Course Description
The development and use of materials will continue to be a major source of job opportunities in today’s marketplace. This course provides high school students with the basic skills necessary to make the transition to either college-level study or to the workplace. Basic principles of physics, chemistry, and biology are used to enhance the learning experience and provide the scientific basis for the study of materials.

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<td>Intended Grade Level</td>
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<tr>
<td>Prerequisite</td>
<td>Chemistry</td>
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STRAND 1
Students will follow safety practices.

Standard 1
Identify potential safety hazards and follow general laboratory safety practices.
- Assess workplace conditions regarding safety and health.
- Identify potential safety issues and align with relevant safety standards to ensure a safe workplace/jobsite.
- Locate and understand the use of shop safety equipment.
- Select appropriate personal protective equipment.
- Learn about and obtain useful information from Safety Data Sheets.

Standard 2
Use safe work practices.
- Use personal protective equipment according to manufacturer rules and regulations.
- Follow correct procedures when using any hand or power tools.

Standard 3
Complete a basic safety test without errors (100%) before using any tools or shop equipment.

STRAND 2
Students will understand the basic nature and properties of materials.

Standard 1
Demonstrate a basic understanding of Chemistry.
- Know the principle parts of an atom.
- Demonstrate the use of the periodic table as a meaningful tool.
- List the different types of chemical bonds.
- Give examples of allotropes.
- Explain how heat and energy are related to different states of matter.

Standard 2
Identify different types of materials in both household and industrial products through examination.
- Separate them into four groups: metals, ceramics and glasses, polymers, and composites.
- Describe the basic differences between the groups and show evidence of similarities.
- Describe the thermal properties of materials.
- Describe the electrical properties of materials.
- Describe the strength of materials.
• Identify and once again separate materials into two categories: crystalline and amorphous.

**Standard 3**
Know three kinds of crystalline structures for metals and that solids may have more than one crystalline structure.
- Body Centered Cubic (BCC)
- Faced Centered Cubic (FCC)
- Hexagonal Close Packed (HCP)
- Identify the effects of heat on crystalline structure (heat treating)

**Standard 4**
List and identify several types of stress to which materials are exposed.
- Tension
- Compression
- Torsion
- Shear

**Standard 5**
Identify tests as destructive or nondestructive.
- Make predictions based on data from a destructive test.

**Standard 6**
Describe the significant developments in the history of materials.
- Investigate and report how the use of materials has changed throughout history.
- Provide an example of how each group of materials is used in today's society.
- Describe and report on the development of technology and the use of materials.

**Standard 7**
State ways in which materials have been closely related to the advancement of civilizations throughout history.
- Provide an example from each category of material used in today's society.
- Explain how science and technology complement one another.
- Explain that the most easily obtained elements are generally the most used ones.

**STRAND 3**
**Students will understand the basic nature of metals.**

**Standard 1**
Examine the characteristics of metals.
- State several properties of metals.
- Identify where the metallic elements are found on the periodic table.
- Define what a ferrous metal is.
• Describe how the amount of carbon in steel greatly affects its strength and hardness.
• Classify a selection of materials as either metal or nonmetal.
• Introduce the phase diagram

**Standard 2**
Describe the changes in metals and their structures through mechanical treatments.
• Explain that the ductility of a metal is related to its crystalline structure.
• Examine the changes in a metal through work hardening and cold hardening of metals. (e.g., rolling, drawing wire, bending, etc).
• Conduct an experiment on the treatment of metals. (e.g., annealing, quenching, tempering, and solutionizing and aging in aluminum).

**Standard 3**
Investigate the properties of alloys.
• Explain that the term “metals” includes elements and alloys.
• State at least two reasons for forming alloys.
• Create a simple binary alloy. Conduct an experiment on the effects of temperature and construct a phase diagram of the binary alloy. Explain the areas of interest on the phase diagram (e.g., solid regions, liquid regions, slush regions, eutectic point).
• Conduct an experiment for molding metals. (e.g., plaster casting, sand casting, silicon casting.)
• Relate mechanical properties to manufacturing properties, weldability, machinability, formability, and castability.

**Standard 4**
Demonstrate an understanding of the effects of corrosion on metals.

**Standard 5**
List characteristics of both oxidation and reduction.

**Standard 6**
Reference a reactivity chart to determine which of two elements is more reactive.

**Standard 7**
Test a variety of metal samples.
• Describe and perform a tensile test.
• Describe the elastic limit.
• Describe what is shown by a stress-strain graph.
• Impact test
• Hardness test

**STRAND 4**
Students will understand the basics of polymers.
Standard 1
Analyze polymer structures.
- Explain that polymers are molecular compounds made of nonmetals.
- Define a hydrocarbon.
- Describe the process of creating a polymer by addition and condensation.
- Differentiate between natural polymers and man-made polymers.
- Understand glass transition and melting temperature.

Standard 2
Characterize polymers.
- Differentiate between thermoplastics, thermosets, and elastomers.
- Construct experiments on various types of polymers and demonstrate how cross-linking affects polymers. (e.g., thermal plastics, epoxy resin, flexible and rigid foams, latex balls, Gak®, and Slime®).
- Differentiate between the various types of polymers, their properties and report on their uses. (e.g., PETE, HDPE, PVC, LDPE, PP, PS).

Standard 3
Research the issues with plastics and polymer recycling.
- Research and report on the recycling of plastics and polymers. (e.g., PETE, HDPE, PVC, LDPE, PP, PS).
- Differentiate between the various recycling codes and how they affect our local communities.
- Analyze the effects of recycling on our global community.
- Explain that a large number of monomers can be used to make polymers.
- Describe how individual polymers can be formed from two or more different types of monomers.
- State that changing one part of a monomer changes the polymer made from that monomer.
- Classify and separate polymers based upon some physical properties.

Standard 4
List a variety of manufacturing processes for producing plastic parts and the associated cost trade-offs.
- Understand traditional manufacturing and 3-D printing properties on the materials.

STRAND 5
Students will understand the basics of ceramics and glasses.

Standard 1
Characterize the properties of ceramics and glasses.
- Conduct experiments on the thermal properties of ceramics and glasses and compare them to the thermal properties of metals.
• Examine and differentiate between the physical properties of ceramics and glasses. Explain that glass is a ceramic that is amorphous.
• Compare and contrast thermal shock in various ceramic and glass materials.
• Explain why ceramics and glasses are not good conductors of electricity.

**Standard 2**
Demonstrate the creation of ceramics.
• State the types of chemical bonds associated with ceramics.
• List three categories of ceramics (i.e. oxides, nonoxides, and composite materials).
• Clarify that ceramics are composed of compounds of metals or semimetals combined with nonmetals.
• Characterize the processes of oxidation and reduction and why they are important to the creation of ceramic art.

**Standard 3**
List at least three ways that ceramic items are formed or shaped.

**Standard 4**
Characterize the unique properties of glasses.
• Analyze the structure of glass and explain its components and their purposes. (e.g., glass former, modifier, intermediate).
• List three categories of glass (i.e. soda-lime silica, borosilicate, and phosphate).
• List at least four properties of glass.
• Analyze the amorphous properties of glass. Explain why glass is an amorphous substance.
• Demonstrate how a modifier lowers the melting temperature of glass.
• State that glass is stronger when placed in compression and weaker when placed under tension.
• State that annealing reduces stress in glass.
• Explain that tempering places the surface of glass under compression.

**Standard 5**
Demonstrate the creation of glass.
• Conduct an experiment to batch glass from its components.
• Conduct an experiment to create glass beads from a simple substance. (i.e., borax beads).

**Standard 6**
List at least two ways that glass objects are formed.

**STRAND 6**
Students will understand the basics of composites.
Standard 1
Characterize the properties of composite materials.
- Define a composite.
- Explain why composites are useful.
- List three major classifications of composites (i.e., polymer matrix, ceramic matrix, and metal matrix).
- Define specific strength.
- Define specific stiffness.
- Explain what Young’s Modulus represents.

Standard 2
Describe wood as a natural composite.
- Explain that wood is made up of tubular cells held together by lignin.
- List some differences between softwoods and hardwoods.
- Explain that shrinkage in wood is due to a loss of moisture and that the amount of shrinkage is dependent upon the grain orientation.
- List at least four human-fabricated wood composites.

Standard 3
Describe concrete as a particular reinforced composite.
- List the main components of concrete and describe a good mix ratio.
- Clarify the difference between concrete and cement.
- State that too much water weakens concrete when it is mixed and that concrete cures rather than dries.

Standard 4
Evaluate composite materials and compare them to non-composite materials.
- Conduct investigations on the strength of a composite vs a non-composite material. (e.g., cement vs concrete, foam board vs laminated foam board).
- Create various objects from composite materials and evaluate them for strength. (e.g., paper, airfoils, balsa wood bridges, etc.).

Standard 5
Describe a fiber reinforced composite.
- Explain that there are many types of fibers that may occur in many different physical configurations.
- Explain that fiber supports most of the load in the typical fiber reinforced composite.
- Explain how the amount of fiber and its orientation affect a composite’s strength.
- List at least three commonly used types of fibers for fiber reinforced polymers (i.e., glass fibers, carbon fibers, aramid fibers).
- Demonstrate that delamination and foreign object debris (FOD) weakens a laminar composite.
Standard 6
Describe at least 5 composite fabrication processes and their uses.
- hand lay-up
- vacuum bagging
- open molding
- filament winding
- pultrusion

Skill Certificate Test Points by Strand
None

Performance Skills
1. Create and utilize an engineering notebook per established conventions. 
   https://schools.utah.gov/cte/ttech/publicationsresources

2. Demonstrate practice of the Technology & Engineering Professional Workplace Skills. 
   https://schools.utah.gov/cte/ttech/publicationsresources

3. Participate in a significant activity that provides each student with an opportunity to 
   render service to others, employ leadership skills, or demonstrate skills they have 
   learned through this course, preferably through participation in a Career & Technical 
   Student Organization (CTSO) such as the Technology Student Association (TSA).