

## Physical Science

Physical Science is a conceptual, inquiry-based course that investigates the basic concepts of chemistry and physics, including energy, waves, electricity and magnetism, atomic structure, nuclear chemistry, matter, and solutions. This course is designed to prepare students for further studies in chemistry and physics by building upon content knowledge, including chemical bonding and reactions and Newton's laws of motion, from Grade 8 Physical Science. In this course, students use evidence from their own investigations and the work of others to develop and refine knowledge of the disciplinary core ideas. They apply mathematical and language skills to create increasingly more sophisticated model-based explanations and arguments. The standards promote a depth of conceptual understanding and scientific literacy that will adequately prepare students for college, career, and citizenship. Various resources, including those specific to the local area and evidence-based literature found within scientific publications, should be used to extend and increase the complexity of the core ideas.

Content standards are organized according to the disciplinary core ideas for the physical science domain. The first core idea, "Matter and Its Interactions," deals with the substances and processes of the universe on microscopic and macroscopic levels. The second one, "Energy," involves conserving energy, energy transformations, and energy applications to everyday life. The third core idea, "Waves and Their Applications in Technologies for Information Transfer," examines wave properties, electromagnetic radiation, information technologies, and instrumentation.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon . Through participation in the engineering design process, students use data to justify the selection of a particular material for a specific application and evaluate the effects of using ions or isotopes of elements as a solution to a complex real-world problem.

Although not included as discrete standards, these scientific practices should be embedded throughout the courses:

- Measurement - Choose appropriate tools and record measurements with the correct number of significant figures to show measured and estimated digits and units.
- Dimensional analysis - Perform unit conversions using dimensional analysis.
- Scientific notation - Use scientific notation to report very large or small quantities with the correct number of significant figures and carry out multiplication, division, addition, and subtraction calculations with scientific notation.
- Graphing - Create graphs to determine and communicate relationships between variables, and analyze graphs to make predictions about unknown data points.

Each content standard completes the stem “*Students will...*”

| Energy |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                           |
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| Energy | <p>1. Evaluate sources of information concerning the law of conservation of energy to illustrate energy transformations in practical applications and natural systems.<br/> <i>Examples: Describe energy transformation when an arrow is fired from a bow. Illustrate how solar energy is transformed into chemical energy and then into mechanical energy which living things use to do work.</i></p> <p>a. Plan and carry out investigations to explore how mechanical energy is transformed within a system, including kinetic energy, gravitational potential energy, elastic potential energy, and work.<br/> <i>Examples: Using a digital simulation of a skateboarder moving through a loop, construct energy bar charts and use mathematical expressions to represent the energy changes.</i></p> | Systems and System Models |
|        | <p>b. Collect, analyze, and use data to explain how thermal energy is transferred by conduction, convection, and radiation.</p> <p>c. Construct explanations to justify the selection of materials for specific applications based on the materials’ specific heat values.<br/> <i>Examples: Engineers choose to use ethylene glycol in coolants because of its high specific heat.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                               | Energy and Matter         |
|        | <p>d. Investigate collisions and other real-world situations to evaluate the effects of impulse on changes in momentum.<br/> <i>Examples: Explain how an airbag increases the contact time during a collision and therefore reduces the force experienced by a crash test dummy.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Cause and Effect          |

## Waves and Their Applications in Technologies for Information Transfer

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| <b>Properties of Waves</b>       | <p>2. Obtain, evaluate, and communicate information to compare and contrast the properties of mechanical and electromagnetic waves as they relate to real-world applications.<br/> <i>Examples: Compare and contrast the transfer of electromagnetic radiation from the sun to Earth with the motion of mechanical waves created by an earthquake.</i></p> <p>a. Analyze and interpret data to identify and describe the relationships among wavelength, frequency, amplitude, and energy in waves.</p> | <b>Energy and Matter</b>         |
|                                  | <p>b. Develop models to illustrate reflection, refraction, interference, and diffraction.</p> <p>c. Analyze the ways in which different media and their characteristics affect the speed of sound and light waves.</p> <p>d. Use models to illustrate the Doppler effect and explain the changes in sound perception associated with it.</p>                                                                                                                                                            | <b>Cause and Effect</b>          |
|                                  | <p>e. Obtain and communicate information from published materials to explain how transmitting and receiving devices use the principles of wave behavior and wave interactions to transmit and capture information and energy.<br/> <i>Example: Research and explain how cell phones utilize electromagnetic and mechanical waves.</i></p>                                                                                                                                                               | <b>Systems and System Models</b> |
| <b>Electricity and Magnetism</b> | <p>3. Construct an explanation of the ways in which modern science uses both magnetic and electric concepts to create usable products.<br/> <i>Examples: induction cooktops, stereo speakers, electric motors, wireless chargers</i></p>                                                                                                                                                                                                                                                                | <b>Energy and Matter</b>         |
|                                  | <p>a. Construct an argument using evidence to support the claim that field forces exist between objects and act on the objects even when the objects are not in contact.<br/> <i>Examples: magnetism, gravity, electrical charge</i></p>                                                                                                                                                                                                                                                                | <b>Systems and System Models</b> |
|                                  | <p>b. Plan and carry out investigations to identify the factors that affect the strength of the electric and magnetic forces between objects.</p>                                                                                                                                                                                                                                                                                                                                                       | <b>Cause and Effect</b>          |

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|                                                     | <ul style="list-style-type: none"> <li>c. Use mathematics and computational thinking to represent and determine the quantitative relationships between voltage, current, and resistance in series and parallel circuits in terms of Ohm's law.</li> <li>d. Develop and use models to determine the relationships among voltage, current, and resistance at specific loads in series and parallel circuits.</li> </ul>          | <b>Systems and System Models</b> |
|                                                     | <ul style="list-style-type: none"> <li>e. Plan and carry out investigations to determine the relationships between magnetism and electrical charge in common devices.<br/><i>Examples: electromagnets, generators, electric motors</i></li> </ul>                                                                                                                                                                              | <b>Cause and Effect</b>          |
|                                                     | <ul style="list-style-type: none"> <li>f. Analyze and interpret data concerning the advantages and disadvantages of the energy sources used to produce electricity.<br/><i>Examples: wind, solar, radioactive elements, fossil fuels, hydroelectric</i></li> </ul>                                                                                                                                                             | <b>Energy and Matter</b>         |
| <b>Matter and Its Interactions</b>                  |                                                                                                                                                                                                                                                                                                                                                                                                                                |                                  |
| <b>Structure, Properties, and Nuclear Processes</b> | <ul style="list-style-type: none"> <li>4. ⚙️ Evaluate the effects of using ions or isotopes of elements as a solution to a complex real-world problem, including cost, safety, trade-offs, and environmental impacts.<br/><i>Examples: Assess the environmental benefits and impacts associated with the production, usage, and disposal of lithium ion batteries.</i></li> </ul>                                              | <b>Stability and Change</b>      |
|                                                     | <ul style="list-style-type: none"> <li>a. Obtain, evaluate, and communicate information from the periodic table concerning the structure of an atom and the arrangement of the atom's protons, neutrons, and electrons.</li> </ul>                                                                                                                                                                                             | <b>Patterns</b>                  |
|                                                     | <ul style="list-style-type: none"> <li>b. Predict the properties of an element based on the element's number of protons and valence electrons.</li> <li>c. Analyze and interpret data to predict properties of ionic and covalent compounds.</li> <li>d. Use mathematics and computational thinking to determine the charge of an ion and the mass number of an isotope based on the number of subatomic particles.</li> </ul> | <b>Structure and Function</b>    |

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|               | <ul style="list-style-type: none"> <li>e. Analyze and interpret data to explain how radioactive decay changes a radioactive isotope over time and explain how the age of an object can be estimated by the ratio of radioactive isotopes contained within the object's atoms.</li> <li>f. Use mathematics and computational thinking to identify types of radioactive decay based on balanced chemical equations, penetrating power, identity of emitted particles, and charge.</li> </ul>                                                                                                                                                                                                   | <b>Cause and Effect</b>          |
|               | <ul style="list-style-type: none"> <li>g. Use models to explain how nuclear fission and fusion reactions can be used as energy sources.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Energy and Matter</b>         |
|               | <ul style="list-style-type: none"> <li>h. Generate and defend a data-based claim regarding the use of radioactive materials as an energy source.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Systems and System Models</b> |
| <b>Matter</b> | <p>5.  Analyze and interpret data to justify the selection of a specific material for a practical application, considering a range of constraints.<br/> <i>Examples: Investigate multiple physical and chemical properties to generate and defend a claim about why engineers choose specific materials in the design of cookware.</i></p> <ul style="list-style-type: none"> <li>a. Carry out investigations and use results to compare and contrast the physical and chemical properties of matter.<br/> <i>Examples: density, hardness, conductivity, magnetism; flammability, reactivity</i></li> </ul> | <b>Cause and Effect</b>          |
|               | <ul style="list-style-type: none"> <li>b. Analyze and interpret data to predict changes in the phase of a material based on changes in particle motion, temperature, pressure, or thermal energy.<br/> <i>Examples: Utilize phase change diagrams to predict state of matter at a given temperature and thermal energy. Analyze a triple point graph to predict the state of matter at a given temperature and pressure.</i></li> </ul>                                                                                                                                                                                                                                                      | <b>Patterns</b>                  |

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|                  | <ul style="list-style-type: none"> <li>c. Use mathematical and computational thinking to determine the quantitative relationships among temperature, pressure, and volume of confined gases.</li> <li>d. Utilize multiple types of models to support and verify the claim that matter is conserved during a simple chemical reaction.<br/><i>Examples: particle diagrams, chemical equations, physical manipulatives, chemical reaction investigation</i></li> </ul>                                   | <b>Energy and Matter</b> |
| <b>Solutions</b> | <ul style="list-style-type: none"> <li>6. Obtain, evaluate, and communicate information to explain how the properties of various types of solutions make them useful in real-world applications.<br/><i>Examples: Make a claim from research to defend why certain alloys are chosen in the production of specific parts of musical instruments (e.g. brass instruments, guitar strings, and metallophones). Explain the selection of citric acid in the flavoring in juices and sodas.</i></li> </ul> |                          |
|                  | <ul style="list-style-type: none"> <li>a. Plan and carry out investigations to determine how various factors, including temperature, surface area, and stirring, affect the rate at which a solute dissolves in a solvent.</li> <li>b. Develop and use particle diagrams to illustrate diluted and concentrated solutions and describe how adjusting amounts of solute and solvent impacts the concentration of a solution.</li> </ul>                                                                 | <b>Cause and Effect</b>  |
|                  | <ul style="list-style-type: none"> <li>c. Analyze and interpret data from experiments to determine whether solutions are acidic, basic, or neutral to predict properties of the solutions.<br/><i>Example: Given the hydronium ion concentration of a solution, predict the color of the solution if phenolphthalein was added. Classify a solution based on the color change of pH paper.</i></li> </ul>                                                                                              | <b>Energy and Matter</b> |
|                  | <ul style="list-style-type: none"> <li>d. Plan and carry out investigations concerning neutralization reactions and describe the properties of the reactants and products.<br/><i>Example: <math>\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}</math>; acidic and basic reactants form salts and water</i></li> </ul>                                                                                                                                                          | <b>Cause and Effect</b>  |