Introduction to Kinetic Energy

What is energy?

"The law is called the *conservation of energy*. It states that there is a certain quantity, which we call energy, that does not change in the manifold changes which nature undergoes. That is a most abstract idea, because it is a mathematical principle; it says that there is a numerical quantity which does not change when something happens. It is not a description of a mechanism, or anything concrete; it is just a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same."

- Richard Feynman - The Feynman Lectures on Physics
  https://www.feynmanlectures.caltech.edu/I_04.html

What are the units for energy?

James Joule is one of the early physicists who laid much of the background and helped establish how we talk about heat and energy. As a result, the joule became the standard unit of energy in the SI system.

What is kinetic energy?

Using the idea that energy is a quantity that is useful to track during interactions, we need to start defining specific forms of this quantity. Often, the first of these quantities for discussion is *kinetic energy*. Kinetic energy is the energy associated with the motion of an object. It takes into account both the mass of the object and how fast it is travelling. Unlike momentum, energy does not take into account the direction of travel. The equation for kinetic energy is:

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

If we look at the units for the equation, we can see a joule in fundamental units:

$$J = (kg)(\frac{m}{s})^2$$

Example Calculations:

Example 1: A 4 kg block that is traveling 3 m/s. Calculate the kinetic energy of the block.

$$KE = \frac{1}{2}mv^2$$
$$KE = \frac{1}{2}(4)(3)^2$$
$$KE = 18\ J$$

Example 2: A ball has a 25 J of energy when it is traveling 10 m/s. Determine the mass of the ball.

$$KE = \frac{1}{2}mv^2$$
$$m = \frac{2KE}{v^2}$$
$$m = \frac{2(25)}{(10)^2} = \frac{50}{100} = 0.5\ kg$$

Example 3: A 1.5 kg cart has 12 J of kinetic energy. Determine how fast it is traveling.

$$KE = \frac{1}{2}mv^2$$
$$v = \sqrt{\frac{2(KE)}{m}}$$
$$v = \sqrt{\frac{2(12)}{1.5}} = \sqrt{\frac{24}{1.5}} = 4\ m/s$$

Practice Calculations

Show your work as you complete the following calculations.

1. Calculate the kinetic energy of a 2.0 kg block that is traveling 4.0 m/s. (*ans 16 J)*
2. Calculate the kinetic energy of a 4.0 kg block that is traveling 4.0 m/s. *(ans 32 J)*
3. Calculate the kinetic energy of a 6.0 kg block that is traveling 4.0 m/s. *(ans 48 J)*
4. Calculate the kinetic energy of a 2.0 kg block that is traveling 8.0 m/s. *(ans 64 J)*
5. Calculate the kinetic energy of a 2.0 kg block that is traveling 12.0 m/s. *(ans 144 J)*

Questions

Show your work as you answer the following questions.

6. A 0.150 kg baseball has 67.5 J of kinetic energy. How fast is it traveling?
7. How fast must a 1200 kg car travel to have the same kinetic energy as a 1000 kg car traveling 15 m/s?
8. A football player is told to get bigger and faster to “win” collisions during a game. Suppose he increases his mass from 85 kg to 90 kg and his maximum speed from 10 m/s to 11 m/s. How much energy did he add to the collision?

Extension

9. Sketch the graph of kinetic energy vs. mass. From the graph, describe the relationship between kinetic energy and mass.
10. Sketch the graph of kinetic energy vs. speed. From the graph, describe the relationship between kinetic energy and speed.