LESSONS IN SCIENCE
Physics Principles Used In Box Cars

GRAVITY

1. All box cars use the same power source--**GRAVITY**.
2. Gravity is the attractive force between any two masses, such as the earth and a box car.
3. Gravity pulls everything down with the same acceleration, regardless of how heavy or how light the object is.
   Excluding wind resistance, a 1 lb. lead ball falls as fast as a 10 lb. lead ball.

FRICTION

Friction is a force which slows or stops objects sliding past each other. The brake system of a box car uses friction between the rear tires and the brake pads to slow or stop the car.

BEARINGS

The most common **bearings** are ball bearings. Bearings support moving parts and enable them to move with less friction. A box car uses ball bearings in its wheels.

LUBRICATION

Lubrication is the use of slippery materials to make surfaces slide over each other more easily by reducing friction. Box cars use different lubricants, such as **Grease** and **Oil**. Grease provides a high degree of lubrication protection against wear, but creates some drag as the surfaces slide by each other. Oil has less drag, but also provides less lubrication protection.

Grease is used where parts slide past each other slowly, such as the steering shaft inside the steering bushings, front axle pivot, brake lever and brake arm pivots.

Oil is used on fast moving parts such as the ball bearings in the wheels.

ENERGY

Energy is the ability to do work. Energy is needed when an object is to be moved through some distance, such as a box car moving down a track. Energy can appear in two forms:

1) **Kinetic Energy**, which is energy of motion, and
2) **Potential Energy**, which is stored energy.

A box car held at the top of the ramp by its brake has potential energy. When the brake is released the potential energy become kinetic energy as the box cars rolls down the ramp.

SPEED

Speed is the rate of motion. It is measured by calculating the distanced moved in a certain time. A box car which moves 5 miles in 1 hour travels at the speed of 5 miles per hour.

CENTER OF GRAVITY

The force of gravity acts on all parts of an object. To understand the **Center of Gravity**, it is helpful to picture a single point in the middle of the object. An object will balance and rotate evenly around the point in its exact middle. This middle point is called the Center of Gravity.

LEVERAGE

A **lever** transmits a force from one place to another. The simplest lever is a rigid rod which is free to pivot around a point called a fulcrum**.** To move a heavy rock you can place a small rock close to the heavy one then push the rod over the small rock and under the heavy rock.

Pressing down the rod (lever) is the **effort**.
The small rock is the **fulcrum**.
The heavy rock which is lifted is the **load.**

1st Class Levers (effort -- fulcrum -- load)

The brake handle of a box car is a 1st class lever:

Effort -- pulling on the brake handle (lever) with your hand
Fulcrum -- the pivot bolt through the brake handle
Load -- the cable which pulls the brake arms

The brake arms are also examples of 1st class levers:

Effort -- the cable being pulled by the brake handle
Fulcrum -- the pivot bolt through the brake arm
Load -- the brake pad against the tire

Which of the above two levers requires the greatest effort? Why?

2nd Class Levers (effort -- load -- fulcrum)

Picking up a box car at one end with the other end resting on its wheels is an example of a 2nd class lever:

Effort -- lifting one end of the box car
Load -- the weight of the box car
Fulcrum -- the axles of the wheels

Compare the effort you use to pick up a box car by one end and how much more you use to pick up the box car completely off the ground. The difference in the amount of your efforts is the amount of work down by using leverage.

A wheel barrow is also an example of a 2nd class lever. Can you think of others?

3rd Class Levers (load -- effort -- fulcrum)

The front axle of a box car is an example of a 3rd class lever.

Load -- the wheel on the end of the axle
Effort -- the cable which pulls the axle
Fulcrum -- the pivot bolt through the axle

These examples of levers show how a lever can be used to convert a small force moving a longer distance into a larger force moving a small distance--or visa-versa. This is the principle of Conversation of Energy. The work done by the effort must equal the work done by the load. A seesaw with unequal weights on each end with the fulcrum adjusted to keep both ends in balance shows how the small weight moves a greater distance then the large weight. The effort is the same to move either the small or large weight.