Demonstrations for the Materials Science Classroom
These demonstrations were developed through funding of the NNIN RET program and the Mineral, Metals, and Materials Society (TMS) Educational Foundation (www.tms.org). Silas Brown has established a web page for these materials designed for Physical Science teachers – http://www.freewebs.com/starrsmillphysicalscience/

Other helpful websites regarding materials science include:
http://en.wikipedia.org/wiki/Materials_science
http://www.strangematterexhibit.com/
http://www.materialsworldmodules.org/

Below is some additional explanatory materials for the demonstrations.

Material Science Introduction
Material science is the study of the five material classes: metals, ceramics/glasses, polymers, semiconductors, and composites, and their applicable properties. It is an exceedingly important subject because every field must deal with the properties of materials, whether or not it is a conscious involvement. Materials have been researched to discover what they are capable of. The promotion of the field of material science has allowed engineers to design structures such as bridges that they know will not fail under normal circumstances, razors to be made with ceramics so the edge lasts longer—making it less painful to shave, and even the creation of computers through a knowledge and understanding of semiconductors.

Explanation of the Challenger failure
The reason that the Challenger failed during its 10th launch was that the temperature at launch time was 15°F lower than any launch prior to this. Additional factors furthered the low temperature of the area surrounding the Challenger including the air that was being blown towards the Challenger was flowing over containers of liquid hydrogen and oxygen.

When the Challenger ignited for launch there was a sudden stress on the o-rings that connected sections of the rocket boosters. Because of the cold temperatures one of the o-rings fractured and was further deteriorated by hot gases escaping at very high speeds. The hot gases escaping through the o-ring were directed towards the external fuel tank. Eventually the external fuel tank was breached and the fuel ignited, which caused the explosion of the Challenger.

This case is similar to that of the Titanic sinking. Different materials behave differently in cold temperatures. Steels are a BCC, body center cubic, metal. BCC is a term that refers to the arrangement of the atoms; this arrangement is what gives a material its properties. When a BCC metal becomes cold, it becomes brittle. The Titanic was constructed from steel and sailing through very cold waters—thus the hull of the boat was very brittle. When the ship hit the
iceberg, there was a large fracture allowing water to enter the ship at a much faster rate than it would have been in warm waters.

In order to avoid this problem today, ships are made out of alloys that behave more like a FCC, face center cubic, metal. An example of a FCC metal is aluminum. These metals are able maintain the same properties is much lower temperatures than BCC metals.

Temperature information from:
http://www.aerospaceweb.org/question/investigations/q0122.shtml

**Laboratory Experiments From the Toy Store**

**Elasticity:** a deformation of an object is considered to be elastic if it recovers completely from the deformation

**Plastic:** a deformation of an object is considered to be plastic if it does not recover completely from the deformation

**Ductility:** the material property that refers to a material’s ability to be plastically deformed without fracturing

**Buckling Breakdown**

The soda can will crumble when there is a dent because it introduces horizontal forces. Prior to the dent, all forces are compression forces and distributed evenly around the entire can. When there is a dent in the can the load on the top creates a moment about the dent. This moment is a force that the structure of the can has nothing to counter. As a result, the forces are not balanced and the can collapses.

**Moment:** a moment is a specific term for a force that causes a turning about another point. It is easy to imagine a moment because it is what you are doing to a screwdriver to tighten a screw.

**Fatigue Demo**

Fatigue is related to angle size by the fact that larger angle sizes cause more dislocations of the atoms. When any material is plastically deformed there is a permanent dislocation of atoms of the structure. After atoms have been dislocated, they interfere with other atoms of the structure, making the material stronger, but more brittle where the dislocations have occurred. Eventually the dislocations will start to interfere with other atoms to a point where necking occurs—necking is when a material becomes thinner in an area due to stresses. For example, when you pull apart a piece of chewing gum it will become thinner and thinner before it eventually breaks.
**Superconductive Experiment**

Electric currents create an impulse, or a field of electrons when they are flowing. The charge of an electron flowing in a direction will cause other electrons to flow around that direction. These fields are the same fields that the solidified structure of a magnet’s atoms create. The two field of electrons, one created by the magnet and the other created by a current with no resistance, will repel each other and allow the magnet to float.

**National Science Education Standards**

Content Standard A:
- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Content Standard B:
- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter.

Content Standard E:
- Abilities of technological design
- Understandings about science and technology

**Georgia Performance Standards**

- SCSh1- Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
- SCSh2- Students will use standard safety practices for all classroom laboratory and field investigations.
- SCSh3- Students will identify and investigate problems scientifically.
- SCSh7- Students will analyze how scientific knowledge is developed.
- SCSh8- Students will understand important features of the process of scientific inquiry.
- SPS1- Students will investigate our current understanding of the atom.
- SPS2- Students will explore the nature of matter, its classifications, and its system for naming types of matter.
- SPS5- Students will compare and contrast the phases of matter as they relate to atomic and molecular motion.
- SPS6- Students will investigate the properties of solutions.
- SPS7- Students will relate transformations and flow of energy within a system.
- SPS8- Students will determine relationships among force, mass, and motion.
- SPS9- Students will investigate the properties of waves.
- SPS10- Students will investigate the properties of electricity and magnetism.