Newton's 2nd Law of Motion - F=ma

Sir Isaac Newton
(1642-1727)

Draw a picture and write about it.

Newton's Second Law Problem Set

Introduction – Newton's second law (**Force** = **M**ass × **A**cceleration) describes the forces necessary to change the motion of objects. It states that "acceleration is produced when a force acts on a mass, the greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object). In other words more mass needs more force to accelerate.

Equation	Gives you.....	If you know......
Force = Mass × Acceleration	Force	Mass and Acceleration
Acceleration = Force ÷ Mass	Acceleration	Force and Mass
Mass = Force ÷ Acceleration	Mass	Force and Acceleration

1. In drag racing, acceleration is more important than top speed. Because of this, drag racers are designed to produce maximum acceleration. Suppose a drag racer has a mas of 1250 kg and accelerates at a constant rate of 16.5 m/sec^2. How large is the unbalanced **force** acting on the racer?

2. A cruise ship, with a mass of 5.22×10^7 kg, is moving at top speed as it comes into a port. The ship then undergoes an acceleration of -0.357 m/sec^2 until it comes to a stop. How large must the unbalanced **force** acting on the ship be in order to bring the ship to rest at the proper location?

3. The force that stops a jet plane as it lands on the flight deck of an aircraft carrier is provided by a series of arresting cables. These cables act like extremely stiff rubber bands stretching just enough to keep from slowing the plane down too suddenly. A Jet with a mass of 13×10^4 kg lands with an acceleration of -27.6 m/sec^2. How large is the unbalanced **force** that the arresting cables exert on the plane?

4. One of the tallest man-made structures is the Warszawa Radio mast in Warsaw, Poland. This radio mast rises 646 meters above the ground. Suppose a worker at the top of the tower accidentally drops a tool. If the force acting on the tool is 3.6 Newton's and its acceleration is 9.8 m/sec^2, what is the **mass** of the tool?

5. The whale shark is the largest of all fish and can have a mass of three adult elephants. Suppose that a crane is lifting a whale shark into a tank for delivery to an aquarium. The crane must exert an unbalanced force of 2.5×10^4 Newton's to lift the shark from rest. If the shark's acceleration is 1.25 m/sec^2 what is the shark's **mass**?

6. A house is lifted from its foundations onto a truck for relocation. The unbalanced force lifting the house is 2850 N. This force causes the house to move from rest to a speed of 0.5 m/sec^2 in 5.0 sec. What is the house's **mass**?

7. The gravitational force that Earth exerts on the moon equals 2.03×10^{20} N. The moon's mass equals 7.35×10^{22} kg. What is the **acceleration** of the moon due to the Earth's gravitational pull?

8. Assume that a catcher in a professional baseball game exerts a force of -65.0 N to stop the ball. If the baseball has a mass of 0.145 kg, what is the **acceleration** as it is being caught?

9. A 4000 kg boat is sinking in the ocean. The force of gravity that draws the boat down is partially offset by the buoyant force of water, so the net unbalanced force on the boat is 1310 N. What is the boat's **acceleration**?

10. The fastest manned jet plane in the skies is the Lockheed SR-71 Blackbird. The plane has a mass of 3.1×10^5 kg and is propelled by an unbalanced force of 7.233×10^5 N. What is the **acceleration** of the SR-71?

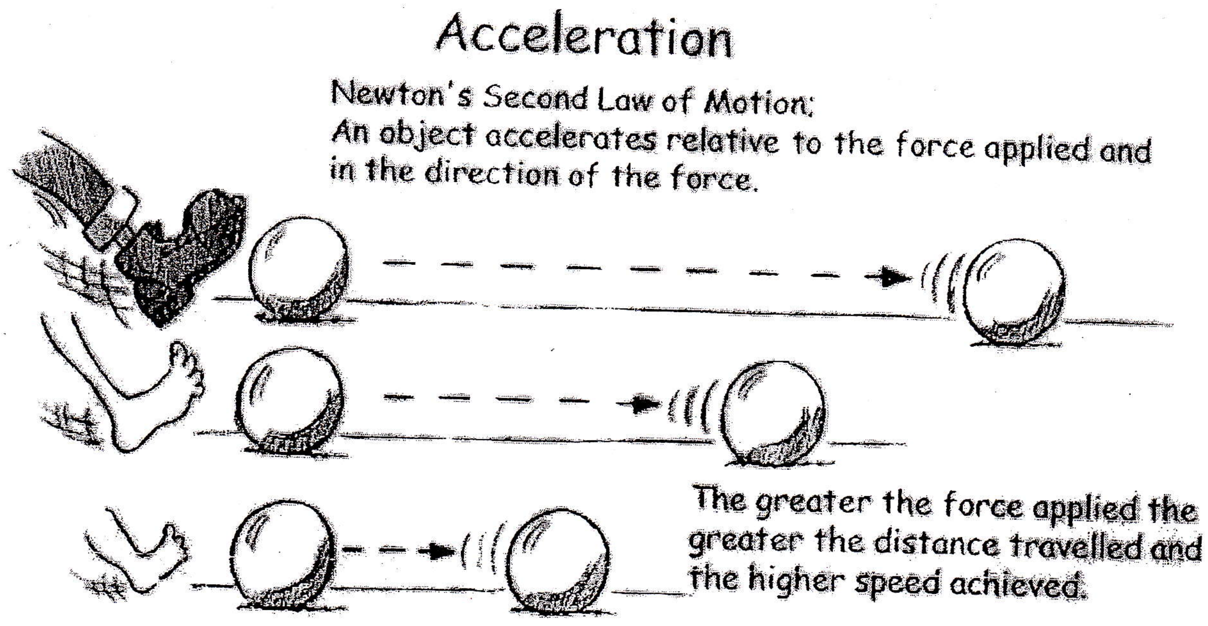
Introduction – You will investigate Newton's second law of motion by observing and changing the motion of a small spheres with different masses. The law of inertia is also applicable here. Newton's first law (inertia) describes what happens to an object when **no** unbalanced forces are acting on an object. Newton's second law (F=MA) describes what happens to an object when unbalanced forces **do** act on an object. In this activity you will observe what happens to a small objet when forces are applied (second law) and when no forces are applied (first law). Friction is ignored.

Part I – Newton's First Law (inertia) – what happens to the motion of an object when no unbalanced forces act on it? A smooth sphere rolling across a smooth, level table top meets the requirements of Newton's first law. The Earth pulls downward on the sphere (weight force) and the table pushes upward on the sphere. These two forces cancel each other as they are equal in magnitude and opposite in direction (balanced forces). There is a small friction force that will slow the sphere down but this will be ignored for the purposes of this investigation.

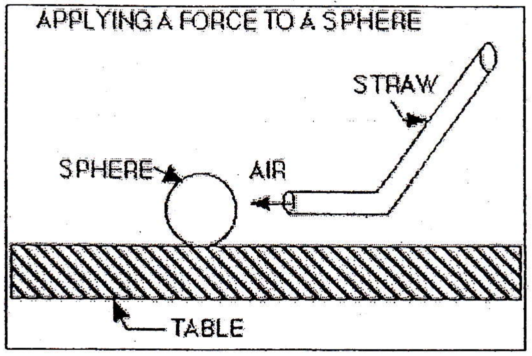
Procedure – Set the sphere in motion by rolling it along the table. Once the sphere is in motion you should begin observing its behavior.

1. Observe and describe the motion of the sphere rolling across a level table. Does the sphere accelerate? If so why or why not?

2. Does the mass of the sphere affect its motion? In other words, do rolling spheres of different masses behave differently as they roll? Why or Why Not? (Note: this question does not ask about the difference in getting the spheres rolling, or about stopping them from rolling. If two spheres, of different masses, are rolling at the same velocity do they behave differently?



Part II – Newton's Second Law (F=MA). You can apply a relatively constant force to a sphere by blowing on it through a straw. Newton's second law describes what happens to the motion of an object if an unbalanced force acts on it.



3. While you apply a force to a sphere, what happens to its motion? Make a diagram, similar to the one above, for each of the following scenarios showing the direction of the motion of the sphere, the direction of the force, and any changes in the motion of the sphere.

   a. Sphere at rest

   b. Force in the same direction as the sphere's velocity.

   c. Force in the opposite direction as the sphere's velocity.

   d. Force at a right angle to the direction of the sphere's velocity.

4. When you stop applying the force what does the sphere do?

5. Are spheres of different masses affected differently by the same force? Explain.

6. If a force is applied to an object then two factors affect its acceleration. What are the two factors and how do they affect acceleration?

7. Is it possible for an object with a large mass to have the same acceleration as an object with small mass? How?