Motion and Speed

Motion is an object's change in position over time. The **position** is the location of an object. Motion is kinetic energy that moves from one object to another. The two parts of motion are distance (measured with a ruler, for example) and direction (indicated with an arrow or by north, south, east, and west).

Motion is described using a **frame of reference**, such as an object used to measure motion or position. Examples would be "four steps in front of the desk" or "three miles past the gas station." Motion is also relative: It depends on whether we are in motion or something else is in motion.

Forces push or pull an object to alter its motion. Either an object will stay still, or it will move at constant speed in the same direction, unless a force affects it. This is **Newton's first law of motion**: An object at rest stays at rest, and an object in motion remains in motion at a constant speed and in a straight line, unless another force acts on it.

The bigger the object (or the greater the mass of an object), the more force is needed to affect it. The more mass an object has, the more inertia it has. **Inertia** is the tendency of an object to stay still or to move at the same speed in the same direction. More mass requires more force, just like rolling a bowling ball requires more force than rolling a marble.

Likewise, an object moving at a faster speed needs more force to affect it. A force opposite to the object's direction slows it. The amount of change in direction depends on the strength of the force and the mass of the object. This is **Newton's second law**: The acceleration of an object depends on its mass and the amount of force used.

The **speed** of an object is how fast the position of the object changes over time. Velocity measures the combined speed and direction of an object. **Velocity** can measure **acceleration**, the change in velocity over time. Another way to explain acceleration is to say that it describes the increase in speed over time. The formula for acceleration is:

acceleration = force ÷ mass
or
force = mass x acceleration

The greater the force pushing or pulling an object, the faster the acceleration of the object. This means more force will be needed to alter the rate or direction of the object. Momentum comes from the word "movement" and describes moving objects. The **momentum** of a moving object describes how long it will take to bring the object to a stop. An object's momentum is its mass multiplied by its velocity or speed.

One force that slows an object is friction. Friction comes from a word that means "to rub." **Friction** is the force that resists motion between two objects touching each other. A hand placed palm down above a surface can be waved back and forth in the air without using much force. That same hand placed down on the surface, rubbing back and forth across the surface, takes more force to rub back and forth. Friction causes the hand to slow down. It also causes the hand and the surface to grow warmer. Rubbing your hands together in winter will warm them because the friction creates heat. One example of friction happens when bicycle brakes are used. Friction causes the brakes to slow the bicycle, but friction also causes the brakes to rub away and wear out over time.

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