Minnesota Science

Physics

Exploring phenomena or engineering problems 9P.1

1 **Asking questions and defining problems** 9P.1.1

1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read. 9P.1.1.1

1 Evaluate questions about the advantages and disadvantages of using digital transmission and storage of information.* ** (P: 1, CC: 7, CI: PS4, ETS1) Emphasis is on the tradeoffs involved in the transmission and storage of data elements. Examples of advantages may include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Examples of disadvantages may include issues of easy deletion, security, and theft. 9P.1.1.1.1

1 **Planning and carrying out investigations** 9P.1.2

1 Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena. 9P.1.2.1

1 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (P: 3, CC: 2, CI: PS2) Examples of contexts for investigations may include coils, motors, generators, and transformers. 9P.1.2.1.1

1 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system. (P: 3, CC: 3, CI: PS3) Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually may include mixing liquids at different initial temperatures or adding objects at different temperatures to water. 9P.1.2.1.2

Looking at data and empirical evidence to understand phenomena or solve problems 9P.2

2 **Analyzing and interpreting data** 9P.2.1

2 Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9P.2.1.1

2 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. (P: 4, CC: 2, PS: 2) Examples of data (including data from student investigations) may include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force. 9P.2.1.1.1

2 **Mathematics and Computational Thinking** 9P.2.2

2 Students will be able to use mathematics to represent physical variables and their relationships; compare mathematical expressions to the real world; and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds 9P.2.2.1

2 Apply mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. (P: 5, CC: 4, CI: PS2) Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples may include investigating changes in momentum before and after collisions in closed systems. 9P.2.2.1.1

2 Apply mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. (P: 5, CC: 1, CI: PS2) Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields and the forces on objects in the fields. 9P.2.2.1.2

2 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in or out of the system are known.** (P: 5, CC: 4, CI: PS3) Emphasis is on explaining the meaning of mathematical expressions used in the model for systems of two or three components. Forms of energy may include thermal energy, kinetic energy, and elastic potential energy . Computational models may include the creation or use of a simulation or the analysis of a data set. 9P.2.2.1.3

Developing possible explanations of phenomena or designing solutions to engineering problems 9P.3

3 **Developing and using models** 9P.3.1

3 Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others 9P.3.1.1

3 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). (P: 2, CC: 5, CI: PS3) Examples of phenomena at the macroscopic scale may include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above Earth, and the energy stored between two electrically-charged plates. Examples of models may include diagrams, drawings, descriptions, and computer simulations 9P.3.1.1.1

3 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between two objects and the changes in energy of the two objects due to the interaction and describe how these forces are present in phenomena. (P: 2, CC: 2, CI: PS3) Examples of models may include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other. Examples of phenomena may include motors, electromagnetic induction, speakers, generators, wireless charging, and induction cooktops. 9P.3.1.1.2

3 **Constructing explanations and designing solutions** 9P.3.2

3 Students will be able to use their understanding of scientific principles and the engineering design process to design solutions that meet established criteria and constraints.* 9P.3.2.2

3 Develop a computer simulation to demonstrate the impact of a proposed solution that minimizes the force on a macroscopic object during a collision.** (P: 6, CC: 2, CI: PS2, ETS1) Emphasis is on applying science and engineering principles and analyzing the energy conversions. Examples of a device may include a helmet, a parachute, an airbag, and packaging for safe shipping. 9P.3.2.2.1

3 Evaluate a solution to a complex energy-related problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, aesthetics, and maintenance, as well as social, cultural, and environmental impacts.* (P: 6, CC: 2, CI: PS3, ETS1) Examples of energy-related problems may be drawn from alternative energy, manufacturing , and transportation systems. 9P.3.2.2.2

Communicating reasons, arguments and ideas to others 9P.4

- 4 **Arguing from evidence** 9P.4.1
  - 4 Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counter arguments. 9P.4.1.1
    - 4 Evaluate the claims, evidence, and reasoning behind the argument that electromagnetic radiation can be described using either by a wave model or a particle model, and that for some phenomena one model is more useful than the other. (P: 7, CC: 4, CI: PS4) Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of phenomena may include resonance, interference, diffraction, and photoelectric effect. 9P.4.1.1.1

- 4 **Obtaining evaluating and communicating information** 9P.4.2
  - 4 Students will be able to read and interpret multiple sources to obtain information, evaluate the merit and validity of claims and design solutions, and communicate information, ideas, and evidence in a variety of formats. 9P.4.2.1
    - 4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (P: 8, CC: 2, CI: PS4) Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples may include medical imaging technology and communication devices. 9P.4.2.1.1
    - 4 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* (P: 8, CC: 2, CI: PS4) Examples of devices may include medical imaging technologies, cell phones, GPS, Doppler radar or solar cells that capture light and convert it to electricity. 9P.4.2.1.2