HS.PS-FE Forces and Energy

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Students who demonstrate understanding can:

a. Plan and carry out investigations in which a force field is mapped to provide evidence that forces can transmit energy across a distance. [Assessment Boundary: Mapping limited to the direction of the force field.]

b. Develop arguments to support the claim that when objects interact at a distance, the energy stored in the field changes as the objects change relative position. [Clarification Statement: An example of this phenomenon could include repelling magnets moving apart, reducing the repelling force and the strength of the field between them.] [Assessment Boundary: Qualitative comparisons only.]

c. Evaluate natural and designed systems where there is an exchange of energy between objects and fields and characterize how the energy is exchanged. [Clarification Statement: Examples of these systems could include motors, generators, speakers, microphones, planets orbiting a start.] [Assessment Boundary: Characterizations limited to qualitative descriptors.]

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 build, test, and revise conceptual, mathematical, physical and empirical models.
- Plan and carry out investigations individually and collaboratively and test designs as part of building and revising models, explaining phenomena, or testing solutions to problems. Consider possible confounding variables or effects, and ensure that the investigation's design has controlled for them. (a)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science.
- Evaluate the claims, evidence, and reasoning of currently accepted explanations or solutions as a basis for the merits of the arguments. (b)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 9–12 builds on 6–8 and progresses to evaluate the validity and reliability of the claims, methods, and designs.
- Generate, synthesize, communicate, and critique claims, methods, and designs that appear in scientific and technical texts or media reports. (c)

Disciplinary Core Ideas

PS3.C: Relationship Between Energy and Forces
- Force fields (gravitational, electric, and magnetic) contain energy and can transmit energy across space from one object to another. (a)
- When two objects interacting through a force field change relative position, the energy stored in the force field is changed. (b),(c)
- Each force between the two interacting objects acts in the direction such that motion in that direction would reduce the energy in the force field between the objects. However, prior motion and other forces also affect the actual direction of motion. (c)

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. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. Mathematical representations are needed to identity some patterns. (a),(b)
- [Clarification Statement for a: Mapping force fields requires evidence of the pattern of the field lines]
- [Clarification Statement for b: Coulomb's law: Proportion is a pattern.]
- [Clarification Statement for c: A pattern of energy transfer will be apparent.]

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (c)

Connections to other DCIs in this grade-level: **HS.ESS-SS, HS.ESS-ES, HS.ESS-CC, HS.ETS-ETSS**

Articulation to DCIs across grade-levels: **MS.PS-E**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA –

RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

RST.11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics –

MP.2 Reason abstractly and quantitatively.

MP.4 Model with Mathematics.

F.BF Build a function that models a relationship between two quantities.

A.CED Create equations that describe numbers or relationships.