Material Science Technology

A new laboratory course providing practical knowledge of the ever expanding use and development of materials in today's world

- **SOLIDS**
- **METALS**
- **CERAMICS**
- **POLYMERS**
- **COMPOSITES**

Great Lakes Training Systems
20729 Wendy Lane
Grosse Pointe Woods, MI 48236

Phone (313) 417-0777
Fax (313) 731-0154

Email pward@great-lakes-training.com
Web www.great-lakes-training.com

Philosophy and Rational

Today's technological society is driven by the development and use of materials. From advanced industrial applications to common everyday objects, materials affect all our lives. The demand for new and improved materials will continue to fuel the global economy as we enter the new century.

Material Science Technology is a multidisciplinary approach to science and technology that teaches students to better understand the properties and uses of materials. It combines scientific theories, practical applications of technology, and actual hands-on experiences to prepare students to work in a technologically rich environment.

Solids, Metals, Ceramics, Polymers, and Composites

Material Science Technology concentrates on the study of materials in our everyday lives. The course is separated into the five categories of Solids, Metals, Ceramics, Polymers, and Composites. The Solids unit provides an introduction to materials and shows students the broad range of materials that exist. This unit provides the foundation of Material Science Technology that the other four units will build upon. The Metals, Ceramics, Polymers, and Composites units further classify materials and show the importance of materials to our technological progress.

Each unit exposes the students to relevant equipment and hands-on projects that will provide them with a better understanding of materials. A key feature of Material Science Technology is the ability to use materials to solve problems. Students learn that there are usually many possible solutions to a problem – some more practical and more economical than others. In a work environment, problem solving is a valuable skill that is prized by today's employers.

Contents

Format

The development and use of the materials will continue to be a major source of job opportunities in today's marketplace. The unique format of Materials Science Technology provides students with all of the skills necessary to make the transition from school to work. Materials Science Technology is the study of materials, and is designed to be user friendly. The basic principles of physics, chemistry and biology are used to enhance the learning experience and provide the scientific basis for the study of materials.

The combination of the five units is designed to fill a normal full-year class. The activities in the course enable it to be taught in a variety of formats. Presently, it is being taught as a one-hour class that lasts a full year, and as a two-hour class that runs for a semester.

Each unit has a separate Student Lab Text that contains experiments as well as text material. The hands-on component is emphasized with a total of 66 experiments in the five separate units. The text exposes the students to knowledge about each topic while they solve problems in the execution of the projects.

Background information, tips, laboratory help, and sample schedules are included in the comprehensive Instructors Guide. This guide gives necessary information for the experiments and provides several demonstrations for each unit. There are also supplementary questions with answers and correlations to the chapter objectives.

A Student Journal is provided for students to record observations and interpretations from the experiments and teacher demonstrations. The journal is flexible; students can add handouts or notes relating to videos, speakers, and other classroom events. Vocabulary and questions are added features of the Student Journal.

Proven Curriculum

Pacific Northwest National Laboratory in Richland, Washington, initially developed the Material Science Technology laboratory program in the late 1980's under support from the U.S. Department of Energy. Material Science Technology is currently being taught in an increasing number of schools throughout the United States.

Unit and Chapter Objectives

Solids Unit

Overview of Solids

In this introductory unit the students are introduced to the importance of Material Science Technology and that it is a combination of science and technology primarily involved with solids. The will learn that solids are typically separated into four categories. They also study some simple chemistry including chemical bonding and the periodic table.

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. The unit includes ***twelve experiments*** and ***four demonstrations***.

CHAPTER 1: SYSTEM FAMILIARIZATION AND SAFETY

Objectives

- Take inventory and become familiar with some of the equipment and materials that are used during the Solids unit of Material Science Technology.
- Recognize and become aware of safety concerns associated with working in a laboratory environment.

Experiment

Exp 1-1: System Familiarization and Safety

Learning Objective:

- Identify much of the equipment used in the Solids unit of the Material Science Technology course.

CHAPTER 2: INTRODUCTION TO MATERIALS

Objectives

- State ways that materials are important in our lives.
- Explain how a journal is used to enhance learning.
- Explain how science and technology enhance one another.
- Give an example of how the properties of materials are not always predictable.
- Obtain useful information from Material Safety Data Sheets.
- State why Material Science is primarily involved with solids.
- Begin to classify solids based on their properties.
- State ways in which materials have been closely related to the advancements of civilizations throughout history.
- Explain how heat and energy are related to different states of matter.
- Understand that mistakes often provide an opportunity for learning to take place.

Experiments

Exp. 2-1: A Property of Materials – Dilatancy

Learning Objectives:

- Demonstrate and describe the property of dilatancy.
- Explain that dilatancy is an unusual (non-Newtonian) type of property.

Laboratory Proficiencies:

- Follow directions to successfully complete an activity.

Exp. 2-2: Material Safety Data Sheets (MSDS)

Learning Objectives:

- Explain what a Material Safety Data Sheet (MSDS) is.
- Demonstrate an ability to obtain helpful information from an MSDS.
- Know that an MSDS exists for every chemical and includes important emergency information on it.

Laboratory Proficiencies:

- Learn how to read an MSDS to obtain information.

Exp. 2-3: Identification of Materials

Learning Objectives:

- Place an object into one of four categories: metal, ceramic, polymer, or composite.
- Give the rational for placing the object in the selected category.

Laboratory Proficiencies:

- Use criteria to place items into specific categories.

Exp. 2-4: Material Systems

Learning Objectives:

- Dismantle a small appliance and organize its parts into groups with similar characteristics.

Laboratory Proficiencies:

- Correctly and safely use small hand tools.

CHAPTER 3: CHARACTERISTICS OF SOLIDS

Objectives

- Know the principal parts of the atom.
- Demonstrate how the periodic table is a useful tool.
- List the different types of chemical bonds.
- Explain that solids are crystalline or amorphous.
- Know the three common crystalline structures for metals.
- Know what an allotrope is.
- Explain that some solids may have more than one crystalline structure.
- Be able to list two ways that crystals can be grown.
- Explain that crystalline solids are usually conglomerations of tiny crystals called grains.
- Explain that metals tend to become more stable by losing electrons to form ions and ionic compounds.

Experiments

Exp. 3-1: Models of Crystals

Learning Objectives:

- Name the three most common crystalline structures for metals.
- Explain how four common crystalline structures differ.

Laboratory Proficiencies:

- Follow directions to produce a model.
- Work cooperatively to form a larger model.

Exp. 3-2: Formation of Solids

Learning Objectives:

- Tell why some materials may have more than one type of structure.
- Explain that the conditions under which material solidifies may affect its form.

Laboratory Proficiencies:

- Use a microscope to observe crystals.
- Follow instructions to successfully complete a procedure.

Exp. 3-3: Crystal Study

Learning Objectives:

- Explain that crystals may grow from a liquid when the liquid is cooled.
- Use polarized light to analyze crystals.

Exp. 3-4: Growing Single Crystals

Learning Objectives:

- Demonstrate that it is difficult to get atomic-sized particles to orient themselves perfectly into a single crystal.
- Grow crystals from a supersaturated solution
- Explain that materials form the same shapes of crystals every time when allowed to grow unrestricted under similar conditions.

Laboratory Proficiencies:

- Use a balance to determine a mass accurately.
- Use a graduated cylinder to measure volume.
- Make a supersaturated solution to grow crystals.

CHAPTER 4: MECHANICAL PROPERTIES AND REACTIVITY

Objectives

- Explain that crystal imperfections influence the properties of materials.
- List and identify several types of stress to which materials are exposed.
- Identify tests as destructive or nondestructive.
- Make predictions based upon data from a destructive test.
- Explain that the most easily obtained elements are also the most used ones.
- Use a reactivity chart to determine which of two elements is more reactive.
- Explain that metals tend to oxidize faster when heated.
- List characteristics of both oxidation and reduction.
- Use density and/or specific gravity formulas to make calculations.

Experiments

Exp. 4-1: Destructive Testing of a Paper Clip

Learning Objectives:

- Explain the difference between destructive and nondestructive testing.
- Use a graph to show that production items will not all be equally strong.
- Plot a bar graph of laboratory results.

Laboratory Proficiencies:

- Follow instructions to complete an exercise.
- Share your experimental results with your peers.
- Construct a bar graph

Exp. 4-2: Simple Iron Reactions Using Steel Wool

Learning Objectives:

- Demonstrate that iron is more reactive than copper.
- Use heat to show that iron will oxidize more readily when hot.

Laboratory Proficiencies:

- Follow directions in order to make and record observations.
- Use a balance to correctly determine mass.

Exp. 4-3: Reduction of Copper

Learning Objectives:

- Explain that most metals are claimed from their ores by a process called reduction.
- State that, when metals undergo reduction, they are converted from ions to atoms.
- Use an activity chart to pick a more reactive element to reduce a metallic ion.
- Choose whether a metal or its compound is more stable.
- Explain that it takes energy to convert an element from a compound to a metallic atom.

Laboratory Proficiencies:

- Use a balance to accurately determine mass.
- Use a graduated cylinder to measure volume.

Metals Unit

Overview of Metals

In the metals 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 discussed. The unit includes ***seven demonstrations*** and ***fourteen experiments***. One of the experiments is a project involving lost wax casting.

CHAPTER 1: SYSTEM FAMILIARIZATION AND SAFETY

Objectives

- Take inventory and become familiar with some of the equipment and materials that are used during the Metals unit of Material Science Technology.
- Recognize and become aware of safety concerns associated with working in a laboratory environment.

Experiment

Exp 1-1: System Familiarization and Safety

Learning Objective:

- Identify much of the equipment used in the Metals unit of the Material Science Technology course.

CHAPTER 2: WHAT ARE METALS

Objectives

- State several properties of metals.
- Identify where metallic elements are located on the periodic table.
- Explain that the term “metals” includes elements and alloys.
- Classify a material as a metal or nonmetal.
- Obtain useful information from Material Safety Data Sheets.
- Explain that manipulating and reforming metals at room temperature causes work hardening.
- State that metals are commonly rolled into sheets or drawn into wires.

Experiments

Exp. 2-1: Properties of Metals

Learning Objectives:

- List some of the characteristics of metals.

- Compare and classify different materials as metals or nonmetals.

Laboratory Proficiencies:

- Use a conductivity device to determine electrical conductivity.
- Use a magnet to test for magnetism.

Exp. 2-2: Rolling a coin

Learning Objectives:

- Know that copper can be rolled into a smaller thickness because it is malleable.
- Explain that rolling a metal produces heat.
- Explain the inverse relationship between the area and the thickness for a specific object.

Laboratory Proficiencies:

- Use a rolling mill to roll a piece of metal to a smaller thickness.
- Use graph paper to estimate area.
- Use a caliper to measure thickness.

Exp. 2-3: Drawing a Wire

Learning Objectives:

- Describe the process of drawing a wire.
- State that heat is produced when a wire is drawn.
- Explain that drawing a wire when it is cold stiffens or work hardens the wire.

Laboratory Proficiencies:

- Use drawing tongs and a drawplate to draw a wire.
- Use a caliper and ruler to accurately measure dimensions.
- Use a balance to measure mass.

CHAPTER 3: HISTORICAL DEVELOPMENT OF METALS

Objectives

- Explain that copper was the first widely used metal because it has a moderate melting point and occurs naturally.
- Explain how technology had to be developed before most metals could be put into use.
- State that a better understanding of chemistry resulted in the rapid development of metals.
- Explain that ores are mixtures that contain a desired metal.
- State that metals undergo reduction when they are claimed from their ores.
- Explain that chemical reduction is used to claim most metals from their ores.
- State that brass is formed by alloying copper and zinc.
- Demonstrate that heating metals speeds their rate of oxidation.
- Show that heating metals to a high temperature will cause them to emit light.
- State that an alloy is a mixture that may possess more desirable characteristics than the elements from which it was formed.
- State that the oxidation of a metal involves the loss of valence electrons by that metal.
- Use a reactivity chart to predict if one metal will reduce another.

Experiments

Exp. 3-1: Alloying Copper and Zinc

Learning Objectives:

- Explain that zinc "plates out" on copper by a reduction process.
- Explain that zinc and copper form an alloy called brass.

Laboratory Proficiencies:

- Follow directions to complete a project.
- Use a burner to allow hot solid metal atoms to diffuse and form an alloy.
- Compare results when applying the same procedure to two different materials.

Exp. 3-2: Making a Light Bulb

Learning Objectives:

- Explain how a light bulb works.
- Explain the purpose of the glass envelope.

Laboratory Proficiencies:

- Follow directions to complete a project.

CHAPTER 4: ALLOYS

Objectives

- Know that the ductility of a metal is related to its crystalline structure.
- Explain that an energy change occurs during a phase change, including a solid-state phase change.
- Interpret a phase diagram for a pure crystalline substance.
- List at least two reasons for forming alloys.
- Define an alloy.
- Identify a binary phase diagram.
- Identify the eutectic temperature on a binary phase diagram and explain what the eutectic point is.
- Explain that materials can be locked into a particular crystalline state by quenching.
- Explain the difference between heat and temperature.
- Show that most alloys do not have a definite melting point.
- State that a material is in equilibrium when that material is in a state of minimum energy for that particular temperature.

Experiments

Exp. 4-1: Tin-Lead Solder

Learning Objectives:

- Make a low temperature alloy that can be used as solder.
- Explain that mixing two metals together to form an alloy usually results in a lowered melting point.
- Identify the eutectic point on a phase diagram and explain what it is.

Laboratory Proficiencies:

- Use a balance to accurately determine the mass of a material.
- Use a heating device to melt metal.
- Measure the melting point or melting range of an alloy.
- Cast a metal using a mold.

Exp. 4-2: Aluminum and Zing Alloy

Learning Objectives:

- Form an alloy that releases energy by making a solid state crystalline change.
- Explain how heat is released when a solid changes from one crystalline state to another.
- Explain how quenching locks the solid into a particular crystalline state.

Laboratory Proficiencies:

- Use a balance to accurately determine the mass of a material.
- Use a heating device to melt metal.
- Quench an alloy to lock the particles in a metastable state.

Exp. 4-3: Caloric Output of the Aluminum and Zinc Alloy

Learning Objectives:

- Explain the difference between temperature and heat.
- Explain how heat is measured in the lab.

Laboratory Proficiencies:

- Use a balance to accurately determine the mass of an object.
- Use a thermometer to determine temperature.
- Use an oven to anneal an ingot.

CHAPTER 5: ALTERING THE MECHANICAL PROPERTIES OF METALS

Objectives

- Describe how imperfections in crystals influence a metal's ability to be reshaped.
- Know that reshaping a metal at room temperature causes the metal to become work hardened.
- Demonstrate how annealing is a heat treatmentthat softens metals.
- Define what a ferrous metal is.
- Describe how the amount of carbon in steel greatly affects the strength and hardness of steel.

- Explain how the allotropic nature of iron is extremely important in the formation of steel.
- Demonstrate how quenching helps make steel become stronger and harder.
- Know that tempering is a heat treatment that reduces the brittleness in steel.
- State why case hardening is a high temperature surface treatment that makes the metal harder.
- Demonstrate that some nonferrous alloys can be made harder by precipitation hardening.

Experiments

Exp. 5-1: Annealing Copper

Learning Objectives:

- Explain how the annealing process occurs.
- Explain that metals soften by annealing.
- Know that cold working copper makes it work hardened.

Laboratory Proficiencies:

- Use a burner or oven to anneal.

Exp. 5-2: Heat Treating Alloys

Learning Objectives:

- Know that heating and quenching mild steel will make the steel harder and more brittle.
- Know that steel can be made tougher and less brittle by tempering the steel.
- Know that some aluminum alloys can be hardened through precipitation hardening.

Laboratory Proficiencies:

- Heat treat a piece of metal by heating, quenching, and tempering it.
- Use a ruler to make measurements for comparisons.

CHAPTER 6: TESTING AND MANUFACTURING PROCESSES

Objectives

- Explain what a tensile test is.
- Explain what the elastic limit is.
- Explain what is happening on a stress-strain graph.
- Describe the forging process.
- List at least four different manufacturing processes for metals.
- Explain the major steps involved with power metallurgy.
- Describe what sintering is.
- Explain the lost wax casting process.
- Write the composition of sterling silver.

Experiments

Exp. 6-1: Powder Metallurgy (P/M)

Learning Objectives:

- Describe the powder metal process for forming metal parts.
- Explain what sintering is.

Laboratory Proficiencies:

- Use a hydraulic press and die to make a part.
- Use a furnace to sinter a part.
- Use a balance to measure a mass

Exp. 6-2: Lost Wax Casting

Learning Objectives:

- Form an object using the lost wax casting process.
- Explain the process of lost wax casting.

Laboratory Proficiencies:

- Follow directions to complete a project.
- Follow and complete a mixing procedure that is time sensitive.
- Use a torch to heat and melt metal.
- Use a vacuum machine to “degas” a mixture.
- Use either a centrifugal caster or a vacuum caster to cast a metal piece.
- Use tools to form a wax model.
- Use sandpaper, rouge, and a polishing machine to place a finish on a metal piece.

Exp. 6-3: A Sterling Silver Alloy

Learning Objectives:

- Make a sterling silver alloy with the correct percentages of components.
- State the composition of sterling silver.

Laboratory Proficiencies:

- Use a balance to correctly find the mass of needed materials.
- Use a torch to melt metal.
- Pickle an alloy to remove the oxides.

CERAMICS UNIT

Overview of Ceramics

In the Ceramics Unit, the students learn that most ceramics are crystalline solids that have properties delated to the ionic or covalent bonds that hold them together. They learn that ceramic materials are frequently divided into three categories one of which is glass.

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. There are 16 experiments including a stained glass project and a Raku pottery project.

CHAPTER 1: SYSTEM FAMILIARIZATION AND SAFETY

Objectives

- Take inventory of and become familiar with some of the equipment and materials used in the Ceramics unit of Material Science Technology.
- To be reminded of safety concerns associated with working in a laboratory environment.

Experiments

Exp. 1-1: Equipment Introduction

Learning Objectives:

- Identify much of the equipment used in the Ceramics unit of the Material Science Technology course.

CHAPTER 2: CERAMICS AND THEIR CHARACTERISTICS

Objectives

- List at least four characteristic properties of ceramics.
- Explain why ceramics are not good conductors of electricity.
- State the types of chemical bonds associated with ceramics.
- List three categories in which ceramics are placed.
- State that most ceramics are made of readily available materials.
- State that clay is workable and pliable because of the water content.
- Clarify that ceramics are composed of compounds of metals or semimetals combined with nonmetals.
- Show that clay loses volume and mass when it dries.
- Explain that clay is made stronger by firing.

Experiments

Exp. 2-1: Light Bulb Filament

Learning Objectives:

- Explain that metals become ceramics when they are oxidized.
- Explain the changes in the properties of tungsten when exposed to air at high temperatures.
- Label the principal parts of a light bulb on an appropriate drawing.
- Describe the purposes of the light bulb's filament and envelope.

Laboratory Proficiencies:

- Use a file to score and break glass.

Exp. 2-2: Forming, Firing, and Glazing Clay

Learning Objectives:

- Explain the process of hand forming a clay object.
- Calculate the clay's percentage loss in volume and mass.

- Explain why clay loses mass as it dries.

Laboratory Proficiencies:

- Use a ruler to measure dimensions accurately.
- Use a balance to accurately determine mass.
- Follow directions to create an object.

CHAPTER 3: GLASS – THE SPECIAL CERAMIC

Objectives

- Explain that glass is a ceramic that is amorphous.
- Tell why glass is considered different from most ceramics.
- State that glass is a mixture of oxides including a glass former, a modifier, and sometimes an intermediate.
- Demonstrate how a modifier lowers the melting temperature of a glass.
- Name and describe at least three different types of glass.
- Answer that most advancements in glass have occurred during the last century.
- State that silica is the main ingredient in most glass.
- Use a glass cutter to score and break glass.
- State that glass is stronger when placed under compression and weaker when placed under tension.
- Use polarizing material to check for stress in glass.
- State that annealing reduce stress in glass.
- State that when the resistance to flow in a fluid increases, the viscosity increases.
- Explain that glass is tempered by rapid cooling.
- Tell that tempering places the surface of a glass under compression.
- Demonstrate that metal oxides are used for coloring glass.

Experiments

Exp. 3-1: Scoring and Breaking Glass

Learning Objectives:

- Use a glass cutter to score ad break glass.
- Know that ceramics are stronger under compression than tension.

Laboratory Proficiencies:

- Use a glass cutter to score and break glass.

Exp. 3-2: Glass Bending and Blowing

Learning Objectives:

- Use a burner to bend glass tubing.
- Use a file to score and cut glass tubing.
- Explain that polarizing material can be used to detect stress in a glass.
- Explain the difference between a rod and tubing.

Laboratory Proficiencies:

- Use a file to cut glass tubing and a glass rod.
- Use a burner to change the shape of glass tubing.

Exp. 3-3: Glass Bead on a Wire

Learning Objectives:

- Explain that borax will form a glass when melted and allowed to cool.
- State that metal oxides are used to color glass.

Laboratory Proficiencies:

- Use a burner to convert a material from one form to another.

Exp. 3-4: Glass Batching Calculations

Learning Objectives:

- Determine the mass of one mole of a given chemical.
- Explain what a source chemical is when making glass.
- Explain the steps and calculations for making a batch of glass.

Laboratory Proficiencies:

- Use the periodic table to determine molecular masses.

Exp. 3-5: Standard Glass Batching

Learning Objectives:

- Measure, combine, and mix the ingredients needed to make a glass.

- State that modifiers lower the melting temperature of the glass.

Laboratory Proficiencies:

- Use a balance to accurately measure masses.

Exp. 3-6: Glass Melting

Learning Objectives:

- Melt, cast, and anneal glass.
- Explain the purpose of annealing glass.

Laboratory Proficiencies:

- Use polarizing material to search for stress.
- Use ovens and equipment to cat and anneal glass.

Exp. 3-7: Dragon Dribble/Dragon Tears

Learning Objectives:

- Use molten glass to make either dragon dribble or a dragon tear.
- State that glass becomes tougher when placed under compression.
- Explain that tempering places the outer surface of glass under compression and makes it stronger.
- State that annealing is a heat treatment that reduces the stress in glass.

Laboratory Proficiencies:

- Pour molten glass to form either a dragon tear or dragon dribble.

Exp. 3-8: Coloring Glass

Learning Objectives:

- Measure, combine, and mix the ingredients needed to make glass.
- Heat, cast, and anneal glass.
- State that glass can be colored using metal oxides.

Laboratory Proficiencies:

- Use a balance to accurately measure mass.

- Use ovens and equipment to cast and anneal glass.

CHAPTER 4: PROPERTIES OF GLASS

Objectives

- List at least four properties of glass.
- Explain that the properties of glass can be varied by the composition of the glass.
- State that a glass-ceramic is a crystalline material formed from glass.
- Show that soil can be made into glass.
- Make a stained glass project using the copper foil technique.
- Explain that glasses with different coefficients of thermal expansion are incompatible.

Experiments

Exp. 4-1: Glass from Soil

Learning Objectives:

- Explain why soil can be converted to glass.
- Use experimental data to form a binary phase diagram.

Laboratory Proficiencies:

- Use a balance to accurately measure masses.
- Use ovens and equipment to cast and anneal glass.

Exp. 4-2: Stained Glass Project

Learning Objectives:

- Explain the steps involved with making a stained glass project.
- Complete a stained glass project using the copper foil technique.

Laboratory Proficiencies:

- Use a glasscutter to score and cut glass.
- Use a glass grinder to smooth glass cuts.
- Use a soldering iron to solder.

Exp. 4-3: Glass Fusing

Learning Objectives:

- Form a fused glass object.
- Explain the meaning of compatible glass.

Laboratory Proficiencies:

- Use a glasscutter to score and gut glass.
- Use a furnace to heat glass until it fuses.

CHAPTER 5: CERAMIC MANUFACTURING PROCESSES

Objectives

- Explain that most clay needs to be processed before it can be used to manufacture products.
- List at least three ways that ceramic items are formed or shaped.
- List at least two ways that glass objects are formed.
- Describe how Raku pottery is different from other pottery.
- Demonstrate the steps involved with slip casting.
- Explain the purpose of a glaze on a ceramic object.

Experiments

Exp. 5-1: Making Raku

Learning Objectives:

- Make a Raku pottery project.
- Explain how the colors are obtained in the Raku process.

Laboratory Proficiencies:

- Follow directions to complete a project.
- Use a furnace to fire a clay project.

Exp. 5-2: Ceramic Slip Casting

Learning Objectives:

- Use a plaster of Paris mold to make a ceramic object using the slip casting process.

- Explain the steps involved with slip casting.

Laboratory Proficiencies:

- Use clay slip to cast a ceramic object.
- Use a knife and sponge to clean and prepare a ceramic casting for firing.

POLYMERS UNIT

Overview of Polymers

What synthetic polymers are and the chemistry involved with them is introduced in this unit. Polymers can be categorized in several ways. They are frequently altered either 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. The unit includes five demonstrations along with 15 experiments.

CHAPTER 1: SYSTEM FAMILIARIZATION AND SAFETY

Objectives

- Take inventor of and become familiar with some of the equipment and materials used in the Polymers Unit of Material Science Technology.
- To be reminded of safety concerns associated with working in a laboratory environment.

Experiments

Exp. 1-1: System Familiarization and Safety

Learning Objectives:

- Identify much of the equipment used in the Polymers unit of the Material Science Technology course.

CHAPTER 2: CHEMISTRY OF POLYMERS

Objectives

- Explain what a polymer is.
- List the three primary classifications of synthetic polymers.
- Demonstrate how cross-linking affect polymers.
- State that polymers may be formed by addition or condensation.
- Explain that polymers are molecular compounds made of nonmetals.
- Define a hydrocarbon.
- Explain that a large number of monomers can be used to make polymers.
- State that hanging one part of a monomer changes the polymer made from that monomer.
- Classify and separate polymers based on some physical properties.

Experiments

Exp. 2-1: Cross-Linking a Polymer

Learning Objectives:
- Describe the properties of a polymeric substance you have made.
- Describe the nature of a polymer.
- Describe how cross-linking affects a polymer using models, drawings, discussion, and writing.

Laboratory Proficiencies:
- Measure volume accurately with a graduate cylinder.

Exp. 2-2: Polymer Identification

Learning Objectives:
- Classify plastics by using their physical properties.
- Use liquids of varying specific gravity's to determine the density ranges of plastics.
- Understand that different categories of plastics may have different physical properties.

Laboratory Proficiencies:
- Accurately measure volume using a graduated cylinder.
- Use a chart as a reference in order to categorize material.

CHAPTER 3: COPOLYMERS AND ELASTOMERS

Objectives

- Describe how individual polymers can be formed from two or more different types of monomers.
- State that synthetic polymers are used to make a large number of fabrics.
- Explain that nylon is a copolymer formed by condensation.
- Realize that there are several types of nylon.
- State that the characteristics of elastomers place them between thermoplastics and thermostats.
- Explain that cross-linking is a integral part of forming elastomers.
- Demonstrate that cross-linking will make an elastomer firmer.
- Explain why synthetic elastomers were created.

Experiments

Exp. 3-1: Nylon 6-10

Learning Objectives:

- Explain that nylon is formed by the reaction between two different typed of chemicals.
- Describe how a polymer can be formed into a filament by drawing it from an interface.

Laboratory Proficiencies:

- Measure volume accurately by using a graduated cylinder.
- Follow directions to produce a project.
- Read an MSDS to determine safety concerns and potential hazards
- Use an equation to determine the length of a filament.

Exp. 3-2: Adding Cross-Linking to an Adhesive

Learning Objectives:

- Tell how cross-linking changes the properties of a polymer.

Laboratory Proficiencies:

- Use a graduated cylinder to measure volume.

- Use a balance to mass a specific amount of material.

Exp. 3-3: Latex Rubber Ball

Learning Objectives:

- Explain some of the characteristics of elastomers.

Laboratory Proficiencies:

- Measure volume with a graduated cylinder.

CHAPTER 4: ENGINEERING POLYMERS

Objectives

- Explain that plastics are separated into seven groups for recycling.
- State that most recycled plastics are thermoplastics.
- Explain that most plastic containers have a recycle symbol on them.
- List several ways that the properties of each type of polymer can be modified.
- Describe what a branched polymer is.
- Explain what cross-linking in a polymer is.
- Describe what a side group is and that its size can influence the properties of a polymer.
- Explain how a silicon-based polymer is different from a carbon-based polymer.
- List some properties of silicone rubber.
- State some purposes of fillers and other additives.
- Explain what a plasticizer is and what it does.

Experiments

Exp. 4-1: Poster for Recycling Polymers

Learning Objectives:

- Explain the different categories used to classify plastics for recycling.
- Identify recycle symbols on containers.

Laboratory Proficiencies:

- Plan to organize and complete a project.

Exp. 4-2: Silicone Rubber Mold

Learning Objectives:

- Describe the process used to make a silicone rubber mold.

Laboratory Proficiencies:

- Use a balance to accurately determine the mass of material.
- Use a vacuum chamber to degas a mixture.

Exp. 4-3: Plasticizer in Plastisol (Coin Purse)

Learning Objectives:

- Explain how plastic can be applied to objects by dip m9lding.
- Explain how plasticizers can be eliminated by heat to make the plastics more rigid.

Laboratory Proficiencies:

- Follow directions to produce a product using a dip molding process.

CHAPTER 5: MANUFACTURING POLYMERS

Objectives

- Explain that most synthetic polymers have been developed during the 20th Century.
- Explain how serendipity was involved in the formation of many polymers.
- Describe how heat will return many distorted plastics to their original shape.
- State that most synthetic polymers are produced from petroleum.
- List some manufacturing processes for producing plastic parts.
- Describe how epoxy is a thermoset.
- Hand cast a part with epoxy resin.
- Explain that there are cost trade-offs in various plastic manufacturing processes.
- State that foam can be made form nay different typed of polymers.
- Demonstrate that there are rigid and flexible foams.
- Realize that many common products are formed from expanded polystyrene beads.

Experiments

Exp. 5-1: Memory in Polymers

Learning Objectives:

- Explain and demonstrate how some plastic materials will return to their original shapes after being distorted.
- Polish acrylic plastic roughened by cutting.

Laboratory Proficiencies:

- Practice sanding and polishing acrylic.
- Use a drill press.
- Color plastic with dyes.

Exp. 5-2: Epoxy Resin Casting in an RTV Mold

Learning Objectives:

- Follow directions to make an epoxy resin casting.
- Explain one technique for producing a thermoset part using a casting method.

Laboratory Proficiencies:

- Practice techniques for properly dispensing a resin from a bottle.
- Determine the amount of resin needed for a casting.
- Use a balance to accurately measure a needed mass.

Exp. 5-3: Epoxy Resin Cast (Plastic Clip)

Learning Objectives:

- Show and explain how a thermosetting resin can be hand cast.

Laboratory Proficiencies:

- Use a balance to determine proper masses of materials.
- Follow directions to cast a part.

Exp. 5-4: Night-Light

Learning Objectives:

- Mix and hand cast an epoxy resin part.

Laboratory Proficiencies:

- Solder with a solder iron.
- Follow directions to produce a useful product.
- Use a drill press to drill holes as directed.
- Use a balance to measure needed amounts of material.

Exp. 5-5: Polymer Foam Creations

Learning Objectives:

- Follow directions to produce foam from two components.
- Compare the similarities and differences of flexible and rigid foams.

Laboratory Proficiencies:

- Use a balance to correctly measure masses.

Exp. 5-6: Cast Expanded Polystyrene (Football)

Learning Objectives:

- Explain how expandable beads are used to form specific shapes.

Laboratory Proficiencies:

- Use a balance to accurately measure needed masses.
- Follow a procedure to produce a desired product.

COMPOSITES UNIT

Overview of Composites

This unit helps tie together many of the ideas presented in previous units. 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. Manufacturing processes, including hand lay-up, pultrusion, and vacuum bagging are presented. The unit includes nine experiments and six demonstrations.

CHAPTER 1: SYSTEM FAMILIARIZATION AND SAFETY

Objectives

- Take inventory of and become familiar with some of the equipment and materials used in the Composites unit of Material Science Technology.
- To be reminded of safety concerns associated with working in a laboratory environment.

Experiments

Exp. 1-1: System Familiarization and Safety

Learning Objectives:

- Identify much of the equipment used in the Composites unit of the Material Science Technology course.

CHAPTER 2: COMPOSITES

Objectives

- Define a composite.
- Explain why composites are made.
- State the impact of the aerospace industry on the formation of many stronger and lighter composites.
- List the three major classifications of composites.
- Define specific strength.
- Define specific stiffness.
- Show that hollow tubes exhibit high specific stiffness.
- Explain what Young's Modulus represents.
- Describe a stressed-skin composite.
- Demonstrate that delamination weakens a laminar composite.

Experiments

Exp. 2-1: Stressed-Skin Composites

Learning Objectives:

- Explain that Young's Modulus is a measurement of stiffness.
- Calculate Young's Modulus when given the formula and data.

- Explain what a laminar composite is.
- Explain what a stress-skin composite is.
- Explain that a delamination weakens a composite under compression.

Laboratory Proficiencies:

- Use a meter stick to measure deflection.
- Place numbers in an equation to arrive at a value.

Exp. 2-2: Plaster of Paris Matrix Composite

Learning Objectives:

- Explain how reinforcement affects the strength of a composite.
- Explain what a three-point tester is.

Laboratory Proficiencies:

- Use a ruler to measure lengths.
- Use a balance to determine mass.
- Use a testing device to determine strength.
- Follow directions to make a composite.

CHAPTER 3: WOOD AND CONCRETE

Objectives

- Describe wood as a natural composite.
- Explain that wood is made up primarily of tubular cells composed of cellulose and held together by lignin.
- List some difference between softwoods and hardwoods.
- Explain that shrinkage in wood is due to loss of moisture and that the amount of shrinkage is dependent upon the grain orientation.
- List at least four different human-fabricated wood composites.
- Explain the importance of the bond is a laminar composite.
- Describe concrete as a particulate reinforced composite.
- List the main components of concrete.
- Clarify the difference between concrete and cement.
- State that too much water weakens concrete when it is mixed.
- State that concrete cures rather than dries. Describe a good mix ration of components for concrete.

Experiments

Exp. 3-1: Laminated Wood Beams

Learning Objectives:

- Explain what a laminated beam is.
- Explain the importance of a bond in a laminar composite.

Laboratory Proficiencies:

- Graph and analyze data.
- Use wood and glue to build a laminated wood beam.
- Use a three-point testing device to make a destructive test.

Exp. 3-2: Using Portland Cement to Make and Test Concrete

Learning Objectives:

- State the recommended composition for concrete.
- Identify the difference between cement and concrete.

Laboratory Proficiencies:

- Follow directions to mix and pour concrete.
- Test two similar materials too compare for strength.

CHAPTER 4: FIBER REINFORCED COMPOSITES

Objectives

- Describe a fiber-reinforced composite.
- Explain that there are many types of fibers that may occur in many different physical configurations.
- Explain that the fiber supports the majority of the load in most fiber-reinforced composites.
- Explain how the amount of fiber and its orientation affect the composite's strength.
- State that glass fiber reinforced polymers (fiberglass) are the most common fiber reinforced composites.
- List at least three commonly used types of fibers for fiber-reinforced polymers.
- Explain that metal and ceramic matrixes replace polymers for high temperature applications.

- Define what hybrid composites are and explain why they are being created.
- Know the high expectations held for ceramic matrix composites and that their major problem is a lack of fracture toughness.
- Lay up a fiber reinforced composite.
- List some characteristics of carbon and Kevlar fibers.

Experiments

Exp. 4-1: Hand Lay-Up of a Glass Fiber Reinforced Polymer (Fiberglass)

Learning Objectives:

- Explain how to do a fiber reinforced composite hand lay-up.
- Do a fiber reinforced composite lay-up.

Laboratory Proficiencies:

- Use a ruler to measure length and width.
- Use a caliper to measure thickness.
- Use a balance to determine mass.
- Make a composite using glass fibers and resin.

Exp. 4-2: A Pressure Laminated Glass Fiber Reinforced Polymer (Fiberglass)

Learning Objectives:

- Explain how to do a fiber composite hand lay-up.
- Do a fiber-reinforced composite using a hydraulic press to apply pressure.

Laboratory Proficiencies:

- Use a ruler to measure length and width.
- Se a caliper to measure thickness.
- Use a balance to determine mass.
- Make a composite using glass fibers and resin.
- Use a hydraulic press to exert pressure.

CHAPTER 5: MANUFACTURING PROCESSES

Objectives

- Explain what sheet molding compounds and prepreg materials are and why they are used.
- Describe what is involved with the hand lay-up process.
- Describe what an open mold is.
- Explain how filament winding is used for producing items.
- Explain what pultrusion is.
- Explain the vacuum bag process.
- Design, construct, and test a composite beam.

Experiments

Exp. 5-1: Using the Vacuum Bag Process to Form a Honeycomb Composite

Learning Objectives:

- Explain what the vacuum bag process is and its purpose.
- Do a hand lay-up composite using a vacuum bag to exert pressure.

Laboratory Proficiencies:

- Use a ruler to measure length and width.
- Use a caliper to measure thickness.
- Use a balance to determine mass.
- Make a composite using glass fibers, honeycomb, and resin.
- Use a vacuum pump.

Exp. 5-2: Composite Beam Contest

Learning Objectives:

- Design, construct, and test a composite beam.
- Explain that cost and weight are important factors when designing or selecting a beam for use.

Laboratory Proficiencies:

- Design a beam based upon cost and weight.
- Use a balance to determine mass.
- Use a three-point testing device to destructively test a beam.