

Grade, Subject: <i>Materials Science</i>	
Strand (Unit): Introduction to Materials Science (15 days)	
Big Idea: <i>Materials science is the study of the stuff that makes life as you know it possible.</i>	
PA Content Standards: 1.1 Lab Safety 1.2 Scientific Method / Engineering Design Process 1.3 Scientific Variables and Graphing 1.4 States of Matter (solid, liquid and gas) 1.5 Organization of Matter (elements, compounds and mixtures) 1.6 History of Materials 1.7 Classification of Metals, Polymers, Ceramics and Composites 1.8 Properties of Materials	NGSS Standards HS-PS1-4 HS-ETS1-2 HS-ETS1-3 PA Standards 3.2.C.A1 3.2.C.A3 3.2.10.A3 3.2.10.A6 3.2.C.A5 3.2.12.A2
Essential Questions: 1. What are the essential components of an investigation? 2. What is proper equipment and safety precautions in materials science lab setting? 3. How does matter exist? 4. How does the structure of solids determine the function of solids? 5. How are variables graphed in science? 6. How are science graphs interpreted? 7. How do physical properties separate mixtures into pure substances? 8. What is the history of materials science? 9. Where are metals, polymers, ceramics, and composites found in your everyday life?	Concepts/Understandings (SWKT...): 1. The scientific method is a circular process whose components are revisited throughout an investigation. 2. Basic first aid and reading safety signage are basic requirements in a materials lab. 3. Matter exists as solids, liquids and gases.; Matter is classified as elements, compounds and mixtures. 4. Solids have a crystalline or amorphous structure that determines properties like workability, strength and plasticity. 5. The independent variable is placed on the x-axis and the dependent variable is graphed on the y-axis. 6. Humans have been using materials for at least 10,000 years of recorded history and are still influencing modern life. 7. Polymers, ceramics, metals and composites are a deeply embedded part of modern life.

<p><u>Vocabulary:</u> Ceramic Claim-Evidence-Reasoning (CER) Compound Composite Element Gas Homogeneous Heterogeneous Hypothesis Inference Kinetic Molecular Theory Liquid Mixture MSDS Safety Sheet Observation Plasma Polymer Solid</p>	<p><u>Competencies/Skills (SWBAT...):</u></p> <ol style="list-style-type: none"> 1. Design an experiment using the scientific method. 2. Interpret GHS symbols, NFPA signage, an SDS sheet and perform basic first aid. 3. Diagram or model the atoms in a solid, liquid and gas. Formulate and perform an experiment to separate a mixture into its component parts of elements and compounds. 4. Create a simple model of crystalline unit cells and identify areas of deformation. 5. Conduct an investigation and graph their data. 6. Design a timeline of materials science using Google slides, draw or sites 7. Classify common objects as ceramics, polymers, metals and composites and design a flowchart to identify materials.
<p><u>Possible Content Extensions:</u></p> <ul style="list-style-type: none"> ● Use a metal crystal as the example of a solid. ● NIH lab to analyze data 	<p><u>Assessments:</u> Lab Safety Quiz Graphing History of Materials Project Rubric for Final Project</p>
<p><u>Resources:</u></p> <ul style="list-style-type: none"> <input type="checkbox"/> Scott's Separation of Mixtures Lab <input type="checkbox"/> Classification of 20 everyday materials 	<p><u>Articles (These articles are student and teacher resources):</u> Find an article about why the Twin Towers fell YouTube Video of the collapse</p>

<p>Grade, Subject: <i>Materials Science</i></p>	
<p>Strand (Unit): Measurement and Calculations of Materials Science (10 days)</p>	
<p>Big Idea: <i>To study materials science, we need to be able to measure the materials and calculate various data from those measurements.</i></p>	
<p>PA Content Standards:</p> <ul style="list-style-type: none"> 1.1 Measurement/Math (Area, Volume, Density) 1.2 Significant Digits 1.3 Scientific Notation 1.4 Accuracy/Precision 1.5 Percent Error 1.6 Dimensional Analysis 1.7 Percent Composition 	<p>PA Core Standards:</p> <ul style="list-style-type: none"> 3.2.C.A2 3.2.C.A4 3.2.10.A5 3.2.C.A3
<p>Essential Questions:</p> <ul style="list-style-type: none"> 1. How are scientific tools used to measure with accuracy and precision? 2. How many digits actually mean anything in a measurement? 3. How are very large and very small numbers represented in science? 4. How are measurements converted from one measuring system to another? 5. How can density be used to determine material composition? 6. How is percent error used to validate data? 7. How is percent composition used to determine the identity of a substance and determine its empirical and molecular formula? 	<p>Concepts/Understandings (SWKT...):</p> <ul style="list-style-type: none"> 8. The metric system is the preferred system of measurement and every tool must be used with its correct degree of accuracy and precision. (1) 9. Significant digits are dependent upon the tool used to measure. (2) 10. Scientific notation is used to represent very large and small numbers in science. (3) 11. Dimensional analysis is the method of converting from one measuring system to another. (4) 12. Density can be calculated mathematically and determined experimentally. (5) 13. Percent error is used to determine how accurate and precise your collection of data is. (6) 14. Percent composition determines a substance's identity and can be used to mathematically calculate a substance's empirical and molecular formula. (7)

<p><u>Vocabulary:</u> Area Volume Density Significant figure Accuracy Precision Scientific Notation (powers of 10) Error Percent Error Percent Composition</p>	<p><u>Competencies/Skills (SWBAT...):</u></p> <ol style="list-style-type: none"> 8. Accurately and precisely measure a variety of materials within a specific percent error using the metric system. (1) 9. Analyze tools to their correct degree of precision. (2) 10. Represent large and small numbers using scientific notation.(3) 11. Solve a three-step dimensional analysis problem converting between the customary and metric system. (4) 12. Calculate for mass, volume, or density mathematically. (5) 13. Determine density using mass and volume measured in lab. (5) 14. Calculate the percent error for their lab data. (6) 15. Determine the identity and formula of a substance from its percent composition from data collected in lab. (7)
<p><u>Possible Content Extensions:</u></p> <ul style="list-style-type: none"> • 	
<p><u>Resources:</u></p> <ul style="list-style-type: none"> <input type="checkbox"/> Labs using more precision measuring tools like calipers <input type="checkbox"/> Bobby’s Aluminum Can Density Lab <input type="checkbox"/> The Thirsty Dinosaur (Calculate Percent Composition) <input type="checkbox"/> Find a STEM lab that would involve precision measuring <input type="checkbox"/> Percent composition of a pizza or ice cream sundae 	<p><u>Articles (These articles are student and teacher resources):</u></p> <p>Find an article about the Metric system Space shuttle calculations / communication activity Skype a scientist How does Dominos determine how much to charge for a pizza depending on composition.</p>

Grade, Subject: <i>Materials Science</i>	
Strand (Unit): Polymers (20 days)	
Big Idea: <i>Polymers have changed our world because of their physical, chemical and mechanical properties.</i>	
PA Content Standards: 1.1 Understand atomic structure, valence electrons and bonding of these electrons(covalent bonds) 1.2 Explain how electrons determine the properties of substances. 1.3 Describe how the rate of chemical reactions depends on many factors. 1.4 Evaluate the influences of technology on society. 1.5 Describe major historical changes in scientific perspectives. 1.6 Know that societal factors can promote or constrain scientific discovery. 1.7 Intermolecular Attractive Forces 1.8 Organic Chemistry--naming	NGSS HS-PS2-6. PA Core Standards: 3.2.10.A1 3.2.C.A1 3.2.C.A2 3.2.10.A5 3.2.12.A2 3.2.10.A1 3.2.C.A5 3.2.C.A2 3.2.C.A4 3.4.12A
Essential Questions: <ol style="list-style-type: none"> How does electron structure contribute to the creation of polymers? How do valence electrons determine the number and types of bonds? How does the naming system of polymers reflect their structure? How does the use of nonrenewable resources influence our current use of synthetic polymers? How do the different types of polymerization influence the physical properties of polymers? How do the molecular and intermolecular forces determine different physical and mechanical properties of plastics? How does the crystalline structure of a polymer influences its physical properties? How have polymers changed society? 	Concepts/Understandings (SWKT...): <ol style="list-style-type: none"> Polymers are arranged in long chains due to covalent bonding and the valence structure of carbon. Polymers are named according to their types of bonds and functional groups. Synthetic polymers are created from the fossil fuels of petroleum and natural gas and are nonrenewable resources. Addition polymerization, condensation polymerization and cross-linking will create different types of plastics that have unique uses. Covalent bonding and intermolecular forces help determine the physical, chemical and mechanical properties of polymers.

	<p>20. Most polymers present an amorphous crystal structure that creates transparency and crystallinity is due to the polymer chains themselves arranging in some long-range order.</p> <p>21. Polymers have helped society by simplifying life, but the cost of using polymers is an ethical debate.</p>																																						
<p>Vocabulary:</p> <table border="0"> <tr> <td>Addition Polymerization</td> <td>Nomenclature</td> </tr> <tr> <td>Alkane</td> <td>Nylon</td> </tr> <tr> <td>Alkene</td> <td>Octet</td> </tr> <tr> <td>Amorphous</td> <td>Opaque</td> </tr> <tr> <td>Chemical Property</td> <td>Physical Property</td> </tr> <tr> <td>Condensation Polymerization</td> <td>Polymer</td> </tr> <tr> <td>Covalent Bond</td> <td>Polymerization</td> </tr> <tr> <td>Cross-linking</td> <td>Synthetic Polymer</td> </tr> <tr> <td>Crystalline</td> <td>Tensile Strength</td> </tr> <tr> <td>Density</td> <td>Thermoplastic</td> </tr> <tr> <td>Elastomer</td> <td>Thermoset</td> </tr> <tr> <td>Entanglement</td> <td>Transparent</td> </tr> <tr> <td>HDPE</td> <td>Viscosity</td> </tr> <tr> <td>Hydrocarbon</td> <td>VSEPR</td> </tr> <tr> <td>Intermolecular Force</td> <td></td> </tr> <tr> <td>Isomer</td> <td></td> </tr> <tr> <td>LDPE</td> <td></td> </tr> <tr> <td>Mechanical Property</td> <td></td> </tr> <tr> <td>Natural Polymer</td> <td></td> </tr> </table>	Addition Polymerization	Nomenclature	Alkane	Nylon	Alkene	Octet	Amorphous	Opaque	Chemical Property	Physical Property	Condensation Polymerization	Polymer	Covalent Bond	Polymerization	Cross-linking	Synthetic Polymer	Crystalline	Tensile Strength	Density	Thermoplastic	Elastomer	Thermoset	Entanglement	Transparent	HDPE	Viscosity	Hydrocarbon	VSEPR	Intermolecular Force		Isomer		LDPE		Mechanical Property		Natural Polymer		<p>Competencies/Skills (SWBAT...):</p> <ol style="list-style-type: none"> 16. Build an electron model and a physical model to represent simple hydrocarbons. 17. Write and name simple hydrocarbon chains. 18. Develop a timeline of the creation of modern synthetic polymers [PVC, polystyrene, epoxy, ABS, polyurethane] 19. Test and compare the physical properties of different polymers that are caused by different types of polymerization. 20. Analyze and compare the physical and mechanical properties of the 7 different types of recycled plastics. 21. Investigate HDPE plastics and LDPE plastics to compare their reaction to heat. 22. Research the impact that polymer usage has had on modern society with both its pros and cons.
Addition Polymerization	Nomenclature																																						
Alkane	Nylon																																						
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Chemical Property	Physical Property																																						
Condensation Polymerization	Polymer																																						
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Cross-linking	Synthetic Polymer																																						
Crystalline	Tensile Strength																																						
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Hydrocarbon	VSEPR																																						
Intermolecular Force																																							
Isomer																																							
LDPE																																							
Mechanical Property																																							
Natural Polymer																																							
<p>Possible Content Extensions:</p> <ul style="list-style-type: none"> • Life based on Silicon instead of carbon (sci-fi linked) [What would life be like?] 																																							
<p>Resources:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Unit Outline <input type="checkbox"/> Polyvinyl Activities 	<p>Articles (These articles are student and teacher resources):</p> <ul style="list-style-type: none"> Sorting Plastics Biodegradable Bags 																																						

	Dissolving Plastic Liquid Bandages Recycled PET History of Plastics Tensile Strength Nylon: They All Laughed
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Grade, Subject: <i>Materials Science</i>	
Strand (Unit): Ceramics and Glass (20 days)	
Big Idea: <i>Even though most materials are made from 30 different elements, the different composition (the combination of those elements) dramatically affects the properties of materials.</i>	
PA Content Standards: 1.1 Law of Conservation of Mass (burn mantles before and after mass) 1.2 Nuclear Chemistry---radioactivity/introduce isotopes/half-life 1.3 How a Geiger counter works 1.4 Elements and the Periodic Table 1.5 Types of Glass [percent composition] 1.6 Types of bonding 1.7 Density 1.8 Crystalline vs. Amorphous Solids 1.9 Intermolecular Attractive Forces affecting properties of ceramics and glass	NGSS: HS-PS1-7 HS-PS3-4 PA Core Standards: 3.2.10.A1 3.2.C.A1 3.2.C.A2 3.2.12.A2 3.2.C.A3
Essential Questions: 1. Why does mass seem to disappear in a chemical reaction? 2. How is it possible for something to withstand extremely high temperatures and yet be fragile to the touch? 3. How do different bonds affect the properties of ceramics and glass? 4. How do intermolecular attractive forces affect the properties of ceramics and glass? 5. What elements are most materials made of and where can we find these elements? 6. Why do we need/use an average atomic mass for the elements? 7. Why are some elements radioactive and how do these breakdown? 8. How do we know something is radioactive? 9. How long does it take for an unstable nucleus to decay? 10. Why can you see through glass but not a flower pot? 11. How can materials be made of the same types of elements but have drastically different properties?	Concepts/Understandings (SWKT...): 22. Ceramics can withstand very high temperatures, but are very fragile. 23. Ceramics contain different types of bonds and thus have different types of intermolecular attractive forces which affect the properties. 24. In a chemical reaction, mass is always conserved in a closed system. 25. Elements on the periodic table are in a certain order depending on their properties, which affect the properties of ceramics and glass. 26. Not all atoms of the same element are exactly the same, there are isotopes. 27. When the ratio of protons to neutrons exceeds 1:1.5 the atom becomes unstable thus radioactive. 28. A Geiger counter is used to measure the amount of radioactivity in a substance. 29. Half-life is calculated mathematically and the artificially made elements are used in nuclear medicine to treat cancer.

<p>12. How can different types of glass be distinguished?</p>	<p>30. Unstable nuclei decay 3 ways - alpha emission, beta emission, and gamma emission.</p> <p>31. There are two different types of solids, crystalline and amorphous.</p> <p>32. The chemical composition and production of ceramics and glass determines its specific properties like melting point, shattering point, strength, and clarity.</p> <p>33. Glass can be identified by observing its physical properties and measuring its density.</p> <p>34. Different types of glass offer various types of protection: bulletproof glass and front windshield vs. side windows [investigate safety glass]</p>
<p><u>Vocabulary:</u> Conservation Mass Radiation Isotope Alpha particle Beta particle Gamma rays Half-life Geiger counter Parent nuclide Daughter nuclide Crystalline solid Amorphous solid Density Ionic bond Non-Polar Covalent bond Polar covalent bond Intermolecular attractive forces</p>	<p><u>Competencies/Skills (SWBAT...):</u></p> <p>23. Identify the physical properties of ceramics that make them useful for high-temperature uses.</p> <p>24. Analyze the crystalline structure of various materials and connect these structures with properties.</p> <p>25. Identify 30 common elements found in most materials.</p> <p>26. Determine the most common isotope of an element.</p> <p>27. Apply the concepts of radioactive decay and predict the daughter nuclide from the parent nuclide.</p> <p>28. Identify different types of bonds and their properties and how these bonds affect the properties of the material.</p> <p>29. Determine the percent composition of different ceramics and types of glass and relate the composition to the properties</p> <p>30. Analyze the results of a chemical reaction (burning of a Coleman mantle) to determine the reasons why mass is “lost”</p> <p>31. Calculate the amount of substance left in a half-life reaction</p> <p>32. Diagram how a Geiger counter works and use it to measure radioactivity</p> <p>33. Compare and contrast the benefits of different types of glass</p> <p>34. Identify different samples of glass by melting and bending glass and measuring its density.</p>

Possible Content Extensions:

- Radioactivity: alpha, beta and gamma--introduce equations like Uranium decaying to Lead/show an example of each and dangers of each type of radiation.
- Introduce half-life math problem--very basic. [Write a medicine problem of half-life transfer to make sure you have enough to get there.]
- Geiger counter--works with a tube on the end and when the alpha or beta particle hits the tube, it creates an energy which is enough to register on the counter. [We have geiger counters and radioactive samples. [can we find someone with a dosimeter badge?]
- Sodium borosilicate, pyrex, fancy crystal
- For density--do a density gradient instead of calculating OR refractive index [Scott has pyrex, safety glass, fake crystal]
- Physical properties--break it, score it, melting, bend it, stretch it
- Amorphous solids are called supercooled liquids because they don't have a melting. Glass doesn't have a melting point--never turns to a liquid because it's already a liquid. It just gets gooey.
- Plexiglass--you can break plastic, but how did they make plexiglass that you can see through, but it's so strong it doesn't break. [doesn't refract the light]
- Space shuttle nose cone can withstand thousands of degrees, but if you tap them they will break. [Check into requesting this]

Resources:

- Coleman Lantern Mantle Lab
- [Why is glass transparent?](#)
- [Quick thermoplastic demo](#)
- [Thermoset and Thermoplastics Resource](#)

Articles (These articles are student and teacher resources):

<p>Grade, Subject: <i>Materials Science</i></p>	
<p>Strand (Unit): Study of Metals (20 days)</p>	
<p>Big Idea: <i>Most materials we come in contact with are made of metals, therefore we should understand the chemical and physical properties of these metals.</i></p>	
<p>PA Content Standards:</p> <ul style="list-style-type: none"> 1.1 Properties of Metals (Malleable, Ductility) and Nonmetals and location on the periodic table 1.2 Crystal Structure of Metals (Metallic Bonds) 1.3 Activity Series of Metals 1.4 The effect of cold working metals 1.5 Annealing and quenching and the effect of heat treating 1.6 Alloys (Percent Composition) 1.7 Corrosion and its impact 1.8 The value of recycling of Metals Metallic bonding 	<p>NGSS</p> <ul style="list-style-type: none"> HS-PS1-1 HS-PS2-6 HS-PS1-2 <p>PA Core Standards:</p> <ul style="list-style-type: none"> 3.2.C.A1 3.2.C.A2 3.2.C.A4 3.2.10.A5 3.2.10.A1 3.2.C.A5
<p>Essential Questions:</p> <ul style="list-style-type: none"> 1. How can metals be distinguished from nonmetals? 2. How does metallic bonding influence the strength and properties of metals? 3. How does the atom arrangement of metals influence the mechanical properties of metals? 4. How do the mechanical properties of metals influence their industrial uses? 5. How does heat and plastic deformation affect the mechanical properties of a metal? 6. How do alloys improve the physical properties of its component metals? 	<p>Concepts/Understandings (SWKT...):</p> <ul style="list-style-type: none"> 1. Metals are opaque, lustrous elements that are good conductors of heat and electricity. Most metals are malleable and ductile and are, in general, denser than the other elemental substances. (1) 2. <i>The strength of metals suggests that atoms are held together by strong bonds, but the properties of metals suggest that these bonds also allow the atoms to move.</i> (2) 3. To form the strongest metallic bonds, metals are packed together as closely as possible. Dislocations of the crystal structure allow the metal to deform to temporarily stretch or bend. (3) 4. Mechanical properties of metals include malleability, ductility, toughness, strength, hardness, tensile and flexural strength. Each of these properties allows the metal to have a specific industrial use. (4)

<ol style="list-style-type: none"> 7. What makes a precious metal valuable? 8. How many different things can you get from a recycled car? 9. How does the activity series of metals determine their use in common products? 	<ol style="list-style-type: none"> 5. Heat treating, quenching, annealing and cold-working a metal change its mechanical properties to make the metal stronger, harder, or more brittle. (5) 6. The properties of alloys can be manipulated by varying their percent composition of the component metals. (6) 7. Different metals have different monetary value according to their investment and industrial uses. (7) 8. Metals can be recycled and reclaimed from one source and used for another. (8) 9. Different metals will react with different substances. (9)
<p><u>Vocabulary:</u> Sea of electrons Delocalized Kernel Malleable Ductile Conductor Reflector Luster</p>	<p><u>Competencies/Skills (SWBAT...):</u></p> <ol style="list-style-type: none"> 1. Identify metal and metal samples through the observation and investigation of physical properties. (1) 2. Cite evidence using a diagram of metallic bonding to show how the bonding allows for the physical properties. (2) 3. Model hexagonal close packing and face centered cubic packing and identify areas of dislocation within the crystal structure. (3) 4. Analyze the results of testing the tensile strength on various metals. (4) 5. Analyze the effect of heat treatment on various metals (5) 6. Calculate the percent composition of component metals in alloys and evaluate the increased benefits of their physical properties. (6) 7. Distinguish between precious and non precious metals. (7) 8. Chemically react a metal and through a series of reactions reclaim the original metal using percent error to determine efficiency. (8) 9. Chemically react a metal and order it in terms of reactivity. (9)
<p><u>Possible Content Extensions:</u></p> <ul style="list-style-type: none"> ● Precious Metals ● Wood’s Metal (melts in water) ● Aluminum used to be called the “King’s metal” because it was so expensive. When aluminum was processed from bauxite, the costs went down. ● Forged in fire tv show ● Damascus steel 	

<p>Resources:</p> <ul style="list-style-type: none"><input type="checkbox"/> Copper cycle lab<input type="checkbox"/> Historical timeline of metals<input type="checkbox"/> Mechanical Properties of Metals Notes and Lab	<p>Articles (These articles are student and teacher resources):</p>
<p>Background Needed</p> <ul style="list-style-type: none">• Measurement of mass and length• Presenting data in graphic form• Considerations of matter as atoms• Differences between chemical and physical changes• The importance of electrons in atomic bonding <p>http://matse1.matse.illinois.edu/metals/intro.html</p>	