Newton's Laws of Motion

<table>
<thead>
<tr>
<th>First law:</th>
<th>&quot;Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it.&quot;</th>
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</thead>
<tbody>
<tr>
<td>Second law:</td>
<td>&quot;Force is equal to the change in momentum per change in time. For a constant mass, force = mass times acceleration.&quot;</td>
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<tr>
<td>Third law:</td>
<td>&quot;For every action, there is an equal and opposite reaction.&quot;</td>
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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." The laws are shown above, and the application of these laws to aerodynamics are described below.

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.

The 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 \( a \):

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F = m \times a
\]
Newton’s Laws of Motion

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.

The 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. It also explains how buoyancy force from the water can support the ship while the gravity and the ship’s mass exerts a force on the water.