Newton's laws of motion

Science, Physics

NEWTON’S LAWS OF MOTION Newton's First Law of Motion An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force. There are two parts to this statement - one that predicts the behavior of stationary objects and the other that predicts the behavior of moving objects. The two parts are summarized in the following diagram. The behavior of all objects can be described by saying that objects tend to " keep on doing what they're doing" (unless acted upon by an unbalanced force). If at rest, they will continue in this same state of rest. If in motion with an eastward velocity of 5 m/s, they will continue in this same state of motion (5 m/s, East). If in motion with a leftward velocity of 2 m/s, they will continue in this same state of motion (2 m/s, left). The state of motion of an object is maintained as long as the object is not acted upon by an unbalanced force. All objects resist changes in their state of motion - they tend to " keep on doing what they're doing." EXAMPLES: 1. Suppose that you filled a baking dish to the rim with water and walked around an oval track making an attempt to complete a lap in the least amount of time. The water would have a tendency to spill from the container during specific locations on the track. In general the water spilled when: * the container was at rest and you attempted to move it * the container was in motion and you attempted to stop it * the container was moving in one direction and you attempted to change its direction. The water spills whenever the state of motion of the container is changed. The water resisted this change in its own state of motion. The water tended to " keep on doing what it was doing." The container was moved from rest to a high speed at the starting line; the water remained at rest and spilled onto the table. The container was stopped near the finish line; the water kept moving and spilled over container's leading edge. The container was forced to move in a different direction to make it around a curve; the water kept moving in the same direction and spilled over its edge. The behavior of the water during the lap around the track can be explained by Newton's first law of motion. 2. Consider some of your experiences in an automobile. Have you ever observed the behavior of coffee in a coffee cup filled to the rim while starting a car from rest or while bringing a car to rest from a state of motion? Coffee " keeps on doing what it is doing." When you accelerate a car from rest, the road provides an unbalanced force on the spinning wheels to push the car forward; yet the coffee (that was at rest) wants to stay at rest. While the car accelerates forward, the coffee remains in the same position; subsequently, the car accelerates out from under the coffee and the coffee spills in your lap. On the other hand, when braking from a state of motion the coffee continues forward with the same speed and in the same direction, ultimately hitting the windshield or the dash. Coffee in motion stays in motion. Newton's Second Law of Motion Newton's second law of motion pertains to the behavior of objects for which all existing forces are not balanced. The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. As the force acting upon an object is increased, the acceleration of the object is increased. As the mass of an object is increased, the acceleration of the object is decreased. Newton's second law of motion can be formally stated as follows: The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object. This verbal statement can be expressed in equation form as follows: a = Fnet / m The above equation is often rearranged to a more familiar form as shown below. The net force is equated to the product of the mass times the acceleration. Fnet = m * a In this entire discussion, the emphasis has been on the net force. The acceleration is directly proportional to the net force; the net force equals mass times acceleration; the acceleration in the same direction as the net force; an acceleration is produced by a net force. The NET FORCE. It is important to remember this distinction. Do not use the value of merely " any 'ole force" in the above equation. It is the net force that is related to acceleration. As discussed in an earlier lesson, the net force is the vector sum of all the forces. If all the individual forces acting upon an object are known, then the net force can be determined.   Consistent with the above equation, a unit of force is equal to a unit of mass times a unit of acceleration. By substituting standard metric units for force, mass, and acceleration into the above equation, the following unit equivalency can be written. The definition of the standard metric unit of force is stated by the above equation. One Newton is defined as the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s. Therefore, this law states that: A. Firstly, this law states that if you do place a force on an object, it will accelerate, i. e., change its velocity, and it will change its velocity in the direction of the force. B. Secondly, this acceleration is directly proportional to the force. For example, if you are pushing on an object, causing it to accelerate, and then you push, say, three times harder, the acceleration will be three times greater. C. Thirdly, this acceleration is inversely proportional to the mass of the object. For example, if you are pushing equally on two objects, and one of the objects has five times more mass than the other, it will accelerate at one fifth the acceleration of the other. EXAMPLES: 1. If a 50 lb child pushes on an 80 lb box, the force would only be half that it would be if a 100 lb child pushed on an 80 lb box. If the same 100 lb man pushed on a 160 lb box, the acceleration would be half that it would be if pushing on the 80 lb box. 2. Try pulling a wagon that weighs slightly less than you do. It will move, but the acceleration is limited because the force limited. Now have someone help you pull the same wagon. Because the mass behind the force increases, so does the acceleration. If you were to double the weight of the wagon, you would decrease by half the acceleration of the wagon because the mass has doubled. Newton's Third Law of Motion A force is a push or a pull upon an object that results from its interaction with another object. Forces result from interactions! Some forces result from contact interactions (normal, frictional, tensional, and applied forces are examples of contact forces) and other forces are the result of action-at-a-distance interactions (gravitational, electrical, and magnetic forces). According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body. There are two forces resulting from this interaction - a force on the chair and a force on your body. These two forces are called action and reaction forces and are the subject of Newton's third law of motion. Formally stated, Newton's third law is: For every action, there is an equal and opposite reaction. The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs. A variety of action-reaction force pairs are evident in nature. Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. But a push on the water will only serve to accelerate the water. Since forces result from mutual interactions, the water must also be pushing the fish forwards, propelling the fish through the water. The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction force. Action-reaction force pairs make it possible for fish to swim. EXAMPLES: 1. Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air downwards. Since forces result from mutual interactions, the air must also be pushing the bird upwards. The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for birds to fly. 2. Consider the motion of a car on the way to school. A car is equipped with wheels that spin. As the wheels spin, they grip the road and push the road backwards. Since forces result from mutual interactions, the road must also be pushing the wheels forward. The size of the force on the road equals the size of the force on the wheels (or car); the direction of the force on the road (backwards) is opposite the direction of the force on the wheels (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for cars to move along a roadway surface. http://www. physicsclassroom. com/Class/newtlaws/