



Park Hill School District

Building Successful Futures • Each Student • Every Day

High School Materials Science & Engineering Curriculum

Course Description: In this hands-on Materials Science course students investigate real materials through labs and demos, using data to explain why specific materials are chosen for everyday and engineering applications. The course emphasizes safe laboratory habits, clear technical communication, and evidence-based decision-making with authentic design challenges. By the end, students can classify materials, relate microscopic structure to macroscopic behavior, and evaluate trade-offs to justify material choices in real-world contexts.

Standards: National Resource Center for Materials Technology Education - Core Competencies

Scope and Sequence:

Timeframe	Unit	Instructional Topics
10 Blocks	Unit 1: Introduction	Safety; Characteristics & Properties; History
25 Blocks	Unit 2: Metals	Characteristics & Properties; Ferrous & Non-Ferrous Metals; Strength & Workability; Conductivity; Corrosion
20 Blocks	Unit 3: Polymers	Characteristics & Properties; Natural & Synthetic; Polymerization; Recycling; Thermoset vs. Thermoplastic
10 Blocks	Unit 4: Ceramics	Characteristics & Properties; Glass; Thermal Shock
15 Blocks	Unit 5: Composites	Characteristics & Properties; Types of Reinforcements & Matrices; Applications of Composites

Curriculum Revision Tracking

Fall 2025

- Curriculum Rewritten
- ISTE & Teaching Tolerance standards removed where relevant
- Added National Resource Center for Materials Technology Education standards where relevant
- Added Learning Targets

Spring 2018

- Curriculum Revised

Unit 1: Introduction to Materials Science

Subject: Materials Science

Grade: 9-12

Name of Unit: Introduction to Materials Science

Length of Unit: 10 Blocks

Overview of Unit: In this unit, students build a foundation for studying materials science by practicing safe laboratory habits, exploring the properties of different materials, and understanding how material structure affects performance. They investigate how scientists and engineers classify and test materials, and consider the trade-offs that guide real-world design decisions. By examining the history of materials, students see how advances in materials have shaped human progress and continue to impact everyday life.

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).
- 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.
- MTE.0.C.c1 - Demonstrate good workplace safety methods
- MTE.1.C.c1 - Demonstrate familiarity with good laboratory practice

Supporting Standards for unit:

- MTE.5.A.a2 - Apply safely the information available in Material Safety Data Sheets

Essential Questions:

1. Why is safety essential in a materials science lab, and how can we practice it every day?
2. How do the properties of materials help us make sense of the world around us?
3. How has the development of materials shaped human history and everyday life?

Enduring Understanding/Big Ideas:

1. Safe practices protect both people and materials, and following consistent safety routines builds responsibility and reliability in science and engineering work.
2. Understanding material properties helps us explain how everyday objects work and why different materials are used to solve different kinds of problems.
3. Advances in materials, from stone and bronze to steel and polymers, have driven human progress and continue to influence society, culture, and innovation.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Chemical Property Density Physical Property	Ceramic Composite Dilatant Metal Mineral Native Metal Ore Polymer Smelting Thixotropic Viscosity

Unwrapped Priority Standards:

Priority Standard: 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).	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can identify simple properties of metals, ceramics, polymers, and composites by observing how they look, feel, or perform.	1
	Remember
I can explain, in simple terms, how the atomic structure of materials leads to everyday properties like hardness, flexibility, or conductivity.	2
	Apply

Priority Standard: 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.

Learning Targets	Webb's DOK Level
	Bloom's Level
I can research how a material was developed and explain what problem it solved in its time.	2
	Understand
I can identify the trade-offs (such as cost, safety, reliability, or social impact) involved in using a material throughout history.	3
	Evaluate
I can evaluate how a material changed society and explain why it was chosen over alternatives.	3
	Evaluate

Priority Standard: MTE.0.C.c1 - Demonstrate good workplace safety methods

Learning Targets	Webb's DOK Level
	Bloom's Level
I can follow and explain basic safety rules in the lab and classroom.	1
	Remember
I can demonstrate safe practices when handling tools, materials, and lab activities.	2
	Apply

Priority Standard: MTE.1.C.c1 - Demonstrate familiarity with good laboratory practice	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can set up, use, and clean lab equipment safely and correctly.	2
	Apply
I can explain why following lab procedures and documenting results are important for good science and engineering practice.	2
	Apply

Engaging Scenario

Engaging Scenario

Title: Glider Challenge

Length of Time: 1 Block

Description/Instructions: In this engineering design challenge, students apply their understanding of material properties to design, build, and test a glider made from limited resources: paper, aluminum foil, and straws. Students begin by analyzing the properties of the materials provided, categorizing them as metals, polymers, or composites, and predicting how those properties might influence the flight of their glider. Individually, they sketch an initial design and then collaborate in groups to develop a collective prototype. Students conduct multiple test flights, recording data on distance and flight stability. An extension challenge requires the glider to carry a "paper clip passenger," reinforcing the importance of balancing strength and weight. Following testing, students reflect on their design's success, discuss trade-offs made during construction, and propose improvements, including new materials or design modifications.

Bloom's Levels: Analyze

Webb's DOK: 3

Topic 1: Safety

Engaging Experience 1

Title: Noodle Tower

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.0.C.c1 - Demonstrate good workplace safety methods

MTE.1.C.c1 - Demonstrate familiarity with good laboratory practice

Detailed Description/Instructions: Students will design and build a pasta noodle tower capable of supporting a large marshmallow, working within constraints on tape and total pasta weight, and choosing from a variety of pasta types.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 2

Title: Safety Activity

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.0.C.c1 - Demonstrate good workplace safety methods

MTE.1.C.c1 - Demonstrate familiarity with good laboratory practice

Supporting: MTE.5.A.a2 - Apply safely the information available in Material Safety Data Sheets

Detailed Description/Instructions: Students will first read the student safety contract. Each student will then select what they consider the most important rules (one rule per student). Next, students will work in table groups to reach a consensus on the top rules. Groups can then compare their selections with another group, and eventually, the entire class will agree on the most important rules. Each student will be assigned one rule and create a notecard summarizing key information about it. Finally, the notecards will be displayed together to form a class safety poster.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 3

Title: Non-Newtonian Fluid

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.0.C.c1 - Demonstrate good workplace safety methods

MTE.1.C.c1 - Demonstrate familiarity with good laboratory practice

Detailed Description/Instructions: Students will make Oobleck, a non newtonian fluid, and look at the different properties it processes while following classroom safety procedures.

Bloom's Levels: Apply

Webb's DOK: 2

Topic 2: Characteristics & Properties

Engaging Experience 1

Title: Introduction & Scavenger Hunt

Suggested Length of Time: 1 Block

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 begin with a box of assorted materials and first sort them in any way they choose. Next, they will re-sort the same items into the four major categories: metals, polymers, ceramics, and composites. After reviewing the correct classifications, students will make observations about the properties they notice in each category. To extend learning, students will complete a school-wide scavenger hunt to identify real-world examples of these material categories in their everyday environment.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 2

Title: Candy Properties & Observations

Suggested Length of Time: 1 Block

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 be given different types of candy and asked to make observations, including how each candy breaks when stress is applied. Afterward, they will be introduced to key physical property vocabulary. Students will then revisit their candy tests and apply this new terminology to describe their observations, practicing how to use scientific language accurately.

Bloom's Levels: Apply

Webb's DOK: 2

Topic 3: History

Engaging Experience 1

Title: Article Socratic Seminar

Suggested Length of Time: 1 Block

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 read the *Materials that Changed History* article and write short reaction statements about the significance of each material. Afterward, they will identify which material they believe is the most important and which is the least important. The activity will conclude with a class discussion or Socratic seminar on the different material types and their impact throughout history.

Bloom's Levels: Evaluate

Webb's DOK: 3

Engaging Experience 2

Title: History Timeline

Suggested Length of Time: 1 Block

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 work in small groups with a stack of laminated pictures showing materials used throughout history. Each group will arrange the materials in chronological order, from oldest to newest (2–4 groups works best). Groups will then compare their sequences with one another before reviewing the correct timeline. Throughout the activity, students record observations about material development. Next, the class will examine a materials graph, and each student will choose a year to focus on for further observations and research. As an extension, students can create posters about their selected year and participate in a gallery walk to share their findings.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Experience 3

Title: Copper Mining Lab

Suggested Length of Time: 1 Block

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 extract copper from the mineral azurite and plate it onto a nail, modeling the processes of mining and purification. The activity connects to the historical importance of copper in the Copper Age and highlights environmental considerations of mining.

Bloom's Levels: Evaluate

Webb's DOK: 3

Engaging Experience 4

Title: Superhero Project

Suggested Length of Time: 2-3 Blocks

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: Assign each group a historical timeframe, such as the Bronze Age, to research the key materials and technologies of that era. Students then design a superhero whose powers are based on the materials of their assigned period and create a poster showcasing their character. In a gallery walk, students take notes on each era's materials and superheroes, then debate or vote on which superhero would triumph over the others.

Bloom's Levels: Evaluate

Webb's DOK: 3

Summary of Engaging Learning Experiences for Topics			
Topic	Engaging Experience Title	Description	Suggested Length of Time
Safety	Noodle Tower	Students will design and build a pasta noodle tower capable of supporting a large marshmallow, working within constraints on tape and total pasta weight, and choosing from a variety of pasta types.	1 block
	Safety Activity	Students collaboratively identify and illustrate key lab safety rules by selecting, discussing, and prioritizing them in groups, then creating notecards that are compiled into a class poster.	1 block
	Non-Newtonian Fluid	Students will make Oobleck, a non newtonian fluid, and look at the different properties it processes while following classroom safety procedures.	1 block
Characteristics & Properties	Introduction & Scavenger Hunt	Students sort assorted materials into metals, polymers, ceramics, and composites, then identify real-world examples of each.	1 block
	Candy Properties & Observation	Students test different candies to observe how they break, then use new vocabulary to describe their results using scientific language.	1 block
History	Article Socratic Seminar	Students analyze the <i>Materials that Changed History</i> article, rank the most and least impactful materials, and discuss their influence in a class Socratic seminar.	1 block
	History Timeline	Students work in groups to arrange materials from different eras in chronological order, analyze patterns in material development, and research one historical period to present in a gallery walk.	1 block
	Copper Mining Lab	Students extract copper from the mineral azurite and plate it onto a nail, modeling the processes of mining and purification.	1 block
	Superhero Project	Students research the materials and technologies of a historical era, design a superhero whose powers reflect those materials, and present their character in a gallery walk and class debate.	2-3 blocks

Unit 2: Metals

Subject: Materials Science & Engineering

Grade: 9-12

Name of Unit: Metals

Length of Unit: 25 blocks

Overview of Unit: In this unit, students explore how the microscopic structure of metals explains their macroscopic properties such as strength, conductivity, and thermal behavior. Through hands-on labs like casting, heat treating, and electroplating, they test how processing changes performance and why different metals are chosen for everyday applications. By connecting structure, processing, and properties, students build a practical understanding of metals' role in engineering and daily life.

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).
- MTE.7.A.a1 - Recognize the general nature and available types of non-ferrous metals
- MTE.7.A.a2 - Describe the general nature of ferrous metals
- MTE.7.I.i5 - Identify methods used to vary the strength and toughness of materials
- MTE.6.B.b1 - Apply concepts of heat, including temperature, thermal conductivity, specific heat, etc.
- MTE.17.A.a1 - Explain methods for finishing material for appearance and corrosion resistance
- MTE.6.C.c2 - Explain the electrical properties of conductors, insulators and semiconductors

Supporting Standards for unit:

- MTE.7.I.i1 - Compare mechanical properties of different classes of materials
- MTE.9.A.a1 - Describe the primary constituents of steel
- MTE.7.I.i3 - Explain property variations caused by annealing, heat treatment and deformation
- MTE.5.B.b9 - Demonstrate knowledge of corrosion potential, chemical batteries and galvanic series
- MTE.7.J.j2 - Describe how the grain structure of a material can affect properties
- MTE.9.A.a2 - Explain the influence of carbon content on the properties of steel
- MTE.8.B.b8 - Perform fatigue testing on materials
- MTE.6.C.c3 - Apply concepts of magnetism and its role in motors and other phenomena
- MTE.9.A.a5 - Describe quenching and tempering processes for steels

Essential Questions:

1. How does the microscopic structure of metals explain their everyday properties and uses?
2. Why are different types of metals (ferrous and non-ferrous) chosen for different applications?
3. In what ways can humans process or treat metals to change their strength, toughness, or durability?
4. How does the way metals conduct heat and electricity influence the technologies we use every day?
5. What factors cause metals to corrode, and how can we prevent or slow this process?

Enduring Understanding/Big Ideas:

1. The bonding and crystalline structure of metals determine their observable properties such as conductivity, strength, and malleability.
2. Metals can be classified as ferrous or non-ferrous, and each category has unique characteristics that influence their applications.
3. Processes like heat treatment, finishing, and alloying can significantly alter the strength, toughness, and durability of metals.
4. Metals' ability to conduct heat and electricity makes them essential in applications from cookware to electronics, and their effectiveness depends on their structure and composition.
5. Metals naturally corrode when exposed to environmental factors like oxygen and moisture, but engineers use protective coatings, alloys, and treatments to extend their useful life.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Elastic Plastic Metallic Bonding Sea of Electrons	Activity Series Alloy Annealing Brass Corrosion Dislocations Electrical Conductivity Failure Fatigue Ferrous Heat Treating Luster Magnetism Non Ferrous Quenching Strain Strength Stress Tempering Thermal Conductivity Toughness Workable

Unwrapped Priority Standards:

Priority Standard: 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).

Learning Targets	Webb's DOK Level
	Bloom's Level
I can explain how metals have delocalized electrons and describe how this electron structure affects their properties, such as conductivity, malleability, and luster.	2
	Apply
I can explain that the crystal structure of a metal influences its properties (e.g., malleability, conductivity, strength).	2
	Apply
I can connect the microscopic structure of a material to its everyday uses (e.g., why copper is used in wiring or steel in bridges).	3
	Analyze

Priority Standard: MTE.7.A.a1 - Recognize the general nature and available types of non-ferrous metals

Learning Targets	Webb's DOK Level
	Bloom's Level
I can identify common non-ferrous metals (e.g., aluminum, copper, titanium) and describe their general properties.	1
	Remember
I can explain how the properties of non-ferrous metals make them useful in specific products.	2
	Understand

Priority Standard: MTE.7.A.a2 – Describe the general nature of ferrous metals	
Learning Targets	Webb’s DOK Level
	Bloom’s Level
I can describe the basic properties of ferrous metals, including their iron content and magnetic behavior.	1
	Remember
I can give examples of common ferrous metals and explain their everyday uses.	2
	Understand

Priority Standard: MTE.7.I.i5 – Identify methods used to vary the strength and toughness of materials	
Learning Targets	Webb’s DOK Level
	Bloom’s Level
I can describe how heat treatment can change the strength or toughness of a metal.	2
	Understand
I can describe that different strengthening methods (e.g., alloying, work hardening, heat treatment) change a metal’s properties.	2
	Understand

Priority Standard: MTE.6.B.b1 - Apply concepts of heat, including temperature, thermal conductivity, specific heat, etc.

Learning Targets	Webb's DOK Level
	Bloom's Level
I can measure and compare how different metals transfer heat.	2
	Apply
I can explain why certain metals are chosen for cooking, insulation, or electronics based on thermal properties.	3
	Analyze

Priority Standard: MTE.17.A.a1 - Explain methods for finishing material for appearance and corrosion resistance

Learning Targets	Webb's DOK Level
	Bloom's Level
I can describe common finishing methods for metals (e.g., plating, painting, polishing) and why they are used.	2
	Understand
I can explain how finishing processes improve a metal's durability or appearance (e.g., corrosion resistance, smoothness, shine).	3
	Analyze

Priority Standard: MTE.6.C.c2 - Explain the electrical properties of conductors, insulators and semiconductors

Learning Targets	Webb's DOK Level
	Bloom's Level
I can classify materials as conductors or insulators based on their electrical properties.	1
	Remember
I can explain why metals are used as conductors in circuits.	2
	Understand

Engaging Scenario

Engaging Scenario 1

Title: Metal Casting

Length of Time: 2 Blocks

Description/Instructions:

In this scenario, students experience the process of casting metals by melting pewter or tin and pouring it into sand molds, using equipment such as Hot Pots or Lee pots. Students will design simple patterns, prepare molds, and observe how molten metal solidifies into a finished part. Along the way, they discuss how structure and composition affect properties, as well as how casting is used in industry to produce parts of varying shapes and sizes. This hands-on process gives students a deeper appreciation for metals as structural materials, highlighting both their advantages and their limitations.

Engaging Scenario 2

Title: Engineering Disaster Project

Length of Time: 3 Blocks

Description/Instructions:

In this project, students will research and analyze real-world engineering disasters, focusing on the materials used and how they failed. Students will identify the types of stress and strain that affected the materials, explain properties such as strength, toughness, and yield stress, and determine how these factors contributed to the failure. Students may choose how to create their project, such as producing a podcast, making a video documentary, building a model of the structure, or writing a detailed case report. This project focuses on understanding the materials involved in engineering structures and how proper material selection and use can potentially prevent similar failures in the future.

Rubric for Engaging Scenario 1:

Criteria	4 – Exceeds Expectations	3 – Proficient	2 – Developing	1 – Beginning
Safety	Always followed all safety rules without reminders; modeled safe behavior for others.	Consistently followed safety rules; needed only one reminder.	Inconsistently followed safety rules; needed multiple reminders.	Did not follow safety rules, creating unsafe conditions.
Participation	Took active role in mold prep, observations, and finishing; contributed to group work consistently.	Participated in group work and completed assigned tasks.	Limited participation; completed only part of assigned tasks.	Minimal effort; relied on others to complete work.
Observations and Data	Recorded detailed, thoughtful observations in all parts of the table; connected observations to scientific reasoning.	Recorded clear observations for most steps in the table.	Recorded incomplete or vague observations; missed key steps.	Few or no observations recorded; little effort shown.
Reflection and Conclusion	Wrote complete, insightful answers that connect lab experience to metals in real-world use.	Wrote complete answers that summarize lab and learning.	Wrote partial or vague answers; minimal connection to learning.	Did not complete conclusion or gave irrelevant responses.

Rubric for Engaging Scenario 2:

Category	4 – Exceeds Expectations	3 – Proficient	2 – Developing	1 – Beginning
Material Properties (MTE.7.I.i5)	Clearly explains how material strength, toughness, and treatment affected the disaster; uses correct science terms.	Explains how materials were involved; mostly accurate.	Mentions materials but lacks detail or accuracy.	Limited or incorrect information about materials.
Disaster Analysis	Gives detailed and accurate description of what happened, including when, where, stress type, and material failure.	Includes most details; some minor gaps.	Gives a basic summary with missing details.	Description is unclear or incomplete.
Research Quality	Information is specific, accurate, and well supported; identifies materials and responsible parties.	Mostly accurate information with a few errors.	Some missing or unclear information.	Many inaccuracies or missing information.
Presentation	Clear, organized, and engaging presentation; visuals support understanding.	Mostly clear and organized; some small issues.	Some organization but hard to follow in places.	Unclear or incomplete presentation.

Topic 1: Characteristics & Properties

Engaging Experience 1

Title: Magnetic Field Print

Suggested Length of Time: .5 Block

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: MTE.6.C.c3 - Apply concepts of magnetism and its role in motors and other phenomena

Detailed Description/Instructions: Students will create a magnetic field print using iron filings, a magnet, and sun paper. This demonstrates magnetic domains and makes the magnetic field of a magnet visible.

Bloom's Levels: Analyze

Webb's DOK: 3

Engaging Experience 2

Title: Wire Fatigue Lab

Suggested Length of Time: 1-2 Blocks

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).

MTE.7.I.i5 - Identify methods used to vary the strength and toughness of materials

Supporting: MTE.7.I.i1 - Compare mechanical properties of different classes of materials
MTE.8.B.b8 - Perform fatigue testing on materials

Detailed Description/Instructions: Students will repeatedly bend wires of different samples (aluminum, steel, copper, etc) to investigate metal fatigue. The results will be recorded in a spreadsheet, compiled as class data, and displayed on a line graph. Students will discuss ductility and work hardening: why some wires get stiffer before breaking.

Bloom's Levels: Analyze

Webb's DOK: 3

Engaging Experience 3

Title: Properties Mini Labs: Grain Boundaries and Homopolar Motor

Suggested Length of Time: .5 Block

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: MTE.7.J.j2 - Describe how the grain structure of a material can affect properties

MTE.6.C.c3 - Apply concepts of magnetism and its role in motors and other phenomena

Detailed Description/Instructions: The following activities are completed during or after the metal properties notes. First, students will melt a small amount of phenyl salicylate on a watch glass, then add a single crystal to the liquid and observe under a microscope as crystal grains form. Next, students will construct a homopolar motor using a battery, a neodymium magnet, and copper wire to explore the interaction between electric current and magnetic fields.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 4

Title: Bismuth Crystals

Suggested Length of Time: 1 Block

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: MTE.7.J.j2 - Describe how the grain structure of a material can affect properties

Detailed Description/Instructions: In this lab, students will grow bismuth crystals outside using a low-heat source. They will observe how cooling affects crystal size, shape, and colorful surfaces. This hands-on activity helps students see how atomic structure and bonding influence the way crystals form.

Bloom's Levels: Apply

Webb's DOK: 2

Topic 2: Ferrous and Non Ferrous Metals

Engaging Experience 1

Title: Ferrous vs Non-Ferrous

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.A.a2 – Describe the general nature of ferrous metals.

Supporting: 9–12.PS1.A.4 – Apply bonding and structure concepts to explain macroscopic properties.

MTE.7.A.a1 – Recognize the general nature and available types of non-ferrous metals.

Detailed Description/Instructions: Students will test and observe the properties of common ferrous metals such as iron nails, steel paper clips, and stainless steel to identify what makes them distinct from non-ferrous metals. Through hands-on testing of magnetism, rusting, and strength, students will describe how iron content influences the structure, behavior, and real-world uses of ferrous materials.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Experience 2

Title: Brassing a Penny

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.A.a1 - Recognize the general nature and available types of non-ferrous metals

Detailed Description/Instructions: Students will zinc-plate a penny and then heat it to transform the surface into brass, a substitutional non-ferrous metal.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Experience 3

Title: Shape Memory Alloy Lab

Suggested Length of Time: 2 Blocks

Standards Addressed

Priority: MTE.7.A.a1 - Recognize the general nature and available types of non-ferrous metals

Detailed Description/Instructions: Students will compare a control metal of copper to nitinol, a memory shape non-ferrous alloy, to observe behaviors.

Bloom's Levels: Apply

Webb's DOK: 2

Topic 3: Strength & Workability

Engaging Experience 1

Title: Stress-Strain

Suggested Length of Time: 1-2 Blocks

Standards Addressed

Priority: MTE.7.I.i5 - Identify methods used to vary the strength and toughness of materials

Supporting: MTE.7.I.i3 - Explain property variations caused by annealing, heat treatment and deformation. MTE.8.B.b8 - Perform fatigue testing on materials

Detailed Description/Instructions: Students will investigate stress and strain relationships by testing metal samples on a stress-strain machine or, as an alternative, using rubber bands with a spring scale. They will record measurements in a spreadsheet, perform calculations, and create graphs to illustrate how different materials respond to applied forces.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Experience 2

Title: Heat Treatment Lab

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.I.i5 - Identify methods used to vary the strength and toughness of materials. MTE.7.A.a2 - Describe the general nature of ferrous metals

Supporting: MTE.7.I.i3 - Explain property variations caused by annealing, heat treatment and deformation. MTE.8.B.b8 - Perform fatigue testing on materials

Detailed Description/Instructions: Students will be using two different ferrous metals in the form of bobby pins and paper clips to look at properties and how they are impacted by heat treatment methods.

Bloom's Levels: Understand

Webb's DOK: 2

Topic 4: Conductivity

Engaging Experience 1

Title: Conductive Dough

Suggested Length of Time: 1-2 Blocks

Standards Addressed

Priority: MTE.6.B.b1 - Apply concepts of heat, including temperature, thermal conductivity, specific heat, etc. MTE.6.C.c2 - Explain the electrical properties of conductors, insulators and semiconductors

Detailed Description/Instructions: Students will create squishy circuits using conductive and insulative dough as an introduction to circuits.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 2

Title: Snap Circuits

Suggested Length of Time: 1-2 Blocks

Standards Addressed

Priority: MTE.6.B.b1 - Apply concepts of heat, including temperature, thermal conductivity, specific heat, etc. MTE.6.C.c2 - Explain the electrical properties of conductors, insulators and semiconductors

Detailed Description/Instructions: Students will use snap circuits to investigate electrical conductivity. An extension of creating a “best circuit” and having a class competition and gallery walk can be used for a second block.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 3

Title: Thermal Conductivity

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.6.B.b1 - Apply concepts of heat, including temperature, thermal conductivity, specific heat, etc. MTE.6.C.c2 - Explain the electrical properties of conductors, insulators and semiconductors

Detailed Description/Instructions: Students will investigate thermal conductivity using thermal conductivity bars, heat conductometers, and bimetallic strips, then rank the metals based on the conductivity they observe.

Bloom's Levels: Analyze

Webb's DOK: 3

Topic 5: Corrosion

Engaging Experience 1

Title: Activity Series Lab

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.17.A.a1 - Explain methods for finishing material for appearance and corrosion resistance. MTE.5.B.b9 - Demonstrate knowledge of corrosion potential, chemical batteries and galvanic series

Detailed Description/Instructions: Students will perform single displacement reactions to observe chemical changes and the reactivity of various metals. They will use their observations to construct an activity series and compare it to the established activity series.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 2

Title: Electroplating Lab

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.17.A.a1 - Explain methods for finishing material for appearance and corrosion resistance

Supporting: MTE.5.B.b9 - Demonstrate knowledge of corrosion potential, chemical batteries and galvanic series

Detailed Description/Instructions: Students will use electrolysis to electroplate a key with a thin layer of copper. They will set up an electrochemical cell using a copper electrode, a copper sulfate solution as the electrolyte, and the key as the cathode. As the process runs, copper ions from the solution will deposit onto the surface of the key. Students will observe the key throughout the plating process and record changes in its appearance and mass to analyze how the copper layer develops.

Bloom's Levels: Apply

Webb's DOK: 2

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Characteristics and Properties	Magnetic Field Print	Students will create a magnetic field print using iron filings, a magnet, and sun paper.	½ block
	Wire Fatigue Lab	Students will repeatedly bend wires of different samples (aluminum, steel, copper, etc) to investigate metal fatigue. The results will be recorded in a spreadsheet, compiled as class data, and displayed on a line graph. Students will discuss ductility and work hardening	1-2 blocks
	Properties Mini Labs	Students observe crystal grain formation by melting and seeding phenyl salicylate, then build a simple homopolar motor to explore how electric current interacts with magnetic fields.	½ block
	Bismuth Crystals	Students will grow bismuth crystals outside using a low-heat source. They will observe how cooling affects crystal size, shape, and colorful surfaces.	1 block
Ferrous and Non Ferrous Metals	Ferrous vs Non-Ferrous	Students will test and observe the properties of common ferrous metals. Students will describe how iron content influences the structure, behavior, and real-world uses of ferrous materials.	1 block
	Brassing a penny	Students will zinc-plate a penny and then heat it to transform the surface into brass, a substitutional non-ferrous metal.	1 block
	Shape Memory Alloy Lab	Students will compare a control metal of copper to nitinol, a memory shape non-ferrous alloy, to observe behaviors.	2 blocks
Strength & Workability	Stress-Strain	Students will investigate stress and strain relationships by testing metal samples on a stress-strain machine	1-2 blocks
	Heat Treat Lab	Students will look at properties and how they are impacted by heat treatment methods.	1 block

Conductivity	Conductive Dough	Students will create squishy circuits using conductive and insulative dough as an introduction to circuits.	1-2 blocks
	Snap Circuits	Students will use snap circuits to investigate electrical conductivity.	1-2 blocks
	Thermal Conductivity	Students will investigate thermal conductivity using thermal conductivity bars, heat conductometers, and bimetallic strips, then rank the metals based on the conductivity they observe.	1 block
Corrosion	Activity Series Lab	Students will perform single displacement reactions to observe chemical changes and the reactivity of various metals. They will use their observations to construct an activity series and compare it to the established activity series	1 block
	Electroplating Lab	Students use electrolysis to copper-plate a key, observing how copper ions move from the solution to the key's surface and recording changes in color and mass to analyze how the coating forms.	1 block

Unit 3: Polymers

Subject: Materials Science

Grade: 9-12

Name of Unit: Polymers

Length of Unit: 20 blocks

Overview of Unit: In this unit, students investigate how the molecular structure of polymers explains their unique properties and wide range of uses. Through labs such as slime, casein plastic, 3D printing, and biodegradable plastic testing, students explore how polymers can be created, modified, and recycled. By connecting structure, processing, and performance, students gain insight into why polymers are both essential and challenging materials in today's world.

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).
- MTE.7.B - Discuss the General Nature of Plastics and Polymers
- MTE.5.B.b10 - Describe the chain structure of polymers
- STB-3.M.1 - Recycling is a process by which certain solid waste materials are processed and converted into new products.
- MTE.10.B.b1 - Describe the general nature of thermoset plastics as compared to thermoplastics

Supporting Standards for unit:

- MTE.7.J.j5 - Define strength-to-weight ratio and its significance in materials performance

Essential Questions:

1. How do the physical and chemical characteristics of polymers explain their unique properties and everyday applications?
2. What are the similarities and differences between natural polymers and synthetic polymers?
3. How does polymerization transform simple molecules into long chains with new properties?
4. Why do polymers have recycling codes, and what do they mean?
5. How do thermoset plastics and thermoplastics respond differently to heat, and why does it matter?

Enduring Understanding/Big Ideas:

1. The flexibility, strength, and durability of polymers come from their molecular structure, making them useful in products from packaging to medicine.
2. Natural polymers like starch and cellulose share repeating structural units with synthetic polymers, but human-made polymers can be tailored for specialized functions and large-scale use.
3. Polymerization links small molecules (monomers) into long repeating chains, and changes in chain length or branching alter the properties of the material.
4. Recycling codes identify the type of plastic, guiding sorting and processing, but not all polymers can be recycled effectively due to chemical and physical limitations.
5. Thermoplastics soften and can be reshaped when heated, while thermosets undergo permanent chemical changes that make them rigid, determining how each type is used in industry and daily life.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Absorption Natural Recycling Codes Synthetic	Hydrophilic Hydrophobic Monomer Plastic Polymer Polymerization Resin Thermoset Thermoplastic

Unwrapped Priority Standards:

Priority Standard: 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).

Learning Targets	Webb's DOK Level
	Bloom's Level
I can describe how the bonding and structure of polymers affect their flexibility, strength, and other properties.	2
	Understand
I can compare polymers with metals by linking their microscopic structure to their macroscopic properties.	3
	Analyze
I can explain why certain polymers are chosen for specific applications based on their molecular structure.	3
	Analyze

Priority Standard: MTE.7.B - Discuss the General Nature of Plastics and Polymers

Learning Targets	Webb's DOK Level
	Bloom's Level
I can identify examples of everyday plastics and describe their general characteristics.	1
	Understand
I can explain why plastics and polymers are important materials in daily life.	2
	Understand

Priority Standard: MTE.5.B.b10 - Describe the chain structure of polymers	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can illustrate or model how polymer chains are formed from repeating units.	2
	Understand
I can explain how chain length and branching affect polymer properties.	3
	Analyze

Priority Standard: STB-3.M.1 - Recycling is a process by which certain solid waste materials are processed and converted into new products.	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can identify common polymers that can and cannot be recycled.	1
	Remember
I can explain how recycling changes polymers into new products.	2
	Understand
I can evaluate the benefits and limitations of recycling polymers.	3
	Evaluate

Priority Standard: MTE.10.B.b1 - Describe the general nature of thermoset plastics as compared to thermoplastics

Learning Targets	Webb's DOK Level
	Bloom's Level
I can describe the difference between thermoplastics and thermosets.	1
	Remember
I can predict whether a plastic will soften when heated based on its type (thermoplastic or thermoset).	2
	Apply
I can explain how the structure of thermoplastics and thermosets affects their uses.	3
	Analyze

Engaging Scenario

Engaging Scenario 1

Title: Make, Break, Bury - Biodegradable Plastics (from MatEdU)

Length of Time: Length of Unit (Students make plastics at the onset of the unit, and then bury them to measure degradation throughout the unit)

Description/Instructions:

The Make, Break, Bury lab introduces students to biodegradable plastics by having them create small samples from starch-based polymers and additives, then test and observe how these materials perform and degrade over time. Students first make their own plastic films using simple ingredients, shaping and drying them into testable specimens. They then break the plastics by measuring strength and flexibility, comparing how different formulations perform under stress. Finally, students bury their samples in soil or compost to monitor degradation, recording changes in mass, appearance, and structure over days or weeks.

Bloom's Levels: Apply

Webb's DOK: 3

Engaging Scenario 2

Title: Bridge Project

Length of Time: 6-8 Blocks

Description/Instructions:

Structural Collapse: Students are presented with an engineering challenge: act as first responders and design a structure capable of supporting a falling building to allow trapped civilians to escape. They must work within size limitations, limited materials, and a set time frame. The structure that meets all requirements and supports the most weight will be the class winner. This activity introduces students to the polymer materials they will use to build their bridges.

Research and Blueprints: Students will research different bridge materials, bridge designs, truss and joint types, and blueprints from famous bridges. Using the given material parameters, they will design their bridge and create hand-drawn, 1:1 scale blueprints from three views, including all length and angle measurements.

Bridge Creation: Students will construct their bridge based on their blueprints. Modifications are allowed, but the general design should be followed. All material usage should be tracked.

Bridge Testing and Reflection: Bridges will be measured to ensure they meet all specifications and weighed to determine their total mass. Two desks will be set up 8 centimeters apart on each side of the bridge. Marks will be placed on the bridge at the 8 centimeter and 16 centimeter points.

Test 1: A motorized car will be driven across the bridge

Test 2: Student selected weights will be placed between the 16 centimeter marks. Additional weight will be added until the bridge fails, and the maximum weight held will be recorded.

Both the bridge mass and the maximum weight held will be entered into a class spreadsheet to calculate percent efficiency. Students will complete a reflection summarizing their experiences and learning from the entire project.

Bloom's Levels: Apply

Webb's DOK: 3

Rubric for Engaging Scenario 2:

Category	10	7	5	3	1	Weighted Score
Research	Thorough, accurate research	Mostly complete	Basic	Minimal	Very limited	Score $\times$ 2
Sketches	Clear, detailed sketches	Mostly clear	Some	Incomplete	Missing	Score $\times$ 1
Blueprints	Accurate 1:1 blueprints, all measurements	Mostly accurate	Partially complete	Inaccurate	Missing	Score $\times$ 3
Bridge Construction	Follows blueprint; meets size; stable; flag; materials tracked	Mostly follows	Partially follows	Does not follow; unstable	Incomplete/fails	Score $\times$ 4
Testing & Efficiency	Passes car and weight tests • Top 20% of the class will receive 50 points • Next 30% of the class will receive 40 points • The remaining students will receive 30 points					
Reflection	Thoughtful, detailed reflection	Covers most aspects	Basic reflection	Minimal	Missing	Score $\times$ 1

Topic 1: Characteristics & Properties

Engaging Experience 1

Title: Grow Dino's

Suggested Length of Time: 5 Blocks (will only take first 15 minutes of blocks 2-5)

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 collect data on a superabsorbent polymer over five days to investigate whether it can expand by 600%. They will graph their results and, in groups, may test the polymer in different liquids to compare effects.

Bloom's Levels: Analyze

Webb's DOK: 3

Engaging Experience 2

Title: Polymer Properties Station Labs

Suggested Length of Time: 1 Block

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 complete several lab stations to explore different polymer properties such as absorption, hydrophobic nature, flexibility, strength, and moldability. Examples of these stations include magic sand, sodium polyacrylate snow, and garbage bag stretching.

Bloom's Levels: Analyze

Webb's DOK: 3

Topic 2: Natural & Synthetic Polymers

Engaging Experience 1

Title: Casein Plastics

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.B - Discuss the General Nature of Plastics and Polymers

Detailed Description/Instructions: Students will create casein, a natural polymer, to investigate its properties and learn about the historical development of plastics. If doing Engaging Scenario 1 skip this activity.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Experience 2

Title: Polymer Research March Madness Bracket

Suggested Length of Time: 2-4 Blocks

Standards Addressed

Priority: MTE.7.B - Discuss the General Nature of Plastics and Polymers

Detailed Description/Instructions: Students will research a variety of synthetic polymers and each choose one to present in a class Google Slides presentation. Presentations will be organized into a bracket-style competition, with students voting after each round to select the winner. Winning polymers will advance to the next round, which continues the following day. The number of participants per round can be increased to shorten the activity time.

Bloom's Levels: Understand

Webb's DOK: 2

Engaging Experience 3

Title: Freeze-Dried Candy

Suggested Length of Time: 1- 2 blocks

Standards Addressed

Priority: MTE.7.B - Discuss the General Nature of Plastics and Polymers

Detailed Description/Instructions: Students observe how removing water through freeze-drying changes the texture, structure, and properties of different candies. This engaging lab helps them connect the role of natural polymers in foods to material properties such as elasticity, brittleness, and stability.

Bloom's Levels: Understand

Webb's DOK: 2

Topic 3: Polymerization

Engaging Experience 1

Title: Popping Boba

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.5.B.b10 - Describe the chain structure of polymers

Detailed Description/Instructions: Students will create popping boba using polymerization spherification and compare theirs to commercially made popping boba.

Bloom's Levels: Analyze

Webb's DOK: 3

Engaging Experience 2

Title: Slime Lab and Nylon Demonstration

Suggested Length of Time: 0.5 Block

Standards Addressed

Priority: MTE.5.B.b10 - Describe the chain structure of polymers

Detailed Description/Instructions: Students will first observe a nylon demonstration and then create their own slime to explore cross-linked polymers and observe how polymerization affects polymer properties.

Bloom's Levels: Understand

Webb's DOK: 2

Topic 4: Recycling

Engaging Experience 1

Title: Scavenger Hunt

Suggested Length of Time: 1 Block

Standards Addressed

Priority: STB-3.M.1 - Recycling is a process by which certain solid waste materials are processed and converted into new products.

Detailed Description/Instructions: Students will examine a variety of plastics with different recycling codes, make observations about each type, and begin identifying patterns and connections related to the recycling codes.

Bloom's Levels: Evaluate

Webb's DOK: 3

Engaging Experience 2

Title: Recycling Lab

Suggested Length of Time: 1-2 Blocks

Standards Addressed

Priority: STB-3.M.1 - Recycling is a process by which certain solid waste materials are processed and converted into new products.

Detailed Description/Instructions: Students will be given samples of each recycling code including two unknowns. Students will make observations and do varying tests of properties.

Bloom's Levels: Understand

Webb's DOK: 2

Topic 5: Thermoset v Thermoplastic

Engaging Experience 1

Title: 3D Printing

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.10.B.b1 - Describe the general nature of thermoset plastics as compared to thermoplastics

Detailed Description/Instructions: Students will have a lesson with a Library Media Specialist to design a 3D model, which will then be prepared for printing.

Bloom's Levels: Apply

Webb's DOK: 2

Engaging Experience 2

Title: Shrink Plastic Lab

Suggested Length of Time: 2 Blocks

Standards Addressed

Priority: MTE.10.B.b1 - Describe the general nature of thermoset plastics as compared to thermoplastics

Detailed Description/Instructions: Students will test their understanding of thermosets and thermoplastics by experimenting with two types of shrink plastics. They will take measurements and compare results with other groups to analyze differences.

Bloom's Levels: Analyze

Webb's DOK: 3

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Characteristics & Properties	Grow Dino's	Students will collect data on a superabsorbent polymer over five days to investigate whether it can expand by 600%.	5 blocks
	Polymer Properties Station Labs	Students will complete several lab stations to explore different polymer properties such as absorption, hydrophobic nature, flexibility, strength, and moldability	1 block
Natural & Synthetic Polymers	Casein Plastics	Students will create casein, a natural polymer, to investigate its properties and learn about the historical development of plastics.	1 Block
	Polymer Research March Madness Bracket	Students will research a variety of synthetic polymers and each choose one to present in a class Google Slides presentation. Presentations will be organized into a bracket-style competition, with students voting after each round to select the winner.	2-4 Blocks
	Freeze-Dried Candy	Students observe how removing water through freeze-drying changes the texture, structure, and properties of different candies.	1- 2 blocks
Polymerization	Popping Boba	Students will create popping boba using polymerization spherification and compare theirs to commercially made popping boba	1 Block
	Slime Lab and Nylon Demonstration	Students will first observe a nylon demonstration and then create their own slime to explore cross-linked polymers and observe how polymerization affects polymer properties.	0.5 Block
Recycling	Scavenger Hunt	Students will examine a variety of plastics with different recycling codes, make observations about each type, and begin identifying patterns and connections related to the recycling codes.	1 Block
	Recycling Lab	Students will be given samples of each recycling code including two unknowns.	1-2 Blocks

		Students will make observations and do varying tests of properties.	
Thermoset v Thermoplastic	3D Printing	Students will have a lesson with a Library Media Specialist to design a 3D model, which will then be prepared for printing.	1 Block
	Shrink Plastic Lab	Students will test their understanding of thermosets and thermoplastics by experimenting with two types of shrink plastics. They will take measurements and compare results with other groups to analyze differences.	2 Blocks

Unit 4: Ceramics

Subject: Materials Science

Grade: 9-12

Name of Unit: Ceramics

Length of Unit: 10 blocks

Overview of Unit: In this unit, students explore the unique properties of ceramics and glasses, connecting their atomic structure to their everyday uses. Through labs such as clay beam testing, glass bead making, and thermal shock demonstrations, students investigate why ceramics are hard, brittle, and heat resistant, and how glass behaves differently due to its amorphous structure. By comparing the performance of different ceramics under stress and temperature changes, students gain insight into how engineers design materials that balance strength, durability, and functionality.

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).
- MTE.7.E.e1 - Discuss the general nature and properties of ceramic materials
- MTE.7.E.e2 - Explain the general behavior of glasses
- MTE.14.A.a6 - Describe the parameters of glasses used in thermal shock resistant applications

Supporting Standards for unit:

- MTE.15.A.a4 - Describe thermal expansion and thermal shock behavior of ceramics

Essential Questions:

1. How do the bonding and structure of ceramics give them their unique properties?
2. How does the structure of glass influence its behavior compared to other ceramics?
3. Why do some glasses and ceramics resist cracking under sudden temperature changes while others break easily?

Enduring Understanding/Big Ideas:

1. The crystalline and ionic structures of ceramics make them hard, brittle, heat resistant, and valuable for specific applications.
2. Unlike crystalline ceramics, glasses have an amorphous structure that makes them transparent and versatile but prone to brittle failure.
3. The ability of a glass or ceramic to withstand thermal shock depends on material composition and engineered properties such as expansion, conductivity, and strength, which can be engineered for specialized uses.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Firing	Amorphous Ceramic Crystalline Glass Thermal Shock

Unwrapped Priority Standards:

Priority Standard: 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).	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can describe how the bonding and crystal structure of ceramics differ from metals and polymers.	1
	Understand
I can explain how the structure of ceramics leads to their macroscopic properties such as hardness, brittleness, and heat resistance.	3
	Analyze

Priority Standard: MTE.7.E.e1 - Discuss the general nature and properties of ceramic materials

Learning Targets	Webb's DOK Level
	Bloom's Level
I can identify common properties of ceramics, such as hardness, brittleness, and resistance to high temperatures.	1
	Remember
I can give examples of everyday ceramic products and explain how their properties make them useful.	2
	Understand

Priority Standard: MTE.7.E.e2 - Explain the general behavior of glasses	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can describe how the amorphous structure of glass differs from crystalline ceramics.	2
	Understand
I can explain why glass is transparent and how its structure influences its brittleness.	3
	Analyze

Priority Standard: MTE.14.A.a6 - Describe the parameters of glasses used in thermal shock resistant applications	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can define thermal shock and describe what happens when glass is exposed to sudden temperature changes.	1
	Recall
I can explain how properties such as thermal expansion and conductivity affect a glass's resistance to thermal shock.	2
	Understand
I can evaluate why certain glasses (like Pyrex or lab glassware) are chosen for thermal shock resistance.	3
	Evaluate

Engaging Scenario

Engaging Scenario

Title: Clay Beam Lab

Length of Time: 2 Blocks (time in between blocks for drying/firing process)

Description/Instructions: Students will explore how the structure and composition of ceramic materials affect their strength. They will create and test clay “beams” to see how much weight each can support before breaking. By changing variables such as beam thickness or added materials, students will examine how structure and bonding influence how ceramics respond to stress. In addition to strength, students will also investigate other properties of their clay beams including: brittleness, hardness, density, and conductivity.

Bloom’s Levels: Evaluate

Webb’s DOK: 4

Rubric for Engaging Scenario:

Criteria	4 – Exceeds Expectations	3 – Proficient	2 – Developing	1 – Beginning
Safety and Lab Practices	Consistently followed all safety protocols and modeled appropriate lab behavior for peers.	Followed all safety expectations with minimal reminders.	Occasionally needed reminders to follow safety rules or handle materials appropriately.	Frequently unsafe or distracted; required direct supervision to stay on task.
Preparation and Procedure	Constructed beams accurately and systematically tested them using a consistent method; demonstrated clear understanding of the procedure.	Constructed beams and completed testing as instructed; followed procedure correctly.	Constructed or tested beams inconsistently; missed one or more key procedural steps.	Did not follow procedure or complete testing; results not usable.
Data Collection and Accuracy	Collected detailed, accurate measurements for all samples; organized data clearly in tables; included relevant qualitative observations.	Collected accurate data for most trials and recorded it in the provided table.	Data incomplete or contains minor inaccuracies; limited observations recorded.	Missing or largely inaccurate data; table incomplete.
Analysis and Interpretation	Explained results using structure–property reasoning (compression vs. tension, brittleness vs. toughness) and connected data to bonding concepts and comparison to metals.	Analyzed results accurately and identified general trends; related strength to material composition.	Described what happened but offered limited explanation or weak connections to structure.	Provided little or no analysis; misconceptions evident.
Conclusion and Reflection	Drew clear, evidence-based conclusions that connect lab results to real-world applications of ceramics.	Wrote a complete conclusion summarizing results and key takeaways.	Conclusion restates data without deeper reasoning or connections.	Conclusion missing, incomplete, or off-topic.

Topic 1: Characteristics & properties

Engaging Experience 1

Title: Clay Project

Suggested Length of Time: 7 Blocks (will only take first 10 minutes of blocks 2-6)

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).

MTE.7.E.e1 - Discuss the general nature and properties of ceramic materials

Detailed Description/Instructions: In this project, students design, construct, and finish a clay bowl while observing changes in material properties throughout the ceramic process. They sketch an initial design, work with clay over multiple sessions, and record data on mass, dimensions, texture, color, temperature, and stage of clay. After drying and firing, students plan and apply a glaze, exploring how the glassy coating affects durability, appearance, and surface properties. Through these observations, they investigate how firing and glazing influence the strength, density, thermal behavior, and overall performance of ceramics compared to metals.

Bloom's Levels: Analyze

Webb's DOK: 3

Topic 2: Glass

Engaging Experience 1

Title: Making Glass Beads

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.E.e2 - Explain the general behavior of glasses

Detailed Description/Instructions: Students will observe how borax (sodium borate) melts and forms a glassy bead when heated on a wire loop. A platinum or nichrome wire loop is first cleaned in a flame, then heated to red heat (~700–800°C) and dipped into powdered borax. When reheated in the hottest part of the flame, the borax melts and solidifies into a clear, glass-like bead. This demonstration shows how glass is formed from borate materials and how additives can change its color and properties.

Bloom's Levels: Analyze

Webb's DOK: 3

Engaging Experience 2

Title: Sugar Glass

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.E.e2 - Explain the general behavior of glasses

Detailed Description/Instructions: In this lab, students create sugar glass to model the structure and properties of real glass. They combine and heat sugar, water, corn syrup, and cream of tartar, observing how temperature changes affect the mixture's behavior at different stages. As the solution progresses from soft to hard crack, students note transformations in texture and structure, exploring how molecular organization influences brittleness, clarity, and strength. After cooling and breaking their sugar glass, they compare its amorphous structure to real glass and discuss how similar materials are used in glassmaking, engineering, and movie special effects.

Bloom's Levels: Analyze

Webb's DOK: 3

Engaging Experience 3

Title: Prince Rupert's Drops

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.7.E.e2 - Explain the general behavior of glasses

Detailed Description/Instructions: In this lab, students create Prince Rupert's drops to explore how rapid cooling creates internal stress in glass. They observe the drops' extreme strength at the thick end and the explosive shattering when the tail is broken, connecting these observations to tempered glass and how stress affects material strength and failure.

Bloom's Levels: Analyze

Webb's DOK: 3

Topic 3: Thermal Shock

Engaging Experience 1

Title: Thermal Shock Lab

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.14.A.a6 - Describe the parameters of glasses used in thermal shock resistant applications

Supporting: MTE.15.A.a4 - Describe thermal expansion and thermal shock behavior of ceramics

Detailed Description/Instructions: In this lab, students explore thermal shock by heating and rapidly cooling different types of glass. They observe how soda lime, borosilicate, and fused silica respond to sudden temperature changes, comparing their thermal resistance and connecting results to real-world applications like cookware.

Bloom's Levels: Evaluate

Webb's DOK: 3

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Characteristics & properties	Clay Project	Students design and build a clay bowl, tracking how its properties change through shaping, drying, firing, and glazing to see how these processes affect the strength, texture, and durability of ceramics.	7 blocks
Glass	Making Glass Beads	Students observe how borax melts and reforms into a glassy bead on a heated wire loop, demonstrating how glass forms from borate materials and how additives can alter its color and properties.	1 block
	Sugar Glass	Students make sugar glass by heating sugar, water, corn syrup, and cream of tartar, observing how temperature affects texture and structure, then comparing the cooled, brittle glass to real glass in terms of strength and molecular organization.	1 block
	Prince Rupert's Drops	Students create Prince Rupert's drops to observe how rapid cooling produces internal stress in glass, noting their high strength at the bulb and explosive shattering at the tail to connect these effects to tempered glass and material stress behavior.	1 block
Thermal Shock	Thermal Shock Lab	Students explore thermal shock by heating and rapidly cooling soda lime, borosilicate, and fused silica.	1 block

Unit 5: Composites

Subject: Materials Science

Grade: 9-12

Name of Unit: Composites

Length of Unit: 15 Blocks

Overview of Unit: In this unit, students investigate how composites combine two or more materials to create new properties not found in a single substance. Through labs such as Pykrete, cement pucks, and paper making, students explore how different matrices and reinforcements change strength, durability, and performance. By analyzing real-world applications, students learn why engineers often choose composites over metals, plastics, wood, or concrete for modern designs.

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).
- MTE.11.A.a3 - Identify common materials used for the matrix of composite materials
- MTE.11.A.a8 - Describe applications of composites for replacing metals, plastics, concrete, and wood
- MTE.11.A.a1 - Describe a composite material

Supporting Standards for unit:

- 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.
- 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.
- MTE.11.A.a4 - Identify typical materials used for the fiber component of fiber composites
- MTE.11.A.a5 - Describe the terminology used for types of composites, e.g. ply, laminate, particle-reinforced

Essential Questions:

1. What makes a composite different from a single material, and why does that matter?
2. How do the choices of reinforcement and matrix materials affect the performance of a composite?
3. Why are composites often chosen instead of metals, plastics, concrete, or wood in engineering and everyday products?

Enduring Understanding/Big Ideas:

1. Composites combine a matrix and a reinforcement, and this structure gives them unique properties that neither material has on its own.
2. Different reinforcements (fibers, particles, fillers) and matrices (polymers, metals, ceramics) create composites with tailored properties such as strength, flexibility, and durability.
3. Engineers select composites because they offer advantages such as lighter weight, higher strength-to-weight ratio, corrosion resistance, or specific performance traits that traditional materials cannot match.

Unit Vocabulary:

Academic Cross-Curricular Words	Content/Domain Specific
Fiber Reinforcement	Composite Laminate Matrix

Unwrapped Priority Standards:

Priority Standard: 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).	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can explain how combining different materials in a composite changes their overall properties.	2
	Understand
I can compare composites with metals, polymers, and ceramics to show how structure leads to performance.	3
	Analyze

Priority Standard: MTE.11.A.a3 - Identify common materials used for the matrix of composite materials	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can identify common matrix materials such as polymers, metals, and ceramics.	1
	Remember
I can explain why certain matrix materials are chosen for strength, flexibility, or durability.	2
	Understand

Priority Standard: MTE.11.A.a8 - Describe applications of composites for replacing metals, plastics, concrete, and wood	
Learning Targets	Webb's DOK Level
	Bloom's Level
I can list real-world applications where composites are used instead of traditional materials.	1
	Remember
I can explain why composites are chosen to replace metals, plastics, concrete, or wood in certain products.	2
	Understand
I can evaluate trade-offs in using composites versus traditional materials in a design.	3
	Evaluate

Priority Standard: MTE.11.A.a1 - Describe a composite material

Learning Targets	Webb's DOK Level
	Bloom's Level
I can define what a composite material is and identify its two main parts: matrix and reinforcement.	1
	Remember
I can give examples of composites and describe how their structure gives them unique properties.	2
	Understand

Engaging Scenario

Engaging Scenario

Title: Thermal Insulative Egg Capsule

Length of Time: 5 Blocks

Description/Instructions:

In this culminating engineering design challenge, students apply their understanding of materials science to design, build, and test a “space capsule” capable of protecting a fragile payload (an egg) while maintaining thermal insulation. The project integrates concepts of heat transfer, insulation, material strength, and energy absorption to simulate real-world engineering considerations in spacecraft design. Students begin by researching and brainstorming design ideas, then create detailed blueprints with labeled materials and dimensions. They document their material selections and justify their choices based on mechanical and thermal properties. After construction, teams conduct both thermal and drop tests, collect and analyze data, and evaluate their designs for effectiveness and areas of improvement. This project emphasizes the practical application of materials science principles and demonstrates how thoughtful engineering design can solve complex, real-world challenges.

Rubric for Engaging Scenario:

Category	5 – Excellent	3 – Satisfactory	1 – Needs Improvement
Design & Planning	Clear, detailed blueprint with labeled materials and good explanation of how the design keeps heat in and protects the egg.	Blueprint mostly complete with some labels and explanation.	Incomplete or unclear blueprint; little explanation.
Thermal Test	Capsule stayed above 50°C for 20 minutes; design showed strong insulation.	Capsule stayed near 50°C for most of the test; some heat loss.	Capsule did not hold heat effectively.
Drop Test	Egg survived both drops; capsule stayed strong and absorbed impact well.	Egg survived one drop or had minor damage.	Egg broke both times; weak design.
Reflection & Improvements	Clearly explains results, what worked, and how to improve next time. Connects ideas to real engineering.	Describes results and at least one improvement.	Limited or unclear reflection; no connection to design ideas.

Topic 1: Characteristics & Properties

Engaging Experience 1

Title: Pykrete

Suggested Length of Time: 1-2 Blocks

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).

MTE.11.A.a1 - Describe a composite material

Detailed Description/Instructions: Students will investigate Pykrete, a composite made from ice and wood fibers, to explore how combining materials changes their properties. By creating and testing Pykrete samples against plain ice for strength and durability, students will connect microscopic structure and bonding to macroscopic properties, discovering how composites can be engineered for specific purposes.

Bloom's Levels: Analyze

Webb's DOK: 3

Topic 2: Types of Reinforcements & Matrices

Engaging Experience 1

Title: Cement Puck

Suggested Length of Time: 2 Blocks

Standards Addressed

Priority: MTE.11.A.a3 - Identify common materials used for the matrix of composite materials

Supporting: MTE.11.A.a4 - Identify typical materials used for the fiber component of fiber composites

MTE.11.A.a5 - Describe the terminology used for types of composites, e.g. ply, laminate, particle-reinforced

Detailed Description/Instructions: Students will create and test small concrete “pucks” to explore how the combination of a matrix (cement paste) and particle reinforcement (aggregate) forms a composite material. By adjusting ratios of materials such as sand, metal wires, plastic grass, and straw, students will identify how different components affect strength and durability, apply terminology such as matrix, fiber, and particle-reinforced, and connect their findings to real-world uses of concrete in construction and engineering.

Bloom’s Levels: Analyze

Webb’s DOK: 2

Engaging Experience 2

Title: Rice Krispies

Suggested Length of Time: 1 blocks

Standards Addressed

Priority: MTE.11.A.a1 - Describe a composite material

Supporting: MTE.11.A.a4 - Identify typical materials used for the fiber component of fiber composites

MTE.11.A.a5 - Describe the terminology used for types of composites, e.g. ply, laminate, particle-reinforced

Detailed Description/Instructions: Students explore the principles of composite materials by modeling how different additives influence material performance. Using Rice Krispies treats as a base matrix, students incorporate various reinforcements (such as chocolate drizzle, M&Ms, or sprinkles) to create and test food-based composites. Through qualitative and quantitative observations, students evaluate each sample’s compressive strength, flexibility, and overall effectiveness as a composite material.

Bloom’s Levels: Analyze

Webb’s DOK: 2

Topic 3: Applications of Composites

Engaging Experience 1

Title: Polymer Clay

Suggested Length of Time: 1 Block

Standards Addressed

Priority: MTE.11.A.a1 - Describe a composite material

Supporting:

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.

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.

Detailed Description/Instructions: Students will use polymer clay to explore what makes a composite material by shaping, stretching, and manipulating it to observe how its different components work together. As they twist, layer, and mold the clay, students will notice changes in texture, flexibility, and strength, then discuss how combining materials can produce new properties that neither component has alone.

Bloom's Levels: Understand

Webb's DOK: 1

Engaging Experience 2

Title: Paper Making & Filler Properties

Suggested Length of Time: 2 Blocks

Standards Addressed

Priority: MTE.11.A.a8 - Describe applications of composites for replacing metals, plastics, concrete, and wood

Supporting: 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.

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.

Detailed Description/Instructions: Students will make handmade paper composites using recycled paper pulp mixed with various natural or synthetic fillers (such as fibers, starch, or polymer additives) to explore how composites can replace traditional materials. Working as design teams, they will test the strength, texture, and appearance of their paper, then evaluate their prototypes based on criteria such as strength, cost, aesthetics, and environmental impact, applying engineering practices to optimize and justify their design decisions.

Bloom's Levels: Analyze

Webb's DOK: 2

Summary of Engaging Learning Experiences for Topics

Topic	Engaging Experience Title	Description	Suggested Length of Time
Characteristics & Properties	Pykrete	Students will investigate Pykrete, a composite made from ice and wood fibers, to explore how combining materials changes their properties.	1-2 Blocks
Types of Reinforcements & Matrices	Cement Puck	Students will create and test small concrete “pucks” to explore how the combination of a matrix (cement paste) and particle reinforcement (aggregate) forms a composite material.	2 Blocks
	Rice Krispies	Students explore the principles of composite materials by modeling how different additives influence material performance.	1 block
Applications of Composites	Polymer Clay	Students will use polymer clay to explore what makes a composite material by shaping, stretching, and manipulating it to observe how its different components work together.	1 Block
	Paper Making & Filler Properties	Students will make handmade paper composites using recycled paper pulp mixed with various natural or synthetic fillers (such as fibers, starch, or polymer additives) to explore how composites can replace traditional materials.	2 Blocks

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.