NGSS Lesson Planning Template DAY 1

Grade/ Grade Band: 7	**Topic: Eclipses**	**Lesson # _1_ in a series of _5_ lessons**

Brief Lesson Description:

Performance Expectation(s):

1. Demonstrate knowledge of Earth-Moon-Sun interactions through modeling and discussion.
2. Investigate historical evidence of eclipses.
3. Differentiate the effects of eclipses on celestial bodies.
4. Design and create a model to view the total solar eclipse of 2017.

Specific Learning Outcomes:

Identify, model, and explain the occurrence of eclipses (to include differences between Solar and Lunar)

Narrative / Background Information

Knowledge is power and our history illustrates this with the utmost clarity. With history in mind, I think the question, "What can eclipses tell us?," pushes students to really consider the evidence that we can gather from these events. Additionally, it provides an advantage for those who know how to predict these events over those who do not (e.g., Columbus versus the Jamaicans and Ottomans versus Byzantines). Eclipses have also given us supporting evidence for the theory of general relativity. In 1919, during a solar eclipse, researchers from Great Britain observed light, from distant stars, bending from the gravitational pull of the Sun. The first question opens the door to the unpacking of the concept of eclipse: obscuring of
light by a celestial body from another celestial body. So this begs the question, "What types of eclipses exist?" By identifying the types of eclipses we can gather data from more common occurrences. For instance, simply observing the Milky Way reveals a large, illuminated area with a cloudy, or milky, texture. The gases, dust, and stars are arranged in such a way where eclipsing is evident and observers see the smoky, cloudy, or milky phenomena.

Prior Student Knowledge:

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
[MS-PS2-4] Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **[MS-PS2-5]** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5) **Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)	**Patterns**: Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) **Scale Proportion and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4), (MS-ESS2-2)

ESS2.A: Earth's Materials and Systems -The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)		

Possible Preconceptions/Misconceptions: Earth-centered plus/minus spinning, sun moving up/down, "magic", circular orbits

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

- **Intro – "Name That Object"**

Facilitator moves an object (stapler, shoe, etc...) in front of a light source - behind a partial concealment so the students cannot see what the object is. The object is projected onto a wall and the students will attempt to name the object and respond to the the question: "How do you know?"

See the following diagrams for example setups:

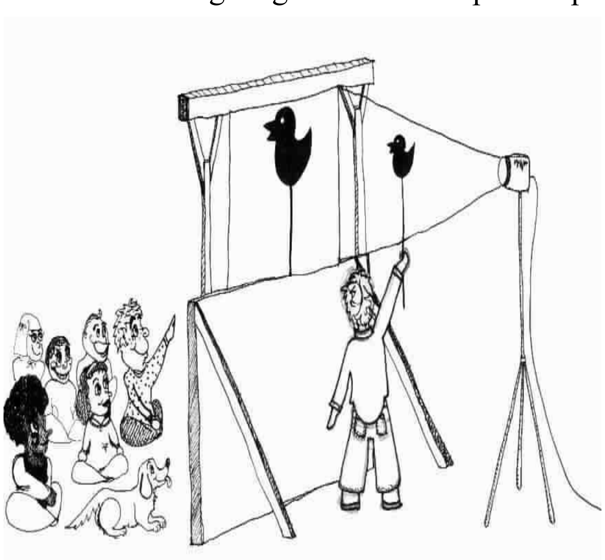

Figure 1 shadow show style (light towards students)

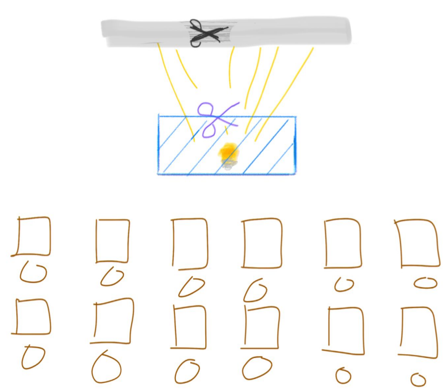

Figure 2 reverse projection, shadow cast away from observers

1. **Pro Tip:**

- attach object(s) to a string or stick. This prevents the hand from complicating the shadow.
- place some objects partially into the light to limit the information about the object(s).
- Group students in teams of 3 and have them write responses on a whiteboard or paper
    a. Include:
        i. What is the object
        ii. Evidence, or characteristics, of the object

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

1. **Sun-Earth-Moon Discussion:**
    i. Pose question(s):
        a. What events occur, astronomically, that are similar to "Name That Object?"
            i. Expected answer: eclipses
    ii. Facilitator discusses S-E-M interactions to prep students for the next activity.
        a. Consideration: Introduce eclipse calenders -
            i. Solar: http://eclipse.gsfc.nasa.gov/SEdecade/SEdecade2011.html
            ii. Lunar: http://eclipse.gsfc.nasa.gov/LEdecade/LEdecade2011.html
2. **Get Up and Move Activity:** Ask the students: "How do eclipses occur?" Small groups address question in teams of 3 to model the interactions of the Earth, Moon, and Sun. These teams need to develop a human-movement-model (each student designated to a celestial body) to explain both Lunar and Solar eclipses (misconceptions will occur here; reteach as needed)
    i. Criteria: account for why eclipses occur two times a year, movement of Sun, Earth, and Moon
    ii. Info: The Moon's orbit is tilted with respect to the plane of the Earth and Sun.
    iii. Materials: Light source (e.g. lamp minus shade) at center of room. Each team uses 2 balls (1 Earth, 1 Moon) to manipulate the orbits and

shadows. Consider ratio of size for Earth and Moon and the distance necessary to achieve an appropriate shadow.

b. Options:
    i. Foamcore moonphases project: http://www.weirdunsocializedhomeschoolers.com/hands-on-moon-phases-project/ or http://www.scienceteachingjunkie.com/2013/03/clearest-way-to-teach-moon-phasesever.html

EXPLAIN: Concepts Explained and Vocabulary Defined:

Earth rotation and revolution: https://www.youtube.com/watch?v=l64YwNl1wr0 (4 minutes)

Vocabulary: Eclipse - an obscuring of the light from one celestial body by the passage of another between it and the observer or between it and its source of illumination.

ELABORATE: Applications and Extensions:

Question: Why do we observe the Moon's shadow moving W to E?

EVALUATE:

Formative Monitoring (Questioning / Discussion):
Small Group Discussions, orbit demonstrations - Use www.ForAllRubrics.com to do mobile assessment.

Summative Assessment (Quiz / Project / Report):

1. **Exit Slip** – 1 Minute Response
    a. Students describe E-M-S orbits and occurrences of eclipses via timed written response (diagrams with labels are encouraged)

Elaborate Further / Reflect: Enrichment:

Extensions:

- **a.** Why do we observe eclipses at less than 6 months apart?
- **b.** Resource: Solar Eclipse shadow 2009 **http://cimss.ssec.wisc.edu/goes/blog/archives/3020**
- **c.** Space time DIY: https://www.youtube.com/watch?v=cHySqQtb-rk

For Eclipse Events:

Expectations for the week:

1. Participation, behavior, tweetchat setup (issue challenge?) to Neil DeGrasse Tyson,

Bill Nye, Mark Rober, NASA, etc... for development of innovative eclipse viewing device.

a. Setup: http://www.socialmediaexaminer.com/twitter-chat-guide/ or https://blog.hootsuite.com/a-step-by-step-guide-to-twitter-chats/

2. **Flickr group setup** (may be done in advance) – seek participation from classes in USA (most of which will view the eclipse to some degree).

    i. Clarification – The Flickr group allows pictures to be geotagged and posted all over a map of the US (or the Earth). The goal is to create the path of the eclipse with images from various solar eclipse viewing devices. For example, the path of totality should all look relatively dark with some rings. The pictures immediately north and south will show a crescent at opposite ends of the Sun. Thus, a great time to ponder the question, "why?" occurs and students will more readily seek answers.

        1. Setup: http://www.wikihow.com/Open-a-Flickr-Account and http://www.slideshare.net/sianjamieson/a-basic-guide-to-setting-up-using-flickr

DAY 2

Grade/ Grade Band: 7	**Topic: Eclipses**	**Lesson # _2_ in a series of _5_ lessons**
Brief Lesson Description: Day 2 asks students to investigate the history of eclipses through a little research using primary sources, if possible.		
Performance Expectation(s): 5. Demonstrate knowledge of E-M-S interactions through modeling and discussion. 6. Investigate historical evidence of eclipses. 7. Differentiate the effects of eclipses on celestial bodies. 8. Design and create a model to view the total solar eclipse of 2017.		
Specific Learning Outcomes: Investigate the benefit of eclipses according to historical accounts. Make connections to real world application of eclipse knowledge.		
Narrative / Background Information Knowledge is power and our history illustrates this with the utmost clarity. With history in mind, I think the question, "What can eclipses tell us?," pushes students to really consider the evidence that we can gather from		

these events. Additionally, it provides an advantage for those who know how to predict these events over those who do not (e.g., Columbus versus the Jamaicans and Ottomans versus Byzantines). Eclipses have also given us supporting evidence for the theory of general relativity. In 1919, during a solar eclipse, researchers from Great Britain observed light, from distant stars, bending from the gravitational pull of the Sun. The first question opens the door to the unpacking of the concept of eclipse: obscuring of light by a celestial body from another celestial body. So this begs the question, "What types of eclipses exist?" By identifying the types of eclipses we can gather data from more common occurrences. For instance, simply observing the Milky Way reveals a large, illuminated area with a cloudy, or milky, texture. The gases, dust, and stars are arranged in such a way where eclipsing is evident and observers see the smoky, cloudy, or milky phenomena.

Prior Student Knowledge:
Planetary rotation, orbital movement, eclipses

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
[MS-PS2-4] Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **[MS-PS2-5]** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects arenot in contact. **ESS2.A:** Earth's Materials and Systems -The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5) **Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)	**Patterns**: Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) **Scale Proportion and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4), (MS-ESS2-2)

Possible Preconceptions/Misconceptions: Earth-centered plus/minus spinning, sun moving up/down, “magic”, circular orbits

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Intro (3-5 mins)

a. Question for students: "What do eclipses tell us?"
    i. Expected answers: science oriented to include size, shape, speed, etc...

– Facilitator shares eclipse story of Christopher Columbus and the Jamaicans and/or Ottomans versus the Byzantines (for reference: A http://www.eclipsewise.com/extra/SEhistory.html, B http://eclipse.gsfc.nasa.gov/SEhistory/SEhistory.html, C http://www.livescience.com/24743-famous-solar-eclipses-history.html)

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EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

1. Intro (3-5 mins)
    a. **Question** for students: "What do eclipses tell us?"
        i. Expected answers: science-oriented to include size, shape, speed, etc...
    b. **Story-Telling for application:** Facilitator shares eclipse story of Christopher Columbus and the Jamaicans and/or Ottomans versus the Byzantines
        i. References:
            1. http://www.eclipsewise.com/extra/SEhistory.html
            2. http://eclipse.gsfc.nasa.gov/SEhistory/SEhistory.html
            3. http://www.livescience.com/24743-famous-solar-eclipses-history.html

EXPLAIN: Concepts Explained and Vocabulary Defined:

Small group activity (3 to 4 students):

1. Research (12-15 mins) with books, chromebooks, internet tools, and/or handouts historical accounts of eclipses from Greeks, Mayans, Chinese, Egyptians, Indians, Islamic World, Babylonians and Sumerians.
    a. Consider resources: https://blogs.loc.gov/teachers/2013/11/exploring-eclipses-through-primary-sources-earth-moon-sun/ and http://siarchives.si.edu/history/exhibits/stories/viewing-aurora-boreali

s-and-eclipse-moon)

b. Handout: Students receive a handout to complete that includes date of occurrence, event surround eclipse, speculation on results opposite to records

2. **Shotgun Presentations** (24 mins) – Each group presents findings back to class in short (3 mins) presentation *use stopwatch, or phone, etc...

Vocabulary: Eclipse, ellipses, precession

ELABORATE: Applications and Extensions:

1. **Discussion/Activity** - What can we learn from eclipses? (8-13 mins)
   a. Evidence for round earth/celestial objects, positions of Sun and Moon, precession, Earth's rotation speed (changing, hence leap seconds/years)
   b. Teacher Tools: Accountability Talk, Retell~Summarize~Sketch, News Flash

EVALUATE:

Formative Monitoring (Questioning / Discussion):
Use ForAllRubrics.com - evaluate student presentations and discussions according to rubrics

Summative Assessment (Quiz / Project / Report):

1. **Exit Slip (3 mins)**
   - Record, individually, one historical and one scientific way eclipses have been influential.

Elaborate Further / Reflect: Enrichment:

Extensions:

1. Why do we experience weather/seasons?
2. Planetary Orbits: Ellipses
3. Observations of space are history: https://www.nasa.gov/audience/foreducators/trainlikeanastronaut/activities/SpeedofLight.html#.V2xSs77LKAU (speed of light activity)
4. Constellations change: http://www.wired.com/2015/03/gifs-show-constellations-transforming-150000-years/ (article and gifs of changing constellations)

Other Activity Resources:
http://www.nuffieldfoundation.org/science-society/activities-universe

For Eclipse Events: **Expectations for the week:** 3. **Check-in** on tweetchat and respond appropriately to Neil DeGrasse Tyson, Bill Nye, Mark Rober, NASA, etc... for development of innovative eclipse viewing device. 4. **Flickr group check-in** (may be done in advance) – seek participation from other classes in USA (most of which will view the eclipse in August 2017 to some degree).

DAY 3

Grade/ Grade Band: 7	**Topic: Eclipses**	**Lesson # _3_ in a series of _5_ lessons**
Brief Lesson Description: Lesson 3 of the Eclipse unit introduces students to the design & construction of safe-solar viewing devices.		
Performance Expectation(s): 1. Demonstrate knowledge of E-M-S interactions through modeling and discussion. 2. Investigate historical evidence of eclipses. 3. Differentiate the effects of eclipses on celestial bodies. 4. Design and create a model to view the total solar eclipse of 2017.		
Specific Learning Outcomes: Build/Modify and operate safe-solar viewing devices		
Narrative / Background Information Knowledge is power and our history illustrates this with the utmost clarity. With history in mind, I think the question, "What can eclipses tell us?," pushes students to really consider the evidence that we can gather from these events. Additionally, it provides an advantage for those who know how to predict these events over those who do not (e.g., Columbus versus the Jamaicans and Ottomans versus Byzantines). Eclipses have also given us supporting evidence for the theory of general relativity. In 1919, during a solar eclipse, researchers from Great Britain observed light, from distant stars, bending from the gravitational pull of the Sun. The first question opens the door to the unpacking of the concept of eclipse: obscuring of light by a celestial body from another celestial body. So this begs the question, "What types of eclipses exist?" By identifying the types of eclipses we can gather data from more common occurrences. For instance, simply observing the Milky Way reveals a large, illuminated area with a cloudy, or milky, texture. The gases, dust, and stars are arranged in such a way where eclipsing is evident and observers see the smoky, cloudy, or milky phenomena.		
Prior Student Knowledge: Planetary rotation, orbital movement, eclipses, eclipses in history		
Science & Engineering Practices:	**Disciplinary Core Ideas:** **Cause and Effect**	**Crosscutting Concepts:** **Patterns**: Patterns in rates of

[MS-PS2-4] Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **[MS-PS2-5]** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects arenot in contact. **ESS2.A:** Earth's Materials and Systems -The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)	Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5) **Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)	change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) **Scale Proportion and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4), (MS-ESS2-2)

Possible Preconceptions/Misconceptions: Earth-centered plus/minus spinning, sun moving up/down, "magic", circular orbits

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Intro (1-2 min)– Entry Task Question: "What do eclipses tell us?"

- 1 minute essay (answer must be different from previous day)
- Facilitator share ring occultation info/ Uranus rings discovery story (http://pds-rings.seti.org/ringocc/, http://csep10.phys.utk.edu/astr161/lect/uranus/rings.html)

Video (2 mins)– total solar eclipse clip

Discussion (12 mins): Think-Pair-Share + Accountability Talk

1. Size Equivalence
2. Moon Orbit, distance
3. Ring Effect

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Engineering Challenge (36-37 mins):

a. Facilitator explains safe viewing eclipse device concept (show examples)
    1. Teacher Resources:
        a. http://solar-center.stanford.edu/observe/
        b. http://www.skyandtelescope.com/astronomy-news/observing-news/how-to-look-at-the-sun/
        c. http://astronomyonline.org/solarsystem/solarsafety.asp
    ii. Design process explanation: http://www.eie.org/overview/engineering-design-process
b. Facilitator shows safety video: https://www.youtube.com/watch?v=R9cMXCemoJI
c. **glancing is not safe viewing!!**
    i. Groups of 3-4 students (ability based) gather, discuss, design, and plan device.
    ii. Facilitator check in with each group to empahsize parameters of device like image capture, safety feature(s), materials, etc...
    iii. Use Pin-Hole Camera design for students struggling to make progress.
        1. *NOTE* – I emphasize innovating, outside-of-box thinking/creation. Failure is OK! For example, a pin-hole camera design with a hole too large can be fixed, but let the students work through it.
d. resource: http://www.exploratorium.edu/eclipse/how-to-view-eclipse

EXPLAIN: Concepts Explained and Vocabulary Defined:

1. Facilitator: consider pin-hole camera and/or sunspotter demo
    a. Encourage creativity, decorations, and multi-use functionality for device

Vocabulary: Eclipse, ellipses, precession,

ELABORATE: Applications and Extensions:

Build & Test:

- Student groups continue work on safe-solar eclipse viewing devices with teacher check-ins to evaluate progress, answer questions, etc...

EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Small** **Journal Entry** (3 mins): 1. Predict what images will look like along the path of the Eclipse. a. What do you think the path of totality is? b. What would it look like? **Summative Assessment (Quiz / Project / Report):** 1. Students will turn in blueprint/design for their safe solar-viewing device.
Elaborate Further / Reflect: Enrichment: **Extensions:** If post-eclipse, take previous designs and challenge students to modify for better results. How can they be used for those in the path? What materials would be available?
For Eclipse Events: **Compare progress with other participating classes. Additionally, check in on tweetchat to share progress with cooperating scientists.**

DAY 4

Grade/ Grade Band: 7	**Topic: Eclipses**	**Lesson # _4_ in a series of _5_ lessons**
Brief Lesson Description: Day 4 provides a “brain break” and directs students to explore eclipses through artistic expression. Additionally, more time is given to students to engineer, or develop, their devices.		
Performance Expectation(s): 1. Demonstrate knowledge of Earth-Moon-Sun interactions through modeling and discussion. 2. Investigate historical evidence of eclipses. 3. Differentiate the effects of eclipses on celestial bodies. 4. Design and create a model to view the total solar eclipse of 2017.		
Specific Learning Outcomes: Identify, model, and explain the occurrence of eclipses (to include differences between Solar and Lunar)		
Narrative / Background Information Knowledge is power and our history illustrates this with the utmost clarity. With history in mind, I think the		

question, "What can eclipses tell us?," pushes students to really consider the evidence that we can gather from these events. Additionally, it provides an advantage for those who know how to predict these events over those who do not (e.g., Columbus versus the Jamaicans and Ottomans versus Byzantines). Eclipses have also given us supporting evidence for the theory of general relativity. In 1919, during a solar eclipse, researchers from Great Britain observed light, from distant stars, bending from the gravitational pull of the Sun. The first question opens the door to the unpacking of the concept of eclipse: obscuring of light by a celestial body from another celestial body. So this begs the question, "What types of eclipses exist?" By identifying the types of eclipses we can gather data from more common occurrences. For instance, simply observing the Milky Way reveals a large, illuminated area with a cloudy, or milky, texture. The gases, dust, and stars are arranged in such a way where eclipsing is evident and observers see the smoky, cloudy, or milky phenomena.
Prior Student Knowledge: Planetary rotation, orbital movement, eclipses, eclipses in history, Earth-Moon-Sun relationship,

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
[MS-PS2-4] Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **[MS-PS2-5]** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects arenot in contact. **ESS2.A:** Earth's Materials and Systems -The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5) **Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)	**Patterns**: Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) **Scale Proportion and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4), (MS-ESS2-2)

Possible Preconceptions/Misconceptions: Earth-centered plus/minus spinning, sun moving up/down, "magic", circular orbits
LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Intro (23 mins)

1. Facilitator showcases eclipse art via [internet images]
    1. Show path of totality: http://www.eclipse2017.org/2017/maps.htm
2. Student activity: students generate their own eclipse art based on their predictions (from yesterdays exit task) of eclipses in path.
    - Materials: paper, paint, coffee grounds, etc...
    - Parameters: students must describe the eclipse to include details on alignment of the Earth, Moon, and Sun
    - Rubric:

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Project Continuation (22 mins)

-consider decorations, fixes, and testing/experimentation

EXPLAIN: Concepts Explained and Vocabulary Defined:

Large Group Activity (8 mins)

-Discuss types of eclipses, elaborate on relationships of the Sun, Earth, and Moon: http://www.universetoday.com/26987/earth-sun-and-moon/ or http://www.slideshare.net/mrzolli/relationship-between-earth-sun-and-moon-whms-2013

1. Teacher resources (eclipse types):
    a. http://www.timeanddate.com/eclipse/eclipse-information.html
    b. http://www.math.nus.edu.sg/aslaksen/gem-projects/hm/0304-1-08-eclipse/Types%20of%20Solar%20Eclipse.htm
    c. http://www.eclipsegeeks.com/types-of-eclipse/4561673346

-Integrate terminology: occultations, penumbra, umbra, antumbra

1. Student tools: Word Sleuth, Word Chart, Vocab map, Yes, No, Why?, CLOZED, Concept-definition map

Vocabulary: Eclipse, ellipses, precession, umbra, penumbra, antumbra, occultations

ELABORATE: Applications and Extensions: 2. **Discussion/Activity** - What can we learn from eclipses? (8-13 mins) a. Evidence for round earth/celestial objects, positions of Sun and Moon, precession, Earth's rotation speed (changing, hence leap seconds/years) b. Accountability Talk, Retell~Summarize~Sketch, News Flash
EVALUATE: **Formative Monitoring (Questioning / Discussion):** Have students turn in their summaries (retell~summarize~sketch or news flash papers), evaluate and provide individualized feedback accordingly **Summative Assessment (Quiz / Project / Report):** Exit Task (2 mins) – Journal 1. Input something learned regarding eclipses from today's discussion 2. Write a question about eclipses focused on material we haven't discussed in depth.
Elaborate Further / Reflect: Enrichment: **Extensions:** 5. Why do we experience weather/seasons? 6. Planetary Orbits: Ellipses 7. Observations of space are history: https://www.nasa.gov/audience/foreducators/trainlikeanastronaut/activities/SpeedofLight.html#.V2xSs77LKAU (speed of light activity) 8. Constellations change: http://www.wired.com/2015/03/gifs-show-constellations-transforming-150000-years/ (article and gifs of changing constellations) **Other Activity Resources:** **http://www.nuffieldfoundation.org/science-society/activities-universe**

DAY 5

Grade/ Grade Band: 7	**Topic: Eclipses**	**Lesson # _4_ in a series of _5_ lessons**

Brief Lesson Description:
Day 5 in the Eclipse unit provides an opportunity for students to demonstrate their knowledge through achievement and presentation. Their devices should be prepared for sharing and explanation. For instance, how is their device safe for solar viewing? Can it be built anywhere?

Performance Expectation(s):

9. Demonstrate knowledge of E-M-S interactions through modeling and discussion.
10. Investigate historical evidence of eclipses.
11. Differentiate the effects of eclipses on celestial bodies.
12. Design and create a model to view the total solar eclipse of 2017.

Specific Learning Outcomes:
represent knowledge of eclipses through successful construction and demonstration of a safe-solar viewing device

Narrative / Background Information
Knowledge is power and our history illustrates this with the utmost clarity. With history in mind, I think the question, "What can eclipses tell us?," pushes students to really consider the evidence that we can gather from these events. Additionally, it provides an advantage for those who know how to predict these events over those who do not (e.g., Columbus versus the Jamaicans and Ottomans versus Byzantines). Eclipses have also given us supporting evidence for the theory of general relativity. In 1919, during a solar eclipse, researchers from Great Britain observed light, from distant stars, bending from the gravitational pull of the Sun. The first question opens the door to the unpacking of the concept of eclipse: obscuring of
light by a celestial body from another celestial body. So this begs the question, "What types of eclipses exist?" By identifying the types of eclipses we can gather data from more common occurrences. For instance, simply observing the Milky Way reveals a large, illuminated area with a cloudy, or milky, texture. The gases, dust, and stars are arranged in such a way where eclipsing is evident and observers see the smoky, cloudy, or milky phenomena.

Prior Student Knowledge: Planetary rotation, orbital movement, eclipses, eclipses in history, Earth-Moon-Sun relationship, path of totality

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
[MS-PS2-4] Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **[MS-PS2-5]** Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects arenot in contact. **ESS2.A:** Earth's Materials and	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5) **Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)	**Patterns**: Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3) **Scale Proportion and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-4), (MS-ESS2-2)

Systems -The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)		

Possible Preconceptions/Misconceptions: Earth-centered plus/minus spinning, sun moving up/down, "magic", circular orbits

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Group presentations! (40 mins) → 8 groups at ~5 minutes/group

1. Each group presents their projects to include demonstrations, image capture, safety feature(s), process of design, and possible applications aside from eclipses. Evaluate with www.ForAllRubrics.com
2. Consideration: recording presentations to share with other participating and/or future classrooms (YouTube?)
    i. Need: Permission slip

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Responses (10 mins)

1. Acknowledge responding individuals from the challenge (if any exist) to exchange ideas and resulting devices
    1. Emphasize appropriate responses (think professional)
    2. Showcase class work
    3. Consider competition:
        2. Vote on class favorites
        3. Use tweetchat participants as judges

EXPLAIN: Concepts Explained and Vocabulary Defined:

Sun Facts:

Resources: http://www.teacherplanet.com/resource/sun.php ,
Vocabulary: Eclipse, ellipses, precession, umbra, penumbra, antumbra, occultations, annularity

ELABORATE: Applications and Extensions:
*Alternative - If post-eclipse, consider showcasing modified devices and how to share with those in the path of future eclipses. Predict future eclipses (develop model)...

EVALUATE:

Formative Monitoring (Questioning / Discussion):

Summative Assessment (Quiz / Project / Report):
End of Unit Reflection – Journal (5 minutes)

1. Recap the process (eclipse knowledge, design and build of device, etc…)
2. Memorable moments (favorite vs least favorite)
3. Remaining questions

Elaborate Further / Reflect: Enrichment:
Extensions:

9. Why do we experience weather/seasons?
10. Planetary Orbits: Ellipses
11. Observations of space are history: https://www.nasa.gov/audience/foreducators/trainlikeanastronaut/activities/SpeedofLight.html#.V2xSs77LKAU (speed of light activity)
12. Constellations change: http://www.wired.com/2015/03/gifs-show-constellations-transforming-150000-years/ (article and gifs of changing constellations)

Other Activity Resources:
http://www.nuffieldfoundation.org/science-society/activities-universe

1. Post-unit:
    a. Community Check-In:
        i. Check in with other classrooms (Edmodo, Skype) to compare ideas, designs, progress and discuss locations in the United States compared with path of Eclipse.
    b. How will images look? Similarities vs differences? What can we infer from the images? Expected errors?

c. Discuss parameters of device and/or image capture to ensure images/data for Flickr are moderately consistent.

Vocabulary: (from http://eclipse.gsfc.nasa.gov/SEhelp/SEglossary.html; also: http://www.moonconnection.com/moon-glossary.phtml)

annular eclipse - A solar eclipse in which the Moon's antumbral shadow traverses Earth (the Moon is too far from Earth to completely cover the Sun). During the maximum phase of an annular eclipse, the Sun appears as a blindingly bright ring surrounding the Moon.

annularity - The maximum phase of an annular eclipse during which the Moon's entire disk is seen silhouetted against the Sun. Annularity is the period between second and third contact during an annular eclipse. It can last from a fraction of a second to a maximum of 12 minutes 29 seconds.

antumbra - The antumbra is that part of the Moon's shadow that extends beyond the umbra. It is similar to the penumbra in that the Sun is only partially blocked by the Moon. From within the antumbra, the Sun appears larger than the Moon which is seen in complete silhouette. An annular eclipse is seen when an observer passes through the antumbra.

Besselian elements - The Besselian elements are a series of time dependent variables used to calculate various aspects of a solar eclipse. They describe the movement of the Moon's shadow with respect to the fundamental plane. This plane passes through the center of Earth and is oriented perpendicular to the Moon's shadow axis. Next, the shadow cone is projected onto Earth's surface including the effects of Earth's rotation, the flattening of Earth and the latitude, longitude and elevation of the observer. The local circumstances at the observer's position can then be calculated including the eclipse contact times, eclipse magnitude and the duration of totality (or annularity).

center of figure - The center of figure of a celestial body (e.g., planet, moon) is the apparent center of the object with respect to its surface and takes into account irregularities in its shape. If the distribution of mass is not uniform, then the *center of mass* does not coincide with the *center of figure*. In the case of the Moon, the offset between the *center of mass* and *center of figure* is ~0.5 kilometers.

center of mass - In orbital mechanics, the equations of motion of celestial bodies (stars, planets, moons, etc.) are formulated as point masses located at the centers of mass. In other words, the motion of a celestial body can be predicted assuming the object's entire mass is concentrated into one single point called the *center of mass*.

central eclipse - A solar eclipse in which the central axis of the Moon’s shadow cone traverses Earth thereby producing a central line in the eclipse track. The umbra or antumbra falls entirely upon Earth so the ground track has both a northern and southern limit. Central solar eclipses can be either total, annular or hybrid.

central eclipse (one limit) - A solar eclipse in which the central axis of the Moon’s shadow cone traverses Earth. However, a portion of the umbra or antumbra misses Earth throughout the eclipse and the resulting ground track has just one limit. Central solar eclipses with one limit can be either total, annular or hybrid.

central line - During a central solar eclipse, the central axis of the Moon’s shadow cone traverses Earth's surface. The track produced by the shadow axis is called the central line of the eclipse. The duration of a total or annular eclipse is longest on the central line (neglecting Earth's curvature and effects introduced by the direction of the shadow with respect to the Equator) and drops to 0 as the observer moves to the path limits.

eclipse magnitude - Eclipse magnitude is the fraction of the Sun’s diameter occulted by the Moon. It is strictly a ratio of diameters and should not be confused with eclipse obscuration, which is a measure of the Sun’s surface area occulted by the Moon. Eclipse magnitude may be expressed as either a percentage or a decimal fraction (e.g., 50% or 0.50). By convention, its value is given at the instant of greatest eclipse.

eclipse obscuration - Eclipse obscuration is the fraction of the Sun’s area occulted by the Moon. It should not be confused with eclipse magnitude, which is the fraction of the Sun’s diameter occulted by the Moon. Eclipse obscuration may be expressed as either a percentage or a decimal fraction (e.g., 50% or 0.50).

eye safety - The only time that the Sun can be viewed safely with the naked eye is during a total eclipse, when the Moon completely covers the disk of the Sun. It is never safe to look at a partial or annular eclipse, or the partial phases of a total solar eclipse, without the proper equipment and techniques. Even when 99% of the Sun's surface (the photosphere) is obscured during the partial phases of a solar eclipse, the remaining crescent Sun is still intense enough to cause permanent retinal damage, especially when viewed through binoculars or other optical aids.

first contact - The instant when the partial phase of an eclipse begins.

fourth contact - The instant when the partial phase of an eclipse ends.

gamma - Gamma is the distance of the Moon's shadow axis from Earth's center in units of equatorial Earth radii. It is defined at the instant of greatest eclipse when its absolute value is at a minimum.

greatest duration - *Greatest Duration* (GD) is defined as the instant when the length of the total (or annular) phase reaches a maximum along the central path of a solar eclipse. The computation of the eclipse duration is typically done using a smooth edge for the Moon that ignores the effects of mountains and valleys along the lunar limb. Although the location of *Greatest Duration* may be relatively close to the point of *Greatest Eclipse*, it differs because of a combination of factors including the relative motion of the Moon's shadow with respect to the curvature of Earth's surface and to Earth's Equator. The length of the total (or annular) eclipse calculated at *Greatest Duration* typically differs by ~1-2 seconds compared with *Greatest Eclipse*, and the geographic location may differ by ~10-100 kilometers or more. Under certain conditions, the instant of *Greatest Duration* for some annular eclipses can occur at either end of the eclipse path at sunrise or sunset. There is no explicit or analytical solution for the determination of *Greatest Duration*. It may be calculated though an iterative series of approximations. When the highest accuracy is needed, a *Corrected Greatest Duration* (GDC) must be calculated that includes the effects of the Moon's *limb profile*, which may differ by a couple seconds from the uncorrected value.

greatest eclipse - For solar eclipses, *Greatest Eclipse* (GE) is defined as the instant when the axis of the Moon's shadow cone passes closest to Earth's center. The computation of the duration of the total (or annular) phase at this point is typically done using a smooth edge for the Moon that ignores the effects of mountains and valleys along the lunar limb. For total eclipses, the instant of *Greatest Eclipse* offers a good approximation (typically ~1-2 seconds) to the Greatest Duration of totality along the entire eclipse path. The instant of *Greatest Eclipse* is easily calculated for total, annular and partial eclipses, and is the standard time used for comparing different eclipses with each other. For annular eclipses, the instant of *Greatest Duration* may occur either near the time of *Greatest Eclipse* or near the sunrise and sunset points of the eclipse path. For lunar eclipses, *Greatest Eclipse* is defined as the instant when the Moon passes closest to the axis of Earth's shadow.

hybrid eclipse - A solar eclipse in which the Moon's umbral and antumbral shadows traverse Earth (the eclipse appears annular and total along different sections of its path). Hybrid eclipses are also known as annular-total eclipses. In most cases, hybrid eclipses begin as annular, transform into total, and then revert back to annular before the end of their track. In rare instances, a hybrid eclipse may begin annular and end total, or vice versa.

non-central eclipse (one limit) - A solar eclipse in which the central axis of the Moon's shadow cone misses Earth. However, one edge of the umbra or antumbra grazes Earth thereby producing a ground track with one limit and no central line. Non-central solar eclipses can be either total, annular or hybrid. (Partial eclipses can also be considered non-central eclipses in which only the penumbral shadow traverses Earth's surface)

partial eclipse - A solar eclipse in which the Moon's penumbral shadow traverses Earth (umbral and antumbral shadows completely miss Earth). During a partial eclipse, the Moon appears to block part (but not all) of the Sun's disk. From the perspective of an individual observer, a partial eclipse is one in which the observer is within the penumbral shadow but outside the path of the umbral or antumbral shadows.

penumbra - The penumbra is the weak or pale part of the Moon's shadow. From within the penumbra, the Sun is only partially blocked by the Moon as in the case of a partial eclipse. This contrasts with the umbra, where the Sun is completely blocked resulting in a total eclipse.

saros - The periodicity and recurrence of solar (and lunar) eclipses is governed by the Saros cycle, a period of approximately 6,585.3d (18yr 11d 8h). When two eclipses are separated by a period of one Saros, they share a very similar geometry. The eclipses occur at the same node with the Moon at nearly the same distance from Earth and at the same time of year. Thus, the Saros is a useful tool for organizing eclipses into families or series. Each series typically lasts 12 or 13 centuries and contains 70 or more eclipses. For more information, see Eclipses and the Saros. The Saros Catalog of Solar Eclipses: Saros 0 - 180 provides complete details for all current Saros cycles.

second contact - The instant when the total or annular phase of an eclipse begins.

third contact - The instant when the total or annular phase of an eclipse ends.

total eclipse - A solar eclipse in which the Moon's umbral shadow traverses Earth (Moon is close enough to Earth to completely cover the Sun). During the maximum phase of a total eclipse, the Sun's disk is completely blocked Moon. The Sun's faint corona is then safely revealed to the naked eye.

totality - The maximum phase of a total eclipse during which the Moon's disk completely covers the Sun. Totality is the period between second and third contact during a total eclipse. It can last from a fraction of a second to a maximum of 7 minutes 32 seconds.

umbra - The umbra is the darkest part of the Moon's shadow. From within the umbra, the Sun is completely blocked by the Moon as in the case of a total eclipse. This contrasts with the penumbra, where the Sun is only partially blocked resulting in a partial eclipse.