WNY 2014 Regents Physics Analysis

NYS Section AAPT Fall Meeting
Siena College, Loudonville, NY

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Why analyze assessment data?

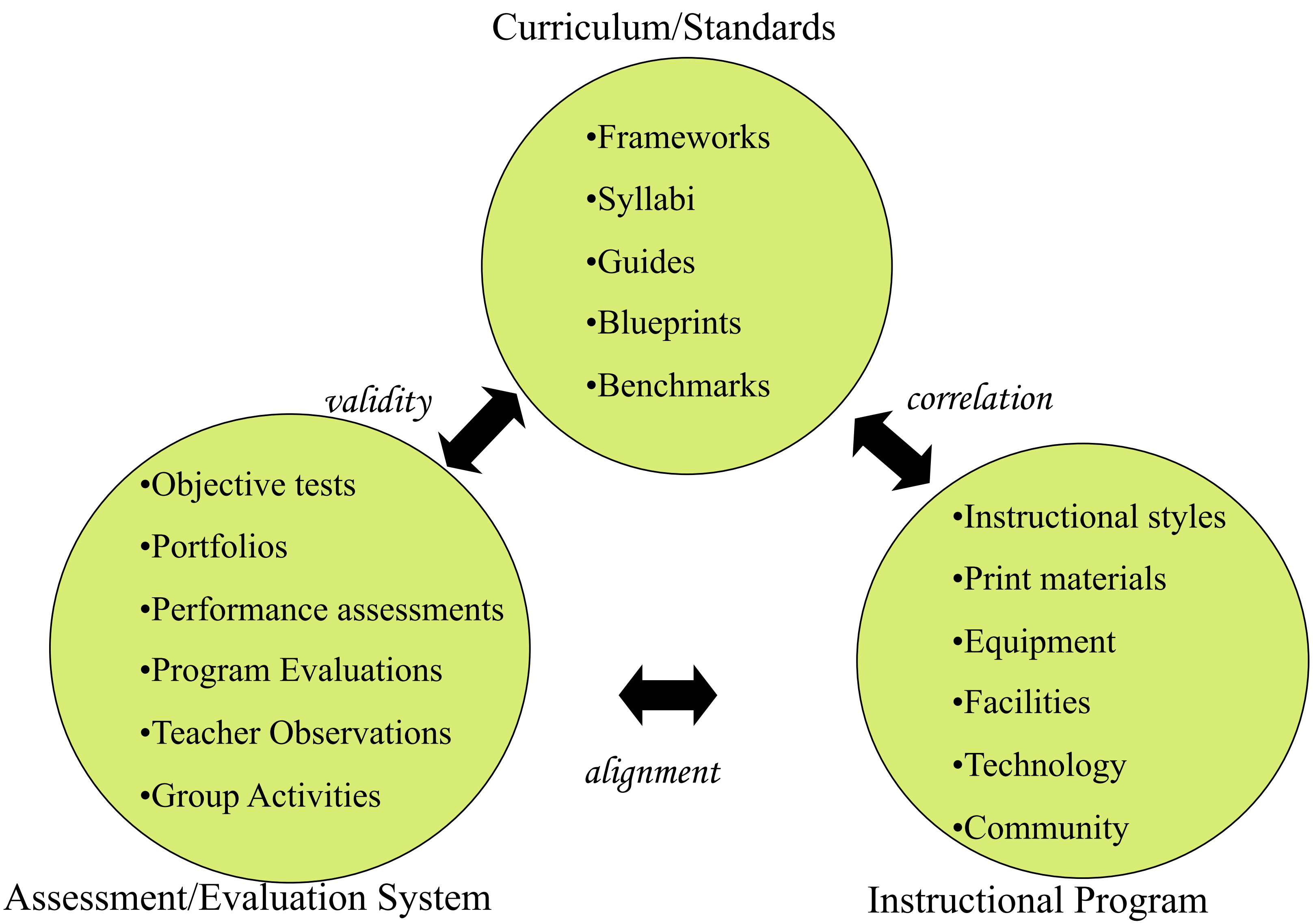
- Pendulum Motion – where is the emphasis?
  1. Technical details (using stop watches, meter sticks)
  2. Data recording (creating, completing tables)
  3. Data analysis (summarizing group results)
  4. Data analysis (summarizing class results)
  5. Constructing understanding of motion from data

Estimating Item Difficulty is Challenging

- van de Watering, G. & van der Rijt, (2006) Teachers' and students' perceptions of assessments: A review and a study into the ability and accuracy of estimating the difficulty levels of assessment items. J. Educational Research Review Vol .1, No. 2, pp. 133–147
- Impara, J., & Plake, B. (1998) Teachers' Ability to Estimate Item Difficulty: A Test of the Assumptions in the Angoff Standard Setting Method, *Journal of Educational Measurement, Vol. 35, No. 1*, pp. 69-81

Objectives

1. To increase student success on science assessments
   a) Knowledge
   b) Skills
2. Methods
   a) Analysis of Student Performance (Aggregate)
   b) Program Review/Brainstorming Teaching Strategies
   c) Implementation of Changes
   d) Evaluation of Efficacy


Curriculum/Standards
•Frameworks
•Syllabi
•Guides
•Blueprints
•Benchmarks
validity
correlation
•Objective tests
•Portfolios
•Performance assessments
•Program Evaluations
•Teacher Observations
•Group Activities
alignment
•Instructional styles
•Print materials
•Equipment
•Facilities
•Technology
•Community
Assessment/Evaluation System
Instructional Program

Assessment Formats

- Classroom Measures
  - **Formative**
    - Embedded assessments
    - Prediction activities (predict/observe/explain)
    - Whiteboard activities
    - Informal assessments
    - Documentation and record keeping
  - **Summative**
    - Final assessments
      - hands-on
      - pencil-and-paper
- Statewide Assessments
  - Multiple Choice
  - Short Constructed Response
  - Open-Ended

ITEM ANALYSIS

- Select Target Areas for Improvement
  - Overview
    - Areas of success
    - Areas for improvement
  - Suggest Program Revision
    - Brainstorm Instructional Strategies
    - Implement Strategies/Interventions
    - Evaluate Intervention Efficacy

Difficulty, Discrimination, Response Pattern

Test Score	Item Score
100	1
95	1
90	1
70	0
65	0
60	0

Examples of “Easier” Items

4.1 Transmission of Energy

14 What is the resistance of a 20.0-meter-long tungsten rod with a cross-sectional area of 1.00×10^{-4} meter^2 at 20°C?

(1) $2.80 \times 10^{-5}\ \Omega$
*(2) $1.12 \times 10^{-2}\ \Omega$
(3) $89.3\ \Omega$
(4) $112\ \Omega$

Performance Indicator	All WNY (8089)
4.1m The factors affecting resistance in a conductor are length, cross-sectional area, . . .	91.62%

5.1 Patterns of Motion

7 A truck, initially traveling at a speed of 22 meters per second, increases speed at a constant rate of 2.4 meters per second^2 for 3.2 seconds. What is the total distance traveled by the truck during this 3.2-second time interval?

(1) 12 m
(2) 58 m
(3) 70. m
* (4) 83 m

Performance Indicator	All WNY (8089)
5.1d An object in linear motion may travel with a constant velocity or with acceleration.	90.65%

5.1 Patterns of Motion

4 What is the time required for an object starting from rest to fall freely 500. meters near Earth's surface?

(1) 51.0 s
(2) 25.5 s
* (3) 10.1 s
(4) 7.14 s

Performance Indicator	All WNY (8089)
5.1e An object in free fall accelerates due to the force of gravity. . .	81.90%

5.1 Patterns of Motion

3 The components of a 15-meters-per-second velocity at an angle of 60.° above the horizontal are

(1) 7.5 m/s vertical and 13 m/s horizontal
* (2) 13 m/s vertical and 7.5 m/s horizontal
(3) 6.0 m/s vertical and 9.0 m/s horizontal
(4) 9.0 m/s vertical and 6.0 m/s horizontal

Performance Indicator	All WNY (8089)
5.1f The path of a projectile is the result of the simultaneous effect of the horizontal and . . .	82.24%

Examples of more challenging problems

4.1 Transmission of Energy

42 A 25-gram paper cup falls from rest off the edge of a tabletop 0.90 meter above the floor. If the cup has 0.20 joule of kinetic energy when it hits the floor, what is the total amount of energy converted into internal (thermal) energy during the cup's fall?

* (1) 0.02 J	(3) 2.2 J
(2) 0.22 J	(4) 220 J

Performance Indicator	All WNY (8089)
4.1f In a nonideal mechanical system, as mechanical energy decreases. . .	48.71%

4.1 Transmission of Energy

39 Which combination of units can be used to express electrical energy?

(1) $\frac{\text{volt}}{\text{coulomb}}$

(2) $\frac{\text{coulomb}}{\text{volt}}$

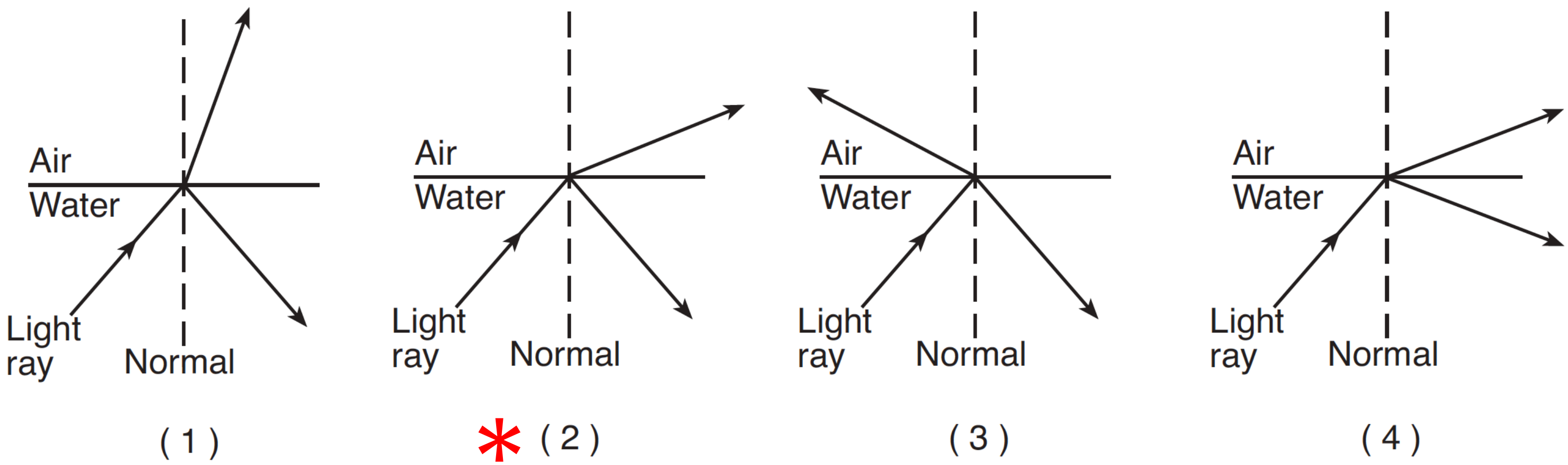
* (3) volt•coulomb

(4) volt•coulomb•second

Performance Indicator	All WNY (8089)
4.1p Electrical power and energy can be determined for electric circuits. . .	56.45%

4.3 Wavelength & Frequency

49 When a ray of light traveling in water reaches a boundary with air, part of the light ray is reflected and part is refracted. Which ray diagram best represents the paths of the reflected and refracted light rays?



Performance Indicator	All WNY (8089)
4.3h When a wave strikes a boundary between two media, reflection, transmission. . .	49.68%

5.1 Patterns of Motion

6 A 2.0-kilogram mass is located 3.0 meters above the surface of Earth. What is the magnitude of Earth's gravitational field strength at this location?

(1) 4.9 N/kg
(2) 2.0 N/kg
* (3) 9.8 N/kg
(4) 20. N/kg

Performance Indicator	All WNY (8089)
5.1e An object in free fall accelerates due to the force of gravity. . .	65.74%

5.1 Patterns of Motion

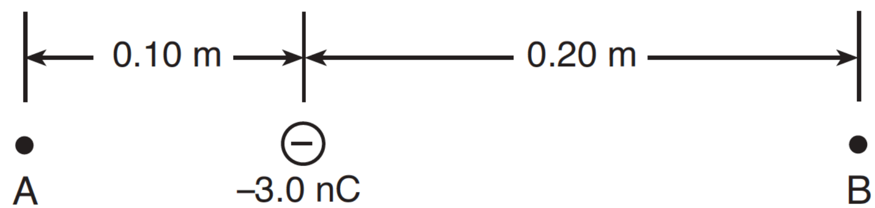
5 A baseball bat exerts a force of magnitude F on a ball. If the mass of the bat is three times the mass of the ball, the magnitude of the force of the ball on the bat is

* (1) F
(2) $2F$
(3) $3F$
(4) $F/3$

Performance Indicator	All WNY (8089)
5.1g A projectile's time of flight is dependent upon the vertical component of its motion.	53.76%

5.1 Patterns of Motion

33 Two points, *A* and *B*, are located within the electric field produced by a –3.0 nanocoulomb charge. Point *A* is 0.10 meter to the left of the charge and point *B* is 0.20 meter to the right of the charge, as shown in the diagram below.



Compared to the magnitude of the electric field strength at point *A*, the magnitude of the electric field strength at point *B* is

(1) half as great
(2) twice as great
* (3) one-fourth as great
(4) four times as great

Performance Indicator	All WNY (8089)
5.1u The inverse square law applies to electrical and gravitational fields. . .	54.33%

Standard 6

36 The height of a 30-story building is approximately

(1) 10^0 m

(2) 10^1 m

* (3) 10^2 m

(4) 10^3 m

Performance Indicator

I3 The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement

All WNY (8089)

56.36%

Lessons Learned…

- Plug & Chug problems are not enough and do not really solve the problem (particularly key for teachers teaching “outside” of their content area)
- Multistep problems are hard
- Sense making is hard
- Many hands-on experiences (with sense making) are needed for students to excel

Common Core Standards

Key Changes, ELA:

- Regular practice with complex texts and their academic language – across grade bands
- Reading, writing, and speaking grounded in evidence from texts, both literary and informational
- Building knowledge through content-rich nonfiction - the explosion of information and the ability to decipher that information is at the heart of this reform component. Students are expected to become familiar with

Common Core Standards

Key Changes, Mathematics:

- Greater focus on fewer topics – Grade specific foci include:
  - In grades K–2: Concepts, skills, and problem solving related to addition and subtraction
  - In grades 3–5: Concepts, skills, and problem solving related to multiplication and division of whole numbers and fractions
  - In grade 6: Ratios and proportional relationships, and early algebraic expressions and equations
  - In grade 7: Ratios and proportional relationships, and arithmetic of rational numbers
  - In grade 8: Linear algebra and linear functions
- Coherence - Linking topics and thinking across grades
- Rigor – pursue conceptual understanding

Common Core Standards

Resources:

- Standards (ELA & Math): http://www.corestandards.org/
- Science and Technology http://www.corestandards.org/ELA-Literacy/RST/introduction/
- Research Supporting Key Elements http://www.corestandards.org/assets/Appendix_A.pdf
- Text Exemplars and Tasks http://www.corestandards.org/assets/Appendix_B.pdf
- Student Samples http://www.corestandards.org/assets/Appendix_C.pdf
- Designing Math Courses http://www.corestandards.org/assets/CCSSI_Mathematics_Appendix_A.pdf

Common Core Standards

Resources (Continued):

- New York State CCLS: https://www.engageny.org.
- Sample lesson plan (LE): http://www.nysut.org/resources/special-resources-sites/common-core/lesson-plans
- *The Common Core Companion: The Standards Decoded, Grades 9-12 - What They Say, What They Mean, How to Teach Them*, by Jim Burke (2013).

Next Generation Science Standards

Five changes from the NGSS:

- More than facts
- Seeing the edifice
- Missing content
- Overturning states' standards
- College and career readiness

Next Generation Science Standards

Earth and Space Science:

- ESS1 - Earth's Place in the Universe
- ESS2 - Earth's Systems
- ESS3 - Earth and Human Activity

The Physical Science focus:

- PS1 - Matter and its Interactions (chemistry)
- PS2 - Motion and Stability: Forces and Interactions
- PS3 - Energy
- PS4 - Waves and their Applications in Technologies for Information Transfer

Next Generation Science Standards

Students who demonstrate understanding can:

HS-PS1-1. **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]

HS-PS1-2. **Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*]

HS-PS1-3. **Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.** [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*]

HS-PS1-4. **Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [*Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.*]

HS-PS1-5. **Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [*Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.*]

HS-PS1-6. **Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [*Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.*]

HS-PS1-7. **Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [*Assessment Boundary: Assessment does not include complex chemical reactions.*]

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.*]

Next Generation Science Standards

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 a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Planning and Carrying Out Investigations
Planning and carrying out investigations 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-PS1-3)

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 support claims. (HS-PS1-7)

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.
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter
- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), *(secondary to HS-PS2-6)*
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

PS1.B: Chemical Reactions
- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)

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. (HS-PS1-8)

PS2.B: Types of Interactions
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3)*

ETS1.C: Optimizing the Design Solution
- 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-PS1-6)*

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. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Energy and Matter
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)
- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)
- 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. (HS-PS1-4)

Stability and Change
- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

NGSS - Physics

PS2 - Motion and Stability: Forces and Interactions

- 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.
- 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.
- Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*
- Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
- 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.
- Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

NGSS - Physics

PS3 - Energy

- Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
- Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
- Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [
- Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
- 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.

NGSS - Physics

PS4 - Waves and their Applications in Technologies for Information Transfer

- Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]
- Evaluate questions about the advantages of using a digital transmission and storage of information.
- Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
- Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

NGSS – NYS (Next Steps)

- NYS Science Education Consortium
  - Meeting with Ken Wagner
  - Moving for adaptation (Decision by Board of Regents)
  - Potential for a year-long "development" phase (adaptation of NGSS for NYS Students)

NGSS Resources

- NGSS may be found at: http://www.nextgenscience.org/.
- (For comparison purposes, the NYS MST Learning Standards may be found at: http://www.p12.nysed.gov/ciai/mst/

Thank you

- Questions?
- For more information:

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