Kinetic Energy

Let's examine what happens to an object when a net force is applied to it.

We'll start with Newton's Second Law and \( v_f^2 = v_i^2 + 2a \Delta d \):

\[
\begin{align*}
\frac{F}{m} &= \frac{\Delta \vec{v}}{\Delta t} \\
\frac{1}{2} m \frac{\Delta v_i}{\Delta t} &= \frac{1}{2} m \frac{\Delta v_f}{\Delta t} \\
\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 &= F \Delta d
\end{align*}
\]

What does it mean?

Let's analyze the units:

\[
\frac{1}{2} m v^2
\]

**Kinetic energy** - the energy of an object due to its **motion**

- it depends on **mass** and **velocity**
- It is a scalar quantity

\[ E_K = \frac{1}{2} m v^2 \]

For example, a hammer can do work on a nail because it has kinetic energy. The faster the hammer moves, the greater its kinetic energy, and the greater the displacement of the nail.

Back to \( F \Delta d = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \)

\[ W = E_{K_2} - E_{K_1} \]

\[ W = \Delta E_K \]

**The Work Energy Theorem (WET)**

This means

1) work results in a change in **kinetic energy**

OR

2) a change in **kinetic energy** means work has been done
Lesson 2 - Kinetic Energy - filled in.notebook

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Example 1

(a) What is the kinetic energy of a baseball, \( m = 0.145 \, \text{kg} \), travelling at 46.7 \( m/s \) (world record fastball)?

(b) How fast would a 1600 \( kg \) car need to travel in order to have the same kinetic energy?

\[
\text{a) } E_k = \frac{1}{2} m v^2 \\
= 158 \, \text{J}
\]

\[
\text{b) } E_k = \frac{1}{2} m v^2 \\
\frac{2 \, E_k}{m} = v^2 \\
\sqrt{\frac{2 \, E_k}{m}} = v \\
0.44 \, \text{m/s} = v
\]

\[
\therefore \text{The kinetic energy is 158J}
\]

\[
\therefore \text{The speed of the car is 0.44 m/s}
\]
Example 2

A 1000 kg car is travelling at 10.0 m/s when the driver hits the gas causing the car to now be travelling at 20.0 m/s.

(a) How much kinetic energy did it gain?
(b) How much work was done on the car during this time?

\[ E_{k1} = \frac{1}{2}mv_1^2 \]
\[ = 500000 \text{ J} \]

\[ E_{k2} = \frac{1}{2}mv_2^2 \]
\[ = 2000000 \text{ J} \]

\[ 2000000 \text{ J} - 500000 \text{ J} \]
\[ = 1500000 \text{ J} \]

\[ = 2000000 \text{ J} \] (silly sig digs!)

\[ W = \Delta E_k \]
\[ W = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 \]
\[ = 2000000 \text{ J} \] of work was done.
Example 3  

A pool ball has a mass of 0.245 kg and is travelling at 12 m/s. Another ball hits it transferring 4.5 J of kinetic energy to the ball. What is its new speed?

\[ v = 13 \, \text{m/s} \]
Example 4

A 165 g hockey puck initially at rest is pushed by a hockey stick on a slippery horizontal ice surface by a constant horizontal force of magnitude 5.0 N (assume the ice is frictionless). What is the puck's speed after it has moved 0.50 m?

Method 1
Big Five

Method 2
Work

6 m/s