ARKANSAS
K-12 SCIENCE STANDARDS
EDUCATION FOR A NEW GENERATION

Fundamental Science Content
Physics Integrated

2023

The Arkansas K-12 Science Standards are available here. The standards are three-dimensional, consisting of a Science and Engineering Practice (SEP), a Disciplinary Core Idea (DCI), and a Cross Cutting Concept (CCC). By the end of the grade level, students should be able to demonstrate the full scope of the standard. Example:

SEP / DCI

P-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

CCC

The focus of this document is specifically on the science core ideas in Physics. In Arkansas K-12 Science Standards, science content is found in the DCI portion of each standard. Three-dimensional learning and assessment best prepares students for success so that students have the opportunity to demonstrate both what they know *and* can do in science. Refer to the full standards document to find the corresponding science and engineering practice and cross cutting concept for each standard. The core ideas are organized into the following domains of science:

- Physical Science
- Life Science
- Earth & Space Science
- Engineering Technology & Applications of Science

Each domain contains core ideas organized into component ideas. By the end of Physics, students are expected to know the bulleted information under each component idea. Standards that address the bulleted information are included in parentheses and those with an asterisk include an engineering component.

3-Dimensions of Science Learning

What Students Do:

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

What Students Should Know:

Physical Science
PS 1: Matter & its Interactions
PS 2: Motion & Stability: Forces & Interactions
PS 3: Energy
PS 4: Waves & Their Applications in Technologies for Information Transfer

Life Sciences
LS 1: From Molecules to Organisms: Structures & Processes
LS 2: Ecosystems: Interactions, Energy, & Dynamics
LS 3: Heredity: Inheritance & Variation of Traits
LS 4: Biological Evolution: Unity & Diversity

Earth & Space Sciences
ESS 1: Earth's Place in the Universe
ESS 2: Earth's Systems
ESS 3: Earth & Human Activity

Engineering, Technology, & the Application of Science
ETS 1: Engineering Design
ETS 2: Links Among Engineering, Technology, Science, & Society

How Students Make Sense:

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

Physical Science

*Asterisks indicate best opportunities to integrate ETS performance expectations into content.

Motion and Stability
Forces & Motion
• Newton's second law accurately predicts changes in the motion (size and direction) of macroscopic objects. (P-PS2-1, P-PS2-2, P-PS1-1AR, P-ESS1-2, P-ESS1-4, P1-ETS1-2)
• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (P-PS2-6AR)
• In any system, total momentum is always conserved. If a system interacts with objects outside itself, the momentum of the object in the system can change; however, any such change is balanced by changes in the momentum of objects outside the system so that total momentum before and after the change remains constant. (P-PS2-6AR) • For objects moving in special motion such as rotating or spinning there is an equivalent quantity to linear motion. Momentum of the system is conserved linearly and rotationally. (P-PS2-4AR)
Types of Interactions
• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.(P-PS1-2AR, P-ESS1-2) (P-PS2-4)
Stability & Instability
• Systems often change in predictable ways; understanding the forces that drive the transformations and cycles within a system, as well as the forces imposed on the system from the outside, helps predict its behavior under a variety of conditions. (P-PS3-4)
• When a system has a great number of component pieces, one may not be able to predict much about its precise future. For such systems (e.g., with very many colliding molecules), one can often predict average but not detailed properties and behaviors (e.g., average temperature, motion, and rates of chemical change but not the trajectories or other changes of particular molecules). (P-PS3-4, P-PS3-1AR, P-PS3-2)
Energy
Definitions of Energy
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (P-PS2-2AR) (P-PS3-1) (P-PS5-1AR)
Conservation & Transfer of Energy
• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be

transported from one place to another and transferred between systems. (P-PS2-2AR) (P-PS3-1AR, P-PS3-3*) (P-PS2-5)
• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). Any object or system that can degrade with no added energy is unstable. Eventually it will do so, but if the energy releases throughout the transition are small, the process duration can be very long (e.g., long-lived radioactive isotopes). (P-PS3-4)
• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (P-PS2-2AR) (P-PS2-5)
Energy & Forces
• When two objects interacting through a force field change relative position, the energy stored in the force field is changed. (P-PS2-1AR, P-PS2-3AR, P-PS2-5AR) (P-PS3-2)
Energy in Everyday Life
• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. Machines are judged as efficient or inefficient based on the amount of energy input needed to perform a particular useful task. Inefficient machines are those that produce more waste heat while performing a task and thus require more energy input. It is therefore important to design for high efficiency so as to reduce costs, waste materials, and many environmental impacts. (P2-ETS1-3) (P-PS3-3, P3-ETS1-1) (P-PS5-2AR*, P-PS5-3AR)
• All forms of electricity generation and transportation fuels have associated economic, social, and environmental costs and benefits, both short and long term. (P-PS5-2AR*, P-PS5-3AR)
Waves
Wave Properties
• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.(P-PS4-1AR, P-PS4-2AR)
• The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties.(P-PS4-3AR)
• Resonance is a phenomenon in which waves add up in phase in a structure, growing in amplitude due to energy input near the natural vibration frequency. Structures have particular frequencies at which they resonate. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments. (P4-ETS1-4)
Waves in Information Technology
• Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, and scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. Knowledge of quantum physics enabled the development of semiconductors, computer chips, and lasers, all of which are now essential components

of modern imaging, communications, and information technologies. (Boundary: Details of quantum physics are not formally taught at this grade level.) (P-PS5-3AR)

Earth & Space Science

Earth's Place in the Universe
Earth and the Solar System
• Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to gravitational effects from, or collisions with, other objects in the solar system. (P-ESS1-4)

Engineering, Technology, and Applications of Science

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Engineering Design
Defining Engineering Problems
• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (P2-ETS1-3) (P3-ETS1-1, P3-ETS1-3)
• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (P2-ETS1-3) (P3-ETS1-1, P3-ETS1-3)
Developing Possible Solutions
• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (P2-ETS1-3) (P3-ETS1-2, P3-ETS1-4)
• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (P2-ETS1-3) (P4-ETS1-4)
Optimizing the Design Solution
• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (P1-ETS1-2) (P2-ETS1-3) (P5-ETS1-1)