E&M
NPTW

Joseph Calmer

Statics on a String

Forces with Tape

Materials

- (Scotch) Tape
- Marker
- Desk

Directions

- Place a “t” and a “b” on 2 pieces of tape
- Put 1 on desk (b-bottom),
- Then the other (t-top), on top of the “b”; that’s on the desk
- Pull apart
- Fill out a data collection grid

Data Collection grid

	Top	Bottom
Top		
bottom		

Identify when there is “attraction” and when there is a “repulsion”

Balloons on a string

Materials

- Balloon
  - Connected
  - loose
- String
- Packing Peanuts

Directions

Part A

- Charge up balloon
  - Interact with Materials
  - Can, wall, sugar…

Part B

- Charge up PVC, glass, rubber…
  - Interact with hanging Balloons
  - Packing Peanuts (Styrofoam)

Fun fly Stick

Materials

- Fun Fly Stick
- Almost anything else
  - Can
  - Balloon
  - Paper
  - Tinsel*

Directions

- The

Various directions and guidance

1. Rubber, Silk, and Styrofoam
Tie a Styrofoam peanut on a string, then charge up the rubber rod with a piece of fur. Bring the rod close, what is the effect?

Tie a Styrofoam peanut on a string, then charge up the glass rod with a piece of silk. Bring the rod close, what is the effect? Explain

2. Sugar Storm
Charge up a Balloon on your arm, hold it close to some sugar. What do you see?

3. Rolling can experiment
Charge up a Balloon on your arm, place the balloon near the sugar
Explain this effect with a diagram

4. Wall Grab
Charge up a Balloon on your arm, place on the wall

5. 2 Balloons
Charge up a Balloon on your arm
Place the charged balloon near a balloon on a string.

5.A Charge by induction Demo
a. Hang 2 balloons
b. Use one balloon, and charge up with a source (anot
balloon, a Fun Fly Stick, various rods…)
c. Carefully replace the hanging (Charged balloon (without touching)), when place near the other balloon, what is observed

6. Water Experiment
Bring a charged object close to a stream of water

7. Electroscope and Faraday Cage
Bring the charged Balloon next to an electroscope

*How does the electric field depend on distance?

*What happens if you touch the top. Explain

NGSS and Circuits

1st Connect to the framework

- Explicit and Implicit
  - "It is important to note, however, that the framework is not intended to define course structure, particularly at the high school level. "
  - "More generally, this framework should not be interpreted as limiting advanced courses that go beyond the material included here—all students at the high school level should have opportunities for advanced study in areas of interest to them, and it is hoped that, for many…"
- Appendix A: Conceptual Shifts
  - "…NGSS are intended to reflect a new vision for American science education."
  - Science is interconnected
  - Performance, not curriculum
  - Build Coherence
  - Focus on Depth
  - Science and Engineering are (~) integrated; in NGSS
  - Prepare for college
  - NGSS and CCSS are aligned

<u>Not</u> helpful, but…

- NGSS, by its nature, is fluid and class dependent (There is built in creativity for a school and teacher)
- This means a teacher has the onus and responsibility (we rely on SCAAPT, NPTW, and James (and others at the helm)
- This means creativity, but not standard (One can connect their own Practices (SEPs, for their classes) to a DCI; <u>phenomena</u> (local and meaningful)
- The focus is not specific content, but a general "coherent" view of science
- The most desirable outcome is for an engineering component; based on a content aspect

AAPT responses (on the Drafts)

- “We are in essence urging that NGSS not define precisely which practice would be assessed with which disciplinary core idea. Teachers may want to assess one cluster of practices in their classrooms, others might be assessed by district or state tests, and yet others by nationally normed assessments. The performance standards should be separated from the details of the assessment tools, which should build on, but should not dictate, performance expectations.”

1st Connect to the framework

- Explicit and Implicit
  - Instructional Segment 3
  - **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**
  - **HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields**
  - **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**
  - **PS-3-1, PS-3-3, PS4-5, ESS3-2, ESS3-3, ETS1-1 though 1-4**

HS-PS2 Motion and Stability: Forces and Interactions

HS-PS2 Motion and Stability: Forces and Interactions		
Students who demonstrate understanding can: **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.** [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K–12 Science Education*:		
Science and Engineering Practices **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)	**Disciplinary Core Ideas** **PS2.B: Types of Interactions** ▪ 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. (HS-PS2-5) **PS3.A: Definitions of Energy** ▪ "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5)	**Crosscutting Concepts** **Cause and Effect** ▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5)
Connections to other DCIs in this grade-band: **HS.PS3.A** (HS-PS2-5); **HS.PS4.B** (HS-PS2-5); **HS.ESS2.A** (HS-PS2-5)		
Articulation to DCIs across grade-bands: **MS.PS2.B** (HS-PS2-5) **MS.ESS1.B** (HS-PS2-5)		
California Common Core State Standards Connections:		

HS-PS3 Energy

HS-PS3 Energy

Students who demonstrate understanding can:

HS-PS3-2. **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.** [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

The performance expectations above were developed using the following elements from the NRC document *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 and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2)	**PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-2) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)	**Energy and Matter** • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Connections to other DCIs in this grade-band: **HS.PS1.A** (HS-PS3-2); **HS.PS1.B** (HS-PS3-2); **HS.PS2.B** (HS-PS3-2); **HS.ESS2.A** (HS-PS3-2)

Articulation to DCIs across grade-bands: **MS.PS1.A** (HS-PS3-2); **MS.PS2.B** (HS-PS3-2); **MS.PS3.A** (HS-PS3-2); **MS.PS3.C** (HS-PS3-2)

California Common Core State Standards Connections:

ELA/Literacy –

HS-PS3 Energy

HS-PS3 Energy

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 expectations above were developed using the following elements from the NRC document *A Framework for K–12 Science Education*:

Science and Engineering Practices

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 and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3–5)

Disciplinary Core Ideas

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. (HS-PS3–5)

Crosscutting Concepts

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. (HS-PS3–5)

Connections to other DCIs in this grade-band: **HS.PS2.B** (HS-PS3–5)

Articulation to DCIs across grade-bands: **MS.PS2.B** (HS-PS3–5); **MS.PS3.C** (HS-PS3–5)

California Common Core State Standards Connections:

ELA/Literacy –

WHST.9–12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3–5)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3–5)

WHST.9–12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3–5)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. ((HS-PS3–5)

Mathematics –

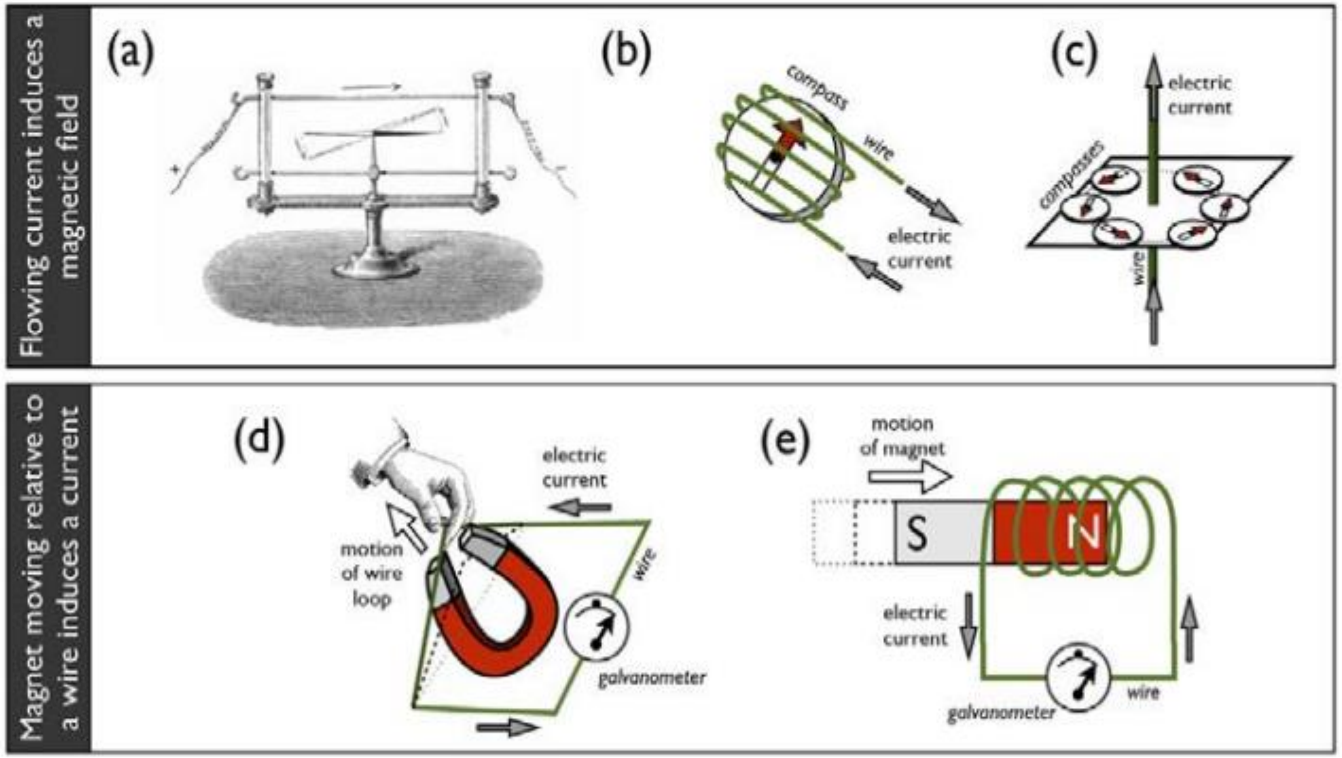
MP.2 Reason abstractly and quantitatively. (HS-PS3–5)

MP.4 Model with mathematics. (HS-PS3–5)

Explicit might be a reach

- Need to talk about energy, materials (periodicity, trends…), mass, forces, sources of energy…
  - Not to mention the non content: dimensional analysis, notation, measurement…
- The phenomena in the NGSS is a powerplant; for electricity production
  - This along with
  - Øerstead and Faraday
  - And…

Figure 7.52. Magnetic Fields and Electric Currents



(a): Øersted's experiment illustrates that an electric current generates a magnetic field. (b and c): Sensitive compasses can detect the magnetic field surrounding a current-carrying wire. (d): Moving a looped wire through a magnetic field generates a current within the wire. (e): Moving a magnet through a looped wire generates an electric current. ***Source*****: M. d'Alessio with images from Privat-Deschanel 1876, 656, fig. 456 and OpenClipart-Vectors 2013c.**

Long description of Figure 7.52.

The Frameworks describes: Student do many examples; use iron filings, use permanent magnets, construct vector diagrams. The focus is that "After gather evidence that an electric current creates a magnetic field, students should investigate if the reverse is true." (pg. 959)

Use all your NPTW demo suggestions

More to address

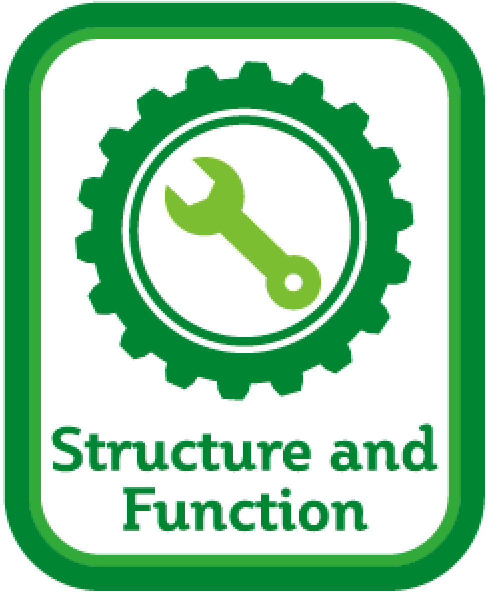
- “In essence, we believe that as a first approximation all science and engineering practices apply to all disciplinary core 7 ideas, while recognizing that the scope of widely-used assessments may need to focus on a relatively small number of practices to be associated with each disciplinary core idea.”
- The SEP and DCI is not meant to be a 1 to 1 correspondence (more flexibility for a teacher’s discretion?

Specifics to include- tie to your class objectives

- "Batteries, bulbs, motors, switches and modern high capacity capacitors provide an excellent area of study where students can construct devices and build simple qualitative and quantitative models of the behavior of electric circuits. Activities that emphasize construction, measurement, and modification of circuits could work well at the middle school level and high school level using the engineering practices. Circuits also provide very nice examples of conservation of energy and conservation of electrical charge."

- (The Ca NGSS Framework includes a lot of simulations and sample activities (not circuits directly though))

My Emphasis



- Students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials
- I think Statics and "Forces at a Distance" are one
  - The next step is Human manipulation of Charge; via engineering

CCC: Progressions

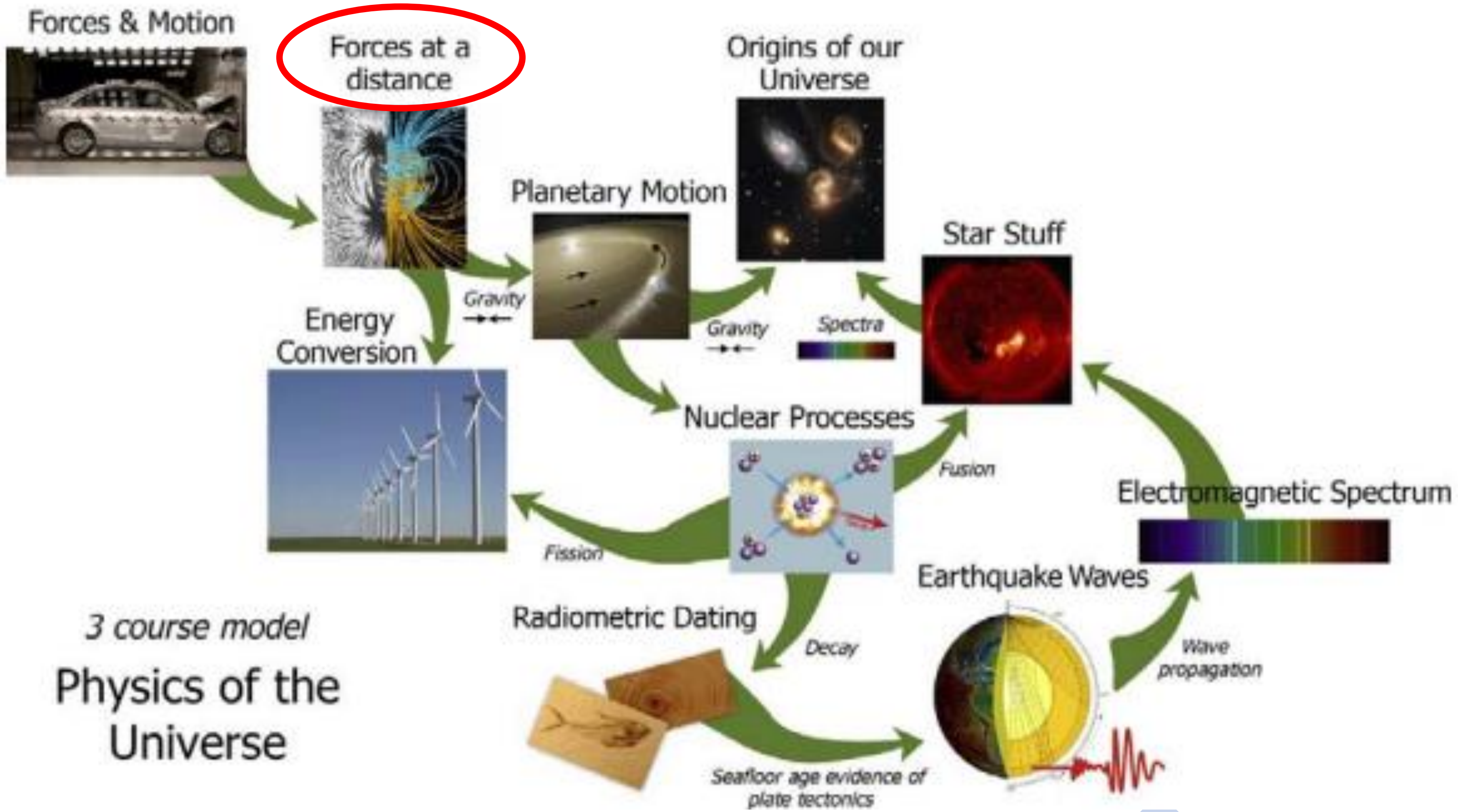
AAPT suggests

5. *Energy and Matter: Flows, Cycles, and Conservation* – Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ Objects may break into smaller pieces, be put together into larger pieces, or change shapes.	▪ Matter is made of particles. ▪ Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. ▪ Energy can be transferred in various ways and between objects.	▪ Matter is conserved because atoms are conserved in physical and chemical processes. ▪ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ▪ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). ▪ The transfer of energy can be tracked as energy flows through a designed or natural system.	▪ The total amount of energy and matter in closed systems is conserved. ▪ 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. ▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. ▪ Energy drives the cycling of matter within and between systems. ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

6. *Structure and Function* – The way an object is shaped or structured determines many of its properties and functions.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
▪ The shape and stability of structures of natural and designed objects are related to their function(s).	▪ Different materials have different substructures, which can sometimes be observed. ▪ Substructures have shapes and parts that serve functions.	▪ Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. ▪ Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Joey Uses

Figure 7.43. Conceptual Flow of Instructional Segments in Example High School Three-Course Model Physics of the Universe



Instructional Segment 2: Forces at a Distance

- Students investigate gravitational and electromagnetic forces and describe them mathematically. They predict the motion of orbiting objects in the solar system. They link the macroscopic properties of materials to microscopic electromagnetic attractions.
- Overview from CA Science Framework
- Bundled NGSS Standards for this Segment
- **Individual Performance Expectations included in this Segment:** HS-PS2-4, HS-PS2-6, HS-ESS1-4
- **Disciplinary Core Ideas in this Segment:**
  PS2.B: Types of Interactions
  ESS1.B: Earth and the Solar System
- **Guiding Questions:**
- How can different objects interact when they are not even touching?
- How do interactions between matter at the microscopic scale affect the macroscopic properties of matter that we observe?
- How do satellites stay in orbit?

The Summary

- NGSS are our standards
- The are nebulous
- Ongoing PD is actively encouraged
- NPTW and SCAAPT is a sources;
- Work like a scientist; pursuit is the drive…
- Intention is to show that science is more than a textbook of information

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Research shows professional development significantly improves implementation. To learn about professional development options and opportunities, visit https://create4stem.msu.edu/professional_learning or send an email to nextgenpbl@create4stem.org.

For more details about the NSF project that funded this curriculum, visit the Interactions project web page.

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