The Physics of Cars
Background Information for Teachers

The word “physics” is derived from the Greek word *physika*, which means “natural things.” **Physics** is an all-embracing science that helps to explain how the world works. Learning about cars and how they work provides a unique opportunity to explore the science of physics.

All of us have been a passenger in some type of vehicle at one time or another, and this makes cars something that we all can relate to. Since some physics principles are abstract, using a car as a means to illustrate these principles makes them easier to understand. The following information provides a solid foundation for teaching about the physics of cars.

Force and Motion

Motion is something we don’t think about very often, yet every activity we undertake involves it. Motion can occur naturally, be human produced or machine induced. For example, walking across a street, driving in a car, or a leaf floating from a branch are all examples of motion.

What is motion? Motion is the act or process of moving from one place to another. The physics of motion is all about **forces**. In order for an object to move, a **force** needs to act upon it and change its motion. A force is a push or a pull on an object. A push or a pull can set a still object in motion and likewise, a push or pull against an object in motion can alter its speed and/or its direction.

How is motion measured? How fast an object moves is called its **speed. Velocity** tells you not only the speed of the object, but also the specific direction in which the object is moving**.** For example, the car is traveling 50 mph in a northwest direction.

Acceleration is the measure of how much the velocity of an object changes in a given amount of time. Like velocity, acceleration has both magnitude and direction. You will accelerate an object if you apply a force to it which changes its speed, its direction or both.

Mass also affects motion. **Mass** is the amount of matter in an object and is generally measured in grams or kilograms. A car has a greater mass than a bicycle. Imagine a block of steel and a block of wood the same size at rest on a table. The block of steel will have more mass, or amount of matter in it. Neither will move without a force—a push or a pull—applied to it.

To get the blocks to move you have to apply a force which is great enough to overcome the blocks' inertia. **Inertia** is the natural inclination of an object to resist changes in its state of motion. This means that if an object is not moving, it will remain motionless until a force is applied to move it. If an object is moving, it will keep moving at the same speed and in the same direction until a force is applied to change its speed, its direction or both. The greater the mass of an object, the greater its inertia will be. You will need to put more effort into moving the steel block than the wooden block because the steel block has more mass and, therefore, more inertia than the wooden block.

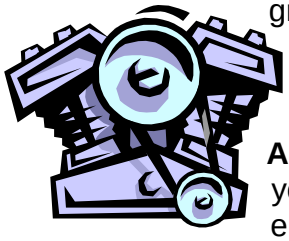
Friction

Friction is the force that opposes motion when you attempt to move one object over the surface of another. There are two types of friction: static and kinetic.

Static friction is the force that must be overcome to set an object that is at rest in motion. Static means "at rest."

Kinetic friction is the force working on a moving object to slow it down and stop it. Kinetic means "in motion."

Friction helps you in many ways. Without it, you could not walk, run, drive, stop a car, or perform other everyday activities you take for granted. Take the example of driving on an icy road. On ice, the force of friction is reduced because of the smoothness of the frozen surface. Adding sand to the road or putting chains on your tires increases the surface contact between your tires and the road, thereby increasing friction. The increased friction gives you better traction, and your car is better able to hold the road.



Friction can also make 'work' harder. Engine parts rubbing together can create friction so that a car engine doesn't run as smoothly. Parts of the engine may grind against one another and wear each other down. Adding oil to the engine keeps engine parts coated and this reduces friction and engine wear.

Air resistance is a type of friction that also affects the efficiency of your car. As your car moves down the road it has to push the air it encounters aside and around it. This causes friction. A vehicle with a boxy front end will have to push more air aside and will, therefore, experience more air resistance than a sports car with a streamlined shape. Since it has to overcome less air resistance, the sports car will be more fuel efficient since it will have to do less work (use less horsepower) to travel at the same speed as the car with the boxy font end.

Gravity

Every object in the universe exerts a pull, or force, on every other object. This attractive force between two objects is called gravity. The size of the pull depends on the masses of the two objects and the distance between them. An object with more mass will exert a greater gravitational pull, and this attractive force will be greater the closer the two objects are to one another. For us to be able to detect the force of gravity, at least one of the two objects has to be very massive, like the earth. The weight of an object is a measure of gravity's pull upon the object and will vary depending on where in the universe the object is located. For example, you weigh more on earth than you would if you were on the moon because the earth is more massive than the moon and, therefore, exerts a greater gravitational pull upon you. Unlike weight, the mass, or the amount of "stuff" in an object remains the same and does not vary with location.

Energy

Energy is defined as the ability to do work. There are many different forms of energy, such as motion, light, heat, sound, chemical, electrical and nuclear energy. Each of these can be classified as either potential or kinetic energy. **Potential energy** is energy that is stored within an object either because of its position or the way in which its parts are arranged. A car parked on the top of a hill, the chemical energy in gasoline, and a coiled spring are all examples of potential energy. **Kinetic energy** is the energy of motion. The potential energy of a car parked in neutral on a hill is transformed into kinetic energy when its emergency brake is released and the car starts moving downhill under the force of gravity. The faster an object travels and the more massive the moving object is, the greater its kinetic energy will be. Energy can change from one form to another, but energy can neither be created nor destroyed. When your car engine burns gasoline, the chemical energy in the fuel is converted into mechanical energy. When you stop your car, your brakes change the motion of the vehicle into heat energy. That's why brake pads are made out of flame-resistant material.

Simple and Compound Machines

In physics, **work** is defined as the product of a force applied to an object and the displacement of the object in the direction of the applied force. **Simple machines** are devices that make work easier and have few or no moving parts. They are machines that use energy to work. A machine can never do more work than the energy put into it; it can only transform one

kind of energy into another kind. There are six different types of simple machines: the lever, inclined plane, pulley, wheel and axle, wedge and screw.

Compound machines are machines that combine two or more simple machines. Many machines are complex and contain a number of parts that are meant to work together. No matter how complex a compound machine is, it is just a combination of simple machines working together. The car is an excellent example of a complex compound machine.