(See Below for Notes)

Handout- Newton's 3 Laws of Motion

The motion of an aircraft through the air can be explained and described by physical principals discovered over 300 years ago by Sir Isaac Newton. Newton worked in many areas of mathematics and physics. He developed the theories of gravitation in 1666, when he was only 23 years old. Some twenty years later, in 1686, he presented his three laws of motion in the "Principia Mathematica Philosophiae Naturalis."

Newton's first law states that every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force. This is normally taken as the definition of **inertia.** The key point here is that if there is **no net force** acting on an object (if all the external forces cancel each other out) then the object will maintain a **constant velocity**. If that velocity is zero, then the object remains at rest. If an external force is applied, the velocity will change because of the force.

Newton's second law explains how the velocity of an object changes when it is subjected to an external force. The law defines a **force** to be equal to change in **momentum** (mass times velocity) per change in time. Newton also developed the calculus of mathematics, and the "changes" expressed in the second law are most accurately defined in differential forms. (Calculus can also be used to determine the velocity and location variations experienced by an object subjected to an external force.) For an object with a constant mass **m**, the second law states that the force **F** is the product of an object's mass and its acceleration **a**:

$$F = m * a$$

For an external applied force, the change in velocity depends on the mass of the object. A force will cause a change in velocity; and likewise, a change in velocity will generate a force. The equation works both ways.

Newton's third law states that for every action (force) in nature there is an equal and opposite reaction. In other words, if object A exerts a force on object B, then object B also exerts an equal force on object A. Notice that the forces are exerted on different objects. The third law can be used to explain the generation of lift by a wing and the production of thrust by a jet engine.

Source: https://www.grc.nasa.gov/WWW/K-12/airplane/newton.html

(See Below for Notes)

Physical Science Notes: 4.4, 4.5, 4.6, 4.7

4.4- Reviewing Newton’s First Law of Motion

What is Newton’s first law of motion? Give an example.

- One way of expressing Newton’s first law is as follows: An object will remain at its current **velocity** unless acted on by an unbalanced **force**.
- A force is unbalanced if it is not opposed by another force of equal magnitude.
- Friction is a force.
- Stationary or moving objects that are subject only to balanced forces are in **equilibrium**.
- Objects in equilibrium do not require forces to continue being stationary or to continue moving.
- The first law is also known as the law of **inertia**.
- Inertia is a property of matter and is not itself a force.
- An example of Newton's first law can be seen when an object is thrown in outer space. It will continue moving in a straight line at a constant **speed** forever unless acted on by an unbalanced force.

4.5- Reviewing Newton’s Second Law of Motion

How do forces affect the motion of objects?

Newton’s second law states that:

- The **acceleration** an object experiences depends on how much **net force** is placed on that object. The more net **force** that is applied, the greater the acceleration.
- The acceleration of an object also depends on the **mass**. The greater the mass, the harder it is to accelerate an object.
- An object accelerates in the same direction as the net force.

In equation form, Newton’s second law can be expressed as:

$$\vec{a} = \frac{\vec{F}_{\text{Net}}}{m}$$

An example of Newton’s second law is when a baseball player hits a baseball. A force is applied to the ball which causes the ball to accelerate in the direction of the force. The acceleration produced depends on the net force and the mass of the baseball.

4.6- Reviewing Newton's Third Law of Motion

When you push on a wall, what does the wall do to you?

Newton discovered that forces always act in pairs. These **force** pairs are known as action and reaction forces. Newton also observed that the forces in an action–reaction pair are always equal in magnitude, but opposite in direction.

- Even though action and reaction forces are of equal strength, they do not necessarily produce the same **acceleration** on objects involved in the interaction. The acceleration also depends on the objects' masses.
- Action and reaction forces do not cancel out since each force acts on a different object.
- An example of a pair of action and reaction forces occurs when a swimmer swims through water. By pushing backward on the water (the action force), the water exerts a reaction force on the swimmer that is directed forward and enables the swimmer to move through the water.

In which situations are Newton's laws of motion not applicable?

- Newton's laws are not applicable at high speeds (generally more than a tenth of the **speed** of light).
- Relativity theory describes motion at high speeds.
- Newton's laws of motion are not applicable on molecular and atomic scales (which are about a nanometer).
- **Quantum mechanics** describes the behavior of matter on atomic scales.

4.7- Applying Newton's Laws of Motion

How can Newton's laws of motion be applied to practical problems involving forces and motion?

- Newton's laws apply to many classes of problems, including inclined planes, circular motion, pulleys, and falling objects.
- If the forces on an object are known, Newton's laws can determine its motion.
- If the motion of an object is known, Newton's laws can determine the forces it is subject to.
- As can be seen from the equation of Newton's second law, $\vec{F} = m\vec{a}$, if an object is not accelerating then the total **force** acting on it must be zero.