Ministry of Higher Education and Scientific Research
Al-Ma’moun University College

كليـــة المــأمون الجامعــة
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General Physics

Lecture (5)

(Work & Energy)

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Work and Energy

- one of the most central concepts in science is energy; the combination energy and matter makes up our universe
- matter is the substance of the universe, while energy is what moves the substance
- matter is what we can see, touch and feel; energy is somewhat more elusive to categorize; energy is not typically seen or felt

Work

- work is the product of the force and distance and is a scalar measurement Work = Force × Distance $W = \boldsymbol{F}d$
- the unit of work is the joule (J); where 1 J = 1 N·m
- when you lift an object off the ground you are doing work; the heavier the load (↑***F***) or the higher you lift the object (↑*d*), the more work you are performing
- there are two things that must occur if work is being done:
  - a force must be exerted
  - the object must move

- sometimes there are situations that appear to be work, but are actually not; for example, if you hold a barbell steady over your head, you are not doing any work (remember, the object has to move in order to do work)
- We will repeat :

there are two things that must occur if work is being done:

  - a force must be exerted
  - the object must move

Power

- What if we can do the same work in shorter time!!??
- the time it takes to perform work makes a difference, indeed.
- this difference in how fast the work is done is called power
- power is equal to the amount of work done per unit time
- Power = Work/time interval

$$P = W/t$$

- one of the original units of power called horsepower was developed by Scottish engineer James Watt (1736 – 1819); Watt was famous for the development of the steam engine
- Watt wanted to know how the steam engine compared to horses in pumping out water out of coal mines; he found that a horse could lift 150 pounds 220 feet in one minute;
- 1 horsepower is equal to 745.2 watts
- the SI unit of power is the watt (W); 1 W = 1 J/s
- engines are valued because they can perform a lot of work very quickly

Mechanical Energy

- energy is that which enables objects to do work
- there are many types of energy; like work, energy is measure in joules (J)
- we will focus of mechanical energy; mechanical energy is separated into two categories; potential and kinetic

Potential Energy

- an object may store energy because of its position; this is called potential energy (PE)
- a book on a shelf, a rock tossed into the sky, and compressed spring, all have potential energy; work was done to all of these objects which stored the energy
- work is required to elevate objects against Earth's gravity; the amount of gravitational potential energy possessed by an object is equal to the amount of work done against gravity in lifting it

- Gravitational Potential Energy = Weight × Height

$$U_g = mgd$$

the unit of potential energy (as with any type of energy) is the joule (J)

Kinetic Energy

- if we perform work on a moving object, then we can change its energy of motion
- if an object is in motion, then by virtue of that motion, it is capable of performing work
- kinetic energy (KE) is energy of motion; the kinetic energy of an object depends on its mass and speed

$$\text{Kinetic Energy} = \tfrac{1}{2}\ \text{mass} \times \text{speed}^2$$

$$KE = \tfrac{1}{2} m v^2$$

- as a result:

$$\text{Net force} \times \text{distance} = \text{kinetic energy}$$

$$\boldsymbol{F} d = \tfrac{1}{2} m v^2$$

$$\text{Work} = \Delta KE$$

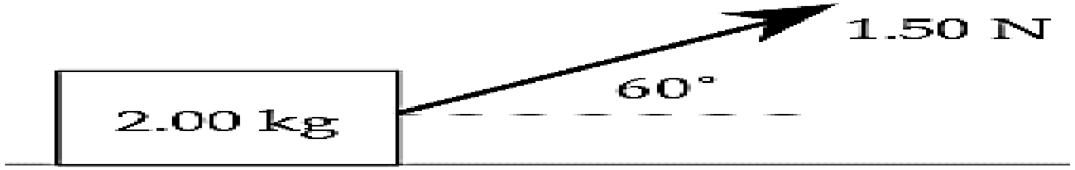
Example (1)
(Work)

- A constant force of 1.50 N is applied at an angle of 60˚ above the horizontal to a 2.00 kg block in contact with a horizontal frictionless surface (Figure below). The block moves a distance of 0.500 m along the surface. Calculate the work done by the agent of the force during this movement

Solution

$$W = F.\Delta r.cos\theta = (1.50N)(0.500m)\cos 60^o = 0.375\, J.$$

It is useful to note that the work done is independent of the mass of the object.



Example (2)
Work done by spring

- A mass is connected to the end of a spring. The spring constant is *k* = 0.020 $N.m^{-1}$. The mass is released from a position $x_i = 0.25\,m$. How much work is done by the spring when the mass moves to the position x_f = – 0.10 m?

Solution:

$$W = \frac{1}{2}k(x_i^2 - x_f^2)$$

$$= \frac{1}{2}(0.020N.m^{-1})[(0.25m)^2 - (-0.10m)^2]$$

$$= 5.25 \times 10^{-4}\ \text{J}.$$

The spring does a positive amount of work.

Example (3)
Power

- The source of a force applied to an object does 2.00 J of work in an elapsed time of 0.500 s. Calculate the average power.

<u>Solution:</u>

$$\overline{P} = \frac{\Delta W}{\Delta t} = \frac{2.00(J)}{0.500(s)} = 4.00 \text{ Watts.}$$

In the elapsed time given, energy is being transferred from the agent of the force to the object at the average rate of 4.00 joules per second.