Park Hill School District

Building Successful Futures • Each Student • Every Day

High School Materials Science & Engineering Curriculum

Course Description: This course involves the study of solid matter. Five major units of study form the basis of the MS course: introduction to material science, metals, ceramics/glass, polymers (plastics), and composites. We will study the properties along with the design, and manufacturing of each major material category. A heavy hands-on, lab-based approach is used in this class. Learning will involve working in small groups, reading and writing as a means of learning, participation in demonstrations and activities, using community experts in materials, showing videos, and using a large variety of written resources including current event articles.

Scope and Sequence:

Timeframe	Unit	Instructional Topics
4-5 weeks	Introduction to Materials Science	Topic 1: History of Materials Topic 2: Periodic Table Topic 3: Properties of Materials
3-4 weeks	Metals	Topic 1: Properties Topic 2: Alloys Topic 3: Corrosion Topic 4: Conductivity
3-4 weeks	Polymers	Topic 1: Properties Topic 2: Natural vs Synthetic Topic 3: Naming Polymers Topic 4: Polymerization Topic 5: Recycling Codes Topic 6: Hydrophilic vs Hydrophobic Topic 7: Thermoset vs Thermoplastic

3-4 weeks	Ceramics/Glass	Topic 1: Properties of Ceramics Topic 2: Traditional v Advance Topic 3: Ceramics vs Glass Topic 4: Thermal Shock
2-3 weeks	Composites	Topic 1: Properties of Composites Topic 2: Types of Reinforcement Topic 3: Types of Matrices Topic 4: Advantages/Disadvantages Topic 5: History

Unit 1: Introduction to Materials Science

Subject: Materials Science
Grade: 10-12
Name of Unit: Introduction to Materials Science
Length of Unit: 4-5 weeks
Overview of Unit: In this unit students will learn to relate the macroscopic properties of materials, such as their type of bond and structure, to their macroscopic physical and chemical properties. They will learn to use the periodic table to be able to predict how certain elements will bond and what properties they will cause a material to have. Lastly, they will learn how the relative importance of materials has changed over time.

Priority Standards for unit:

- 9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]
- 9-12.PS1.A.3 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite).
- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]
- EK 3.C.1 LO 3.10 The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.
- EK 1.C.1 LO 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity.

Supporting Standards for unit:

- 9-12.ETS1.A.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.
- ISTE - COMPUTATIONAL THINKER.5: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Unwrapped Concepts (Students need to know)	Unwrapped Skills (Students need to be able to do)	Bloom's Taxonomy Levels	Webb's DOK
the organization of the periodic table	Use	Apply	2
the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms	Predict	Analyze	3
an investigation to gather evidence	Plan	Create	2
an investigation to gather evidence	Conduct	Apply	3
physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity	Compare	Understand	2
the relative strength of attractive forces between particles	Infer	Understand	2
the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of	Evaluate	Evaluate	3

covalent interactions and noncovalent interactions			
with evidence the arrangement of the periodic table	Justify	Understand	2
periodic properties to chemical reactivity	Apply	Understand	2
the concepts of bonding and crystalline/molecular structure	Apply	Apply	2
the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers	Explain	Understand	3

Essential Questions:

1. How has the usage of materials changed over time?
2. How does the periodic table of elements provide insight into the microscopic and macroscopic properties of materials?
3. How are materials classified and what are their key properties?

Enduring Understanding/Big Ideas:

1. Usage and relative importance of materials have changed over time due to accessibility, safety, and changes in technology.
2. The periodic table provides information about include reactivity of elements, types of bonds formed, numbers of bonds formed, and characteristics of elements in the same family. This information helps about microscopic properties assists in predicting macroscopic properties.
3. The four main categories of materials are metals, ceramics, polymers, and composites. They can be described and compared by physical and chemical properties including elemental bonds, physical structure, and elements involved.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Compound Mixture Physical Property Chemical Property	Dilatant Thixotropic Viscosity Metal Polymer Composite Ceramic

	Native Metal Mineral Ore Smelting Valence Electron

Topic 1: History of Materials

Engaging Experience 1

Title: Examining the Relative Importance of Materials Over Time

Suggested Length of Time: 20 minutes

Standards Addressed

Priority:

- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Detailed Description/Instructions: Examine with the students the graph of relative importance of materials over time. Assist them with understanding how to read the graph and have them rank the importance of the materials in different years to check for understanding. Have the brainstorm reasons why materials might change in relative importance. If the students do not talk about accessibility (such as fire and refining metal), discovery of a material being unsafe (ie. asbestos or lead paint), or changes in technology (discovery of synthetic polymers), then try to lead them towards some examples.

Bloom's Levels: Understand

Webb's DOK: 2

Supporting Material:

http://mathewpeet.org/science/materials/steel/future/Ashby_Importance_of_materials.jpg

Topic 2: Periodic Table

Engaging Experience 1

Title: Cracking the Periodic Table Code POGIL Activity

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- 9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]

Supporting:

- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Detailed Description/Instructions: The student will be able to describe the atomic structure of an element and how it relates to the organization of the periodic table.

Bloom's Levels: Analyze

Webb's DOK: 3

Supporting Material:

Cracking the Periodic Table Code

https://drive.google.com/open?id=1S455bFgFrtuYHiLntIY5TnQ1W8nZvomv

Topic 3: Properties of Materials

Engaging Experience 1

Title: Analyze a Comparison Chart of Materials

Suggested Length of Time: 25 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Detailed Description/Instructions: Students should be given the types of bonding chart. This includes across the top; metallic, covalent, ionic, and intermolecular forces. The rows of the chart include elements involved, givers and/or takers of electrons, description of bond, type of material formed, strength of bond, and properties produced. Students should be asked to draw connections, such as how the properties relate to the type of electron interaction. They should also begin to compare and contrast groups. For example, have them predict which group they would pick for the strongest material or for an insulating material.

Bloom's Levels: Analyze

Webb's DOK: 1

Engaging Scenario

Engaging Scenario:
Title: Qualitative Analysis & Chemical Bonding lab
Suggested Length of Time: 2 Class Periods
Detailed Description/Instructions: Students will conduct an introductory activity comparing 4 different solids based on their melting point, conductivity, and chemical reactivity. After the introductory activity, students are given unknown solids and must plan and conduct an experiment to determine the type of bonding which occurs in each solid.
Bloom's Levels: Apply
Webb's DOK: 3

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
History of Materials	Examining the Relative Importance of Materials Over Time	Examine with the students the graph of relative importance of materials over time. Assist them with understanding how to read the graph and have them rank the importance of the materials in different years to check for understanding. Have the brainstorm reasons why materials might change in relative importance. If the students do not talk about accessibility (such as fire and refining metal), discovery of a material being unsafe (i.e., asbestos or lead paint), or changes in technology (discovery of synthetic polymers), then try to lead them towards some examples.	20 minutes
Periodic Table	Cracking the Periodic Table Code POGIL Activity	The student will be able to describe the atomic structure of an element and how it relates to the organization of the periodic table.	1 class period
Properties of Materials	Analyze a Comparison Chart of Materials	Students should be given the types of bonding chart. This includes across the top; metallic, covalent, ionic, and intermolecular forces. The rows of the chart include elements involved, givers and/or takers of electrons, description of bond, type of material formed, strength of bond, and properties produced. Students should be asked to draw connections, such as how the properties relate to the type of electron interaction. They should also begin to compare and contrast groups. For example, have them predict which group they would pick for the strongest material or for an insulating material.	25 minutes

Unit 2: Metals

Subject: Materials Science
Grade: 10-12
Name of Unit: Metals
Length of Unit: 3-4 weeks
Overview of Unit: Students will be introduced to the properties of metals and how those properties can be utilized to produce more effective materials. Crystalline structure, alloys, and corrosion are all discussed to underscore the importance of the use of metals in the world of materials science.

Priority Standards for unit:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal.]
- EK 2.C.3 LO 2.20 The student is able to explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity) and the shell model of the atom.
- EK 5.A.2 LO 5.3 The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions.
- EK 2.D.2 LO 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys.
- EK 2.D.4 LO 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance.

Supporting Standards for unit:

- 9-12.ETS1.A.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

- ISTE - COMPUTATIONAL THINKER.5: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Unwrapped Concepts (Students need to know)	Unwrapped Skills (Students need to be able to do)	Bloom's Taxonomy Levels	Webb's DOK
the concepts of bonding and crystalline/molecular structure	Apply	Apply	2
the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers	Explain	Understand	3
how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity) and the shell model of the atom.	Explain	Understand	2
about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions.	Explain	Understand	1
about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions.	Predict	Apply	1
the electron sea model of metallic bonding	Use	Understand	3
the macroscopic properties of metals or alloys	Predict	Understand	2
a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance	Create	Create	2

Essential Questions:

1. What are the properties of metals and how do they compare to other materials?
2. What is an alloy and how do the component metals influence the properties of the alloy?
3. How are metals affected by corrosion and what happens at the atomic level?
4. Why are metals thermally and electrically conductive?
5. How do the properties of metals vary within the category of metals?

Enduring Understanding/Big Ideas:

1. Metals are unique in that they are shiny, ductile, malleable, conductive, corrode, and can be magnetic. They are also dense, strong, opaque, and melt when heated.
2. An alloy is a mixture of two or more metals which can provide greater strength or corrosion resistance.
3. All metals are affected by corrosion and undergo the process of oxidation-reduction. Oxidation is the loss of electrons and reduction is the gain of electrons. As metals corrode, the loss and gain of electrons causes changes to the material.
4. Metals have metallic bonds which means the electrons move freely in a "sea of electrons." This allows for metals to conduct electricity and thermal energy through the movement of electrons.
5. Metals can be compared to each other by making observations of their range of chemical and physical properties. This can be done through tests such as single replacement reactions.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
	Activity Series Alloy Annealing Bronze Cold-working Corrosion Dislocations Ductile Elastic deformation Face-centered cubic Failure Fatigue Grain Grain boundary Hall process

	Haradening Heat treating Hexagonal-close packed Malleable Metallic bonding Ore Oxide Oxidation Plastic deformation Quenched Reduction Reduction of metals Steel Strength Stress Toughness

Topic 1: Properties

Engaging Experience 1

Title: Metals Stations Lab

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Supporting:

- ISTE - COMPUTATIONAL THINKER.5: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Detailed Description/Instructions: Students perform various experiments on metals to discover different properties inherent to metals. Students conduct the "Cost of a Penny" lab to discover the reactivity of copper and zinc, they conduct the "Rolling a Penny" lab to discover the malleability of metals, they conduct the "Drawing a Wire" lab to discover the ductility of metals, and finally they conduct the "Brassing a Penny" lab to discover physical changes.

Bloom's Levels: Apply

Webb's DOK: 2

Supporting Materials:

Metals Stations Lab

https://drive.google.com/open?id=1ZgWc-niYacD6ciUqimYj3WgyBcxw2L72

Topic 2: Alloys

Engaging Experience 1

Title: Great Copper Article (Reading and Questions)

Suggested Length of Time: 30 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal.]

Supporting:

- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

Detailed Description/Instructions: Students should read "The Copper Advantage: A Guide to Working With Copper and Copper Alloys" pages 1-6 and examine a comparison chart of copper alloys on page 26. If time allows have them read the introductions to each section or the whole guide as an extended assignment. Have students answer questions about the reading in order to engage them further with the material and to examine further the properties of alloys.

Bloom's Levels: Analyze

Webb's DOK: 2

Supporting Material: **https://drive.google.com/open?id=1Eg9xLm4_-NpYUERGf_-M5IQe-HK5TIUC**

Topic 3: Corrosion

Engaging Experience 1

Title: Corrosion Study with Fruit

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- EK 2.D.2 LO 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys.

Supporting:

- ISTE - COMPUTATIONAL THINKER.5: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Detailed Description/Instructions: Students will conduct an experiment using two different metal strips to act as electrodes for a fruit battery. Students will test fruits of varying acidity to see which will produce the highest voltage. Because corrosion reactions are electrochemical in nature, these principles can be demonstrated very simply by measuring voltages. Students will be able to see some basic principles of electrochemistry such as: electric current, the flow of electrons through a conductor, resistance, which is a measure of how difficult it is for electrons to flow through a conductor, and, electrolytes, which are solutions containing ions through which electricity can flow.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Material:

Corrosion Study with Fruit Lab

https://drive.google.com/open?id=1gO0I-3jkAi7AGa3fGBcLJ0nY55rTRHTQ

Topic 4: Conductivity

Engaging Experience 1

Title: Conductivity Lab

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- EK 5.A.2 LO 5.3 The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions.
- EK 2.D.2 LO 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys.
- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal.]

Supporting:

- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

Detailed Description/Instructions: In this lab students will explore the thermal and electrical conductivity of metals. For thermal conductivity 2 metals should be provided, one preferably copper for high conductivity. Students should heat 3 beakers of water that are ⅘ full to their boiling point. Next, 3 beakers at room temperature and ⅘ full should be aligned close to the boiling beakers. The two metals being examined should be bent into a V shape in order to connect a boiling beaker and a room temperature beaker. A thermometer should be added to the room temperature beaker and the temperature should be recorded every 5 minutes for 30 minutes. Students can then compare how well each metal conducted thermal energy. This lab works best if more than one piece of metal is added (keeping the amount of metal equal to the other set of beakers) and if the boiling water remains on a hot pad to keep it boiling.

If time allows have students design a circuit from a battery to a resistor to a piece of the metal being tested and then back to the battery. An altimeter can be used to check the current across each piece of metal to determine which is more conductive and how different they are.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Materials:

https://drive.google.com/open?id=1Eg9xLm4_-NpYUERGf_-M5lQe-HK5TIUC

Topic 5: Comparing Metals

Engaging Experience 1

Title: Metal Density and Property Lab

Suggested Length of Time: 45 minutes

Standards Addressed

Priority:

- EK 2.C.3 LO 2.20 The student is able to explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity) and the shell model of the atom.

Supporting:

- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

Detailed Description/Instructions: In this lab students explore how to identify metals based on density. Students will put various pieces of metal into water filled graduated cylinders and measure the change in volume. They will also need to weigh the cubes on scales to calculate the mass in grams. Lastly, they can calculate the density by dividing mass by volume. They can use a chart of common metal densities to identify the metal. If time allows students can hammer the metals to observe properties such as hardness, brittleness, malleability, and ductility.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Materials:

https://drive.google.com/open?id=1Eg9xLm4_-NpYUERGf_-M5IQe-HK5TIUC

Engaging Scenario

Engaging Scenario
Title: Wire Fire Lab
Suggested Length of Time: 1 hour
Detailed Description/Instructions: In this lab students explore what happens when you heat treat copper, iron, and nitinol wire. They will use pliers to hold samples of each wire over a Bunsen burner flame. They should have beakers of water in order to observe what happens when metal is heated and then quenched, annealed, or tempered. The iron wire can be wound around the pliers to make a spring shape. Students should examine how the "springiness" changes after being quenched, annealed, or tempered. Lastly, Nitinol is a Shape Memory Alloy that when bent and shaped can be heated to a very high temperature (bunsen burner flame) in order to "learn" that shape. Once quenched and stretched out it can then be warmed to a moderate temperature (dipped in beaker of near boiling water) and it will "remember" or return to the memory shape.
Bloom's Levels: Apply
Webb's DOK: 3
Supporting Material:
https://drive.google.com/drive/folders/1Eg9xLm4_-NpYUERGf_-M5IQe-HK5TIUC?usp=sharing

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Properties	Metal Stations Lab	Students perform various experiments on metals to discover different properties inherent to metals. Students conduct the "Cost of a Penny" lab to discover the reactivity of copper and zinc, they conduct the "Rolling a Penny" lab to discover the malleability of metals, they conduct the "Drawing a Wire" lab to discover the ductility of metals, and finally they conduct the "Brassing a Penny" lab to discover physical changes.	1 class period
Alloys	Great Copper Article (Reading and Questions)	Students should read "The Copper Advantage: A Guide to Working With Copper and Copper Alloys" pages 1-6 and examine a comparison chart of copper alloys on page 26. If time allows have them read the introductions to each section or the whole guide as an extended assignment. Have students answer questions about the reading in order to engage them further with the material and to examine further the properties of alloys.	30 minutes
Corrosion	Corrosion Study with Fruit	Students will conduct an experiment using two different metal strips to act as electrodes for a fruit battery. Students will test fruits of varying acidity to see which will produce the highest voltage. Because corrosion reactions are electrochemical in nature, these principles can be demonstrated very simply by measuring voltages. Students will be able to see some basic principles of electrochemistry such as: electric current, the flow of electrons through a conductor, resistance, which is a measure of how difficult it is for electrons to flow through a conductor, and, electrolytes, which	1 class period

		are solutions containing ions through which electricity can flow.	
Conductivity	Conductivity Lab	In this lab students will explore the thermal and electrical conductivity of metals. For thermal conductivity 2 metals should be provided, one preferably copper for high conductivity. Students should heat 3 beakers of water that are ⅘ full to their boiling point. Next, 3 beakers at room temperature and ⅘ full should be aligned close to the boiling beakers. The two metals being examined should be bent into a V shape in order to connect a boiling beaker and a room temperature beaker. A thermometer should be added to the room temperature beaker and the temperature should be recorded every 5 minutes for 30 minutes. Students can then compare how well each metal conducted thermal energy. This lab works best if more than one piece of metal is added (keeping the amount of metal equal to the other set of beakers) and if the boiling water remains on a hot pad to keep it boiling. If time allows have students design a circuit from a battery to a resistor to a piece of the metal being tested and then back to the battery. An altimeter can be used to check the current across each piece of metal to determine which is more conductive and how different they are.	1 class period
Comparing Metals	Metal Density and Property Lab	In this lab students explore how to identify metals based on density. Students will put various pieces of metal into water filled graduated cylinders and measure the change in volume. They will also need to weigh the cubes on scales to calculate the mass in grams. Lastly, they can calculate the density by dividing mass by volume. They can use a chart of common metal densities to identify the metal. If time allows students can hammer the metals to observe properties such as hardness, brittleness, malleability, and ductility.	45 minutes

Unit 3: Polymers

Subject: Materials Science
Grade: 10-12
Name of Unit: Polymers
Length of Unit: 3-4 weeks
Overview of Unit: In this unit students will learn how polymers form and how the microscopic bonds and elements involved contribute to their macroscopic properties. Furthermore, they will learn to categorize polymers based on if they are natural or synthetic, hydrophyllic or hydrophobic, and thermosets or thermoplasts. Lastly, students will explore how polymers, specifically plastics, are sorted and recycled.

Priority Standards for unit:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]
- EK 2.D.3 LO 2.29 The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance.

Supporting Standards for unit:

- 9-12.ETS1.A.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.
- ISTE - KNOWLEDGE COLLECTOR.3: Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.
- ISTE - CREATIVE COMMUNICATOR.6: Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.
- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Unwrapped Concepts (Students need to know)	Unwrapped Skills (Students need to be able to do)	Bloom's Taxonomy Levels	Webb's DOK
the concepts of bonding and crystalline/molecular structure	Apply	Apply	2
the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers	Explain	Understand	3
a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance	Create	Create	3

Essential Questions:

1. What are the properties of polymers and how do they compare to other materials?
2. What are natural polymers and how did synthetic polymers arise?
3. How do we name polymers based on their molecular structure?
4. What are the parts of a polymer and how are they created by polymerization?
5. How are plastics (category of polymers) sorted and recycled?
6. Why are some polymers hydrophilic and some hydrophobic?
7. What are the two main types of plastics and how do they compare?

Enduring Understanding/Big Ideas:

1. Polymers are unique in that they have a low density, poor conductivity, and low melting points. They also exhibit a wide range of properties as they can be transparent or opaque, weak or stough, natural or synthetic, absorbent or non-absorbent, and stretchy or firm.
2. Natural polymers are found in nature and include organic material such as fibers and DNA. Synthetic polymers are man-made and started with Bakelite but is now ubiquitous in modern society.
3. Polymers are named by their carbon chains and side groups with the simplest having only carbon single bonds and no side groups (alkanes) and followed by chains with carbon double bonds (alkenes).
4. Polymers are made of single units called monomers that are joined together by the process of polymerization, most commonly of addition and condensation polymerization.
5. Plastics are identified by their resin identification code which corresponds to a specific polymer that can be sorted by its physical and chemical properties.
6. Based on the molecular structure of a molecule, some polymers are hydrophobic (water-fearing) and will repel water, while others are hydrophilic (water-loving) and will absorb

water. Polymer molecules which are nonpolar are typically hydrophobic and those which are polar are typically hydrophilic.

7. The two main types of plastics are thermosets and thermoplastics. Thermosets are a class of plastics which undergo a chemical change during the curing process and cannot be melted down and recycled (i.e., rubber). Thermoplastics are a class of plastics which can be melted down and recycled (i.e., water bottles).

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Abrasive Absorption Casting	Alkanes Alkenes Hydrophilic Hydrophobic Monomer Nomenclature Polymer Polymerization Resin Thermoset Thermoplastic

Topic 1: Properties

Engaging Experience 1

Title: Poly Density Tubes Lab

Suggested Length of Time: 45 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Supporting:

- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Detailed Description/Instructions: Students analyze a mixture of salt water, rubbing alcohol, polypropylene pellets and PET pellets to distinguish a density pattern among the different materials.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Materials:

Poly Density Tubes lab

https://drive.google.com/open?id=1yWYnLBURusKJYFYWPWpU1XECH2Bujda_

Topic 2: Natural vs Synthetic

Engaging Experience 1

Title: Polymer Poster Project

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- EK 2.D.3 LO 2.29 The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance.

Supporting:

- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.
- ISTE - KNOWLEDGE COLLECTOR.3: Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

Detailed Description/Instructions: In this lesson students should research some examples of natural and synthetic polymers. Next, they should pick 1 from each category and design two posters to advertise their polymer. The poster should include where it comes from or how it is made, the chemical structure and monomer, the various properties, and how much it costs to obtain. Other criteria can be added, and students should include sources on their work. They should also draw or add an image of an object the polymer is used to make. Posters should then be hung around the room or presented to the class for others to learn from.

Bloom's Levels: Create

Webb's DOK: 4

Topic 3: Naming Polymers

Engaging Experience 1

Title: Alkanes vs Alkenes Video

Suggested Length of Time: 6 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Detailed Description/Instructions: Watch a video describing the differences to naming alkane hydrocarbons versus alkene hydrocarbons.

Bloom's Levels: Remember

Webb's DOK: 1

Supporting Materials:

https://www.youtube.com/watch?v=Sfm3eHe57PU

Topic 4: Polymerization

Engaging Experience 1

Title: Slime/Gak Lab

Suggested Length of Time: 45 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Supporting:

- TT.AB.D.6: Students will express comfort with people who are both similar to a and different from them and engage respectfully with all people.

Detailed Description/Instructions: Students will combine a 4% Borax solution with a specified amount of Elmer's glue to create a polymer known as Gak. The resulting chemical reaction is a polymerization reaction.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Materials:

Slime/Gak Lab

https://drive.google.com/open?id=1sghaQeo92vhPvSDcrrO9C1clTX7sqmDf

Topic 5: Recycling Codes

Engaging Experience 1

Title: Sorting Plastics Lab

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Detailed Description/Instructions: Students will be provided with a sample (1cm x 1cm square) from each category of recycling code (1-7). They will have to make 4 beakers with different densities.

1. 100 mL 70% isopropyl alcohol/40 mL water 0.91 g/mL
2. 80 mL 70% isopropyl alcohol/40 mL water 0.93 g/mL
3. 150 mL water 1.00 g/mL
4. 75 g (3 Tbsp) sugar/150 mL water 1.14 g/ml

Students will then place each square in each beaker, one at a time, while recording whether the piece sinks or floats. Lastly, they should be given an unknown sample to test and determine which recycling code it is based on observations of density and appearance. The post-lab questions should ask students how this process might be applied to a factory setting to sort plastics quickly.

Bloom's Levels: Create

Webb's DOK: 2

Supporting Materials:

https://drive.google.com/open?id=1xR8erKZRhMcPKmLQSYS8chPVzzO8FOvL

Topic 6: Hydrophilic vs Hydrophobic

Engaging Experience 1

Title: Hydrophilic and Hydrophobic Polymers Lab

Suggested Length of Time: 40 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Supporting:

- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.

Detailed Description/Instructions: In this lab students will use HDPE (a hydrophobic polymer) powder and Sodium Polyacrylate (hydrophilic polymer) to observe their interactions with water. Students should use the base of a cup to make 2 circles on a paper towel then place a tablespoon of the powder in each circle. Students can this use a pipette and count how many drops it takes for the water to move from the powder in the center of the towel to the ring on the outside. The hydrophilic polymer will take a significantly larger amount of water to reach the outside of the ring.

Bloom's Levels: Apply

Webb's DOK: 1

https://drive.google.com/drive/folders/15ZwnIDuaOH8mxw_PG97n3YUbmQetdN42?usp=sharing

Topic 7: Thermoset vs Thermoplastic

Engaging Experience 1

Title: Polymer Nobel Prize Reading

Suggested Length of Time: 25 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Detailed Description/Instructions: In this lesson students should read the Nobel Prize article on plastics. Students should take notes or answer prepared questions regarding the article. Topics covered in the article include plastics processing, polymerization, thermosets and thermoplastics, as well as the work of Karl Ziegler, a chemist who won the Nobel Prize for his work in polymers. Students should take the time to create a Venn diagram on the various properties of thermosets and thermoplastics.

Bloom's Levels: Understand

Webb's DOK: 2

Supporting Material: https://www.nobelprize.org/educational/chemistry/plastics/readmore.html

Engaging Scenario

Engaging Scenario

Title: Recycling Project

Suggested Length of Time: 2-3 class periods

Detailed Description/Instructions: Students will create a project, on poster board, to display the 7 different types of plastics as identified by their recycling codes. Students will include information about each type of plastic, including recycling symbol, full name, abbreviation, picture of the monomer that makes up the polymer, uses, properties which make it advantageous for its use, and an example of each type of plastic. Plastics should be identified further by previously discussed categories such as thermoset or thermoplastic, hydrophylic or hydrophobic, and natural or synthetic. Students then present their projects in a project gallery walk.

Bloom's Levels: Create

Webb's DOK: 1

Supporting Materials:

Recycling Project

https://drive.google.com/open?id=1_JD7ZjUe3Oi4HvLpGshWMGP4NUJWPtF8

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Properties	Poly Density Tubes Lab	Students analyze a mixture of salt water, rubbing alcohol, polypropylene pellets and PET pellets to distinguish a density pattern among the different materials.	45 minutes
Natural vs. Synthetic	Polymer Poster Project	In this lesson students should research some examples of natural and synthetic polymers. Next, they should pick 1 from each category and design two posters to advertise their polymer. The poster should include where it comes from or how it is made, the chemical structure and monomer, the various properties, and how much it costs to obtain. Other criteria can be added, and students should include sources on their work. They should also draw or add an image of an object the polymer is used to make. Posters should then be hung around the room or presented to the class for others to learn from.	1 class period
Naming Polymers	Alkanes vs Alkenes Video	Watch a video describing the differences to naming alkane hydrocarbons versus alkene hydrocarbons.	6 minutes
Polymerization	Slime/Gak Lab	Students will combine a 4% Borax solution with a specified amount of Elmer's glue to create a polymer known as Gak. The resulting chemical reaction is a polymerization reaction.	45 minutes
Recycling Codes	Sorting Plastics Lab	Students will be provided with a sample (1cm x 1cm square) from each category of recycling code (1-7). They will have to make 4 beakers with different densities.	1 class period

		100 mL 70% isopropyl alcohol/40 mL water 0.91 g/mL 80 mL 70% isopropyl alcohol/40 mL water 0.93 g/mL 150 mL water 1.00 g/mL 75 g (3 Tbsp) sugar/150 mL water 1.14 g/ml Students will then place each square in each beaker, one at a time, while recording whether the piece sinks or floats. Lastly, they should be given an unknown sample to test and determine which recycling code it is based on observations of density and appearance. The post-lab questions should ask students how this process might be applied to a factory setting to sort plastics quickly.	
Hydrophilic vs. Hydrophobic	Hydrophilic and Hydrophobic Polymers Lab	In this lab students will use HDPE (a hydrophobic polymer) powder and Sodium Polyacrylate (hydrophilic polymer) to observe their interactions with water. Students should use the base of a cup to make 2 circles on a paper towel then place a tablespoon of the powder in each circle. Students can this use a pipette and count how many drops it takes for the water to move from the powder in the center of the towel to the ring on the outside. The hydrophilic polymer will take a significantly larger amount of water to reach the outside of the ring.	40 minutes
Thermoset vs. Thermoplastic	Polymer Nobel Prize Reading	In this lesson students should read the Nobel Prize article on plastics. Students should take notes or answer prepared questions regarding the article. Topics covered in the article include plastics processing, polymerization, thermosets and thermoplastics, as well as the work of Karl Ziegler, a chemist who won the Nobel Prize for his work in polymers. Students should take the time to create a Venn diagram on the various properties of thermosets and thermoplastics.	25 minutes

Unit 4: Ceramics/Glass

Subject: Materials Science
Grade: 10-12
Name of Unit: Ceramics/Glass
Length of Unit: 3-4 weeks
Overview of Unit: In this unit, students will learn about the properties, similarities and differences, and uses of ceramics and glass. Emphasis will be placed on how their properties are important to their functionality in certain applications, i.e., using fire bricks in a fireplace because of their ability to absorb large amounts of heat. Additionally, the historical uses of ceramics and glass will be compared to the uses of newer, advanced ceramic materials.

Priority Standards for unit:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Supporting Standards for unit:

- 9-12.ETS1.A.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.
- ISTE - COMPUTATIONAL THINKER.5: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

Unwrapped Concepts (Students need to know)	Unwrapped Skills (Students need to be able to do)	Bloom's Taxonomy Levels	Webb's DOK
the concepts of bonding and crystalline/molecular structure	Apply	Apply	2
the macroscopic properties of various categories of structural	Explain	Understand	3

materials, i.e. metals, ionic (ceramics), and polymers			

Essential Questions:

1. How do the properties of ceramics differ from other materials?
2. How are ceramic materials used in terms of traditional versus advanced?
3. How are ceramics different than glass?
4. Why does thermal shock affect different types of glass differently?

Enduring Understanding/Big Ideas:

1. Ceramic materials typically are poor conductors, have low density, high melting points, are brittle, and have traditionally been used in bricks, pottery, and china. More recent advances in technology have led to advanced ceramic materials, including use in automobile engine parts, space shuttle tiles, superconductors, and piezoelectric materials.
2. Ceramics are typically bonded ionically and have a crystalline structure. Glass materials typically have an amorphous structure.
3. Thermal shock depends on the thermal conductivity and the coefficient of thermal expansion of a material. Based on the properties of glass and how it is manufactured, different levels of thermal shock are achieved.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
	Abrasive Absorption Amorphous Ceramic Crystalline Electronegativity Firing Glass Hardness Opaque Slip Strain Stress Thermal expansion Toughness

Topic 1: Properties of Ceramics

Engaging Experience 1

Title: Ceramic Rod vs Aluminum Rod Demo

Suggested Length of Time: 20 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Detailed Description/Instructions: Teacher leads a demonstration of the properties of heat conductivity and brittleness of ceramics as compared to metal. A ceramic rod is compared to an aluminum rod through which each rod is dotted with dried wax. A propane torch flame is administered to the end of each rod. Time is kept to see which rod's wax will melt first. The aluminum rod's wax melts first, thus showing the better insulating (non-conducting) properties of ceramics. In addition, weights are suspended from both rods (after they have cooled). The ceramic rod will hold less weight before breaking due to its low tensile-strength capacity.

Bloom's Levels: Understand

Webb's DOK: 2

Topic 2: Traditional v Advanced

Engaging Experience 1

Title: Glass Theory Articles

Suggested Length of Time: 30 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers

Detailed Description/Instructions: Students read the glass theory articles and journal their reactions to the readings.

Bloom's Levels: Understand

Webb's DOK: 2

Supporting Materials:

Glass Theory Articles

https://drive.google.com/open?id=1P9MLdltmWqcLuUkR8zyStHFohruRTDV9

Topic 3: Ceramics vs Glass

Engaging Experience 1

Title: Refraction Lab

Suggested Length of Time: 1 class period

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Supporting:

- ISTE - COMPUTATIONAL THINKER.5: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

Detailed Description/Instructions: In this lab students explore some properties that are unique to glass due to its transparent and amorphous properties. Although glass is a ceramic, its unique properties allow light to pass through and reflect, refract, or defract. Students start this lab with the Phet Simulation software, exploring different ways light can pass through glass. After they explore the index of refraction of various materials students can use a laser pointer to perform the simulation at their lab tables. Students should use graph paper in order to measure the angles at which the light bends. Hollow, clear, prisms can be filled with various fluids to measure different angles and indices of refraction.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Material:

https://drive.google.com/drive/folders/16hyz0FhUwoJn_gqh2yQRCpxLEDSlBr3S?usp=sharing

Topic 4: Thermal Shock

Engaging Experience 1

Title: Thermal Shock Demo

Suggested Length of Time: 30 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Detailed Description/Instructions: Teacher leads a demonstration of the thermal shock capabilities of different types of glass. Soda lime glass, borosilicate glass, and fused silica glass are compared. Each glass rod is heated with a propane torch and submerged into a beaker of cold water. Resulting shatter patterns are observed to determine the level of thermal shock. More occurrence of shattering indicates a higher level of thermal shock experienced by the glass. Typically, soda lime glass will be the least resistant to thermal shock, whereas fused silica glass will show the most resistance to thermal shock.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Scenario

Engaging Scenario
Title: Raku Project
Suggested Length of Time: 2-3 Class Periods
Detailed Description/Instructions: Students will create a Raku project from stoneware clay. Raku pottery uses stoneware clay due to the extremely high temperatures used in the firing process. Students mold the clay into a desired shape. The clay is left to dry out in the fume hood over the course of several days. Students measure the mass of their project each day, noting differences due to the evaporation of water. When the mass has stabilized, the pieces are bisquefired for several hours. The pieces are left to cool, after which time, students will use glaze to detail their piece. Once the glaze has dried, the pieces go back into the kiln for the glaze-firing process. The pieces are taken out of the kiln while still hot, put into a coffee can with organic material (i.e., straw, sawdust, shredded paper, horsehair, etc.). After a few minutes, the piece is then submerged in a quench can. An oxidation-reduction reaction happens, which varies each time to produce interesting glazing patterns.
Bloom's Levels: Apply
Webb's DOK: 3
Supporting Materials:
Raku Project
https://drive.google.com/open?id=1EJcnrf70T9XjfzIEX0zIe7QoHJpISEZV

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Properties of Ceramics	Ceramic Rod vs Aluminum Rod Demo	Teacher leads a demonstration of the properties of heat conductivity and brittleness of ceramics as compared to metal. A ceramic rod is compared to an aluminum rod through which each rod is dotted with dried wax. A propane torch flame is administered to the end of each rod. Time is kept to see which rod's wax will melt first. The aluminum rod's wax melts first, thus showing the better insulating (non-conducting) properties of ceramics. In addition, weights are suspended from both rods (after they have cooled). The ceramic rod will hold less weight before breaking due to its low tensile-strength capacity.	20 minutes
Traditional vs. Advanced	Glass Theory Articles	Students read the glass theory articles and journal their reactions to the readings.	30 minutes
Ceramics vs. Glass	Refraction Lab	In this lab students explore some properties that are unique to glass due to its transparent and amorphous properties. Although glass is a ceramic, its unique properties allow light to pass through and reflect, refract, or defract. Students start this lab with a Phet Simulation exploring different ways light can pass through glass. After they explore the index of refraction of various materials students can use a laser pointer to perform the simulation at their lab tables. Students should use graph paper in order to measure the angles at which the light bends. Hollow, clear, prisms can be filled with various fluids to measure different angles and indices of refraction.	1 class period

Thermal Shock	Thermal Shock Demo	Teacher leads a demonstration of the thermal shock capabilities of different types of glass. Soda lime glass, borosilicate glass, and fused silica glass are compared. Each glass rod is heated with a propane torch and submerged into a beaker of cold water. Resulting shatter patterns are observed to determine the level of thermal shock. More occurrence of shattering indicates a higher level of thermal shock experienced by the glass. Typically, soda lime glass will be the least resistant to thermal shock, whereas fused silica glass will show the most resistance to thermal shock.	30 minutes

Unit 5: Composites

Subject: Materials Science
Grade: 10-12
Name of Unit: Composites
Length of Unit: 2-3 weeks
Overview of Unit: In this unit students will learn how materials can be combined together to create a composite material that has unique properties from either material. They will explore the different types of matrices, reinforcement, and advantages/disadvantages based on these different types. Lastly, students will explore how composites have evolved from the first man made composite to the immense variety of composites used today.

Priority Standards for unit:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]
- EK 2.D.4 LO 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance.

Supporting Standards for unit:

- 9-12.ETS1.A.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- 9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- EK 2.D.4 LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.
- ISTE - KNOWLEDGE COLLECTOR.3: Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.
- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Unwrapped Concepts (Students need to know)	Unwrapped Skills (Students need to be able to do)	Bloom's Taxonomy Levels	Webb's DOK
the concepts of bonding and crystalline/molecular structure	Apply	Apply	2
the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers	Explain	Understand	3
a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance	Create	Create	3

Essential Questions:

1. How is a composite different from other materials?
2. How does adding different reinforcing materials to a composite affect its properties?
3. How are different matrices utilized in composite materials?
4. Why can the use of composite materials be advantageous over non-composite materials?
5. How have composites been utilized throughout history?

Enduring Understanding/Big Ideas:

1. A composite material is made from two or more distinct materials and exhibits superior properties to the individual materials making up the composite. A composite material is generally composed of a matrix (binder) and a reinforcing material.
2. The addition of different reinforcing materials can improve the strength and stiffness, thermal expansion, and electrical/thermal conductivity of the material.
3. Different matrices are utilized in composites to produce materials with different properties. Three main types are metal matrix composites, ceramic matrix composites, polymer matrix composites.
4. The use of composite materials can be advantageous by reducing the weight of a material, increasing mechanical & chemical strength, reducing the amount of required maintenance, increasing freedom of design and reducing cost.
5. Composite materials have been used for thousands of years, including cementitious materials and bamboo used in the Great Wall of China and adobe brick used in building. The Egyptians, Mesopotamians, and Greeks knew how to make concrete, but the Romans used it extensively. Composite materials are used in many facets of society today and their development has been in the forefront of scientific research for many years.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
	Advanced composites Composite Composite material Continuous filament Crack Cure Epoxy plastic Fiber Hardener Interface Laminar Matrix Modulus Mold Resin Shear strain Shear strength

Topic 1: Properties of Composites

Engaging Experience 1

Title: Intro to Composites Video

Suggested Length of Time: 5 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Detailed Description/Instructions: Students will watch a video over the introduction of composites and be prepared to discuss the various properties of composites and they differ depending on the types of materials utilized in the composite.

Bloom's Levels: Remember

Webb's DOK: 1

Supporting Materials:

Intro to Composites

https://www.youtube.com/watch?v=WYqCnEvTRUQ

Topic 2: Types of Reinforcement

Engaging Experience 1

Title: Composite Beam Project

Suggested Length of Time: 2 class periods

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Supporting:

- TT.AB.D.6: Students will express comfort with people who are both similar to and different from them and engage respectfully with all people.

Detailed Description/Instructions: Students will construct beams with a cement matrix and differing reinforcing materials, such as iron wire, fabric, and gravel. Each cement bar with reinforcing material will be measured to see how much weight it can support before fatiguing.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Materials:

Concrete Beam Project

https://drive.google.com/open?id=1rAY1q4_YHcn-BWhr7IcbsO7qX0fLhsuz

Topic 3: Types of Matrices

Engaging Experience 1

Title: Composite Matrix Materials Article

Suggested Length of Time: 25 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.

Detailed Description/Instructions: Students will read, take notes, and discuss with a partner, the various types of matrices used in composite materials.

Bloom's Levels: Understand

Webb's DOK: 2

Supporting materials:

Composite Matrix Materials Article

https://drive.google.com/open?id=1dtgCORWhG81I9o4dL6G_i2N6hINWMGSU

Topic 4: Advantages/Disadvantages

Engaging Experience 1

Title: NASA Composites Video

Suggested Length of Time: 35 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Detailed Description/Instructions: In this activity students will watch the NASA 360 - Composite Material video. While watching the video they should take notes on what the composite are being used for, why NASA chooses composites for these components (advantages), as well as what some of the challenges (disadvantages) are by using composites. After students have watched the video and written examples in their notebooks, they should discuss in small groups what they have learned. A student from each group should be called on to share one composite and its advantages and disadvantages that their group talked about.

Bloom's Levels: Analyze

Webb's DOK: 2

Supporting Material:

https://www.youtube.com/watch?v=tZhH2B-EI1I&t=1s

Topic 5: History

Engaging Experience 1

Title: Composites Poster Activity

Suggested Length of Time: 40 minutes

Standards Addressed

Priority:

- 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]

Supporting:

- ISTE - KNOWLEDGE COLLECTOR.3: Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

Detailed Description/Instructions: Students should start this activity by watching the Primitive Technology video about straw-mud bricks, the first composite material. After they finish, they should research a composite that was around during the turn of the 20th century and a composite that is used during the 21st century. Students on their poster should have a composite on each side and discuss the components of the composite, how it is reinforced, what is used for, what properties is has, and how it is manufactured. Students should be sure to include sources and the posters can be hung around the room and/or presented to the class.

Bloom's Levels: Create

Webb's DOK: 3

Supporting Material:

https://www.youtube.com/watch?v=D59v74k5flU

Engaging Scenario

Engaging Scenario

Title: Heat and Strength Composites Lab

Suggested Length of Time: 2-3 Class Periods

Detailed Description/Instructions: In this lab students first explore composites used in space shuttles and their insulating properties. Students are then challenged to use the materials they have worked with over the entire course to design a "space capsule" for an egg. They must pass two tests, first the egg must be dropped from a height over 10 feet and survive. Second, the capsules are filled with boiling water and the temperature is measured over 30 minutes to determine how well it insulates the egg for reentry into the atmosphere. The challenges can be altered to require students to think about the best material to use to meet the challenge. The students must follow the engineering design process by doing the research, creating the blueprint, building the prototype, testing the prototype, and then writing a conclusion about the success of the tests and what they would do differently if given another chance.

Bloom's Levels: Apply

Webb's DOK: 3

Supporting Materials:

https://docs.google.com/document/d/1RymNQ-94d_X-9cVbu8Zyp-qN8ZXnbCn7BbZsQB497T4/edit?usp=sharing

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Properties vs. Composites	Intro to Composites Video	Students will watch a video over the introduction of composites and be prepared to discuss the various properties of composites and they differ depending on the types of materials utilized in the composite.	5 minutes
Types of Reinforcement	Composite Beam Project	Students will construct beams with a cement matrix and differing reinforcing materials, such as iron wire, fabric, and gravel. Each cement bar with reinforcing material will be measured to see how much weight it can support before fatiguing.	2 class periods
Types of Matrices	Composite Matrix Materials Article	Students will read, take notes, and discuss with a partner, the various types of matrices used in composite materials.	25 minutes
Advantages/ Disadvantages	NASA Composites Video	In this activity students will watch the NASA 360 - Composite Material video. While watching the video they should take notes on what the composite are being used for, why NASA chooses composites for these components (advantages), as well as what some of the challenges (disadvantages) are by using composites. After students have watched the video and written examples in their notebooks, they should discuss in small groups what they have learned. A student from each group should be called on to share one composite and its advantages and disadvantages that their group talked about.	35 minutes

History	Composites Poster Activity	Students should start this activity by watching the Primitive Technology video about straw-mud bricks, the first composite material. After they finish, they should research a composite that was around during the turn of the 20th century and a composite that is used during the 21st century. Students on their poster should have a composite on each side and discuss the components of the composite, how it is reinforced, what is used for, what properties is has, and how it is manufactured. Students should be sure to include sources and the posters can be hung around the room and/or presented to the class.	40 minutes

Unit of Study Terminology

Appendices: All Appendices and supporting material can be found in this course's shell course in the District's Learning Management System.

Assessment Leveling Guide: A tool to use when writing assessments in order to maintain the appropriate level of rigor that matches the standard.

Big Ideas/Enduring Understandings: Foundational understandings teachers want students to be able to discover and state in their own words by the end of the unit of study. These are answers to the essential questions.

Engaging Experience: Each topic is broken into a list of engaging experiences for students. These experiences are aligned to priority and supporting standards, thus stating what students should be able to do. An example of an engaging experience is provided in the description, but a teacher has the autonomy to substitute one of their own that aligns to the level of rigor stated in the standards.

Engaging Scenario: This is a culminating activity in which students are given a role, situation, challenge, audience, and a product or performance is specified. Each unit contains an example of an engaging scenario, but a teacher has the ability to substitute with the same intent in mind.

Essential Questions: Engaging, open-ended questions that teachers can use to engage students in the learning.

Priority Standards: What every student should know and be able to do. These were chosen because of their necessity for success in the next course, the state assessment, and life.

Supporting Standards: Additional standards that support the learning within the unit.

Topic: These are the main teaching points for the unit. Units can have anywhere from one topic to many, depending on the depth of the unit.

Unit of Study: Series of learning experiences/related assessments based on designated priority standards and related supporting standards.

Unit Vocabulary: Words students will encounter within the unit that are essential to understanding. Academic Cross-Curricular words (also called Tier 2 words) are those that can be found in multiple content areas, not just this one. Content/Domain Specific vocabulary words are those found specifically within the content.