# Kinetic Energy

**Unit:** Energy, Work & Power

**NGSS Standards/MA Curriculum Frameworks (2016):** HS-PS3-1

**AP® Physics 1 Learning Objectives/Essential Knowledge (2024):** 3.1.A, 3.1.A.1, 3.1.A.2, 3.1.A.3, 3.3.A, 3.3.A.1, 3.3.A.2, 3.3.A.3, 3.3.A.4, 3.3.A.4.i, 3.3.A.4.ii, 3.3.A.4.iii, 3.3.A.5

**Mastery Objective(s):** (Students will be able to…)

- Calculate the kinetic energy of an object.

**Success Criteria:**

- Correct equation(s) are chosen for the situation.
- Variables are correctly identified and substituted correctly into equation(s).
- Algebra is correct and rounding to appropriate number of significant figures is reasonable.

**Language Objectives:**

- Explain when & why an object has potential energy.
- Explain when & why an object has kinetic energy.

**Tier 2 Vocabulary:** work, energy

## Labs, Activities & Demonstrations:

- "Happy" and "sad" balls.
- Popper.

## Notes:

kinetic energy: the energy that an object has due to the combination of its mass and velocity

Because energy is a conserved quantity, if energy is used to cause a macroscopic object to increase its velocity, that energy is then contained within the moving object. We call this energy "kinetic energy", and the amount of kinetic energy that an object has is related to its mass and velocity. An object has translational kinetic energy (the kinetic energy of an object or system that is moving in the *xy* plane or *xyz* space) if its center of mass is moving. Translational kinetic energy is given by the equation:*

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

Note that a single object can have kinetic energy. An entire system can also have kinetic energy if the center of mass of the system is moving (has nonzero mass and nonzero velocity).

* In these notes, $K$ without a subscript is assumed to be translational kinetic energy. In problems involving both translational and rotational kinetic energy, translational kinetic energy will be denoted as $K_t$ and rotational kinetic energy as $K_r$.

The above equation is for translational kinetic energy only. Kinetic energy also exists in rotating systems; an object can have rotational kinetic energy whether or not its center of mass is moving. *Rotational Kinetic Energy* will be discussed in a later topic, starting on page 479.

## Internal (Thermal) Energy

Kinetic energy is both a macroscopic property of a large object (*i.e.,* something that is at least large enough to see), and a microscopic property of the individual particles (atoms or molecules) that make up an object. Internal (thermal) energy is the aggregate microscopic energy that an object (often an enclosed sample of a gas) has due to the combined kinetic energies of its individual particles. (Heat is thermal energy added to or removed from a system.)

As we will see when we study thermal physics, temperature is the average of the microscopic kinetic energies of the individual particles that an object is made of. Kinetic energy can be converted to internal energy if the kinetic energy of a macroscopic object is turned into the individual kinetic energies of the particles of that object and/or some other object. Processes that can convert kinetic energy to internal energy include friction and collisions.

## Homework Problems

1. **(M)** Calculate the kinetic energy of a car with a mass of 1200 kg moving at a velocity of $15\frac{m}{s}$.

Answer: 135 000 J