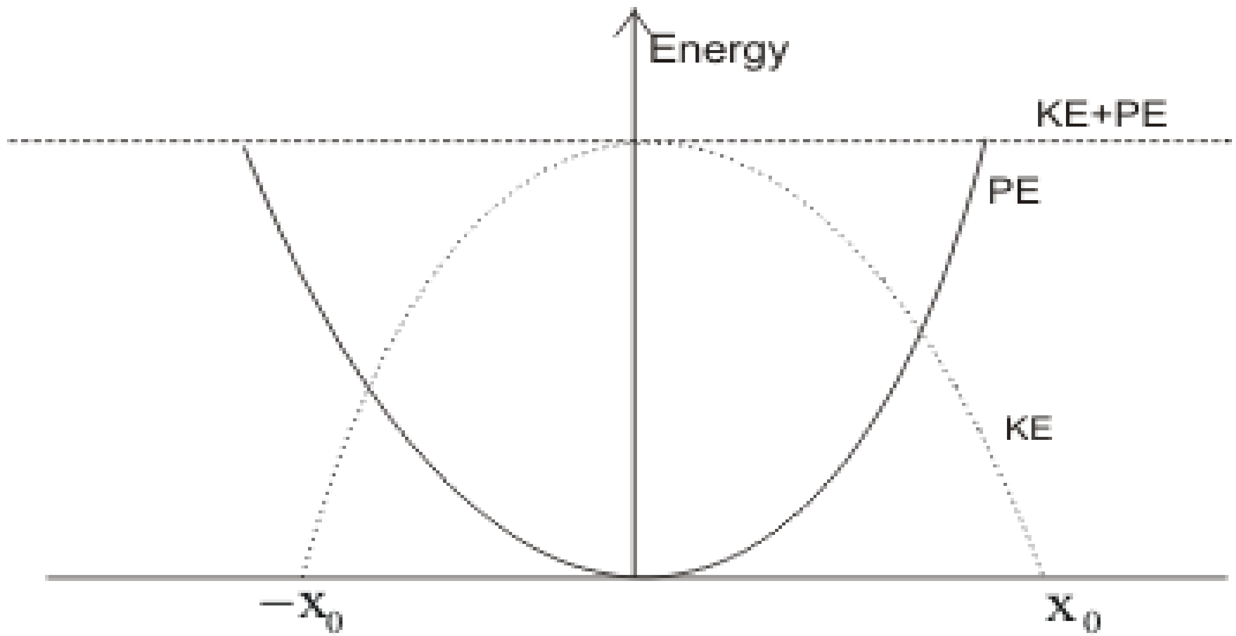


Figure 7. Graphs for KE and PE of a spring