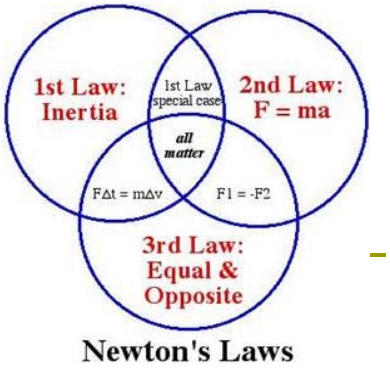
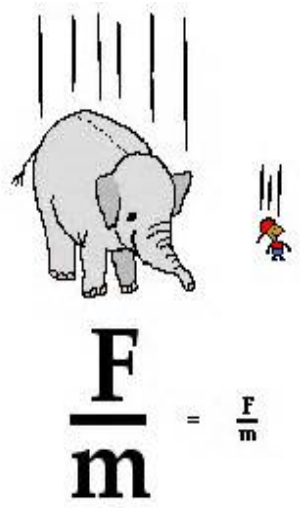
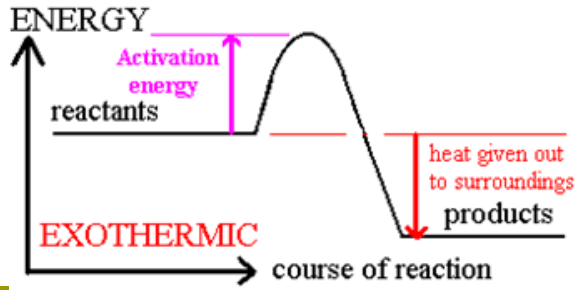
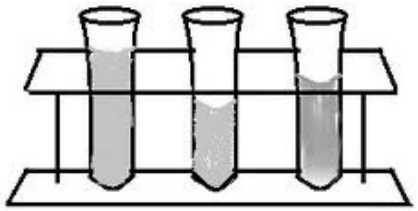








PS-21

Physical Science in the 21st Century

Second Fall Institute

November 4, 2016

University of Alabama, Tuscaloosa AL

J. W. Harrell, John Vincent, Rainer Schad, Dennis Sunal, Cynthia Sunal, Marilyn Stephens, Krystal Flantroy

PS-21 Website: http://ps21.ua.edu

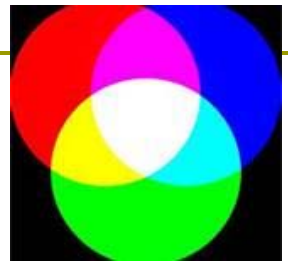
PS-21 Partners: Alabama Commission on Higher Education (ACHE), UA College of Arts and Sciences – Physics Department, Chemistry Department; UA College of Education, C&I Dept. – Science Education; AMSTI, Office of Research in the Disciplines; and Alabama City and County Schools

PS–21 First Fall Institute Day 2016- 2017:
Teaching Physical Science

Friday, November 4, 2016 at the *University of Alabama, 3408 SEC, Tuscaloosa AL*

- ***8:30 am:*** **Registration, Coffee, Agenda, Institute and CEU Credit sign-up, and *PS-21 update* and Concept Pre-tests**
- ***9:00-10:30: Concept–1)*** **Energy I-*Energy Transfer;*** ACOS #15, p. 41 … "analyze and interpret data… **engaging students & sharing teaching/learning ideas.**
- ***10:30 – 10:40:*** **Break**
- ***10:40-12:20: Concept–2)*** **Energy II** - ACOS #13 p. 40; #11 p. 44 "**create and analyze graphs of data** to show **relationships of energy, mass, and velocity." + engaging students & sharing teaching/learning ideas.**
- ***12:20 – 1:30: Lunch***
- ***1:30-2:50: Concept–3)*** **Matter and its Interactions I-** ***??***
- ***2:50– 3:20 Concept–4) Student Prior Knowledge;*** Using a prior knowledge lesson planning (formative) assessment tool – Diagnoser **+ developing lessons to motivate and engage students**
- ***3:30– 3:45: Wrap up,*** **Institute surveys, Feedback, post-tests, CEU Credits, & Institute graduate credit assignments**

PS–21 Resources: PS-21 Web Site

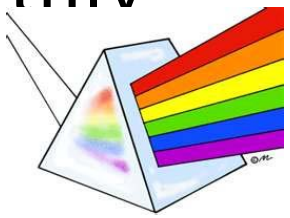


Website:PS-21

URL: http://ps21.ua.edu

Current activities and many resources

- Post your questions to be answered. Respond to other teachers questions
- Threaded discussions on physical science questions – e.g. light & color and other discussions.
- Request each teacher make a monthly posting to the discussion board at **http://ps21.ua.edu**



PS-21 Year long objectives

- Acquire and demonstrate greater and deeper 21st century content knowledge on key physics concept themes in the physical sciences found in the national and state standards,
- Acquire and implement in science classrooms effective teaching techniques aimed at facilitating students' meaningful understanding of physical science content [Science pedagogical content knowledge (PCK)]
- Use student inquiry labs and interactive approaches to model conceptual themes in the physical sciences
- Engage in professional development with both science content and pedagogy during the school year through varied venues as a means of maintaining and enhancing practice as highly qualified science teachers.

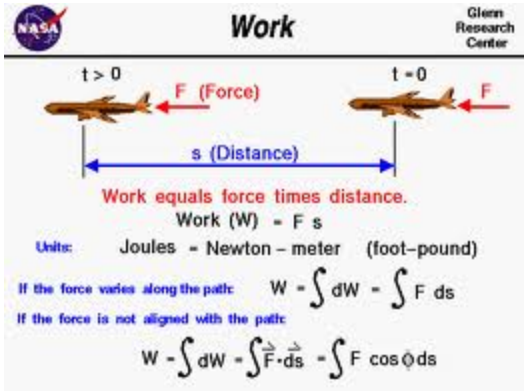
PS–21 Institute Objectives

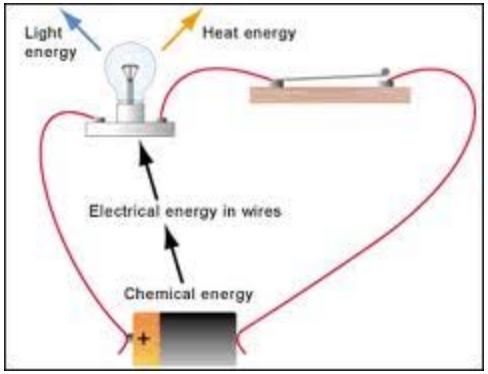
Experiencing, inquiring, using, and measuring to create meaningful learning of concepts in physical science through three questions:

1. **What misconceptions do your students bring to physical science and what should you do about them?**
2. **What engaging explanations and activities can be used in teaching the concepts?**
3. **What applications can be used with the concepts to assist application and transfer to the real world?**

Bring the following materials. We will use them with science concepts at this PS-21 Institute.

Bring lap top computer and/or a flash drive if you have one, you can bookmark URLs of useful sites on it. <u>We have lap top (netbooks) spares here if you need one.</u>





Websites to Accompany PS-21 Institute Activities

Concept 1: Newton's laws of motion - Force and motion, conservation of momentum

The Physics Classroom

NEWTON'S LAWS OF MOTION

http://www.physicsclassroom.com/SpecialPages/Search.aspx?searchtext=newton%27s+laws+&searchmode=

FORCE AND MOTION

http://www.physicsclassroom.com/SpecialPages/Search.aspx?searchtext=force%20and%20motion%20&searchmode=anyword

CONSERVATION OF MOMENTUM

http://www.physicsclassroom.com/SpecialPages/Search.aspx?searchtext=conservation%20of%20momentum%20&searchmode=anyword

PhET

NEWTON'S LAWS OF MOTION

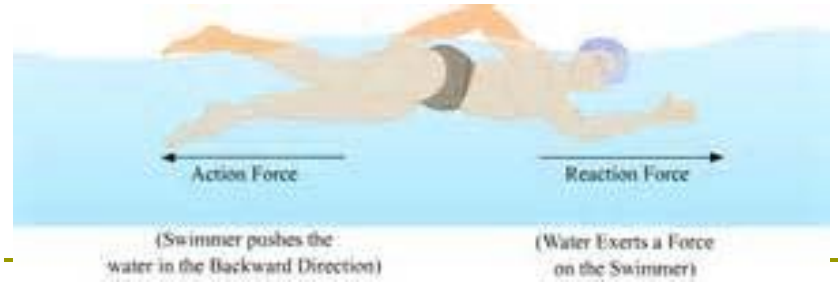
https://phet.colorado.edu/en/search?q=Newton%27s+laws

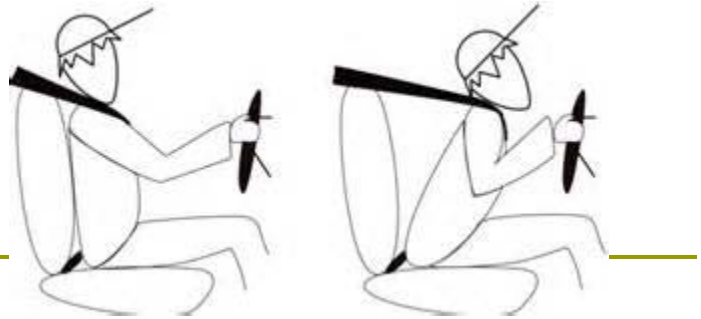
FORCE AND MOTION

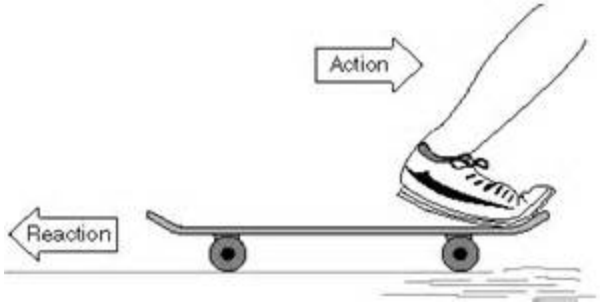
https://phet.colorado.edu/en/search?q=Force+and+motion+

CONSERVATION OF MOMENTUM

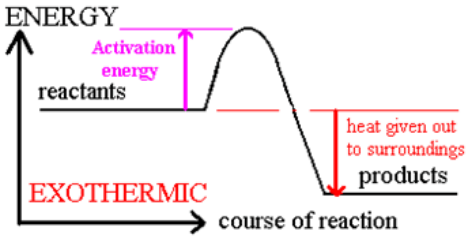
https://phet.colorado.edu/en/contributions/view/3318

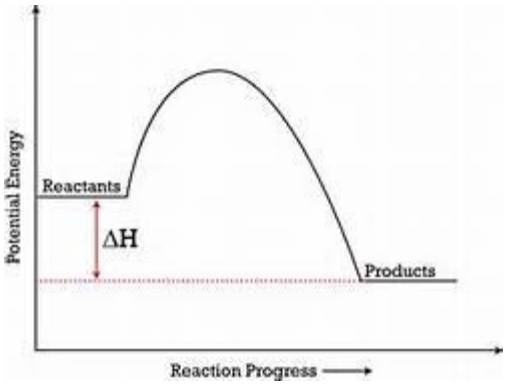

Action Force
Reaction Force
(Swimmer pushes the water in the Backward Direction)
(Water Exerts a Force on the Swimmer)

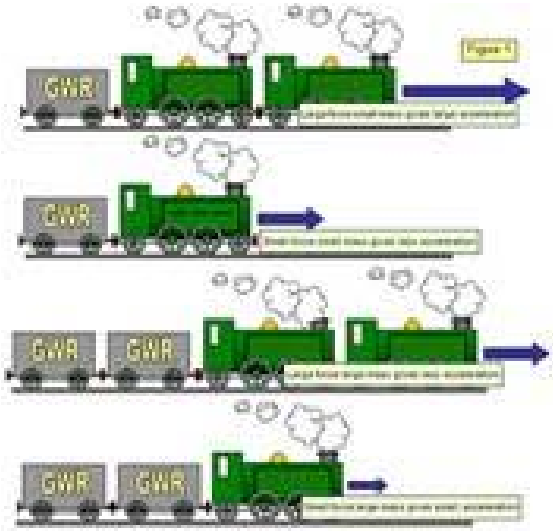


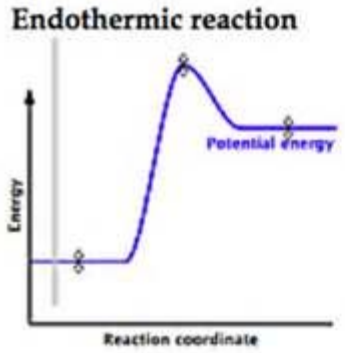

Action
Reaction

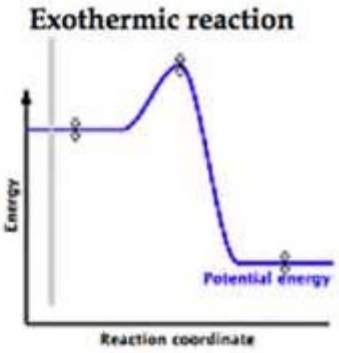

Chemical Reactions


ENERGY
Activation energy
reactants
heat given out to surroundings
products
EXOTHERMIC
course of reaction


Potential Energy
Reactants
ΔH
Products
Reaction Progress


GWR
GWR
GWR
GWR
GWR
GWR


Endothermic reaction
Potential energy
Energy
Reaction coordinate


Exothermic reaction
Potential energy
Energy
Reaction coordinate

Websites to Accompany PS-21 Institute Activities

Concept 1: Continued

- **Newton's Laws: Khan Academy :**

https://www.khanacademy.org/science/physics/forces-newtons-laws

- **Newton's Law: WebQuests**

http://www.mpsaz.org/stapley/staff/clewis/sc09assign/files/newton_webquest.pdf

http://mrhites1.weebly.com/uploads/1/0/4/4/10444331/newtons_laws_webquest_2014.pdf

http://kabittel.pbworks.com/w/page/37675557/Newton's%20Fun%20Park%20Webquest

- **Force & Motion Interactive:**

http://interactivesites.weebly.com/physics-and-motion.html

http://www.sciencechannel.com/games-and-interactives/newtons-laws-of-motion-interactive.htm

Hyper Physics:

http://hyperphysics.phy-astr.gsu.edu/hbase/newt.html#ntcon

Momentum Conversions:

http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html

Websites to Accompany PS-21 Institute Activities

Concept 3: Chemistry Demonstrations

- Chemistry PhETs
- Purdue Chemistry
- Khan Academy

Websites to Accompany PS-21 Institute Activities

Concept 3: Cont.

- Energy Education
- Definitions and Primer
- PS-21 Website
- Kids Web
- Movies and Animations
- Explanation

Websites to Accompany PS-21 Institute Activities

Concept 4: *Inquiry Lesson Planning with the Common Core and NGSS ideas*

- Common Core
- NGSS
- Inquiry Lessons from Office of Science Outreach
- Community Resources for Inquiry Teaching
- Exploratorium Institute for Inquiry
- Science Treasure Trove of Websites


Science and Engineering Practices
Disciplinary Core Ideas
Crosscutting Concepts
NEXT GENERATION
SCIENCE
STANDARDS

Why were these standards developed?

- NGSS Video

Developing the Standards

Groups Involved in the Writing of NGSS

Need for NGSS

- Current Standards are out of date
  - Advances in science & technology
  - Advances in understanding of learning
- College & Career Readiness
  - Lagging achievement of U.S. students
  - Demands of the Job Market
  - Global Competitiveness

The NGSS reflects a national need. What do you think the need is for new science standards for the students in your school and community?

Conceptual Shifts in NGSS

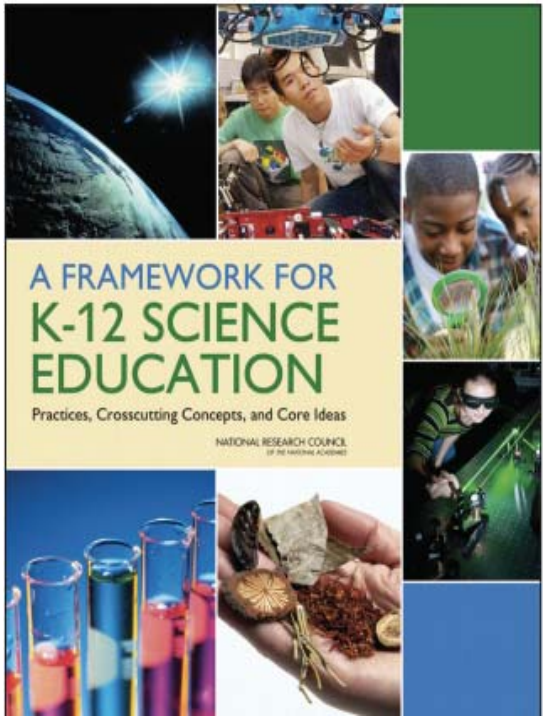
1. K-12 Science Education Should Reflect the Interconnected Nature of Science as it is Practiced and Experienced in the Real World.
2. The Next Generation Science Standards are student performance expectations – NOT curriculum.
3. The science concepts in the NGSS build coherently from K-12.
4. The NGSS Focus on Deeper Understanding of Content as well as Application of Content.

Science and Engineering are Integrated in the NGSS from K–12.

5. The NGSS are designed to prepare students for college, career, and citizenship.

6. The NGSS and Common Core State Standards (Mathematics and English Language Arts) are Aligned.

A Framework for K-12 Science Education



Three-Dimensions:

- **Scientific and Engineering Practices**
- **Crosscutting Concepts**
- **Disciplinary Core Ideas**

What Does NGSS Look Like?
Boxes with Information

Performance Expectations

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Cross-cutting Concepts

Foundation Boxes

Performance Expectations

MS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

MS-PS1-d. **Develop molecular models of reactants and products to support the explanation that atoms, and therefore mass, are conserved in a chemical reaction.** [Clarification Statement: Models can include physical models and drawings that represent atoms rather than symbols. The focus is on law of conservation of matter.] [Assessment Boundary: The use of atomic masses is not required. Balancing symbolic equations (e.g. N2 + H2 -> NH3) is not required.]

- Students are required to operate at the **intersection of practice, content, and connection.**
- Integrates the 3 dimensions
- Provides Specificity
- Sets tone for instruction – Coherent, Rigorous, Application of content, Problem Solving and Scientific Reasoning (NGSS page 4)

Performance Expectations, cont.

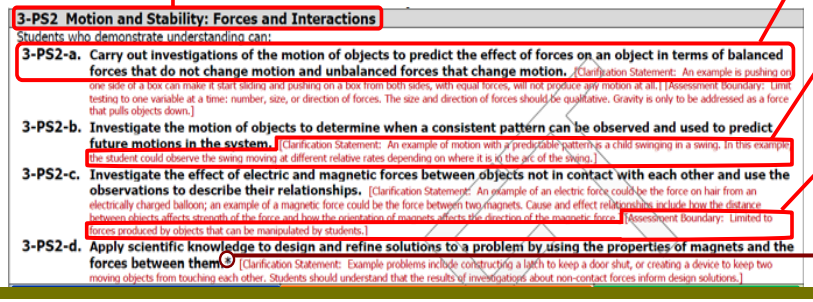
Inside the NGSS Box

What is Assessed

A collection of several performance expectations describing what students should be able to do to master this standard.

Title and Code

The titles of standard pages are not necessarily unique and may be reused at several different grade levels. The code, however, is a unique identifier for each set based on the grade level, content area, and topic it addresses.



Performance Expectations

A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned.

Clarification Statement

A statement that supplies examples or additional clarification to the performance expectation.

Assessment Boundary

A statement that provides guidance about the scope of the performance expectation at a particular grade level.

Engineering Connection (*)

An asterisk indicates an engineering connection

- Performance Expectations …
  - Are presented in collections to represent the standard
  - Include “clarification statements” of examples and further detail
  - Include “assessment boundaries” that define the scope for the grade level

Scientific and Engineering (Student) Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

DCI – Disciplinary Core Ideas

A core idea for K-12 science instruction is a scientific idea that:

- Has broad importance across multiple science or engineering disciplines or is a key organizing concept of a single discipline
- Provides a key tool for understanding or investigating more complex ideas and solving problems
- Relates to the interests and life experiences of students or can be connected to societal or personal concerns that require scientific or technical knowledge
- Is teachable and learnable over multiple grades at increasing levels of depth and sophistication

CCC – Cross Cutting Concepts

Crosscutting Concepts In NGSS

Crosscutting concepts bridge boundaries across the various sub-disciplines of science and engineering.

The crosscutting concepts provide students with an organizational framework for making sense of and connecting knowledge across the various science disciplines.

Cross Cutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

Common Core Ideas in the Framework: Physical Sciences - PS-21 Institute 11/4/16

PS1:Matter and its interactions

PS1A: Structure and properties of matter

PS1B:Chemical reactions

PS1C: Nuclear processes

PS2: Motion and stability: Forces and interactions

PS2A: Forces and motion

PS2B: Types of interaction

PS2C: Stability and instability in physical systems

PS2A: Forces and motion

Example 1

PS2.A: Forces and Motion

Key Question

How can one predict an object's continued motion, changes in motion, or stability?

Key Concept

Interactions of an object with another object can be explained and predicted using the concept of forces, which can cause a change in motion of one or both of the interacting objects.

PS1:Matter and Its Interactions

Example 2

- ***PS1.B: Chemical Reactions***

Key Question

Why are some physical systems more stable than others?

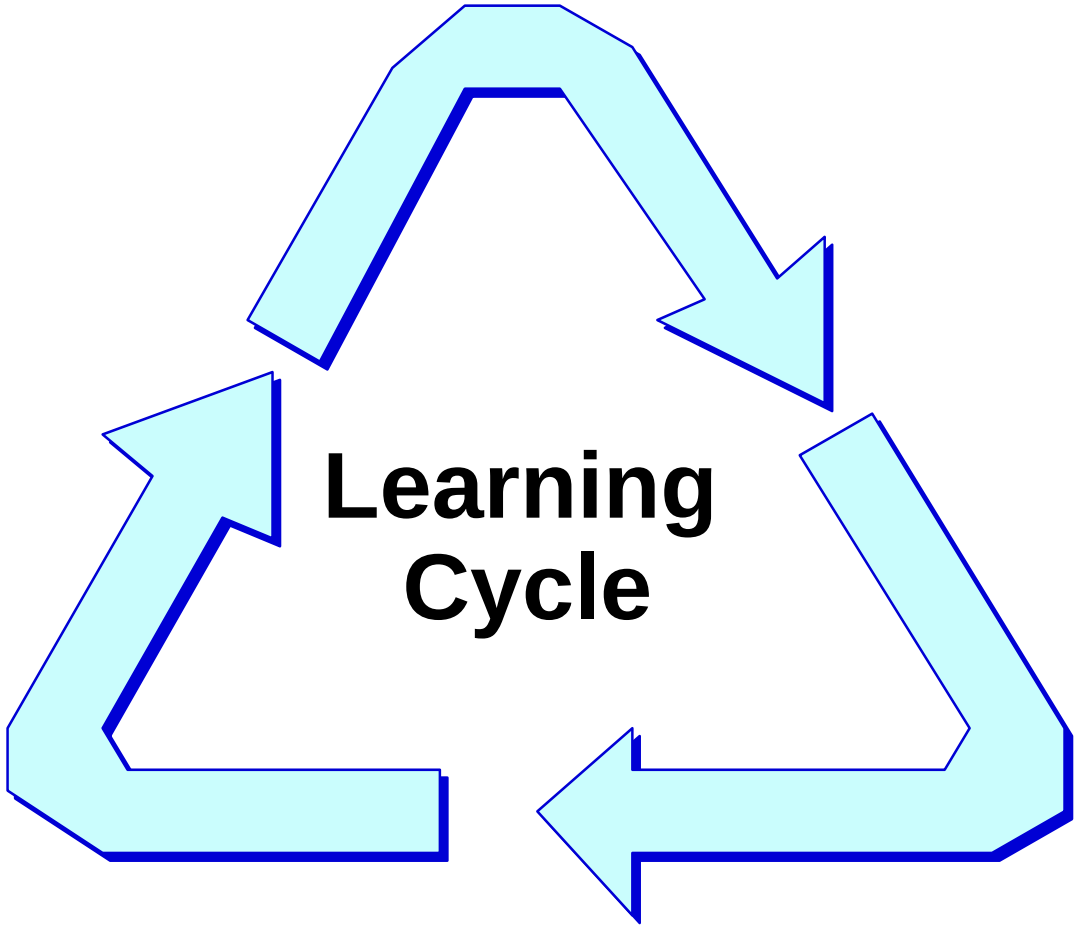
Key Concept

Many substances react chemically with other substances to form new substances with different properties. This change in properties results from the ways in which atoms from the original substances are combined and rearranged in the new substances. However, the total number of each type of atom is conserved.

PS–21 Resources: Next Generation Science Standards (NGSS) & Common Core Standards

- **The *Next Generation Science Standards (Practices, crosscutting concepts, and core ideas)* were released summer 2013 by the National Academies Press. The NGSS are based on the Common Core framework.**
- **These new core standards (NGSS) are designed to strengthen the National Science Education Standards and gradually replace them. Free access at http://www.nextgenscience.org/**
- **The Common Core Standards have already been developed in English-Language Arts and Math to teach science across all subjects. http://www.nap.edu/catalog.php?record_id=13165**

PS–21 Resources: Inquiry Instruction Sequence



Students Prior Knowledge

- Created from personal experiences
- Disagrees with scientific inquiry
- Partially valuable and useful in coping with everyday world
- Uses household meanings of scientific words
- Acquired from physical and social world
- Incorporated new facts with prior knowledge

Newton's laws of motion - force and motion, momentum misconceptions

- To sustain motion you must have a continuous input of force from outside the moving object. (Misconception with Newton's 1st Law

Big Misconception #1

- Object being pushed experience a larger force exerted by the imparter (e.g., a person) while the force exerted on the imparter by the object should "logically" be less (Misconception with Newton's 3rd Law)

Big Misconception #2

Newton's laws of motion - force and motion, momentum misconceptions

- **Faster moving objects have a larger force acting on them.**

  For more information, review "Common-sense concepts about motion," I. A. Halloun and D. Hestenes, Am. J. Phys. 53, 1056-1065 (1985).

- **A constant force is needed to keep an object moving at constant speed.**

  For more information review, (Sadanand &Ken, 1990; Twigger et al., 1994; Jung, 1981; Champne et al., 1980; Watts, 1983; Osborne, 1985)

FOR MORE INFORMATION ALSO REVIEW:

http://www.physics.montana.edu/physed/misconceptions/forces/forces.html

http://www.physicsclassroom.com/class/newtlaws/Lesson-3/The-Big-Misconception

http://assessment.aaas.org/topics/FM#/

Chemical interaction misconceptions

- Indications of a chemical change Misconception: “The substance changes in colour, mass and state, so it would appear to be obvious that a chemical change has taken place”.
- Big Misconception #1
- The mass has melted but the grams have decreased. The substance has melted so the mass has gone higher.”
- Big Misconception #2

What are Research Based Strategies in Teaching Force, Motion, and Chemistry Reaction Models

- It is important to teach what a model is and that all models are limited in specific ways (force, distance, transformation, concentration, etc.)
- Teaching should present students with cognitive conflict challenging their existing models.
- Then students should be offered a new “better” model that must be practiced.
- Next, the new model must impress the students by working when applied in new settings

- The new models must be simple ones that clearly relate to students prior knowledge.
- A great amount of experience is needed with predicting and measuring work or equilibrium in various contexts order to challenge prior ideas.
- Then, ask students to explain what and why these phenomena occur.
- Important to ask students to develop a generalized theory force, motion, and chemical transformations.

Using the LEARNING CYCLE to Plan Lessons*

- **EXPLORATION**
  - Confront existing knowledge - focus student's attention
  - Recall and relate previous knowledge in small groups
  - Try out prior knowledge in a new setting
- **INVENTION**
  - Reflect on and discuss the results of exploration
  - Use a variety of analogies
  - Provide examples and models
  - Provide closure
- **EXPANSION**
  - Provide additional student practice
  - Provide application and transfer skills
  - Provide summary

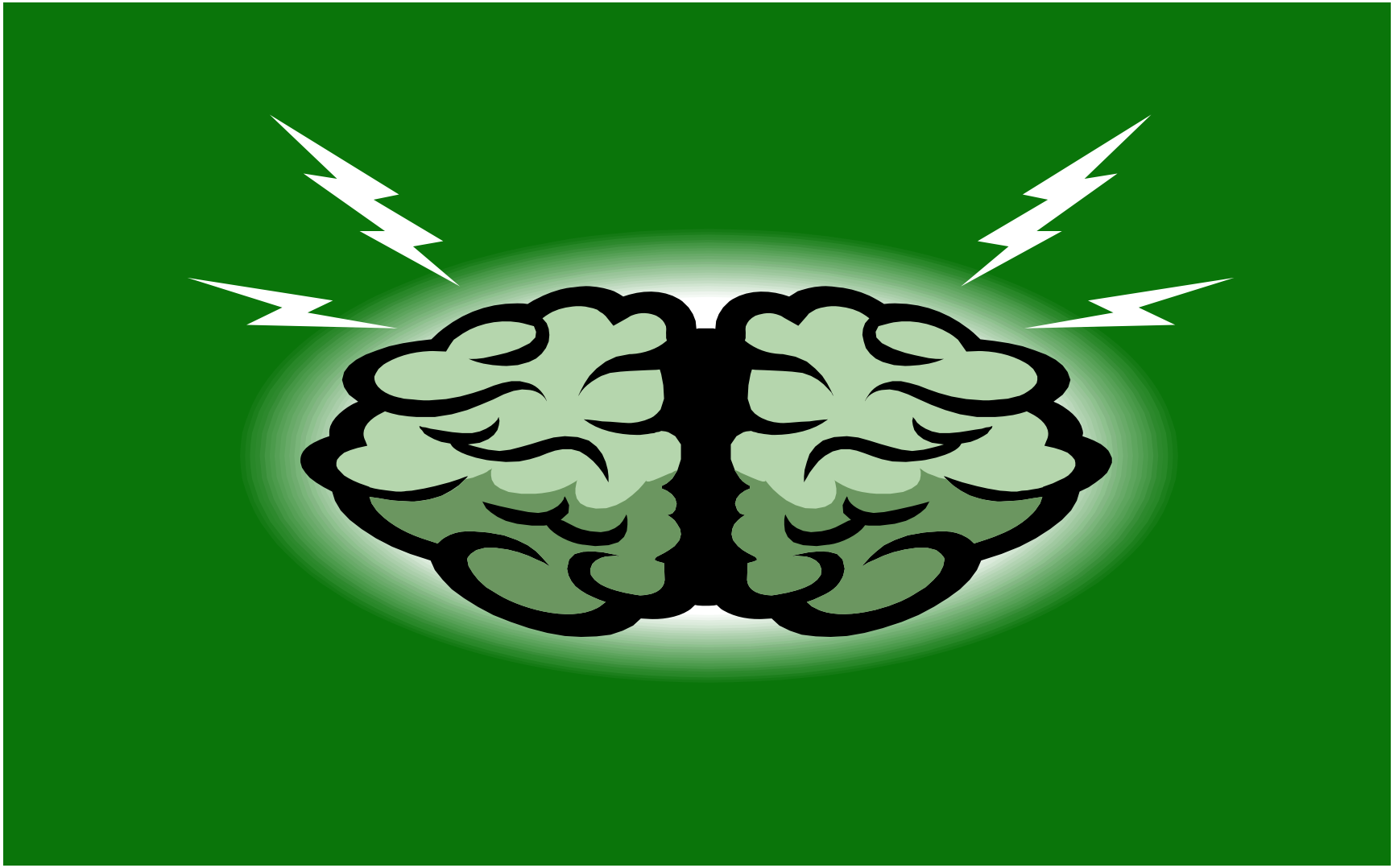
* See ALCOS - Science

Group Activity

Can you complete the task below?

Review the ideas and materials presented earlier for a Forceand Motion concept and **create / write** student activities that when sequenced form a **learning / teaching cycle** for the concept selected.

Brain Storm Some Lesson Ideas on One of the Workshop Concepts



How do I plan my lessons around these requirements?

Ask these questions when planning your lessons:

1) What do my students need to know? (Content)
2) What do my students need to do? (Practices)
3) To what other sciences is this topic related (Cross-cutting)
4) Where do I get the materials that I need to teach this? (ASIM, AMSTI, UA)
5) How do I assess the content knowledge and the science skills they learned? (Assessment)

PS-21 Internet General Resources

Table of Contents

PS–21 Resources:
1. PS-21 Web Site

Website:PS-21 WEEBLY
http://ps21pd.weebly.com/

- Current activities and many resources
- Post your questions to be answered. Respond to other teachers questions
- Threaded discussions on physical science questions – e.g. light & color and other discussions.
- Request each teacher make a monthly posting to the discussion board on **http://ps21pd.weebly.com/**

PS–21 Resources:
2. Pathway

1. **Pathway: Physics Teaching Web Advisory**

- http://www.physicspathway.org/
- Digital video library for physics teaching at secondary school level
- Four expert physics teachers provide expert advice in short scenes through synthetic interviews - Roberta Lang, Paul Hewitt, Chuck Lang, & Leroy Salary
- Related Videos are also available

PS–21 Resources:
3. Physics Front

K-8 Physical Science

Physics First

Conceptual Physics

http://www.thephysicsfront.org/items/detail.cfm?ID=2493

Some Topics

Education Foundations
- Alternative Conceptions

Modern Physics
- General

Oscillations & Waves
- Wave Motion
= Interference and Diffraction
= Longitudinal Pulses and Waves
= Phase and Group Velocity
= Transfer of Energy in Waves
= Transverse Pulses and Waves

Quantum Physics
-Probability, Waves, and Interference

PS–21 Resources:
4. AAAS 2061 Science Assessment

- Here you will find free access to more than 600 items. The items:
- Are appropriate for middle and early high school students.
- Test student understanding in the earth, life, physical sciences, and the nature of science.
- Test for common misconceptions as well as correct ideas.

http://assessment.aaas.org/

- This website also includes:
- Data on how well U.S. students are doing
- My Item Bank," a feature that allows you to select, save, and print items
- A feature that allows you to create and take tests online using items from the item collection

PS–21 Resources:
5. Physical Science Teaching Videos

Annenberg Free videos online

http://www.learner.org/resources/browse.html

- **The Missing Link: Essential Concepts for Middle School Math Teachers**

This video workshop for middle school math teachers covers essential topics missed in most U.S. math curricula.

- **Physics for the 21st Century**

A multimedia course for high school physics teachers, undergraduate students, and science enthusiasts; 11 half-hour programs, online text, facilitator's guide, and Web site.

- **The Science of Teaching Science**

This video workshop for new and veteran K-8 science teachers inspires them to explore new methods of teaching science.

- **Teaching High School Science**
- This video library for high school teachers shows the practice of effective inquiry teaching in the science classroom.

PS–21 Resources:
6. PS Resource Center URL

Physical Science Resource Center

- **http://www.compadre.org/psrc/**

Browse the PSRC by Subject:

- **- Astronomy**
- **- Education Practices**
- **- Electricity & Magnetism**
- **- General Physics**
- **- Modern Physics**
- **- Optics**
- **- Oscillations & Waves**
- **- Other Sciences**

PS–21 Resources:
7. The Physics Classroom Topics URL

Physics Topics

www.physicsclassroom.com/Class

- **The Physics Classroom Tutorial**
- **Multimedia Physics Studios**
- **Shockwave Physics Studios**
- **Minds on Physics Internet Modules**
- **Curriculum Corner**
- **The Laboratory**

- Physics Tutorials
  - 1-D Kinematics
  - Newton's Laws
  - Vectors - Motion and Forces in Two Dimensions
  - Momentum and Its Conservation
  - Work, Energy, and Power
  - Circular Motion and Satellite Motion

PS–21 Resources:
8. Physics Forums URL

Physics Forums: help in teaching science

- **http://physicsforums.com/**

- **Science Education**
- **Physics**
- **Astronomy & Cosmology**
- **Mathematics**
- **Engineering**
- **Chemistry**
- **Biology**
- **Other Sciences**

PS–21 Resources:
9. Physics-Related Websites

- American Association of Physics Teachers
  http://www.aapt.org.
- Alabama Section of AAPT http://bama.ua.edu/~alaapt/
- More links from AL/AAPT
  http://bama.ua.edu/~alaapt/links.htm
- Colorado http://phet.colorado.edu/index.php
- Campadre http://www.compadre.org/
- MERLOT http://www.merlot.org/merlot/index.htm
- American Physical Society educators' page
  http://www.aps.org/studentsandeducators/index.cfm
- Physics Central http://www.physicscentral.org/
- Particle physics http://particleadventure.org/
- Physics Teacher Education Coalition
  http://www.phystec.org/
- Live photo project http://livephoto.rit.edu/
- A good site for physics applets is:
  http://www.falstad.com/mathphysics.html

PS–21 Resources:
10. Interactive Science Simulations

Interactive, research based simulations of physical phenomena from the PhET project at the University of Colorado.

http://phet.colorado.edu/index.php

PS–21 Resources:
11. The Physical Science Classroom

- **Physical Science Activities** Teacher's Guides by Program Title

http://www.pbs.org/wgbh/nova/teachers/resources/title.html

- **Chemistry Activities – Videos**

http://www.pbs.org/wgbh/nova/teachers/resources/subj_02_03.html

Chemistry Activities – Videos

- **PBS-NOVA for Teachers**

PBS-NOVA for Teachers

http://www.pbs.org/wgbh/nova/teachers/

Bibliography

- Alabama State Department of Education. (2005). *Alabama Course of Study: Science*. Montgomery, AL: Alabama State Department of Education - http://alex.state.al.us/browseSC.php
- American Association for the Advancement of Science. (1993). *Benchmarks for scientific literacy*. New York: Oxford University Press. http://project2061.aaas.org/tools/benchol/bolframe.html
- American Association for the Advancement of Science (1990). *Science for all Americans.* New York: Oxford University Press. **http://www.project2061.org/tools/sfaaol/sfaatoc.htm**
- American Association for the Advancement of Science. (2001). *Atlas of scientific literacy*. Volume 1, New York: Oxford University Press. **http://www.project2061.org/tools/atlas/default.htm** **http://www.project2061.org/publications/atlas/sample/toc.htm** Table of Contents Vol 1 & 2 at **http://www.project2061.org/publications/atlas/media/combinedTOC.pdf**

Bibliography

- American Association for the Advancement of Science. (2001). *Atlas of scientific literacy*. Volume 2, New York: Oxford University Press. Accessed free online at http://www.project2061.org/publications/atlas/sample/toc2.htm
- Beisenherz, P. & Dantonio, M. (1996). *Using the learning cycle to teach physical science*, Portsmouth, NH: Heinemann Publishers.
- Driver, Squires, Rushworth, Wood-Robinson, (1994). *Making Sense of Secondary Science*, New York: Routledge.
- Driver, R. (1983). *The pupil as scientist*, Philadelphia: Open University Press,

Bibliography

- National Research Council (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (***Common Core***)*, Committee on Conceptual Framework for the New K-12 Science Education Standards. Washington D. C: National Academy Press. Accessed free online at http://www.nap.edu/catalog.php?record_id=13165
- National Research Council (2013). Next generation science standards (**NGSS**) Washington D. C: National Academy Press. **http://www.nextgenscience.org/**
- National Research Council (2000). *Inquiry and the national standards.* Washington D. C: National Academy Press. ISBN 0-309-06476-7 pbk & pdf. Accessed free online at http://www.nap.edu/booksearch.php?term=Inquiry+and+the+National+standards&isbn=030906533X&Search+This+Book.x=17&Search+This+Book.y=15

Bibliography

- National Research Council, (1996). *National science education standards*, Washington, DC: National Research Council. Accessed free online at http://www.nap.edu/readingroom/books/nses/html http://www.nap.edu/catalog.php?record_id=4962#toc/
- Sunal, D. & Wright E. (2011). (Series Eds.) *Research in Science Education:* DeBoer, G. (Ed. Vol. 5), *The role of public policy in K-12 science education*. Charlotte, NC: Information Age Publishing.
- Sunal, D., Sunal, C., & Wright, E. (Eds.). (2010). *Teaching Science with Hispanic ELLs in K-16 Classrooms.* Charlotte, NC: Information Age Publishing.
- Sunal, D., Wright, E., & Sundberg, C. (Eds.) (2008). *The impact of the laboratory and technology on learning and teaching science K-16.* Greenwich, CT: Information Age Publishing.

Bibliography

- Sunal, D. & Wright, E. (Eds.) (2006). *The impact of state and national standards on K-12 science teaching*, Greenwich, CT: Information Age Publishing.
- Sunal, C., Karr, C., & Sunal, D., (2003). Fuzzy logic, neural networks, genetic algorithms: Views of three artificial intelligence concepts used in modeling scientific systems, *School Science and Mathematics*, *103*(2), 81-91.
- Wright, E. and Govindarajan, G. (1992). *Teaching with scientific conceptual discrepancies*, Manhattan, KS: Kansas State University. (C/O Emmett Wright, College of Education, Bluemont Hall, Kansas State University, Manhattan, KS 1-913-532-7838)

Use of Analogies in Teaching Physical Science Concepts

- Analogies have both value and problems. You must judge the cost vs benefit.
- Students naturally use their own experience and generate analogies
- Biological, hydrodynamic, thermal, and mechanical analogies can be used. There are many traps and false conclusions with analogies.
- As with all analogies you must review or teach the analogy first – understand and experience it, then make specific connections.

- Important to use multiple analogies citing limitations in each.
- Research has shown some value in mechanical analogies
- Students applying ideas find it hard to recognize concepts in the practical analogy situations unless taught the analogy AND the science concept the analogy represents.

Teaching Strategy for Science Analogies

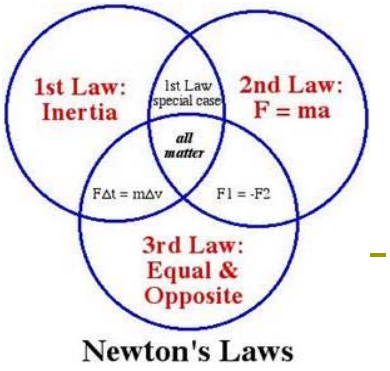
- Step 1--Introduce the concept to be learned
- Step 2--Review with the students' the analogous situation.
- Step 3--Identify the relevant features of the analog model.
- Step 4--Map out the similarities between the analog model and the concept.
- Step 5--Indicate where the analogy breaks down.
- Step 6--Draw conclusions about the concept.

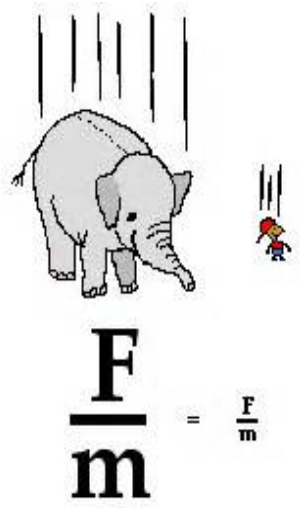
Planning Physical Science Lessons
General process

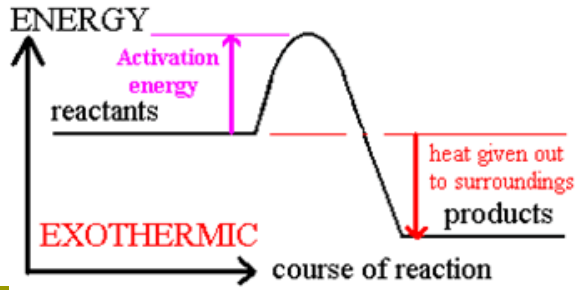
- Elicit student ideas
- Provide data to link student ideas to science concepts
- Have students present and defend their ideas
- Introduce scientific perspective
- Change context
- Have students apply and defend their new understanding
- Have students reflect on their learning

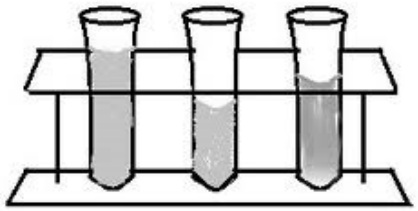
Feedback

- Status: How are you doing? What are you doing? What is coming up next in your planning?
- Planning: What are you now planning that relates to this workshop? How far are you along? Do you need any help?
- Light and Color Concepts: Do you see difficult physical science concepts coming up that we could discuss with you?
- Technical: What comments on problems do you have with using technology/internet materials or other technical questions?









PS-21

Physical Science in the 21st Century

Second Fall Institute

November 4, 2016

University of Alabama, Tuscaloosa AL

J. W. Harrell, John Vincent, Rainer Schad, Dennis Sunal, Cynthia Sunal, Marilyn Stephens, Krystal Flantroy

PS-21 Website: http://ps21.ua.edu

PS-21 Partners: Alabama Commission on Higher Education (ACHE), UA College of Arts and Sciences – Physics Department, Chemistry Department; UA College of Education, C&I Dept. – Science Education; AMSTI, Office of Research in the Disciplines; and Alabama City and County Schools