Materials Science and Technology

Overview of MST Curriculum Content

This page is an overview of the content of the MST curriculum. It includes a description of topics covered and lists examples of labs performed in class. MST is a contextual, hands-on course that integrates science and technology.

SOLIDS:

This is the introductory unit in which students are exposed to the importance of Materials Science and Technology. They learn that solids are typically separated into four categories. They also study simple chemistry including chemical bonding, the periodic table, and oxidation-reduction.

Crystal structures, physical properties, and how metals are claimed from their ores are areas of emphasis. The importance of maintaining a student journal and keeping good records is stressed. Examples of experiments include:

Material Safety Data Sheets (MSDS)
Identification of Materials
Formation of Crystals
Corrosion Labs
Destructive Testing
Activity Series of Metals
Oxidation/Reduction of Copper

METALS:

In this unit, the students are introduced to many of the properties and historical developments of metals. Some of the mechanical properties of metals are investigated along with the effects of heat treating. Different types of alloys and alloying techniques are emphasized along with the study of phase diagrams. Techniques for testing metals and manufacturing processes are also studied. A major project is the making of sterling silver jewelry using the process of lost wax casting. Examples of experiments include:

Rolling a Coin
Drawing a Wire
Alloying Copper and Zinc
Cost of a Penny
Making a Light Bulb
Making Tin-Lead Solder
Annealing Copper
Powder Metallurgy
Lost Wax Casting

CERAMICS/GLASS:

In the ceramics unit, the students learn that most ceramics are crystalline solids that have properties related to the ionic or covalent bonds that hold them together. Students also learn that glass has different properties than most ceramics due to the amorphous structure of glass. A variety of processes used to manufacture ceramics are studied including a stained glass project and a Raku pottery project. Examples of experiments include:

Forming, Firing, and Glazing Clay
Thermal Shock
Glass Bending and Blowing
Glass Batching and Melting
Dragon Dribble/Dragon Tears
Coloring Glass
Stained Glass Project
Making Raku
Ceramic Slip Casting
Lantern Mantles and Lightbulbs

POLYMERS:

What synthetic polymers are and the chemistry involved with them is introduced in this unit. The classification of polymers is included along with how they are altered chemically or with additives. Concerns with recycling are emphasized along with the chemical changes brought about by cross-linking. Historical developments and manufacturing processes are also included. Examples of experiments include:

Cross-Linking a Polymer (slime)
Polymer Identification
Making Nylon 6-10
Latex Rubber Ball
Memory in Polymers
Polyurethane Resin Cast
Polymer Foam Creations
Expanded Polystyrene Beads

COMPOSITES:

Types of composites are described and categorized. Strength-to-weight ratios are emphasized including strength measuring, testing, and altering. Wood and concrete are two traditional composites used to introduce many concepts. An emphasis is placed on fiber reinforced composites including those containing graphite and Kevlar fibers. Examples of experiments include:

Stressed-Skin Composites
Compression and Tension in a Bending Beam
Using Portland Cement to Make & Test Concrete
Plaster of Paris Matrix Composite
Laminated Wood Beams

This is only a partial listing of the experiments and projects. Many teacher demonstrations are also included in the curriculum. Major themes weave from one unit to the next making it easier for the students to make connections and applications.

Materials Science Curriculum Sources

* Materials Science and Technology

Energy Concepts, Inc.
595 Bond Street
Lincolnshire, IL 60069
Phone: 800-621-1247
Fax: 847-821-1940

5 units: Solids
Metals
Ceramics
Polymers
Composites

This is a complete curriculum for a one year course in materials science.

Student Manuals
Teacher Manuals
Student Journals
Equipment/Supplies

* MAST Modules

Judy Brewer
c/o MAST Modules
Department of Materials Science and Engineering
University of Illinois
1304 W. Green Street
Urbana, IL 61801
Phone: 217-333-1441
http://matse1.mse.uiuc.edu/~tw/

Materials Science and Technology Teacher's Workshop
Developed with a 3 year NSF grant.
Can be downloaded off the internet or a hard copy may be purchased for $40 per set.

Modules include:

Overview	Metal
Ceramics	Polymer
Composites	Concrete
Energy	Semiconductor

* Materials World Modules

Northwestern University
2220 Campus Drive
Cook Hall, Room 2078
Evanston, IL 60208
Phone: 847-467-2489
Fax: 847-491-4181
E-mail: mwm@northwestern.edu

The Materials World Modules Program is supported by the National Science Foundation grant #ESI-9353833 to Northwestern University, R.P.H. Chang, Principal Investigator.

Web site: http://www.materialsworldmodules.org

There are nine modules available:

- Composites
- Biodegradable Materials
- Biosensors
- Ceramics
- Sports Materials
- Food Packaging
- Concrete
- Polymers
- Smart Sensors

* Materials Science and Technology Teachers Handbook (Battelle Manual)

Richland, WA
Pacific Northwest Laboratory
Contact: Karen Wieda
Program Manager
Science and Engineering Education
Pacific Northwest National Laboratory
Kj.wieda@pnl.gov
509-375-3811
Cost: $35
A CD version is also available.

Materials Science Resources and Web Sites

Included is a list of some useful web sites and organizations. There is some wonderful stuff here and it is easy to spend several hours learning and enjoying yourself without realizing where the time has gone.

http://asmcommunity.asminternational.org/portal/site/asm/

ASM International. Not just metals - has information on all materials. This association is a great resource. Hosts Materials Science teacher and student camps in the summer.

University of Washington materials science web site:

http://depts.washington.edu/mti/

Check out the following topics under "Resources":

- Books and Texts
- Materials Sources
- Materials Web Links
- Teaching Resources

http://www.polymerambassadors.org

Find out what we do and how to become a Polymer Ambassador.

http://www.chem.ox.ac.uk/icl/heyes/structure_of_solids/strucsol.html

Good site for crystals/solids with excellent links to other sites.

http://www.chemistry.co.nz/crystals_defined.htm

More basic crystal information

http://www.steel.org//AM/Template.cfm?Section=Home

American Iron and Steel Institute

http://www.pslc.ws/macrog/index.html

"The Macrogalleria - a Cyberwonderland of Polymer Fun". This is a great site for polymers. It is a "polymer mall" with five different levels:

- Polymers are Everywhere
- Polymers Up Close and Personal
- How They Work
- Makin' Polymers
- Getting Polymers to Talk

It would be easy to generate student research assignments from this site.

http://www.mrs.org/s_mrs/index.asp

Materials Research Society

http://www.mii.org
The Mineral Information Institute. Lots of great free stuff to order or download.

http://portal.acs.org/portal/acs/corg/content
The American Chemical Society

http://nickelalloy.com
Metal prices. Useful in research projects.

http://www.handsonplastics.com
Can order free stuff from this one!!

http://www.plasticsmuseum.org
The National Plastics Center & Museum. Order their CD entitled "Exploring the World of Plastics" if it is still available. Well worth the $10 cost.

http://www.corning.com
Lots of stuff about glass.

http://www.tms.org
Minerals, Metals, and Materials Society. Great web site and a very useful organization.

http://www.acers.org/
The American Ceramics Society

http://scifun.chem.wisc.edu/scifun.html
Lots of info - check out the "Chemical of the Week" link.

http://www.strangematterexhibit.com/
A great site with information and activities about all types of materials.

http://www.sciencemuseum.org.uk/onlinestuff.aspx
A site with great links.

http://www.thecatalyst.org/m05demos.html
Chemistry Resources For The Secondary Education Teacher On The WWW

http://www.sciencegems.com/
Frank Potter's Science Gems

http://www.careercornerstone.org/
Sloan Career Cornerstone Center

http://www.learner.org/resources/series61.html
The World of Chemistry - movie resources

http://www.sfsa.org/tutorials/index.html
metal casting scenarios

http://www.madehow.com
How It's Made - articles on how everyday items are made

http://manufacturing.stanford.edu/
Manufacturing Alliance - virtual tours of manufacturing processes

http://www.museumofglass.org/s02_virtual_hotshop.jsp
From the Museum of Glass in Tacoma. Neat interactive site allows you to create a 'Macchia'/spotted bowl, using glass blowing techniques

http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_TRANSITIONMAIN&node_id=1090&use_sec=false&sec_url_var=region1
ChemMatters - articles with many, many MST connections

http://www.pbs.org/wgbh/buildingbig/lab/materials.html
Interactive website by PBS. Great for exploring tension and compression strength of various materials. Incorporates real life architectural examples.

http://www.marcopolo-education.org/home.aspx
great teacher resources - now called "Thinkfinity"

http://blog.nam.org/csbmindex.php
National Association of Manufacturers. Cool videos on how all kinds of things are made. Constantly being updated.

http://www.tipmagazine.com/tipcd.html
The Industrial Physicist - check out the past issues for all kinds of articles related to MST

http://www.ndt-ed.org/EducationResources/CommunityCollege/Materials/cc_mat_index.htm
Check out this website for great information about many different materials science topics.

http://www.thatcrystalsite.com/downloads/NaicaCrystalCave.pps#257,1,Slide1
Giant crystals in cave in Mexico

http://hazard.com/msds/
National MSDS database

There are a large number of universities that have materials science departments as well.

One last web site that is great - you need to check it out:
http://www.howstuffworks.com
You will be amazed at the things you will learn.

Two resources for buying materials/supplies related to materials science:

IASCO (Industrial Arts Supply Co.)
1-888-919-0899
www.IASSCO-TESCO.com
Great supplier for metal or polymer projects.

Educational Innovations
1-888-912-7171
www.teachersource.com
Fun, fun, fun. Coolest science "toys

Book List

Stuff: The Materials the World Is Made Of
by Ivan Amato
ISBN: 0-380-73153-3
Materials science: past, present, and future. A great book to learn the story of materials science.

The Substance of Civilization
by Stephen L. Sass
ISBN: 1-55970-473-X
A good primer on the history of the use of materials by humans. "Materials and human history from the Stone Age to the Age of Silicon"

Techno-Matter: The Materials Behind The Marvels
by Fred Bortz
ISBN: 0-7613-1469-5
A great first book to learn about the categories of materials. Less than 100 pages.

Superstuff!: Materials That Have Changed Our Lives
by: Fred Bortz
ISBN: 0-531-10887-2
Good overview of microstructure and recent revolutions in materials science.

Engineering Materials Technology: Structures, Processing, Properties, and Selection 4th Edition
by: James A. Jacobs and Thomas F. Kilduff
ISBN: 0-13-014280-8
Introductory College Textbook

Introduction to Materials & Processes
by: John R. Wright and Larry D. Helsel
ISBN: 0-8273-5020-1
Textbook that gives an overview of the structure, properties, and characteristics of the main material categories and then focuses on material processing from harvesting and converting raw materials into usual products, all the way to recycling and recovery.

Industrial Materials
by: Larry D. Helsel and Peter P. Liu
ISBN: 1-56637-815-X
Textbook covers standards and standards organizations, properties and nature of materials, materials testing, and applications as well as information on conventional and advanced materials.

Serendipity: Accidental Discoveries in Science
by: Royston M. Roberts
ISBN: 0-471--60203-5
Wonderful book with stories pertaining to materials science, chemistry, medicine, biology, archaeology, etc.

They All Laughed...
by: Ira Flatow
ISBN: 0-06-016445-X
From light bulbs to lasers, the fascinating stories behind the great inventions that have changed our lives.

Uncle Tungsten - Memories of a Chemical Boyhood
by: Oliver Sacks
ISBN: 0-375-40448-1 or 0-375-70404-3 a MUST read!!!!!!!!!!!!

Chemical Elements - From Carbon to Krypton
by: David E. Newton
ISBN: 0-7876-2844-1
3 volume set containing all of the elements. Great resource that contains the following information for each element: overview, discovery and naming, physical properties, chemical properties, occurrence in nature, isotopes, extraction, uses, compounds, health effects. Some illustrations.

The Periodic Kingdom
by: P.W. Atkins
ISBN: 0-465-07266-6
Basic chemistry presented in a very creative and comprehensible manner.

Glass
by: William S. Ellis
ISBN: 0-380-79139-0
From the first mirror to fiber optics, the story of the substance that changed world. Interesting book and easy to read.

Green Plastics - An Introduction to the New Science of Biodegradable Plastics
by: E.S. Stevens
ISBN: 0-691-04967-X
Excellent background reading. Divided into two parts. The first part covers basic concepts in polymer science and statistics on the use of plastics and environmental issues. The second part deals with bioplastics. The appendix contains instructions for preparing some basic bioplastics.

Polymer Chemistry - Introduction to an Indispensable Science
by: David Teegarden (NSTA Press)
ISBN: 0-87355-221-0
Divided into 4 sections: 1. basic introduction to polymer science including their history 2. synthesis and preparation of polymers and properties 3. methods of processing, disposing and recycling, and future directions 4. demonstrations and experiments.

Molecules
by: P.W. Atkins
ISBN: 0-7167-6004
Great illustrations and photos as well as information about molecules in our everyday world.

Crystals and Crystal Growing
by: Alan Holden and Phylis Morrison
ISBN: 0-262-58050-0
Lots of information as well as twelve recipes for growing crystals.

2 books dealing with engineering aspects:
To Engineer is Human
by: Henry Petroski
ISBN: 0-679-73416-3

The Evolution of Useful Things
by: Henry Petroski
ISBN: 0-679-74039-2

Why Things Break
by: Mark E. Eberhart
ISBN: 1-40000-4760-9
Understanding the world by the way it comes apart.

There Are No Electrons
By: Kenn Amdahl
ISBN: 0-9627815-9-2
A fun, entertaining book that teaches the basic of electronics so even I could understand it.

2 great resource books that offer simple explanations for the mysteries of everyday life by Robert L. Wolke
What Einstein Didn't Know ISBN:0-440-50856-8
What Einstein Told His Barber ISBN: 0-440-50879-7

Journal Prompts for Reading Assignments

1. What did this article make you think of?
2. What did you read that you did not understand?
3. What did you learn from the article?
4. What puzzles you about this article?
5. Do you agree or disagree with this article?
6. If you had one question to ask the author, what would it be and why?
7. What made sense to you about this article?

Language for Learning is different than Language for Informing .....

Language for learning is:

- personal
- exploratory
- for the purpose of thinking, not testing
- incomplete
- a process, not a final product
- informal
- nongraded in the traditional sense

Journal Prompts

1. I observed .....
2. My idea worked because .....
3. My goal in this project is to .....
4. Next time I'll .....
5. My modification was to .....
6. The experiment was successful (unsuccessful) because .....
7. I wonder what would happen if .....
8. What did you do? think? feel?
9. What did you observe?
10. What was the most useful thing you heard in the last 30 minutes?
11. Write down what is bugging you.
12. What could the "stuff" be used for?
13. What was the "stuff" (material) like? What are its properties?
14. How did its behavior change/remain stable?
15. How is it different from similar "stuff"?
16. How would its properties be useful?
17. What did the "stuff" do?
18. Why do you think it does what it does?

Name _____

Date _____

Journal Page #'s _____

JOURNAL CRITIQUE

At least three different people must critique your journal this hour. Each person should use the following directions.

Read the assigned journal entry. Check for completeness of thoughts, clarity, and accuracy. Write two comments about the journal entry. The first comment should be something positive. The second comment should be a suggestion for improvement (worded in a constructive and helpful manner.) Asking questions about something you do not understand is an example. Try to be specific in both your comments so that the student will know what he/she is doing well and what he/she needs to improve upon. As you read the journal entries of other students, think about how you can improve your own journaling efforts. Learn from each other!!!!!!

When your journal critique form is returned to you, do the self-assessment on the back page.

1. _____ Comment 1:
Name

Comment 2:

2. _____ Comment 1:
Name

Comment 2:

14-A

3. _____ Comment 1:
Name

Comment 2:

Self-Assessment:

Read the comments made by your classmates. Re-read your own journal entry. Now critique your journal entry. Write at least one positive comment and at least one suggestion for improvement. Re-write (or add) a sentence or paragraph that would improve your journal entry.

15-A

Leadership Points Name _____ Period ____

Leadership and learning are indispensable to each other.

John F. Kennedy (1917-1963), *speech prepared for delivery in Dallas the day of his assassination, November 22, 1963*

Directions: Showing leadership is a requirement of this class. This semester you are responsible for obtaining the necessary signatures on this form and/or attach any papers showing proof of your activity. You are expected to have 50 points by the end of the semester. **Five days before your final exam** you must turn in this form for my signature. At that time I will review your efforts and record your points. When in doubt about an activity, **check with your teacher. In the event this form is lost or for whatever reason is no longer in your possession, all points completed will be forfeited and you must start over.** These points will be included in your grade.

Approved by:	Points	Leadership – Individual skills
		No **tardies** for the entire semester (15)
		Perfect **attendance** (15)
		Make a list of ten (10) things you would like to accomplish in your life. THINK BIG! (5)
		Take **one topic from this class** which interests you and write a two page paper. Get permission for the topic and further directions from your teacher before you begin (20)
		Job shadow a person in a business or industry related to this course. Write a one page paper about your experience (20)
		Arrange and introduce a **guest speaker** for your class who will cover a topic related to the class (20)
		Write a **thank you note** to a guest speaker or staff member (10)
		Use the internet to research information about what it takes to be **a good leader.** In your own words, describe strategies of good leaders and explain what you could do to develop these skills. (2 page minimum) (20)
		Research a **new project** for your class. Provide all background information, research, notes to students, notes to instructors and purchasing information. List all tools, materials and equipment needed for the project (35)
		Other:
		Leadership – Group Skills
		Compete at a regional debate, math competition or competition in any subject area (25)
		Attend a **regional conference** in any subject area (25)
		List the general principles of **parliamentary procedure** (5)
		Use the internet to identify 10 **characteristics of effective leaders.** Explain them to your teacher (10)
		Use the internet to find information on how to **conduct a meeting.** Explain your strategy to your teacher (10)
		Belong to a club, organization or sport outside of school? Explain your purpose and/or contribution to the group (10)
		Leadership – Community and Career Skills
		Type a one page paper describing five important **skills for job interviewing** (25)
		Participate in a **blood drive, food drive** or similar fund raising drive (10)
		Working at a **job** outside of school? Requires supervisor signature (35)
		Identify a career you would like do after high school. Describe the qualifications, education and duties required for this position (20)
		Meet with your counselor and obtain an **official record** of your earned graduation credits (10)
		Attend an event sponsored by the **career center** (ie: college or military presentation (20)
		Prepare a **resume and cover** letter which would be appropriate for an entry level job at a retail store, fast food restaurant, grocery store, construction site, etc. (25)
		Volunteer for a community organization or event (5 hours minimum, not blood donation, no double dipping). Write a paragraph explaining your involvement (20)

16-A

MSDS Glossary

Glossary

The following is an alphabetical listing of many of the items used in a Material Safety Data Sheet along with their definition.

appearance: What the material looks like.

boiling point: Temperature in °F or °C at which the material boils and releases vapors.

conditions to avoid during handling: Precautions to take when working with the material.

decomposition – hazardous products of: What the material can form if it breaks down.

decontamination procedures: What to use to eliminate any hazards should the materials spill or leak.

disposal material: What treatment will make it safe to discard the material in regular ways or what special procedures should be followed.

effects of overexposure: Early symptoms you should watch for that indicate exposure to levels higher than permissible.

environmental considerations: Hazards the material presents to the environment if it is not disposed of or handled properly.

extinguishing media: What you should use to put out the fire should the material or its vapors ignite.

eye contact: Hazards of accidentally getting the material in your eye.

fire-fighting protective equipment and hazards: What you should wear when extinguishing a fire in the material and what special precautions to take.

first aid procedures: **Immediate** steps to take if the material is inhaled, swallowed, gets in eyes, or gets onto skin or clothing.

flammable limits – UFL and LFL: The range of vapor concentrations that will burn in air.

flashpoint: The temperature at which the material releases vapor that can be ignited by a flame or spark.

handling precautions: Special procedures to follow whenever you work with the material.

ingestion: Hazards of accidentally swallowing the material.

ingredients: Chemical makeup of the material.

inhalation: Hazards of accidentally breathing the material.

labels: Methods of telling the user of a hazardous chemical the name of the chemical and the hazards of using it improperly.

melting point: Temperature in °F or °C at which material will become liquid.

name of material: Material's trade name, chemical name, or brand name.

odor: What the material smells like – not a reliable identifying characteristic.

overexposure: Exposure to levels higher than permissible or recommended.

pH: Reference number identifying whether the chemical is acidic (low numbers: 0-6), neutral (7), or basic (high numbers, 8-14).

protection information: Procedures and equipment needed to protect yourself from the hazards of the material.

protective gear: Respiratory protection, protective clothing, and eye protection you're required to wear when handling the material.

reactivity: Conditions that might cause the material to become unstable or break down to other products which may be hazardous.

shipping paper description: Brief description of the material spelled out on container.

skin absorption: Possible consequences if material is absorbed through the skin.

skin contact: Hazards of accidentally getting the material on your skin.

solubility in water: How easily the material will dissolve in water, and consequently how easily you can wash it off your skin.

specific gravity: Whether the material is heavier or lighter than water.

spills: What to do if the material spills from its container.

stability: Whether or not the material is likely to react with other materials in a hazardous way.

storage precautions: Special procedures to follow when storing the material.

synonyms: Other common names for the material besides its trade name.

threshold limit value – TLV: The concentration of the material that you can safely be exposed to during a full working shift.

time weighted average – TWA: The average concentration of the chemical that you are exposed to over a certain period of time (usually 8 to 10 hours).

vapor density: Whether the material's vapors will rise or fall.

vapor pressure: The higher this number, the more likely that the material will give off vapors at the indicated temperature.

ventilation requirements: Special ventilation procedures to follow when handling the material.

weight: Shipping weight per gallon and/or per cubic foot

Name _____

Period _____

MATERIAL SAFETY DATA SHEET (MSDS)

1. What is the common name of the product? _____

2. What is a synonym of the name of this product? _____

3. What are two hazards of this chemical?

    1. _____

    2. _____

4. What should I do if I get this material in my eye? _____

5. Do I need to call a physician or seek further medical treatment after first aid treatment? ___

6. What kind of fire extinguisher should be used around this chemical? _____

7. What materials should this product be stored near? _____

8. What type of personal protection should be worn when using this product? _____

    _____

9. What is the Specific Gravity of this product? _____

10. What type of odor does this product have? _____

11. Which chemicals or products should not be used near this product? _____

    _____

12. What does MSDS stand for? _____

13. Where is the MST - MSDS book stored? _____