Exploring the Motion of the Earth

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HILLSBOROUGH PUBLIC SCHOOLS
CONNECT-ED
Big Idea Module

PRESENTED To the Raytown School District by:

Chari Zeiss, Grade 3, Hillsborough Elementary School
Debbie Gross, Grade 7, Hillsborough Middle School
Stephen Grabowski, Hillsborough High School
Kim Feltre, Supervisor of Science
Dr. Gary Pajer, Rider University Physics program

Facilitated by Dr. Kathy Browne, Rider University

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BIM Focus Question

What will happen to the solar system when the Sun loses half its mass?

Elementary Activities

Motion of the Earth

Name________________________________

Date_________________________________

FOCUS QUESTIONS:

1. There are two ways that the Earth moves. What do you think these are?

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2. These two movements have specific names. Write down what you think these two terms might be.

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Motion of the Earth

EXPLORE ACTIVITY: In this activity each student will represent the Earth and will model the motions of the Earth through the movement of his or her body.

1. Draw a diagram of the way you were standing when it was nighttime. Use circles to represent the Sun and Earth and place an **X** on the Earth to represent the location of your nose.

2. Draw a diagram of the way you were standing when it was daytime. Use circles to represent the Sun and Earth and place an **X** on the Earth to represent the location of your nose.

3. Draw a diagram to show Earth's revolution around the Sun. Use circles to represent the Sun and Earth and arrows to show Earth's revolution.

REFLECTION QUESTIONS:

1. Based on your observations, describe the rotation of the earth in your own words.

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2. Based on your observations, describe the revolution of the Earth in your own words.

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3. Explain the difference between rotation and revolution.

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4. What “Big Idea” do you think this activity addresses?

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5. Can any other “Big Ideas” be tied into this activity? If so, which ones?

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APPLICATION QUESTIONS:

1. What would happen if the Earth did not rotate?

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2. What would happen if the Earth did not revolve?

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Elementary Activity

How High Can You Jump?

(*Universe at Your Fingertips was used as a resource for this activity.)

NAME ______________________________________

DATE _______________________________________

FOCUS QUESTIONS:

1. Describe what happens when you jump in the air and explain why you think this happens.

   ____
   ____
   ____
   ____
   ____
   ____

2. Where do you think you would be able to jump higher, on Earth or on the Moon and why?

   ____
   ____
   ____
   ____
   ____

How High Can You Jump?

EXPLORE ACTIVITY: Students will use the distance they can jump on Earth to calculate the distance they could jump on the Moon and other planets in the solar system.

1. Record the measurement of the distance you can jump on Earth.
____
____

2. Calculate how high you could jump on the Moon (you can do this by multiplying your answer in the previous question times 6, or you can use repeated addition).

3. Now, calculate how high you could jump on the following planets:

PLANET	PROCEDURE FOR HEIGHT OF JUMP
Mercury	multiply by 5 then divide by 2=_______
Venus	multiply by 10 then divide by 9=______
Mars	multiply by 5 then divide by 2=_______
Jupiter	multiply by 2 then divide by 5=_______
Saturn	multiply by 7 then divide by 8=_______
Uranus	multiply by 11 then divide by 12=_____
Neptune	multiply by 5 then divide by 7=_______
Pluto	multiply by 30=____________

REFLECTION QUESTIONS:

1. Based on your calculation, where would you be able to jump higher, on Earth or on the Moon?

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2. What is different about the Earth and the Moon that would affect how high you could jump on each?

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3. Based on your observations today, describe gravity and what it does.

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APPLICATION QUESTIONS:

1. Think about what you have learned. On which planet would you experience the greater force of gravity, Mars or Jupiter?

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____

Middle School Activities

Planetary Motion

FOCUS ACTIVITY:

Students should answer the first two focus questions on the next page before viewing the CD-ROM entitled *Exploring the Planets*. All other focus questions should be answered after viewing this CD-ROM.

Below are additional resource materials that can be used during this introductory focus activity.

The CD-ROM/software *Starry Night Backyard*.

The internet site www.geocities.com/thesciencefiles/gravity/simulator.html

* The materials used for the middle school explore activities in this BIM were adapted from the STC program *Earth In Space*.

Middle School Activities
Planetary Motion

FOCUS QUESTIONS:

Questions to be completed before viewing the CD-ROM *Exploring the Planets*:

Describe the motion of the planets in our solar system. What is the shape of the path they take?

What role, if any, do you think the sun plays in determining the motion of the planets in our solar system?

Questions to be completed after viewing the CD-ROM *Exploring the Planets*:

Do you think the motion of the planets would change if the sun suddenly disappeared? If so, what type of change would you expect to see?

What do you think would happen if the planets stopped revolving and suddenly stood still?

Planetary Motion
Applying a Net Force

EXPLORE ACTIVITY: In this activity students will discover the effects a net force can have on the motion of an object. This activity was adapted from the STC activity entitled *Testing Balanced and Unbalanced Forces*.

Materials per individual:
Goggles
Materials per group:
1 metal canning ring
1 marble

Procedure:
1. Place the metal ring on the floor with the lip up. Place the marble inside the metal ring. Without moving the metal ring, describe the motion of the marble. Record your observation below.

2. Use the ring to move the marble in circles in a counter-clockwise direction. Keep the ring on the floor at all times. Record your observations. Discuss with your group how the ring creates a force that influences the marble's motion.

3. Make a prediction about what will happen if you lift the ring.

4. Move the marble in circles again, and then lift the ring. Describe what happens when the ring is lifted. Try this several times. Record your observations in both words and pictures in the space provided below.

Planetary Motion
Applying a Net Force

REFLECTION QUESTIONS:

1. Suppose you lifted the ring when the counter-clockwise orbiting marble was at the top of the circle. Draw the path the marble would take.

2. Explain why the marble moved the way it did with the ring in place.

3. Explain why the marble moved the way it did when the ring was removed.

APPLICATION QUESTION:

The force exerted on the marble by the jar lid represents the net gravitational force exerted on the planets by the sun. The planets, like the marble, move forward due to inertia and inward due to an unbalanced or net force. Based on your observations during this explore activity, do you think the motion of the planets would change if the sun suddenly disappeared and if so how?

Planetary Motion
Building a Model

EXPLORE ACTIVITY: Students will use a model to simulate planetary motion. This activity was adapted from the STC activity entitled *Observing Planetary Motion*.

Materials per individual:
Goggles
Materials per group:
1 Planetary Motion Model – A latex sheet (27" x 27") stretched and secured in a wooden quilting hoop 23" in diameter.
3 pedestals for the Planetary Motion Model
1 yellow balloon filled with water
1 marble

Procedure:
1. Place the Planetary Motion Model on the three pedestals provided for it. The lip of the hoop should be facing down. Allow any extra sheeting to hang down under the hoop. The pedestals should be evenly spaced around the hoop and the edge of the hoop should sit in the grooves of the pedestals.

2. Make a prediction about the path the marble would take if you rolled it onto the latex sheet toward the edge of the hoop. Use words and pictures.

3. Roll the marble, with moderate force, onto the latex sheet toward the edge of the hoop. Observe the marble. Repeat this several times. Discuss your observations with your group. Record your results in the space provided below.

4. Place the balloon in the center of the latex sheet. Let go of the balloon. Discuss what the balloon does to the sheet. Then roll the marble, with moderate force, onto the sheet toward the edge of the hoop. Watch the marble carefully. Describe the shape of the path the marble takes. Discuss your observations with your group and record them.

5. Test the motion of the marble several times and observe the motion carefully. Let everyone take a turn. How does the motion of the marble change as it nears the balloon?

6. Now try to get the marble to move in a true circular path. What did you have to do to accomplish this?

Planetary Motion
Building a Model

REFLECTION QUESTIONS:

1. The balloon at the center of the latex represents the Sun at the center of our solar system. The marble represents a planet. What force exists between our Sun and the planets? Based on your observations, how does this force affect the motion of the planets?

2. Once again, the balloon represents the Sun and the marble represents a planet. What does the slope of the latex surface represent? What force changes as the distance between the Sun and a planet decreases? In what way does this force change? How does this change in the force affect the speed of the planet?

APPLICATION QUESTIONS:

1. Based on your observations, which planet do you think would have the fastest orbital speed and why?

2. After completing this explore activity, what do you think would happen to the planets if they stopped revolving around the sun? Think about how you might manipulate the equipment (the Planetary Motion Model) to discover the answer to this question. Once you have come up with an idea, try it.

ADDITIONAL REFLECTION QUESTIONS:

1. Now that you have experienced both the elementary and middle school activities, do you think the "Big Idea" you originally identified for this BIM is correct? If not, what "Big Idea" do you think this BIM is exploring?

2. How does the elementary activity tie into the middle school activities?

3. What specific Benchmarks do the elementary and middle school activities address?

High School Activity

BIM Focus Question Revisited

What will happen to the solar system when the Sun loses half its mass?

Orbital Motion of Planets and Moons

EXPLORE ACTIVITY: This activity was adapted from the GEMS program ***Moons of Jupiter.***

Materials:

Slides of Moons of Jupiter (GEMS)
Moon tracking sheet (one for each student)
Pencil
Hula hoop
2" diameter ball

Procedure:

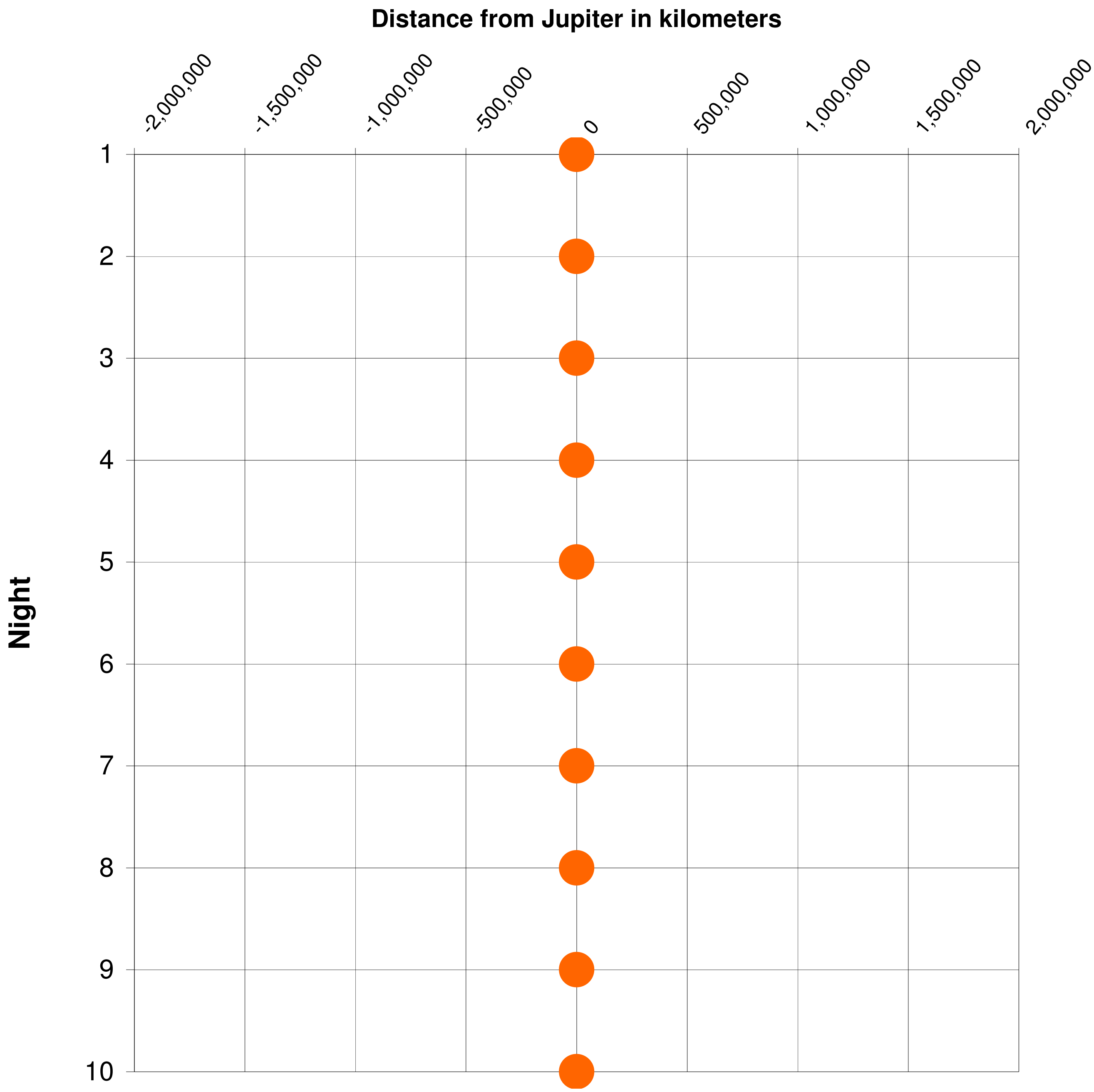
1. Review the history of scientists who studied the solar system and made contributions to the question of planetary motion relative to the sun.
2. Discuss Galileo and how his observations of Jupiter and its four largest moons led him to propose the idea that the planets orbit the sun.
3. Show students the first slide showing Jupiter and its moons, and explain how each moon will be colored a different color to more easily identify them.
4. Divide class into teams, and assign each team one of the moons to track.
5. Hand out tracking sheets and have each team write the color of the moon that they will observe.
6. Proceed to show all nine nights while students observe and record the positions of their moon for each night.

Summarizing the data:

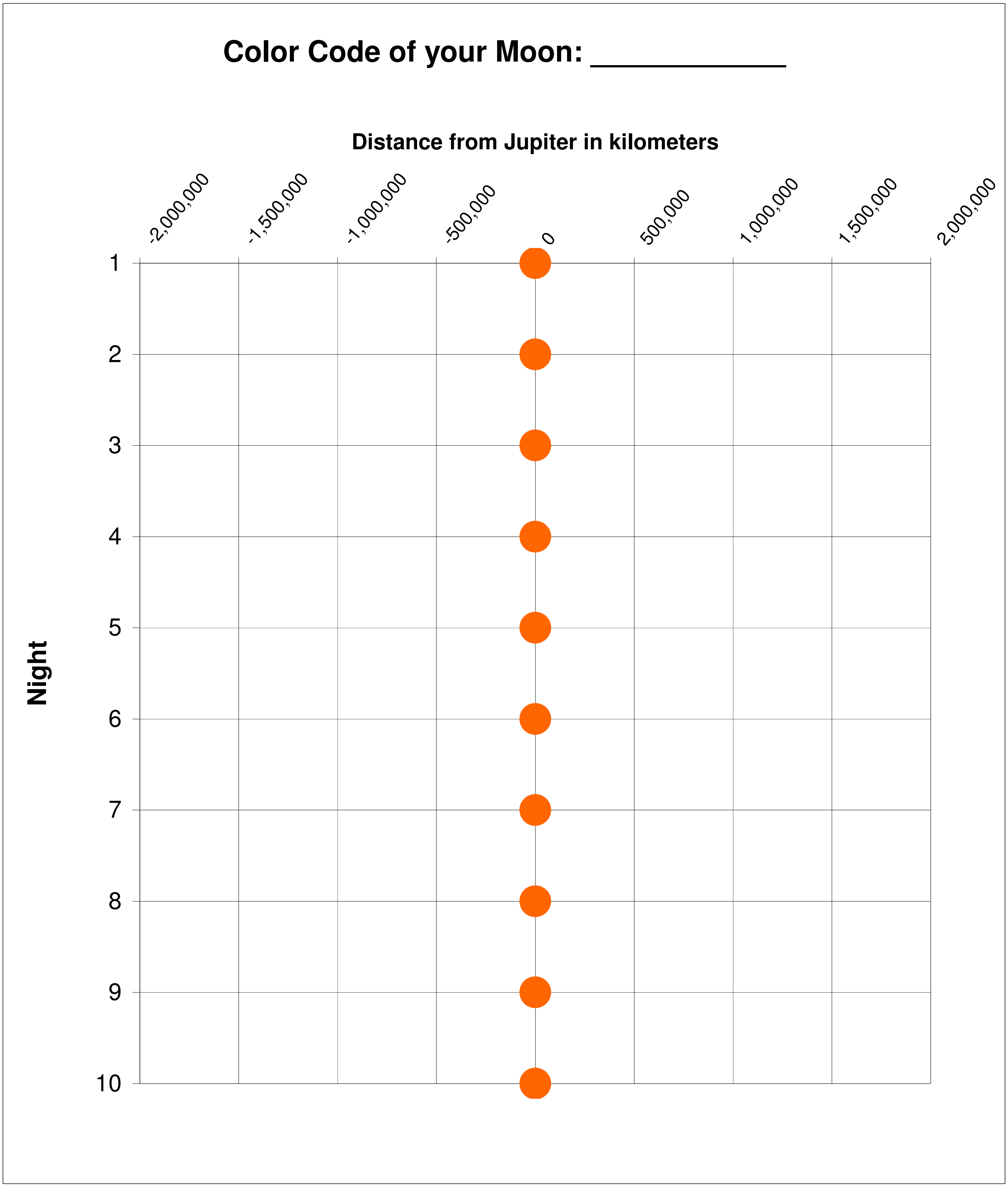
1. Have students draw a line on their data sheets connecting the positions of the moon as it changed position each night and compare data with their teammates.
2. Ask them what might be happening that might explain why their moons seemed to change position each night, and why some moons are not visible on certain nights. Demonstrate orbit with the hula hoop and ball.
3. Ask students how to go about determining how long it takes for a moon to go around Jupiter once, and have them determine how long it takes their moon to orbit once around Jupiter. Tell them this is called the **orbital period.**
4. Have each team report their results to the class and enter this on the data table.
5. Explain how to determine distance on the slides, and have each team report the maximum distance their moon is from Jupiter, and enter it on the data table.
6. Make a graph of distance vs. orbital period. Have students discuss the relationship between distance and orbital period of the moons.
7. Calculate the **orbital distance** and **orbital velocity** of the moons.

Tracking Jupiter's Moons

Color Code of your Moon: ____________



Tracking Jupiter's Moons



Data Table for Jupiter's Moons

Moon	Orbital Period (t)	Distance to Jupiter (r)	Orbital distance ($2\Pi r$)	Orbital Velocity (km/day)
Io				
Europa				
Ganymede				
Callisto				

Formulae for calculating orbital distance and orbital velocity:

Orbital distance = $2\prod r$

Orbital velocity = $\frac{2\prod r}{t}$

REFLECTION QUESTIONS:

Examine the data table. Do you notice a relationship between the orbital period and the moon's distance from the planet?

Notice the relationship between Io's distance from Jupiter and Callisto's distance from Jupiter. How would you expect the orbital period of Io to compare to Callisto's orbital period? Do the data agree with your expectation? What is the explanation for this?

Now calculate the orbital velocity of each moon. What do you notice about the relationship between the distance of each moon from the planet and the moon's orbital velocity?

APPLICATION QUESTIONS:

1. Io and Earth's Moon have similar masses, are approximately the same size, and are both approximately the same distance from their respective planets, yet Io takes 2 days to make one revolution around Jupiter, while Earth's Moon takes 27 days. Based on this activity, how can you explain this?

2. Based on your observations of this activity, as well as previous activities, what two factors affect gravitational force, and how?

3. The Law of Universal Gravitation can be represented mathematically in the following manner: $F = \frac{G\,m_1\,m_2}{r^2}$

   a. Based on this formula, describe mathematically how doubling the mass of a planet or its moon will change the force of gravity between them.

   Based on this formula, describe mathematically what happens to the gravitational force when the distance between two bodies is doubled.

ADDITIONAL REFLECTION QUESTIONS:

1. Now that you have completed the high school activity, do you feel the “Big Idea” you identified for this BIM is still correct? If not, what “Big Idea” do you think this BIM is exploring?

2. How do the elementary and middle school activities tie into the high school activity?

3. What specific Benchmarks do the elementary, middle and high school activities address?

BIM Focus Question Revisited

What will happen to the solar system when the Sun loses half its mass?

Appendices

Background content material

Additional lessons

Famous Astronomers from the Past

Background for Teachers

Elementary School Lessons

Exploring the Motion of the Earth

Background Information

The Earth rotates on its axis. It takes 24 hours for the Earth to complete one rotation. Along with spinning on its axis, the Earth revolves around the Sun. It takes Earth 365 days, or one year, to travel a complete orbit around the Sun. The Earth rotates and revolves in a counter-clockwise direction.

A way to help third graders remember these terms is to point out that "rotation" has three syllables and "day" has three letters. On the other hand, "revolution" has four syllables and "year" is spelled with four letters.

Materials

Lamp base
Stool (or something you can put the lamp on)

Procedure:

While the teacher is setting up, the students should be answering the first two questions on the Activity Record.

Center the stool in the room. This will represent the sun, but don't tell the students. Have the students form a circle around the stool, making sure to allow space between each student. Ask them to identify what the lamp represents. Once they have figured out that it's the Sun, ask them to infer what each of them might represent (the earth). Then, tell the students that their nose will represent their home town. Ask them to show you how they should stand if it were nighttime where they live. Observe their positioning and then discuss why they stood that way. They should understand that for it to be nighttime, they should be facing away from the Sun. Repeat this process to illustrate daytime, observe their positioning and discuss.

Next, through discussion, help them understand that the Earth rotating on its axis causes our day and night. Have a few (or all) students demonstrate their idea of rotation. Notice which students move in a counter-clockwise direction and which do so in a clockwise direction. Select two or three students – making sure you have at least one student who turned clockwise and one who turned counter-clockwise. Have them demonstrate again and see if the other students notice the difference in the way they are turning. Take a vote to decide which one they think is the correct direction. After this, have them discuss what they think the Earth's movement might be. In what direction might the earth revolve? Have them demonstrate revolution.

If the class is able to handle it, you can have some or all members demonstrate rotation and revolution at the same time!

How High Can You Jump? (Gravity)

Teacher's Plan

Materials

Activity Record – 1 for each student
Tape measure – 1 for each group
Calculators – 1 for each group

Procedure

Have your class divided into groups of 3 or 4 before you begin.

At the beginning of class, give students an Activity Record and have them answer the first two questions.

List their ideas to the questions on the board (the teacher makes no corrections at this time).

Next, demonstrate what they will be doing with their groups. To find you how high you can jump on earth, you stand facing a wall (chalkboard works too). Reach up and place a small piece of tape on the wall at the highest spot you can touch. Then jump and see how high you can place a second piece of tape. Repeat the jump a few times to make sure the first jump was accurate (or to enable students to take an average of the trials).

Use a meter stick or tape measure to measure the distance between the two pieces of tape. This distance is how high you can jump on earth.

To find out how high you can jump on the Moon, you multiply the earth distance by six.

After you have demonstrated and answered students' questions, assign groups and work areas.

While students work, circulate to see that all are working and helping their classmates.

When students have completed the activities, discuss their results and then refer to question 1 to see if their results were what they expected.

(*Universe at Your Fingertips was used as a resource for this activity.)

Middle School Lessons

Planetary Motion

Instruction to provide to students:

<u>Introduction</u>

Today we are going to explore **planetary motion**. We will consider the **speed** and **direction** the planets take as they move around the sun.

There are two laws of physics that help explain the motion of the planets in our solar system. They are the Law of Intertia and the Law of Universal Gravitation.

The **Law of Inertia** was set forth by the physicist named **Newton** and it states in part: an **object in motion** will tend to **stay in motion** moving forward at a constant speed and in a **straight line**, unless acted upon by an **unbalanced force**. An object at rest will tend to stay at rest unless acted upon by an unbalanced force.

The **Law of Universal Gravitation** was also set forth by **Newton**. It states that a **force of attraction** exists **between** any **two objects** anywhere in space. Furthermore, this force known as gravity will:

- **increase** as the **mass** of either object **increases** (this is known as a **direct relationship**)
- **increase** as the **distance** between the objects **decreases** (this is known as an **inverse relationship**).

<u>Explore Activities</u>

Work in your cooperative groups to complete activities 15.1, 15.2, and 15.3 in *Earth in Space*. (You picked up a copy of these activities on your way into class.) Consider how the laws we discussed can be used to explain the observations you make during these activities. Record all observations, as well as the answers to all hypothesis and conclusion questions found in these activities, on separate paper. Be sure to write in complete sentences.

<u>Safety Tips:</u>

- All books remain under your desk at the front of the room.
- The only supplies students should take to their lab stations should be activity sheets, lined paper and pencils.
- The marble should not take flight at any time during the activity.
- San should not leave the plastic bins.
- Be sure not to damage the rulers.

<u>Teacher Background information:</u>

Provided in STC teacher guide.

Middle and High School Lessons

Background information: Vocabulary for Planetary Motion

Force = a **push or a pull**. Examples of forces include frictional force, gravitational force and elastic force.

Motion = a **change in position**. A point of reference is always needed when describing motion.

Newton's **Law of Inertia** states that an object's **motion will remain unchanged** if the **forces** acting on it are **balanced**. An object's motion is considered unchanged it is:

- standing still, or
- continues moving in a straight line at a constant speed

Newton's **Law of Inertia** states that an **object will accelerate** if there is an **unbalanced force or new force** acting upon it.

Acceleration = a change in motion. This can include:

- an object at rest begins to move
- an object that is moving speeds up
- an object that is moving slows down
- an object that is moving changes direction
- an object moving comes to rest or stops moving.

Newton's second law of motion, the Universal Law of Gravitation, states that the **acceleration** of an object is **directly related** to the **amount of force** applied to it and **indirectly related** to the **mass of the object**.

Newton's Universal Law of Gravitation: $F = \frac{G\, m_1\, m_2}{r^2}$

A force of attraction exists between any two objects in the universe.
The force of gravity between two objects increases as the mass of either object increases.
The force of gravity between two objects decreases as the distance between them increases.

Speed = rate at which an object moves. Distance traveled in a given time.

Velocity = rate at which an object moves in a given direction.

Momentum = the mass of an object multiplied by its velocity. Momentum determines how difficult it will be to change an object's motion.

Orbit = the path taken by one body in space as it revolves around another.

Additional Lessons

Planetary Motion
The Effects of Gravity - Middle School lesson

EXPLORE ACTIVITY: This activity is adapted from the STC lesson *Gravity's Effect on Objects in Motion*.

Materials per individual:
Goggles
Materials per group:
1 plastic box (16in. x 11in. x 6in.) filled with sand
1 metric ruler (30cm.)
1 marble
1 metric measuring tape

Procedure:

1. Hold the marble 40 cm above the plastic box. With the marble in your hand, decide what two forces are acting on the marble. Are the forces balanced (both pulling equally) or unbalanced (one is pulling more than the other and serving as a net force)? Discuss your ideas with your group and record them in the space provided.

2. Predict what will happen if you release the marble from your hand. Discuss your prediction with your group and record it.

3. Let go of the marble. Discuss your observations of the marble's motion with your group. Compare your observations with your predictions.

4. Repeat steps 1 and 3 of the procedure. Does the marble move the same way each time? Discuss your observations and record them below.

5. Use a ruler as a ramp to gently roll the marble into the plastic box. Keep the ruler nearly flat. Discuss your observations. How did the marble move once it left the ruler? Use pictures and words to record your observations.

6. Experiment by rolling the marble down the ruler at different speeds. Keep the ruler nearly flat. How does the marble move each time it leaves the ruler? If possible, measure the distance that your marble travels each time. Record your observations using pictures and words.

Planetary Motion
The Effects of Gravity

REFLECTION QUESTIONS:

1. What pulling force acted on the marble at all times (both before and after it left the ruler)?

2. Describe the motion of the marble before it left the ruler. Did the pulling force you identified appear to change the direction of the marble's motion before it left the ruler?

3. How did the motion of the marble change once it left the ruler? Identify the force responsible for the change you observed and explain why this force did not change the direction of the marble's motion until the marble left the ruler.

4. How did increasing the forward speed of the marble affect the motion of the marble once it left the ruler?

5. What do you think would happen to the motion of the marble if you continued to increase its forward speed?

APPLICATION QUESTIONS:

1. The planets, like the marble after it left the ruler in this explore activity, are traveling forward, and at the same time falling toward the Sun. Based on your observations during this activity, describe the shape of the path you would expect objects in this situation to take.

Exploring the effects of Planetary Mass and Distance on a Moon's Orbital Speed
A Teacher Demonstration

Adapted from STC's *Earth in Space*.

Materials:
1 pre-assembled Moon Orbitor (materials can be obtained from the STC *Earth in Space* kit)
25 large steel washers
Stopwatches
Safety goggles

Procedure:

1. Place 5 washers in the tube and begin twirling the Styrofoam ball. Continue twirling until the plastic tube containing the washers is pulled up to the base of the handle. Tell students to observe the speed of the ball as the washers are pulled up and the distance from the handle to the ball increases. Students may determine the speed of the ball quantitatively by using a stopwatch to measure the time it takes to orbiter to complete ten revolutions.

2. Ask the students:
   a. What dfo you notice about the speed of the ball when twirling begins and the distance between the cylinder of washers and the ball is smaller?
   b. What do you notice about the speed of the ball when the washers are pulled all the way up and the distance between the cylinder of washers and the ball is larger?
   c. How long does it take the ball to complete 10 revolutions after the washers are pulled all the way up?

3. Now place 15 more washers in the plastic tube and repeat Procedure 1.

4. Ask the students the questions in Procedure 2 as well as the additional questionbs below:
   a. What did you observe happened to the speed of the ball when additional washers were added to the cylinder thereby increasing its mass?
   b. In this demonstration, what do the washers in the clinger represent?
   c. What does the Styrofoam ball represent?

5. Have the students then state the relationship of a moon from the planet it is orbiting, and its orbital speed.

6. Have the students state the relationship of the mass of a planet to the speed of a moon revolving around it.

Appendix A

Famous Astronomers from the Past

Name	Heritage	What he did
Nicholas Copernicus (1473-1543)	Polish	• Described sun-centered universe
Galileo Galilei (1564-1642)	Italian	• Found evidence for sun-centered universe in the movement of moons around Jupiter • Discovered sunspots • Discovered craters and mountains on Moon
Tycho Brahe (1546-1601)	Danish	• Very detailed naked eye observations (no telescope) • Supernova are as far away as the stars
Johannes Kepler (1571-1630)	German	Developed the laws of planetary motion: 1. Planets orbit in ellipses, with the Sun at one focus 2. The line joining a planet and the Sun sweeps out equal areas in equal amounts of time. 3. Relationship between the average distance of a planet from the Sun (which equals half the length of the major axis, or semi-major axis) and the planet's sidereal period, the length of time it takes for the planet to orbit once around the Sun. $P^2=A^3$
Sir Isaac Newton (1642-1727)	English	• Developed Calculus • Discovered that white light can be broken into spectrum • Developed laws of gravity

Appendix B

CONNECT-ED Background

Professional Development in Science and Mathematics

CONNECT-ED (Consortium for New Explorations in Coherent Teacher Education)
www.rider.edu/2559_5881.htm

Established in 2003, CONNECT-ED (C-E) is a Consortium of 16 central NJ districts/ independent schools, Rider and Princeton Universities, Raritan Valley Community College, and Bristol-Myers Squibb Company dedicated to providing a coherent, sustained *system* of professional development for K-12 teachers of science and math that **models the inquiry approach** to teaching/learning and **organizes content around the Big Ideas** in science and math.

Phase I: 2003 - 2008

In Phase I, there are 2 tiers to C-E professional development:

- In Tier 1, district-based Design Teams of 3 teachers (1 each from ES, MS and HS), 1 district administrator and 1 university or industry scientist spend 6 months designing 6-hour **Big Idea Modules (BIMs)** that trace the development of a big idea (core concept) across the elementary, middle, and high school levels, modeling the inquiry approach and making important concept connections across grade levels and among science and math disciplines. BIM design is the most powerful professional development experience in CONNECT-ED.

- In Tier 2, Design Teams present their BIMs to other teachers in 2-week **Summer Institutes** in conjunction with Princeton University's QUEST program, and/or in school-year **Mini-Institutes** offered either at Rider or in districts, often incorporated into district staff development days.

By 2008, Phase I will have generated significant resources:

- 45 Design Teams with expertise in big ideas thinking and inquiry-centered teaching/learning
- Many C-E districts will have clusters of up to six Design Teams representing multiple disciplines.
- 45 Big Idea Modules (BIMs) in 5 disciplines: chemistry, physics/astronomy, earth science, life science, and mathematics.
- 45 materials "kits" to support existing BIMs
- Annual 2-week Summer Institutes, regional C-E Conferences, and multiple 1-day Mini-Institutes

Phase II: 2008 – 2011

The aim of Phase II is to leverage the substantial resources created in Phase I to build teacher leadership in the districts, and to support the application of "big ideas thinking" to teachers' day-to-day classroom practice and to districts' long-term K-12 science/math curriculum planning. The goal is to transform teacher practice and institutionalize the big ideas and inquiry approaches within Consortium districts *for the long term*. To accomplish this, Phase II will establish CONNECT-ED Professional Learning Communities in each Consortium district. Existing design team members will form the core membership of each district's PLC, with new teacher members to be added over time. Each PLC will be responsible for setting its own goals (consistent with the CONNECT-ED approach), based on the learning needs of its members and the science/math priorities of the district. Each PLC will then create its own 3-year plan for accomplishing its goals. CONNECT-ED will support the PLCs by providing teacher leadership training, BIM design "train-the-trainers" workshops (so that many more teachers may have the rich experience of designing a BIM), and a menu of elective professional development programs available either from Consortium partners (such as the CONNECT-ED

Summer Institutes and Mini-Institutes, Princeton's QUEST program, and Raritan Valley CC's summer astronomy institute) or other providers.

Phase II shifts the locus of CONNECT-ED activity to Consortium districts, giving them the autonomy to set and advance toward their own goals for science/math, and the opportunity to develop teacher leadership within the district that can sustain change for the long-term. Further, Phase II promotes Professional Learning Communities as the medium for ongoing, coherent, district-based professional learning for teachers. This strategy is aligned with the National Staff Development Council's standards for professional development and supports the New Jersey Department of Education's new mandate that "collaborative learning" be the mode for teacher professional development in all districts.

CONNECT-ED (C-E) Phase II: Collaborative Professional Learning Organized Around the Big Ideas in Science and Mathematics

CONNECT-ED Partner Districts

Each partner district creates a **C-E Professional Learning Community (PLC)** with BIM Design Team member clusters as initial core members; other teachers, curriculum admins, principals, others join over time. **Goal**: Apply Big Ideas thinking to classroom instruction and district-wide K-12 science/math programs. Each PLC will:

- Develop and implement a three-yr plan/budget for its work
- Participate in "Core" activities and selected "Electives" to support their plan
- Request a "PLC Grant" toward the cost of three-year plan
- Report to C-E Leadership Team

PLC work supported by CONNECT-ED and

"Core" Common Experiences (required)

- Leadership Development
  Multiple-year program of support for PLCs
- BIM Design & Use in District (C-E)
  -Train PLC members: BIM designing for other teachers
  -Use existing BIMs for district PD

"Electives"

PLCs choose Elective programs, funded by PLC Grants, to strategically support their three-year plan.

Electives are existing professional development programs available within the Consortium from C-E partners, or from other providers.

Evaluation by Education Development Center & TCC

14 CONNECT-ED Phase II District Partners:

1. City of Burlington (Abbott District)
2. East Windsor Regional School District
3. Ewing Township School District
4. Hamilton Township Public Schools
5. Hillsborough Township School District
6. Hopewell Valley Regional School District
7. Lawrence Township Public Schools
8. Montgomery Township School District
9. Newgrange School (independent school)
10. South Brunswick Public Schools
11. Trenton Public Schools (Abbott District)
12. Warren Township Schools
13. Robbinsville School District
14. West Windsor-Plainsboro Regional Schools

Other Core Partners: Rider University (lead institution), Princeton University, Raritan Valley CC, Bristol-Myers Squibb Company

For Information, contact the CONNECT-ED Project Director, Dr. Kathleen M. Browne, Rider University, 609-896-5333, browne@rider.edu.

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SELECT
The Science Education and Literacy Center

Rider University
Bristol-Myers Squibb Center for Science Teaching & Learning
2083 Lawrenceville Road, Lawrenceville, NJ 08648
Phone: 609-896-5333 Fax: 609-896-5334 e-mail: tlc@rider.edu

Explanations for BIM Sections

BIM FOCUS: **The Introduction to the BIM**
In this introduction, get participants thinking about the topic you will be exploring. Present a challenge that gets at the Big Idea somehow through a problem to solve. You should aim this challenge at the high school level. It should be something most participants will not be able to answer completely until they work through the entire BIM. You have succeeded with this part if they feel left hanging and really want to know the answer. Be sure though to revisit the challenge at the end of the BIM. In some cases, it has worked well to use the HS lesson focus for the BIM focus.

Each grade level will need the following:
FOCUS: A grade level appropriate challenge for the participants to think about, discuss and write about. For most students, they should not be able to answer it before completing the Explore, or at least not be certain about their answer! The approach to this Focus should be similar to the BIM Focus.
EXPLORE: The 3 Activities

- Participants will experience a grade level appropriate activity tied to your big idea and the concept strand y9u selected from the AAAS *Atlas of Science Literacy* or other concept map (e.g. NSES or NJ CCC Standards). The actual lesson *will* need to be modified for the BIM.
- The activities should come from your own classrooms when possible. Make use of exemplary curricular materials if you can. Even if it is a great lesson, it *will* need to be adapted for the BIM.
- Participants will experience the lesson as a child would along with discussion of the learning process, content, skills, prior knowledge and attitudes from a teacher's perspective during and/or after the lesson.
- Your scientist will add adult level content mini-lessons relevant to the big idea presented and activities used. You will decide when these should happen (during the activity or the reflection time). The teachers on the team should help the scientist plan these efforts.
- All team members should be involved in adapting all lessons for the BIM and be very familiar with each lesson.

REFLECT: Discussion after each Lesson
Keep this part very focused on the pt of the lesson. In planning this part, consider the following:

What each participant learned and still need so know. Can they now answer the lesson focus?
How the content builds through the grade levels; connection to the Big Idea
What additional content participants need to know/learn to teach the activities and the big ideas
How each lesson is developmentally appropriate
How the Atlas can be used to inform us on how a big idea is developed
How each lesson maintained an inquiry focus
How the activities are standards-based
How the content covered can assist with breaking down misconceptions

Optional for each grade level: APPLY
Consider extending the content to a new grade level appropriate problem that requires an understanding of the content covered in the lesson for this part of the BIM to answer. Many teams end up adding application questions within their reflection…we will help you with this. Your scientist may need to add some discussion about additional content needed or real world applications of the content covered.
BIM REFLECTION After you finish the HS lesson component, you should tie together the entire BIM.
BIM APPLY
At the end of the day, teachers apply what they have learned to their own classroom, curricular materials, teaching approaches, instructional decision making, additional content interests, and/or district issues.
So, each BIM, will actually have the following cycle: F-FER-FER-FER-R-A. Each "FER" is for the 3 different grade levels included in the BIM. The Last "R" is the time to pull the entire BIM together.

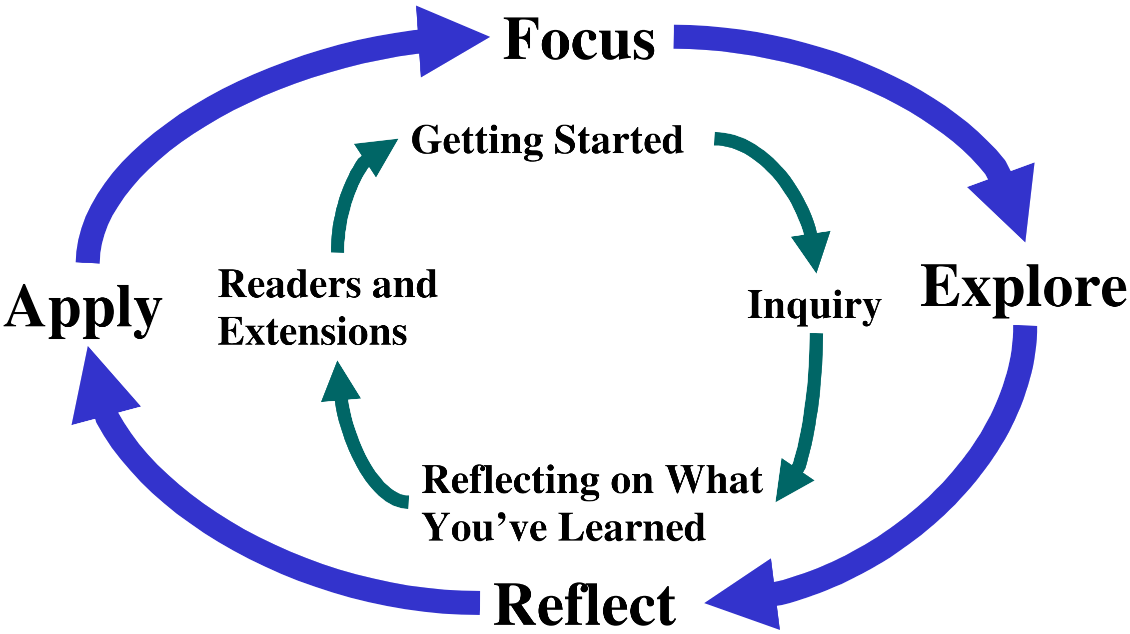
Basic Format of a CONNECT-ED Big Idea Module

EVERY full-day BIM will be unique so don't worry about your BIM not looking exactly like any other. Think creatively! We do ask that you design it around a basic structure. Below is an *average* model of a 6-hour BIM. Keep in mind that one lesson may only take 40 minutes rather than 60 minutes…this might allow you to add extra time to another lesson, or to spend some additional time discussing the integration of technology/math/literacy components, or the application session, etc. Make sure that for each grade level lesson, you include all components: a focus activity, explore three lessons/experiments/activities with reflection and content (from the STC's FERA cycle). The FERA Cycle is explained in the next page.

During a full day BIM presentation, lunch occurs about 3 hours after the start (and is not included in the 6 hr time budget). In most presentations, we take advantage of the natural transitions in the BIM to break for lunch.

BIM Component	Example Time Needed			
Focus/Intro to BIM	~15 min.			~6 hrs
Focus & ES Level Lesson (Explore)	~35 min.	~70 min.	~4.5 hrs	
Reflection & Content Session	~35 min.			
Focus & MS Level Lesson (Explore)	~45 min.	~90 min.		
Reflection & Content Session	~45 min.			
Focus & HS Level Lesson (Explore)	~55 min.	~125 min.		
Reflection & Content Session	~55 min.			
Revisit BIM Focus	~15 min			
Application Session	~60 min.			

STC & STC/MS FERA Learning Cycle



The "Focus-Explore-Reflect-Apply" learning cycle incorporated into NSRC's STC units is based on research findings about children's learning. These findings indicate that knowledge is actively constructed by each learner and that children learn science best in a hands-on experimental environment where they can make their own discoveries. The steps pf the learning cycle are as follows:

- FOCUS: Explore and clarify the ideas that children already have about the topic.
- EXPLORE: Enable children to engage in hands-on exploration of objects, organisms, and science phenomena to be investigated [and with continual encouragement to think about what they are experiencing].
- REFLECT: Encourage children to discuss their observations and to reconcile their ideas and prior knowledge.
- APPLY: Help children discuss and apply their new ideas in new situations.

Text modified from http://www.nsrconline.org/pubs/stc/overv.htm