Achieving Conceptual Change Using a Differentiated Instructional Approach

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Achieving Conceptual Change Using a Differentiated Instructional Approach

By:

Elena Chmielowiec

June, 2015

A culminating project submitted to the Department of Education and Human Development of The College at Brockport, State University of New York in partial fulfillment of the requirements for the degree of Master of Science in Education
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By:

Elena Chmielowiec

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Advisor                                                                 Date

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Chairperson, Education and Human Development  Date
Abstract

Currently, the way that science education is implemented in our schools is inadequate for enabling students to understand abstract science and all of the misconceptions that surround complicated topics, specifically in astronomy (Cil, 2014). Simply taking notes doesn’t allow the student or teacher to discover or correct these misconceptions. There must be novel lesson teaching approaches that educators may take in order to explore and correct misconceptions, ultimately achieving conceptual change.

Teachers must take into account who they are teaching. When students enter the classroom, they each have different skills, experiences and interests. It is the teacher’s responsibility to adapt the content and learning environment to these unique learners (Carver, 2010). Unique approaches to discover these skills and interests, as well as current misconceptions must be implemented in the classroom or the educator will not know how to cater each lesson to their individual students.

Conceptual change, or correcting a misconception, in a students’ mind is considered to be an evolutionary process. This occurs when a change may occur in a certain topic over time with multiple experiences. During the process of conceptual change in the classroom, other influences such as the individual’s beliefs, motivational needs, learning attitudes, and situational and cultural contexts need to be taken into consideration (Hobson, 2010). A differentiated instructional approach should be considered in the modern classroom. It is important to include different modalities for student learning, which could potentially benefit all types of learners as each student is unique. There are many ways for an educator to go about incorporating differentiated instruction into conceptual change lessons.
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Chapter I-Introduction

Rationale

“Misconceptions are a mistaken thought, idea, or notion: a misunderstanding” (Manolas, 2011). Many different types of misconceptions exist including preconceived notions, nonscientific beliefs, conceptual misunderstandings, vernacular misconceptions and factual misconceptions. These misconceptions can come from a number of places, and are often very difficult to correct. However, there are strategic ways of teaching scientific concepts so that students not only correct their misconception themselves, but also learn the validity behind the correct concepts.

Misconceptions are formed in everyday experiences as children begin to make sense of the world around them. The facts that they obtain are often fragmented, or pieces of information. Misconceptions that students have seem to have a conflict between their own experiences and the facts that they learn in the classroom. It is a challenge for students to take in all of this new information and try and formulate new models for themselves to make sense of the concept. Misconceptions are also influenced by news items, popular science journals, and misleading science texts (Stein, 2008). There has been documentation of many consistent misconceptions over the last 20 years (Stein, 2008). Misconceptions can be defined as “ideas that are at a variance with accepted views” (Stein, 2008). They refer to ideas that are different from ones generally accepted by scientists, and begin before any formal science education. They stem from concepts that are abstract for learners to understand and are very difficult to challenge.

Educators need to develop “experiences that will specifically challenge commonly held misconceptions and require students to critically reflect upon their current constructs to being to consider the ideas generally held by scientists” (Stein, 2008). These experiences are more
meaningful when students can choose which ones would be the most beneficial for them.

Instructors need to offer different experiences because every student in the classroom is an individual with different needs such as visual vs. auditory learners, students with disabilities, and even ESL students.

**Significance of Project**

Compared to traditional teaching methods, which are inefficient in conceptual change and require children to memorize facts, conceptual change techniques effectively enable children to understand the concepts. Currently, the way that science education is implemented in our schools is inadequate for enabling students to understand contemporary views about the NOS and their misconceptions (Cil, 2014). Teachers must also take into account who they are teaching. When students enter the classroom, they have different skills, experiences and interests. It is the teacher’s responsibility to adapt the content and learning environment to these unique learners (Carver, 2010). Conceptual change in a students’ mind is considered to be an evolutionary process when a change may occur in a certain topic over time with multiple experiences. During the process of conceptual change in the classroom, other influences such as the individual’s beliefs, motivational needs, learning attitudes, and situational and cultural contexts. (Hobson, 2010) A differentiated instructional approach should be considered in the modern classroom. It is important to include different modalities for student learning, which would benefit all types of learners as each student is unique. There are many ways for an educator to go about incorporating differentiated instruction into conceptual change lessons which is what this module includes, specifically for astronomy in the Earth Science curriculum.
It is no surprise that misconceptions are plentiful in science classrooms; however they are especially prevalent in astronomy. Examples include: “the sky is blue because of reflection of light from the oceans, temperature is a measure of heat, no forces are acting on objects at rest” (LoPresto, 2011). Many concepts in astronomy are extremely abstract. For instance, the size of the universe can’t be perceived when reading about it in a textbook. The movement of the Earth around the Sun is hard to visualize when we don’t even feel like we’re moving. Misconceptions are created when we make sense of our observations, which may not be correct. For instance, feeling like the Earth isn’t moving is just relative compared to the actual speed and shape of our orbit. However, we can’t just tell students that it is a certain way if we want them to truly understand concepts. Also, students ideas can’t just be pushed aside for new concepts, they tend to hold onto their misconceptions. By using a differentiated instructional approach to offer conceptual change in the topic of astronomy with the use of this module is different than other instructional techniques. Currently, a module incorporating differentiated instruction for astronomy specifically is not available. A more individualized approach acknowledging student differences such as ability, type of learner, students with disabilities and ESL students makes it a more meaningful educational experience for the students, which leads to a better understanding of material.
Definition of Terms

ARGUMENTATION: The action or process of reasoning systematically in support of an idea, action, or theory. It includes debate, dialogue, conversation, and persuasion.

ARGUMENTATIVE APPROACH: A process of reasoning between alternative viewpoints based on data.

CONCEPTUAL CHANGE: Pertaining to concepts or to the forming of concepts.

CONSTRUCTIVIST: Learners make sense of the world around them, as well as new information, by working to construct knowledge through interaction with others, texts, social media, etc.

DIFFERENTIATION: Giving students multiple options for taking in information.

MISCONCEPTION: A belief that is incorrect because it is based on faulty thinking or understanding of how the world works. Often erroneous conclusions based on observations.

NATURE OF SCIENCE: Key principles and ideas which provide a description of science as a way of knowing.
Chapter II-Literature Review

Overview

Misconceptions can become part of the learning process (NRC, 1997). Compared to traditional teaching methods, which are inefficient in conceptual change and require children to memorize facts, conceptual change techniques effectively enable children to understand the concepts. It is more effective to teach the concepts that support the phenomena or concept in question. It is helpful to view misconceptions as problems, and teaching students the aspects of problem solving. Students must understand the reasoning process that leads to the generalizations behind concepts. Using an active approach, rather than passive approaches at teaching are more effective (Manolas, 2011).

The argumentative approach to teaching science has gained popularity within recent years. It is clearly defined as “a process of reasoning between alternative viewpoints based on data” (Acar, 2015). This can readily be done by encourage students to engage, explore, explain, elaborate and evaluate the conceptions (Manolas, 2011). The model is better referred to as the 5E Learning Cycle Model which was created based upon the constructivist learning model (Bybee, 2006). The constructivist approach to education assumes that “learners make sense of the world around them, as well as new information, by working to construct knowledge through interaction with others, texts, social media, etc” (Bryant, 2015). The role and nature of interaction enhances connections with prior knowledge and connects to new information and acknowledges that the real world exists. There is an understanding that the world can never be known in one single way and that understanding is “dependent on the learner” (Bryant, 2015)

Many times, students believe that their misconceptions are correct and aren’t at all aware that they are wrong. Students usually have a hard time giving up their misconceptions because it
is probable that they’ve had them for a long time. It becomes a major problem when students start to build knowledge on misconceptions. This can have a serious impact on their learning and may affect how they solve problems or apply their knowledge (Manolas, 2011). Either one of these strategies is time consuming and takes away from other activities. If the educator wants to teach the student to overcome their misconceptions, it is necessary. Other tips for teachers would be to anticipate the most common misconceptions, which is often compiled by others and published; you can find common misconceptions for each discipline in science (Larkin, 2012).

Compared to traditional teaching methods, which are inefficient in conceptual change and require children to memorize facts, conceptual change techniques effectively enable children to understand the concepts. Currently, the way that science education is implemented in our schools is inadequate for enabling students to understand contemporary views about the NOS and their misconceptions (Cil, 2014). Teachers must also take into account who they are teaching. When students enter the classroom, they have different skills, experiences and interests. It is the teacher’s responsibility to adapt the content and learning environment to these unique learners (Carver, 2010). Conceptual change in a students’ mind is considered to be an evolutionary process when a change may occur in a certain topic over time with multiple experiences. During the process of conceptual change in the classroom, other influences such as the individual’s beliefs, motivational needs, learning attitudes, and situational and cultural contexts. (Hobson, 2010) A differentiated instructional approach should be considered in the modern classroom. It is important to include different modalities for student learning, which would benefit all types of learners as each student is unique. There are many ways for an educator to go about incorporating differentiated instruction into conceptual change lessons.
Benefits of Conceptual Change Techniques

Incorporating activities that are authentic to students’ everyday life is a goal of many educators for a meaningful experience. In order to fully understand students’ conceptions, we must enable the students to express both verbally and nonverbally. Visual representations that a student constructs will provide their understanding of what has and has not been learned. For example, using student generated photographs in lessons to display certain laws in physics or scientific concepts allows for the extension of the students internal world and how they apply it to real life situations in the outside world (Eshach, 2010). The method has the ability to determine if students are able to apply an abstract idea to a real life situation.

It proves that students have difficulty bridging the abstract world of science, learned in class, to the world outside of the classroom. It is vital to connect school science with students' everyday lives, which proves to be a complex task for educators. Through this activity, it was found that students may learn misconceptions in the classroom as some educators also have misconceptions.

It was found that students and educators use differences in language, which plays a crucial role in the process of conceptual growth. Educators should encourage students to use scientific terms when explaining real situations to make them more accurate. This method is not sufficient for eliciting all possible student misconceptions, so other methods may be necessary. However, using student generated photographs proves to have its own unique benefits. By incorporating different strategies and student choice, the educator is catering the experience to every single type of student. The student differences can range from ability, to a visual or
auditory learner, even students with disabilities and English as Second Language (ESL) learners. This is important because it makes for a more meaningful experience for each individual student.

**Limitations of Conceptual Change Techniques**

An educator needs to be aware that too much instruction may cause confusion, and cause the child to discard all new information and use only their own experience to gain an understanding which is counterintuitive to the entire conceptual change process. When children become overloaded, they fall back to a simpler way of processing and re-organizing the information. By using so many different approaches, it may tend to get overwhelming for some students. For an educator, it is easy to want to include as much as they can into a single lesson or activity. This only confuses the student more, and therefore they will not retain the information.

A challenge of the argumentative approach is that often times, students have difficulties constructing evidence-based arguments and reasoning between alternatives (Acar, 2015). Thus students’ incorrect notions of a science concept can be changed through argumentative practice that invites students to address their alternative conceptions, and to reflect and change their prior conceptions through discussion. Some students are naturally more shy or quiet than others, while some are at the opposite end of the spectrum. For these students, arguments or discussions might not work as well. The educator is going to have to take this into consideration and work with them more in activities that are based on communication and argumentation.

The challenge with hands-on science experimental approaches for conceptual change is that it will “require a great deal of effort, time, collaboration, and motivation from all participants” (Phillips, 2014). Hands-on experiments have a tendency to get messy and may not always go as
planned. These types of lessons are very time consuming, both in preparation and implementation. The instructor needs to be flexible and able to modify lessons if time constraints do occur. It is also important to point out that teachers need to continuously monitor and coach students’ performance which may take a lot of extra effort during the instruction. Some students may be more motivated than others to actually perform a hands-on activity. This is a reason why educators need to make specific, strategic groups.

**Implementation Strategies for Conceptual Change**

One thing to remember before implementing such techniques is that the classroom environment has to be conducive to different learning levels. Students need to respect their differences and understand that they will be doing different activities to all learn the same concept. Teachers should realize that in order for differentiation to be successful, they must be flexible with their lessons and assessment techniques.

Differentiation is not an easy task. Having a classroom full of students who each have different skills, interests, and learning levels with common curricular outcomes at the end of the year seems like a daunting task for teachers. However, there are many techniques that can be used to differentiate successfully. One thing to remember before implementing such techniques is that the classroom environment has to be conducive to different learning levels. Students need to respect their differences and understand that they will be doing different activities to all learn the same concept. Teachers should realize that in order for differentiation to be successful, they must be flexible with their lessons and assessment techniques.

Differentiation develops a community in which all students develop a sense of belonging and acceptance. It occurs because educators know that all students can learn although in different
ways, and should have a say in that process. In order for differentiation to be successful, students need to feel safe and respected in the learning environment. Students need to understand what differentiation is and need to accept it, meaning that fair is not always equal.

A pretest is necessary to give at the beginning of each unit or lesson that is going to use any of the differentiation techniques. It is recommended in order to gauge student readiness. Educators can use the pretest to group students with similar readiness to complete differing levels of assignments and directions, which ultimately all have the same end goal. A pretest is also needed to measure the students’ level of knowledge so that you can expose all students to engaging experiences that are appropriate for their level. A survey is helpful in getting an idea of student’s misconceptions, and they should be dealt with “openly, honestly, and immediately” (LoPresto, 2011).

Assessment is a very important aspect of differentiation. Formal and summative assessments may not be the same for each student. It is important to offer students multiple methods in which they can show understanding. Student choice allows students to truly own their learning experience. Varied activities should be more enjoyable because students are engaged in meaningful learning.

Often when discussions are had about in the classroom, some students dominate the discussion while others may be shy and do not speak up. This technique is implemented so that students will have an equal amount of discourse. Having discussions increases the teachers’ awareness of student understanding; however students may need time to make sense of what they’ve learned. In the outlined framework, students and teachers are working together for a shared learning experience. Instead of teachers consistently questioning students, they are the ones asking peers to answer or respond. It is important to note that in order for successful student
group discussions, students need to be aware that you are there to help them learn, that you’re on their side and you’ll do what needs to be done to help them grow as an individual (Helibronner, 2013). Small groups are less threatening, such as think pair share activities. Student journals are also helpful to assess true understanding of the concepts. It is important for the teacher to guide engagement and high level thinking as this produces richer and deeper discussion. It was discovered that creating roles within groups helped each student to engage. This is helpful in differentiation as students may have different skills and be better prepared for different roles within the group, while all get an equal learning experience. One of these ideas are facilitating debates and ensuring that there is enough time for discussion about the new concepts. The study pointed out that if using material models, one should be careful because children often interpret these models as copies of reality. Similar problems have been found when using analogies in lessons. Sometimes, misconceptions can arise from illustrations used within teaching.

Cartoons are drawings with minimal text involving visual representations of a specific idea in a certain subject. They offer students alternative viewpoints on the situation. They identify common areas of misunderstanding and are a good tool to probe students’ ideas and beliefs. They can also promote or spark argumentation between peers. Conceptual change texts "state a common misconception about a natural phenomenon and directly refute it while providing the scientifically acceptable idea with asking students to make a prediction about the given situation" (Cil, 2014). They are useful in introducing misconceptions of science and encourage students to challenge their own that they may have. Texts may provide evidence to explain and demonstrate to students why their misconceptions are not scientific. They are also helpful in persuading students to change their misconceptions. Out of three groups of students who were each taught the NOS in different ways, the best way to change views of students was
using the conceptual change approach, both cartoon and text. Students proved to justify their views and try to refute others.

A strategy called "Unit Pages" allows students to take charge of their own learning. It combines a flexible tiered approach, where grouping is based on student need and interest. At the first level, students are given basic knowledge. At the second level, students are asked to investigate the topic and produce an artifact to prove that they can apply their knowledge. The third level includes assessments. In the second and third level, students can make choices about the artifacts and assessments that they want to complete. Flexibility is important because assignments may need to be adjusted based on individual. The process of using unit pages allows students to have ownership of their process, environment, and products while allowing the teacher to guide the content and monitor the learning through formal and informal assignments (Dotger, 2010). Unit pages encourage students to engage in higher-level thinking skills as they advance through the levels.

Teachers can produce a menu of options for students using the “tic tac toe” method. In order to do this, teachers need a full understanding of learning outcomes. The tasks created should allow students to represent their learning in several ways aligned with these outcomes. Varied activities should be more enjoyable because students are engaged in meaningful learning. Students needing more time can complete one of the tasks on the “tic tac toe” board, while faster learners can complete multiple tasks. Again, it is important to remember and for all students to understand that fair is not equal. After completing the required number of tasks, student discussion should occur. Rubrics are helpful in outlining specific guiding principles and outcomes so that students are aware of what is expected of them.
Wikis prove to be extremely beneficial in differentiated lessons and even units. In this approach, teachers keep the learning objectives similar for all students; however it allows them to express what they've learned in multiple ways. Wikis are helpful in delivering a wealth of content via pictures, text, hyperlinks to other pages, and multimedia such as sound (pg 25). The websites allow teachers to share resources with other educators, students, and parents. It is important to first lay groundwork for using wikis appropriately in the classroom. A pretest is needed to measure the students’ level of knowledge so that you can expose all students to engaging experiences that are appropriate for their level. The teacher’s role when implementing a differentiated wiki unit turns into that of a facilitator. Students will be on task with their own learning. Students may also work together on projects. The wikis can be reused from year to year with the possibility of alterations.

Discussion is an important aspect of student learning. It not only enhances student understanding, but allows the educator to assess whether the students understand a concept or not, and if they have any misconceptions. It is unfortunate however that some students seem to dominate discussion, while students who are shy or need more time in order to fully grasp a concept are silent. Differentiation of groups and assigning roles within these groups has proven to lead a more engaging experience for all learners. It is also easier to scaffold lessons that are split into small groups. Differentiation is all about structuring learning for students. Each level requires less and less scaffolding. To implement different levels, teachers may begin a lower student at a more guided level and higher students with less structure. All students should have the same learning objectives at the end of the lesson.

Students often need experiences that allow them to formulate questions about concepts and an inquiry approach would allow them to test those questions and communicate findings.
with peers. A guided inquiry approach was used as this study was focusing on fourth graders. Hobson's goal was to encourage students to think scientifically about everyday events. Students worked collaboratively to gather, record, and analyze data which required some type of structure such as scaffolded learning. Using technology to support scientific inquiry was an effective way for students to be actively engaged. It was found that students can learn more advanced concepts in addition to developmentally appropriate ones with the help of such activities. Some concepts involve thinking in three dimensions from two different perspectives. A computer simulation would be able to provide students two perspectives dynamically in a virtual environment therefore making it possible for them to learn the concepts. Complex science concepts require learners to pay attention to and process a large number of knowledge elements and the relationship among them. This computer based guided inquiry activity reduces the burden on cognitive capacity.

If students are given options about their education, they are more likely to respond to it. Having a say in their own education through multiple strategies offers a more individualized approach which caters to each students unique abilities. Of course the instructors’ role in this technique will be crucial; whether it is the issue of effort, time constraints, or collaboration, however it will be worth it. Taking the time to use multiple strategies and techniques will not only enhance a students’ education, they will better understand the material. Differentiating these lessons to the students specific needs, whether it is a type of learning style they prefer, a student with disabilities, or an ESL student, each student will be able to truly learn the concepts behind common misconceptions. Only once these concepts are truly understood can conceptual change occur.
Summary

Instead of educators teaching students to simply memorize facts, conceptual change techniques allow students to effectively understand abstract science concepts. Currently, many education establishments do not incorporate conceptual change techniques. Using the techniques outlined above can effectively enable children to fully understand concepts. Conceptual change techniques are utilized best when an educator can base their lessons on students’ previous knowledge, interest, and current misconceptions as assessed through a pre-test. Once an educator can judge what misconceptions can be changed, they can choose the most effective conceptual change method to utilize in their classroom. True conceptual can be achieved when educators use an active, rather than passive approach to make their teaching more effective as compared to more traditional teaching methods.

Recently, a more argumentative approach to teaching science has gained popularity often used as the 5E Learning Cycle Method which is based upon the constructivist learning model. This approach offers a way for students to make sense of the world around them, and use the nature of interaction to enhance connections with prior knowledge to new information (Bybee, 2006). This creates a deeper understanding of the material and can offer conceptual change for students. A differentiated instructional approach is also gaining popularity in the modern classroom as it accommodates the need to include different modalities for student learning, benefiting all types of learners. Overall, a need for true conceptual change in the science classroom has shown a need for the utilization and implementation of new techniques.
Chapter III-Capstone Project

Overview

This project is composed of a collection of lessons that incorporate specific conceptual change techniques to enhance astronomy lessons. The lessons that were selected are notorious for student misconceptions and need for true conceptual change. The project design is detailed, followed by handouts that will be used during the lessons or labs. A comprehensive lesson plan that encompasses all of the conceptual change techniques as well as student and teacher actions is included and can be used to example a specific lesson that educators can use in their own Earth Science classrooms.

Project Design

This project will be to develop the lesson plans for the astronomy unit in Earth Science, covering key ideas in the New York State Earth Science curriculum standards.

- Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.
- Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.
- Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

The unit will be composed of 10-12 (80 minute) differentiated lessons. Each unit will include a methodologically appropriate integration of history of science. The lessons will include, as applicable:
- Title of lesson
- NYS standards that fit the lesson
- Rationale for integrating differentiation with these standards, and rationale for method chosen
  - Primary learning target and lesson objectives
  - List of necessary instructional resources and materials
    - Assessments and data collection
    - Instructional strategies and learning tasks
  - Possible problems that may be encountered because of misconceptions
Where the above points are not addressed by research in the attached literature review, the information provided will be either based on the thesis author’s own experience or projected implementation in the classroom.

For example, one lesson in a unit on ellipses:

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>What is the shape of Earth’s orbit around the sun and how can we calculate it’s eccentricity?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary learning target</strong></td>
<td>The focus learner will be able to draw and calculate an ellipse using laboratory techniques. They will draw multiple ellipses of planets of their choice and compare how the distance between the foci will change the eccentricity.</td>
</tr>
</tbody>
</table>
| **Content Standard(s)** | **NYS Earth Science Curriculum**  
1.1b Nine planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites. |
| **2 Learning objectives with measurable criteria, associated with the content standards.** | 1. Students will design models to replicate four different ellipses.  
2. Students will correctly complete calculations of eccentricity.  
3. Students will argue why the Earth’s orbital shape being perfectly circular is a misconception. |
| **Rationale** | "Unit Pages” allow students to take charge of their own learning. It combines a flexible tiered approach, where grouping is based on student need and interest. At the first level, students are given basic knowledge. At the second level, students investigate the topic and produce an artifact. The third level includes assessments. |
| **Possible problems** | Some students may need more direction than others. Physical impairments not allowing the drawing of ellipses using the string-push pin technique. |
| **Instructional resources and materials Include materials for teachers & students** | **Teacher**  
- Examples of ellipses, worksheets with information on eccentricity and an orbital shape  
**Students**  
- Pencil, worksheets, cardboard, string, two push pins |
| **Assessments & data collection** | **Formal**  
- Written discussion arguing why the Earth’s orbit is not perfectly circular and how the student came to this conclusion.  
- 4 Ellipses drawn using the string and push pin. Eccentricity calculations for each ellipse.  
**Informal**  
- Participation in laboratory exercise. Teacher observations of student behavior. |
Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.

<table>
<thead>
<tr>
<th>Teacher Actions</th>
<th>Student Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Introduce Kepler’s Laws. Define eccentricity, ellipse.</td>
<td>Share ideas as a class based on the results of bellwork assignment.</td>
</tr>
<tr>
<td>Show diagrams of Earth’s orbit from science textbook. Group students by ability.</td>
<td>Students take notes, class discussion occurring</td>
</tr>
<tr>
<td>Show diagram of true Earth’s orbit</td>
<td>Class discussion what may be correct and incorrect with the diagram. Have groups write ideas on the board.</td>
</tr>
<tr>
<td>Explain laboratory activity and how to safely design an ellipse as well as calculate eccentricity</td>
<td>Class discussion.</td>
</tr>
<tr>
<td>Explain that students can choose 4 planets to draw ellipses of and calculate eccentricity..</td>
<td>Students get into different groups by interest.</td>
</tr>
<tr>
<td>Monitors group work and provides feedback.</td>
<td>Groups choose.</td>
</tr>
<tr>
<td>Checks and approves ellipse</td>
<td>Groups construct ellipses, calculates eccentricity. Proving the Earth’s orbit is slightly eccentric.</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions.</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Lesson: 1 – Eccentricity

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>What is the shape of Earth’s orbit around the sun and how can we calculate it’s eccentricity?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary learning target</td>
<td>The focus learner will be able to draw and calculate an ellipse using laboratory techniques. They will draw multiple ellipses of planets and compare how the distance between the foci will change the eccentricity.</td>
</tr>
</tbody>
</table>
| Content Standard(s) | **NYS Earth Science Curriculum**  
1.1b Nine planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites. |
| 2 Learning objectives with measurable criteria, associated with the content standards. | 1. Students will design models to replicate four different ellipses.  
2. Students will correctly complete calculations of eccentricity.  
3. Students will argue why the Earth’s orbital shape being perfectly circular is a misconception.  
Upon completion of this lesson, students will also be able to:  
(1) Define the words: eccentricity, ellipse, and foci  
(2) Calculate the eccentricity of an ellipse.  
(3) Describe how eccentricity changes as the distance between foci changes.  
(4) Describe how Earth’s orbit compares to any given eccentrical orbit  
(5) Describe the shape of an ellipse with an eccentricity of 0.00 or 1.00  
(6) Describe Earth’s orbital shape. |
| Rationale | "Unit Pages" allows students to take charge of their own learning. It combines a flexible tiered approach, where grouping is based on student need and interest. At the first level, students are given basic knowledge. At the second level, students investigate the topic and produce an artifact. The third level includes assessments. |
| Possible problems | Some students may need more direction than others. Physical impairments not allowing the drawing of ellipses using the string-push pin technique. |
| Instructional resources and materials | Teacher |
### Include materials for teachers & students

- Examples of ellipses, worksheets with information on eccentricity and an orbital shape

### Students

- Pencil, worksheets, cardboard, string, two push pins

### Assessments & data collection

**Formal**
- Written discussion arguing why the Earth’s orbit is not perfectly circular and how the student came to this conclusion.
- 4 Ellipses drawn using the string and push pin.
  - Eccentricity calculations for each ellipse.

**Informal**
- Participation in laboratory exercise. Teacher observations of student behavior.
- Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.

### Instructional strategies and learning tasks

<table>
<thead>
<tr>
<th>Teacher Actions</th>
<th>Student Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Introduce Kepler’s Laws. Define eccentricity, ellipse.</td>
<td>Share ideas as a class based on the results of bellwork assignment.</td>
</tr>
<tr>
<td>Show diagrams of Earth’s orbit from science textbook. Group students by ability.</td>
<td>Students take notes, class discussion occurring</td>
</tr>
<tr>
<td>Class discussion what may be correct and incorrect with the diagram. Have groups write ideas on the board.</td>
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<tr>
<td>Action</td>
<td>Response</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Show diagram of true Earth’s orbit</td>
<td>Class discussion.</td>
</tr>
<tr>
<td>Explain laboratory activity and how to safely design an ellipse as well as calculate eccentricity</td>
<td>Students get into different groups by ability</td>
</tr>
<tr>
<td>Explain that students can draw 4 ellipses of and calculate eccentricity</td>
<td>Groups choose.</td>
</tr>
<tr>
<td>Monitors group work and provides feedback.</td>
<td>Groups construct ellipses, calculates eccentricity. Proving the Earth’s orbit is slightly eccentric.</td>
</tr>
<tr>
<td>Checks and approves ellipse</td>
<td></td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Bellwork

1. The true shape of the Earth’s orbit is best described as a

1. slightly eccentric ellipse
2. perfect ellipse
3. slightly oblate sphere
4. highly eccentric ellipse

2. Which object is located at one foci of the elliptical orbit of Mars?

1. the Sun
2. Betelgeuse
3. Earth
4. Jupiter

3. Which planet has an orbit with an eccentricity most similar to the eccentricity of the Moon’s orbit around Earth?

1. Earth
2. Jupiter
3. Pluto
4. Saturn
4. The diagram represents a planet revolving in an elliptical orbit around a star.

As the planet makes one complete revolution around the star, starting at the position shown, the gravitational attraction between the star and the planet will

A. decrease, then increase
B. increase, then decrease
C. continually decrease
D. remain the same

5. Which model of a planet's orbit best represents the actual eccentricity of the orbit of Mars?

[Models are drawn to scale.]
Ticket Out the Door

Base your answers to questions 1 and 2 on the diagram below, which represents the elliptical orbit of a planet traveling around a star. Points A, B, C, and D are four positions of this planet in its orbit.

1. The gravitational attraction between the star and the planet will be greatest at position
   A. A
   B. B
   C. C
   D. D

2. As the planet revolves in orbit from position A to position D, the orbital velocity will
   A. continually decrease
B. continually increase
C. decrease, then increase
D. increase, then decrease

Diagram I represents the orbit of an Earth satellite, and diagram II shows how to construct an elliptical orbit using two pins and a loop of string.

E. 3. The Earth satellite takes 24 hours to move between each numbered position on the orbit. How does area $A$ (between positions 1 and 2) compare to area $B$ (between positions 8 and 9)?

A. Area $A$ is smaller than area $B$.
B. Area $A$ is larger than area $B$.
C. Area $A$ is equal to area $B$. 
4. According to the reference table *Solar System Data*, which planet’s orbit would most closely resemble a circle?

A. Mercury  
B. Venus  
C. Saturn  
D. Pluto

5. At which position represented in diagram I would the gravitational attraction between the Earth and the satellite be greatest?

A. 1  
B. 7  
C. 3  
D. 11
TIERED I APPROACH - Class Discussion

Perceived shape of Earth’s orbit

Actual shape of Earth’s orbit

148 million kilometers (January)

152 million kilometers (July)

Eccentricity

(not to scale)

~100,000 years
TIERED II APPROACH

INTRODUCTION:
The earth revolves around the sun in an orbit which is called an ellipse. An ellipse has two "center points". Each one is called a focus. The Sun is not in the exact middle of the earth's orbit. The Sun is found at one of the focal points.

OBJECTIVE:
You will compare the shape of the Earth's orbit and orbits of other planets with the shape of a circle.

MATERIALS:
cardboard
2 push pins
string
Safe-T compass
pencil
ruler
plain white paper

PROCEDURE:
1. On plain white paper, draw a straight line lengthwise down the middle of the paper. (This should already be part of the lab papers.)
2. Near the center of this line, draw two dots 3 cm apart.
3. Placing the paper on a piece of cardboard, put a straight pin in each dot (focus).
4. Loop the string around the straight pins and draw the ellipse by placing your pencil inside the loop. (Ask your teacher for help if you don't understand this step.)
5. Label this ellipse #1.
6. Measure the distance between the straight pin holes (foci). This is "d". Record this on your Report Sheet.
7. Measure the length of the major axis (L) and record this on the Report Sheet.
8. Move each pin out 1 cm and draw a new ellipse. Label it #2 and measure and record d and L.
9. Move each pin out another 1 cm and draw a new ellipse. Label it #3 and measure and record d and L.
10. Place a dot in the exact middle of the first two foci. Using a compass construct a circle. Place the point of the compass in the center dot. Extend the compass along the major axis so the pencil touches ellipse #1. This will be the radius of the circle you are drawing.
11. Using the given equation, calculate the eccentricity (e) of each of the five figures. Show ALL work on your report sheet. Round your answers to three decimal places.

ECCENTRICITIES OF THE PLANETS
Mercury 0.206
Venus 0.007
Earth 0.017
Mars 0.093
Jupiter 0.048
Saturn 0.056
Uranus 0.047
Neptune 0.008
REPORT

Ellipse #1
Calculations
d = __________
L = __________
e = __________

Ellipse #2
Calculations
d = __________
L = __________
e = __________

Ellipse #3
Calculations
d = __________
L = __________
e = __________

Ellipse #4
Calculations
d = __________
L = __________
e = __________

TIERED III APPROACH- ASSESSMENT

Group A

QUESTIONS:
1. What is the equation for eccentricity?

2. What is the eccentricity for Earth’s orbit?

3. How does Earth’s orbit compare to the shape of Mercury’s orbit?

4. What is the smallest an eccentricity can be? What shape is this?

5. What is the largest an eccentricity can be? What shape is this?

Group B

QUESTIONS: (answer in complete sentences)

1. What change takes place in the eccentricity of the ellipses when you increase the distance between the foci?

2. Which of the four ellipses you drew (not counting the circle) was the most eccentric?
3. Which of the four ellipses you drew (not counting the circle) was the least eccentric?

4. What is the minimum eccentricity an ellipse can have?

5. What is the name of the geometric figure which has the minimum eccentricity?

6. How does the numerical value of "e" change as the shape of the ellipse approaches a straight line?

7. Where is the sun located on a diagram of the earth's orbit?

8. What was the eccentricity you calculated for Ellipse #1?

9. Which is rounder (less eccentric), the orbit of the Earth or your Ellipse #1?

10. In the table, Eccentricities of the Planets, the planets are listed in order by their distance from the sun. Is there a direct relationship between the eccentricity of its orbit and the distance a planet is from the sun?

11. List the planets in order of increasing eccentricity of their orbits.

CONCLUSION:
Describe the true shape of the earth's orbit.

Group C

1. What change takes place in the eccentricity of the ellipses when you increase the distance between the foci?

2. Which of the four ellipses you drew (not counting the circle) was the most eccentric?

3. Which of the four ellipses you drew (not counting the circle) was the least eccentric?

4. What is the minimum eccentricity an ellipse can have?

5. What is the name of the geometric figure which has the minimum eccentricity?
6. How does the numerical value of "e" change as the shape of the ellipse approaches a straight line?

7. Where is the sun located on a diagram of the earth's orbit?

8. What was the eccentricity you calculated for Ellipse #1?

9. Which is rounder (less eccentric), the orbit of the Earth or your Ellipse #1?

10. In the table, Eccentricities of the Planets, the planets are listed in order by their distance from the sun. Is there a direct relationship between the eccentricity of its orbit and the distance a planet is from the sun?

11. List the planets in order of increasing eccentricity of their orbits.

Advanced Questions- Research Kepler’s Laws on your own!

1. At approximately what orbital eccentricity is the maximum orbital velocity twice as much as the minimum orbital velocity?

2. If you double the eccentricity you found in the previous problem, what is the relationship between the minimum and maximum orbital velocities?

3. The Sun appears slightly larger in the sky during January than it does during July. Based on this information, during which of these months is the Earth travelling faster in its orbit? Explain your answer.
## Lesson: 2 – Stars

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>Are stars all white as they appear from Earth? Do stars die?</th>
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</thead>
<tbody>
<tr>
<td><strong>Primary learning target</strong></td>
<td>The focus learner will be able to explain that stars are different colors based on their temperature and the HR diagram. Students will be able to explain the life cycle of a star using the HR diagram.</td>
</tr>
</tbody>
</table>
| **Content Standard(s)** | NYS Earth Science Curriculum  
1.1c Earth’s coordinate system of latitude and longitude, with the equator and prime meridian as reference lines, is based upon Earth’s rotation and our observation of the Sun and stars. |
| **2 Learning objectives with measurable criteria, associated with the content standards.** | 1. Synthesize a stellar life cycle based on observation.  
2. Contrast students’ life sequences with stars sequence  
3. Students will identify the relationship between star color and temperature |
| **Rationale** | Instead of teachers always asking questions, think pair share activities allow students to ask questions of their peers and answer/respond in a small group setting that is less threatening. |
| **Possible problems** | Some students may need more direction than others. Physical impairments not allowing the drawing of HR diagram. |
| **Instructional resources and materials Include materials for teachers & students** | Teacher  
Laptop Cart  
**Students**  
Laptop- one per student or one per group, pencil, worksheets, colored pencils |
| **Assessments & data collection** |  
- **Formal**  
Written discussion arguing stellar life cycles  
Completed HR diagram  
- **Informal**  
  - Participation in laboratory exercise. Teacher observations of student behavior.  
Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers. |
<table>
<thead>
<tr>
<th>Teacher Actions</th>
<th>Student Actions</th>
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<tbody>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Teacher asks class two questions to discuss with a partner of their choice: Do stars ever die? Are all stars white?</td>
<td>Students discuss with one partner their thoughts. They write this down in their journal as “before” lab activity. They will then share their ideas with another group.</td>
</tr>
<tr>
<td>Teacher assigns lab assignments. Provides ticket-out-the-door questions.</td>
<td>Students work together to determine the stellar life cycle and HR diagram.</td>
</tr>
<tr>
<td>Teacher asks students to reconvene with a different group than they have previously talked with.</td>
<td>Students write an “after lab activity” entry in their journals.</td>
</tr>
<tr>
<td>Assign ticket out the door questions to ensure students understand the objective.</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Bellwork

1. Stars spend most of their life as
   A. Blue supergiants
   B. Main sequence stars
   C. White dwarfs
   D. Red giants

2. Which two groups of stars can have similar brightness?
   A. Blue supergiants and white dwarfs
   B. White dwarfs and red giants
   C. Red dwarfs and red giants
   D. Blue supergiants and supergiants

3. Which of the following stars has a surface temperature of approximately 9,000 K and luminosity about 1 to 20 times greater than the Sun’s luminosity?
   A. Sirius
   B. Procyon B
   C. Rigel
   D. Polaris

4. According to the Characteristics of Stars graph in the reference tables, which of the following stars is about 100 times brighter than the Sun but has a surface temperature about 2,000 K cooler than the Sun?
   A. Alpha Centauri
   B. Aldebaran
   C. Sirius
   D. Barnard’s Star

5. According to the Characteristics of Stars graph in the reference tables, which of the following stars is cooler than the Sun?
   A. Procyon B
   B. Rigel
   C. Barnard’s Star
   D. Sirius
Ticket Out the Door

1. Which of the following groups of stars represent the final observed stages of stars with masses similar to the Sun?
   A. White dwarfs
   B. Red dwarfs
   C. Red giants
   D. Blue supergiants

2. Which of the forces listed below is most responsible for the formation of stars?
   A. Gravity
   B. Magnetism
   C. Electromagnetism
   D. Light

3. Which star has a higher luminosity and a lower surface temperature than the Sun?
   A. Rigel
   B. Barnard’s Star
   C. Alpha Centauri
   D. Aldebaran

4. Compared to the surface temperature and luminosity of the star Polaris, the star Sirius is
   A. hotter and more luminous
   B. hotter and less luminous
   C. cooler and more luminous
   D. cooler and less luminous
5. The Sun is inferred to spend the greatest amount of time in its life cycle

A. contracting from a gas cloud (nebula)

B. as a main sequence star

C. moving away from the main sequence and becoming a giant star

D. changing from a giant star to a white dwarf star
**STARS- Think Pair Share**

*Directions*

Possible Questions about Stars: Do stars ever die? Are all stars white?

<table>
<thead>
<tr>
<th><strong>Think</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Write three answers or ideas you have about this question or problem.</td>
<td></td>
</tr>
<tr>
<td>1.</td>
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<tr>
<td>2.</td>
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<tr>
<td>3.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pair</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss your ideas with a partner. Check any ideas above that your partner also wrote down.</td>
<td></td>
</tr>
<tr>
<td>Write down ideas your partner had that you did not.</td>
<td></td>
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<tr>
<td>1.</td>
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<td>2.</td>
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<td>3.</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Share</strong></th>
<th></th>
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<tbody>
<tr>
<td>Review all of your ideas and circle the one you think is most important. One of you will share this idea with the whole group. As you listen to the ideas of others, write down three you liked.</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td></td>
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<tr>
<td>2.</td>
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<tr>
<td>3.</td>
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</tbody>
</table>
Massive Star Life Cycle Activity

**Directions:** Rank each of the following pictures by age, going from youngest to oldest. Put a 1 in the blank by the picture you think is the youngest star, a 2 in the blank by the second youngest, and so on. If you wish, try to guess the age of each star. These are pictures of the formation sequence of really BIG stars. Your FIRST task is to figure out and record the correct sequence of pictures from birth formation to stellar death. SECOND, and most important, write a paragraph or two that describes the sequence of stellar formation, life cycle, and death. Use sketches or pictures from a website to support your description if you need to.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Image]</td>
<td>[Image]</td>
<td>[Image]</td>
</tr>
<tr>
<td>D</td>
<td>E</td>
<td>F</td>
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<td>[Image]</td>
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<tr>
<td>G</td>
<td>H</td>
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</tbody>
</table>
Star Color and Temperature Graph

Materials:
Colored pencils (red, orange, yellow, blue)

Procedure:
1. Study the star data charts below. Note that the sun, used as a standard of brightness, is
given a value of 1. The brightness given for each other star shows how that star compares
with the sun.

2. Plot the data from both charts on the graph on the next page.

3. Stars with surface temperatures up to 3,500°C are red. Shade a vertical band from 2000°C
to 3500°C a light red.

4. Shade other color bands as follows: Stars up to 5000°C are orange-red, up to 6000°C
yellow-white, up to 7500°C blue-white, and up to 40,000°C blue.

5. Look for patterns in your graph. Compare it to the diagram in your ESRT page 16!

6. Label the main sequence, red super giants, and the white dwarf stars

<table>
<thead>
<tr>
<th>Star Name</th>
<th>Temperature (°C)</th>
<th>Brightness (Luminosity) Sun = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 SUN</td>
<td>5300</td>
<td>1</td>
</tr>
<tr>
<td>2 ALPHA CENTAURI A</td>
<td>5500</td>
<td>1.3</td>
</tr>
<tr>
<td>3 ALPHA CENTAURI B</td>
<td>3900</td>
<td>0.36</td>
</tr>
<tr>
<td>4 BARNARD’S STAR</td>
<td>2500</td>
<td>0.0004</td>
</tr>
<tr>
<td>5 SIRIUS A</td>
<td>10100</td>
<td>23</td>
</tr>
<tr>
<td>6 SIRIUS B</td>
<td>10400</td>
<td>0.008</td>
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<tr>
<td>7 PROCYON A</td>
<td>6200</td>
<td>7.6</td>
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<td>8 PROCYON B</td>
<td>7100</td>
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<tr>
<td>9 VEGA</td>
<td>10400</td>
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<tr>
<td>10 CAPELLA</td>
<td>5600</td>
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<td>11 RIGEL</td>
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<td>12 BETELGEUSE</td>
<td>2900</td>
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<td>18 DENEB</td>
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### Hertzsprung-Russell Diagram

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<th>A</th>
<th>F</th>
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</tbody>
</table>

**Approximate Temperature (°C)**

- 4500
- 3000

**Brightness**

- 40000
- 20000
- 10000
- 7000
- 6000
- 4000
- 3000
Questions

1. What is the general relationship between temperature and star brightness?

2. What relationship do you see between star color and temperature?

3. List the colors from coolest to hottest:

4. How does the sun compare to the other stars on the main sequence?

5. What spectral class does our sun belong to? ______________

6. If a star is class B, what is its temperature ____________________ and
   color_____________________________?

7. Dwarf stars are smaller than our Sun. How can they be so bright?

8. Circle and label dwarf stars, red giants, blue giants and main sequence stars.
# Lesson: 3 – Planets

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>What are the sizes of planets and how far away are they from the Sun?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary learning target</strong></td>
<td>The focus learner will be able to explain the differences between terrestrial and jovian planets. They will be able to explain the distance from the sun and how this differs and affects each planet.</td>
</tr>
</tbody>
</table>
| **Content Standard(s)** | **NYS Earth Science Curriculum**  
1.1b Eight planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites.  
1.1a Most objects in the solar system are in regular and predictable motion. These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides. Gravity influences the motions of celestial objects. The force of gravity between two objects in the universe depends on their masses and the distance between them. |
| **2 Learning objectives** | **with measurable criteria, associated with the content standards.** |
| | 1. Students will be able to assess their prior misconceptions based off of their “after” drawing when finished with the lab portion of the activity.  
2. Students will be able to accurately space out planets, in a centimeter scale, in order of distance from the sun.  
3. Students will be able to put the planets in order of size, based on the mass and equatorial diameter of the planets. |
| **Rationale** | Cartoon/Text-Cartoons are drawings with minimal text involving visual representations of a specific idea in a certain subject. They offer students alternative view points on the situation. They identify common areas of misunderstanding and are a good tool to probe students' ideas and beliefs. They can also promote or spark argumentation between peers. |
Conceptual change texts "state a common misconception about a natural phenomenon and directly refute it while providing the scientifically acceptable idea with asking students to make a prediction about the given situation" (Cil, 2014 p. 341). They are useful in introducing misconceptions of science and encourage students to challenge their own that they may have. Texts may provide evidence to explain and demonstrate to students why their misconceptions are not scientific. They are also helpful in persuading students to change their misconceptions.

<table>
<thead>
<tr>
<th>Possible problems</th>
<th>Some students may need more direction than others. Physical impairments not allowing the drawing of planets. Students may not be able to tie knots around the beads and may need assistance.</th>
</tr>
</thead>
</table>
| Instructional resources and materials | Planet Beads:  
Sun (yellow)  
Mercury (red)  
Venus (cream)  
Earth (blue)  
Mars (red)  
Jupiter (orange)  
Saturn (gold)  
Uranus (blue)  
Neptune (blue)  
Pluto (brown)  

4.5 Meters of String  
Ruler  
Earth Science Reference Table  
Colored pencils/crayons/markers |

| Assessments & data collection | • Formal  
Pre and post drawings of the solar system  
Completed Lab  
Informal  
  • Participation in laboratory exercise. Teacher observations of student behavior.  
Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers. |
## Instructional strategies and learning tasks

<table>
<thead>
<tr>
<th>Teacher Actions</th>
<th>Student Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Pass out papers to draw, allow students to obtain colored pencils, markers or crayons.</td>
<td>Collect materials.</td>
</tr>
<tr>
<td>Walk around, ask students what they are drawing.</td>
<td>Students draw, share drawings.</td>
</tr>
<tr>
<td>Show students the video: <a href="https://www.youtube.com/watch?v=At0w3pnLVgc">https://www.youtube.com/watch?v=At0w3pnLVgc</a></td>
<td>Watch video silently</td>
</tr>
<tr>
<td>And <a href="https://www.youtube.com/watch?v=zR3Igc3Rhfg">https://www.youtube.com/watch?v=zR3Igc3Rhfg</a></td>
<td>Watch video silently</td>
</tr>
<tr>
<td>Discuss how student drawings differ from the videos</td>
<td>Discussion</td>
</tr>
<tr>
<td>Hand out lab and begin to fill out table. Answer any student questions.</td>
<td>Read lab directions.</td>
</tr>
<tr>
<td>Hand out lab materials, walk around making sure that students are on task. Answer any questions that students may have. Help to tie knots around beads.</td>
<td>Work to finish lab. Measure with rulers. Work cooperatively</td>
</tr>
<tr>
<td>When the lab is finished, direct students to revise their drawing.</td>
<td>Revise drawing.</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions.</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Bellwork

1. Which member of the solar system has an equatorial diameter of $3.48 \times 10^3$ kilometers?
   A. Moon
   B. Earth
   C. Sun
   D. Mercury

The diagram below represents Earth.

2. Which diagram best represents Mars, drawn to scale?
   A. 
   B. 
   C. 

3. Compared to Jupiter and Saturn, Venus and Mars have greater
   A. periods of revolution
   B. orbital velocities
   C. mean distances from the Sun
   D. equatorial diameters

4. Three planets that are relatively large, gaseous, and of low density are
   A. Mercury, Jupiter, and Saturn
   B. Venus, Jupiter, and Neptune
C. Mars, Jupiter, and Uranus
D. Jupiter, Saturn, and Uranus

5. Which statement correctly compares the size, composition, and density of Neptune to Earth?

A. Neptune is smaller, more gaseous, and less dense.
B. Neptune is larger, more gaseous, and less dense.
C. Neptune is smaller, more solid, and more dense.
D. Neptune is larger, more solid, and more dense.
Ticket out the Door

1. Which sequence correctly shows the relative sizes of the planets of our solar system?

A. 

B. 

C. 

D.
2. Which planet is located approximately ten times farther from the Sun than Earth is from the Sun?

A. Mars
B. Jupiter
C. Saturn
D. Uranus

3. Which pair of shaded circles best represents the relative sizes of Earth and Venus when drawn to scale?

A.  
B.  
C.  
D.  

4. Which planet has the least distance between the two foci of its elliptical orbit?

A. Venus
B. Earth
C. Mars
D. Jupiter

5. Compared to the average density of the terrestrial planets (Mercury, Venus, Earth, and Mars), the average density of the Jovian planets (Jupiter, Saturn, Uranus, and Neptune) is
   A. less
   B. greater
   C. the same
Solar System Bead Distance Lab

Description: You will create a model demonstrating the scale distances of the Solar System using astronomical units that have been converted into a 10-centimeter scale.

Concepts: Astronomical Unit - 1 AU = approximately 150 million kilometers (93 million miles)

Materials:

Planet Beads:
Sun (yellow)
Mercury (red)
Venus (cream)
Earth (blue)
Mars (red)
Jupiter (orange)
Saturn (gold)
Uranus (blue)
Neptune (blue)
Pluto (brown)

4.5 Meters of String
Ruler
Earth Science Reference Table

Instructions:
Our Solar System is immense in size by normal standards. We think of the planets as revolving around the Sun, but rarely consider how far each planet is from the Sun. Furthermore, we fail to appreciate the even greater distances to the other stars. Astronomers use the distance from the Sun to the Earth as one “astronomical unit”. This unit provides an easy way to calculate the distances of the other planets from the Sun. We will construct a distance model of the Solar System to scale, using colored beads as planets. The chart below shows the planets and asteroid belt in order along with their distance from the Sun in astronomical units. First, complete the chart by multiplying each AU distance by our scale factor of 10 cm per astronomical unit. Next, use the new distance to construct a scale model of our Solar System. Start your model by cutting a 4.5 m piece of string. Use the distances in cm that you have calculated in the chart below to measure the distance from the Sun on the string to the appropriate planet and tie the colored bead in place.
What’s Going On?
Astronomical Unit - 1 AU = approximately 150 million kilometers (93 million miles)
Consider that if you were traveling at the speed of light, it would take 8 minutes to travel from
the Sun to the Earth (1 AU). It would take 4.3 years (traveling at the speed of light - 300,000
kilometers per second) to reach the next nearest star, Alpha Centauri!

Directions
1. Fill out the chart below using a calculator and your ESRT.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance (million km)</th>
<th>AU (divide by_____)</th>
<th>Scale Value (multiply by_____)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun (not a planet!)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mars</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jupiter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uranus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neptune</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pluto</td>
<td>5850.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. At one end of the string tie the sun bead in a loop so that it cannot move.
3. Measure the distance from the sun to Mercury. Tie the Mercury bead
   at the correct distance.

4. Repeat for each planet.

---

**Lesson: 4 – The Universe**

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>How big is the universe?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary learning target</strong></td>
<td>The focus learner will be able to explain our place in the universe and state our cosmic address.</td>
</tr>
<tr>
<td><strong>Content Standard(s)</strong></td>
<td><strong>NYS Earth Science Curriculum</strong></td>
</tr>
<tr>
<td></td>
<td>1.1b Eight planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites.</td>
</tr>
<tr>
<td><strong>2 Learning objectives</strong> with measurable criteria, associated with the content standards.</td>
<td>1. Correctly state cosmic address</td>
</tr>
<tr>
<td></td>
<td>2. Understand that the universe is the largest possible portion of the address.</td>
</tr>
<tr>
<td><strong>Rationale</strong></td>
<td>Cartoon/text-Cartoons are drawings with minimal text involving visual representations of a specific idea in a certain subject. They offer students alternative view points on the situation. They identify common areas of misunderstanding and are a good tool to probe students' ideas and beliefs. They can also promote or spark argumentation between peers. Conceptual change texts &quot;state a common misconception about a natural phenomenon and directly refute it while providing the scientifically acceptable idea with asking students to make a prediction about the given situation&quot; (Cil,</td>
</tr>
</tbody>
</table>
They are useful in introducing misconceptions of science and encourage students to challenge their own that they may have. Texts may provide evidence to explain and demonstrate to students why their misconceptions are not scientific. They are also helpful in persuading students to change their misconceptions.

**Possible problems**
Some students may need more direction than others.

**Instructional resources and materials**
- **Worksheet**
- Writing utensil
- **Optional**: Access to internet via computer

**Assessments & data collection**
- **Formal**
  - Completed cosmic address with drawings
- **Informal**
  - Participation in laboratory exercise. Teacher observations of student behavior.

Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.

<table>
<thead>
<tr>
<th>Instructional strategies and learning tasks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher Actions</strong></td>
<td><strong>Student Actions</strong></td>
</tr>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Hand out student worksheet</td>
<td>Students begin drawing</td>
</tr>
<tr>
<td>Walk around the classroom assisting students that may need it</td>
<td>Students complete address worksheet</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Bellwork

1. Which statement best describes how galaxies generally move?
   A. Galaxies move toward one another.
   B. Galaxies move away from one another.
   C. Galaxies move randomly.
   D. Galaxies do not move.

2. Billions of stars in the same region of the universe are called
   A. solar systems
   B. asteroid belts
   C. constellations
   D. galaxies

3. The Milky Way galaxy is best described as
   A. a type of solar system
   B. a constellation visible to everyone on Earth
   C. a region in space between the orbits of Mars and Jupiter
D. a spiral-shaped formation composed of billions of stars

4. The redshift of light from distant galaxies provides evidence that the universe is
A. shrinking, only
B. expanding, only
C. shrinking and expanding in a cyclic pattern
D. remaining the same size

5. Which celestial feature is largest in actual size?
A. the Moon
B. Jupiter
C. the Sun
D. the Milky Way
Ticket out the Door

1. Compared to Earth’s solar system, the universe is inferred to be

   A. younger and larger
   B. younger and smaller
   C. older and larger
   D. older and smaller

2. The diagram below represents the shape of the Milky Way Galaxy.

   The Milky Way Galaxy is best described as

   A. elliptical
B. irregular
C. circular
D. spiral

3. Which sequence correctly lists the relative sizes from smallest to largest?

A. our solar system, universe, Milky Way Galaxy
B. our solar system, Milky Way Galaxy, universe
C. Milky Way Galaxy, our solar system, universe
D. Milky Way Galaxy, universe, our solar system

4. Most scientists believe the Milky Way Galaxy is

A. spherical in shape
B. 4.6 billion years old
C. composed of stars revolving around Earth
D. one of billions of galaxies in the universe

The symbols below are used to represent different regions of space.

Universe = □   Earth = ⊙   Galaxy = /\   Solar system = ○

5. Which diagram shows the correct relationship between these four regions? [If one symbol is within another symbol, that means it is part of, or included in, that symbol.]
Cosmic Address Drawing Activity

Cosmic Address Map 1: Draw the classroom. Mark where your desk is.

Cosmic Address Map 2: Draw the School. Mark where the classroom is.
Room #______________

Cosmic Address Map 3: Draw the Neighborhood. Mark where the school is.
School Street Address:__________________

Cosmic Address Map 4: Draw the city. Mark where the school is located. City name______________
Cosmic Address Map 5: Draw the state. Mark where your city is. State name________________

Cosmic Address Map 6: Draw the country. Mark where your state is. Country name___________

Cosmic Address Map 7: Draw The World. Mark where your country is. Planet Name____________

Cosmic Address Map 8: Draw the Solar System. Mark where your planet is. Name:: Solar System

Cosmic Address Map 9: Draw the Galaxy. Mark where our Solar System is. Name of Galaxy:________
Cosmic Address map 10:
Galaxy Cluster: Mark where the Milky Way galaxy is. Name of cluster:________

Cosmic Address map 11: Galaxy Supercluster. Mark where the Local Group is. Name of supercluster:__________________________
Please write your complete Cosmic Address below:

1) Classroom ________________________________
2) School ________________________________
3) Street and # ________________________________
4) City ________________________________
5) State ________________________________
6) Country ________________________________
7) Planet ________________________________
8) Planet System ________________________________
9) Galaxy ________________________________
10) Galaxy Cluster ________________________________
11) Galaxy Supercluster ________________________________
# Lesson: 5 – Sun’s Path

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>Does the Sun always rise in the East and set in the West?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary learning target</strong></td>
<td>The focus learner will be able to draw the sun across the sky, including the directions the sun rises and sets for each season in NYS.</td>
</tr>
<tr>
<td><strong>Content Standard(s)</strong></td>
<td><strong>NYS Earth Science Curriculum</strong></td>
</tr>
<tr>
<td></td>
<td>1.1b Eight planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites.</td>
</tr>
<tr>
<td></td>
<td>1.1d Earth rotates on an imaginary axis at a rate of 15 degrees per hour. To people on Earth, this turning of the planet makes it seem as though the Sun, the moon, and the stars are moving around Earth once a day. Rotation provides a basis for our system of local time; meridians of longitude are the basis for time zones.</td>
</tr>
<tr>
<td></td>
<td>1.1e The Foucault pendulum and the Coriolis effect provide evidence of Earth’s rotation.</td>
</tr>
</tbody>
</table>

### 2 Learning objectives with measurable criteria, associated with the content standards.

1. Students will be able to identify what direction the sun will rise and set for each season in NYS.
2. Students will be able to describe the relationship between altitude of the sun and the time of year in NYS.

**Rationale**

Cartoon/text-Cartoons are drawings with minimal text involving visual representations of a specific idea in a certain subject. They offer students alternative viewpoints on the situation. They identify common areas of misunderstanding and are a good tool to probe students' ideas and beliefs. They can also promote or spark argumentation between peers. Conceptual change texts "state a common misconception about a natural phenomenon and directly refute it while providing the scientifically acceptable idea with asking students to make a prediction about the given situation" (Cil, 2014 p. 341). They are useful in introducing misconceptions of science and encourage students to challenge their own that they may have. Texts may provide evidence to explain and demonstrate to students why their misconceptions are not scientific. They are also helpful in persuading students to change their misconceptions.

**Possible problems**

Some students may need more direction than others. Physical impairments not allow certain activities.

**Instructional resources and materials**

*Include materials for teachers & students*

**Teacher**

*Make copies of activity for students. Ensure a laptop cart or computer lab*

**Students**

- Computers, packet

**Assessments & data collection**

**Formal**

*Completed drawings of 4 different seasons of an observer in NYS*

**Informal**

- Participation in laboratory exercise. Teacher observations of student behavior.

Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.

**Instructional strategies and learning tasks**
<table>
<thead>
<tr>
<th><strong>Teacher Actions</strong></th>
<th><strong>Student Actions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Hand out packets for students. Make sure that they have a lab top.</td>
<td>Get a lap top or sign on to a computer.</td>
</tr>
<tr>
<td>Make sure students are on the website, putting in the correct settings, drawing etc.</td>
<td>Follow directions in packet. Draw the suns paths.</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions.</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>

Bellwork

1. Locations in the Northern Hemisphere are warmest in summer because sunlight in summer is

2. least intense and of shortest duration

3. least intense and of longest duration

4. most intense and of shortest duration

5. most intense and of longest duration

3. In which diagram is the observer experiencing the greatest intensity of insolation?
The diagram represents a portion of Earth’s surface that is receiving insolation. Positions A, B, C, and D are located on the surface of Earth.

3. At which position would the intensity of insolation be greatest?

1. A
2. B
3. C
4. D
4. At which latitude would the duration of insolation be greatest on December 21?
   1. $23\frac{1}{2}^\circ$ South
   2. $0^\circ$
   3. $10^\circ$ North
   4. $23\frac{1}{2}^\circ$ North

5. In New York State, the risk of sunburn is greatest between 11 a.m. and 3 p.m. on summer days because
   1. the air temperature is hot
   2. the angle of insolation is high
   3. Earth’s surface reflects most of the sunlight
   4. the Sun is closest to Earth
Ticket out the Door

1. The average temperature at Earth’s equator is higher than the average temperature at Earth’s South Pole because the South Pole
   2. receives less intense insolation
   3. receives more infrared radiation
   4. has less land area
   5. has more cloud cover

2. In New York State, summer is warmer than winter because in summer New York State has
   1. fewer hours of daylight and receives low-angle insolation
   2. fewer hours of daylight and receives high-angle insolation
   3. more hours of daylight and receives low-angle insolation
   4. more hours of daylight and receives high-angle insolation
3. On which date does the maximum duration of insolation occur in the Northern Hemisphere?

1. March 21
2. June 21
3. September 23
4. December 21

4. What is the primary reason the United States is warmer in July than in February?

1. The Earth is traveling faster in its orbit in February.
2. The altitude of the noon Sun is greater in February.
3. The insolation in the United States is greater in July.
4. The Earth is closer to the Sun in July.

5. The average temperature at Earth’s North Pole is colder than the average temperature at the Equator because the Equator

1. receives less ultraviolet radiation
2. receives more intense insolation
3. has more cloud cover
4. has a thicker atmosphere
Sun’s Path Activity

1. Winter

Go to this website and make sure that the date, time of day, observer’s latitude and all other settings look exactly as the screen shot below.
What direction does the Sun appear to rise?_________________________
What direction does the Sun appear to set?_________________________
What is the Sun’s altitude? ____________________

Start Animation. Observe and draw the Sun’s Path complete with arrows. Keep in mind the questions above!!
Make sure that the date, time of day, observer’s latitude and all other settings look exactly as the screen shot below.

What direction does the Sun appear to rise? _______________________
What direction does the Sun appear to set? _______________________
What is the Sun’s altitude? _______________________

Start Animation. Observe and draw the Sun’s Path complete with arrows. Keep in mind the questions above!!

3. Summer
Make sure that the date, time of day, observer’s latitude and all other settings look exactly as the screen shot below.

What direction does the Sun appear to rise? ________________________
What direction does the Sun appear to set? ________________________
What is the Sun’s altitude? ______________________________________

Start Animation. Observe and draw the Sun’s Path complete with arrows. Keep in mind the questions above!!
Make sure that the date, time of day, observer’s latitude and all other settings look exactly as the screen shot below.

What direction does the Sun appear to rise?_________________________
What direction does the Sun appear to set?_________________________
What is the Sun’s altitude? ____________________

Start Animation. Observe and draw the Sun’s Path complete with arrows. Keep in mind the questions above!!
Central Focus

Is the Sun always overhead at noon?

Primary learning target

The focus learner will be able to draw and explain the paths of the sun for each season and at least 5 different locations on Earth.

Content Standard(s)

NYS Earth Science Curriculum

1.1a Most objects in the solar system are in regular and predictable motion. These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides.

1.1d Earth rotates on an imaginary axis at a rate of 15 degrees per hour. To people on Earth, this turning of the planet makes it seem as though the Sun, the moon, and the stars are moving around Earth once a day. Rotation provides a basis for our system of local time; meridians of longitude are the basis for time zones.

1.1f Earth’s changing position with regard to the Sun and the moon has noticeable effects. Earth revolves around the Sun with its rotational axis tilted at 23.5 degrees to a line perpendicular to the plane of its orbit, with the North Pole aligned with Polaris. During Earth’s one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun’s rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.

1.1g Seasonal changes in the apparent positions of constellations provide evidence of Earth’s revolution.

1.1h The Sun’s apparent path through the sky varies with latitude and season.

2 Learning objectives

with measurable criteria, associated with the content standards.

1. The sun is only overhead within the Tropics.

2. The sun is never overhead in NYS, causing us to always have a shadow.

Rationale

Tic Tac Toe with rubric-The tasks created should allow students to represent their learning in several ways aligned with these outcomes. Varied activities should be more enjoyable because students are engaged in meaningful learning. Students needing more time can complete one of the tasks on the “tic tac toe” board, while faster learners can complete multiple tasks. Again, it is important to remember and for all students to understand that fair is not equal. After completing the required number of tasks, student discussion
<table>
<thead>
<tr>
<th><strong>Possible problems</strong></th>
<th>Some students may need more direction than others. Physical impairments not allow some activities.</th>
</tr>
</thead>
</table>

| **Instructional resources and materials**  
*Include materials for teachers & students* | **Teacher**  
*Worksheets*  
**Students**  
- Notes, computers, textbook, materials will vary depending on student choice |

| **Assessments & data collection** | **Formal**  
*Completion of students choice activities (up to 30 points)*  
**Informal**  
- Participation in laboratory exercise. Teacher observations of student behavior.  
Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers. |

| **Instructional strategies and learning tasks** | **Teacher Actions**  
*Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions*  
*Hand out worksheets for students. Make sure that they have a laptop, notes, materials etc.*  
*Go over directions; make sure students understand that they have one required activity and a choice over the others, as long as they gain at least 30 points.*  
*Make sure students are on the task, choosing activities of their choice and completing them.*  
*Provides ticket-out-the-door questions.*  
**Student Actions**  
*Students answer five questions using clickers*  
*Listening to directions. Asking questions.*  
*Completing activities of their choice, using notes, laptops etc. Asking for materials if needed.*  
*Students complete ticket-out-the-door questions.* |
Bellwork

1. At which latitude does the Earth receive the greatest intensity of insolation on June 21?
   
   1. 0°
   2. 23¼° South
   3. 23¼° North
   4. 90° North

The diagram below represents Earth at a specific position in its orbit as viewed from space. The shaded area represents nighttime.

2. Which Earth latitude receives the greatest intensity of insolation when Earth is at the position shown in the diagram?

   1. 0°
   2. 23½° N
   3. 66¼° N
   4. 90° N
3. On which day of the year would the intensity of insolation at Kingston, New York, most likely be greatest?

1. March 21
2. June 21
3. September 23
4. December 21

4. On June 21, where will the Sun appear to rise for an observer located in New York State?

A. due west
B. due east
C. north of due east
D. south of due east

The diagram below shows the apparent daily path of the Sun, as viewed by an observer at a certain latitude on three different days of the year.

5. At which latitude were these apparent Sun paths most likely observed?

A. 0°
B. 23.5° N
Ticket out the Door

The diagram below shows the apparent path of the Sun as viewed by an observer at a certain Earth location on March 21.

1. At which latitude is the observer located?

A. the Equator (0°)

B. 23° N

C. 66° N

D. 90° N
Base your answers on the diagram, which shows a model of the apparent path and position of the Sun in relation to an observer at four different locations, A, B, C, and D, on Earth’s surface on the dates indicated. The zenith (z) and the actual position of the Sun in the model at the time of the observation are shown. [The zenith is the point directly over the observer.]

2. Where on Earth’s surface is the observer at location C located?

A. at the Equator  
B. at the South Pole  
C. at the North Pole  
D. in Oswego, New York

3. From sunrise to sunset at location B, the length of the observer’s shadow will

A. increase, only  
B. decrease, only  
C. increase, then decrease  
D. decrease, then increase
The model below shows the Sun’s apparent path across the sky for an observer in New York State.

4. On which day of the year was this path observed?

A. March 21  
B. June 21  
C. September 21  
D. December 21

The diagram below shows the altitude of the Sun at solar noon on March 21, as seen by an observer at 42° N latitude.
5. Compared to the altitude of the Sun observed at solar noon on March 21, the altitude of the Sun observed at solar noon on June 21 will be

A. 15° higher in the sky
B. 23.5° higher in the sky
C. 42° higher in the sky
D. 48° higher in the sky
Think-Tac-Toe Activities  
Sun’s Path

Select three activities (one of which is the required center activity) to total at least 30 points. Use notes, literature, or the internet to assist you in your answers.

<table>
<thead>
<tr>
<th>(15 pts)</th>
<th>(5 points)</th>
<th>(5 points)</th>
</tr>
</thead>
</table>
| Construct a model that shows the Sun’s daily path for Batavia, NY, Equator and one of the Tropics. | Write a paragraph that connects the following words: angle of insolation, shadows, seasons, zenith, noon, sunrise and sunset. | *This takes planning!!*
You must begin this portion at sunrise. Go outside with a partner and have them mark your shadow. Note the length and direction. Do the same at noon and sunset. Compare all lengths and directions to the position of the sun at the time the shadow was measured. What would happen if you did this the first day of each season? |

<table>
<thead>
<tr>
<th>(15 pts)</th>
<th>Required (10 pts)</th>
<th>(15 pts)</th>
</tr>
</thead>
</table>
| Create a book or show that shows how the rotation of Earth has an effect on how shadows are created. Do not forget to make note of the differing lengths of shadows for different seasons and different times of the day. | Define the Key Terms on a separate sheet of paper: 
- Angle of Insolation 
- Duration of Insolation 
- Solar Noon 
- Rotation 
- Revolution 
- Zenith | Use the computer to make a drawing that shows how the rotation and revolution of the Earth works to create different sun’s paths at 3 different latitudes. You may choose any latitude in the Northern hemisphere, the Equator, and any latitude in the Southern Hemisphere. |

<table>
<thead>
<tr>
<th>(10 points)</th>
<th>(10 points)</th>
<th>(15 pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A planet has been discovered that does not rotate (spin on its axis) at all through its orbit. It does have a tilted axis, just as Earth. Describe how this would affect the Sun’s daily path and seasonal differences in the Sun’s altitude.</td>
<td>Construct a model to show what the Sun’s daily path would look like for Batavia if the Earth wasn’t tilted at all. How would this affect seasons?</td>
<td>Write a poem that explains the Earth’s rotation, revolution, sun’s daily path and seasons for NYS.</td>
</tr>
</tbody>
</table>
# Lesson: 7 – Cause of Moon Phases

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>What causes the phases of the moon if it’s not the shadow of Earth?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary learning target</td>
<td>The focus learner will be able to draw the phases of the moon. They will be able to explain the moon-earth-sun relationship and why an eclipse doesn’t happen every month.</td>
</tr>
</tbody>
</table>
| Content Standard(s) | **NYS Earth Science Curriculum**  
1.1b Eight planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites. |
| 2 Learning objectives with measurable criteria, associated with the content standards. | 1. Students will be able to identify 8 moon phases in order.  
2. Students will be able to identify solar and lunar eclipses. |
| Rationale | Journal and wiki- Wikis prove to be extremely beneficial in differentiated lessons and even units. In this approach, teachers keep the learning objectives similar for all students; however it allows them to express what they’ve learned in multiple ways. Wikis are helpful in delivering a wealth of content via pictures, text, hyperlinks to other pages, and multimedia such as sound (pg 25). The websites allow teachers to share resources with other educators, students, and parents. It is important to first lay groundwork for using wikis appropriately in the classroom. The teacher’s role when implementing a differentiated wiki unit turns into that of a facilitator. Students will be on task with their own learning. Students may also work together on projects. The wikis can be reused from year to year with the possibility of alterations. |
| Possible problems | Some students may need more direction than others. |
| **Instructional resources and materials**  
Include materials for teachers & students | **Teacher**  
Laptops, updated wiki  
**Students**  
- Laptops, journals |
| **Assessments & data collection** | **Formal**  
Journal entries, discussion entries on wiki  
**Informal**  
- Participation in activity. Teacher observations of student... |
Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.

<table>
<thead>
<tr>
<th>Teacher Actions</th>
<th>Student Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administering clickers and bellwork to assess ability, interest, prior knowledge and misconceptions</td>
<td>Students answer five questions using clickers</td>
</tr>
<tr>
<td>Prompt students to write in journal about the reasons they believe moon phases occur.</td>
<td>In journal, draw and/or write the reason that you believe causes the phases of the moon.</td>
</tr>
<tr>
<td>Have students obtain a laptop and keep out their journals. Direct them to the wiki site: <a href="http://bataviaearthscience.wikispaces.com/Moon+Phases">http://bataviaearthscience.wikispaces.com/Moon+Phases</a></td>
<td>Obtain a laptop and go to the following website: <a href="http://bataviaearthscience.wikispaces.com/Moon+Phases">http://bataviaearthscience.wikispaces.com/Moon+Phases</a> *Students must have a log in to view. Look below for screenshots of the actual website.</td>
</tr>
<tr>
<td>Direct students to follow the directions on the website. View videos, work with interactives, leave comments and answer questions in journals. Have students turn in journals</td>
<td>Students will be following the directions on the website which includes viewing videos, working with interactives, leaving comments on the wiki site, answering questions in their journals and having an online discussion with peers.</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions.</td>
<td>Turn in journals.</td>
</tr>
<tr>
<td></td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Bellwork

The diagram shows the relative positions of the Earth, Moon, and Sun for a 1-month period.

1. Which phase best describes the appearance of the Moon at position $P$ when viewed from Earth?
   A. new
   B. full
   C. quarter
   D. crescent

2. An observer on Earth sees the phases of the Moon because
   A. the Moon revolves around the Sun
   B. the Moon rotates on its axis
   C. Earth revolves around the Sun
   D. the Moon revolves around Earth

3. The time required for the Moon to show a complete cycle of phases when viewed from Earth is approximately
A. 1 day  
B. 1 week  
C. 1 month  
D. 1 year  

The diagram below represents the Moon in its orbit, as viewed from above Earth’s North Pole. Position 1 represents a specific location of the Moon in its orbit.

4. Which phase of the Moon will be seen from Earth when the Moon is at position 1?

![Diagram of the Moon's phases](image)

A.  
B.  
C.  
D.  

5. Which sequence of Moon phases could be observed from Earth during a 2-week period?
Key

<table>
<thead>
<tr>
<th></th>
<th>Full Moon phase</th>
<th>New Moon phase</th>
</tr>
</thead>
</table>

A. [Diagram of moon phases]

B. [Diagram of moon phases]

C. [Diagram of moon phases]

D. [Diagram of moon phases]
Ticket out the Door

The diagram represents eight positions of the Moon as it revolves around the Earth.

1. When viewed from the Earth, which phase of the Moon will be seen when the Moon is at point $E$?

   1. first quarter
   2. full moon
   3. new moon
   4. last quarter

The diagram below shows the Moon at four positions in its orbit around Earth as viewed from above the North Pole.
2. Beginning with the Moon at position X (the new-Moon phase), which sequence of Moon phases would be seen by an observer on Earth during 1 month?

1.  
2.  
3.  
4.  

3. Which diagram sequence correctly shows the order of Moon phases, as viewed from Earth, for a period of 1 month? [Note that some phases have been omitted.]

1.  

94
4. The diagram shows the relative positions of the Sun, Earth, and Moon in space. Letters A, B, C, and D represent locations on the Earth’s surface.

At which location would an observer on the Earth have the best chance of seeing a total solar eclipse?

1. A
2. B
3. C
4. D

5. The diagram below shows Earth’s orbit around the Sun and different positions of the Moon as it travels around Earth. Letters A through D represent four different positions of the Moon.
An eclipse of the Moon is most likely to occur when the Moon is at position

1.  $A$
2.  $B$
3.  $C$
4.  $D$
Moon Wiki Activity with Journals

Obtain a laptop and go to the following website:
http://bataviaearthscience.wikispaces.com/Moon+Phases
*Students must have a log in to view. Look below for screenshots of the actual website.

Answer all questions required in journals. Turn in when completed.
2. Go to this page and complete a moon phase diagram in your journal. Include drawings and names of the 8 phases. Make sure it is set up so it looks similar to this (Remember to indicate which direction the sun is coming from):
3. Answer the following questions in your journal using the 2015 moon phase calendar:

1. How many full moons will be visible in November?
2. What will be the moon phase be on November 11th?
3. What date will the moon be full in November?
4. On what date in November will we see a 1st quarter moon?
5. How many days are there between the third quarter and new moon?
6. On what date in November will you see a waxing gibbous?
7. How many days are there between a new moon and the next new moon?
8. Between November 11 and November 25, does the moon add light from the right or left side?
9. Between November 25 and December 11, what side of the moon will appear lit?
10. Look very carefully at the craters. Do they change throughout the month or year?
11. What was the moon phase on your birthday?
12. What phase of the moon will you see on Halloween?
13. What phase of the moon will you see on December 25?
14. A “blue moon” is NOT actually blue! It is when there are two full moons in one calendar month. A.) How many fall moons occurred in 2015? B.) Did a “blue moon” occur in 2015? If so, what month?
15. Look at the key at the bottom of the moon phase calendar. Find the symbol for a lunar eclipse. A.) How many occurred in 2015? B.) During which phase of the moon did they occur?
16. Look at the key at the bottom of the moon phase calendar. Find the symbol for a solar eclipse. A.) How many occurred in 2015? B.) During which phase of the moon did they occur?
5. Comment on the true cause of the phases of the moon with the words: Revolution and cycle.
6. Watch the video and answer the following questions in your journal.

What’s the difference between a solar and lunar eclipse?

1. How is an eclipse different from a moon phase? Hint: Think about what the word eclipse actually means.
2. What is the order of the sun, moon, and earth during a solar eclipse?
3. What is the order of the sun, moon, and earth during a lunar eclipse?
4. What moon phase is it during a solar eclipse?
5. What moon phase is it during a lunar eclipse?
6. Why is a lunar eclipse more common than a solar eclipse?
7. Why doesn’t an eclipse happen every month?
1. How is an eclipse different from a moon phase? Hint: Think about what the word eclipse actually means.
2. What is the order of the sun, moon, and earth during a solar eclipse?
3. What is the order of the sun, moon, and earth during a lunar eclipse?
4. What moon phase is it during a solar eclipse?
5. What moon phase is it during a lunar eclipse?
6. Why is a lunar eclipse more common than a solar eclipse?
7. Why doesn’t an eclipse happen every month?

[Forum post]

Moon Phases
Elenarosec  a day ago

In a paragraph, explain how the phases of the moon and eclipses are both similar and different. Once you’re done, comment on two peers ideas.
# Lesson: 8 – Dark Side of The Moon

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>Is there really a side of the moon that never receives sunlight?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary learning target</td>
<td>The focus learner will be able to draw the phases of the moon. The learner will be able to explain the relationship and effect of the moons rotation and revolution periods being equal to one another.</td>
</tr>
</tbody>
</table>
| Content Standard(s) | NYS Earth Science Curriculum  
1.1b Nine planets move around the Sun in nearly circular orbits. The orbit of each planet is an ellipse with the Sun located at one of the foci. Earth is orbited by one moon and many artificial satellites. |
| 2 Learning objectives with measurable criteria, associated with the content standards. | 1. Students will be able to relate the Moon’s rate of rotation and revolution.  
2. Students will be able to explain why we only see one side of the moon. |
| Rationale | Demonstrations and discussion- Discussion is an important aspect of student learning. It not only enhances student understanding, but allows the educator to assess whether the students understand a concept or not, and if they have any misconceptions. |
| Possible problems | Some students may need more direction than others. Physical impairments not allowing the drawing of ellipses using the string-push pin technique. |
| Instructional resources and materials Include materials for teachers & students | Teacher  
Lamp  
Students  
N/A |
| Assessments & data collection | Formal  
Ticket out the Door  
Informal  
- Participation in discussion. Teacher observations of student behavior.  
Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.  
- |
<table>
<thead>
<tr>
<th>Instructional strategies and learning tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher Actions</strong></td>
</tr>
<tr>
<td>Demonstration: Teacher has all of the</td>
</tr>
<tr>
<td>students go toward the center of the room.</td>
</tr>
<tr>
<td>Once there, start the demonstration on the</td>
</tr>
<tr>
<td>outside of them, facing them. Tell them</td>
</tr>
<tr>
<td>that you are the moon and that they are</td>
</tr>
<tr>
<td>Earthlings. Ask the students what one</td>
</tr>
<tr>
<td>revolution looks like. Ask the students</td>
</tr>
<tr>
<td>what one rotation would look like. Then,</td>
</tr>
<tr>
<td>ask the students what side of your body</td>
</tr>
<tr>
<td>they can see and what side of the room</td>
</tr>
<tr>
<td>your back is facing. Be sure to have a light</td>
</tr>
<tr>
<td>shining on you from the back. Begin to</td>
</tr>
<tr>
<td>revolve around students while still facing</td>
</tr>
<tr>
<td>them. (this may take some fancy</td>
</tr>
<tr>
<td>footwork). When you are a quarter of the</td>
</tr>
<tr>
<td>way around them, ask them again which</td>
</tr>
<tr>
<td>side of your body is facing them and which</td>
</tr>
<tr>
<td>side of the room your back is facing, as</td>
</tr>
<tr>
<td>well as what side of your body is lit by the</td>
</tr>
<tr>
<td>&quot;sun&quot;. Keep doing this, while stopping</td>
</tr>
<tr>
<td>every quarter of the way in the revolution</td>
</tr>
<tr>
<td>around them. When you get back to where</td>
</tr>
<tr>
<td>you started, talk about how you completed</td>
</tr>
<tr>
<td>one rotation and one revolution. The</td>
</tr>
<tr>
<td>rotation was just slow as the rates of</td>
</tr>
<tr>
<td>rotation and revolution is equal.</td>
</tr>
<tr>
<td>Discuss how this relates to the moon. Was</td>
</tr>
<tr>
<td>one side of your body always dark? Is this</td>
</tr>
<tr>
<td>true for the moon as well? How does this</td>
</tr>
<tr>
<td>relate to the moon and Earth? At what</td>
</tr>
<tr>
<td>point in the cycle was I the new moon?</td>
</tr>
<tr>
<td>Full moon? Quarters?</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions.</td>
</tr>
<tr>
<td><strong>Student Actions</strong></td>
</tr>
<tr>
<td>Students watch demonstration, ask and answer</td>
</tr>
<tr>
<td>questions, join in on discussion.</td>
</tr>
<tr>
<td>Students complete ticket-out-the-door</td>
</tr>
<tr>
<td>questions.</td>
</tr>
</tbody>
</table>
Ticket out the Door

1. An observer on Earth sees the phases of the Moon because
   A. the Moon revolves around the Sun
   B. the Moon rotates on its axis
   C. Earth revolves around the Sun
   D. the Moon revolves around Earth

2. The time required for the Moon to show a complete cycle of phases when viewed from Earth is approximately
   A. 1 day
   B. 1 week
   C. 1 month
   D. 1 year

3. The same side of the Moon always faces Earth because the
   A. Moon’s period of rotation is longer than its period of revolution around Earth
   B. Moon’s period of rotation is shorter than its period of revolution around Earth
   C. Moon rotates once as it completes one revolution around Earth
   D. Moon does not rotate as it completes one revolution around Earth

4. How many days are required for the Moon to go from one full-Moon phase to the next full-Moon phase when viewed from Earth?
A. 24
B. 27.3
C. 29.5
D. 365
### Lesson: 9 – Seasons

<table>
<thead>
<tr>
<th>Central Focus</th>
<th>Why does the Earth experience seasons?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary learning target</strong></td>
<td>The focus learner will be able to draw the seasons diagram and explain why the Northern Hemisphere is warmer during summer and cooler during the winter.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content Standard(s)</th>
<th><strong>NYS Earth Science Curriculum</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1f</td>
<td>Earth’s changing position with regard to the Sun and the moon has noticeable effects. Earth revolves around the Sun with its rotational axis tilted at 23.5 degrees to a line perpendicular to the plane of its orbit, with the North Pole aligned with Polaris. During Earth’s one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun’s rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.</td>
</tr>
<tr>
<td>1.1g</td>
<td>Seasonal changes in the apparent positions of constellations provide evidence of Earth’s revolution.</td>
</tr>
<tr>
<td>1.1h</td>
<td>The Sun’s apparent path through the sky varies with latitude and season.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>2 Learning objectives</strong>&lt;br&gt;with measurable criteria, associated with the content standards.</th>
<th>1. Students will be able to explain the reason for the seasons.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Students will be able to complete a seasons diagram.</td>
</tr>
</tbody>
</table>

| **Rationale** | Pretest for grouping, journals and wiki- A pretest is necessary to give at the beginning of each unit or lesson that is going to use any of the differentiation techniques. It is recommended in order to gauge student readiness. Educators can use the pretest to group students with similar readiness to complete differing levels of assignments and directions, which ultimately all have the same end goal. A pretest is also needed to measure the students’ level of knowledge so that you can expose all students to engaging experiences that are appropriate for their level. Student journals are also helpful to assess true understanding of the concepts |

| **Possible problems** | Some students may need more direction than others. Physical impairments not allowing the drawing of ellipses using the string-push pin technique. |

| **Instructional resources and** | **Teacher** |
### materials
Include materials for teachers & students

<table>
<thead>
<tr>
<th>Pretest, laptops, updated wiki site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students</strong></td>
</tr>
<tr>
<td>● Pretest, laptops, journals</td>
</tr>
</tbody>
</table>

### Assessments & data collection

<table>
<thead>
<tr>
<th><strong>Formal</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal entries, discussion entries</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Informal</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>● Participation in activity. Teacher observations of student behavior.</td>
</tr>
</tbody>
</table>

Ticket out the door questions: Five regents questions about the lesson’s material answered independently by the students and collected via electronic clickers.

## Instructional strategies and learning tasks

<table>
<thead>
<tr>
<th><strong>Teacher Actions</strong></th>
<th><strong>Student Actions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prompt students to complete the pre-test. Group students by like misconceptions and abilities.</td>
<td>Students take pretest and are grouped by the teacher.</td>
</tr>
<tr>
<td>Have students obtain a laptop and keep out their journals. Direct them to the wiki site: <a href="http://bataviaearthscience.wikispaces.com/Reason+For+The+Seasons">http://bataviaearthscience.wikispaces.com/Reason+For+The+Seasons</a></td>
<td>Obtain a laptop and go to the following website: <a href="http://bataviaearthscience.wikispaces.com/Reason+For+The+Seasons">http://bataviaearthscience.wikispaces.com/Reason+For+The+Seasons</a>. *Students must have a log in to view. Look below for screenshots of the actual website.</td>
</tr>
<tr>
<td>Direct students to follow the directions on the website. View videos, work with interactives, leave comments and answer questions in journals.</td>
<td>Students will be following the directions on the website which includes viewing videos, working with interactives, leaving comments on the wiki site, answering questions in their journals and having an online discussion with peers.</td>
</tr>
<tr>
<td>Have students turn in journals</td>
<td>Turn in journals.</td>
</tr>
<tr>
<td>Provides ticket-out-the-door questions.</td>
<td>Students complete ticket-out-the-door questions.</td>
</tr>
</tbody>
</table>
Name ________________________________
Seasons Pre-Test

1. What causes the angle of the sun’s rays to change during the year on Earth?

2. If you live in the Southern Hemisphere, during which months does autumn occur?

3. What is the difference between rotation and revolution?

4. Seasons are caused by Earth’s…? 

5. During the month of May, in the Northern Hemisphere, the number of daylight hours slowly decreases each day.

6. Where would you be on the surface of the earth is you were in complete darkness for twenty-four hours on December 21?

7. The gradual change in the length of your shadow over the course of the day is caused by________.

8. What occurs when the Sun is directly above Earth’s equator?

9. In the Northern Hemisphere, the longest day occurs on what date?

10. In the Northern Hemisphere, the shortest day occurs on what date?
Seasons Activity with Journals

Obtain a laptop and go to the following website:
http://bataviaearthscience.wikispaces.com/Reason+For+The+Seasons
*Students must have a log in to view. Look below for screenshots of the actual website.

Answer all questions required in journals. Turn in when completed.
But which one is correct? And why do we have seasons anyway? Listen to these HARVARD graduates struggle to answer the question. At the end of the lesson, you'll be able to answer with ease!

Harvard Graduates Explain Seasons

1. Let's discover WHY we have seasons before we choose a correct seasons diagram.

Earth's Tilt 1: The Reason for the Seasons
Earth’s Tilt 1: The Reason for the Seasons

Answer the following questions in your journal when you’re done watching.

1. Is it the same season for everyone on Earth?
2. Is Earth’s orbit almost circle or ellipse?
3. Does the distance of Earth from the Sun cause seasons?
4. During what season are we actually closest to the Sun?
5. What motion causes seasons: rotation or revolution?
6. What is the tilt of the angle of Earth?
7. Does the axis wobble around in its revolution?
8. When the N. hemisphere is angled toward the Sun what season is it?
9. When the N. hemisphere is angled away from the Sun what season is it?
10. In 3 sentences, explain how can it be summer in the US but winter in Australia at the same time?
Go to the following website:

http://esminfo.prenhall.com/science/geoanimations/animations/01_EarthSun_F2.html

The animation will begin in the March position which is Spring. Draw an outline of this in your journal. Click the forward button and be sure to draw arrows from one season to the next. You should have an “earth” drawn in 4 places in its orbit around the Sun. These include March-Spring, June-Summer, September-Fall, and December-Winter. Be sure to include the tilt of the Earth and label the Northern Hemisphere in all positions.

After you have completed all of the above, with your partner describe the reason for the seasons using the words or phrases: revolution, tilt, ellipse,
The animation will begin in the March position which is Spring. Draw an outline of this in your journal. Click the forward button and be sure to draw arrows from one season to the next. You should have an "earth" drawn in 4 places in its orbit around the Sun. These include: March-Spring, June-Summer, September-Fall, and December-Winter. Be sure to include the tilt of the Earth and label the Northern Hemisphere in all positions.

After you have completed all of the above, with your partner describe the reason for the seasons using the words or phrases: revolution, tilt, ellipse, circular, close to the sun, far from the sun. Post this below in the discussion area.

Reason for the Season
Elmanasec about 13 hours ago

Include names of all partners in the group
Ticket out the Door

1. In the Northern Hemisphere, during which season does the Earth reach its greatest distance from the Sun?
   1. winter
   2. spring
   3. summer
   4. fall

The diagram below represents Earth at four different positions, A, B, C, and D, in its orbit around the Sun.

2. Between which positions would New York State be experiencing the summer season?
   1. A and B
   2. B and C
   3. C and D
   4. D and A

3. Earth is farthest from the Sun during the Northern Hemisphere’s summer, and Earth is closest to the Sun during the Northern Hemisphere’s winter. During which season in the Northern Hemisphere is Earth’s orbital velocity greatest?
   1. winter
2. spring
3. summer
4. fall

4. The tilt of the Earth on its axis is a cause of the Earth’s
   1. uniform daylight hours
   2. changing length of day and night
   3. 24-hour day
   4. 365 1/4-day year

The diagram illustrates the position of Earth in relation to the Sun on one particular day. Points A, B, C, and D are locations on Earth’s surface.

5. Which month is represented by the diagram?
   1. March
   2. June
   3. September
   4. December
References


