Ohio Science Academic Content Standards,  
Grade Level Indicators 
(Grade 9) 

Review Information for OGT study 

Standard: EARTH AND SPACE SCIENCES 

The Universe: 

Benchmark A 

Indicator # 1 

1. Describe that stars produce energy from nuclear reactions and that processes in stars have led to the formation of all elements beyond hydrogen and helium. 

Fission: Meaning … “Separating”… atoms split apart and they give off energy. 

Click on the link for an animation of the Fission processes.  
http://www.eas.asu.edu/~holbert/eee460/fission.html 

Fusion: Meaning … “Coming together”. 4 hydrogen’s come together to form He. 

***Fusion happens in the sun! 

Also… see explanation of Big Bang theory in the next indicator. 

Processes in the Sun due to high temperature and pressure have caused hydrogen and helium atoms to combine to form other heavier atoms. More than 60 elements have been identified in the sun’s gases. It is thought that all the naturally occurring elements are present in the sun. 

Click on the link for an animation of the Fusion processes.  
http://www.eas.asu.edu/~holbert/eee460/fusion.html
The H-R Diagram is a graph that shows that stars fall into groups related to their temperature and brightness.

*** Most stars appear in a band that is referred to as the Main Sequence. Several groups of stars such as the Giants and Dwarfs appear outside of the main sequence.

H-R Diagram

Internet site for VERY USEFULL information on H-R Diagrams

***Play the animated movie to see how age is related to a star’s brightness. http://sunshine.chpc.utah.edu/labs/star_life/hr_interactive.html

Internet link for more interactive help on H-R Diagrams

http://sunshine.chpc.utah.edu/labs/star_life/hr_interactive.html

Key characteristics of STARS to remember….

*** In a stars lifespan the star continues to change size and temperature
*** The star will continue to move UP the main sequence as it gains matter from its local cloud of gas and dust. If the star is massive enough it will become a bright blue-white star. Look at the diagram above… the stars following the path up and go from orange to yellow to white to finally blue.
The sun is considered to be about 5 billion yrs old and will continue to shine as long as its hydrogen fuel lasts and nuclear fusion continues. (This is thought to be available for approximately another 5 billion yrs.) Thus...The sun is considered to be average age. A star's color is dependent on its surface temperature. A red star is relatively cool and a blue star is a very hot star.

Indicator # 2
2. Describe the current scientific evidence that supports the theory of the explosive expansion of the universe, the Big Bang, over 10 billion years ago.

The universe is expanding according to scientists... and the fact that it is expanding is used as the evidence for the big bang theory. The big bang theory suggests that all matter and energy that exist today in the universe were once concentrated in a very small, dense object, perhaps the size of an atom. For unknown reasons, this object suddenly expanded outward, creating the beginning of space and time. Matter and energy moved outward in all directions. Over time simple atomic particles combined to form light elements like hydrogen and helium, and eventually, with the evolution of stars.

1) If the big bang really occurred... scientists would expect to see galaxies continuing to move away from each other at speeds proportional to their distance. In 1929, astronomer Edwin Hubble observed that galaxies are, in fact, moving away from each other. Hence... scientists use this to explain the theory of the Big Bang.

2) Secondly... if the big bang occurred then radiation would have been released during the explosion and be moving away from the central point. It should be detectable in thin quantities and evenly distributed. Scientists can detect this radiation which is referred to as “background radiation.”

Example questions from previous OGT tests covering this Standard...Benchmark...

Multiple Choice Question: (March 2005)
23. When examining the red shift of galaxies outside our own, every galaxy appears to be moving away from the observer. This observation supports the Big Bang Theory because it indicates that

A. our galaxy is not moving.
B. the universe is expanding.
C. most galaxies have the same mass.
D. Earth is at the center of the universe.

**Multiple Choice Question: (March 2006)**

6. Which property of a star can be determined most directly from its color?  
A. mass  
B. diameter  
C. precise age  
D. surface temperature

---

**Benchmark C**

**Indicator # 3**

3. Explain that gravitational forces govern the characteristics and movement patterns of the planets, comets, and asteroids in the Solar System.

ALL objects have a gravitational force between them. EVERY object pulls towards one another. The earth’s pull of gravity is towards you and you towards the earth. You towards the chair you sit in and the chair pull of gravity back on you. The larger the object… the larger the gravitational force will be, and thus… control the movement of an object.  
Example… you drop an object such as a coin and it will fall to the earth due to the Earth’s gravitational pull ( 9.8 m/s² ) Obviously the coin can pull the earth back towards it.  
Also… the closer the two objects are together the more the gravitational force between them will be.  
Example…The earth is more massive than the moon… so the moon rotates around the earth.  
Example…The Sun is more massive than the earth… so the earth rotates around the sun.

Gravity is also responsible for the oval shape of large objects in the universe. Stars, planets, and most natural satellites have a spherical shape to them. (Oval) This is due to the gravitational pull towards the center of the object.

Objects revolving around the sun are influence by the sun’s gravitational pull and they travel in an elliptical orbit. The elliptical orbit creates a pattern that brings the planet closer to the sun at some point than at other points. See diagram…

If the planet is located here → ← orbit of planet or Comet it will travel much  
*FASTER than what it* ↑
Example question from previous OGT test covering this Standard…Benchmark…

Multiple Choice Question: (March 2005)

26. Our solar system is thought to have formed from a nebula of dust and gas. Most of this nebula condensed to form the sun.

What is primarily responsible for causing these materials to condense?
A. electrical attraction between charged dust particles
B. gravitational pull of nebula materials on each other
C. heat released by nuclear fusion at the center of the nebula
D. chemical reactions between hydrogen and other nebula gases

Earth Systems:

Benchmark B

Indicator # 4
4. Explain the relationships of the oceans to the lithosphere and atmosphere (e.g. transfer of energy, ocean currents, and landforms)

The Earth can be thought of as having THREE types of spheres:

1) The **lithosphere**... which is the rock part of the earth.
2) The **hydrosphere** which is the water part of the earth.
3) The **atmosphere** which is the air part of the earth.

** All three of these layers come into contact with each other and thereby affect one another through the interaction of matter and energy.

How does the ocean “hydrosphere” affect the other two? (Lithosphere and atmosphere)

*** Hydrosphere (ocean) affecting the Lithosphere-(rock) – Ocean waves break along beaches transporting sand particles, causing coastline erosion.
*** Hydrosphere (ocean) affecting atmosphere (air)—Climate is affected by warm ocean currents that travel north and warm the land they contact, and by cold ocean currents that travel south and cool the land they contact.

*** Wind provides the energy that moves ocean waters in large circular patterns.

Example question from previous OGT test covering this Standard…Benchmark…

Multiple Choice Question:

20. What type of energy from the oceans is responsible for weather patterns?
   A. electrical
   B. magnetic
   C. mechanical
   D. thermal

Processes that Shape the Earth:

Benchmark E

Indicator # 5
5. Explain how the slow movement of material within Earth results from

a. thermal energy transfer (conduction and convection) from the deep interior
   Conduction: Transfer of energy from substance to substance. (Heat will travel to the area of cooler temperature. Always Hot to Cold)
   (Example… Holding an ice cube… the heat from your hand travels to the ice cube)

   Convection: Hot air rises… Cold air drops Convection currents cause heated rock to move upward towards the surface and the areas where it is cooled the rock moves downward.
b. the action of gravitational forces on regions of different density.

There are two main scientific ideas for explaining plate movement: gravity and convection currents. All objects on and in the Earth are pulled towards its center by the force of gravity. This may affect the plates at converging plate boundaries in areas called subduction zones, where one plate sinks into the mantle. Some evidence suggests that gravity pulls the sinking plate down. The rest of the plate is dragged along behind it. This is physically similar to slowly pushing a piece of paper off a table; it eventually bends, and slides off, pulling the rest of the paper behind it. The other reason for plate motion relates to convection currents within the upper part of the mantle. Convection is the heat-driven circulation of a fluid. In the mantle, heat from deeper in the Earth causes the overlying mantle to circulate. The mantle can circulate because it contains a little magma (molten rock); it behaves like a very hot mush. Mantle convection currents move...
very, very, slowly. It is possible that as the mantle convects, it drags the overlying plates along with it. It is likely that both convection and gravity contribute to the movement of the plates.

**Indicator # 6**

6. Explain the results of plate tectonics activity (e.g., magma generation, igneous intrusion, metamorphism, volcanic action, earthquakes, faulting and folding).

**Plate Techtonics:** According to theory… the earth’s crust is broken up into a number of large pieces, (plates) that slowly move and interact at their boundaries in various ways. Some plates are spreading apart, some are colliding, and some are sliding past each other. The stress and strain of this activity causes: Mountain building; volcanic activity; earthquakes; and metamorphism of crustal rocks.

**Folding:** Will occur when plate tectonic forces cause rocks to come together from the sides and the rock layers tend to fold. The land is squeezed together forming high ridges and low valleys.

**Faulting:** Occurs when forces pull or squeeze the rock beyond its capacity. The result is a fracture or “fault”.

**Rock masses sliding along a fault line result in an Earthquake**

**Volcanic Action:** Volcanic activity occurs when rock in the lower crust melts due to pressure and temperature and forms a liquid rock material called MAGMA. The magma will then push upward and reach the surface. When it is on the surface it is called LAVA. A volcano can be produced if the lava forms a mountain. The lava will then flow outward from this area.

**Volcanoes form in two major areas.**
1) A subduction zone where collision of plates have formed an ocean trench.
2) A mid-ocean ridge.

**Indicator # 7**

7. Explain sea-floor spreading and continental drift using scientific evidence (e.g., fossil distributions, magnetic reversals and radiometric dating).

Scientists have discovered evidence that the earth’s magnetic poles have reversed positions throughout time. The lava flowing to the surface (with Iron in it) solidifies. The magnetic rocks give proof of these reversals at the mid-ocean ridge, because matching patterns have been discovered on both sides of the ridge.

**Magnetic Reversals give evidence of sea-floor spreading.**

The rocks on both sides of the ridge have been dated. And……the youngest are closest to the ridge and the oldest are located farther away from the ridge.

**Therefore,**

**Radioactive Dating give evidence of sea-floor spreading as well.**
Fossils distribution can be used to match up rock layers that are far apart.

Example questions from previous OGT test covering this Standard…Benchmark…

**Multiple Choice Question: (March 2005)**

Use the diagram to answer question 1.

![Earth's Cross Section](image)

1. Scientists believe that forces in Earth’s mantle move Earth’s crustal plates. What do the arrows in the diagram represent?
   A. ocean currents
   B. gravity
   C. convection currents
   D. wind patterns

**Multiple Choice Question: (March 2006)**

1. The following diagram shows a cross-section of the mid-Atlantic Ridge.
Which area is likely the oldest crust?
A. 1
B. 2
C. 3
D. 4

**Historical Perspectives and Scientific Revolutions**

**Benchmark F**

**Indicator # 8**
8. Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., heliocentric theory, plate tectonics theory, atomic theory, quantum theory, Newtonian mechanics).

Scientific Theories and ideas are developed and based on the evidence that is available at that particular time. The evidence is from observations made from the technology that is available at that particular time. In early times the limited technology and equipment made it difficult to develop theories that were accepted by many. These theories were debated and sometimes changed after newer technology was used to discover different evidence which altered our previous assumptions. Also… theories continue to build and change through contributions from many scientists who add their observations and knowledge to the theory.

**Geocentric Theory:** Idea that the Earth was at the center of the Universe and the planets and sun revolved around the Earth. (Many people believed this in early times based on their beliefs and evidence at that time.)
Heliocentric Theory: Idea that the Sun is at the center of the universe and the planets, including earth, revolve around the Sun. Nicholas Copernicus developed this idea based on mathematical calculations and scientific observations. (This is the current understanding of how the universe is based and how planets revolve.)

Plate Tectonics Theory: See Above INDICATOR # 6

Atomic Theory: The idea that substances are made from tiny particles called ATOMS. The atomic theory and the structure of the atom… Protons, neutrons, electrons, etc. have continued to develop from advanced technology that has become available.

Quantum Theory: Suggest that light has characteristics of the particles, waves and bundles of energy. A Quantum (plural Quanta) is a packet of energy. EVEN TODAY… the quantum theory does not completely explain the nature and behavior of light.

Newtonian Mechanics: The principles of motion based on Isaac Newton’s three laws.

Example questions from previous OGT test covering this Standard…Benchmark…

Multiple Choice Question: (March 2005)

8. The early development of the theory of plate tectonics was supported by which of these observations?
   A. matching fossils on the continents of Africa and South America
   B. glacier deposits far from existing continental glaciers
   C. thick sediment layers at the mouths of rivers
   D. sudden volcanic activity of long-dormant volcanoes

Multiple Choice Question: (March 2006)

34. In Aristotle’s treatise *On Meteorology*, he stated that:
“The same parts of the Earth are not always moist or dry, but they change accordingly as rivers come into existence and dry up. And so the relation of land to sea changes too and a place does not always remain land or sea throughout all time, but where there was dry land there comes to be sea, and where there is now sea, there one day comes to be dry land. ...”

Aristotle was referring to the
A. depletion of natural resources.
B. cyclic nature of Earth processes.
C. relationship between latitude and climate.
D. effects of humans on biogeochemical cycles.

Standard: PHYSICAL SCIENCE

Nature of Energy:

Benchmark F

Indicator # 11
11. Explain how thermal energy exists in the random motion and vibrations of atoms and molecules (kinetic energy). Recognize that the higher the temperature, the greater the average atomic or molecular motion (potential energy), and during changes of state the temperature remains constant.

Kinetic Theory: States that matter is composed of tiny particles called molecules which are in constant random, vibrating motion. Heat is a form of energy that is produced by the vibrating motion of the molecules. Therefore, ALL substances have some amount of heat. Therefore...The greater the amount of motion... the greater the heat will be.

*** Remember… When a substance changes its state of matter, (Ex. Going from a liquid to gas) the temperature DOES NOT change. Example... when water boils (changing from liquid to gas) the temperature will NO longer go up. If the water starts to boil at 100 degrees Celsius, then it will stay at 100 degrees until all of the liquid has boiled away. It will not go up to 101 degrees.
Multiple Choice Question: (March 2006)

Water Temperature Experiment
Students studied the effect of ice on the temperature of a sample of water. First, they put 500 mL of cold water (at 10°C) into each of four beakers. Next, they measured and recorded the initial temperature of the water in each beaker. Then, they added various amounts of ice as shown in the table below. They continued to measure the temperature over a period of 30 minutes. Their results are shown in the graph below. The temperature of the room during the experiment was 22°C.

Data Table

<table>
<thead>
<tr>
<th>Beaker</th>
<th>Amount of Ice (in scoops)</th>
<th>Volume of Water (in milliliters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>500</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>500</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>500</td>
</tr>
</tbody>
</table>
12. During the first five minutes of the experiment,
   A. the total energy of the system decreased by half.
   B. kinetic energy is transferred from the ice to the water.
   C. thermal energy is transferred from the water to the ice.
   D. thermal energy is transferred from the water to the surrounding air.

**Benchmark E**

**Indicator # 12**
12. Explain how an object’s kinetic energy depends on its mass and its speed.

*** Equation for Kinetic Energy… KE=1/2 MV^2

The GREATER THE MASS of an object… The GREATER THE KINETIC ENERGY.  
The GREATER THE SPEED of an object… The GREATER THE KINETIC ENERGY.

Example questions from previous OGT test covering this  
Standard… Benchmark…
**Multiple Choice Question: (March 2006)**

32. A student plans to collect data needed to calculate the kinetic energy of a thrown baseball. She plans to measure the distance from pitcher to catcher, the time it takes for the baseball to arrive in the catcher’s glove, the mass of the baseball, and the circumference of the baseball.

Which of these measurements is **not** needed to calculate the kinetic energy?

A. measuring the mass of the ball  
B. measuring the flight time of the ball  
C. measuring the circumference of the ball  
D. measuring the distance from pitcher to catcher

**Multiple Choice Question: (March 2005)**

**Inclined Plane Experiment**

In doing the following inclined plane experiment in “ideal conditions,” students assume that friction from the air, incline or floor is negligible. A stationary box at the top of a frictionless incline is released and is allowed to slide to the bottom. The figure below illustrates the box in four positions labeled A through D as it is sliding from the incline onto the level floor. As the box moves from the bottom of the incline to the floor, students assume that the box experiences no change in speed, only a change in direction.
2. At what time does the box have the greatest kinetic energy?
   A. 0.00 s
   B. 0.85 s
   C. 1.17 s
   D. 1.25 s

Indicator #13
13. Demonstrate that near Earth’s surface an object’s gravitational potential energy depends upon its weight \((mg)\) where \(m\) is the object’s mass and \(g\) is the acceleration due to gravity) and height \((h)\) above a reference surface.

*** The equation for Potential Energy is... \(PE=mg\) \((m=\text{mass}, g=\text{acceleration of gravity}, h=\text{height})\)

Example questions from previous OGT test covering this Standard...Benchmark...

Multiple Choice Question: (March 2005)
Inclined Plane Experiment

In doing the following inclined plane experiment in “ideal conditions,” students assume that friction from the air, incline or floor is negligible. A stationary box at the top of a frictionless incline is released and is allowed to slide to the bottom. The figure below illustrates the box in four positions labeled A through D as it is sliding from the incline onto the level floor. As the box moves from the bottom of the incline to the floor, students assume that the box experiences no change in speed, only a change in direction.

4. Where is the potential energy of the box greatest?
   A. The potential energy is constant throughout the motion.
   B. The potential energy is greatest at the top of the incline.
   C. The potential energy is greatest midway along the incline.
   D. The potential energy is greatest at the bottom of the incline.

Benchmark F

Indicator # 14
14. Summarize how nuclear reactions convert a small amount of matter into a large amount of energy. (Fission involves the splitting of a large nucleus into smaller nuclei; fusion is the joining of two small nuclei into a larger nucleus at extremely high energies.)

There are strong nuclear forces that hold the protons and neutrons together inside the nucleus of an atom. Albert Einstein developed the equation $E=mc^2$ where $E$ is energy, $m$ is mass and $c$ is the speed of light. This equation summarizes the enormous amount of energy that is stored inside the nucleus of an atom where the protons and neutrons are located. Fission and fusion are processes that can release this stored energy. See Indicator #1 for definitions and flash animation of both processes.

Indicator #15

15. Trace the transformations of energy within a system (e.g., chemical to electrical to mechanical) and recognize that energy is conserved. Show that these transformations involve the release of some thermal energy.

Forms of Energy and Changes in Objects

Many forms of energy exist around us. Energy cannot be created or destroyed, only changed from one form to another. If a person ever says that energy is lost, what really happens is that energy is spent or changed into different forms. It never really is lost. For example, if you use water energy to create mechanical energy, (hydropower) you might "lose" some energy by creating heat energy in the form of friction.

Some forms of energy are:

- Mechanical
- Heat
- Nuclear
- Electrical
- Light
- Sound
- Chemical
- Electromagnetic

When energy interacts with an object, that object might change in some way. Many times the change in an object is so small that your senses such as sight and hearing cannot detect any change at all. Sometimes the change in an object that interacts with forms of energy is so great that it is hard to miss!

<table>
<thead>
<tr>
<th>Event</th>
<th>Object</th>
<th>Energy Transfer</th>
<th>Change in Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>burning coal</td>
<td>fossil fuel</td>
<td>chemical to heat</td>
<td>gets hotter, glowing, evaporating, cracking,</td>
</tr>
<tr>
<td>earthquake</td>
<td>buildings</td>
<td>heat to sound</td>
<td></td>
</tr>
</tbody>
</table>
Transformations of Energy

The usefulness of any form of energy depends on our ability to control that energy. In other words, a device or method must be created that will control the way the energy is moved or changed so that a desired outcome can happen.

If a firefly lights up, he or she is changing chemical energy into light energy. This is useful to the firefly but not useful to man because we cannot control the firefly's chemical reactions and light. But if a person created a special box with reflectors and filled it with a thousand lightning bugs, and then directed this light with a reflector to read words in a book, this form of "glowing" energy can become useful.

But do you really think this is a good source of energy? Do you think this is a useful way to redirect, or transform energy from one form to another?

We have much better ways of taking forms of energy and capturing it, or controlling it, and then changing it from one form to another.

Here are some examples:

- solar (light) energy
- solar panels
- heat energy
- turbines and mechanical energy
- wind energy
- windmill
- water energy
- watermill
- mechanical energy
- chemical energy
- candle wax (candle)
- light and heat energy

Indicator # 16
16. Illustrate that chemical reactions are either endothermic or exothermic (e.g., cold packs, hot packs and the burning of fossil fuels).
Reactions that release heat energy are **EXOTHERMIC**. Bond formation within a compound is always Exothermic. Ex. When the chemicals in a hand warmer are mixed together the reaction releases heat energy, *feel hot* and would be considered exothermic.

Reactions that absorb heat energy are **ENDOTHERMIC**. When bonds are broken it is always Endothermic. When chemicals in an ice pack are mixed together the energy is absorbed and the pack *feels cold*. The cold pack feels cold because it is absorbing thermal energy from the surroundings.

**Burning of fossil fuels** would be considered Exothermic, because energy stored in the chemical bonds holding the atoms together in the compound are broken, and as a result is released as heat. (Sometimes light energy as well)

**Indicator # 17**

17. Demonstrate that thermal energy can be transferred by conduction, convection or radiation (e.g., through materials by the collision of particles, moving air masses or across empty space by forms of electromagnetic radiation.)

Heat Flows from objects of warmer temperature to objects of colder objects. (From hot to cold) The heat will try to become evenly distributed throughout its surroundings and travel by means of **CONDUCTION, CONVECTION, Or ELECTROMAGNETIC RADIATION.**

**Conduction:** is the transfer of energy (heat or electricity) by the direct molecular contact in a substance. **METALS** are GOOD CONDUCTORS of heat transfer. (Non-metals are not.) Example…holding a spoon on the stove will eventually burn your fingers. The heat energy travels through the spoon by direct contact from atom to atom. (The closer the atoms are together… the better the conduction. (Heat or Electricity)

**Convection:** is the transfer of heat energy by a liquid or gas. Warmer air will rise because it is LESS DENSE... and cooler air will sink because it is DENSER THAN AIR.

**Electromagnetic Radiation:** is the transfer of heat through space in the form of waves. Examples… the sun gives of heat that travels through space and reaches the earth in the form of radiation. Also… a light bulb gives off heat through waves in the air before reaching your hand when holding your hand above the bulb.

**Example questions from previous OGT test covering this Standard…Benchmark**
Multiple Choice Question: (March 2006)

Use the information to answer question 22.

The following graph shows the change in temperature of a sample of H₂O, which begins as ice, as thermal energy is added.

22. Which region of the graph represents water (H₂O) in the liquid form only?
   A. 1
   B. 2
   C. 3
   D. 4

Benchmark G

Indicator # 18
18. Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays).

**The Electromagnetic Spectrum**

The relationship between wave length and wave frequency is inverse. (As one gets higher…the other gets smaller.

Humans are capable of seeing only a small portion of the entire electromagnetic spectrum. (Only the ROY G BIV visible light section)

**Electromagnetic Radiation:** is the transfer of energy through space in the form of waves. (Also… see Indicator # 17 above)

Light is a visible form of energy. Light travels in waves that move outward in all directions.

**There are 4 main theories of light.**
1) The particle theory
2) The wave theory
3) The electromagnetic theory
4) The quantum theory

**Indicator # 19**
19. Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.

The speed, direction, and motion of a wave depend on the medium that it is traveling through. The denser the medium, the faster it will travel. Why... the denser the object, the closer the molecules are together which gives the wave particles something to collide with and travel from particle to particle.

Light waves cannot travel around corners like sound waves can. Light can travel through a vacuum. Sound waves cannot travel through a vacuum. LIGHT TRAVELS A MILLION TIMES FASTER THAN SOUND. This is why when clocking a track athlete from the other end of the track... you would start your stop watch when you see the smoke from the gun. If you started the stop watch when you heard the gun... you would be inaccurate because the athlete would have already started to run before you even heard the gun. (You will see the smoke before you hear the gun.)

***The sun is our main source of light energy.

The speed of a sound wave will also increase with the temperature of the air. The warmer the air, the faster the speed of sound will be.

Indicator # 20
20. Describe how waves can superimpose on one another when propagated in the same medium. Analyze conditions in which waves can bend around corners, reflect off surfaces, are absorbed by materials they enter, and change direction and speed when entering a different material.

When two waves superimpose on one another, and are aligned the same way, they increase there amount of energy. The wave energy is larger. When the two waves superimpose on one another and are OUT of phase, they cancel some of the energy and are not as strong.

When light strikes the surface of an object three things can happen...

1) The light energy is REFLECTED back.
2) The light energy may be absorbed as heat energy
3) The light energy may be transmitted through the object. (pass through)

*** We see objects because the light is REFLECTED back to us. The smoother the surface... the more is reflected back. (A smooth mirror gives an excellent REFLECTION)

*** Dark colored objects ABSORB most of the light energy as heat. (So...don't wear dark clothing on a hot day in the summer. The light colored clothing will REFLECT most of the light back and not be absorbed.)
Transparent materials - allow light to pass through. Example... glass

Translucent materials - allow some light to travel through, but distort the image to a degree. Example... wax paper

Opaque materials - do not allow any light to pass through. Example... wood

Example questions from previous OGT test covering this Standard... Benchmark

Multiple Choice Question: (March 2006)

Use the table to answer question 33.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Temperature (°C)</th>
<th>Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry air</td>
<td>0</td>
<td>331</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>346</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>366</td>
</tr>
</tbody>
</table>

33. Could the speed of sound be used to estimate dry air temperature, based on the data above?
   A. No, because the speed of sound in dry air is the same regardless of temperature.
   B. No, because as temperature increases, the speed of sound in dry air increases.
   C. Yes, because as temperature increases, the speed of sound in dry air increases.
   D. Yes, because as temperature decreases, the speed of sound in dry air increases.

Multiple Choice Question: (March 2005)

Use the table to answer question 7.

<table>
<thead>
<tr>
<th>Solids</th>
<th>Density</th>
<th>Speed</th>
</tr>
</thead>
</table>

Speed of Sound in Solids
<table>
<thead>
<tr>
<th></th>
<th>(g/cm³)</th>
<th>(m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cork</td>
<td>0.25</td>
<td>500</td>
</tr>
<tr>
<td>brick</td>
<td>1.80</td>
<td>3650</td>
</tr>
<tr>
<td>glass</td>
<td>2.24</td>
<td>4540</td>
</tr>
<tr>
<td>stainless steel</td>
<td>7.90</td>
<td>5000</td>
</tr>
</tbody>
</table>

7. For the solids listed in the data table, which seems to be true about the relationship between the speed of sound and density?

A. The speed of sound decreases as density increases.
B. The speed of sound increases as density increases.
C. The speed of sound increases as density decreases.
D. There is no apparent relationship between density and the speed of sound.

**Nature of Matter:**

**Benchmark A**

**Indicator # 1**

1. Recognize that all atoms of the same element contain the same number of protons and elements with the same number of protons may or may not have the same mass. Those with different masses (different numbers of neutrons) are called isotopes.

Isotopes: Are atoms of the same element but differing in their number of neutrons, therefore, also differing in the mass number.

Example... Hydrogen has three different isotopes. Hydrogen 1 called protium, Hydrogen 2 called deuterium, and Hydrogen 3 called Tritium.

**Hydrogen 1 Protium Hydrogen 2 Deuterium Hydrogen 3 Tritium**

1 Proton
0 Neutrons

1 Proton
1 Neutron

1 Proton
2 Neutrons
Protons ALWAYS stay the same number as the atomic number. The electrons will always stay the same number as well UNLESS the atom loses or gains an electron to become charged. (Called an ion)

**** Mass is always Protons and Neutrons located in the nucleus added together.

*** The mass you see on the periodic chart for each element is an AVERAGE of all of those elements isotopes.

Also... the isotope is always referred to as the mass number. Example isotope Uranium 235 has a mass of 235. There is also isotope Uranium 238 with a mass of 238. The only difference between the two is the number of neutrons and therefore mass.

Indicator # 2
2. Illustrate that atoms with the same number of positively charged protons and negatively charged electrons are electrically neutral.

See Above diagrams... Protons are positive and electrons are negative. A NUETRAL atom will always have the same number of protons as it does electrons. (This makes it neutral) If an atom loses or gains electrons the atoms neutral state will change. If it gains electrons (non-metals will do this) the atom will become a negative ion. If the atom loses electrons (metals do this) then the atom becomes a positive ion.

Example. Sodium (Na) atomic # 11 Mass 23 Means

11 protons (+ charge) 11 protons +
12 neutrons If the atom loses an 12 neutrons
11 electrons (-charge) electron 10 electrons -
Neutral charge + and – charges are = now... Positive 1 charge

Example questions from previous OGT test covering this Standard...Benchmark

Multiple Choice Question(March 2005)

Use the partial periodic table to answer question 27.
27. A neutral atom of silicon has
   A. 12 electrons.
   B. 13 electrons.
   C. 14 electrons.
   D. 15 electrons.

**Benchmark F**

**Indicator # 3**

3. Describe radioactive substances as unstable nuclei that undergo random spontaneous nuclear decay emitting particles and/or high energy wavelike radiation.
A radioactive isotope is one in which is unstable and begins to decay in order to become stable. Example… Carbon 14 is unstable and will spontaneously change to become Nitrogen 14 which is stable. The unstable isotope is called a radioactive isotope. The process in which it changes is called nuclear decay. During the process the nucleus emits particles and energy called radiation.

Example questions from previous OGT test covering this Standard…Benchmark

See Previous Benchmark F with questions.

Benchmark A

Indicator # 4
4. Show that when elements are listed in order according to the number of protons (called the atomic number), the repeating patterns of physical and chemical properties identify families of elements. Recognize that the periodic table was formed as a result of the repeating pattern of electron configurations.

The periodic table increases in atomic number and mass from left to right and top to bottom. The atom gets larger as we go ACROSS the table (which is called a ROW or PERIOD).

The up and down columns in the chart are called FAMILIES or GROUPS because they have similar physical and chemical properties. Example… the noble gases are located in group 8 and ALL have stable atoms due to having 8 outer shell electrons (Octet Rule) Example… All elements in group 3 would have 3 valence electrons and react similar to various other atoms. All elements in group 1 are VERY reactive because they only have 1 valence electron and it is easy to lose.

Metals are located in the left… and non-metals on are on the right side. The most reactive metal is lower left, and the most reactive non-metal is upper right group 7.

*** Because of these repeating patterns you would be able to place a new discovered element in the chart based on its physical and chemical characteristics.

Example questions from previous OGT test covering this Standard…Benchmark
Multiple Choice Question (March 2005)

Use the partial periodic table to answer question 35.

35. Suppose scientists discovered four new elements (W, X, Y, Z) while studying rock and soil samples brought back from a Mars mission. Which Lewis dot structure represents an element that should be placed in column VIIA (17) of the periodic table?

A. \( \cdot W \cdot \)
B. \( \cdot X \cdot \)
C. \( \cdot Y \cdot \)
D. \( \cdot Z \cdot \)

Indicator # 5
5. Describe how ions are formed when an atom or a group of atoms acquire an unbalanced charge by gaining or losing one or more electrons.

See Benchmark A indicator # 1 above. Also... The ion formed when the metal loses an electron is positive and called a CATION. If the atom is from a non-metal then the resulting ion is negative and called an ANION.

**Benchmark B**

**Indicator # 6**

6. Explain that the electric force between the nucleus and the electrons hold an atom together. Relate that on a larger scale, electric forces hold solid and liquid materials together (e.g., salt crystals, water).

The nucleus of an atom will be positive due to the fact that it contains only positive protons and neutral neutrons. The electrons on the outside of the nucleus have a negative charge. The positive charge of the nucleus pulls the negative electrons close to the nucleus. (Opposite charges attract.)

Also electric forces hold compounds together such as salt. (Ionic bond) The positive cation (sodium metal) is attracted to the negative anion (chlorine non-metal).

**Indicator # 7**

7. Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas, and writing balanced chemical equations).

**Lewis Dot structure of Calcium is... Ca:** it will want to LOSE the two outer negative electrons to become stable. (octet rule). When it does... it will be a positive ion.

Calcium (Ca) atomic # 20 Mass 40 Means

20 protons (+ charge) 20 protons +
20 neutrons If the atom loses 20 neutrons
20 electrons (-charge) electron when bonding 18 electrons -
Neutral charge now... Positive 2 charge
2 more + than – charges

Ionic Bonding of Sodium and Chlorine using Lewis Dot structure...

\[ \text{Na}^- + \cdot \text{Cl}^- \rightarrow \text{Na}^+ : \text{Cl}^- \]

Ionic Bond (Metal Cation combines with a Non-metal Anion)
***Ionic Bonds- electrons are totally lost or gained resulting in a charged atom. (Ion)

***Covalent Bonding is the SHARING of electrons which are two or more NON-METALS combining together.

Examples of types of reactions;

(General equation) (An actual equation)
↓↓↓↓
1) Synthesis- \( A + B \rightarrow AB \) Ex. \( Mg + Cl_2 \rightarrow MgCl_2 \)

2) Decomposition- \( AB \rightarrow A + B \) Ex. \( MgCl_2 \rightarrow Mg + Cl_2 \)

3) Single Displacement- \( A + BC \rightarrow AC + B \) Ex. \( Ag + NaNO_3 \rightarrow AgNO_3 + Na \)

4) Double Displacement- \( AB + CD \rightarrow AD + CB \) Ex. \( AgNO_3 + NaCl \rightarrow AgCl + NaNO_3 \)

5) Combustion- A hydrocarbon reacts with Oxygen to always produce H2O and CO2
Ex. \( CH_4 + O_2 \rightarrow H_2O + CO_2 \)

6) An Acid reacting with a Base- Will always produce a Salt and Water.
Ex. \( HCL + Ca(OH)_2 \rightarrow CaCL_2 + HOH \) (a.k.a. \( H_2O \))

Example questions from previous OGT test covering this Standard…Benchmark

Multiple Choice Question: (March 2005)

27. When methane \( (CH_4) \) is burned in the presence of oxygen \( (O_2) \), the two chemicals react together in a process called combustion.

Which of these compounds could be a possible product of this combustion reaction?
A. \( NH_3 \)
B. \( SO_2 \)
C. \( H_2O \)
D. \( CS_2 \)
**Indicator # 8**

8. Demonstrate the pH scale (0-14) that is used to measure acidity and classify solutions as acidic, basic or neutral substances.

Substances that have a pH of 0-6.9 will be classified as an ACID. If the pH falls between a range of 7.1-14 than it is considered to be a BASE. Neutral will be a pH of 7.

If the substance disassociates (comes apart) into separate ions of H or OH than it will be considered to be an acid or base.

A substance considered to be an Acid will have H ions that separate out in a solution of water. Acids are associated with H which is called the Hydronium ion. The more H ions separate out…the stronger the acid will be, and Also the lower the pH in the acid range, the stronger the Acid. Example… a substance with a pH of 3 is STRONGER than a substance with a pH of 5.

Bases will be associated with the OH ion called Hydroxide. The more hydroxide ions that separate out… the stronger the base will be. Also… a substance with a pH of 12 will be stronger than a substance with a pH of 8.

There are also acid/base indicators that will determine the acidity of a substance. Example… litmus paper will turn red with an acid, and it will turn blue with a base. Phenolphthalein is another example of an acid/base indicator. It will stay clear with an acid and turn pinkish/purple in a base.

Click on the link below to view a diagram of the pH scale with common substances. [http://www.geography.hunter.cuny.edu/~tbw/wc.notes/13.air.pollution/ph_scale.htm](http://www.geography.hunter.cuny.edu/~tbw/wc.notes/13.air.pollution/ph_scale.htm)

**Benchmark C**

**Indicator # 9**

9. Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, and properties of alloys, superconductors and semiconductors).

Pure substances are classified as Mixtures are classified as

1) Elements 1) Heterogeneous
2) Compounds 2) Homogeneous

Elements are the simplest of pure substances made up of atoms. Ex. Carbon (C), Aluminum (Al)

Compounds are made up of two or more elements chemically combined together. Ex. NaCl, H₂O.
A HETEROGENEOUS mixture is one in which you can see the parts of the mixture. Ex. Pepperoni Pizza.

A HOMOGENEOUS mixture is one in which it is UNIFORMILY mixed together and you cannot pick out the parts. Ex. Milk, kool-aid, tap water. (Tap water has more than just H\textsubscript{2}O in it. It has S, Fe, Cu and some other various elements which make it NOT pure.) Therefore, it is classified as a mixture.

***REMEMBER*** A compound is different than a mixture because it ALWAYS has to have a specific ratio of what makes it up in order to be classified as that substance. Ex. NaCl is a compound because you always have to have 1 Na to 1 Cl in order to have NaCl. (Salt)

A mixture DOES NOT have to have that specific ratio. You can have a million pepperonis on your pizza or just 2 pepperonis and it would still be classified as a pepperoni pizza. No specific ratio needed.

Density = \( \frac{M}{V} \) m=mass v= volume Density can be used to identify different substances because the density of various objects are always different from one another and consistent. Ex. D of water is 1. The D of copper is going to be different, but always the same for copper no matter how large the copper piece is. To identify an unknown object you could take its density and then go to a reference book and look up the density of various substances and compare which one it might be.

Conductivity- Able to allow heat or electricity to pass through. Metals are good conductors of both heat and electricity. Non-metals are not. If the unknown material conducted heat and electricity, then you would know it must have metallic properties and you could rule out the substance being a non-metal.

Hardness- is a property used to compare minerals. Ex. Diamond (C) is harder than talc.

### Hardness Testing

<table>
<thead>
<tr>
<th>Mohs Scale of Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mineral</strong></td>
</tr>
<tr>
<td>Tab</td>
</tr>
<tr>
<td>Gypsum</td>
</tr>
<tr>
<td>Calcite</td>
</tr>
<tr>
<td>Fluorite</td>
</tr>
<tr>
<td>Apatite</td>
</tr>
<tr>
<td>Orthoclase</td>
</tr>
<tr>
<td>Quartz</td>
</tr>
<tr>
<td>Topaz</td>
</tr>
<tr>
<td>Corundum</td>
</tr>
<tr>
<td>Diamond</td>
</tr>
</tbody>
</table>
**Alloy**-An alloy is a mixture of different metals. Ex. A penny would be considered an alloy, because it no longer is just copper. It is now a mixture of both copper and zinc metal.

**Superconductor**-ability to conduct electricity without resistance: the ability of some metals, alloys, and ceramics to conduct electric current with negligible internal resistance at temperatures near absolute zero and, in some cases, at higher temperatures.

**Semiconductor**-partially conductive solid: a solid material that has electrical conductivity between that of a conductor and an insulator.

**Indicator # 10**
10. Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.

Ionic compounds allow for conductivity. Ex. When NaCl is placed in pure water the Na and Cl ions separate out and you have a solution of salt water and the more ions that separate out... the greater the conductivity.

Also...it is the electrons that pass through wire allowing for the flow of electricity.

**Example questions from previous OGT test covering this Standard...Benchmark**

**Multiple Choice Question: (March 2006)**

26. At 25°C, water has a density of 1.0 g/mL and vegetable oil has a density of 0.90 g/mL.

   How would a substance with a density of 0.95 g/mL behave when placed in both oil and water?
   A. sink in both oil and water
   B. sink in oil and float on water
   C. float on oil and sink in water
   D. float on both oil and water

**Multiple Choice Question: (March 2005)**

28. Gertrude cut two bars of different types of soap into four pieces each. She put one piece from each bar into each of four beakers, labeled Beaker W,
Beaker X, Beaker Y and Beaker Z. Each beaker contained a different unknown liquid.

According to the results shown above, which beaker contained the liquid that was densest?
A. Beaker W
B. Beaker X
C. Beaker Y
D. Beaker Z

**Forces and Motion:**

**Benchmark D**

**Indicator # 21**
21. Demonstrate that motion is a measurable quantity that depends on the observer’s frame of reference and describe the object’s motion in terms of position, velocity, acceleration and time.

Motion is a change in the position of an object, when compared to an object that is stationary. (At rest) Ex. An airplane in the sky flying towards you may not look as if it is moving, but when you view it from the side, and have stationary objects to compare it to, the motion will be more observable.
**Velocity** is the speed of an object. Velocity = distance / time \( V = \frac{d}{t} \)

**Acceleration** is the change of speed an object has. \( A = \frac{\text{change in } V}{t} \)

**Indicator # 22**

22. Demonstrate that any object does not accelerate (remains at rest or maintains at constant speed and direction of motion) unless an unbalanced (net) force acts.

Newton’s second law… an object will stay at rest or be moving at a CONSTANT speed unless an unbalanced force (net force) acts on it. \( F = \text{force} \), \( A = \text{acceleration} \), \( M = \text{mass} \)

**Equation**… \( F(\text{net}) = m \times a \)

Click on the link below to view animated examples of Newton’s laws of Motion

[http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html](http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html)

**Indicator # 23**

23. Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. \( F(\text{net}) = ma \). Note that weight is the gravitational force on a mass.

See above indicator

Also… Be sure to understand that **MASS** is different than **Weight**.

**Mass** is “how much stuff something is made of”

**Weight** is how much stuff there is and multiplied by gravity. \((9.8 \text{m/s}^2)\)

Example… If we took you to the moon your mass would stay the same. (Your’ not going to shrink or expand) But your WEIGT would change. Why is this… because your weight is your mass multiplied by gravity. Since there is less than 9.8 of gravity on the moon, you would weight less.

Click on the link below to view animated examples of Newton’s laws of Motion

[http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html](http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html)

**Indicator # 24**
24. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.

Newton’s third law of motion. For every action there is an equal and opposite reaction.

Click on the link below to view animated examples of Newton’s laws of Motion
http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html

Indicator # 25

25. Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, and an airplane in flight).

The force of friction is the force between two objects surfaces’. If the two objects are a car tire and ice on the road, there will be little frictional force. If the car tire is on a surface similar to sandpaper there will be a greater frictional force.

If it were not for friction…objects would not be able to move. (Or stop!!! ) The tread on a car’s tire is irregular which allows for more friction and more control.

It is the friction that eventually causes a penny slid across the table to come to a stop. (Unless some other external force such as your hand stops the motion.)

A car traveling around a curve would need to go VERY slow if there was little frictional force between the tire and the road. (Think of an icy road and how easy it would be to slide off the road and go into a ditch). On dry pavement the car would be able to travel faster around the curve and still remain on the road because of the greater friction. (Which is a good thing)

Air friction would be the force that slows an airplane or a ball thrown in the air down. The gravitational force is what pulls the ball down to the earth.

Example questions from previous OGT test covering this Standard…Benchmark

Multiple Choice Question: (March 2005)

Inclined Plane Experiment
In doing the following inclined plane experiment in “ideal conditions,” students assume that friction from the air, incline or floor is negligible. A stationary box at the top of a frictionless incline is released and is allowed to slide to the bottom. The figure below illustrates the box in four positions labeled A through D as it is sliding from the incline onto the level floor. As the box moves from the bottom of the incline to the floor, students assume that the box experiences no change in speed, only a change in direction.

5. The weight of the box used in the experiment is 10 Newtons (N) as illustrated in the figure.
   The weight of the box is a measure of the
   A. velocity of the box while sliding.
   B. friction between the air and the box.
   C. kinetic energy at the top of the incline.
   D. force acting on the box due to gravity.

Short Answer Question: (March 2006)

Use the information and illustration to answer question 43 and 44.
A snowboarder begins his run from rest (point 1) on top of a hill. He moves straight down the slope until he reaches the bottom of the hill (point 4) and the ground levels off. The snowboarder continues to move horizontally across the level ground and eventually comes to a stop (point 5).

43. Using the same board, the snowboarder decides to make another run down the hill to see if he can increase his speed. Describe one thing the snowboarder could do to increase his speed on the slope. Explain why this would cause his speed to increase. Respond in the space provided in your Answer Document. (2 points)

Multiple Choice Question: (March 2006)

5. The picture below shows the four major forces acting on an airplane in flight.
What causes the force indicated by the X?
A. gravity  
B. air friction  
C. magnetic force  
D. force exerted by the engine

Multiple Choice Question:(March 2006)

41. A teacher dropped one light ball and one heavy ball simultaneously from the roof of a school building. Both balls struck the ground at the same time.

The students correctly concluded from this experiment that falling objects
A. lose mass as they fall.  
B. are influenced by the height of the building.  
C. do not accelerate under the influence of gravitational force.  
D. accelerate at the same rate, regardless of mass, due to the force of gravity.

Benchmark H

Indicator # 26

26. Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., atomic theory, quantum theory, Newtonian mechanics)

Scientific Theories and ideas are developed and based on the evidence that is available at that particular time. The evidence is from observations made from the technology that is available at that particular time. In early times the limited technology and equipment made it difficult to develop theories that were accepted by many. These theories were debated and sometimes changed after newer technology was used to discover different evidence which altered our previous assumptions. Also… theories continue to build and change through contributions from many scientists who add their observations and knowledge to the theory.

Atomic Theory: The idea that substances are made from tiny particles called ATOMS. The atomic theory and the structure of the atom…. Protons, neutrons,
electrons, etc. have continued to develop from advanced technology that has become available.

Quantum Theory: Suggest that light has characteristics of the particles, waves and bundles of energy. A Quantum (plural Quanta) is a packet of energy. EVEN TODAY… the quantum theory does not completely explain the nature and behavior of light.

Newtonian Mechanics: The principles of motion based on Isaac Newton’s three laws.

Indicator # 27
27. Describe advances and issues in physical science that have important, long-lasting effects on science and society (e.g., atomic theory, quantum theory, Newtonian mechanics, nuclear energy, nanotechnology, plastics and ceramics and communication technology)

Remember… Science and Technology Advance each other. Scientific discoveries often lead to the development of new or better technological devices and processes. These technologies may, in turn, lead to new discoveries or to a better understanding of the scientific principles.

The advancement of science has provided new discoveries which have increased our technology providing society with new ways of communicating (ex, cell phones, e-mail, etc…) and industrial technology. (Ex. Plastics which can be used in many ways such as cars, building materials etc…) The plastic can be reused and help eliminate waste in landfills, and as a result be more environmentally friendly.

See previous indicators as well for Atomic theory, Quantum theory, Newtonian Mechanics.

Example questions from previous OGT test covering this Standard…Benchmark

Multiple Choice Question: (March 2006)

42. In his investigations of air, Henry Cavendish discovered a small bubble of leftover gas that would not combine with nitrogen. His observations went unnoticed until William Ramsay performed experiments in which he obtained similar results. Ramsay recalled and repeated Cavendish’s experiments exactly to verify the results. Then, using Gustav Kirchhoff’s spectroscopy technique, Ramsay was able to identify the leftover gas as
the element he called argon. Upon further investigation, he found the elements neon, krypton and xenon.

Based on this information, it can be said that
A. the combined work of Cavendish, Kirchhoff and Ramsay led to the discovery of the noble gases.
B. Kirchhoff’s work was insignificant in the investigations leading to the discovery of argon.
C. Ramsay violated ethical practice in science by repeating Cavendish’s experiments.
D. Cavendish is directly responsible for the discovery of argon, but not neon, krypton or xenon.

Standard: SCIENCE AND TECHNOLOGY

Understanding Technology:

Benchmark B

Indicator # 1
1. Describe means of comparing the benefits with the risks of technology and how science can inform public policy.

Technological process Benefit Risk
Or Device
1) Nuclear Energy Additional clean electricity Accidents, Radioactive Waste

2) Medicines Treat Diseases, Treat Pain Addiction through abuse

3) Chemical Fertilizers Increased Agricultural Crops Damage lakes, steams, land

Technological advances allow people around the world to interact more easily and more frequently. We can witness news events by television via satellite, e-mail, and other various means of transportation make interaction easy.

Science can help decide public policy by keeping society aware of current discoveries and their risks and benefits.
Example questions from previous OGT test covering this Standard…Benchmark

Extended Response Question: (March 2006)

25. Telemedicine is defined as the practice of medicine from a distance. It allows doctors to communicate with patients and other health care workers from a remote area. Early ways of transmitting medical information included the postal service and telegraph. Identify two advances in technology that have improved the speed and accuracy of modern telemedicine. Explain how each improves the ability of doctors to treat or diagnose patients.

Respond in the space provided in your Answer Document. (4 points)

Short Answer Question: (March 2005)

24. In 1960, physicist Theodore Maiman constructed the first working laser. This design was improved upon by Bell Telephone Laboratories in 1961. Since then, lasers have been found to have a wide variety of applications. Identify one application of laser technology and explain how this application has impacted society. Respond in the space provided in your Answer Document. (2 points)

Abilities to Do Technological Design

Benchmark A

Indicator # 2
2. Identify a problem or need, propose designs and choose among alternative solutions for the problem.

Example

The Problem and Solution

The Problem
The quality of the river during warm weather periods caused problems. When a river's velocity is too slow, oxygen is depleted, threatening the health of the river.

The river near the dam was a nearly stagnant dam pool. Large amounts of vegetation and algae formed on the surface of the water. Decaying algae robbed the river of oxygen.

Summit County's Department of Environmental Services (DOES), in cooperation with the Ohio Environmental Protection Agency (OEPA), tested the oxygen levels in the stretch of river upstream from the dam. The oxygen levels were too low for the river to meet water quality standards.

**The Solution: Increase the Velocity of the Water**
If the velocity of the river is increased, so are the oxygen levels, creating a healthier river and aquatic environment. After considering several alternatives to improve the water quality, the Summit County DOES and OEPA agreed to increase the velocity by lowering the dam.

Other examples

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
<th>Other Alternative</th>
<th>Other Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced amount of fossil fuels available</td>
<td>Use alternative fuels Ex. Ethanol, wood, etc…</td>
<td>Buy a hybrid Car (use renewable resources)</td>
<td></td>
</tr>
</tbody>
</table>

Indicator # 3

3. Explain why a design should be continually assessed and the ideas of the design should be tested, adapted and refined.

A design (such as a car design, airplane design, or a way of doing something) should always be evaluated and changed if necessary to become better. With new technology better designs can be made and also accommodate our society. The new designs may make our life easier or better in some capacity.

Example questions from previous OGT test covering this Standard…Benchmark

Multiple Choice Question: (March 2006)

40. Engineers are designing an auditorium that will be used for performances by orchestras.

What must they do to maximize the loudness of the sound heard by the audience?
A. hang curtains behind the orchestra
B. put carpet all around the walls of the auditorium
C. hang reflecting panels from the ceiling behind the orchestra
D. install narrow glass windows and skylights around the top of the walls

Multiple Choice Question: (March 2005)

40. Hydroelectric power is considered a “clean” energy source because it
   A. is available in most areas.
   B. increases the amount of power available.
   C. does not produce the pollutants that burning fossil fuels do.
   D. requires minimal investment in equipment.

Standard: Scientific Inquiry

Doing Scientific Inquiry:

Benchmark A

Indicator # 1
1. Distinguish between observations and inferences given a scientific situation

An OBSERVATION is made by using one of our 5 senses.
   1) Taste
   2) Smell
   3) Touch
   4) Hear
   5) See

An INFERENCe is the conclusion or prediction we make BASED on the OBSERVATION

Examples…
The milk stinks. (Observation… I can use my sense of smell to detect the odor)
The milk is spoiled. (Inference…because it is based on the fact that the milk stinks. Is it really spoiled? Maybe it is or maybe it is not.)
**Indicator # 2**

2. Research and apply appropriate safety precautions when designing and conducting scientific investigations (i.e., OSHA, Material Safety Data Sheets [MSDS], eyewash, goggles and ventilation).

**OSHA Occupational Safety and Health Administration** is a government agency that works to ensure work places are safe. Anyone who works in an environment in which there are chemicals, (schools, hospitals, factory plants, janitorial areas, etc…) is supposed to be informed on the chemicals and their hazards.

**MSDS Material Safety Data Sheet** lists all the characteristics of each chemical that is in the work environment. (Even if it is as common as household bleach) The MSDA must be on file in the work force and be provided if inspected by a government agent. The list will inform you of the potential hazard of the chemical, first aid measures if exposed improperly and suggested safety measures when handling.

Also…Review safety contract which gives examples of safety precautions in the lab setting.

**Indicator # 3**

3. Construct, interpret and apply physical and conceptual models that represent or explain systems.

**What is a Model?**

- A model can come in many shapes, sizes, and styles. It is important to emphasize that a model is not the real world but merely a human developed example to help us better understand real world systems.
**Model Types:**

**Conceptual Models** are qualitative models that help highlight important connections in real world systems and processes. They are used as a first step in the development of more complex models.

**Teaching with Interactive Demonstrations** Interactive demonstrations are physical models of systems that can be easily observed and manipulated and which have characteristics similar to key features of more complex systems in the real world. These models can help bridge the gap between conceptual models and models of more complex real world systems.
Mathematical and Statistical Models involve solving relevant equation(s) of a system or characterizing a system based upon its statistical parameters such as mean, mode, variance or regression coefficients. Mathematical models include Analytical models and Numerical Models. Statistical models are useful in helping identify patterns and underlying relationships between data sets.

Teaching with Visualizations By this we mean anything that can help one visualize how a system works. A visualization model can be a direct link between data and some graphic or image output or can be linked in series with some other type of model so to convert its output into a visually useful format. Examples include 1-, 2-, and 3-D graphics packages, map overlays, animations, image manipulation and image analysis.

Indicator # 4
4. Decide what degree of precision based on the data is adequate and round off the results of calculator operations to the proper number of significant figures to reasonably reflect those of the inputs

Rules for significant figures

All numbers are significant Example. 145 Sig figs = 3
15667 sig figs = 5
2275 sig figs = 4
Zeros in between numbers are significant Ex. 1004 sig figs = 4
  101         sig figs = 3
  1909        sig figs = 4

Zeros to the right of the number are NOT significant Ex. 2220 sig figs = 3
  132         sig figs = 3
  130880      sig figs = 5

Zeros to the left of the number are NEVER significant Ex. .0077 sig figs = 2
  .008099     sig figs = 4
  .011003     sig figs = 5

When using scientific notation numbers in front are significant Ex. $6.02 \times 10^{23}$ sig figs = 3
  $22.4 \times 10^4$ sig figs = 3

When adding or subtracting use decimal places to the right to determine sig figs
Ex. 22.222 (3 dec. places)
  + 22.2 (1 dec place)
  answer should be 44.4 (1 dec. place)

When mult. or dividing use least number of sig figs in the numbers you are working with
Ex. 222.2 (4 sig figs)
  x 1.22 (3 sig figs)
  271.084
  answer should be 271 (3 sig figs)

**Indicator # 5**
5. Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.

*** Classroom work and assignments have hopefully reinforced this indicator.

**Indicator # 6**
6. Draw logical conclusion based on scientific knowledge and evidence from investigations.

The scientific method should be properly carried out to ensure an accurate conclusion.

The procedure should include…
1) Problem statement or Question

2) Hypothesis…which is an educated guess based on previous knowledge.

3) Experiment or test. The experiment must have a control group and an experimental group. (With Many samples or repeated trials) EVERYTHING is the same between the two groups EXCEPT the ONE variable you are testing. The control group is used to compare, and give you evidence that the different variable in your experimental group actually made a difference.

4) Data representing the information observed during the experiment.

5) Conclusion which is based on the observations made and data collected.

Example questions from previous OGT test covering this Standard…Benchmark

Short Answer Question:

Water Temperature Experiment

Students studied the effect of ice on the temperature of a sample of water. First, they put 500 mL of cold water (at 10°C) into each of four beakers. Next, they measured and recorded the initial temperature of the water in each beaker. Then, they added various amounts of ice as shown in the table below. They continued to measure the temperature over a period of 30 minutes. Their results are shown in the graph below. The temperature of the room during the experiment was 22°C.

<table>
<thead>
<tr>
<th>Beaker</th>
<th>Amount of Ice (in scoops)</th>
<th>Volume of Water (in milliliters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>500</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>500</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>500</td>
</tr>
</tbody>
</table>
13. After reviewing these results, Archie suggested, “The more ice you add to a drink, the colder the drink will become.” Using data collected in the experiment, write an explanation to Archie for why his conclusion is incorrect and what effect additional ice will have on the temperature of his drink. Respond in the space provided in your Answer Document. (2 points)

SCIENTIFIC WAYS OF KNOWING:

Nature of Science:

Benchmark A

Indicator # 1
1. Comprehend that many scientific investigations require the contributions of women and men from different disciplines in and out of science. These people study different topics, use
different techniques and have different standards of evidence but share a common purpose – to better understand a portion of our universe.

“Different Disciplines” means different areas of study, such as chemistry, biology, earth science, physics, psychology, sociology, etc…

The data collected from researchers from all these areas can be very helpful in making knowledgeable decisions. The more data, and information obtained, the more accurate your conclusions can be.

Benchmark C

Indicator # 2
2. Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.

Information gained from research and experimentation should be accurately reported so that the knowledge gained can be used in future research and conclusions. It will save time and also perhaps reinforce the future findings that occur.

Benchmark A

Indicator # 3
3. Demonstrate that reliable scientific evidence improves the ability of scientists to offer accurate predictions.

See Benchmark C Indicator # 2

Example questions from previous OGT test covering this Standard…Benchmark

Multiple Choice Question: (March 2006)

Cataracts

In 2004, wildlife rescuers found a great horned owl nearly dead from starvation. The owl’s eyes had formed cataracts, which cloud the natural lens and inhibit the eye’s ability to focus and form clear images. Cataracts can be inherited or acquired as a result of aging, disease and/or use of certain
medications. Without clear vision, the owl, named Minerva, had been unable to hunt.

Minerva was taken to the Veterinary School at the University of Wisconsin, Madison, after a local veterinarian confirmed the presence of cataracts. A pair of lenses specifically made for owls was implanted in Minerva’s eyes. After the surgery and a recovery period, Minerva was moved to a large, enclosed area where small rodents were released and her ability to hunt was to be evaluated. Scientists confirmed that, if she showed a clear ability to hunt, she would be released back into her natural habitat.

10. All cataracts were originally thought to be acquired; however, recent research indicates that some cataracts are genetic in nature.

What type of study would be most likely to lend support to the claim that cataracts can be inherited?

A. analysis of cataract thickness in several species
B. studying age-related onset of cataracts within a species
C. linkage studies on DNA from families with a history of cataracts
D. comparing characteristics of cataracts caused by specific diseases

Ethical Practices:

Benchmark C

Indicator # 4
4. Explain how support of ethical practices in science (e.g., individual observations and confirmations, accurate reporting, peer review and publication) are required to reduce bias.

Ethical practices in Science means... that the research that has been done, and conclusions made, have NOT been influenced by some outside source. To be ETHICAL is to do things that are right. Example...it would NOT be ethical for a doctor to prescribe antibiotics to a person just to get money if the person was not going to benefit from the medicine.

Peer review means that other people have reviewed the research procedures and conclusions and have determined that research has been done correctly and there was no biased influence of the conclusions.

Example questions from previous OGT test covering this Standard...Benchmark
Short Answer Question:

Use the information to answer questions 7.

Cataracts

In 2004, wildlife rescuers found a great horned owl nearly dead from starvation. The owl’s eyes had formed cataracts, which cloud the natural lens and inhibit the eye’s ability to focus and form clear images. Cataracts can be inherited or acquired as a result of aging, disease and/or use of certain medications. Without clear vision, the owl, named Minerva, had been unable to hunt.

Minerva was taken to the Veterinary School at the University of Wisconsin, Madison, after a local veterinarian confirmed the presence of cataracts. A pair of lenses specifically made for owls was implanted in Minerva’s eyes. After the surgery and a recovery period, Minerva was moved to a large, enclosed area where small rodents were released and her ability to hunt was to be evaluated. Scientists confirmed that, if she showed a clear ability to hunt, she would be released back into her natural habitat.

7. Provide two reasons why the researchers’ actions in rescuing and operating on Minerva either were or were not ethical. Respond in the space provided in your Answer Document. (2 points)

Scientific Theories:

Benchmark B

Indicator # 5
5. Justify that scientific theories are explanations of large bodies of information and/or observations that withstand repeated testing.

Scientific theories can last for long periods of time and the observations that support the theory can be repeated over and over to verify the results are accurate. New technology or research can often times bring about new discoveries that may change the original theory.

Indicator # 6
6. Explain that inquiry fuels observation and experimentation that produce data that are the foundation of scientific disciplines. Theories are explanations of this data.

“INQUIRY” means to question, “look into”, to research, to investigate. When you are inquisitive about something you research it and try to find information. The observations you make when researching or investigating may give you even more questions to answer and the process continues.

**Indicator # 7**

7. Recognize that scientific knowledge and explanations have changed over time, almost always building on earlier knowledge.

Scientific knowledge continues to build on previous knowledge and grow due to new technology and discoveries that lead to more information about the topic. It will continue to grow over time. (Hopefully, for the better)

**Science and Society:**

**Benchmark D**

**Indicator # 8**

8. Illustrate that much can be learned about the internal workings of science and the nature of science from the study of scientists, their daily work and their efforts to advance scientific knowledge in their area of study.

The scientific method is carried out by everyone...not just scientists. It is a procedure that allows for Question, Predictions, Testing, Observations and Coming to some type of answer. If carried out correctly with no bias, and no mistakes in collecting data, accurate answers can be made. We should all follow the same procedures of Scientists when we have questions in our own lives.

**Indicator # 9**

9. Investigate how the knowledge, skills and interests learned in science classes apply to the careers students plan to pursue.

Problem solving is a common activity in science class and this type of procedure will be used in many aspects of life. Other life skills would be reading, writing, and mathematics. This can lead to observations, analysis and critical thinking. The knowledge, interests, and skills learned in science class can contribute ideas for a career choice.
Extended Response Question: (March 2005)

Use the following information and graph to answer question 36.

A medical researcher is investigating immune response in patients exposed to a specific pathogen. The graph below shows the concentration of a particular antibody in the bloodstream produced during the process of acquired immunity. One curve shows the primary immune response (after the first exposure to the pathogen), and the other curve shows the secondary immune response (after the second exposure to the pathogen).

A vaccination serves as the first exposure to a pathogen and triggers the body’s primary immune response. Some vaccines contain weakened or inactive pathogens. Other vaccines contain highly similar but nonpathogenic forms.

36. Describe two benefits of receiving a vaccine, such as the polio vaccine, in protecting the body against disease, and include data from the graph to support each benefit. Respond in the space provided in your Answer Document. (4 points)
Multiple Choice Question: (March 2005)

10. When a medical technician analyzes human body fluids such as blood, which safety precaution would not be necessary?
   A. protective gloves
   B. safety goggles/face shield
   C. closed-toed shoes
   D. lead-lined apron