Secondary Physics 2 Endorsement Specs

Purpose

This endorsement, when attached to a current Secondary Education License, verifies that the individual has the skills and knowledge necessary to teach students in an advanced secondary physical science classroom and is required to teach Advanced Physics (AP, CE, and IB) courses. Those with this endorsement can also teach all the courses a Physics 1 endorsed educator can teach. NOTE: Advanced Physics (AP, CE, and IB) courses may also include additional requirements in order to be approved by the university or college board to teach.

Endorsement Prerequisites

To be eligible for this endorsement, candidates must meet the following prerequisites:

- Have a Secondary Education License
- Have the Secondary Science Core Endorsement
- Have the Secondary Physics 1 Endorsement

Endorsement Requirement Areas

The Science Core Endorsement has the following 2 requirement areas:

1. Advanced Quantitative Physics Reasoning Content Knowledge
2. Advanced Physics Content Knowledge

Endorsement Type

A professional endorsement will be awarded when all of the requirement areas have been met. An associate endorsement will be awarded if the applicant holds a professional Physics 1 endorsement **OR** has completed at least 1 of the 2 requirement areas.

Requirement Area Options

The different options available to complete each of the requirement areas are described below. Quick links to the requirement area competencies are linked in parentheses.

Requirement Area 1: Advanced Quantitative Physics Reasoning Content Knowledge (P2.1)

Complete <u>one</u> of the following options to show evidence of competency in this Requirement Area

University Courses

- Any 3+ credit university course (passed with a grade of C or higher) in Calculus I or higher
    - A course in Precalculus or Business Calculus does not meet this requirement

College Major (Meets Requirement Areas 1-2 for this endorsement)

- College Major in Physics or a Physics Variation (e.g. Physics, Astrophysics, Theoretical Physics, Nuclear Physics)
- Other College Majors may be approved for this endorsement with approval of USBE Science Specialist based on a transcript review

Requirement Area 2: Advanced Physics Content Knowledge (P2.2)

Complete one of the following options to show evidence of competency in this Requirement Area

University Courses

- Complete **TWO** 3+ credit university courses (passed with a grade of C or higher) in Advanced/Applied Physics in addition to the courses taken to meet Physics 1 Endorsement requirements (if applicable). Examples of course could include: Astronomy or Astrophysics; Electricity and Magnetism; Mechanical Engineering; Mechanics; Statics; Modern Physics; Thermodynamics; or Waves, Acoustics, and Sound
    - **NOTE:** Lab course is not required but recommended

College Major (Meets Requirement Areas 1-2 for this endorsement)

- College Major in Physics, Physics Education, or a Physics Variation (e.g. Physics, Astrophysics, Theoretical Physics, Nuclear Physics)
- Other College Majors may be approved for this endorsement with approval of USBE Science Specialist based on a transcript review

Requirement Area Competencies

The Secondary Physics 2 competencies are organized into 1 section:

1. **Physics 2 Core Ideas** – This endorsement is required to teach Advanced Physics (AP, CE, and IB) and high school physics elective courses. These competencies and requirements go above that of the core ideas found in the SEEd Physics Standards.
   P2.1 Advanced Quantitative Physics Reasoning
   P2.2 Advanced Physics Content Knowledge

Each of the requirement area competencies are described below. Quick links to each requirement area options are provided in the parentheses.

Requirement Area 1 - Advanced Quantitative Physics Reasoning Content Knowledge (Options)

Requirement Area P2.1: Advanced Quantitative Physics Reasoning

Area P2.1.A: Question, Methods, and Argumentation

- P2.1.A.a Identify a testable scientific question based on an observation, data, or a model
- P2.1.A.b Formulate a hypothesis or predict the results of an experiment.
- P2.1.A.c Identify experimental procedures that are aligned to a scientific question (which may include a sketch of a lab setup).
- P2.1.A.d Make observations or collect data from representations of laboratory setups or results, while attending to precision where appropriate.
- P2.1.A.e Identify or describe potential sources of experimental error.
- Explain how modifications to an experimental procedure will alter results.
- P2.1.A.f Make a scientific claim. and support it with evidence from experimental data.
- P2.1.A.g Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.
- P2.1.A.h Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.
- P2.1.A.i Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.

- P2.1.A.j Explain the connection between experimental results and chemical concepts, processes, or theories.
- P2.1.A.k Explain how potential sources of experimental error may affect the experimental results.

Area P2.1.B: Models, Data, Analysis, and Mathematical Routines

- P2.1.B.a Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only.
- P2.1.B.b Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopic level properties.
- P2.1.B.c Represent chemical phenomena using appropriate graphing techniques, including correct scale and units.
- P2.1.B.d Represent chemical substances or phenomena with appropriate diagrams or models (e.g., electron configuration).
- P2.1.B.e Represent visually the relationship between the structures and interactions across multiple levels or scales (e.g., particulate to macroscopic).
- P2.1.B.f Explain chemical properties or phenomena (e.g., of atoms or molecules) using given chemical theories, models, and representations.
- P2.1.B.g Explain whether a model is consistent with chemical theories.
- P2.1.B.h Explain the connection between particulate-level and macroscopic properties of a substance using models and representations.
- P2.1.B.i Explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties.
- P2.1.B.j Identify quantities needed to solve a problem from given information (e.g., text, mathematical expressions, graphs, or tables).
- P2.1.B.k Identify an appropriate theory, definition, or mathematical relationship to solve a problem.
- P2.1.B.l Explain the relationship between variables within an equation when one variable changes.
- P2.1.B.m Identify information presented graphically to solve a problem.
- P2.1.B.n Determine a balanced chemical equation for a given chemical phenomenon.
- P2.1.B.o Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (e.g., performing dimensional analysis and attending to significant figures).

Requirement Area 2 - Advanced Physics Content Knowledge (Options)

Requirement Area P2.2: Advanced Physics Content Knowledge

Area P2.2.A: Kinematics and Dynamics

- P2.2.A.a All forces share certain common characteristics when considered by observers in inertial reference frames.
- P2.2.A.b The acceleration of the center of mass of a system is related to the net force exerted on the system.
- P2.2.A.c The internal structure of a system determines many properties of the system
- P2.2.A.d At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
- P2.2.A.e Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles
- P2.2.A.f All forces share certain common characteristics when P2.2.A.g considered by

observers in inertial reference frames.
- P2.2.A.g The acceleration of an object interacting with other objects can be predicted.
- P2.2.A.h The acceleration of the center of mass of a system is related to the net force exerted on the system.

Area P2.2.B: Motion, Energy, and Momentum
- P2.2.B.a A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces), as well as a variety of other physical phenomena.
- P2.2.B.b Certain types of forces are considered fundamental.
- P2.2.B.c Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
- P2.2.B.d The acceleration of the center of mass of a system is related to the net force exerted on the system.
- P2.2.B.e All forces share certain common characteristics when considered by observers in inertial reference frames.
- P2.2.B.f Certain quantities are conserved, in the sense that the changes of those quantities in a given system are always equal to the transfer of that quantity to or from the system by all possible interactions with other systems.
- P2.2.B.g A force exerted on an object can change the kinetic energy of the object.
- P2.2.B.h A force exerted on an object can change the momentum of the object.
- P2.2.B.i Interactions with other objects or systems can change the total linear momentum of a system.
- P2.2.B.j Certain quantities are conserved, in the sense that the changes of those quantities in a given system are always equal to the transfer of that quantity to or from the system by all possible interactions with other systems.
- P2.2.B.k The linear momentum of a system is conserved.
- P2.2.B.l A force exerted on an object can cause a torque on that object.

Area P2.2.C: Electric Charge and Force
- P2.2.C.a Electric charge is a property of an object or a system that affects its interactions with other objects or systems containing charge
- P2.2.C.b Make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.
- P2.2.C.c Choose and justify the selection of data needed to determine resistivity for a given material.
- P2.2.C.d Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches.
- P2.2.C.e Apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed

Area P2.2.D: Mechanical Waves and Sound
- P2.2.D.a A wave is a traveling disturbance that transfers energy and momentum
- P2.2.D.b A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy.
- P2.2.D.c Interference and superposition lead to standing waves and beats.

Area P2.2.E: Astronomy and Astrophysics

- P2.2.E.a Patterns in ancient structures, instruments, philosophies, and civilizations influenced the study of astronomy.
- P2.2.E.b Patterns in telescopic data of various electromagnetic spectra to explain astronomical phenomena.
- P2.2.E.c Significance of historical and future space exploration as they relate to affecting leaps in technology, cultural cooperation, knowledge, and inspiration.
- P2.2.E.d Structure and properties of objects in our solar system and the zones they inhabit.
- P2.2.E.e Explain the formation of the solar system leading to differing proportions of matter and energy within varying areas of the system.
- P2.2.E.f Model gravitational force at varying scale and proportion that explain motion and interaction of objects in the solar system.
- P2.2.E.g Explain stability and change during the process of stellar evolution from birth to death of a star.
- P2.2.E.h Evidence from the Hertzsprung-Russell diagram to investigate properties (structure) of stars.
- P2.2.E.i Explain the patterns that describe the formation of the universe. Emphasize the scientific theory of the Big Bang and evidence that supports it.
- P2.2.E.j Evidence to support the existence of dark matter and dark energy.