**Acceleration, Force, and Newton’s Laws**

**Acceleration**

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_= the rate at which velocity changes with time
  + A measure of how quickly velocity is changing
  + If \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ doesn’t change, there is NO acceleration
* We generally say acceleration means to speed up, but in physics, it can refer to slowing down too.
* Acceleration can also refer to changing direction without changing speed (ex: runner turning a corner at a constant speed)

**Calculating Acceleration**

* Acceleration = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* A = \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Remember, velocity is expressed in units of meters per second (m/s) (just like speed but with direction), and time is expressed in seconds.
* Acceleration is expressed in units of m/s over time, so they are expressed in \_\_\_\_\_\_\_\_\_\_\_.

**Calculating Acceleration**

* Anna starts sliding with a velocity of 1 m/s. After 3 s, her velocity is 7 m/s. What is Anna’s acceleration?
* Use KQS!
* What do we know?
* What is the question?
* Solve! A = v(final) – v(initial)

t

* A =
* Anna’s acceleration is:

**Practice Problems**

1. A man walking at 0.5 m/s accelerates to a velocity of 0.6 m/s in 1 s. What is his acceleration?
2. A train traveling at 10 m/s slows down to a complete stop in 20 s. What is the acceleration of the train

**Force**

* Force = a \_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_
* Anytime you change the motion of an object, you use \_\_\_\_\_\_\_\_\_\_\_\_.
* Example: a pitcher throws a ball, the batter hits it, and a fan in the stands catches it. Each of these people uses

force. The pitcher sets the ball in motion, the batter changes the direction of the ball’s motion, and the fan stops the ball’s motion.

**Types of Force**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- when one object pushes or pulls another object by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
   * Ex: Skater applies contact force as she pushes against the ground.
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_- force of attraction between two masses.
   * Ex: Earth’s gravity pulls on skater, holding her to ground.
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_- force that resists motion between two surfaces that are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
   * Ex: Friction between the surface of the ground and the wheels of the skates exerts a force that resists the skater’s forward motion.

**Balanced and Unbalanced Force**

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_= the overall force acting on an object when all the forces are combined.
* If the net force of an object is \_\_\_\_\_\_\_\_\_\_, the forces acting on the object is balanced.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_forces have the same effect as no force at all, meaning the motion of the object does not

change.

* Only an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force can change the motion of an object.

**Newton’s First Law**

* An object at rest stays at rest, and an object in motion stays in motion at the same velocity, unless acted upon by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Simply put: Applying \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ changes the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of an object.

**Inertia**

* Inertia = the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of an object to a change in the \_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_ of its

motion.

* Newton’s First Law is also called the Law of Inertia.
* Inertia is closely related to mass. When you measure the mass of an object, you are also measuring its inertia.
* The more mass something has, the harder it is to change its motion.
* Ex: It’s easier to stop an empty wagon than a wagon full of sand.

**The more mass, the greater the inertia**

**Newton’s Second Law**

* Acceleration of an object increases with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force and decreases with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mass.
* The direction in which an object accelerates is the same as the direction of the force.
* Simply put: Newton’s Second Law is…

F = \_\_\_\_\_\_\_\_

(Force = \_\_\_\_\_\_\_\_\_ x \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

* Force is measured in \_\_\_\_\_\_\_\_\_\_\_\_\_\_ (N).

**Sample Problem**

* What force is needed to accelerate a 10 kg shopping cart 3 m/s2?
* Remember KQS!
* What do we know?
* Question?
* Solve! F = ma…

**Practice Problems**

1. If a 5 kg ball is accelerating 1.2 m/s2, what is the force on it?
2. A person on a scooter is accelerating 2 m/s2. If the person has a mass of 50 kg, how much force is acting on that person?

**Forces can change the direction of motion**

* Generally we think force either speeds up or slows down the motion of an object, but it can also make it change \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* If you apply a force to an object, the direction the object accelerates is the same as the direction of the force.

This can allow an object to change direction without changing speed.

Ex: A soccer player can control the motion of a soccer ball by applying force that changes the ball’s direction but not its speed.

**Newton’s 3rd Law**

* Forces always act in \_\_\_\_\_\_\_\_\_\_\_\_\_\_!
* Newton’s Third Law: For every action, there is an \_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_reaction.
* Every time one object exerts a force on another object, the second object exerts a force that is equal in size and opposite in direction back on the first object.

**Action/Reaction Force Pairs**

* The force that is exerted on an object and the force that the object exerts back are known together as

an \_\_\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force pair.

* Ex: the jellyfish pushing on the water is the action force, the water pushing back on it is the reaction

force.

* Action/Reaction force pairs do not always result in motion. For example, if you press down on a table,

the table resists the push with the same amount of force even though nothing happens.

**Momentum**

* MOMENTUM = a measure of mass in motion; the product of its \_\_\_\_\_\_\_\_ and its \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Example: If you throw a tennis ball and a wrecking ball at the same brick wall with the same velocity,

the tennis ball will bounce back but the wrecking ball would likely destroy the brick wall. This is because the wrecking ball has more mass. You can’t change their masses, but you could increase the momentum of either ball by increasing the velocity.

* Conservation of Momentum states that the total momentum of a system of objects does not change, as

long as no outside forces are acting on that system.

* The combined momentum of both objects after a collision is the same as the combined momentum of

both objects before the collision