Lesson Plan Summary
(The dates and times are specific to your class schedules)

<table>
<thead>
<tr>
<th>Date and Times</th>
<th>Activity</th>
<th>Lesson</th>
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</table>
| **Class 1** (~60 min) | • Create Crystal Geodes | • Discuss metals having a repeating crystalline pattern of atoms  
• Introduction to crystal defects (If there is time) |
| **Class 2** (~100 min) | • Property Testing (Gallium/Penny) | • Discuss imperfections of metals and how it affects their properties |
| **Class 3** (~100 min) | • Property Testing (Steel Heat Treatment)  
• Crystal Geodes Observations | • Compare geodes to the Earth's plates  
• Talk about Creep Deformation (if there is time) |
| **Class 4** | None | • Creep Deformation |
Metallic Properties Testing
Major Lesson II

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(May 2013 – May 2014 fellow)
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I. **Grade Level**: 8th grade

II. **Class Size**: 35 – 40 students (worked in groups of 4 or 5)

III. **Time**: 4 class sessions  
   a. Session 1 – 60 minutes  
   b. Session 2 – 100 minutes  
   c. Session 3 – 100 minutes  
   d. Session 4 – (whatever time needs to be made up)

IV. **Introduction**:

   Living in Los Angeles presents a unique problem for its residents. So much so that it is viewed as a normal daily occurrence that most of the United States would never have to experience. Earthquakes have done their damage to many cities along the west coast, primarily due to its placement along the San Andreas Fault. Engineers have devised ways to deal with the natural disaster by enhancing building structures and also understanding their seismic activity. But how do they know how to make those enhancements?

   This lesson aims to teach students about the different properties of metals and how engineers use these properties to make our city stronger and safer.

V. **Objectives**:

   a. Students will make their own crystal geodes in order to understand how atoms form together to make a crystal. They will learn that metals are actually crystals in themselves.  
   b. Students will test the properties of two different elements of the periodic table (gallium and steel) under a heat treatment. They will analyze their results using a worksheet (attached).  
   c. Students will learn how these varying properties affect the strength of a material/metal. They will then conclude why engineers use certain metals for certain applications.

VI. **Grade 8 California Science Standards**:

   3. *(Structures of Matter)*  
   Each of the more than 100 elements of matter has distinct properties and a distinct atomic structure. All forms of matter are composed of one or more of the elements.

   7. *(Periodic Table)*
The organization of the periodic table is based on the properties of the elements and reflects the structure of atoms.

9. (Investigation and Experimentation)
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

VII. **Summary:**

Students will go through a series exercises that build on each other incrementally. The first day's goal is to understand what makes a crystalline material. The crystal geodes give the students the opportunity to engineer their own "metal"-like substance with salt and water. This will show students that even though every group executed the same procedure, each of their crystals will turn out slightly different. This introduces the topic of deformity (i.e. no crystal is perfect).
The second and third day of the lesson will recap the first day by reiterating its main message. It is told to the students that there is no way to make a "perfect" crystal and that engineers use these deformities to their advantage. An experiment on gallium and galvanized steel restate this message. The class performs heat treatments on these metals and uses the scientific method to analyze the results.
The last day will sum everything together by introducing Creep Deformation explaining how defects move through the material to changes its properties.

VIII. **Keywords:**
Atoms
Crystalline Structure
Deformation
Dislocation
Ductile
Hardness
Analyze

IX. **Materials:**
a. **Day 1**
   Epsom Salt
   Water
   Hot Plate
   Oven Mitts
   Stirring Rod or Spoon
2 beakers (one large, one small)

b. **Day 2**
   - Gallium
   - A penny
   - One beaker
   - Kettle of hot water

c. **Day 3**
   - Stainless steel shingles
   - Furnace or incubator
   - Oven mitts
   - Tongs

d. **None needed**

X. **Procedure of Each Day:**

**DAY 1 (Making Crystal Geodes)**

a. Have the materials for the day’s lab already on each table to save time. Each table should have a hot plate, oven mitts, two beakers (one large, one small) and a stirring rod. *It is recommended to begin the experiment at the start of class and then give the mini lesson during the 30-minute down period.

b. **Lab Safety!**
   (A PowerPoint slide can be made to make it easier to go over with the class all at once. A sheet can be placed on each group’s table as well so it is easily accessible throughout the lab)
   [1] When you are not actively participating in one of the steps, you should remain in your seat!
   [2] All backpacks should be placed underneath the tables, NOT in the aisles. Would you want to trip with a beaker full of boiling hot water?
   [3] When handling the hot beaker, you **must** use the oven mitts and handle with BOTH hands!
   [4] **Please** do not smell anything directly nor taste anything.
   [5] Gloves should be worn at all times when handling the salt.

c. Show a brief “Crystal Geodes” PowerPoint. It should be explained that geodes are naturally occurring rocks in the Earth’s crust and a picture can be shown.

d. **Experimental Procedure:**
(A PowerPoint slide can be made to make it easier to go over with the class all at once. A sheet should be placed on each group’s table as well so it is easily accessible throughout the lab)

1. Each table is given:
   - 1 hot plate,
   - 1 500-mL beaker
   - 1 pair of oven mitts
   - 1 stirring rod

2. Each person is given one 5-oz plastic cup (every student gets to make their own geode!).

3. Before beginning anything, each person should write his/her name AND period on the bottom of their cup with a black sharpie marker.

4. Person seated in SEAT 1 will fill the beaker up with water to the 250-mL line and then place the beaker on your group’s hotplate.

5. Person seated in SEAT 2 will turn the hotplate dial to HIGH. Once the water starts boiling, turn OFF the hotplate, put on an oven mitt, remove the beaker from the hot plate and place on your group’s table. (You should also monitor the beaker to make sure the water does not boil over.)

   *It will take about 30-40 minutes for the water to begin boiling. This is when the “Day 1” Power Point should be shown.*

6. Person seated in SEAT 3 will slowly add 300-mL of Epsom Salt to the beaker, and with the stirring rod, stir the solution until all of the salt is dissolved.

7. Ask one of the teachers for food coloring. Your group may pick a color of your choice. Keep in mind that your whole table is sharing the salt solution so whatever color you guys choose with be the same for all member of your group.

8. Person seated in SEAT 4 will very cautiously pour your group’s over-saturated salt solution into each of the cups. You should only pour until the plastic cups are about halfway filled.

9. Once completed, place all beakers in the center of the table and ask a teacher to come collect them.

10. Wait patiently while others are finishing up.

DAY 2 (Gallium and Copper Penny Heat Treatment)

a. The first part of “Day 2 & 3” PowerPoint should be shown.

b. **Lab Safety!**
   (A PowerPoint slide can be made to make it easier to go over with the class all at once. A sheet can be placed on each group’s table as well so it is easily accessible throughout the lab)
When you are not actively participating in one of the steps, you should remain in your seat!

All backpacks should be placed underneath the tables, NOT in the aisles. Would you want to trip with a beaker full of boiling hot water?

Please do not smell anything directly nor taste anything.

c. Experimental Procedure:

(A PowerPoint slide can be made to make it easier to go over with the class all at once. A sheet should be placed on each group’s table as well so it is easily accessible throughout the lab)

Each group (two tables put together) should have:
1 250-mL beaker
1 copper penny
1 piece of gallium

Each person should have a worksheet titled “Gallium and Copper Heat Treatment Activity”

Each person (with the help of their tablemates, if you wish) will fill in the worksheet for steps: Question, Observations, Hypothesis and Experiment.

The teacher will come around to put hot water in the beakers.

The person who is the youngest in your group will drop the gallium chip into the beaker

The person who is oldest in the group will drop the copper penny into the beaker.

Every member of the group will make their own independent observation as to what happens. Write these down in your Data section.

Every member of the group will write whether they accept or reject their hypothesis in the Conclusion section.

Communicate your conclusions!

d. If there is time left in the class period, the teacher should go over the “Understanding Metals” worksheet (attached below).

DAY 3 (Galvanized Steel Heat Treatment)

a. The first part of “Day 2 & 3” PowerPoint should be shown.

b. Lab Safety!

(A PowerPoint slide can be made to make it easier to go over with the class all at once. A sheet can be placed on each group’s table as well so it is easily accessible throughout the lab)

When you are not actively participating in one of the steps, you should remain in your seat!
All backpacks should be placed underneath the tables, NOT in the aisles. Would you want to trip with a beaker full of boiling hot water?

Please do not smell anything directly nor taste anything.

c. Experimental Procedure:
   (A PowerPoint slide can be made to make it easier to go over with the class all at once. A sheet should be placed on each group's table as well so it is easily accessible throughout the lab)

- Each table should have:
  - 2 sheets of galvanized steel
  - 1 pair of oven mitts

- Each person should have a worksheet titled “Galvanized Steel Heat Treatment Activity”

- Each person (with the help of their partner, if you wish) will fill in the worksheet for steps: Question, Observations, Hypothesis and Experiment.

- The oldest member of the pair will bring one sheet to the back of the classroom where Ms. Green will place it inside the furnace.

- The youngest member of the pair will (carefully) take the second sheet metal and bend it in half!

   *Since the shingle will be in the furnace for 30 minutes, this is when the student should work on the Word Search (see below) in order to occupy their time*

- After 30 minutes, the youngest member will retrieve their metal from the furnace.

- The oldest member will then try to bend the sheet metal!

- Every member of the group will write whether they accept or reject their hypothesis in the Conclusion section.

- Communicate your conclusions!

DAY 4 (Lesson Recap)

a. Finish up either of the previous labs if necessary

b. Tie everything together by showing the “Day 4” power point.

c. Students should write down, in 2-3 sentences, what they learned in the lesson.
Metals and Metallic Properties

BXGZJLMAFEWMTXDGUKPAGYOKMY
EXPERIMENTDUAWOVJAKGLDUNEGQ
ABTDTAQKINSNHGNYGLYUPATNXK
PACUKKTSGDOPAQNHEATLMQAVPKX
HCPKQSBNNXIAZIWEIWNILBKQFG
TWNRGEFSIWTCRLJSXOLNUWBZZD
REENIGNETQACPIPWIXWUIMQFKW
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LMLCNHHGEHRLTKQAJKLMSGQJFD0
CHJADSGMVOMAUDCDFIZBLJQBNGV
CRYSTALOFGFZCOTHYKQLDEERDV
SDKQSLSLFLEXLJOCCCCGVEXSATE
BZIZMZLIFDDSRZULIRNIESWNSUA
NNAJNLUACGIVKPDIJUANTGPALMY
RHKUGAIADQUOWORZOAEESEFYLVBO
PEERCENJSJIQHCBYFGIHVSLUYDBW
BTBWDLFCEWNDINVGQEBNNEK2SRC
XWPOVMIQSERRTVPOFJOCMCRCEBWT
SEQFPWPWKJFIKKGVBCKAVTYSSG
KGRURUJFPQOZYLYYFQSUGXYIIW

ALUMINUM
CREEP
DISLOCATION
EXPERIMENT
GOLD
MAGNESIUM
RESEARCH

ANALYZE
CRYSTAL
DUCTILE
GALLIUM
HARDNESS
MELTING
STEEL

ATOMS
DEFORMATION
ENGINEER
GEODE
HEAT
METAL

Created by Puzzlemaker at DiscoveryEducation.com
**Understanding Metals**

What are some properties of metals?
1. 
2. 
3. 
4. 

Necessary Vocabulary

<table>
<thead>
<tr>
<th>Vocabulary Word</th>
<th>Definition</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deformation</td>
<td></td>
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</tbody>
</table>
Gallium and Copper Heat Treatment Activity

Question: Which metal, Gallium or Copper, will melt faster?

Observation: (What are 2 or 3 properties of each metal? (i.e. - color, luster, heavy or light, etc.)

<table>
<thead>
<tr>
<th>Gallium</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
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<td></td>
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</table>

Hypothesis (make an educated guess.):
I think that __________ will melt faster than __________, because
________________________________________________________________________
________________________________________________________________________

Experiment: (Explain what you will do to answer your above question.)
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Data: (Write down your observations.)
________________________________________________________________________
________________________________________________________________________

Conclusion: (Do you accept or reject hypothesis, and why?)
________________________________________________________________________
________________________________________________________________________

Communicate your results.
Galvanized Steel Heat Treatment Activity

**Question:** Which slate is harder? The one that was not put in the furnace or the one that was in the furnace for 30 minutes?

**Observation:**
(What are 2 or 3 properties of each sample? (i.e. - color, luster, heavy or light, etc.)

<table>
<thead>
<tr>
<th>Steel (No Furnace)</th>
<th>Steel (30 minutes in Furnace)</th>
</tr>
</thead>
</table>

**Hypothesis** (make an educated guess.):

I think that ____________ will be harder than ______________, because

________________________________________________________________________
________________________________________________________________________

**Experiment:**
(Explain what you will do to answer your above question.)

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

**Data:**
(Write down your observations.)

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

**Conclusion:**
(Do you accept or reject hypothesis, and why?)

________________________________________________________________________
________________________________________________________________________

**Communicate your results.**