Middle School Topic Model Course III

Narrative and Rationale: This course model arranges the Performance Expectations (PEs) outline in the third year of the California Integrated Middle School Model into four different bundles of PEs using a topical arrangement. The disciplinary core ideas of each eighth grade standard were used in this model to arrange units into topics. The authors found that the 8th grade PEs fell naturally into the following topic areas: forces and energy, energy in waves, mechanisms of diversity, and the changing Earth. The bundle focused on forces and energy was placed early in the year so that students' understandings developed may be used to explain phenomena within later units on the topics of waves, mechanisms of diversity, and the cosmos.

It is important to note that the SEPs and CCCs described are intended as end-of-unit expectations and not curricular designations. Additional SEPs and CCCs should be used throughout instruction in each unit.

Unit 1: Forces and Energy: How do objects affect other objects? **~ 8 weeks**	**Unit 2:** Energy in Waves: How do waves transfer energy and information? **~ 4 weeks**	**Unit 3:** Mechanisms of Diversity: What makes organisms different from one another? **~ 9 weeks**	**Unit 4:** Changing Earth: What has the history of Earth looked like? **~ 8 weeks**
MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* **MS-PS2-2.** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. **MS-PS2-3.** Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. **MS-PS2-4.** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **MS-PS2-5.** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. **MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. **MS-PS3-2.** Develop a model to describe that when the arrangement of objects	**MS-PS4-1.** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. **MS-PS4-2.** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. **MS-PS4-3.** Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	**MS-LS3-1.** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. **MS-LS4-1**. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.[1] **MS-LS4-2.** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.[1] **MS-LS4-3.** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evidence in the fully formed anatomy. **MS-LS4-4.** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving	**MS-LS4-1.** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.[1] **MS-LS4-2.** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.[1] **MS-ESS1-1.** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. **MS-ESS1-2.** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. **MS-ESS1-3.** Analyze and interpret data to determine scale properties of objects in the solar system. **MS-ESS1-4.** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

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interacting at a distance changes, different amounts of potential energy are stored in the system. **MS-ESS1-2.** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.[1] **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.		and reproducing in a specific environment. **MS-LS4-5.** Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. **MS-LS4-6.** Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.	**MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

1. The bundle only includes part of this PE; the PE is not fully assessable in a unit of instruction leading to this bundle.

Middle School Topics Model Course 3 Flowchart

Bundle 1

PS2.A as found in MS-PS2-1
- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).

PS2.A as found in MS-PS2-2
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

To ESS1.A in Bundle 4

PS2.B as found in MS-PS2-3
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

PS2.B as found in MS-PS2-4
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.

To ESS1.B in Bundle 4

PS2.B as found in MS-PS2-5
- Forces that act at a distance (electric and magnetic) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

PS3.A as found in MS-PS3-1
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.

PS3.A as found in MS-PS3-2
- A system of objects may also contain stored (potential) energy, depending on their relative positions.

To ESS1.B in Bundle 4

PS3.C as found in MS-PS3-2
- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

Bundle 2

PS4.A as found in MS-PS4-1
- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

PS4.A as found in MS-PS4-2
- A sound wave needs a medium through which it is transmitted.

PS4.B as found in MS-PS4-2
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

PS4.C as found in MS-PS4-3
- Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

ETS1.B as found in MS-ETS1-2
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of problem.

ETS1.B as found in MS-ETS1-4
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- Models of all kinds are important for testing solutions.

ETS1.C as found in MS-ETS1-4
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

Bundle 3

LS3.A as found in MS-LS3-1
- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.

LS3.B as found in MS-LS3-1
- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

LS4.A as found in MS-LS4-1
- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

LS4.A as found in MS-LS4-2
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.

LS4.A as found in MS-LS4-3
- Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

LS4.B as found in MS-LS4-4
- Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

LS4.B as found in MS-LS4-5
- In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

LS4.C as found in MS-LS4-6
- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

Bundle 4

LS4.A as found in MS-LS4-1
- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

LS4.A as found in MS-LS4-2
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.

ESS1.A as found in MS-ESS1-1
- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.

ESS1.A as found in MS-ESS1-2
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B as found in MS-ESS1-2 and MS-ESS1-3
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

ESS1.B as found in MS-ESS1-2
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

ESS1.B as found in MS-ESS1-1
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

ESS1.C as found in MS-ESS1-4
- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

ESS3.C as found in MS-ESS3-4
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

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ESS1.A as found in MS-ESS1-2
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B as found in MS-ESS1-2
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

ETS1.A as found in MS-ETS1-1
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

ETS1.B as found in MS-ETS1-3
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.

ETS1.C as found in MS-ETS1-3
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.