High School Conceptual Progressions Model Course II – Bundle 1
Matter and Energy in the Universe

This is the first bundle of the High School Conceptual Progressions Model Course II. Each bundle has connections to the other bundles in the course, as shown in the [Course Flowchart.]

Bundle 1 Question: This bundle is assembled to address the question "where do matter and energy in the universe come from?"

Summary

The bundle organizes performance expectations (PEs) with a focus on helping students understand matter and energy changes in the universe. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, but recognize that instruction is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs

The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth (ESS1.A as in HS-ESS1-3). An example is the star called the sun, which is changing and will burn out over a lifespan of approximately 10 billion years (ESS1.A as in HS-ESS1-1). Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and that process releases electromagnetic energy (ESS1.A as in HS-ESS1-3). These ideas connect to the concepts that nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy (PS1.C as in HS-PS1-8) and that forces at a distance are explained by fields permeating space that can transfer energy through space (PS2.B as in HS-PS2-4). This last idea also connects to the concept that when two objects interacting through a field change relative positon, the energy stored in the field is also changed (PS3.C as in HS-PS3-5), and the concept that 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 (PS2.B as in HS-PS2-4).

The engineering design concept that it is important to take into account a range of constraints when evaluating solutions (ETS1.B as in HS-ETS1-3) could be applied to several bundle DCIs, such as that forces at a distance are explained by fields that permeate space and that can transfer energy through space (PS2.B as in HS-PS2-4) and that nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy (PS1.C as in HS-PS1-8). Students can make connections through an engineering design task such as researching safety considerations for using magnetic resonance imaging or for dealing with waste from electricity production at nuclear power plants.

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of developing and using models (HS-PS1-8, HS-PS3-5, and HS-ESS1-1), using mathematical thinking (HS-PS2-4), and communicating information (HS-ESS1-3). Many other practice elements can be used in instruction.

Bundle Crosscutting Concepts

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the crosscutting concepts of Patterns (HS-PS2-4), Scale, Proportion, and Quantity (HS-ESS1-1), Energy and Matter (HS-PS1-8 and HS-ESS1-3), and Cause and Effect (HS-PS3-5). Many other crosscutting concept elements can be used in instruction.

All instruction should be three-dimensional.	
Performance Expectations HS-PS2-4 is partially assessable	HS-PS1-8. **Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.] 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.** [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.] HS-PS3-5. **Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.] HS-ESS1-1. **Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.] HS-ESS1-3. **Communicate scientific ideas about the way stars, over their life cycle, produce elements.** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.] 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.**
Example Phenomena	I got a sunburn when I went outside. Pictures of the sun make it look like a burning ball.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions to clarify and refine a model, an explanation, or an engineering problem. Students could *ask questions to clarify and refine a model* [for how] ***the light spectra and brightness of stars are used to identify compositional elements of stars***. HS-ESS1-3

Additional Practices Building to the PEs (Continued)	**Developing and Using Models** • Evaluate the merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. Students could *evaluate the merits and limitations of two different models in order to select or revise a model that best fits the evidence* [that] ***forces at a distance are explained by fields permeating space that can transfer energy through space***. HS-PS2-4 **Planning and Carrying Out Investigations** • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Students could *plan an investigation to produce data to serve as the basis for evidence* [that] ***forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space***. HS-PS2-4 **Analyzing and Interpreting Data** • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. Students could *compare and contrast various types of data sets to examine consistency of measurements* [for how] ***nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy***. HS-PS1-8 **Using Mathematical and Computational Thinking** • Create and/or revise a computational simulation of a phenomenon, designed device, process, or system. Students could *create a computational simulation of* ***the change in the energy stored in a field when two objects interacting through a field change relative position***. HS-PS2-4 **Constructing Explanations and Designing Solutions** • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Students could *apply scientific reasoning to link evidence to the claims* [for how] ***nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy***. HS-PS1-8 **Engaging in Argument from Evidence** • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. Students could *present an oral argument* [about how] ***nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy***. HS-ESS1-3

Additional Practices Building to the PEs (Continued)	**Obtaining, Evaluating, and Communicating Information** • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Students could *compare, integrate and evaluate sources of information* [for how] ***the sun is changing and will burn out over a lifespan of approximately 10 billion years***. HS-ESS1-1
Additional Crosscutting Concepts Building to the PEs	**Scale, Proportion, and Quantity** • Patterns observable at one scale may not be observable or exist at other scales. Students could construct an argument for how *patterns observable at one scale may not be observable at other scales* ***when two objects interacting through a field change relative position causing the energy stored in the field to change***. HS-PS3-5 **Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Students could develop a model representing *energy and matter flows into, out of, and within a system* [when] ***nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, release or absorption of energy***. HS-PS1-8 **Stability and Change** • Changes and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Students could *communicate information about changes and rates of change over very short or very long periods of time*, [such as how] ***the sun is changing and will burn out over a lifespan of approximately 10 billion years***. HS-ESS1-1
Additional Connections to Nature of Science	**Scientific Knowledge is Open to Revision in Light of New Evidence (SEP):** • Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. Students could construct an argument for how *most scientific knowledge is quite durable, but is subject to change based on new evidence and/or reinterpretation of existing evidence* [about how] ***nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy***. HS-ESS1-3 **Scientific Knowledge Assumes an Order and Consistency in Natural Systems (CCC):** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Students could construct an argument for [how the fact that] *scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do in the future* [affects our understanding of the origins of] ***elements heavier than iron.*** HS-ESS1-3

HS-PS1-8

Students who demonstrate understanding can:

HS-PS1-8. **Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [*Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.*]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students develop models in which they identify and describe* the relevant components of the models, including:	
		i.	Identification of an element by the number of protons;
		ii.	The number of protons and neutrons in the nucleus before and after the decay;
		iii.	The identity of the emitted particles (i.e., alpha, beta — both electrons and positrons, and gamma); and
		iv.	The scale of energy changes associated with nuclear processes, relative to the scale of energy changes associated with chemical processes.
2	Relationships		
	a	Students develop five distinct models to illustrate the relationships between components underlying the nuclear processes of 1) fission, 2) fusion and 3) three distinct types of radioactive decay.	
	b	Students include the following features, based on evidence, in all five models:	
		i.	The total number of neutrons plus protons is the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.
		ii.	The scale of energy changes in a nuclear process is much larger (hundreds of thousands or even millions of times larger) than the scale of energy changes in a chemical process.
3	Connections		
	a	Students develop a fusion model that illustrates a process in which two nuclei merge to form a single, larger nucleus with a larger number of protons than were in either of the two original nuclei.	
	b	Students develop a fission model that illustrates a process in which a nucleus splits into two or more fragments that each have a smaller number of protons than were in the original nucleus.	
	c	In both the fission and fusion models, students illustrate that these processes may release	

		energy and may require initial energy for the reaction to take place.
	d	Students develop radioactive decay models that illustrate the differences in type of energy (e.g., kinetic energy, electromagnetic radiation) and type of particle (e.g., alpha particle, beta particle) released during alpha, beta, and gamma radioactive decay, and any change from one element to another that can occur due to the process.
	e	Students develop radioactive decay models that describe* that alpha particle emission is a type of fission reaction, and that beta and gamma emission are not.

HS-PS2-4

Students who demonstrate understanding can:

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.** [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects.*]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical representations of phenomena to describe explanations.

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Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Theories and laws provide explanations in science.
- Laws are statements or descriptions of the relationships among observable phenomena.

Disciplinary Core Ideas

PS2.B: 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.
- 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.

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Observable features of the student performance by the end of the course:		
1	Representation	
	a	Students clearly define the system of the interacting objects that is mathematically represented.
	b	Using the given mathematical representations, students identify and describe* the gravitational attraction between two objects as the product of their masses divided by the separation distance squared $\left(F_g = -G\frac{m_1 m_2}{d^2}\right)$, where a negative force is understood to be attractive.
	c	Using the given mathematical representations, students identify and describe* the electrostatic force between two objects as the product of their individual charges divided by the separation distance squared $\left(F_e = k\frac{q_1 q_2}{d^2}\right)$, where a negative force is understood to be attractive.
2	Mathematical modeling	
	a	Students correctly use the given mathematical formulas to predict the gravitational force between objects or predict the electrostatic force between charged objects.
3	Analysis	
	a	Based on the given mathematical models, students describe* that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance.

	b	Students describe* that the mathematical representation of the gravitational field $\left(F_g = -G\frac{m_1 m_2}{d^2}\right)$ only predicts an attractive force because mass is always positive.
	c	Students describe* that the mathematical representation of the electric field $\left(F_e = k\frac{q_1 q_2}{d^2}\right)$ predicts both attraction and repulsion because electric charge can be either positive or negative.
	d	Students use the given formulas for the forces as evidence to describe* that the change in the energy of objects interacting through electric or gravitational forces depends on the distance between the objects.

HS-PS3-5

Students who demonstrate understanding can:

HS-PS3-5. **Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [*Assessment Boundary: Assessment is limited to systems containing two objects.*]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students develop a model in which they identify and describe* the relevant components to illustrate the forces and changes in energy involved when two objects interact, including:	
		i.	The two objects in the system, including their initial positions and velocities (limited to one dimension).
		ii.	The nature of the interaction (electric or magnetic) between the two objects.
		iii.	The relative magnitude and the direction of the net force on each of the objects.
		iv.	Representation of a field as a quantity that has a magnitude and direction at all points in space and which contains energy.
2	Relationships		
	a	In the model, students describe* the relationships between components, including the change in the energy of the objects, given the initial and final positions and velocities of the objects.	
3	Connections		
	a	Students use the model to determine whether the energy stored in the field increased, decreased, or remained the same when the objects interacted.	
	b	Students use the model to support the claim that the change in the energy stored in the field (which is qualitatively determined to be either positive, negative, or zero) is consistent with the change in energy of the objects.	
	c	Using the model, students describe* the cause and effect relationships on a qualitative level between forces produced by electric or magnetic fields and the change of energy of the objects in the system.	

HS-ESS1-1

Students who demonstrate understanding can:

HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [*Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]*

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS1.A: The Universe and Its Stars** • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. **PS3.D: Energy in Chemical Processes and Everyday Life** • Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. *(secondary)*	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students use evidence to develop a model in which they identify and describe* the relevant components, including:	
		i.	Hydrogen as the sun's fuel;
		ii.	Helium and energy as the products of fusion processes in the sun; and
		iii.	That the sun, like all stars, has a life span based primarily on its initial mass, and that the sun's lifespan is about 10 billion years.
2	Relationships		
	a	In the model, students describe* relationships between the components, including a description* of the process of radiation, and how energy released by the sun reaches Earth's system.	
3	Connections		
	a	Students use the model to predict how the relative proportions of hydrogen to helium change as the sun ages.	
	b	Students use the model to qualitatively describe* the scale of the energy released by the fusion process as being much larger than the scale of the energy released by chemical processes.	
	c	Students use the model to explicitly identify that chemical processes are unable to produce the amount of energy flowing out of the sun over long periods of time, thus requiring fusion processes as the mechanism for energy release in the sun.	

HS-ESS1-3

Students who demonstrate understanding can:

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [*Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.*]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Observable features of the student performance by the end of the course:			
1	Communication style and format		
	a	Students use at least two different formats (e.g., oral, graphical, textual, and mathematical) to communicate scientific information, and cite the origin of the information as appropriate.	
2	Connecting the DCIs and the CCCs		
	a	Students identify and communicate the relationships between the life cycle of the stars, the production of elements, and the conservation of the number of protons plus neutrons in stars. Students identify that atoms are not conserved in nuclear fusion, but the total number of protons plus neutrons is conserved.	
	b	Students describe* that:	
		i.	Helium and a small amount of other light nuclei (i.e., up to lithium) were formed from high-energy collisions starting from protons and neutrons in the early universe before any stars existed.
		ii.	More massive elements, up to iron, are produced in the cores of stars by a chain of processes of nuclear fusion, which also releases energy.
		iii.	Supernova explosions of massive stars are the mechanism by which elements more massive than iron are produced.
		iv.	There is a correlation between a star's mass and stage of development and the types of elements it can create during its lifetime.
		v.	Electromagnetic emission and absorption spectra are used to determine a star's composition, motion and distance to Earth.

HS-ETS1-3

Students who demonstrate understanding can:

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.**

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.

- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

ETS1.B: 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.

Crosscutting Concepts

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Observable features of the student performance by the end of the course:			
1	Evaluating potential solutions		
	a	In their evaluation of a complex real-world problem, students:	
		i.	Generate a list of three or more realistic criteria and two or more constraints, including such relevant factors as cost, safety, reliability, and aesthetics that specifies an acceptable solution to a complex real-world problem;
		ii.	Assign priorities for each criterion and constraint that allows for a logical and systematic evaluation of alternative solution proposals;
		iii.	Analyze (quantitatively where appropriate) and describe* the strengths and weaknesses of the solution with respect to each criterion and constraint, as well as social and cultural acceptability and environmental impacts;
		iv.	Describe* possible barriers to implementing each solution, such as cultural, economic, or other sources of resistance to potential solutions; and
		v.	Provide an evidence-based decision of which solution is optimum, based on prioritized criteria, analysis of the strengths and weaknesses (costs and benefits) of each solution, and barriers to be overcome.
2	Refining and/or optimizing the design solution		
	a	In their evaluation, students describe* which parts of the complex real-world problem may remain even if the proposed solution is implemented.	