High School Conceptual Progressions Model Course 1

**Narrative and Rationale:** This model course map is the first in a three-year course sequence that uses a customized version of the High School Conceptual Progressions model from NGSS Appendix K as the instructional year end goals. The PEs from year one were then arranged into six different bundles of PEs based on a conceptual flow throughout the year.

The understanding of the natural world both biological and non-biological starts with the understanding of matter, how it is constructed, and how it interacts and combines with other matter to make up all of the substances in the universe. Understanding the structure of and interactions between matter and the role energy has in changing or sustaining matter is essential. All life and earth processes have their foundation in matter and how it interacts, is constructed, and is altered. Energy plays a unique role in the understanding of matter. The addition or removal of energy from a system can change the physical motion of matter and in the right conditions, rearrange how matter is configured through the breaking and forming of bonds. The bundles for Course 1 seek to lay a foundation for understanding the complexities of the biological and physical domains by deeply understanding the driving principles that allow matter to exist and function as it does in the universe.

It is important to note that the practices and crosscutting concepts described are intended as end-of-instructional unit expectations and not curricular designations. Additional practices and crosscutting concepts should be used throughout instruction toward each bundle.

<table>
<thead>
<tr>
<th>Bundle 1: Interactions Between Objects (Macro)</th>
<th>Bundle 2: Electrical Forces and Matter or Interactions Between Particles</th>
<th>Bundle 3: Forces, Energy, and Motion</th>
<th>Bundle 4: Energy and Bonds</th>
<th>Bundle 5: Changes In Energy</th>
<th>Bundle 6: Electric and Electromagnetic Energy</th>
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<td>HS-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.</td>
<td>HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.</td>
<td>HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.</td>
<td>HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*</td>
<td>HS-PS2-5. 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.</td>
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<td>HS-PS2-4. Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects.</td>
<td>HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.</td>
<td>HS-PS2-2. Use 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.</td>
<td>HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.</td>
<td>HS-PS3-1. 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 and out of the system are known.</td>
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<td>HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and</td>
<td>HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.</td>
<td>HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*</td>
<td>HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*</td>
<td>HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wave length, and speed of waves traveling in various media.</td>
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<td>~4 weeks</td>
<td>HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is</td>
<td>HS-PS3-2. 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).</td>
<td>HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.</td>
<td>HS-PS5-1. Use mathematical representations to support a claim regarding relationships among the frequency, wave length, and speed of waves traveling in various media.</td>
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<td>HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal</td>
<td>HS-PS5-2. 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.</td>
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<td>HS-PS6-1. Use mathematical representations to support a claim regarding relationships among the frequency, wave length, and speed of waves traveling in various media.</td>
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<td>composition of matter in the universe.</td>
<td>important in the functioning of designed materials.¹</td>
<td>energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).</td>
<td>HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).</td>
<td>into smaller, more manageable problems that can be solved through engineering.¹</td>
<td>HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.</td>
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<td>HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.</td>
<td>HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.¹</td>
<td>HS-ESS2-3. Develop a model based on evidence of Earth’s interior to describe the cycling of matter by thermal convection.¹</td>
<td>HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.¹</td>
<td>HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.¹</td>
<td>HS-PS4-5. 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.¹</td>
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¹. The bundle only includes part of this PE; the PE is not fully assessable in a unit of instruction leading to this bundle.
The Big Bang theory is supported by evidence from the cosmic microwave background (the afterglow of the Big Bang), which is uniform in all directions and at a constant temperature. This provides the mathematical model to describe the interactions of matter and radiation within that system. The fact that a system's total energy is conserved even as the system changes, energy is continually transferred from one object to another and between its various forms.

The study of stars' light spectra and brightness characteristics allow identification of the elements involved, can be used to describe and predict chemical reactions.

The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of its environment.

Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow the identification of the presence of an element, even in microscopic quantities.

Atoms are charged subatomic particles, comprising of protons and neutrons, surrounded by electrons. The structure and interactions of matter at the bulk scale are determined by electrical forces between and within atoms.

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Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields electric charges or changing magnetic fields cause electric fields.

Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

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.

Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

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.

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At an atomic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

Energy cannot be destroyed, or created, but it can be transported from one place to another and transferred between systems.

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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.

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.

Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior.

The radioactive decay of unstable isotopes continually generates new energy within Earth’s crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

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.

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Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

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, 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.