HS. Forces and Interactions

A Performance Expectations HS.PS2.FI

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. HS.PS2.1

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. HS.PS2.2

3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. HS.PS2.3

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. HS.PS2.4

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.PS2.5

B Science and Engineering Practices HS.FI.SEP

1 Planning and Carrying Out Investigations HS.FI.SEP.1

a 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) HS.FI.SEP.1A

2 Analyzing and Interpreting Data HS.FI.SEP.2

a Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ▪ Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS- PS2-1) HS.FI.SEP.2A

3 Using Mathematics and Computational Thinking HS.FI.SEP.3

a Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) HS.FI.SEP.3A

4 Constructing Explanations and Designing Solutions HS.FI.SEP.4

a Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) HS.FI.SEP.4A

5 Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena HS.FI.SEP.5

a Theories and laws provide explanations in science. (HS-PS2- 1),(HS-PS2-4) HS.FI.SEP.5A

C Disciplinary Core Ideas HS.FI.DCI

1. PS2.A: Forces and Motion HS.FI.DCI.PS2.A
   a. Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) HS.FI.DCI.PS2.A.1
   b. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) HS.FI.DCI.PS2.A.2
   c. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) HS.FI.DCI.PS2.A.3
2. PS2.B: Types of Interactions HS.FI.DCI.PS2.B
   a. 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. (HS-PS2-4) HS.FI.DCI.PS2.B.1
   b. 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-PS2-4),(HS-PS2-5) HS.FI.DCI.PS2.B.2
3. ETS1.A: Defining and Delimiting Engineering Problems HS.FI.DCI.ETS1.A
   a. 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. (secondary to HS-PS2- 3) HS.FI.DCI.ETS1.A.1
4. ETS1.C: Optimizing the Design Solution HS.FI.DCI.ETS1.C
   a. 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. (secondary to HS-PS2-3) HS.FI.DCI.ETS1.C.1

D Crosscutting Concepts HS.FI.CC

1. Patterns HS.FI.CC.1
   a. 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. (HS-PS2-4) HS.FI.CC.1A
2. Cause and Effect HS.FI.CC.2
   a. Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HSPS2-5) HS.FI.CC.2A
   b. Systems can be designed to cause a desired effect. (HSPS2-3) HS.FI.CC.2B
3. Systems and System Models HS.FI.CC.3
   a. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) HS.FI.CC.3A