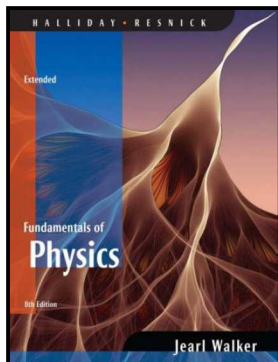


Workshop Physics

1017 - 311

University Physics I

Week 7 : Day 2



Kinetic and Potential Energy

□ Kinetic Energy

- The **kinetic energy** of an object is the extra energy which it possesses due to its motion.

$$K = \frac{1}{2}mv^2$$

□ Potential Energy

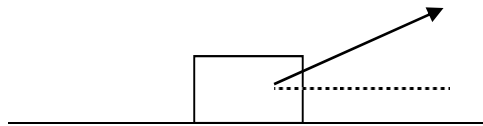
- The **Potential energy** is energy stored within a physical system as a result of the position or configuration of the different parts of that system.

$$U_g = mg\Delta h, \quad U_s = \frac{1}{2}kx^2, \dots$$

Activity – Work and Kinetic Energy Problems

□ Consider the

- A box has mass 2.5 kg and moves along a horizontal track. There is NO friction.
 - *At the first location that you see the box, it moves to the right at 4.0 m/s, and you notice that it is being pulled by a rope angled at 30° with tension of 6.0 N.*

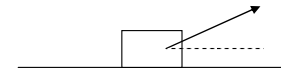


- An object of mass 2.5 kg moves in a straight line and a force that acts on it given by
$$F_x = -\frac{10 \text{ N m}^2}{x^2}$$

Work-Kinetic Energy Problems

1. A box has mass 2.5 kg and moves along a horizontal track. There is NO friction. At the first location that you see the box, it moves to the right at 4.0 m/s, and you notice that it is being pulled by a rope angled at 30° with tension of 6.0 N.

(a) Draw a free body diagram for the box.



(b) You want to find the speed of the block after it has moved 1.5 m to the right.

- (i) How much work on the box does the normal force do?
- (ii) How much work on the box does the weight do?
- (iii) How much work on the box does the pull do?
- (iv) What is the net work done on the box?

(c) What is the speed of the box after it has moved the 1.5 m?

(d) Now suppose that there IS a coefficient of friction of 0.12. Show that the friction force is 2.6 N.

(e) What is the work done on the box by friction?

(f) Including friction, what is the net work, and what is the speed of the box after it moves?

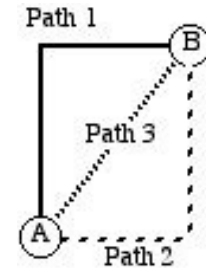
Conservative and Non-conservative Forces

□ Mechanical Energy

➤ $ME = KE + PE \longrightarrow E = K + U$

□ Conservation of Energy

- If all of the forces acting in a system are conservative the mechanical energy of the system will remain constant.
- Conservative Force (e.g., Gravity)
 - *A conservative force that acts on a closed system has an associated mechanical work that allows energy to convert only between kinetic or potential forms. This means that for a closed system, the net mechanical energy is conserved whenever a conservative force acts on the system. The force, therefore, is related directly to the difference in potential energy between two different locations in space*
 - *The work done by a conservative force is generally independent of the path taken...*
- Non-conservative Forces (e.g., Friction)
 - *In macroscopic closed systems, non-conservative forces act to change the internal energies of the system, and are often associated with the transfer of heat.*
 - *The work done by a non-conservative force generally depends upon the path taken...*



Activity – Con. And Non-Con Forces

□ Consider the motion of a book

- Conservative: gravity

$$\vec{F}_g = m\vec{g}$$

- No-conservative: friction

$$\vec{F}_f \leq \mu\vec{F}_N$$

Conservative and Non-Conservative Forces

1. Force of gravity: Motion in a Vertical Plane

Point A is at your feet, point B is 2 m vertically up and 1.5 m horizontally from the first point. Three paths between point A and point B are shown.

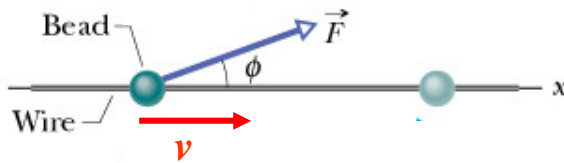


You move a ball from A to B along each of the paths. The ball has a mass of 4.0 kg and is motionless at the start and at the end.

- What is the net work done on the ball in each for each of the three paths?
- Determine the work done by the force of gravity for Path 1.
- Determine the work done by the force of gravity for Path 2.
- Determine the work done by the force of gravity for the diagonal line, Path 3.
- Are your answers the same or different for the three paths?
- Does the work of gravity equal the net work? Why or why not?

Power from a Constant Force

Consider a force F acting on a particle at an angle ϕ to the motion. The rate at which F does work is given by $P = \frac{dW}{dt} = \frac{F \cos \phi dx}{dt} = F \cos \phi \frac{dx}{dt} = Fv \cos \phi$.



$$P = Fv \cos \phi = \vec{F} \cdot \vec{v}$$

□ Power and work

- The instantaneous power is defined as follows:

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

Units of Power and Average Power

Unit of P : The SI unit of power is the watt. It is defined as the power of an engine that does work $W = 1 \text{ J}$ in a time $t = 1 \text{ second}$.

A commonly used non-SI power unit is the horsepower (hp), defined as $1 \text{ hp} = 746 \text{ W}$.

The kilowatt-hour The kilowatt-hour (kWh) is a unit of work. It is defined as the work performed by an engine of power $P = 1000 \text{ W}$ in a time $t = 1 \text{ hour}$, $W = Pt = 1000 \times 3600 = 3.60 \times 10^6 \text{ J}$. The kWh is used by electrical utility companies (check your latest electric bill).

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

We define "power" P as the rate at which work is done by a force F .

If F does work W in a time interval Δt then we define the average power as

Activity - Power

□ Power calculations

- Isolate forces
- Determine pieces

□ Average Power

- Amount of work

Power

Power is defined to be the rate work is done, or energy changes. If a force does work W over some interval, the average power is given by

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

The instantaneous power is given by $P=dW/dt$. If the force is constant, the work is given by $W = \vec{F} \cdot \vec{d}$ thus the power is the time derivative of this, or $P = \vec{F} \cdot \vec{v}$.

1. A tired physics student trudges up from the ground floor to his third floor physics class.
 - a) Estimate the mass of a student, and the height of the third floor.
 - b) What is the work done by gravity?
 - c) What is the work done by the student?
 - d) If it took him 50 seconds to get up to the third floor, what was the average power of the student?
 - e) If he was eager to get to class and do a fun lab, and he ran up the stairs in 15 seconds, what was the power?