

**California State Science Curriculum Standards
Grades K-12 – Spiraled**

Content Area: PHYSICAL SCIENCE

The following document lists the standards that should be covered from Kindergarten through 12th grade in this content area.

Kindergarten

1. Properties of materials can be observed, measured, and predicted. As a basis for understanding this concept:
 - a. *Students know* objects can be described in terms of the materials they are made of (e.g., clay, cloth, paper) and their physical properties (e.g., color, size, shape, weight, texture, flexibility, attraction to magnets, floating, sinking).
 - b. *Students know* water can be a liquid or a solid and can be made to change back and forth from one form to the other.
 - c. *Students know* water left in an open container evaporates (goes into the air) but water in a closed container does not.

Grade 1

1. Materials come in different forms (states), including solids, liquids, and gases. As a basis for understanding this concept:
 - a. *Students know* solids, liquids, and gases have different properties.
 - b. *Students know* the properties of substances can change when the substances are mixed, cooled, or heated.

Grade 2

1. The motion of objects can be observed and measured. As a basis for understanding this concept:
 - a. *Students know* the position of an object can be described by locating it in relation to another object or to the background.
 - b. *Students know* an object's motion can be described by recording the change in position of the object over time.
 - c. *Students know* the way to change how something is moving is by giving it a push or a pull. The size of the change is related to the strength, or the amount of force, of the push or pull.
 - d. *Students know* tools and machines are used to apply pushes and pulls (forces) to make things move.
 - e. *Students know* objects fall to the ground unless something holds them up.
 - f. *Students know* magnets can be used to make some objects move without being touched.
 - g. *Students know* sound is made by vibrating objects and can be described by its pitch and volume.

Grade 3

1. Energy and matter have multiple forms and can be changed from one form to another. As a basis for understanding this concept:
 - a. *Students know* energy comes from the Sun to Earth in the form of light.
 - b. *Students know* sources of stored energy take many forms, such as food, fuel, and batteries.
 - c. *Students know* machines and living things convert stored energy to motion and heat.
 - d. *Students know* energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.
 - e. *Students know* matter has three forms: solid, liquid, and gas.
 - f. *Students know* evaporation and melting are changes that occur when the objects are heated.
 - g. *Students know* that when two or more substances are combined, a new substance may be formed with properties that are different from those of the original materials.

- h. *Students know* all matter is made of small particles called atoms, too small to see with the naked eye.
- i. *Students know* people once thought that earth, wind, fire, and water were the basic elements that made up all matter. Science experiments show that there are more than 100 different types of atoms, which are presented on the periodic table of the elements.

2. Light has a source and travels in a direction. As a basis for understanding this concept:

- a. *Students know* sunlight can be blocked to create shadows.
- b. *Students know* light is reflected from mirrors and other surfaces.
- c. *Students know* the color of light striking an object affects the way the object is seen.
- d. *Students know* an object is seen when light traveling from the object enters the eye.

Grade 4

1. Electricity and magnetism are related effects that have many useful applications in everyday life. As a basis for understanding this concept:

- a. *Students know* how to design and build simple series and parallel circuits by using components such as wires, batteries, and bulbs.
- b. *Students know* how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.
- c. *Students know* electric currents produce magnetic fields and know how to build a simple electromagnet.
- d. *Students know* the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.
- e. *Students know* electrically charged objects attract or repel each other.
- f. *Students know* that magnets have two poles (north and south) and that like poles repel each other while unlike poles attract each other.
- g. *Students know* electrical energy can be converted to heat, light, and motion.

Grade 5

1. Elements and their combinations account for all the varied types of matter in the world. As a basis for understanding this concept:

- a. *Students know* that during chemical reactions the atoms in the reactants rearrange to form products with different properties.
- b. *Students know* all matter is made of atoms, which may combine to form molecules.
- c. *Students know* metals have properties in common, such as high electrical and thermal conductivity. Some metals, such as aluminum (Al), iron (Fe), nickel (Ni), copper (Cu), silver (Ag), and gold (Au), are pure elements; others, such as steel and brass, are composed of a combination of elemental metals.
- d. *Students know* that each element is made of one kind of atom and that the elements are organized in the periodic table by their chemical properties.
- e. *Students know* scientists have developed instruments that can create discrete images of atoms and molecules that show that the atoms and molecules often occur in well-ordered arrays.
- f. *Students know* differences in chemical and physical properties of substances are used to separate mixtures and identify compounds.
- g. *Students know* properties of solid, liquid, and gaseous substances, such as sugar (C₆H₁₂O₆), water (H₂O), helium (He), oxygen (O₂), nitrogen (N₂), and carbon dioxide (CO₂).
- h. *Students know* living organisms and most materials are composed of just a few elements.
- i. *Students know* the common properties of salts, such as sodium chloride (NaCl).

Grade 6

3. Heat moves in a predictable flow from warmer objects to cooler objects until all the objects are at the same temperature. As a basis for understanding this concept:

- a. *Students know* energy can be carried from one place to another by heat flow or by waves,

- including water, light and sound waves, or by moving objects.
- b. *Students know* that when fuel is consumed, most of the energy released becomes heat energy.
 - c. *Students know* heat flows in solids by conduction (which involves no flow of matter) and in fluids by conduction and by convection (which involves flow of matter).
 - d. *Students know* heat energy is also transferred between objects by radiation (radiation can travel through space).

Grade 7

6. Physical principles underlie biological structures and functions. As a basis for understanding this concept:

- a. *Students know* visible light is a small band within a very broad electromagnetic spectrum.
- b. *Students know* that for an object to be seen, the eye must detect light emitted by or scattered from it.
- c. *Students know* light travels in straight lines if the medium it travels through does not change.
- d. *Students know* how simple lenses are used in a magnifying glass, the eye, a camera, a telescope, and a microscope.
- e. *Students know* that white light is a mixture of many wavelengths (colors) and that retinal cells react differently to different wavelengths.
- f. *Students know* light can be reflected, refracted, transmitted, and absorbed by matter.
- g. *Students know* the angle of reflection of a light beam is equal to the angle of incidence.
- h. *Students know* how to compare joints in the body (wrist, shoulder, thigh) with structures used in machines and simple devices (hinge, ball-and-socket, and sliding joints).
- i. *Students know* how levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
- j. *Students know* that contractions of the heart generate blood pressure and that heart valves prevent backflow of blood in the circulatory system.

Grade 8

Motion

1. The velocity of an object is the rate of change of its position. As a basis for understanding this concept:
- a. *Students know* position is defined in relation to some choice of a standard reference point and a set of reference directions.
 - b. *Students know* that average speed is the total distance traveled divided by the total time elapsed and that the speed of an object along the path traveled can vary.
 - c. *Students know* how to solve problems involving distance, time, and average speed.
 - d. *Students know* the velocity of an object must be described by specifying both the direction and the speed of the object.
 - e. *Students know* changes in velocity may be due to changes in speed, direction, or both.
 - f. *Students know* how to interpret graphs of position versus time and graphs of speed versus time for motion in a single direction.

Forces

2. Unbalanced forces cause changes in velocity. As a basis for understanding this concept:
- a. *Students know* a force has both direction and magnitude.
 - b. *Students know* when an object is subject to two or more forces at once, the result is the cumulative effect of all the forces.
 - c. *Students know* when the forces on an object are balanced, the motion of the object does not change.
 - d. *Students know* how to identify separately the two or more forces that are acting on a single static object, including gravity, elastic forces due to tension or compression in matter, and friction.
 - e. *Students know* that when the forces on an object are unbalanced, the object will change its velocity (that is, it will speed up, slow down, or change direction).
 - f. *Students know* the greater the mass of an object, the more force is needed to achieve the same rate of change in motion.

g. *Students know* the role of gravity in forming and maintaining the shapes of planets, stars, and the solar system.

Structure of Matter

3. Each of the more than 100 elements of matter has distinct properties and a distinct atomic structure. All forms of matter are composed of one or more of the elements.

As a basis for understanding this concept:

- a. *Students know* the structure of the atom and know it is composed of protons, neutrons, and electrons.
- b. *Students know* that combining two forms compounds or more different elements and that compounds have properties that are different from their constituent elements.
- c. *Students know* atoms and molecules form solids by building up repeating patterns, such as the crystal structure of NaCl or long-chain polymers.
- d. *Students know* the states of matter (solid, liquid, gas) depend on molecular motion.
- e. *Students know* that in solids the atoms are closely locked in position and can only vibrate; in liquids the atoms and molecules are more loosely connected and can collide with and move past one another; and in gases the atoms and molecules are free to move independently, colliding frequently.
- f. *Students know* how to use the periodic table to identify elements in simple compounds.

Reactions

5. Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept:

- a. *Students know* reactant atoms and molecules interact to form products with different chemical properties.
- b. *Students know* the idea of atoms explains the conservation of matter: In chemical reactions the number of atoms stays the same no matter how they are arranged, so their total mass stays the same.
- c. *Students know* chemical reactions usually liberate heat or absorb heat.
- d. *Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction.
- e. *Students know* how to determine whether a solution is acidic, basic, or neutral.

Periodic Table

7. The organization of the periodic table is based on the properties of the elements and reflects the structure of atoms. As a basis for understanding this concept:

- a. *Students know* how to identify regions corresponding to metals, nonmetals, and inert gases.
- b. *Students know* each element has a specific number of protons in the nucleus (the atomic number) and each isotope of the element has a different but specific number of neutrons in the nucleus.
- c. *Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.

Density and Buoyancy

8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept:

- a. *Students know* density is mass per unit volume.
- b. *Students know* how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.
- c. *Students know* the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.
- d. *Students know* how to predict whether an object will float or sink.

Physics (High School)

Motion and Forces

1. Newton's laws predict the motion of most objects. As a basis for understanding this concept:

- a. *Students know* how to solve problems that involve constant speed and average speed.
- b. *Students know* that when forces are balanced, no acceleration occurs; thus an object continues to

- move at a constant speed or stays at rest (Newton's first law).
- Students know* how to apply the law $F = ma$ to solve one-dimensional motion problems that involve constant forces (Newton's second law).
 - Students know* that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).
 - Students know* the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.
 - Students know* applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (e.g., Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).
 - Students know* circular motion requires the application of a constant force directed toward the center of the circle.
 - * *Students know* Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.
 - * *Students know* how to solve two-dimensional trajectory problems.
 - * *Students know* how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.
 - * *Students know* how to solve two-dimensional problems involving balanced forces (statics).
 - * *Students know* how to solve problems in circular motion by using the formula for centripetal acceleration in the following form: $a = v^2/r$.
 - * *Students know* how to solve problems involving the forces between two electric charges at a distance (Coulomb's law) or the forces between two masses at a distance (universal gravitation).

Conservation of Energy and Momentum

- The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept:
 - Students know* how to calculate kinetic energy by using the formula $E = (1/2)mv^2$.
 - Students know* how to calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) $=mgh$ (h is the change in the elevation).
 - Students know* how to solve problems involving conservation of energy in simple systems, such as falling objects.
 - Students know* how to calculate momentum as the product mv .
 - Students know* momentum is a separately conserved quantity different from energy.
 - Students know* an unbalanced force on an object produces a change in its momentum.
 - Students know* how to solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.
 - * *Students know* how to solve problems involving conservation of energy in simple systems with various sources of potential energy, such as capacitors and springs.

Heat and Thermodynamics

- Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:
 - Students know* heat flow and work are two forms of energy transfer between systems.
 - Students know* that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.
 - Students know* the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as *thermal energy*. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.
 - Students know* that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.
 - Students know* that entropy is a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system.

- f. **Students know* the statement “Entropy tends to increase” is a law of statistical probability that governs all closed systems (second law of thermodynamics).
- g. ** Students know* how to solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings.

Waves

4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:
- a. *Students know* waves carry energy from one place to another.
 - b. *Students know* how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
 - c. *Students know* how to solve problems involving wavelength, frequency, and wave speed.
 - d. *Students know* sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
 - e. *Students know* radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second).
 - f. *Students know* how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

Electric and Magnetic Phenomena

5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:
- a. *Students know* how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
 - b. *Students know* how to solve problems involving Ohm’s law.
 - c. *Students know* any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula $\text{Power} = IR$ (potential difference) $\times I$ (current) = I^2R .
 - d. *Students know* the properties of transistors and the role of transistors in electric circuits.
 - e. *Students know* charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.
 - f. *Students know* magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
 - g. *Students know* how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.
 - h. *Students know* changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.
 - i. *Students know* plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.
 - j. **Students know* electric and magnetic fields contain energy and act as vector force fields.
 - k. ** Students know* the force on a charged particle in an electric field is qE , where E is the electric field at the position of the particle and q is the charge of the particle.
 - l. ** Students know* how to calculate the electric field resulting from a point charge.
 - m. **Students know* static electric fields have as their source some arrangement of electric charges.
 - n. ** Students know* the magnitude of the force on a moving particle (with charge q) in a magnetic field is $qvB \sin(a)$, where a is the angle between v and B (v and B are the magnitudes of vectors v and B , respectively), and students use the right-hand rule to find the direction of this force.
 - o. ** Students know* how to apply the concepts of electrical and gravitational potential energy to solve problems involving conservation of energy.