



North Carolina Department of Public Instruction

## **INSTRUCTIONAL SUPPORT TOOLS** FOR ACHIEVING NEW STANDARDS

This document is designed to help North Carolina educators teach the Essential Standards (Standard Course of Study). NCDPI staff are continually updating and improving these tools to better serve teachers.

### *Physical Science* • Unpacked Content

For the new Essential Standards that will be effective in all North Carolina schools in the 2012-13 school year.

#### **What is the purpose of this document?**

To increase student achievement by ensuring educators understand specifically what the new standards mean a student must know, understand and be able to do.

#### **What is in the document?**

Descriptions of what each standard means a student will know, understand and be able to do. The “unpacking” of the standards done in this document is an effort to answer a simple question “What does this standard mean that a student must know and be able to do?” and to ensure the description is helpful, specific and comprehensive for educators.

#### **How do I send Feedback?**

We intend the explanations and examples in this document to be helpful and specific. That said, we believe that as this document is used, teachers and educators will find ways in which the unpacking can be improved and made ever more useful. Please send feedback to us at [feedback@dpi.state.nc.us](mailto:feedback@dpi.state.nc.us) and we will use your input to refine our unpacking of the standards. Thank You!

#### **Just want the standards alone?**

You can find the standards alone at <http://www.ncpublicschools.org/docs/acre/standards/phase1/science/physical.pdf> .

Note on Numbering: **PSc**–Physical Science

# Forces and Motion

## Essential Standard and Clarifying Objectives

### PSc.1.1 Understand motion in terms of speed, velocity, acceleration, and momentum.

PSc.1.1.1 Explain motion in terms of frame of reference, distance, and displacement.

PSc.1.1.2 Compare speed, velocity, acceleration, and momentum using investigations, graphing, scalar quantities, and vector quantities.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.1.1.1

- Interpret all motion as relative to a selected reference point. Identify distance and displacement as a scalar-vector pair.
- Describe motion qualitatively and quantitatively in terms of an object's change of position, distance traveled, and displacement.

### PSc.1.1.2

- Compare speed and velocity as a scalar-vector pair. Velocity is a relationship between displacement and time:  $\bar{v} = \frac{\Delta d}{\Delta t}$
- Apply concepts of average speed and average velocity to solve conceptual and quantitative problems.
- Explain acceleration as a relationship between velocity and time:  $\bar{a} = \frac{\Delta v}{\Delta t}$
- Using graphical analysis, solve for displacement, time, and average velocity. Analyze conceptual trends in the displacement vs. time graphs such as constant velocity and acceleration.
- Using graphical analysis, solve for velocity, time, and average acceleration. Analyze conceptual trends in the velocity vs. time graphs such as constant velocity and acceleration.
- Infer how momentum is a relationship between mass and velocity of an object,  $p = mv$ . The focus should be on the conceptual understanding that the same momentum could be associated with a slow-moving massive object and an object moving at high velocity with a very small mass (e.g.- 100 kg object moving 1 m/s has the same momentum as a 1-kg object moving 100m/s)

- Explain change in momentum in terms of the magnitude of the applied force and the time interval that the force is applied to the object. Everyday examples of the impulse/momentum relationship include: the use of airbags in cars; time of contact and “follow-through” in throwing, catching, kicking, and hitting objects in sports; bending your knees when you jump from a height to the ground to prevent injury.

## Essential Standard and Clarifying Objectives

### PSc.1.2 Understand the relationship between forces and motion.

PSc.1.2.1 Explain how gravitational force affects the weight of an object and the velocity of an object in freefall.

PSc.1.2.2 Classify frictional forces into one of four types: static, sliding, rolling, and fluid.

PSc.1.2.3 Explain forces using Newton’s three laws of motion.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.1.2.1

- Recognize that the weight of an object is a measure of the force of gravity and is the product of its mass and the acceleration due to gravity:  $F_g = mg$
- With negligible air resistance, explain acceleration due to gravity as an example of uniformly changing velocity:  $g = 9.8 \frac{m}{s^2}$
- Relate the presence of air resistance to the concept of terminal velocity of an object in free fall.

### PSc.1.2.2

- Identify friction as a force that opposes motion of an object. (Review from middle school.)
- Classify the frictional forces present in a situation such as a book resting on a table (static), a box pushed across the floor (sliding), a ball rolling across the floor (rolling), a boat moving through a river (fluid), or an object in free-fall (fluid).

## PSc.1.2.3

- Explain the property of inertia as related to mass - the motion of an object will remain the same (either at rest or moving at a constant speed in a straight line) in the absence of unbalanced forces; if a *change in motion* of an object is observed, there must have been a net force on the object.
- Explain balanced and unbalanced forces mathematically and graphically with respect to acceleration to establish the relationship between net force, acceleration, and mass:  $a \propto F$  and  $a \propto \frac{1}{m}$  (no trigonometry).
- Explain qualitatively and quantitatively the relationship between force, mass and acceleration– the greater the force on an object, the greater its change in motion; however, the *same amount of force* applied to an object with *less mass* results in a *greater acceleration*.
- While the second law describes a single object, forces always come in equal and opposite pairs due to interaction between objects. Give examples of interaction between objects describing Newton’s third law – whenever one object exerts a force on another, an equal and opposite force is exerted by the second on the first. The third law can be written mathematically as  $F_{A \rightarrow B} = -F_{B \rightarrow A}$ . Students should explain why these forces do not “cancel each other out”.

## Matter: Properties and Change

### Essential Standard and Clarifying Objectives

#### PSc.2.1 Understand types, properties, and structure of matter.

PSc.2.1.1 Classify matter as: homogeneous or heterogeneous; pure substance or mixture; element or compound; metals, nonmetals, or metalloids; solution, colloid, or suspension.

PSc.2.1.2 Explain the phases of matter and the physical changes that matter undergoes.

PSc.2.1.3 Compare physical and chemical properties of various types of matter.

PSc.2.1.4 Interpret the data presented in the Bohr model diagrams and dot diagrams for atoms and ions of elements 1 through 18.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.2.1.1

- Classify a sample of matter as homogeneous or heterogeneous based on uniformity of the material.
- Classify a sample of matter as a pure substance or mixture based on the number of elements or compounds in the sample.
- Classify an element as a metal, nonmetal, or metalloid based on its location on the periodic table.
- Classify a substance as an element or compound using its chemical formula.
- Classify samples and sets of matter as a solution, colloid or suspension based on the application of characteristic properties: particle size, “settling out” of one or more components, and interaction with light (Tyndall Effect).

### PSc.2.1.2

- Develop a conceptual cause-and-effect model for the phase change process that shows the relationship among particle attraction, particle motion, and gain or loss of heat - when a solid melts it has absorbed heat that increased the potential energy of its particles (space between particles) thus reducing the attraction between particles so that they can flow in a liquid phase. (Consider conditions of normal atmospheric pressure as well as the qualitative affects of changes in pressure involving gases.)
- The focus should be on the following phase changes: solid to liquid (melting), liquid to gas (vaporization), gas to liquid (condensation), and liquid to solid (freezing).
- Compare the process of evaporation to vaporization – materials that evaporate verses those which do not; attraction between surface particles and colliding air molecules.
- Recognize that the formation of solutions is a physical change forming a homogenous mixture. (Review from 8<sup>th</sup> grade.)
- Develop a conceptual model for the solution process with a cause and effect relationship involving forces of attraction between solute and solvent particles. A material is insoluble due to a lack of attraction between particles.
- Interpret solubility curves to determine the amount of solute that can dissolve in a given amount of solvent (typically water) at a given temperature.
- Qualitatively explain concentration of solutions as saturated, unsaturated or supersaturated; dilute or concentrated.

### PSc.2.1.3

- Calculate the density of different substances using the relationship  $D = \frac{m}{V}$ .
- Compare physical properties of a mixture that could be used to separate its components such as solubility, density, boiling point, magnetic property, etc.
- Compare various physical and chemical properties of metals, nonmetals and metalloids such as state of matter at a given temperature, density, melting point, boiling point, luster, conductivity, ductility, malleability, color, reactivity, etc.
- Compare physical and chemical properties of various everyday materials such as salt, sugar, baking soda, corn starch, rubbing alcohol, water, etc.

#### PSc.2.1.4

- Describe the charge, relative mass, and the location of protons, electrons, and neutrons within an atom.
- Calculate the number of protons, neutrons, electrons, and mass number in neutral atoms and ions.
- Explain how the different mass numbers of isotopes contributes to the average atomic mass for a given element (conceptual, no calculations).
- Use isotopic notation to write symbols for various isotopes (ex. Carbon-12, C-12,  $^{12}\text{C}$ , etc.)
- Explain Bohr's model of the atom.
- Draw Bohr models from hydrogen to argon including common isotopes and ions.
- Construct dot diagrams, a shorthand notation for Bohr models, using the element symbol and dots to represent electrons in the outermost energy level.

\* Note: While there is value in students understanding the historical development of atomic theory, the focus is on understanding the relationship between structure and properties of matter. The Quantum Mechanical Model of the atom provides a more in-depth understanding of atomic structure; it can be included as an enrichment topic, but goes beyond the level of the objective. Students taking Chemistry would extend to this depth of understanding.

## Essential Standard and Clarifying Objectives

### PSc.2.2 Understand chemical bonding and chemical interactions.

PSc.2.2.1 Infer valence electrons, oxidation number, and reactivity of an element based on its location in the Periodic Table.

PSc.2.2.2 Infer the type of chemical bond that occurs, whether covalent, ionic, or metallic, in a given substance.

PSc.2.2.3 Predict chemical formulas and names for simple compounds based on knowledge of bond formation and naming conventions.

PSc.2.2.4 Exemplify the law of conservation of mass by balancing chemical equations.

PSc.2.2.5 Classify types of reactions such as synthesis, decomposition, single replacement, or double replacement.

PSc.2.2.6 Summarize the characteristics and interactions of acids and bases.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.2.2.1

- Predict the number of valence electrons of representative elements (A Groups or 1, 2, 13-18) based on its location in the periodic table.
- Predict an element's oxidation number based on its position in the periodic table and valence electrons. (Representative groups including multiple oxidation states for tin and lead.)
- Predict reactivity of metals and nonmetals from general periodic trends.

### PSc.2.2.2

- Describe how ionic, covalent, and metallic bonds form and provide examples of substances that exhibit each type of bonding.
- Predict the type of bond between two elements in a compound based on their positions in the periodic table.

### PSc.2.2.3

- Name and write formulas for simple binary compounds containing a metal and nonmetal using representative elements (A Groups or 1, 2, 13-18) and compounds involving common polyatomic ions: ammonium ( $\text{NH}_4^+$ ), acetate ( $\text{C}_2\text{H}_3\text{O}_2^-$ ), nitrate ( $\text{NO}_3^-$ ), hydroxide ( $\text{OH}^-$ ), carbonate ( $\text{CO}_3^{2-}$ ), sulfate ( $\text{SO}_4^{2-}$ ), phosphate ( $\text{PO}_4^{3-}$ ).
- Name and write formulas for binary compounds of two nonmetals using Greek prefixes (mono-, di-, tri-, tetra-, etc.).

## PSc.2.2.4

- Use coefficients to balance simple chemical equations involving elements and/or binary compounds.
- Conclude that chemical equations must be balanced because of the law of conservation of matter.

## PSc.2.2.5

- Classify chemical reactions as one of four types: single replacement, double replacement, decomposition and synthesis. (Neutralization reaction is a type of double replacement reaction.)
- Summarize reactions involving combustion of hydrocarbons as *not* fitting into one of these four types. Hydrocarbon + oxygen  $\rightarrow$  carbon dioxide + water.

## PSc.2.2.6

- Recognize common inorganic acids including hydrochloric (muriatic) acid, sulfuric acid, acetic acid, nitric acid and citric acid.
- Recognize common bases including sodium bicarbonate, and hydroxides of sodium, potassium, calcium, magnesium, barium and ammonium.
- Define acids and bases according to the Arrhenius theory.
- Develop an understanding of the pH scale and the classification of substances therein.
- Generalize common characteristics of acids and bases– pH range, reactivity with metals and carbonates (acids) or fats/oils (bases), conductivity.
- Relate general household uses of acids and bases with their characteristic properties.
- Explain what happens in a neutralization reaction, identifying each component substance.

## Essential Standard and Clarifying Objectives

### PSc.2.3 Understand the role of the nucleus in radiation and radioactivity.

PSc.2.3.1 Compare nuclear reactions including alpha decay, beta decay, and gamma decay; nuclear fusion and nuclear fission.



PSc.2.3.2 Exemplify the radioactive decay of unstable nuclei using the concept of half-life.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.2.3.1

- Compare the characteristics of alpha and beta particles and gamma rays – composition, mass, penetrability.
- Compare alpha, beta, and gamma decay processes –alpha decay reduces the mass of an atom by 4 and the atomic number by 2; beta decay increases the atomic number by 1 (a neutron decays into a proton and electron); gamma rays are electromagnetic waves released from the nucleus along with either an alpha or beta particle.
- Compare the processes of fission (splitting of a very large atom) and fusion (joining of atoms) in terms of conditions required for occurrence, energy released, and the nature of products.

### PSc.2.3.2

- Conceptually explain half-life using models.
- Perform simple half-life calculations based on an isotope's half-life value, time of decay, and/or amount of substance.

## Energy: Conservation and Transfer

### Essential Standard and Clarifying Objectives

#### **PSc.3.1 Understand types of energy, conservation of energy and energy transfer.**

PSc.3.1.1 Explain thermal energy and its transfer.

PSc.3.1.2 Explain the law of conservation of energy in a mechanical system in terms of kinetic energy, potential energy and heat.

PSc.3.1.3 Explain work in terms of the relationship among the applied force to an object, the resulting displacement of the object, and the energy transferred to an object.

PSc.3.1.4 Explain the relationship among work, power and simple machines both qualitatively and quantitatively.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.3.1.1

- Infer the ability of various materials to absorb or release thermal energy in order to conceptually relate mass, specific heat capacity, and temperature of materials to the amount of heat transferred. (Calculations with  $q = mC_p\Delta T$  should be used to aid in conceptual development through laboratory investigation and analysis, not as problem-solving exercises.)
- Compare thermal energy, heat, and temperature.
- Relate phase changes to latent heat that changes the potential energy of particles while the average kinetic energy of particles (temperature) remains the same. (Link to PSc.2.1.2)
- Compare conduction, convection, and radiation as methods of energy transfer.

### PSc.3.1.2

- Exemplify the relationship between kinetic energy, potential energy, and heat to illustrate that total energy is conserved in mechanical systems such as a pendulum, roller coaster, cars/balls on ramps, etc.
- Relate types of friction in a system to the transformation of mechanical energy to heat.

### PSc.3.1.3

- Explain scenarios in which work is done, identifying the force, displacement, and energy transfer- work requires energy; when work is done on an object, the result is an increase in its energy and is accompanied by a decrease in energy somewhere else.
- Compare scenarios in which work is done and conceptually explain the differences in magnitude of work done using the relationship  $W = F\Delta d$ .

### PSc.3.1.4

- Infer the work and power relationship:  $P = \frac{W}{\Delta t} = \frac{F\Delta d}{\Delta t} = F\bar{v}$

- Determine the component simple machines present in complex machines – categorize a wedge and screw as variations of an inclined plane; a pulley and wheel & axle as variations of a lever.
- Explain the relationship between work input and work output for simple machines using the law of conservation of energy.
- Define and determine ideal and actual mechanical advantage:  $IMA = \frac{d_E}{d_R}$      $AMA = \frac{F_R}{F_E}$
- Define and determine efficiency of machines:  $Efficiency = \frac{W_{out}}{W_{in}} \times 100$
- Explain why no machine can be 100% efficient.

## Essential Standard and Clarifying Objectives

### PSc.3.2 Understand the nature of waves.

PSc.3.2.1 Explain the relationships among wave frequency, wave period, wave velocity, amplitude, and wavelength through calculation and investigation.

PSc.3.2.2 Compare waves (mechanical, electromagnetic, and surface) using their characteristics.

PSc.3.2.3 Classify waves as transverse or compressional (longitudinal).

PSc.3.2.4 Illustrate the wave interactions of reflection, refraction, diffraction, and interference.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.3.2.1

- Identify the basic characteristics of a longitudinal (compressional) wave: amplitude, rarefaction, and compression.
- Recognize the relationship between period and frequency (focus on conceptual understanding of this inverse relationship).
- Explain the relationship among velocity, frequency, and wavelength and use it to solve wave problems:  $v_w = f\lambda$

- Exemplify wave energy as related to its amplitude and independent of velocity, frequency or wavelength.

#### PSc.3.2.2

- Classify waves as one of three types: mechanical, electromagnetic or surface waves based on their characteristics.
- Compare different wave types based on how they are produced, wave speed, type of material (medium) required, and motion of particles.

PSc.3.2.3 Compare compressional (longitudinal) and transverse waves in terms of particle motion relative to wave direction.

#### PSc.3.2.4

- Illustrate reflection and refraction of waves at boundaries: reflection of a transverse pulse at the fixed-end of a spring or rope; reflection of sound (SONAR) and radio waves (RADAR); reflection of water (surface) waves; refraction of water waves as the depth of the water changes; sound as it changes media; refraction of light as it passes from air into water, glass, oil etc.
- Illustrate the effects of wave interference (superposition)—constructive and destructive interference of surface waves, mechanical waves (sound, pulses in springs/ropes, etc.), light (soap bubbles/thin films, diffraction gratings). Emphasis is on conceptual understanding – not mathematical relationships.

## Essential Standard and Clarifying Objectives

### **PSc.3.3 Understand electricity and magnetism and their relationship.**

PSc.3.3.1 Summarize static and current electricity.

PSc.3.3.2 Explain simple series and parallel DC circuits in terms of Ohm's law.

PSc.3.3.3 Explain how current is affected by changes in composition, length, temperature, and diameter of wire.

PSc.3.3.4 Explain magnetism in terms of domains, interactions of poles, and magnetic fields.

PSc.3.3.5 Explain the practical application of magnetism.

## Unpacking

What does this standard mean a child will know, understand and be able to do?

### PSc.3.3.1

- Identify interactions between charged objects - opposite charges attract and like charges repel.
- Compare the three methods of charging objects: conduction, friction, and induction – explain the re-distribution or transfer of electrons for each method for both positively and negatively charged objects.
- Compare static and current electricity related to conservation of charge and movement of charge (without calculations).

### PSc.3.3.2

- Interpret simple circuit diagrams using symbols.
- Explain open and closed circuits.
- Apply Ohm's law and the power equation to simple DC circuits:  $V = IR$  and  $P = VI$ .
- Compare series and parallel circuits. Conceptually explore the flow of electricity in series and parallel circuits. (Calculations may be used to develop conceptual understanding or as enrichment.)
- Explain how the flow of electricity through series and parallel circuits is affected by voltage and resistance.

### PSc.3.3.3

- Explain how the wire in a circuit can affect the current present – for a set voltage, the current in a wire is inversely proportional to its resistance (more current exists where resistance is low); the resistance of a material is an intensive property called resistivity; increasing the length of a wire increases the resistance; increasing the temperature increases the resistance; increasing the diameter of a wire decreases its resistance.
- Explain using a cause-and-effect model how changes in composition, length, temperature, and diameter of a wire would affect the current in a circuit.

### PSc.3.3.4

- Describe the characteristics and behaviors of magnetic domains.
- Explain the attractions of unlike poles and the repulsion of like poles in terms of magnetic fields.

- Explain magnetic fields produced around a current-carrying wire and wire coil (solenoid).
- Explain the relationship between strength of an electromagnet and the variance of number of coils, voltage, and core material.

PSc.3.3.5

- Explain the relationship between electricity and magnetism in practical applications such as generators and motors – the process of electromagnetic induction in electric generators that converts mechanical energy to electrical energy; transformation of electric energy to mechanical energy in motors.
- Extrapolate other practical applications such as security cards (ATM, credit or access cards), speakers, automatic sprinklers, traffic signal triggers, seismometers, battery chargers, transformers, AC-DC adapters.