What's the Matter? Part II

Last week we left you with the question: What parts of a car are the automotive engineers' responses to the property of ***inertia***? In other words, what parts of a car affect the tendency of matter to resist change in motion?

Your first thought is probably seatbelts. When a car is in motion, everything in the car is moving at the same speed and in the same direction. When the car comes to a quick stop, what happens to objects in the car that are not fastened to the car, for instance, a book or carton of milk on the back seat of the car? A book laying on the back seat will move along with the car until the car comes to a quick stop. The book keeps going and lands on the floor of the car.

Inertia can be dangerous to passengers. If the car makes an abrupt stop, a passenger can continue in a forward motion and hit the dashboard or windshield. Automotive engineers use seatbelts to attach passengers to the car so that, whatever changes in motion the car undergoes, the passengers will undergo the same change.

Other parts of the car also affect the tendency of the car to resist changes in motion. These parts change the speed and direction the car is moving. Think back; last week we listed possible changes in motion that an object might undergo. Each time you drive a car, you change the motion of the car in all those ways. With those changes in mind, here are some examples of parts of a car that allow the driver to overcome the car's resistance to changing its motion.

- **An object can go from being at rest to being *in motion***
  The car is sitting at rest in your garage. You start the engine, put it in gear, and when you push on the accelerator, the car, which was at rest, starts to move.

- **An object can be traveling in a straight line and *stop* moving**
  When your car gets to the end of the driveway and you press on the brake, the car, which was moving backward, stops moving.

- **An object can be traveling in a straight line and *change direction***
  After checking the traffic, you press the accelerator to set the car in motion again and, at the same time, turn the steering wheel to change the direction in which the car is moving (from a straight line backward to moving in a curved direction).

- **An object traveling in a straight line at a constant speed can speed up, slow down, or change direction**
  As car moves along you press the accelerator to speed up, the brake to slow down, and turn the steering wheel to change direction

Our interaction with the automobile is just one example of how the property of inertia affects our daily lives. Now let us turn to how matter's natural tendency to resist change in motion is overcome.

Think about a wooden block resting on a table. Its state of motion is *at rest*. What must we do to set the block in motion? Of course, we either *push* or *pull* on it. To set the block in motion, we exert a ***force*** (a push or pull) on it.

Now let's do a thought experiment. Imagine a concrete cube, six feet long on each side, sitting next to a cork cube, also six feet long on each side. How will the push necessary to set the concrete block in motion compare with the push necessary to set the cork cube in motion?

Your intuition is that it will take a greater push to start the concrete cube in motion than to start the cork cube in motion. Because it takes a greater ***force*** to start the concrete cube in motion than the cork cube, we say the ***mass*** of the concrete cube is greater than the ***mass*** of the cork cube.

We can test this idea using a spring scale and two different brass cylinders.

We will use the spring scale to exert a force on the larger brass cylinder just large enough to set the cylinder in motion.

When we pull (exert a force) on the larger brass cylinder we observe that, at the time the cylinder <u>just starts to move</u>, the spring scale reads **1 Newton**. This is a measure of the ***force*** needed to just <u>start</u> the larger cylinder in motion.

Now we will use the spring scale to exert a force on the smaller brass cylinder just large enough to set the cylinder in motion.

When we pull (exert a force) on the smaller brass cylinder we observe that, at the time the cylinder <u>just starts to move</u>, the spring scale reads **.2 Newton**. This is a measure of the ***force*** needed to <u>start</u> the smaller cylinder in motion.

We observe that the force necessary to set the larger brass cylinder in motion is more than the force necessary to set the smaller brass cylinder in motion. Because it takes more force to overcome the resistance to change in motion of the larger cylinder, we say that the ***mass*** of the larger cylinder is greater. We have not actually measured the masses of the two cylinders. We have measured the ***forces*** required to overcome their resistance to change in motion and then drawn conclusions about the cylinders' masses.

You may have observed that the spring scale is calibrated using two units, **Newtons** and **kilograms**.

Scientifically speaking, spring scales measure ***force***. The Newton is a measure of force. (Remember, we just measured the forces exerted to start the two cylinders in motion.) Why then is the spring scale also calibrated in kilograms, a measure of mass?

In our next e-mail we will examine the most perplexing of the perplexing pairs you and your students will ever meet, mass and weight. Investigation of this perplexing pair will require taking the brass cylinders and the spring scale to the moon and to Jupiter.