A Teacher’s Guide for
“Seeing The Beginning of Time”

Life as an Astronomer

Middle School Earth Science / Astronomy Unit

Developed by The Centrality of Advanced Digitally ENabled Science (CADENS) in collaboration with CEISMC

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Lesson 1: The Universe

Purpose:
The students will learn about the tools that scientists use to study the universe by watching the movie “Seeing the Beginning of Time.” When we are looking deep into space, we are essentially looking back in time. In this lesson, students will be able to explore, ask questions, and develop an argument on the origin of the Universe. The student will obtain information on how views of the universe change throughout time. Plan and investigate what role has advanced technology played in changing scientific theories.

Grade levels:
Middle and High school

Next Generation Science Standards:
MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Anchoring Phenomenon:
What Clues Does Objects in Space Provide About the Universe?

Lesson Phenomenon:
What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?

Science and Engineering Practices:
• Asking Questions/Defining Problems
• Planning & Carrying Out Investigations
• Using Mathematics & Computational Thinking
• Developing & Using Models
• Analyzing & Interpreting Data
• Constructing Explanations/ Designing Solutions
• Engaging in Argument from Evidence

Crosscutting Concepts:
• Patterns
• Cause and Effect
• Scale, Proportion and Quantity
• Systems and Systems Models
• Energy and Matter
• Structure and Function
• Stability and Change
Disciplinary Core Ideas:

- Matter and Its Interaction
- Motion and Stability: Forces and Interactions
- Energy
- Earth Place in the Universe

Knowledge Learning Targets:

- Obtain information about the Universe through observing the movie “Seeing the Beginning of Time”
- Explain the evidence gathered to explain the origin of the Universe
- Complete a KWL “How Did the Universe Begin”
- Complete a Graphic Organizer-Scale, Size, and Distances

Reasoning Learning Targets:

- Ask questions about the origins of the Universe in group discussions
- Use an online simulation to explore the scale of the universe and apply Mathematics and Computational Thinking to engage interactive multimedia website (Scale of the Universe)
- Calculate velocity as a function of distance and time in a hands-on activity that illustrates the expansion of the universe?

Performance Learning Targets:

- Engage in Expanding Universe Balloon Activity
- Develop a conceptual model of the Universe (Your cosmic address relative to the objects in the solar system)
- Develop and engage in argument of evidence for the origin of the Universe

Product Learning Targets:

- Write an essay that describe how theories of the universe have change over time. In your essay explain your understanding of Josh Frieman’s comment “Dark energy is our best current hypothesis for what’s causing the universe to speed up, but it's still on what I would say is shaky ground
- Create a mind map to describe the beginning of the Universe (Think Quest)

Materials:

- Pencil
- Paper
- Balloon
- Pen/marker
- Resources Needed for the lessons:
- Access to:
- The Internet, the movie “Seeing the Beginning of Time”
- Lesson 1: The Universe Student worksheet
Resources:
http://scaleofuniverse.com

Suggested Citation:

Class time:
Suggested time: Two (45-minutes) lessons, which includes almost 14 minutes of video clips from the movie. The total time of the film is 48 minutes, not covered in the lesson.

Essential Questions:
• Why is it important to know how the universe began?
• How has our view of the universe change throughout time? What role has advanced technology played in changing scientific theories?
• What hypothesis does scientist have to answer the question?
• What variables are used to study the universe?

Guided Questions from the movie:
• Scientists are asking, “How did the universe we know emerge from the darkness of early times?”
• What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?

Engage: (45 minutes)

Activity 1: (10 minutes)
Teacher introduces the following questions and allows time for group discussion:
• How did everything begin?
• What are the different claims of the beginning of origins?
• How did our view of the universe change?
• What is the difference between facts and theories?
• Why is it important to learn about the beginning of origins?
• How have theories of the formation and structure of the universe changed?

No one was around the when the universe began, so who can say what actually took place?
• The best that scientist can do is work out a theory, backed up by observations of the universe.
• Scientists theories change when new evidence emerges from discoveries made by advanced technologies.

Prior knowledge: Students should be able to know about early astronomers and their theories of the universe. However, the video, How Did Our View of the Universe Change?, Khan Academy provides this information.
Activity 2: (5 minutes)
The students will complete the graphic organizer below:

The movie explains that our galaxy is part of a local group. Gravity binds this local group to a large formation, the Virgo cluster.

Excerpt from “Seeing the beginning of time” (2:23 - 4:05)

“Only a century ago, astronomers debated whether the universe is confined to a giant rotating disk of stars, dust, and gas… the Milky Way… or whether our galaxy is one of many so-called “island universes.”

We now know that our galaxy is part of a formation of 3 major galaxies, along with some 51 dwarf galaxies, called the “Local Group.”

The Local Group is bound by gravity to a much larger formation…. The Virgo Cluster, with up to 2000 galaxies.

Beyond Virgo, galaxy clusters are linked to superclusters, in a pattern laid out by the first great cosmic mapping project… the Sloan Digital Sky Survey, beginning in the year 2000.

As the Sloan data shows, superclusters are connected to each other by streams or filaments of galaxies… bounded by immense empty regions.

To understand how the universe got this way, astronomers must identify its basic components of matter and energy.”
Activity 3: (20 min)
After showing this section of the movie, allow the students to discover the scale of the universe in the following interactive multimedia website: https://scaleofuniverse.com “Scale of the Universe”

Activity 4: (10 min)
To assess students’ prior knowledge of the universe, they will complete the first two parts of a KWL chart answering the questions: What is the universe and how it all began?

What do I know about this topic? What do I want to know about it? What have I learned?

Explore: (45 minutes)
The Universe
Activity 1: (10 minutes)
Students will complete the explore section of the student’s worksheet. The students use the Scale of the Universe web site to find the answers to the following questions:

**Scale of the universe**

- What is the diameter of the Milky Way? $10^{21}$ meters

**Scale of the Universe**

[Image of Scale of the Universe diagram]

- What is the diameter of the Virgo cluster? $10^{23}$ meters

The education link from Sloan Digital Sky Survey explains how scientists use the light-year as a unit of measurement since celestial objects are “…so far away that our regular units of distance are no longer useful to measure it” (SDSS, n.d).

The students will research the relationships or conversion units of meters, kilometers, miles, and light-years and complete the explore section of the worksheet.

The Universe
Activity 2: (35 minutes)

Expanding Universe Balloon Activity (SDSS.n.d)

Explore 1:
Make a model for the expanding universe. Your teacher will divide the class into pairs. He or she will give you and your partner a balloon and a permanent marker. Use the permanent marker to make four to six small dots on one side of the balloon. Don’t put all the dots in a straight line; spread them out a little. Each of these dots represents a galaxy. Now, blow the balloon up slowly, and note what happens to these dots.

Blow up the balloon about halfway. Use the permanent marker to circle one of the outermost dots (the ones farthest to the left or right). This dot represents the Milky Way. Put a piece of paper up to the balloon, and measure the distance from “The Milky Way” to the other “galaxies.” (Your teacher will show you how to make the measurement.) Record your data.

Now blow up the balloon all the way. Again, measure the distance from “The Milky Way” to the other galaxies. Record your data. You should now have two columns of data: the distance to each galaxy the first time and the distance to each galaxy the second time.

Use this SkyServer workbook to store all your data and make your calculations:
http://skyserver.sdss.org/dr14/en/proj/basic/universe/workbooks/explore1.xls

Explore 2:
Calculate the “average speed” of each dot on the balloon with respect to the Milky Way dot. Subtract the distance at the first time from the distance at the second time (d2 - d1). Divide by the amount of time it took you to blow up the balloon (t). If you don’t remember how long it took, just assume a reasonable value, like 5 or 10 seconds.

Calculate the average speed of the dots [(d2−d1)/t]. Record the average speed of each dot as the third column in your workbook.

Explore 3:
Use a graphing program such as Excel to graph the second distance on the x-axis and average speed on the y-axis. See SkyServer’s Graphing and Analyzing Data tutorial (http://skyserver.sdss.org/dr14/en/help/howto/graph/graphhowtohome.aspx) to learn how to use Excel to graph data. If you don’t have a graphing program, you can download a free program such as Open Office (http://www.openoffice.org).

What does the graph look like? Why do you think the graph has this shape?
The teacher will present excerpt from “Seeing the Beginning of Time” and explain the concept to the students.

18:48 “Because of the time it takes for the light of distant objects to reach us, when these astronomers look deep into the cosmos, they are looking back in time”

The teacher will explain: The light of the sun travels at the speed of light 299,792,458 meters/second or 60,616,629 miles per hour. Sunlight travels across the vacuum of space to reach earth. It takes 8 minutes and 20 seconds to reach our eyes. The light that we see from the sun is from its past.

The teacher will explain: Scientist learn about the universe by mapping galaxies near and far.

01:18 “Felipe Menanteau and colleagues from the University of Illinois are part of a global push to advance the science of cosmology, the study of the universe as a whole.

They are mapping the positions of galaxies across the sky and extending deep into the universe. Their goal… to link the evolution of planets, stars, and galaxies... the universe we see around us... with conditions that existed at the dawn of time.

They are asking… how did the universe we know emerge from the darkness of early times?

What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?” 2:15

The teacher will explain: Felipe Menanteau explains that scientists use the light from distant galaxies as an indicator of time, a function of cosmic time.

5:42 “One of the tools that we have in cosmology to pin down the kind of universe we live in is the growth of the structures…. The places in the universe where the matter gets to be a large, cohesive, gravitationally bound structure is these clusters of galaxies... these are giant systems with hundreds of thousands of galaxies. And these ones that are particularly big are rare. And the number of those that you can find as a function of cosmic time, you know from here to the past, is a predictor of the universe we live in.” 6:12

The teacher will explain: He also compares the job of a cosmologist to an archaeologist. The goal is to understand how the universe has changed from its beginning until now.

19:00 “Felipe Menanteau: We are looking back in time, kind of like an archaeologist, digging deeper into the ground. We are kind of like seeing the relics, the fossils that were left. So we cannot follow a galaxy back in time, but we can take snapshots of populations at different cosmic times and see how they have been changing from early on until today.19:22

The teacher will ask the question: How would you like to be an astronomer? A humble collector of light.

42:07 Felipe Menanteau: If you are a physicist, you have a lab. And in your lab you can keep changing the parameters of your experiment and keep testing it. When you are an astronomer, you cannot create stars, you cannot create galaxies. The universe is your lab and you are a humble collector of light.

42:27

The teacher will explain: Thinking like a scientist. We need to learn how to measure what we observe; we create hypothesis, theories and test it. We analyze the evidence and make corrections along the way.

The teacher will explain: Galaxies are moving away from the earth, the further away they are, the faster they are moving. How do we interpret these observations? Scientist inferred that since galaxies are moving away in the universe, they must have been close together at some point. Scientist speculate that just like us, the universe has a history that includes a beginning, the big bang theory. The expansion of the universe has been is used as evidence for this theory.

The Universe
According to this theory, everything that exist was formed from a single point of matter, light and energy. The universe started to expand as explained in the movie. However, scientist expected the expansion to reach a point where galaxies were slowing down, such as the example of the balloon. However, recent observation shows that the galaxies are actually moving fast towards the edge of the universe. Scientist now believe that the cause for this unexpected increase in speed in due to dark energy.

43:58 “Discovering the shapes and contours of the universe is only the first step in understanding how it came to be.

Astronomers will sift the data for clues to the initial conditions that came together in the cosmic dawn. They’ll test theories about the identity of dark matter and dark energy.”

Josh Frieman
“But there is also this more fundamental question, which is, do these things exist? I think the evidence for dark matter is quite strong, we see that it really explains a number of different phenomena. Dark energy is our best current hypothesis for what’s causing the universe to speed up, but it’s still on what I would say is shaky ground…

We really want to understand the physical properties of dark energy. Is dark energy just the energy of empty space? Or is it the energy associated with some new fundamental particle in the universe… as opposed to something going on with gravity?

Assuming current observations hold up, astronomers in the distant future may produce a very different cosmic map… one that reflects a universe pushed farther apart by dark energy.

Many of the galaxies we see today will have receded beyond our horizons, becoming invisible from Earth.

Our own Milky Way will remain intact, still enveloped in the dark matter that spawned it.

Its halo will become increasingly entwined…

…with that of the Andromeda galaxy, our larger neighbor. It is now moving toward us at about 400,000 kilometers per hour. When the two meet, several billion years from now, their interaction will dominate our night sky.

From a point of view unique to their time, those future astronomers will look out at the horizon and ask… how did it all come to be? Where does it end?

We ask the same questions today, based on our point of view at this moment in cosmic history. Our technologies are allowing us to see nearly to the beginning of time, and to track the behavior of the universe on the largest of scales.

And yet, the more we see, and the more detailed our maps become, the deeper the mysteries about how it all came to be.”

Elaborate: (25 minutes)

What tools do scientist use to study the universe?

00:00 Astronomers have begun one of the most far-reaching efforts ever undertaken to study the universe.

They are forging giant new lenses and mirrors… while marshaling vast computational power.

These new technologies are at the center of a historic quest… to peer into the deepest recesses of time…

… to find out how the universe set the stage for galaxies and worlds like ours… in an era known as the cosmic dawn. 00:51

What is cosmology?

01:18 “Felipe Menanteau and colleagues from the University of Illinois are part of a global push to advance the science of cosmology, the study of the universe as a whole.” 01:30

Evaluate: (45 minutes)
Activity 3:

Create a multimedia presentation of the following:
- Plan and develop Conceptual model of the universe
- How theories change over time with technology
- Construct an explanation on evidence of an expanding Universe

Consider the following:
- How did everything begin?
- What are the different claims of the beginning of origins?
- How did our view of the universe change?
- What is the difference between facts and theories?
- Why is it important to learn about the beginning of origins?
- How have theories of the formation and structure of the universe changed?
- No one was around when the universe began, so who can say what actually took place?
- The best that scientist can do is work out a theory, backed up by observations of the universe.
- Scientists theories change when new evidence emerges from discoveries made by advanced technologies.

Create a mind map to describe the beginning of the universe (Think Quest)
Topic: The beginning of the universe

Include (teacher will determine the number) the following items:

• Theories change
• Distance and scales
• Evidence for expansion of the universe
• The tools and the challenges that scientist face
• Measurements, limitations, errors, accuracy, and precision
• Current hypothesis about why the universe is expanding.
• Models – why do we use it, benefits and limitations (use the balloon activity as an example)
• Technology and its impact in the development of new theories
• Why is it important to know how the universe began?
• How has our view of the universe change throughout time?
• What role has advanced technology played in changing scientific theories?
• What hypothesis does scientist have to answer the question?
• What variables are used to study the universe?
• State what you think the modern goals of science are, what new challenges astronomers face today?

Extend:

Projects from Sloan Digital Sky Survey. SkyServer DR14 Projects. Education. Basic Projects. The Universe (This project takes five to six 45 minutes class sessions and use data from the SDSS)

From NASA:

https://imagine.gsfc.nasa.gov/educators/programs/au/docs/sessions/Session_2.pdf

General Description: Questions on how big, how far, and how old objects in the Universe are might launch students into discussions about where in space the objects are located and when they formed. Students work in teams to physically manipulate paper images of objects in space, allowing them to develop and present their own mental models to address these questions. Students can work in groups of 3 or 4. This activity can also be done in pairs if the overall group is small.


General Description: Students learn what a galaxy is and also learn that we live in a galaxy called the Milky Way Galaxy. They work individually or in pairs to make a model of our Milky Way Galaxy and see how our Sun and the Earth fit into it. They learn that our galaxy is only one of billions of galaxies, and that galaxies have different shapes.
Lesson 2: Shedding Light on Dark Energy and Matter

Purpose:
The student will explore the force that governs the Universe. The student will obtain, evaluate, and communicate the evidence to support the existence of dark matter and dark energy in our Universe. Describe how current astronomical data supports a model in which the universe is expanding at an increasing rate. Explain how data is used to support scientific claims and how our model of the universe flows from the data collected. Explain the scientific process, particularly how collected data and theories are related.

Grade levels:
Middle and High school

National Science Standards:

MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Anchoring Phenomenon:
How can dark energy and dark matter explain the behavior of the Universe?

Lesson Phenomenon:
What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?

Science and Engineering Practices:

- Asking Questions/Defining Problems
- Planning & Carrying Out Investigations
- Using Mathematics & Computational Thinking
- Developing & Using Models
- Analyzing & Interpreting Data
- Constructing Explanations/Designing Solutions
- Engaging in Argument from Evidence

Crosscutting Concepts:

- Patterns
- Cause and Effect
- Scale, Proportion and Quantity
- Systems and Systems Models
- Energy and Matter
- Structure and Function
- Stability and Change
Disciplinary Core Ideas:

- Matter and Its Interaction
- Motion and Stability: Forces and Interactions
- Energy
- Earth Place in the Universe

Knowledge Learning Targets:

- Define dark energy and dark matter
- Compare and contrast dark energy and dark matter
- Students will cite evidence to support the existence of dark matter and dark energy in our universe.
- Students will compare and contrast the observational effects of gravitational force and Dark Energy.

Reasoning Learning Targets:

- Planning and Investigating evidence to support the existence of dark matter and dark energy in the Universe
- Ask questions about the forces that govern the Universe
- Explain how scientist and astronomers use data to develop an investigation into dark energy and dark matter

Performance Learning Targets:

- Complete a web quest
- Construct an explanation of dark energy and dark matter
- Create a model which represents dark matter and dark energy
- Develop an argument through citing evidence to support dark matter and dark energy

Reasoning Learning Targets:

- Planning and Investigating evidence to support the existence of dark matter and dark energy in the Universe
- Ask questions about the forces that govern the Universe
- Explain how scientist and astronomers use data to develop an investigation into dark energy and dark matter

Performance Learning Targets:

- Complete a web quest
- Construct an explanation of dark energy and dark matter
- Create a model which represents dark matter and dark energy
- Develop an argument through citing evidence to support dark matter and dark energy
Materials:

- Pencil
- Paper
- Balloon
- Pen/marker

Resources Needed for the Lessons:

- Access to: The Internet, the movie “Seeing the Beginning of Time”
- Lesson 2 student worksheet

Resources:
Minute Physics - Dark Energy

Suggested Citation:

Cpalms.org.(n.d) Contributed by: Eliza Gonsalves  Name of Author/Source: Eliza Gonsalves District/ Organization of Contributor(s): Brevard. Retrieved from:

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/45953

https://www.darkmatterday.com/educational-resources-dark-matter-day/


https://www.ouruniverseforkids.com/dark-matter/

Class time: 2 (45 minutes class period)
Adapted from: https://www.ck12.org/earth-science/Dark-Matter/

Summary:
In the movie, “Seeing the Beginning of time, Scientist mentions dark matter and dark energy could provide clues to understanding the origin of the Universe. There are many unanswered questions about the birth of the Universe, however, with advanced technology there maybe a dark mystery lurking within our Universe. Universe?

What is Dark Matter?
What is dark matter? Actually, we don’t really know. Dark matter could just be ordinary matter, like what makes up Earth. The Universe could contain lots of objects that don’t have enough mass to glow on their own. There might just be a lot of black holes. Another possibility is that the Universe contains a lot of matter that is different from anything we know. If it doesn’t interact much with ordinary matter, it would be very difficult or impossible to detect directly.

Most scientists who study dark matter think it is a combination. Ordinary matter is part of it. That is mixed with some kind of matter that we haven’t discovered yet. Most scientists think that ordinary matter is less than half of the total matter in the Universe. Dark Energy We know that the Universe is expanding. Astronomers have wondered if it is expanding fast enough to escape the pull of gravity. Would the Universe just expand forever?
If it could not escape the pull of gravity, would it someday start to contract? This means it would eventually get squeezed together in a big crunch. This is the opposite of the Big Bang (https://www.ck12.org/c/earth-science/big-bang)

**Essential Questions:**

- What evidence exists to support the existence of dark energy?
- How are the effects of gravity and dark energy different?
- What evidence exists to support the existence of dark matter?
- How have Dark Energy and gravitational force affected the distribution of matter in the Universe?
- They are asking... how did the universe we know emerge from the darkness of early times?
- What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?

https://www.nasa.gov/audience/forstudents/9-12/features/what-is-dark-matter.html

**Guided Questions from the movie:**

- Scientists are asking, “How did the universe we know emerge from the darkness of early times?”
- What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?

**Engage (45 minutes)**

**Activity 1: ABC strategy (10 minutes)**
(Activity Before Content)

*Adapted from Dark Matter: “Probing What You Can’t See” http://universe.sonoma.edu*

- What makes up our universe? (Write all ideas on board)
- Ask students to describe movement in the universe... (Students may mention that the Earth rotates/spins, as do other planets, solar systems and galaxies.)

*(Prep Work Required Prior to Demonstration/Lab)*

**Demonstrate:**

Ask students to imagine that the universe could be represented by a paper plate. Spin one plate, without any hidden masses, on a pencil and ask students to share their observations. This will represent the observation scientist expected when they looked at distant stars and galaxies. Now spin a second plate, with the extra mass. This represents the actual observation scientists made. This unexpected observation led scientists to determine that there must be something more to the galaxy than we can see.

**Materials:**

- Paper plate
- “Hidden Matter” plate (teacher prepared)
- Pencil Per group • “Hidden Matter” plate (teacher prepared)
- Pencil
- Scale
- 1 paper plate
- 1 quarter (or metal washer)
- Provide students (Lesson 2 worksheet for students to complete)

Shedding Light on Dark Energy and Matter
Exploring Dark Matter

Prepare Hidden Matter Plates
You must prepare the "hidden matter" plates before doing the investigation.

You'll need:
- Paper plates (the cheap ones work fine)
- Ballpoint pen
- Masses (at least 7 per plate; quarters work well. So do large washers)
- Clear tape
- Ruler

Carefully find the center of a plate.
Poke a very small hole at the center location.
Draw a diameter through this center all the way to the edges.

On each side of the center, place three masses along the line.
Use the ruler to make certain they are equally spaced.

Tape each mass to the plate.
Now decide where to put the remaining mass.

*When making a classroom set, consider putting the extra mass at different locations for various plates. Make certain that it is in a location that will make the plate tilt heavily to one side.

Now tape a second paper plate on top of this plate, so that they are in the "stacked" on top of one another like a sandwich with the masses in between.
Activity 2: (10 minutes)
Using multimedia to engage students in a discussion. Teacher introduces the following questions and allows time for group discussion:

Show the video “Dark Energy” from the Minute Physics series: Minute Physics - Dark Energy (http://www.youtube.com/watch?v=v6o2bUPdxV0)

After watching the video, facilitate a class discussion of the following:

• Why did scientists believe that the expansion of the Universe should be slowing down?
• What did scientists observe to lead them to believe that “Dark Energy” should exist?
• How do you think the forces of “Dark Energy” and “Gravity” are different?

Allow students to discuss the answer as a class, guiding the discussion loosely, but allowing students to defend their own ideas and points. This entire section should take no more than five minutes.

• The best that scientist can do is work out a theory, backed up by observations of the universe.
• Scientists theories change when new evidence emerges from discoveries made by advanced technologies.

Prior knowledge:
Students should be able to know about early astronomers and their theories of the universe. Students should be able to explain how gravity is a factor that governs the universe. If students need additional information, the links below with explain:

• Dark Matter https://www.ouruniverseforkids.com
• Dark Matter https://www.youtube.com/watch?v=HneiEA1B8ks

The movie explains that our galaxy is part of a local group. Gravity binds this local group to a large formation, the Virgo cluster.

Excerpt from “Seeing the beginning of time”:

As the Sloan data shows, superclusters are connected to each other by streams or filaments of galaxies... bounded by immense empty regions.

To understand how the universe got this way, astronomers must identify its basic components of matter and energy.” 4:05

Explore: (45 min)
Activity 1: (30 minutes)

Explore Lesson 2 Student Handout:

• Each group will receive a “hidden matter” plate to represent the universe.
• Tell students that their task will be two-fold. First, they need to determine how much mass is present in their universe. Second, they will need to determine its distribution.
• Students should work together to determine a procedure of determining the mass in the universe. To do this they will also have access to tools. (1 paper plate, a mass (1 quarter-or metal washer), a scale.
• Students should record their procedure, and results, in their science notebook.
• Students are likely to use the following procedure: Measure the mass of their hidden matter plate. Then subtract the weight of two plates. Using that total, students can find the mass of their quarter (or washer) and divide the remaining mass of their plate universe to determine how many exist in their universe. How many masses are in their universe? How do they know? What was their procedure?
• Now that they have mathematical evidence of the mass. Groups should decide on the distribution in the plate universe. Where are the masses located? Are they distributed evenly? What is your evidence?
• In your science notebook, draw where you believe the masses in your universe are located. (Create a map) Since we are not allowed to take the plates apart, what are some ways we might discover the locations/distribution? How is this similar to what scientists do to study dark matter?

Teacher Note:
All of the masses are distributed evenly, except the ‘extra’ mass. If students had a plate with only 6 masses, in theory, it should spin smooth and level. The ‘extra’ mass is responsible for the imbalance in their plate universe.

Driving Questions:
• How much mass is in your universe? (How many quarters, or washers?)
• How is it distributed?

Probing Questions:
• Did you see the extra mass directly? If not, then how do you know that it is there? • How was most of the mass distributed in the plate universes?
• Did the extra mass effect how the plate spun? How could you tell? • Is there any way to determine if the extra mass is one or more masses?
• Do you have enough tools to make your universe balance?

Analyze and Reflect Just like today, the search for dark matter involves indirect measurements and investigations. It would have been very easy to tear apart the paper plate in order to discover how much “hidden matter” there was and where it was located. So when we study a subject such as dark matter, it is important to understand the tools at hand to probe its nature. Dark Matter is one of the biggest mysteries of our time. Scientists around the world are studying and looking for Dark Matter every day.
Explain: (20 min of video and 15 min discussion)

The teacher will present excerpt from “Seeing the Beginning of Time” and explain the concept to the students.

They are asking… how did the universe we know emerge from the darkness of early times?

What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?” 2:15

The teacher will explain: Felipe Menanteau explains that scientists use the light from distant galaxies as an indicator of time, a function of cosmic time.

5:42 “One of the tools that we have in cosmology to pin down the kind of universe we live in is the growth of the structures…. The places in the universe where the matter gets to be a large, cohesive, gravitationally bound structure is these clusters of galaxies… these are giant systems with hundreds of thousands of galaxies. And these ones that are particularly big are rare. And the number of those that you can find as a function of cosmic time, you know from here to the past, is a predictor of the universe we live in.” 6:12

The teacher will explain: He also compares the job of a cosmologist to an archaeologist. The goal is to understand how the universe has changed from its beginning until now.

19:00 “Felipe Menanteau: We are looking back in time, kind of like an archaeologist, digging deeper into the ground. We are kind of like seeing the relics, the fossils that were left. So we cannot follow a galaxy back in time, but we can take snapshots of populations at different cosmic times and see how they have been changing from early on until today. 19:22

The teacher will ask the question: How would you like to be an astronomer? A humble collector of light.

42:07 Felipe Menanteau: If you are a physicist, you have a lab. And in your lab you can keep changing the parameters of your experiment and keep testing it. When you are an astronomer, you cannot create stars, you cannot create galaxies. The universe is your lab and you are a humble collector of light. 42:27

The teacher will explain: Thinking like a scientist. We need to learn how to measure what we observe; we create hypothesis, theories and test it. We analyze the evidence and make corrections along the way.

The teacher will explain: Galaxies are moving away from the earth, the further away they are, the faster they are moving. How do we interpret these observations? Scientist inferred that since galaxies are moving away in the universe, they must have been close together at some point. Scientist speculate that just like us, the universe has a history that includes a beginning, the big bang theory. The expansion of the universe has been is used as evidence for this theory.
According to this theory, everything that exist was formed from a single point of matter, light and energy. The universe started to expand as explained in the movie. However, scientist expected the expansion to reach a point where galaxies were slowing down, such as the example of the balloon. However, recent observation shows that the galaxies are actually moving fast towards the edge of the universe. Scientist now believe that the cause for this unexpected increase in speed in due to dark energy.

43:58 “Discovering the shapes and contours of the universe is only the first step in understanding how it came to be.

Astronomers will sift the data for clues to the initial conditions that came together in the cosmic dawn. They’ll test theories about the identity of dark matter and dark energy.

**Josh Frieman**

“But there is also this more fundamental question, which is, do these things exist? I think the evidence for dark matter is quite strong, we see that it really explains a number of different phenomena. Dark energy is our best current hypothesis for what’s causing the universe to speed up, but it’s still on what I would say is shaky ground…

We really want to understand the physical properties of dark energy. Is dark energy just the energy of empty space? Or is it the energy associated with some new fundamental particle in the universe… as opposed to something going on with gravity?

Assuming current observations hold up, astronomers in the distant future may produce a very different cosmic map… one that reflects a universe pushed farther apart by dark energy.

Many of the galaxies we see today will have receded beyond our horizons, becoming invisible from Earth.

Our own Milky Way will remain intact, still enveloped in the dark matter that spawned it.

Its halo will become increasingly entwined…

…with that of the Andromeda galaxy, our larger neighbor. It is now moving toward us at about 400,000 kilometers per hour.

When the two meet, several billion years from now, their interaction will dominate our night sky.

From a point of view unique to their time, those future astronomers will look out at the horizon and ask… how did it all come to be? Where does it end?

We ask the same questions today, based on our point of view at this moment in cosmic history. Our technologies are allowing us to see nearly to the beginning of time, and to track the behavior of the universe on the largest of scales.

And yet, the more we see, and the more detailed our maps become, the deeper the mysteries about how it all came to be.”

**Elaborate: (25 minutes)**

Shedding Light on Dark Energy and Matter
Activity: JIGSAW (cooperative learning)
Adopted from http://www.cpalms.org/Public/PreviewResourceLesson/Preview/45953

Before this activity, students should be assigned into four equally sized groups based on reading ability, such that the strongest readers are in one group, the weakest readers are in another, and so on. The weakest readers should be placed in Group A, the strongest readers in Group D. For instance, if your school used FAIR data, then the class could be sorted by Lexile reading score and then divided up evenly. If no such numerical data is available, the teacher may sort the students based on observed reading skill level.

Once students are assigned into their four groups, the students will read their assigned article for that group. Each article has questions to accompany it, which the students should answer to reinforce understanding of the concepts covered in the article.

After all students are finished reading and answering the questions with their articles, the letter groups should meet together in order to discuss the answers to their questions.

At the end of the reading period, students should discuss the questions with their assigned letter groups. This would be the time for students to help each other understand their assigned articles and to clear up any misconceptions peer-to-peer. During this time, the teacher circulates among the groups to provide feedback and monitor for understanding.

Dark Energy, Dark Matter, and Gravity – Differentiated Articles

Group A: The Dark Side of the Universe
  Lexile Measure: 990L
  Mean Sentence Length: 14.72
  Mean Log Word Frequency: 3.45

Group B: Dark Energy, Dark Matter
http://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy/
  Lexile Measure: 1030L
  Mean Sentence Length: 16.28
  Mean Log Word Frequency: 3.53

Group C: Dark energy map puts the squeeze on dark matter - The Guardian
  Lexile Measure: 1250L
  Mean Sentence Length: 19.97
  Mean Log Word Frequency: 3.36

Group D: Dark Matter Is an Illusion, New Antigravity Theory Says - National Geographic
  Lexile Measure: 1450L
  Mean Sentence Length: 24.20
  Mean Log Word Frequency: 3.21
Dark Energy Articles: Jigsaw Activity Instructions
Lesson adapted from Dark Energy Articles: Jigsaw Activity Instructions

After students have read and discussed their articles with classmates who have read the same article, the class should be redistributed. Students now form into new groups of four in which each new group member has read a different article (in other words, each group has an A, B, C, and D). Students will now go through a series of Jigsaw activities to discuss their different articles. Have each group sit in a circle or around a table to facilitate the following activities.

Materials Needed:

- Timer
- Bell or chime (to indicate the end of an activity)
- Three sheets of computer paper for each group
- One pack of markers for each group (or one marker for each student; all students in a single group should have a different color marker)

Activity 1: General Discussion

- Students will each have one minute to summarize their article and its main points to their group members.
- Instruct students to focus on the concepts of Dark Energy and Dark Matter as defined by their articles.
- You should have a timer set for one minute and indicate when the next student should start discussing their article, for instance by sounding a bell.

Activity 2: Round Robin – Talking
Students go around the group in a circle for 60 seconds. Each group member will say one thing about the topic. The next person to speak will say something positive about the last response before they contribute. The topics are as follows:

1. Things you can use a spoon for (or some other introductory topic to make sure students understand the activity)
2. Gravity
3. Dark Energy
4. Dark Matter

Before beginning the first round, make it clear to the students that the goal is to go around as many times as possible. Use excerpts below from the movie “Seeing the Beginning of Time” to support students’ academic discourse

What tools do scientist use to study the universe?

00:00 Astronomers have begun one of the most far-reaching efforts ever undertaken to study the universe.

They are forging giant new lenses and mirrors... while marshaling vast computational power.

These new technologies are at the center of a historic quest... to peer into the deepest recesses of time...

Shedding Light on Dark Energy and Matter
... to find out how the universe set the stage for galaxies and worlds like ours... in an era known as the cosmic dawn. 00:51

What is cosmology?

01:18 “Felipe Menanteau and colleagues from the University of Illinois are part of a global push to advance the science of cosmology, the study of the universe as a whole.” 01:30

Activity 3: Round Robin – Writing

• Give each group three pieces of paper and one pack of markers. Have each group member choose a different color marker.
• Each piece of paper will receive one of the three following titles. The title should be written on both sides of the paper.
  1) Dark Energy
  2) Dark Matter
  3) Gravity
• Now, have students pass around the papers and write their name on each paper in their chosen color of marker. This system will make students accountable for their contributions.
• For two minutes the students will pass around these pieces of paper (all three will be in circulation at once so that three out of four group members are writing at any given time). Have them write down one thing they know about the topic on the piece of paper and then pass it on.
• Students keep writing and passing until time is called.
• Make it clear to the students that the object is to get as many things written on each paper as possible.
• Students should all be writing on the same side of the paper (so that the backs of the papers remain blank for the next activity).

Activity 4: Round Robin – Drawing

• Now, students flip over the pieces of paper that they have just written on.
• They will pass around the papers for another two minutes, but this time they will draw pictures to describe the concepts.
• When students get stuck, encourage them to flip over the paper to remind themselves of the notes they have already made on each topic.

At the end of these four activities, students will have done the following:

  1) Discussed their articles verbally
  2) Described what they have learned about Dark Energy, Dark Matter, and Gravity verbally
  3) Written notes on Dark Energy, Dark Matter, and Gravity and reviewed their peers’ notes
  4) Drawn picture notes on Dark Energy, Dark Matter, and Gravity and reviewed their peers’ contributions

This jigsaw portion of the lesson should take approximately 12-15 minutes. After the activity, the picture notes (or written notes) could be displayed around the classroom.
Extend:

Option 1: (Shortened - if there are extreme time constraints)
Have students write one paragraph each to explain what they have learned about each of the following:

1) Gravitational Force
2) Dark Energy
3) Dark Matter

It is often helpful to put a time limit on section as well. For instance, depending on time constraints, you may wish to give the students two minutes to write as much as possible about each topic. Students may remain seated with their groups during this activity so that they may refer to the pictures and notes they completed as a group. However, students should be writing individually and in silence. This option should take approximately ten minutes.

Option 2: (Extended - recommended if time permits)
Dark Energy Rubric Extended Response

Activity:
Write an essay that describe how theories of the universe have change over time. In your essay explain your understanding of Josh Frieman’s comment “Dark energy is our best current hypothesis for what’s causing the universe to speed up, but it’s still on what I would say is shaky ground…”
Lesson 3: Enrichment / Extended Visualization

Purpose:
The student will obtain information about CADEN project and mission. The student will evaluate and communicate the significance of data visualization and collaboration of numerous science team. Seeing the Beginning of Time, takes viewers on a visually-compelling journey through deep space and time. The 50-minute, 4K science documentary was co-produced by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, and Thomas Lucas Productions. Donna Cox, director of NCSA's Advanced Visualization Laboratory (AVL) leads the CADENS project to help raise public awareness about computational scientific discovery. “The AVL team members developed state-of-the-art technologies and used NCSA’s Blue Waters supercomputer to create cinematic production-quality data visualizations showcasing hundreds of millions of years of galactic evolution,” says Donna Cox. “We collaborated with numerous science teams and were deeply involved in the co-production of the film.”

Resources:
http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time

National Science Standards:

MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Anchoring Phenomenon:
How can models using computation and visualization help us understand the origin of the Universe?

Lesson Phenomenon:
What forces came together to form the very first generation of stars and galaxies, and over time, the vast architecture of matter and light we see in our telescopes?

Science and Engineering Practices:

• Asking Questions/Defining Problems
• Planning & Carrying Out Investigations
• Using Mathematics & Computational Thinking
• Developing & Using Models
• Analyzing & Interpreting Data
• Constructing Explanations/ Designing Solutions
• Engaging in Argument from Evidence
Crosscutting Concepts:

- Patterns
- Cause and Effect
- Scale, Proportion and Quantity
- Systems and Systems Models
- Energy and Matter
- Structure and Function
- Stability and Change

Disciplinary Core Ideas:

- Matter and Its Interaction
- Motion and Stability: Forces and Interactions
- Energy
- Earth Place in the Universe

Knowledge Learning Targets:

- Obtain information about the making of “Seeing the Beginning of Time”

Reasoning Learning Targets:

- Ask questions about the data collection
- Engage in academic discourse on origins of the Universe in group discussions

Performance Learning Targets:

- Construct an explanation of the clips chosen
- Plan and carry out investigation about the 2 or more featured clips

Product Learning Targets:

- Create an advertisement to encourage the public to view “Seeing the Beginning of Time”
- Using a social media platform (Twitter, Snapchat, Instagram Facebook, podcast, YouTube or etc.)
- Write a persuasive essay convincing government to continue to fund CADEN’s project Include the following:
  - CADEN’s Mission
  - The significance of their work and vision
  - Collaboration among science communities
  - Feature clips or excerpts from the movie “Seeing the Beginning of Time”
  - Create curiosity for future generation in the Visualization careers
**Engage: Class Discussion** (10 minutes)
Lead the students in a class discussion about the importance of awareness of movies through commercials which includes previews and other form of advertisement on social media. The student will discuss the important components of visually appealing to the audience.

**Explore:** (10 minutes)
Students will select 2 of the 8 clips available on [http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time](http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time)

**Teacher Notes:**
Teachers can preassign clips for students #1-8

**Clip 1:** Stars From The First Supernovae  
**Clip 2:** Milky Way Analogue Isolated  
**Clip 3:** First Light In The Renaissance Simulation: Formation Of The Very First Galaxies In The Universe  
**Clip 4:** Cosmic Bubble Bath: How The First Galaxies Reionize The Universe  
**Clip 5:** Large Synoptic Survey Telescope Model And Planned Network  
**Clip 6:** The Fornax Cluster Imaged By Dark Energy Camera  
**Clip 7:** The Dark Energy Survey.Sky Coverage And Image Zoon  
**Clip 8:** Dark Energy Survey To Large Synoptic Survey Telescope Sky Coverage Comparison

**Differentiate Learning:**
(Student can choose) any of the clips to obtain, evaluate, and communicate information. Select two of the video clips below from the website and discuss in a group what you find to be important  
Jigsaw Learning (4-person group)

**Explain:** (10 minutes)
Students will teach other students about their clips. The other students in the group will listen and take notes from their peers.

**Elaborate:** (15 minutes)
After reading and viewing the clips, students can engage in discussion among their groups and select the significance of their multimedia clips. The students will construct an explanation of their clip

**Evaluate:** (25 minutes)
The student will create an advertisement to promote “Seeing the Beginning of Time.”  
They may choose one of more of the following social media platform:

- Twitter
- Snap Chat
- Instagram
- Poster (Multimedia)
- Facebook
- YouTube
Extend: (45 minutes)
Write a persuasive essay convincing government to continue to fund CADEN’s project
Include the following:

• CADEN’s Mission
• The significance of their work and vision
• Collaboration among science communities
• Feature clips or excerpts from the movie “Seeing the Beginning of Time”
• Create curiosity for future generation in the Visualization careers
A Teacher’s Guide for
“Seeing The Beginning of Time”

Supernova Explosion
Supernova and Heavy Elements

Middle and High School

Developed by The Centrality of Advanced Digitally ENabled Science (CADENS) in collaboration with CEISMC

Ricardo Pacheco
Lesson: Supernova Explosion

Purpose:
Stars eight times more massive than our sun end their lives as a supernova. In the movie “seeing the beginning of time”, scientist use computer models to understand how this explosion takes place. The purpose of this lesson is to understand the physics of this event.

National Science Standards:

HS-ESS1-3 Earth’s Place in the Universe - Communicate scientific ideas about the way stars, over their cycle, produce elements.

Science and Engineering Practices:
Communicate scientific ideas in multiple formats (including orally, graphically, textually and mathematically)

Crosscutting Concepts:
In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas:
The study of star’s light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

Knowledge Learning Targets:
• Describe the law of conservation of mass
• List the different types of energy involved in an explosion
• Describe the law of conservation of momentum
• Understand the basic principles of radiation laws

Reasoning Learning Target:
• Communicate scientific ideas about the way supernovae explode.
• Balance a chemical equation and use dimensional analysis to calculate the amount of energy released in the explosion of a small balloon filled with hydrogen.
• Compare and contrast the scales and proportions of energy released in the explosion of different sources.

Performance Learning Targets:
Conduct a lab activity that requires mixing Hydrochloric and Magnesium to produce Hydrogen. The Hydrogen will be collected in a balloon and the students will ignite the balloon

Product Learning Targets:
Create a three-minute video clip using frames from the computer model used in the movie “Seeing the beginning of times” to explain the physics behind the explosion.
Materials:

- 250ml Erlenmeyer flasks.
- One 9.5-inch balloon
- 100 mL graduated cylinder
- 300 mL of 1.0 M HCl 1.2 g of Mg turnings
- Folder named Supernova Model. Contains 100 frames of supernova explosion
- Video editing software

Procedure:

- Add 100 mL of the HCl solution to the Florence flasks.
- Fill the balloon with 1.2 g of Mg. Place the balloon around the mouth of one of the flasks by stretching the end of the balloon over it. Make sure the balloon hangs limp off to the side.
- To add the Mg to the HCl, simply lift up the balloon and the Mg will fall into the flask. The balloon will begin to inflate.
- After the reaction has ceased, tie the balloon and clip it to the end of the yardstick.
- Light the candle on the light stick and have a partner hold it for you.
- Both you and your partner standing far away, hold the flame under the balloon.

Video Clip:

- Create a script that describes the physics of the supernovae from the beginning to the end of the explosion.
- Input the 100 frames of the model of a supernova in the video editing software and overlap the voice recording of the script with the frames.

Safety:

Magnesium ribbon is a flammable solid. Hydrochloric acid is a corrosive liquid. Hydrogen gas is explosive. However, the very small quantities and low dilutions used in or produced by this activity present little hazard. Wear safety goggles. Keep flammables and open flame away from the vicinity of this activity.

Resources:

Donna C. (Producer), Robert P. (Producer) & Thomas, L. (Director). (December 2017). Seeing the Beginning of Time [Documentary]. USA: Magellan TV.


Essential Questions:

What is the law of conservation of mass?
Mass can not be created or destroyed, simply transformed.

Which laws of physics are involved in any explosion?
Discuss the question with your teammate(s) and record the answer:

- Law of conservation of energy
- Gas laws
- Law of conservation of momentum
- Radiation Laws
- Blackbody radiation

Engage:

Lab activity:
The physics involved in the explosion of a supernova is very similar to the explosion of a bomb or the shock wave of a fireball of a Hydrogen explosion in the classroom.

![Supernova Explosion](image)

When Magnesium and hydrochloric acid combine, it forms Hydrogen gas. In this lab, the student will trap the Hydrogen gas or H$_2$ into a balloon and set it on fire.

Explore:
The chemical reaction between the magnesium and hydrochloric acid will produce magnesium chloride and hydrogen gas

$$\text{Mg}(s) + \text{HCl}(aq) \rightarrow \text{MgCl}_2(aq) + \text{H}_2(g)$$
Law of conservation of mass:
The formula above shows that before and after the reaction. However, the amounts of hydrogen and chlorine are not the same in the reactant and the product. The mass is not conserved.

1. Write the balance the equation

\[ \text{Mg} + 2 \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2 \]

2. How many moles of HCl are in 100 mL of 1.0 M HCl?

\[ \text{Molarity of HCl} = \frac{\text{mol of HCl}}{\text{Liters of HCl}} \]

\[ 1.0 \text{ M HCl} = \frac{\text{mol of HCl}}{0.1 \text{ L of HCl}} \]

0.1 mol of HCl

3. How many grams of Mg are needed to completely react with 0.1 mole HCl?

\[ 1 \text{ mol of Mg} = 2 \text{ mol HCl} \]
\[ 24.3 \text{ g of Mg} = 1 \text{ mol of Mg} \]

\[ 0.1 \text{ mol HCl} \times \frac{1 \text{ mol Mg}}{2 \text{ mol HCl}} \times \frac{24.3 \text{ g Mg}}{1 \text{ mol Mg}} = 1.2 \text{ g Mg} \]

4. How many grams of Hydrogen were consumed in the explosion?

\[ 0.1 \text{ mol HCl} \times \frac{1 \text{ mol H}}{2 \text{ mol HCl}} \times \frac{1 \text{ g H}}{1 \text{ mol Mg}} = 0.1 \text{ g H} \]

The combustion of 2 grams of Hydrogen (H\textsubscript{2}) with Oxygen (O\textsubscript{2}) releases 285.8 KJ of Energy.

5. How many Joules of energy were produced in the balloon explosion?

\[ 0.1 \text{ g H} \times \frac{285.8 \text{ KJ}}{2 \text{ g H}} = 14.29 \text{ KJ} \text{ or } 14290 \text{ Joules} \]

6. List the forms of energy present in the explosion

- Kinetic (the energy of motion)
- Potential (stored energy)
- Thermal (heat)
- Chemical (chemical reactions)
A chemical explosion produces heat and throws objects over great distances, but all of these are forms of the same energy. Mass and energy are conserved.

- 1 Stick of Dynamite $2 \times 10^6$ J
- 1 Ton of TNT $4.2 \times 10^9$ J
- Combustion of 1 Barrel of Oil $6 \times 10^9$ J
- Kinetic Energy of Int. Space Station $1.3 \times 10^{13}$ J
- Small Nuclear Bomb (15 kT) $6.3 \times 10^{13}$
- Zimbleman (n.d)

We can measure the energy of objects such as a barrel of Oil $6 \times 10^9$ J, how can we know for sure the amount of energy of a supernova? By using theoretical models.

**Explain:**
Stars eight times more massive than our sun end their lives as a supernova. In the movie “Seeing the Beginning of Time”, scientist use computer models to understand how this explosion takes place.

**Movie Clip:**
“Seeing the Beginning of Time” [33:50]

[31:57] “hydrogen gas forms clouds that become more and more dense over time.

As gravity compresses the clouds, they begin to heat up, then finally ignite to form the first generation of stars. These stars are giants, much larger than any today.

One blows up in a powerful supernova.

The model shows an environment transformed by the explosion. The supernova litters its surroundings with heavier elements created in nuclear fusion… carbon, silicon, iron, and more.” Seeing The Beginning of Times,
Model of the Explosion:
After the explosion, the brightness increase is so great that a distant galaxy can clearly be distinguished from a normal star; a single supernova can outshine the galaxy. This event involves the explosive ejection of about half the star’s mass into its surroundings with a velocity of about one hundredth of the speed of light. The total kinetic energy is typically $10^{43}$ to $10^{44}$ J.

1. Explain how energy is conserved and which forms or energy are present?
The law of conservation of energy demands that the total kinetic and thermal energy is the same before and after the explosion.

The explosion of a supernova takes place in a small part of the galaxy. Dust is all around the galaxy and the star. Before the supernova explodes the light of the supernova shine on this interstellar gas. The explosion releases high amounts of energy, increasing the temperature and pressure.

2. Which gas law makes a relationship between temperature and pressure? Include the formula.

Joseph Gay-Lussac

$$\text{Pressure} / \text{Temperature} = \text{Constant}$$

Scientist call this first phase of the explosion “Free Expansion”, soon after the explosion, the temperature increases and the velocity remains constant.

The interstellar gas moves a supersonic (faster than the speed of sound) velocities creating a shock wave such as the hot and expanding gas from our balloon.
3. **Is there sound in space?**

   No, there is no air for sound to travel.

   The explosion expands like a shell. The gas takes the shape a sphere and total energy of the explosion does not change or “Law of conservation of energy”.

   ![Image of supernova explosion]

   In the second phase of the explosion, the velocity decrease.

   ![Image of supernova explosion]

   The shock velocity decreases with time as well as the temperature. The cooling deforms the shell and the energy is not constant anymore. There is no additional energy and the now weak and deformed shell starts to sweep dust. The momentum or mass time’s velocity before the deformation is the same as the momentum after the explosion starts to sweep the dust surrounding the supernova.
4. Describe the Law of Conservation of Momentum

“For a collision occurring between object 1 and object 2 in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision. That is, the momentum lost by object 1 is equal to the momentum gained by object 2.” The Physics Classroom (2019)

The third phase of the explosion is called the Snow-plow. The temperatures continues to drop and the atoms radiates light that can be detected by different telescopes.

5. Explain the radiation law in stars, starlight and black body:
Refer to Blackman (n.d) to understand radiation laws.

The laws of physics that help us understand the explosion of our Hydrogen-filled balloon are the same laws that scientist use to describe the explosion of a supernovae. We can measure with accuracy energy, temperatures, volume, pressure, density and several other physical quantities in objects here on earth. However, scientist cannot measure with certainty the amount of energy of a supernova or the amount of dust on its surrounding.

Elaborate:
To understand how supernovae explode, scientist have created models using the laws of physics, mathematical equations and visualization tools with the help of supercomputers. Now that you have completed the activities, return to the essential question. Would you like to modify or change your answer?

Evaluate:

Video Clip Project:

The goal of this project is to create a video clip is to communicate scientific ideas about the way supernovae explode. Create a script that describes the physics of the supernovae from the beginning to the end of the explosion. Make sure to include all the concepts mentioned above. In a video editing software, insert the 100 frames of the model of a supernova found in the folder name Supernova model. Overlap the voice recording of the script with the frames.
Lesson: Supernova and Heavy Elements

Purpose:
In the movie “Seeing the beginning of time” scientist explain that supernovae liters the universe with heavy metals. In this lesson, you will learn the basic physical and chemical processes that the stars undergo before the explosion to create metals up to Iron.

National Science Standards:

HS-ESS1-3 Earth’s Place in the Universe - Communicate scientific ideas about the way stars, over their cycle, produce elements.

Science and Engineering Practices:
Communicate scientific ideas in multiple formats (including orally, graphically, textually and mathematically)

Crosscutting Concepts:
In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas:
The study of star's light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

Knowledge Learning Targets:
• Explain the concept of spectral lines
• Define nuclear fission.
• Explain how computer models can be used to simulate observed supernovae explosions such as SN 1987A.

Reasoning Learning Targets:
• Analyze the nuclear process in supernovae in which atoms are not conserved, but the total number of protons plus neutrons is conserved.
• Compare pictures of the sky before and after a supernovae explosion
• Describe how astronomers learn about the chemical composition of a star by examining its spectral lines.
• Explain how supernovae create metals from Hydrogen to Iron.

Performance Learning Targets:
• Make a presentation on supernovae 1987A by using visualization videos, pictures from Hubble telescope and other telescopes, and by analyzing the spectrum of the element’s abundance in the remnant of the supernovae.
• Create a 3D printing of supernovae 1987A remnants.
Product Learning Targets:
Create an Argument-Driven Inquiry (Sampson 2009) that: Ask questions that challenge the premise that supernovae litter the cosmic environment with heavy metals, heavier than Iron. Conduct a research looking for empirical evidence to sustain the claim that supernovae are responsible for creating elements heavier than Iron.

Materials:
- Empty aluminum soft-drink can
- 2- or 3-liter (2- or 3-quart) saucepan
- Pair of kitchen tongs
- Computer and internet access
- Argument-Driven Inquiry worksheet (Sampson, 2009)
- Movie “Seeing the beginning of the Universe”

Resources:
Donna C. (Producer), Robert P. (Producer) & Thomas, L. (Director). (December 2017). Seeing the Beginning of Time [Documentary]. USA: Magellan TV.


**Essential Questions:**

How does the atomic emission spectrum is used to identify elements in a gas?

Why does the nuclear reactions in supernovae only create elements no heavier than Iron?

**Engage:**

**Demo: Implosion:**

“Fill the saucepan with cold water. Put 15 milliliters (1 tablespoon) of water into the empty soft-drink can. Heat the can on the kitchen stove to boil the water. When the water boils, a cloud of condensed vapor will escape from the opening in the can. Allow the water to boil for about 30 seconds. Using the tongs, grasp the can and quickly invert it and dip it into the water in the pan. The can will collapse almost instantaneously.” Chemical demonstration by Bassam (2011)

The rest of this demo has been adapted and modified form NASA’s “Big Explosions and Strong Gravity: Supernovae explosion” activity. NASA (2015).

“Stars generate energy by converting lighter elements into heavier elements through nuclear fusion in their cores. These elements are the “fuel” that generates a star’s energy that then flows outward and counterbalances the inward pull of gravity. Stars spend the majority of their lives with these two forces in balance, as shown in the image to the right.”

“After the can has been emptied of liquid, the shape is held in equilibrium by the pressure of the air inside the can directed outward and the pressure of the air outside of the can directed inward. Heating the water in the can causes it to turn into steam, which drives the air out of the can because the steam has higher pressure. Now the can is held in equilibrium by the pressure of the steam pushing outwards (analogous to the radiation pressure in the core of the star) and the pressure of the outside air directed inwards (analogous to the gravity of the star directed inwards). During our demonstration we heat water in our soda can, which means the can fills with steam, which balances the air pressure from outside. We compare this to the balance of forces in a star during the majority of its life.”

---

**Supernova and Heavy Elements**

---

11
“When the can is inverted over the cold water, the steam instantly condenses into water. The water occupies a much smaller volume than the steam did, resulting in much less pressure inside the can. With nothing on the inside to balance the outside pressure the can will implode (like the core of a star collapsing).”

“This diagram shows the can collapsing because there is no longer a balance of forces. This is sort of like what happens in a supernova, the end of the line for large stars. The star collapses when the two forces that were balancing each other – pressure outwards from the energy generated at the center countering the force of gravity inwards – are no longer in equilibrium. The lack of fusion energy inside the star to balance the gravity causes the final collapse of the star. The central core of the star collapses (similar to the implosion of the can) and the material in the rest of the star starts to fall onto this core. It rebounds and sends the material in the star flying out.”
Explore:

Movie Clip: [33:50]

Scientists are using a supercomputer model to recreate the eruption of stars

[31:57] “hydrogen gas forms clouds that become more and more dense over time. As gravity compresses the clouds, they begin to heat up, then finally ignite to form the first generation of stars. These stars are giants, much larger than any today. One blows up in a powerful supernova.

The model shows an environment transformed by the explosion. The supernova litters its surroundings with heavier elements created in nuclear fusion... carbon, silicon, iron, and more.” Seeing The Beginning of Times (2017).

Explain:

Fusion:

In the collision of two Hydrogen atoms, the speed is so great that the nucleus, containing one proton, overcome the repulsion of the positive charges. Consequently, Helium forms by the fusion of the two Hydrogen protons. According to Glencoe (2018) “Nuclear fusion releases even more energy per gram of fuel than nuclear fission. In our sun and stars that are similar to the sun, hydrogen nuclei combine at extremely high temperature and pressure to form a helium nucleus with a loss of mass and release of energy. The net reaction is illustrated in Figure 4.3.”

Supernova and Heavy Elements
Since supernovae have higher mass than stars like the sun, it can create heavier elements in its core. The higher temperatures and density of the star allows the fusion of heavy elements. However, Iron is particular because is slightly more stable than the previous elements so the star cannot make heavier elements. Since there is not more energy released by fusion and with the lack of energy released the star soon will die.

![Diagram of nuclear fusion stages in a star's core](image)

This picture shows how heavier elements stack in layers from the nucleus. When the star runs out fuel to continue the fusion process, the core collapses. The regions near the core fall in and bounce off the core.

Explain why in the nuclear process in supernovae atoms are not conserved but the total number of protons plus neutrons is conserved.

The identity of an atom changes if the composition of the nucleus changes. The student can use the Phet interactive simulation of “Built an atom” to create a model that describe this process.

**Spectroscopy**

Astronomers use a spectrometer to disperse the light that comes from the star to create a spectrum that identifies the elements from the light source.

Let’s consider the light from a Hydrogen gas tube. When electricity pass through the tube, similar to a light bulb, the atoms in the tube absorb energy and become exited. These excited atoms return to their stable state by emitting light to release that energy. If the light emitted by the hydrogen is passed through a glass prism, hydrogen’s atomic emission spectrum is produced. The spectrum consists of several individual lines of color corresponding to the frequencies of the radiation emitted by the atoms of hydrogen. Each element’s atomic emission spectrum is unique and can be used to identify an element.

Supernova and Heavy Elements
Here is an example to the spectrum of a supernova

https://webhome.phy.duke.edu/~kolena/snrspectra.html

In this spectrum, you can see the presence of the atoms of O, Ni, Fe, Mg, Si, and S

**Elaborate:**

**The Model:**

Dr. John Wise from Georgia Tech created a model that replicates the explosion of a supernova. With the help of supercomputers, he uses mathematical formulas and algorithms to simulate physical quantities such as matter, densities, temperatures, and energy. With the support of video and movie producers, this data is transformed into pixels and colors to create a three-dimensional model that renders a visualization of the explosion.

Scientific models are used to generate data, to support an explanation, to predict a phenomena and to solve a problem (NGSSS, 2013). However, scientific models do not explain every detail of the phenomena, such as the explosion of a supernova, and is not identical to the actual event. For this reason, when scientist create a model to make predictions, it is paramount to have empirical evidence, or observations that support the model.
Consider the model of an atom:

**Does the model allow scientists to make predictions?**

Yes, the atomic theory allows to predict the properties of atoms.

**Was there empirical evidence to support the model?**

JJ Thompson used the cathode ray to determine the mass of an electron

Millikan oil’s drop experiment measured the mass of an electron

Rutherford use the gold foil experiment to determine to find evidence of the nucleus of the atom

**Did the model change over time?**

From Dalton in the early 1700s to Fermi in the early 1900s

In the movie, Josh Freeman explains that computations, such as the models shown in the movie, translate into observables that can be tested with observations.

**ADI: Argument-Driven Inquiry by Sampson(2009)**

**Guiding Question 1:** Is there empirical evidence that dust clouds collapse to become a star?

According to MIT Technology Review (2011), “the experimental evidence is sparse”. However, given periods of times in the orders of millions of years, it is theoretically possible.

**Guiding Question 2:** Is there empirical evidence that supernovae produce elements heavier than Iron?

The teacher groups the students into small research teams and each team will select one of the guiding questions above.

**Data Collection:** The teams are then directed to design a method that they can use to collect the data they will need to answer the guiding question.

**Develop a tentative argument:** Students analyze the data they collected and then develop an initial argument. The argument consists of a claim, evidence in support of the claim, and a justification of the evidence.

**Argumentation:** The students share their initial arguments and critique the arguments of their classmates. At the end of the argumentation session, each team has an opportunity to revise their arguments in order to make them better.

**Explicit and Reflective Discussion:** The teacher should encourage the students to share what they know about the disciplinary core ideas they used during the investigation and their ideas plans for designing better investigations in the future.

**Write and Investigation Report:** Each student writes an investigation report to share the goal of the investigation, the method used during the investigation, and his or her final argument.

Supernova and Heavy Elements
Double-Blind Group Peer Review: Each research team reviews several investigation reports in order to ensure quality and to provide their classmates with the feedback they need in order to improve.

Revise and Submit the Report: Students use the feedback from the peer review to revise their review.

Evaluate:

Supernovae 1987A:

The article “The Dawn of a New Era for Supernova 1987a” by Hille (2017) provide a wealth of information about an event that took place only thirty years ago. For the first time in about four hundred years, astronomers have been able to observe and study the explosion of a supernova in detail.

Create a power point presentation that includes:

• Images of the supernova before and after the explosion
• Describe the astronomer’s description of the rings around the remnants of the star
• Explain the relationship between the models of the explosion of supernovae 1987A and the actual observations in the last thirsty years
• Analyze the multicolor observations conducted by astronomers and explain why is necessary to make observations in different ranges of the electromagnetic spectrum
• Compare and contrast the spectra of supernova 1987a with the fusion reaction that took place in the star
• Present your views about the relationship between models and observations of supernovae. What are the strengths and limitations of the model?
• Create a model, 3D printing, of the supernovae remnant using the models published by NASA 3D printing resources at https://nasa3d.arc.nasa.gov/detail/sn1987a

Supernova and Heavy Elements
Supernova and Heavy Elements
Student Worksheet

Purpose:
In the movie “Seeing the beginning of time” scientist explain that supernovae
litters the universe with heavy metals. In this lesson, you will learn the basic
physical and chemical processes that the stars undergo before the explosion to
create metals up to Iron.

Essential Questions:

How does the atomic emission spectrum is used to identify elements in a gas?

Why does the nuclear reactions in supernovae only create elements no heavier
than Iron?

Demo: Implosion

Why does the soda can collapse?

How is this demonstration similar to the implosion of a supernova?

Draw a force diagram of the soda can and of a star.
Using the interactive simulation “Build an Atom” from Phet
https://phet.colorado.edu/en/simulation/build-an-atom

Explain why in the nuclear process in supernovae atoms are not conserved but
the total number of protons plus neutrons is conserved.

https://webhome.phy.duke.edu/~kolena/snrspectra.html

In the spectrum of supernovae 1987A, you can see the presence of the atoms of
O, Ni, Fe, Mg, Si, and S.

Explain how scientist can use the light of a star to determine its chemical
composition.
In your small research team, select one of the following guiding questions:

**Guiding Question 1**: Is there empirical evidence that dust clouds collapse to become a star?

**Guiding Question 2**: Is there empirical evidence that supernovae produce elements heavier than Iron?

**Data Collection**: 

*Develop a tentative argument*

**Argumentation**: 

*Explicit and Reflective Discussion*:

*Write an Investigation Report*:

*Double-Blind Group Peer Review*:

*Revise and Submit the Report*:
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Lesson 2: Shedding Light on Dark Matter and Dark Energy

Lesson Lab Sheet Adopted from
https://universe.sonoma.edu/activities/dark_matter.html

Probing What You Cannot See:
Astronomers have known for many years that most of the matter (at least 90%, if not more) in the Universe is invisible; we cannot see it; over the whole range of the electromagnetic spectrum, it does not radiate any light that we can detect. It is, in effect, "hidden" from our usual ways of learning about the Universe. Identifying this "dark matter" is a crucial step in the understanding of the Universe. Dark matter does not emit light, and so, we are left to ask ourselves the following questions:

- What is dark matter?
- How does dark matter help us understand the Universe and its expansion?

In this investigation, you will use several methods to determine what "hidden matter" lies between two paper plates. Through analogies associated with the cutting-edge research that is now going on with dark matter, you will uncover the "hidden matter" in your lab.

Materials:

- Ruler
- Tape Measure
- Balance or Scale
- Flashlight or strong light source
- Pencil and paper
- Quarter or two
- Two loose paper plates

Procedure:

1. Determine the mass of the two paper plates and a quarter.
   
   Paper Plates ________________ Quarter ________________

2. Determine the mass of your "hidden mass" plate. _______________________

3. From this, calculate the number of hidden masses you are looking for.
   
   Number of Masses Hidden in the Plates ____________________________

4. Hold the missing mass plate near a strong light source, such as a flashlight.
5. Locate the positions of the masses. Trace carefully around their perimeters on the convex paper plate side.
6. Measure the distances from the center of the plate to each mass location. Draw the locations and write the distances to each location in the diagram below.

7. What pattern do you notice?

__________________________________________________________________
__________________________________________________________________

8. Given what you now know, set up a table with the possibilities for the number of masses at each location.

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9. Place your missing mass plate on the screwdriver such that it is spin around its center. Is the plate flat or does it tilt to one side? Spin it around its axis of a few times. Does the same side always stay lower? What does this tell you about the distribution of mass inside the plate?

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10. Given your observations, how many of the hidden masses are there in the plates, how many do you now know the locations of, and how many masses are you still looking for?

__________________________________________________________________

__________________________________________________________________

11. Use your extra quarters and your table of possibilities for the number of masses at each location to reveal the hidden mass(es). How will you know when you have discovered the missing mass distribution?

__________________________________________________________________

__________________________________________________________________
12. Draw the locations and original mass distribution at each location in the diagram below.

**Analyze and Reflect:**

Similar to this lab investigation, astronomy involves indirect measures and investigations. It would have been very easy for us to tear apart the paper plate in order to discover how much "hidden matter" there was and where it was located. So when we study a subject such as dark matter, it is important to understand the tools at hand to probe its nature.

- When you took a total mass measurement of the "hidden matter" in the paper plates, it was just like you were a scientist at NASA who had taken total mass measurements from gravitational binding of clusters.

- When the light was shone through the paper plate to locate the "hidden matter", it was as if you were applying the concept of gravitational lensing to locate dark matter as at Bell Labs scientists have done.

- Lastly, you can think of balancing torques in paper plates as analogous to the rotational curve observations of galaxies that is being done now to reveal even more about dark matter.

**Reflect:**

Think about this lab and the studies that are being done right now on dark matter. What has this lab investigation taught you about the scientific approach to revealing the nature of dark matter? Discuss below.
Construct an explanation of Dark Matter:

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Compare and Contrast Dark Matter and Dark Energy:

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## Dark Energy Summative Assessment - Extended Writing Response Rubric

<table>
<thead>
<tr>
<th></th>
<th>Unsatisfactory 0 points</th>
<th>Needs Improvement 1 point</th>
<th>Satisfactory 2 points</th>
<th>Exemplary 3 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Evidence to Support the Existence of Dark Matter and Dark Energy</td>
<td>This section is absent.</td>
<td>This section is incomplete or does not correctly address the prompt. Two or fewer pieces of evidence are cited.</td>
<td>The point is addressed. At least three pieces of evidence are appropriately cited in support of the student’s argument.</td>
<td>The point is addressed. More than three pieces of evidence are appropriately cited in support of the student’s argument. The argument is clear, concise, and coherent.</td>
</tr>
<tr>
<td>2. Effect of gravitational force on the distribution of matter in our Universe</td>
<td>This section is absent.</td>
<td>This section is incomplete or does not correctly address the prompt.</td>
<td>The point is correctly addressed. The argument is clear and coherent.</td>
<td>The point is correctly addressed. The argument is clear, concise, and coherent. It is evident that the student has mastered the topic.</td>
</tr>
<tr>
<td>3. Effect of Dark Energy on the distribution of matter in our Universe</td>
<td>This section is absent.</td>
<td>This section is incomplete or does not correctly address the prompt.</td>
<td>The point is correctly addressed. The argument is clear and coherent.</td>
<td>The point is correctly addressed. The argument is clear, concise, and coherent. It is evident that the student has mastered the topic.</td>
</tr>
<tr>
<td>4. Prediction if gravitational force proves stronger than Dark Energy</td>
<td>This section is absent.</td>
<td>This section is incomplete or does not correctly address the prompt.</td>
<td>The point is correctly addressed. The argument is clear and coherent and uses evidence the student has gathered as support.</td>
<td>The point is correctly addressed. The argument is clear, concise, and coherent and uses evidence the student has gathered as support. It is evident that the student has mastered the topic.</td>
</tr>
</tbody>
</table>

**Overall**

<table>
<thead>
<tr>
<th></th>
<th>No response is submitted or the submitted response is incoherent or illegible.</th>
<th>The response is incomplete; it does not demonstrate thought or mastery of the topic</th>
<th>The response is complete, coherent, and thoughtful.</th>
<th>The response is complete, coherent, and thoughtful. It is evident that the student has achieved mastery of the topic.</th>
</tr>
</thead>
</table>

**Total**
### GIFT Action Plan Template

<table>
<thead>
<tr>
<th>Title</th>
<th>Astronomy Unit: Life as A Astronomer</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIFT Fellow</td>
<td>Harnary Seng</td>
</tr>
<tr>
<td>E-mail of Fellow</td>
<td><a href="mailto:hseng360@gmail.com">hseng360@gmail.com</a>/ <a href="mailto:teachingyou08@gmail.com">teachingyou08@gmail.com</a></td>
</tr>
<tr>
<td>Sponsoring Organization</td>
<td>GIFT: CEISMC: Center for Education Integrating Science, Mathematics, and Computing</td>
</tr>
<tr>
<td>Mentor</td>
<td>Dr. Lizanne DeStefano</td>
</tr>
<tr>
<td>Subject(s) Targeted</td>
<td>Earth Science / Astronomy Unit</td>
</tr>
<tr>
<td>Grade Level</td>
<td>6th grade</td>
</tr>
</tbody>
</table>
| Essential Questions    | - How do gravity and the distance to the sun affect the length of a planet’s year?  
- How did the work of Isaac Newton help explain the observations of earlier scientist?  
- What is the relationship between cosmic background and the big bang theory?  
- How does the current model of the solar system differ from past models?  
- How does the Earth differ from the other planets?  
- Why does a star look different if you move from place to place?  
- How could you tell a planet from a star if you look at the same constellations over several nights?  
- How are asteroids and comets different? |
### Georgia Performance Standards

**Next Generation Science Standards (NGSS)**

<table>
<thead>
<tr>
<th>Georgia Performance Standards</th>
<th>NGSS: 3-D Science</th>
</tr>
</thead>
</table>

#### S6E1. Obtain, evaluate, and communicate information about current scientific views of the universe and how those views evolved.

**S6E1a.** As questions to determine changes in models of Earth’s position in the solar system, and origins of the universe as evidence that scientific theories change with the addition of new information.

*Clarification statement:* Students should consider Earth’s position in geocentric and heliocentric models and the Big Bang as it describes the formation of the universe.

**S6E1b.** Develop a model to represent the position of the solar system in the Milky Way galaxy and in the known universe.

**S6E1c.** Analyze and interpret data to compare and contrast the planets in our solar system in terms of: size relative to Earth, surface and atmospheric features, relative distance from the sun, and ability to support life.

**S6E1d.** Develop and use a model to explain the interaction of gravity and inertia that governs the motion of objects in the solar system.

**S6E1e.** Ask questions to compare and contrast the characteristics, composition, and location of comets, asteroids, and meteoroids.

#### Developing and Using Models

Model in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

#### Analyzing and Interpreting Data

Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings.
Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas:

SS1.A: The Universe and its Stars
- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

ESS1.B: Earth and the Solar System
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Crosscutting Concepts:

Patterns
Patterns can be used to identify cause-and-effect relationships.

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.

Systems and System Models

Models can be used to represent systems and their interactions.

http://www.nextgenscience.org/

Students who demonstrate understanding can:

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<table>
<thead>
<tr>
<th>School Improvement Plan</th>
<th>&lt;Please list (cut and paste) the School Improvement Plan to be addressed.&gt; <a href="https://011.clayton.k12.ga.us/common/pages/UserFile.aspx?fileId=4109053">https://011.clayton.k12.ga.us/common/pages/UserFile.aspx?fileId=4109053</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview of National Standards</td>
<td>ESS1.A and ESS1.B. Middle school students can examine the Earth’s place in relation to the solar system, Milky Way galaxy, and universe. There is a strong emphasis on a systems approach, using models of the solar system to explain astronomical and other observations of the cyclic patterns of eclipses, tides, and seasons. There is also a strong connection to engineering through the instruments and technologies that have allowed us to explore the objects in our solar system and obtain the data that support the theories that explain the formation and evolution of the universe. The crosscutting concepts of patterns; scale, proportion, and quantity; systems and system models; and interdependence of science, engineering, and technology are called out as organizing concepts for these disciplinary core ideas. In the MS.Space Systems performance expectations, students are expected to demonstrate proficiency in developing and using models and analyzing and interpreting data; and to use these practices to demonstrate understanding of the core ideas.</td>
</tr>
</tbody>
</table>
| Safety Considerations | Do not look directly at the Sun  
Practice safety procedures  
Follow all directions of the teacher |
| The Learning Plan: | **Lesson Overview:** Unit Summary: The purpose of the lesson is to increase digital literacy and inform the general public about computational and data-enabled scientific discovery (NCSA, 2018). The unit will be taught during the first part of the semester during the Astronomy unit. It will align with CCPS (Clayton County School System curriculum pacing guide) and Georgia Standard of Excellence in |
Science for 6th grade level. The lessons are taught as enrichment lessons to increase rigor in the science classroom. The lessons will be driven by the movie, “Seeing the Beginning of Time”. The unit is an integration in collaboration efforts of GATECH (CEISMIC), University of Illinois under the direction of Lizanne DeStafano and Donna Cox. Ricardo Pacheco and I, Harnary Seng worked on the project to ensure that the lessons are middle through high school based. The lesson for this learning plan focuses on the 6th grade Georgia Standard of Excellence in Science. The lesson is part of an integrated unit that involves Mathematics, Language Arts, and Social Studies. The task requires students to complete a GRASPS activity. The unit has multiple sections or modules that will be teacher-driven and student focus as background information is building build. This unit will address perceptions and misconceptions of the beginning of the Universe. The Unit will enable students to develop 21st century skills and focuses of 3D learning for Science. The overall goals of the lesson unit plan is provide meaningful lessons to any audience K-12, college, and general public to increase digital literacy and inform about computational and data enabled scientific discovery. The lessons focuses on data-driven visualization and the use of computational and data-driven research. The lessons plans can be used as a stand-alone plan or as supplemental lessons that are engaging, relevant, and challenging for all students.

**Big Ideas:**
- How can students obtain information from the multimedia (Cinematic Movie?)
- How can we evaluate the information from the movie?
- How can students communicate their understanding of the movie/

**Align it with the purpose of the team’s mission**
- Digital Literacy
- Make the Public Aware of computational and data-driven research
- Scientific information communicated using visualization information and meaningful science stories
- Encourage questions
Encourage investigation
Use of the scientific processes
Engineering Processes (Telescopes/ survey mapping)

General Standards
Georgia Standards of Excellence (6th grade)

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NGSS: 3-D Science

Developing and Using Models
Model in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

• Develop and use a model to describe phenomena.

Analyzing and Interpreting Data
Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

• Analyze and interpret data to determine similarities and differences in findings.

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

• Construct a scientific explanation based on valid and reliable evidence obtained from sources
(including the students own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

**Disciplinary Core Ideas:**

**SS1.A: The Universe and its Stars**
- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

**ESS1.B: Earth and the Solar System**
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

**The Learning Plan: Unit Overview: “How the Universe Began?”**

**Purpose of the lesson:** Students will answer questions based on the information from the movie, “Seeing the Beginning of Time”. This lesson will align with CADENS vision of “increase digital literacy and inform the general public about computational and data-enabled scientific discovery” (NCSA, 2018).

**Big Idea:**
- The students will answer the question “How the Universe Began?” by dissecting the movie.
- The students will gather, evaluate, and communicate the evidence presented by scientists to create a model of the universe in its early stages.
- The students will research and explore careers related to the study of the universe with telescopes, supercomputing applications and visualization to understand the early universe.
- The students will learn the content that links the evolution of planets, stars, and galaxies.
- The students will learn about scales, proportions and distance.
- The students will understand how computational science can help explain and model phenomena through simulation to investigate natural phenomena such as the death of a star and help to find solutions.
- The student will see how science ideas can evolve as new evidence approaches.
- The student will understand the importance of earlier work and how it paves the way for more
questions to be asked

- The student will learn that scientists work is significant and improves as much evidence emerges and advanced technology is developed.

**Essential Questions:**

- Why is it important to know how the universe began?
- What hypothesis do scientist have to answer the question?
- What variables are used to study the universe?
- What challenges and constraints scientist face as the use the sky as their laboratory?
- Explain how scientist use ground and space telescopes, algorithms and mathematical equations to create models that describe the origin of the universe.
- How are the models communicated to the public (visualization)? Why is it important?

**Content-Driven Questions:**

- How do scientist measure distance in the universe?
- What is a supernova and what role does it play in star and galaxy formation?
- Why do astronomer use different filters in the electromagnetic spectrum to observe galaxies and stars?
- How is our current understanding of gravity changing as new evidence emerge from the research conducted by astronomers and cosmologists?
- What is ionization energy?
- What is the Doppler Effect?
- What is cosmology?
- What is time domain astronomy?
- Explain the cosmic microwave background radiation and why does it provide evidence of a big bang.
- What evidence disprove the big bang theory?

**Guided Questions from the Movie**

What forces came together to form the first generation of stars and galaxies?

How to interpret the vast architecture of matter and light we see in our telescopes?

The lesson is part of an integrated unit that involves Mathematics, Language Arts, and Social Studies.

The task requires students to complete a GRASPS activity.

**ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:**
- Introduce the lesson using an anchoring phenomenon: “The life of a Star”

https://www.youtube.com/watch?v=PM9CQDIQ1OA

Writing Prompt: What would happen if the Sun died?

How can the Sun’s future death help us understand how the Universe was born?

What clues do Stars give to help us understand what happen in the past?

Students will complete a journal prompt and share using chart paper or whiteboards

Watch the intro music clip for the show “Big Bang Theory” and will discuss how the universe began.

- Writing prompt: How the universe began?
- Share out – group discussion (teachers will address misconceptions and interest)
- Discussed the lifespan of a star. Our sun one day will die! Explain the life cycle of a Star
- Create a thinking map and sequencing of events.
- Use a multimedia clip with the scale of the universe app.
- Vocabulary driven activity to address content. (Word Sort / Matching game), Scavenger Hunt, Station Activity
- Research Supernova 1987a visualization, 3D model and Hubble pics from the last 30 years.
- Research the basics of stars - development/our sun
- Write and Discuss 2 truths and 1 lie about the universe. (Teacher-Student Discussion/ Group Activity)
- Anticipation Guide: What they know about Cosmology (Addressing Perceptions and Misconceptions)

Activities:

- Use a teaching strategy Walk-About. The strategy provides students a sneak peek of the content for the upcoming unit on Astronomy (). Students will visit stations in the class with images from Hubble-Telescope and multimedia presentation about Stars, Supernovas, other objects in the Universe. The students will write down information for each station. The task is timed. There will be 8 stations in the room and the students will circulate 2 minutes at each station for a total of 16 minutes.
-Preconception and misconceptions about the Universe: Introduce students using 2 truths and 1 lie. The students will have to figure out the lie about the Universe. Student will create 2 truths and 1 lie about the Universe for other students to uncover.

-Whiteboard activity: What evidence supports the formation of the Universe?
How can technology help us understand the formation of the Universe?
What can we use to measure the size and scale of the Universe?

Journal activity: Write a summary or response after the video

<table>
<thead>
<tr>
<th>Engage</th>
<th>Problem-Based Learning Challenge:</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>Students will complete a webquest to build vocabulary and address misconceptions of the formation of the Universe</td>
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<td>Complete a word sort/ vocabulary matching game of information</td>
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<td>Vocabulary words included are:</td>
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<tr>
<td>Matching Magnet:</td>
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<tr>
<td>Direction: One student will have the word and the another student will have the definition (cards tape to their back and they have to find a match in the class (timed-activity)</td>
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<td>Big Bang, Evidence, Star, Life-cycle, Cosmology, Microwave Radiation, Dark Matter, Dark Energy, Gravity, Scale, Astronomical Unit (AU), Light-year, Sun, Star, Nebula, Telescope, Computational Science, Data, Astronomer</td>
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<tr>
<td>If time permits, students will complete a Webquest on careers</td>
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<td>Answer the question “How the universe began?” students will watch the clip “First Light in the Renaissance simulations: Formation of the very first galaxies in the universe.”</td>
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• Complete a chart or table comparing and contrasting the jobs of Astronomer, Cosmologist, Visualization and Computation scientist.

The chart should include information from the Bureau of Labor statistics. The chart should include:

• career preparation
• job description
• demands
• predicted demand, etc.

Below is a possible sample of the chart

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<tr>
<th>Experts</th>
<th>Career Preparation/Education</th>
<th>Job Description/Pay</th>
<th>Vacancies Demand/Predicted demands</th>
<th>Significance of the job/benefits to society and etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomer</td>
<td></td>
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<td></td>
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<tr>
<td>Physicist</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Cosmologist</td>
<td></td>
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Content and early model

*Quote from the video clip, First Light* “Largest and more complex calculations of our time.”

*Quote from the video clip, First Light* “Early galaxies burst with new stars flooding the universe with light.”

Students will gather information/evidence from the movie through the completion of the guided notes given by the teacher.

Explain

Check one of the following:

• Original Work

The teacher explicitly explain the expected outcome of the lesson unit overview

The standard being address

- The learning goals
- Essential questions
The teacher will explain how scientists use visualization to illustrate complex models to the public.

The teacher will explain how visualization is utilized to help the public understand the complexity of the universe in terms of size, scale.

The teacher will explain the challenges scientists face with observational and computational science and only through simulation using supercomputers are we able to theoretically predict or investigate the phenomenon of the beginning of the Universe.

*Quote from the video clip, First Light* “Time-evolving visualization gives insight into dynamics that are impossible to understand from quantitative analysis alone. Only through simulation, we can study this era.”

**Career:** Teacher led discussion.

**Content and early model from the clip First Light**

“Early galaxies burst with new stars flooding the universe with light. The most massive stars explode as a supernova, exploding heavier elements, called metals, to their surroundings, primitive star formation.

*Supernova explosion drive star-forming gas out of their host galaxies local limiting star formation.*

The universe rapidly evolve as galaxies assemble. Over 15 million computational hours on the blue water super computer model gas, stars, dark matter and radiation producing a host of physical observables.

Cool neutral hydrogen gas traces the dark matter that forms filaments and halos. The most massive stars produce a tremendous amount of UV light ionizing the surrounding gas. The resulting clouds on ionizing gas hydrogen reveal galaxies and stars that recently formed.

Ionization as well as shock waves from supernova explosion heat the gas. Heavy elements from supernovae enable gas to cool, collapse and form the new generation of stars. The combine physical variables show the anatomy and structure of the modeled early universe.”

**Data from telescopes to test the model**

“We now approaching an early galaxy only 1/1000 the mass of the Milky Way.”
They will be on the reach of present telescopes. The James Webb space telescope will detect tiny distant galaxies. With this observation scientist will be able to test these large scale computational models are capturing the essence of galaxy formation in the early universe.”

Students will

- Research and create a resume from a list of scientists (differentiated by interest)
- Job Interview (Presentation): Student-led activity Student as (Astronomer, Visualization Scientist, Computational Scientist)
- Create a children’s book with illustrations and narrate the story
- Create their own script explaining the movie

**Possible Topics/ Content/Activities**

<table>
<thead>
<tr>
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<th>Possible Activities</th>
<th>Grade-Level/Time of the movie</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-Based Learning GRASPS</td>
<td>-Create a 1-3 minute animation to promote the movie</td>
<td>All grade levels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Select a famous celebrity that will narrate your movie</td>
<td></td>
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<tr>
<td></td>
<td>-explain why you choose them (What mood/tone)</td>
<td></td>
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<tr>
<td></td>
<td>-what part of the movie would you select and explain</td>
<td></td>
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<tr>
<td></td>
<td>-explain the significance of the clip coloring/images</td>
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</tr>
</tbody>
</table>

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Extend

Check one of the following:

X Original Work

Source:
the Beginning of the time.

What computations did they use to create
The colors being used and why they are being used
- Provide the importance of understanding science literacy (communication)
- As new information/evidence approaches/science must make sense

PBL: Team Activity
- Challenge
Should we continue to fund research (Space/animation)

Allocation of monies
What research/software/experts (Project)
Financial Constraints
Environment Constraints
Time Constraints - Data Collection/

Obtain
Evaluate
Communicate

Gravity

Models/Space/time Sheet: Objects floating on it

Middle/High

Building Background Knowledge/

Supernovas Telescope Hubble

M/H
<table>
<thead>
<tr>
<th>Science Vocabulary</th>
<th>Dark Energy/Matter Galaxies...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supernovas: Chemistry/ Fusion (Onion) H, He, Li, Fe...</td>
<td>Electronic Configuration/ ionization energy</td>
</tr>
<tr>
<td>Optics/ Telescopes/Mirrors</td>
<td>-airplane (location) -surveys/ patterns of stars and galaxies</td>
</tr>
<tr>
<td>Surveys/Patterns Data collections</td>
<td>M/H physics</td>
</tr>
<tr>
<td>Doppler Effect/ Redshift/ Blue Shift</td>
<td></td>
</tr>
<tr>
<td>Informational Technology/ Data collection/ Scientific Method</td>
<td>Variables/ Controls Precision/Accuracy/ Errors</td>
</tr>
<tr>
<td>Communicating information in Scientific Community</td>
<td>Presentation/ data collection/ suggestions for future studies/ recommendations</td>
</tr>
<tr>
<td>Using Animation to communicate abstract information/scales/models information</td>
<td>Using data to create animation to demonstrate a concept</td>
</tr>
<tr>
<td>Physics/ Angular</td>
<td>Bicycle wheel/</td>
</tr>
<tr>
<td>Momentum</td>
<td>Rotating stool/</td>
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<tr>
<td>Electromagnetic Spectrum</td>
<td>Neon Gas Observation of Spectrum of Neon Gases</td>
</tr>
<tr>
<td>Relativity</td>
<td>Twin Paradigm Interstellar (Movie)</td>
</tr>
<tr>
<td>Frame of Reference</td>
<td>Motions/Speed/Acceleration/Comparisons</td>
</tr>
<tr>
<td>Mapping/surveying/vectors</td>
<td>Plotting/Locations</td>
</tr>
<tr>
<td>Thermodynamics/Cosmic background</td>
<td>Calorimeter: Heat Capacity Heat Transfer</td>
</tr>
<tr>
<td>Models/Scales</td>
<td></td>
</tr>
</tbody>
</table>

<p>| Star/Hertzsprung Russell Chart | Diagram/Plotting stars |
| Gravity/governing force | mass/Distances activity Lab (Density) |
| Life-cycle of a star | |
| Galaxies | Shapes/Sizes/Origins |
| Arts: Why do we choose the colors or certain images to help others understand the video | scale/size/proportion (HD tech) 4K/Flat screen Music: Choosing the music for the certain sections of the video |</p>
<table>
<thead>
<tr>
<th>Animation (Timing)</th>
<th>Imagery</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does surveying/patterns of informational technology help create a visual understanding of the science information</td>
<td></td>
</tr>
<tr>
<td>-instead of the textbook</td>
<td></td>
</tr>
</tbody>
</table>

Overall potential purpose
- Relevance of how technology can help the public understand the scientific communities
- keep the public aware of the importance of scientific information through a multimedia means
- critical thinking skills
- perseverance of learning
- evolution of scientific ideas which leads to more questions needed to be answered
- investigation/processes (Data collections)
- integration of all content areas
- systems
- connections

<table>
<thead>
<tr>
<th>Argumentative: Is the Universe Expanding Speeding Up</th>
<th>Debate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Argumentative Writing:</strong></td>
<td></td>
</tr>
<tr>
<td>- Potential Connection: Software for teachers and students to create animation</td>
<td></td>
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<tr>
<td>- s</td>
<td></td>
</tr>
<tr>
<td>1. Students will create an animated script:</td>
<td></td>
</tr>
<tr>
<td>Science will drive the project but all the other subjects can be anchor for the lesson</td>
<td></td>
</tr>
<tr>
<td>- Literacy: Script/communication/mood/tone/</td>
<td></td>
</tr>
<tr>
<td><strong>Argumentative Writing:</strong> Students state a claim/ provide evidence</td>
<td></td>
</tr>
<tr>
<td><strong>Why should we have movies like this (to promote literacy/continuation of grants -using the movie as evidence to support dark energy/dark matter</strong></td>
<td></td>
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<tr>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Using the movie (analogy) of archeologist -digging the past to make sense of the future</td>
<td></td>
</tr>
<tr>
<td>Clues to the Past  Tells a Story of the Past, using current technologies</td>
<td></td>
</tr>
<tr>
<td><strong>Units of measurements/Scientific notation/measuring space/time</strong></td>
<td>Math</td>
</tr>
<tr>
<td>Career in Astronomy</td>
<td>Professionals involved in the making of the movie?</td>
</tr>
<tr>
<td>Donna Cox/ The making of the movie Film Producer</td>
<td>Computer Science/career</td>
</tr>
</tbody>
</table>

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**Assessment Plan:**
- Students will compared the writing prompt at the beginning of the lesson with what they have learn and reflect on how their views about the universe has changed.
- Complete the WebQuest about careers.
- Complete the guided notes from the movie
- Writing prompt about change in perception and evidence
- Presentation:
  - Careers
  - Content
  - Models

**G: Goal:** Project-Based Learning
**GRASPS:**
**You as:** An Advertising Agent Hired by Caden to Promote the Movie “Seeing the Beginning of Time”
**Goal:** Caden wants to increase digital literacy and inform the general public
about computational and data-enabled scientific discovery. They need your help in ensuring the mission is accomplished. You are charge with create a trailer or behind the scenes for the Beginning of the time.

Role: You are an advertising agency hired by Caden to promote and advertise the movie trailer to engage and inform the public of “Seeing the Beginning of Time”

A: Audience: Potential: Moviegoers: The public and moviegoers would like to watch a movie about the “Beginning of Universe”. The public who may not be aware of how computational science and how simulation through visualization help make sense of the scale and size of the Universe and its beginnings.

Situation: The Movie “Seeing the Beginning of Time” will be featured in theaters World-Wide. Caden wants the public to aware that this is just not another eye-appealing cinematic movie. There is more to the movie, the use of supercomputers to create simulations and visualization can only come alive thanks to a team of scientist which include astronomers and computational visualization scientist. You are the agency hired to ensure that this goal is met, that the public understands the importance of digital literacy.

- Performance/Products:
  - The Universe/ Building Vocabulary/ Background information (sheet complete)
  - Webquest (Careers in Astronomy/ Computational Scientist/ Visualization Scientist
  - Notes taken from watching the movie “Seeing the Beginning of Time”
  - Create a 1-3 minute animation to promote the movie
  - Select a famous celebrity that will narrate your movie
  - Explain why you choose them (What mood/tone)
  - What part of the movie would you select and explain
  - Explain the significance of the clip
  - coloring/ images
  - What computations did they used to create?
  - The colors being used and why they are being used
  - -Provide the importance of understanding science literacy (communication)
  - As new information/evidence approaches/ science must make sense

Standard Addressed:

S6E1. Obtain, evaluate, and communicate information about current scientific views of the universe and how those views evolved.

S6E1a. As questions to determine changes in models of Earth’s position in the solar system, and origins of the universe as evidence that scientific theories
change with the addition of new information.

*(Clarification statement: Students should consider Earth’s position in geocentric and heliocentric models and the Big Bang as it describes the formation of the universe.)*

**S6E1b.** Develop a model to represent the position of the solar system in the Milky Way galaxy and in the known universe.

**S6E1d.** Develop and use a model to explain the interaction of gravity and inertia that governs the motion of objects in the solar system.

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- Develop and use a model to describe phenomena.

**Analyzing and Interpreting Data**

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**Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

**Activity: Engage**

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

-Introduce the lesson using an anchoring phenomenon: “The life of a Star”
Writing Prompt: What would happen if the Sun died?

How can the Sun’s future death help us understand how the Universe was born?

What clues do Stars give to help us understand what happen in the past?

Students will complete a journal prompt and share using chart paper or whiteboards

Scale-Size of the Universe: Graphic Organizer

This student will complete a blank map and the map should look similar to the image above. This lesson allows students to understand scale of the objects in the universe.

Activity: Explain

The teacher explicitly explain the expected outcome of the lesson unit overview

The standard being address

-The learning goals

-Essential questions

-Tasks needed to complete prior to the GRASPS activity

-GRASPS activity

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The teacher will explain how visualization is utilize to help the public understand the complexity of the universe in terms of size, scale.

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**Career:** Teacher led discussion.

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**Data from telescopes to test the model**

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*Activity: Explore*

**Students will**

Explore information:

Students will complete a WebQuest to build vocabulary and address misconceptions of the formation of the Universe
Complete a word sort/ vocabulary matching game of information
Vocabulary words included are:

Matching Magnet:
Direction: One student will have the word and another student will have the definition (cards tape to their back and they have to find a match in the class (timed-activity)

Big Bang, Evidence, Star, Life-cycle, Cosmology, Microwave Radiation, Dark Matter, Dark Energy, Gravity, Scale, Astronomical Unit (AU), Light-year, Sun, Star, Nebula, Telescope, Computational Science, Data, Astronomer

If time permits, students will complete a WebQuest on careers

Answer the question “How the universe began?” students will watch the clip “First Light in the Renaissance simulations: Formation of the very first galaxies in the universe.”

- Complete a WebQuest activity they will research information about careers in science.
- Complete a chart or table comparing and contrasting the jobs of Astronomer, Cosmologist, Visualization and Computation scientist.

The chart should include information from the Bureau of Labor statistics. The chart should include:

- career preparation
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Content and early model

*Quote from the video clip, First Light* “Largest and more complex calculations of our time.”

*Quote from the video clip, First Light* “Early galaxies burst with new stars flooding the universe with light.”

Students will gather information/evidence from the movie through the completion of the guided
Activity: Extend

Students will

- Research and create a resume from a list of scientists (differentiated by interest)
- Job Interview (Presentation): Student-led activity Student as (Astronomer, Visualization Scientist, Computational Scientist)
- Create a children’s book with illustrations and narrate the story
- Create their own script explaining the movie

Possible Topics/ Content/Activities

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<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-Based Learning GRASPS</td>
<td>-Create a 1-3 minute animation to promote the movie</td>
<td>All grade levels</td>
<td></td>
</tr>
<tr>
<td>Goal: Caden wants to increase digital literacy and inform the general public about computational and data-enabled scientific discovery. They need your help in ensuring the mission is accomplished. You are charge with create a</td>
<td>-Select a famous celebrity that will narrate your movie</td>
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<td></td>
<td>-explain why you choose them (What mood/tone)</td>
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<td></td>
<td>-what part of the movie would you select and explain</td>
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<td></td>
<td>-explain the significance of</td>
<td></td>
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</tr>
<tr>
<td>trailer or behind the scenes for the Beginning of the time.</td>
<td>the clip coloring/images What computations did they used to create The colors being used and why they are being used -Provide the importance of understanding science literacy (communication) -As new information/evidence approaches/science must make sense</td>
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</tr>
<tr>
<td>PBL: Team Activity -Challenge Should we continue to fund research (Space/animation)</td>
<td>Allocation of monies What research/software/experts (Project) Financial Constraints Environment Constraints Time Constraints -Data Collection/Obtain Evaluate Communicate</td>
<td>Middle/High</td>
<td></td>
</tr>
<tr>
<td>Gravity</td>
<td>Models/Space/time Sheet: Objects floating on it</td>
<td>Middle/High</td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>Supernovas</td>
<td>M/H</td>
<td></td>
</tr>
<tr>
<td>Background Knowledge/Science Vocabulary</td>
<td>Telescope Hubble Dark Energy/Matter Galaxies...</td>
<td>Chemistry</td>
<td>Scales/Proportion</td>
</tr>
<tr>
<td>----------------------------------------</td>
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</tr>
<tr>
<td>Supernovas: Chemistry/Fusion (Onion) H, He, Li, Fe...</td>
<td>Electronic Configuration/ionization energy</td>
<td>Chemistry</td>
<td>Scales/Proportion</td>
</tr>
<tr>
<td>Optics/Telescopes/Mirrors</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Surveys/Patterns Data collections</td>
<td>-airplane (location) -surveys/patterns of stars and galaxies</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Doppler Effect/Redshift/Blue Shift</td>
<td>-</td>
<td>M/H physics</td>
<td>-</td>
</tr>
<tr>
<td>Informational Technology/Data collection/Scientific Method</td>
<td>Variables/Controls Precision/Accuracy/Errors</td>
<td>M/H</td>
<td>-</td>
</tr>
<tr>
<td>Communicating information in Scientific Community</td>
<td>Presentation/data collection/suggestions for future studies/recommendations</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Using Animation to communicate abstract information/scale models information</td>
<td>Using data to create animation to demonstrate a concept</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Physics/ Angular Momentum Galaxies rotations</td>
<td>Bicycle wheel/ Rotating stool/ Tilt the wheel</td>
<td>High/ physics</td>
<td></td>
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<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------</td>
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</tr>
<tr>
<td>Electromagnetic Spectrum</td>
<td>Neon Gas Observation of Spectrum of Neon Gases</td>
<td>Chemistry/Physics Physical Science M/H</td>
<td></td>
</tr>
<tr>
<td>Relativity</td>
<td>Twin Paradigm Interstellar (Movie)</td>
<td>High School/ Physics</td>
<td></td>
</tr>
<tr>
<td>Frame of Reference</td>
<td>Motions/ Speed/Acceleration/ Comparisons</td>
<td>M/H Physics</td>
<td></td>
</tr>
<tr>
<td>Mapping/surveying/ vectors</td>
<td>Plotting/ Locations</td>
<td>Math/map skills Social Studies</td>
<td></td>
</tr>
<tr>
<td>Thermodynamics / Cosmic background</td>
<td>Calorimeter: Heat Capacity Heat Transfer</td>
<td>Physics/ Chemistry</td>
<td></td>
</tr>
<tr>
<td>Models/Scales</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Star/ Hertzsprung Russell Chart           | Diagram/ Plotting stars                       |              |
| Gravity/ governing force                  | mass/Distances activity Lab (Density)         |              |
| Life-cycle of a star                      |                                               |              |
| Galaxies                                  | Shapes/ Sizes/ Origins                        |              |
| Arts: Why do we choose the colors or certain images to help others understand the | scale/size/proportion ( HD tech) 4K/ Flat screen Music: Choosing the music for the |  |
certain sections of the video
- Animation (Timing)
- imagery
- How does surveying/patterns of informational technology help create a visual understanding of the science information
- instead of the textbook

Overall potential purpose
- Relevance of how technology can help the public understand the scientific communities
- keep the public aware of the importance of scientific information through a multimedia means
- critical thinking skills
- perseverance of learning
- evolution of scientific ideas which leads to more questions needed to be answer
- investigation/ processes (Data collections)
- integration of all content areas
- systems
- connections

<table>
<thead>
<tr>
<th>Argumentative: Is the Universe Expanding Speeding Up</th>
<th>Debate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argumentative Writing:</td>
<td></td>
</tr>
<tr>
<td>- Potential Connection: Software for teachers and students to create animation</td>
<td></td>
</tr>
<tr>
<td>- s</td>
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</tr>
<tr>
<td>2. Students will create an animated script:</td>
<td></td>
</tr>
<tr>
<td>Science will drive the project but all the other subjects can be anchor for the lesson</td>
<td></td>
</tr>
<tr>
<td>- Literacy: Script/communication/ mood/tone/</td>
<td></td>
</tr>
<tr>
<td>Argumentative Writing: Students state a</td>
<td></td>
</tr>
<tr>
<td>Activity: Evaluate</td>
<td></td>
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<td>-------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Assessment Plan:</strong></td>
<td></td>
</tr>
<tr>
<td>• Students will compared the writing prompt at the beginning of the lesson with what they have learn and reflect on how their views about the universe has changed.</td>
<td></td>
</tr>
<tr>
<td>• Complete the WebQuest about careers.</td>
<td></td>
</tr>
<tr>
<td>• Complete the guided notes from the movie</td>
<td></td>
</tr>
<tr>
<td>• Writing prompt about change in perception and evidence</td>
<td></td>
</tr>
<tr>
<td>• Presentation:</td>
<td></td>
</tr>
<tr>
<td>• Careers</td>
<td></td>
</tr>
<tr>
<td>• Content</td>
<td></td>
</tr>
<tr>
<td>• Models</td>
<td></td>
</tr>
</tbody>
</table>

G: Goal: Project-Based Learning

GRASPS:

You Are An Advertising Agent Hired by Caden to Promote the Movie
“Seeing the Beginning of Time”
Goal: Caden wants to increase digital literacy and inform the general public about computational and data-enabled scientific discovery. They need your help in ensuring the mission is accomplished. You are charge with create a trailer or behind the scenes for the Beginning of the time.

Role: You are an advertising agency hired by Caden to promote and advertise the movie trailer to engage and inform the public of “Seeing the Beginning of Time”

A: Audience: The public and moviegoers that would like to watch a movie about the “Beginning of Universe”. The public who may not be aware of how computational science and how simulation through visualization help make sense of the scale and size of the Universe and its beginnings.

Situation: The Movie “Seeing the Beginning of Time” will be featured in theaters World-Wide. Caden wants the public to aware that this is just not another eye-appealing cinematic movie. There is more to the movie, the use of supercomputers to create simulations and visualization can only come alive thanks to a team of scientist which include astronomers and computational visualization scientist. You are the agency hired to ensure that this goal is met, that the public understands the importance of digital literacy.

• Performance/Products:
  - The Universe/ Building Vocabulary/ Background information (sheet complete)
  - Webquest (Careers in Astronomy/ Computational Scientist/ Visualization Scientist
  - Notes taken from watching the movie “Seeing the Beginning of Time”
  - Create a 1-3 minute animation to promote the movie
  - Select a famous celebrity that will narrate your movie
  - Explain why you choose them (What mood/tone?)
  - What part of the movie would you select and explain
  - Explain the significance of the clip
  - coloring/ images
  - What computations did they used to create the visualization?
  - The colors being used and why they are being used
  - -Provide the importance of understanding science literacy (communication)
  - As new information/evidence approaches/ science must make sense

Standard Addressed:

S6E1. Obtain, evaluate, and communicate information about current scientific views of the universe and how those views evolved.

S6E1a. As questions to determine changes in models of Earth’s position in the solar system, and origins of the universe as evidence that scientific theories change with the addition of new information.

(Clarification statement: Students should consider Earth’s position in geocentric and heliocentric models and the Big Bang as it describes the formation of the universe.)

S6E1b. Develop a model to represent the position of the solar system in the Milky Way galaxy and in
the known universe.

**S6E1d.** Develop and use a model to explain the interaction of gravity and inertia that governs the motion of objects in the solar system

**NGSS: 3-D Science**

**Developing and Using Models**

Model in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

**Analyzing and Interpreting Data**

Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings.

**Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

**Space for additional activities – click on table, insert row above for additional activities**

****Assessment Instrument – rubric, GRASP**

**Documentation of Resource**  
[https://www.youtube.com/watch?v=PM9CQDlQI0A](https://www.youtube.com/watch?v=PM9CQDlQI0A)

“Seeing the Beginning of Time” movie available of amazon prime  
[http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time](http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time): The resources used to drive the lesson overall goals
<table>
<thead>
<tr>
<th>GIFT Work Experience Summary</th>
</tr>
</thead>
</table>
| This summer 2018 GIFT fellowship internship, I was selected to work under the direction of Lizanne DeStafano. The project I was charged with completing is writing an Educators Guide for middle and high school. I worked alongside Ricardo Pacheco. This project focused on the cinematic movie “Seeing the Beginning Of Time”. As mentioned on the University of Illinois website, Seeing the Beginning of Time, takes viewers on a visually-compelling journey through deep space and time. The 50-minute, 4K science documentary was co-produced by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, and Thomas Lucas Productions. Donna Cox, director of NCSA’s Advanced Visualization Laboratory (AVL) leads the CADENS project to help raise public awareness about computational scientific discovery. “The AVL team members developed state-of-the-art technologies and used NCSA’s Blue Waters supercomputer to create cinematic production-quality data visualizations showcasing hundreds of millions of years of galactic evolution,” says Donna Cox. Dr. DeStefano met with us on the first day and went over the expectations of our project. She wanted the Educator’s guide to be teacher-friendly and meaningful for anyone who chooses to utilize in their teaching practice. The collaboration between Ricardo, high school science coordinator and me, 6th grade science teacher should look like a team wrote it and not separate. There were many hours spent of researching information and watching the movie to grasps the essence and goal of the movie. We also worked under the direction of the Donna Cox, the producer of the movie. There were many phone calls, meetings, and conferences to ensure the integrity of the movie and its intended purpose. We travel using GATech Trolley to the Astrophysics department to meet with experts. Ricardo met with John Wise, he is a professor at GATech and took part in the simulation showed in the movie. This project has help me grow tremendously in my practice, especially working alongside Ricardo. He has a strong background in this topic and he helped me understand new information about the cosmos. We worked extremely well together, spending countless hours on ensuring the project will be meaningful, engaging, and most importantly aligning with the goal “CADENS (The Centrality of Advanced Digitally Enabled Science) is a National Science Foundation-supported project to increase digital literacy and inform the general public about computational and data-enabled scientific discovery”. Dr. DeStefano has been an amazing boss, she trust and listens to our ideas about the project. Despite her busy schedule, we meet to discuss ideas and bounce ideas. The project we are working on allows me to see how more effective I can implement into my classroom. The integration of the math, science, and technology flows smoothly in the lessons we created
- Scale and size proportion of the Universe
- Measuring Distance
- Use of data (Computer Visualization)
- The life cycle of a Star
- The GRASPS activity

Teachers should be able to teach 6th grade Earth science and become familiar with the Georgia Standard of Excellence in science. To utilize my classroom transfer plan, they should collaborate with their colleagues to ensure that the plan is successfully implemented. They need to understand problem-based learning. This is not a one lesson deal; the teachers will need to continue to focus on STEM integration of the lesson. They will need to utilize the website link http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time. The multimedia serves as a meaningful tool for the students to gather, evaluate, and communicate their learning.

**GIFT Communication Plan**

**Your Students:** What are realistic ways the summer experience can be shared with your students?

This summer experience at the GATECH CEISMC will be shared with my students in various ways. I will utilize the curriculum I wrote at here to help engage and provide meaning experience with my students. My students will be understand that the making of the documentary is not
just a visually appealing cinema but there were computational science through visualization. There were collaboration efforts among difference experts. This will help students see how they too can be part of a team that utilizes science and math to bring about awareness of vast information for everyone to understand. This project may inspire them to look into a career in science. More importantly, I will communicate to my students how my experience will result in them learning more about how their actions can impact the environment we live in. I will share my experience by bringing a visual representation of my experience with the Décor of my classroom.

**Your Classroom:** What is your personal vision for your classroom? What are the realities faced in your classroom that may help or hinder your vision?

My teachers have had a tremendous influence in my career choice also. Having teachers who envisioned the possibilities of my future was a powerful motivator. When I had little or no vision on my own behalf, they provided vision and motivation to persevere in attaining my education and to pursue excellence along the way.

As a teacher leader, I have invested myself—my energies, my time, and my passion—into serving my professional community as they serve the children of this county. My personal vision is to engender a love for
all we do, all we can do, all those we serve, and all that may come to pass because of what we do in education. I believe very strongly in creating a culture of inquiry-based love of learning at the classroom, school, and community levels. I want very much for students to become lifelong learners who continue to love the wonders of science learning and learning in general. What I bring to the profession is my own childlike wonderment and the heart to see my colleagues energized and activated in the same quality, and inspiring and igniting it in our students.

Practically speaking, this means that I serve the profession in any capacity that opens up for me to do so. I have engaged in curriculum writing and pacing, teacher support and training, team leading, and classroom teaching as a visionary and an encourager of those who pursue learning and hope. If I can inspire some of this generation to engage in solving problems and facing its challenges with courage and thoughtfulness, I will count myself a success. I bring a fresh perspective, a persistent zeal, and a relentless drive into education towards our shared goals as educators.

The most obvious element of my teaching, I am told, is my enthusiasm and sheer joy about learning. Teaching is, as many have said before me, both a science and an art. The science of teaching is what professional development addresses. The art, however, is a matter of heart and conviction, and wonderment, and joy, and love for the investigation,
discovery, and understanding. The art of teaching is in the building of relationships that allow me the open doors for sharing the joys of discovery and learning. Relationship gives me the right to insist on my students’ taking responsibility for themselves and their learning. It gives me the platform to effect positive change in attitudes and in visions. It gives me permission to speak into difficult situations and draw forth responses that lead students into success.

Instructional strategies that I use are used in the context of this community spirit in my classroom. Every activity is a community activity, and learning is shared and celebrated. I use project-based learning quite a bit, and expect them to make meaningful use of technology in that. We use a lot of theme-based units to relate instruct to real-world scenarios and to give learning its true meaning. I want kids to think “outside the box” that is the classroom. We don’t learn a body of information that stays with us; we learn processes and big ideas that carry us on to higher levels of learning. Science is, fundamentally, a discipline of investigation. Therefore, we must conduct investigations in the classroom to prepare the future scientists of the world.

I give students challenges to address that are grounded in actual challenges of their world and generation. My job is to prepare them to face those very real challenges, so I need to script their learning as challenges to be met. I am preparing a literacy event that will involve
reading a particularly rich piece of informational text and addressing a
text-dependent question within a Socratic seminar setting. In addition, it
is important that we include mathematics where it naturally occurs in
science investigations. Finally, as an earth science teacher, I often lead
instruction towards social studies content where the disciplines clearly
overlap. Geography is a product of earth science processes, and a
defining aspect of place. The point is this—learning happens
authentically around topics that don’t occur in isolation.

Often time, with new innovative ideas, I will be faced with challenges
that may hinder my vision and mission for my classroom. I have various
responsibility to help teachers become more effective in planning and
teaching their students by integrating all content areas to have a focus
on math and science. This is not always an easy task to get other
teachers to change their mindset when it comes to teaching.

I also will need to exercise time-management and that means saying no
to when it will take away from my goal of helping my student’s success. I
often stop what I am doing to help others even though it may not be
convenient for me. To be a great leader, I have to model to others the
value of someone’s effort and time, which means I have to say no when
it does not serve a greater purpose.

Another challenge I may face is being able to work on project-based
learning and not always being able to keep up with pacing guide. This can
hinder my vision because county expectations and new teachers’ expectations when teaching often influence my decision to move on. I want to make sure I am always remembering my intentions for my classroom.

**Mentor:** How will you continue to interact with your GIFT Mentor following your GIFT experience? Consider ways for long term communication.

As the summer internship comes to an end, Dr. DeStefano, my mentor will continue her work as a Director of CEISMC. I will continue to work under her direction to complete the educator’s guide since I was in Cambodia, Ricardo and I expect to complete the project by September. She has mentioned, we will have asked to delivered information at a National Science Conference (NSTA). We will also work on a future project.

**Colleagues:**

How will you share your GIFT experience with your colleagues at your school or district?

This upcoming 2018-2019 school year, I will be at new school, Babb Middle School. I am part of a team responsible for integrating STEM curriculum to all teachers in the 6th grade from all content area. This is a
new position which all of the students will have their own laptops, Grade 6: disseminate information from leadership team; submit grade-level concerns; serve as a communicator/liaison among the teachers of the department; the principal, and other school groups; assist teachers with the development of strategies to improve instruction, including classroom management techniques; assist with inventory of materials and supplies. I will embed STEM focus lessons that I wrote this summer into the first unit. This will be implemented with the support of my administrators, school leaders, and teachers at my school.

Optional: District/State:

I had the opportunity this summer to participate in a professional development course alongside other 6th grade science teachers in the county. I helped write the first unit plan for the district this fall. I gave ideas on how to incorporate the “Seeing the Beginning of Time” into the 6th grade curricula for the teachers. I can upload my strategies to DOE and become an ambassador for the state. My colleagues can assist me in helping me reach more teachers through their implementation of the curricula. The district science facilitator, Mrs. Greenwood also took part in GIFT internship in previous years and will be eager to help support me in sharing my experience. Moreover, the curricula I wrote will be used by
| teachers in the classroom or on a off-site fieldtrip to see the movie “Seeing the Beginning of Time” | 2018 |
# GIFT Action Plan Rubric

**Teacher:** Ricardo Pacheco

<table>
<thead>
<tr>
<th>Components</th>
<th>Exemplary</th>
<th>Satisfactory</th>
<th>Needs Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Implementing the GIFT</strong></td>
<td>Teaching and learning goals are clearly correlated to a concept or major idea and clearly linked to National and Georgia Performance Standards, needs assessment and work experience. The “big ideas” and essential questions are well correlated to activities. Safety considerations were included if appropriate.</td>
<td>Teaching and learning goals are correlated to a concept or major idea and linked to National and Georgia Performance Standards. The “big ideas” and essential questions are correlated to activities. Safety considerations were included if appropriate.</td>
<td>Teaching and learning goals or “big ideas” and essential questions are not included or did not correlate to activities. The “big ideas” and essential questions are not included or did not correlate to activities. Safety considerations were not included, but needed.</td>
</tr>
<tr>
<td><strong>Engage</strong></td>
<td>At least one <em>exemplary</em> engage activity that will focus student’s attention, stimulate thinking and access, prior knowledge is included.</td>
<td>Appropriate engage activity that will focus student’s attention, stimulate thinking and access, prior knowledge is included.</td>
<td>Engage activity that will focus student’s attention, stimulate thinking and access, prior knowledge is not included or does not meet criteria.</td>
</tr>
<tr>
<td><strong>Explore</strong></td>
<td>At least one <em>exemplary</em> explore activity which gives students time to think, investigate, make decisions, problem solve, collect information are included.</td>
<td>Appropriate explore activity which gives students time to think, investigate, make decisions, problem solve, collect information is included.</td>
<td>Explore activity which gives students time to think, investigate, make decisions, problem solve, collect information is NOT included or does not meet criteria.</td>
</tr>
<tr>
<td><strong>Explain</strong></td>
<td>At least one <em>exemplary</em> explain activity which allows students to analyze their exploration is included to clarify students understanding and reflect on the experience is included.</td>
<td>Appropriate explain activity which allows students to analyze their exploration is included to clarify students understanding and reflect on the experience is included.</td>
<td>Appropriate explain activity which allow students to analyze their exploration is included to clarify students understanding and reflect on the experience is NOT included or does not meet criteria.</td>
</tr>
<tr>
<td><strong>Extend</strong></td>
<td>At least one <em>exemplary</em> extend activity which expands and solidifies thinking and/or connects topic to a real-world situation and includes strategies for differentiating for different learners is included.</td>
<td>Appropriate extend activity which expands and solidifies thinking and/or connects topic to a real-world situation is included or includes strategies for differentiating for different learners is included.</td>
<td>Appropriate extend activity which expands and solidifies thinking and/or connects topic to a real-world situation is NOT included or does not meet criteria.</td>
</tr>
<tr>
<td><strong>Evaluate</strong></td>
<td>At least one <em>exemplary</em> evaluate activity which allows the teacher to assess student performance and understandings of concepts, skills, processes and applications is included. Evaluation/ assessment instruments are well tied to goals/objectives and a GRASP is included.</td>
<td>Appropriate excellent evaluate activity which allows the teacher to assess student performance and understandings of concepts, skills, processes and applications is included. Evaluation/ assessment instruments are tied to goals/objectives.</td>
<td>Appropriate evaluate activity which allows the teacher to assess student performance and understandings of concepts, skills, processes and applications is NOT included or does not meet criteria. Evaluation/ assessment instruments are not clearly tied to goals/objectives.</td>
</tr>
<tr>
<td><strong>Summarizing the GIFT</strong></td>
<td>The GIFT project and practical applications of science, mathematics and technology are clearly articulated. The content/background needed to duplicate the CTP is excellent.</td>
<td>The GIFT project and practical applications of science, mathematics and technology are articulated. The content/background needed to duplicate the CTP is appropriate.</td>
<td>The GIFT project and practical applications of science, mathematics and technology is too brief or included inappropriate information. The content/background needed to duplicate the CTP is not included or too brief.</td>
</tr>
<tr>
<td><strong>Sharing the GIFT</strong></td>
<td>Excellent outline of realistic ways the experience can be shared with students included a well articulated personal vision for the classroom. A clear plan to share the GIFT experience with colleagues and district and/or state is well developed.</td>
<td>Appropriate outline of realistic ways the experience can be shared with students included an articulated personal vision for the classroom. A plan to share the GIFT experience with colleagues is well developed.</td>
<td>A description of interactions was stated, but there was no clear plan for continued interaction.</td>
</tr>
</tbody>
</table>

*Captures the essence of the “E” strategy, detailed and thorough, highly motivating to learner; may include more than one appropriate strategy

*Any component of the Action Plan receiving a Needs Improvement must be resubmitted to GIFT by _ _ _ _ _ _ _ _ _ _ _ _ in order to receive PLU credit.
## GIFT Action Plan

<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Creating a teacher’s guide for the movie “Seeing the Beginning of time” movie developed by The Centrality of Advanced Digitally ENabled Science (CADENS) in collaboration with CEISMC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GIFT Fellow</strong></td>
<td>Ricardo Pacheco</td>
</tr>
<tr>
<td><strong>E-mail of Fellow</strong></td>
<td><a href="mailto:Ricardo.pacheco@cobbk12.org">Ricardo.pacheco@cobbk12.org</a></td>
</tr>
<tr>
<td><strong>Sponsoring Organization</strong></td>
<td>CEISMC</td>
</tr>
<tr>
<td><strong>Mentor</strong></td>
<td>Dr. Lizanne DeStefano</td>
</tr>
<tr>
<td><strong>Subject(s) Targeted</strong></td>
<td>Middle and High school science</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td>6-12</td>
</tr>
<tr>
<td><strong>“Big Ideas”</strong></td>
<td>The students will learn how scientist use telescopes and computational power to study the universe.</td>
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<tr>
<td><strong>Essential Questions</strong></td>
<td>What forces came together to form the first Generation of stars and Galaxies?</td>
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<tr>
<td></td>
<td>How to interpret the vast architecture of matter and light we see in our telescopes?</td>
</tr>
<tr>
<td><strong>Georgia Performance Standards</strong></td>
<td>S6E1. Obtain, evaluate, and communicate information about current scientific views of the universe and how those views evolved.</td>
</tr>
<tr>
<td></td>
<td>(Physics) SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects.</td>
</tr>
<tr>
<td><strong>Next Generation Science Standards (NGSS)</strong></td>
<td>Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.</td>
</tr>
<tr>
<td></td>
<td>Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.</td>
</tr>
<tr>
<td></td>
<td>Communicate scientific ideas about the way stars, over their life cycle, produce elements.</td>
</tr>
<tr>
<td><strong>School Improvement Plan</strong></td>
<td>Goal: To increase school performance on ALL end of course assessments by 6% at the proficiency level (Level III and IV) over the 2017/18 school year.</td>
</tr>
<tr>
<td><strong>Overview of National Standards</strong></td>
<td>&lt;Choose one or two National Standards that demonstrate an overview of your Classroom Transfer Plan&gt;</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Safety Considerations</strong></td>
<td>N/A</td>
</tr>
</tbody>
</table>

**The Learning Plan:** Unit Overview: “How the Universe Began?”

**Purpose of the lesson:** Students will answer questions based on the information from the movie, “Seeing the Beginning of Time”. This lesson will align with CADENS vision of “increase digital literacy and inform the general public about computational and data-enabled scientific discovery” (NCSA, 2018).

**Big Idea:**

- The students will answer the question “How the Universe Began?” by dissecting the movie.
- The students will gather, evaluate, and communicate the evidence presented by scientists to create a model of the universe in its early stages.
- The students will research and explore careers related to the study of the universe with telescopes, supercomputing applications and visualization to understand the early universe.
- The students will learn the content that links the evolution of planets, stars, and galaxies.
- The students will learn about scales, proportions and distance.
- The students will understand how computational science can help explain and model phenomena through simulation to investigate natural phenomena such the death of a star and help to find solutions.
- The student will see how science ideas can evolve as new evidence approaches
- The student will understand the importance of earlier work and how it paves the way for more questions to be asked
- The student will learn that scientists work are significant and improves as much evidence emerges and advanced technology is developed.

**Essential Questions:**

- Why is it important to know how the universe began?
- What hypothesis do scientist have to answer the question?
- What variables are used to study the universe?
- What challenges and constraints scientist face as the use the sky as their laboratory?
- Explain how scientist use ground and space telescopes, algorithms and mathematical equations to create models that describe the origin of the universe.
- How are the models communicated to the public (visualization)? Why is it important?

**Content-Driven Questions:**

- How do scientist measure distance in the universe?
- What is a supernova and what role does it play in star and galaxy formation?
- Why do astronomer use different filters in the electromagnetic spectrum to observe galaxies and stars?
- How is our current understanding of gravity changing as new evidence emerge from the research conducted by astronomers and cosmologists?
- What is ionization energy?
- What is the Doppler Effect?
- What is cosmology?
- What is time domain astronomy?
- Explain the cosmic microwave background radiation and why does it provide evidence of a big bang.
- What evidence disprove the big bang theory?
- What is dark energy?
- What is dark matter?

**Guided Questions from the Movie**

What forces came together to form the first generation of stars and galaxies?
How to interpret the vast architecture of matter and light we see in our telescopes?

**Engage**

Check one of the following:

- √ Original Work

We have created lesson plans based on the movie “Seeing the beginning of the universe”. In that sense the work have been original. However, we have used materials from NASA, Sloan and other sources.

- √ Source: Referenced in the lessons

**Students will:**

- Watch the intro music clip for the show “Big Bang Theory” and will discuss how the universe began.
- Writing prompt: How the universe began?
- Share out – group discussion (teachers will address misconceptions and interest)
- Discussed the lifespan of a star. Our sun one day will die! - Explain the life cycle of a Star
- Create a thinking map and sequencing of events.
- Use a multimedia clip with the scale of the universe app.
- Vocabulary driven activity to address content.(Word Sort/ Matching game), Scavenger Hunt, Station Activity
- Research Supernova 1987a visualization, 3D model and Hubble pics from the last 30 years.
- Research the basics of stars - development/our sun
- Write and Discuss 2 truths and 1 lie about the universe. (Teacher-Student Discussion/ Group Activity)
- Anticipation Guide: What they know about Cosmology (Addressing Perceptions and Misconceptions)

**Engage**

Check one of the following:

- √ Original Work

We have created lesson plans based on the movie “Seeing the beginning of the universe”. In that sense the work have been original. However, we have used materials from NASA, Sloan and other sources.

- √ Source: Referenced in the lessons

**Students will**

Answer the question “How the universe began?” students will watch the clip “First Light in the Renaissance simulations: Formation of the very first galaxies in the universe.”

- Complete a WebQuest activity they will research information about careers in science.
- Complete a chart or table comparing and contrasting the jobs of Astronomer, Cosmologist, Visualization and Computation scientist.

The chart should include information from the Bureau of Labor statistics. The chart should include:

- career preparation
- job description
- demands
- predicted demand, etc.

Below is a possible sample of the chart

<table>
<thead>
<tr>
<th>Experts</th>
<th>Career Preparation/ Education</th>
<th>Job Description/ Pay</th>
<th>Vacancies Demand/Predicted demands</th>
<th>Significance of the job/ benefits to society and etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physicist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cosmologist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Content and early model**

*Quote from the video clip, First Light “Largest and more complex calculations of our time.”*
<table>
<thead>
<tr>
<th><strong>Engage</strong></th>
<th><strong>Supernova: Project Based Learning activity</strong></th>
</tr>
</thead>
</table>
| **Check one of the following:** | *Quote from the video clip, First Light “Early galaxies burst with new stars flooding the universe with light.”*
| √ Original Work | Students will gather information/evidence from the movie through the completion of the guided notes given by the teacher. |
| | **Supernova: Project Based Learning activity** |
| **Engage** | |
| Check one of the following: | The teacher will explain how scientist use visualization to illustrate complex models to the public. |
| √ Original Work | *Quote from the video clip, First Light “Time-evolving visualization gives insight into dynamics that are impossible to understand from quantitative analysis alone. Only through simulation, we can study this era.”* |
| | **Career:** Teacher led discussion. |
| | **Content and early model from the clip First Light** |
| | *“Early galaxies burst with new stars flooding the universe with light. The most massive stars explode as a supernova, exploding heavier elements, called metals, to their surroundings, primitive star formation.”* |
| | *Supernova explosion drive star-forming gas out of their host galaxies local limiting star formation.* |
| | The universe rapidly evolve as galaxies assemble. Over 15 million computational hours on the blue water super computer model gas, stars, dark matter and radiation producing a host of physical observables. |
| | Cool neutral hydrogen gas traces the dark matter that forms filaments and halos. The most massive stars produce a tremendous amount of UV light ionizing the surrounding gas. The resulting clouds on ionizing gas hydrogen reveal galaxies and stars that recently formed. |
| | Ionization as well as shock waves from supernova explosion heat the gas. Heavy elements from supernovae enable gas to cool, collapse and form the new generation of stars. The combine physical variables show the anatomy and structure of the modeled early universe.”* |
| | **Data from telescopes to test the model** |
| | *“We now approaching an early galaxy only 1/1000 the mass of the Milky Way. They will be on the reach of present telescopes. The James Webb space telescope will detect tiny distant galaxies. With this observation scientist will be able to test this large scale computational models are capturing the essence of galaxy formation in the early universe.”* |
| **Engage** | Students will |
| Check one of the following: | • Research and create a resume from a list of scientist (differentiated by interest) |
| √ Original Work | • Job Interview (Presentation): Student-led activity Student as (Astronomer, Visualization Scientist, Computational Scientist) |
| We have created lesson plans based on the movie | • Create a children’s book with illustrations and narrate the story |
| | • Create their own script explaining the movie |
| **Possible Topics/ Content/Activities** | |
“Seeing the beginning of the universe”. In that sense the work have been original. However, we have used materials from NASA, Sloan and other sources.

√ Source: Referenced in the lessons

<table>
<thead>
<tr>
<th>Topics</th>
<th>Possible Activities</th>
<th>Grade-Level/Time of the movie</th>
<th>Standards</th>
</tr>
</thead>
</table>
| **Project-Based Learning GRASPS** | -Create a 1-3 minute animation to promote the movie  
-Select a famous celebrity that will narrate your movie  
-explain why you choose them (What mood/tone)  
-what part of the movie would you select and explain  
-explain the significance of the clip  
-coloring/ images  
-What computations did they used to create  
The colors being used and why they are being used  
-Provide the importance of understanding science literacy (communication)  
-As new information/evidence approaches/ science must make sense | All grade levels |           |
| PBL: Team Activity            | Allocation of monies  
What research/software/ experts (Project)  
Financial Constraints  
Environment Constraints  
Time Constraints  
-Data Collection/ Obtain Evaluate Communicate | Middle/High |           |
<p>| Gravity                       | Models/ Space/time Sheet: Objects floating on it | Middle/High |           |
| Building Background Knowledge/ Science Vocabulary | Supernovas Telescope Hubble Dark Energy/Matter | M/H |           |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
<th>Subject(s)</th>
<th>Scales/Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galaxies…</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supernovas: Chemistry/ Fusion (Onion) H, He, Li, Fe…</td>
<td>Electronic Configuration/ ionization energy</td>
<td>Chemistry</td>
<td>Scales/Proportion</td>
</tr>
<tr>
<td>Optics/ Telescopes/Mirrors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surveys/Patterns Data collections</td>
<td>-airplane (location) -surveys/ patterns of stars and galaxies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doppler Effect/ Redshift/ Blue Shift</td>
<td></td>
<td>M/H physics</td>
<td></td>
</tr>
<tr>
<td>Informational Technology/ Data collection/ Scientific Method</td>
<td>Variables/ Controls Precision/Accuracy/ Errors</td>
<td>M/H</td>
<td></td>
</tr>
<tr>
<td>Communicating information in Scientific Community</td>
<td>Presentation/ data collection/ suggestions for future studies/ recommendations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using Animation to communicate abstract information/scales/ models information</td>
<td>Using data to create animation to demonstrate a concept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics/ Angular Momentum Galaxies rotations</td>
<td>Bicycle wheel/ Rotating stool/ Tilt the wheel</td>
<td>High/ physics</td>
<td></td>
</tr>
<tr>
<td>Electromagnetic Spectrum</td>
<td>Neon Gas Observation of Spectrum of Neon Gases</td>
<td>Chemistry/Physics</td>
<td>Physical Science</td>
</tr>
<tr>
<td>Relativity</td>
<td>Twin Paradigm Interstellar (Movie)</td>
<td>High School/ Physics</td>
<td></td>
</tr>
<tr>
<td>Frame of Reference</td>
<td>Motions/ Speed/Acceleration/ Comparisons</td>
<td>M/H Physics</td>
<td>Scales/size/ proportion</td>
</tr>
<tr>
<td>Mapping/surveying/ vectors</td>
<td>Plotting/ Locations</td>
<td>Math/map skills</td>
<td>Patterns</td>
</tr>
<tr>
<td>Thermodynamics/ Cosmic background</td>
<td>Calorimeter: Heat Capacity Heat Transfer</td>
<td>Physics/ Chemistry</td>
<td></td>
</tr>
<tr>
<td>Models/Scales</td>
<td>Star/ Hertzsprung Russell Chart</td>
<td>Diagram/ Plotting stars</td>
<td></td>
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<td>--------------------------------</td>
<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td>Gravity/ governing force</td>
<td>mass/Distances activity</td>
<td>Lab (Density)</td>
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<tr>
<td>Life-cycle of a star</td>
<td></td>
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</tr>
<tr>
<td>Galaxies</td>
<td>Shapes/ Sizes/ Origins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arts: Why do we choose the colors or certain images to help others understand the video</td>
<td>scale/size/proportion ( HD tech) 4K/ Flat screen</td>
<td></td>
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</tr>
<tr>
<td>Music: Choosing the music for the certain sections of the video</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Animation (Timing)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>-imagery</td>
<td></td>
<td></td>
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<tr>
<td>-How does surveying/patterns of informational technology help create a visual understanding of the science information</td>
<td></td>
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<tr>
<td>-instead of the textbook</td>
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<tr>
<td>Overall potential purpose</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-Relevance of how technology can help the public understand the scientific communities</td>
<td></td>
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<tr>
<td>-keep the public aware of the importance of scientific information through a multimedia means</td>
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<td></td>
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<tr>
<td>-critical thinking skills</td>
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<tr>
<td>-perseverance of learning</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-evolution of scientific ideas which leads to more questions needed to be answer</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>-investigation/ processes (Data collections)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- integration of all content areas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-connections</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Argumentative: Is the Universe Expanding Speeding Up</td>
<td>Debate Argumentative Writing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Potential Connection: Software for teachers and students to create animation</td>
<td></td>
<td></td>
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<tr>
<td>-</td>
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</tr>
<tr>
<td>1. Students will create an animated script:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Science will drive the project but all the other subjects can be anchor for the lesson</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Literacy: Script/communication/ mood/tone/ Argumentative Writing:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students state a claim/ provide evidence</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Why should we have movies like this (to promote literacy/continuation of grants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-using the movie as evidence to support dark</td>
<td></td>
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</tbody>
</table>
Using the movie (analogy) of archeologist -digging the past to make sense of the future

Clues to the Past
Tells a Story of the Past, using current technologies

Units of measurements/
Scientific notation/measuring space/time

Math

Scale/size/proportion

Career in Astronomy

Professionals involved in the making of the movie?

Donna Cox/ The making of the movie
Film Producer

Computer Science/career

Engage

Check one of the following:

√ Original Work

We have created lesson plans based on the movie “Seeing the beginning of the universe”. In that sense the work have been original. However, we have used materials from NASA, Sloan and other sources.

√ Source: Referenced in the lessons

*Activity: Cut and paste ENGAGE here. Included in the attached lesson plans

*Activity: Cut and paste EXPLAIN here. Included in the attached lesson plans

*Activity: Cut and paste EXPLORE here. Included in the attached lesson plans

*Activity: Cut and paste EXTEND here. Included in the attached lesson plans

*Activity: Cut and paste EVALUATE here. Included in the attached lesson plans

Documentation of Resources


Palma, C (n.d.) Luminosity and apparent brightness, retrieved from https://www.e-education.psu.edu/astro801/content/l4_p4.html


This year, I was selected to work under the direction of Lizanne DeStafano. I am working with Hanary Seng to create an Educators Guide for the movie “Seeing the beginning of time”. This movie is significant because it presents a model of the universe from the point of view of astronomers, cosmologist and visualization scientist using Hollywood quality visuals.

This movie, takes viewers on a visually-compelling journey through deep space and time. The 50-minute, 4K science documentary was co-produced by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, and Thomas Lucas Productions. Donna Cox, director of NCSA’s Advanced Visualization Laboratory (AVL) leads the CADENS project to help raise public awareness about computational scientific discovery. “The AVL team members developed state-of-the-art technologies and used NCSA’s Blue Waters supercomputer to create cinematic production-quality data visualizations showcasing hundreds of millions of years of galactic evolution,” says Donna Cox.

Dr. DeStefano met with us on the first day and went over the expectations of our project. She wanted the Educator’s guide to be teacher-friendly and meaningful for anyone who chooses to utilize in their teaching practice. To meet our goal, we have worked under the direction of the Donna Cox, the producer of the movie and Dr. John Wise, cosmologist from Georgia Tech.

This project has challenged me to learn new things related to the understanding of the universe and led me to think of how to teach these concepts to the students in a way that is engaging. Also, I have been challenged on how to deliver this instruction. I want the students to learn by inquiring and understanding the strengths and limitations presented in the model of an early universe as presented by the movie.

Dr. DeStefano has been an amazing boss, she trust and listens to our ideas about the project. Despite her busy schedule, we meet to discuss ideas and bounce ideas.
We are working on integrating math, science, and technology through the following lessons:
- Scale and size proportion of the Universe
- Measuring Distance
- Use of data (Computer Visualization)
- The life cycle of a Star
- The GRASPS activity

<table>
<thead>
<tr>
<th>GIFT Communication Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>The vision for our lessons is to provide teachers from all over the world a guide they can use, before or after, they watch the movie “Seeing the beginning of the universe”</td>
</tr>
<tr>
<td>Our lessons are designed to address national standards addressing models of the universe.</td>
</tr>
<tr>
<td>One of the challenges of this project have been trying to zoom into specific topics. The scope of the information presented in the movie is vast and it could be overreaching trying to cover all the material. However, we are still working on lessons that can be achieved in a given time frame, are engaging and meaningful, and can be used by teachers in different levels.</td>
</tr>
</tbody>
</table>
Lesson 2: Shedding Light on Dark Matter and Dark Energy

Lesson Lab Sheet Adopted from
https://universe.sonoma.edu/activities/dark_matter.html

Probing What You Cannot See:
Astronomers have known for many years that most of the matter (at least 90%, if not more) in the Universe is invisible; we cannot see it; over the whole range of the electromagnetic spectrum, it does not radiate any light that we can detect. It is, in effect, "hidden" from our usual ways of learning about the Universe. Identifying this "dark matter" is a crucial step in the understanding of the Universe. Dark matter does not emit light, and so, we are left to ask ourselves the following questions:

- What is dark matter?
- How does dark matter help us understand the Universe and its expansion?

In this investigation, you will use several methods to determine what "hidden matter" lies between two paper plates. Through analogies associated with the cutting-edge research that is now going on with dark matter, you will uncover the "hidden matter" in your lab.

Materials:

- Ruler
- Tape Measure
- Balance or Scale
- Flashlight or strong light source
- Pencil and paper
- Quarter or two
- Two loose paper plates

Procedure:

1. Determine the mass of the two paper plates and a quarter.

   Paper Plates _________________ Quarter _________________

2. Determine the mass of your "hidden mass" plate. _______________________

3. From this, calculate the number of hidden masses you are looking for.

   Number of Masses Hidden in the Plates ____________________________

4. Hold the missing mass plate near a strong light source, such as a flashlight.
5. Locate the positions of the masses. Trace carefully around their perimeters on the convex paper plate side.

6. Measure the distances from the center of the plate to each mass location. Draw the locations and write the distances to each location in the diagram below.

![](image)

7. What pattern do you notice?

_________________________________________________________________
_________________________________________________________________

8. Given what you now know, set up a table with the possibilities for the number of masses at each location.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
9. Place your missing mass plate on the screwdriver such that it is spin around its center. Is the plate flat or does it tilt to one side? Spin it around its axis of a few times. Does the same side always stay lower? What does this tell you about the distribution of mass inside the plate?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

10. Given your observations, how many of the hidden masses are there in the plates, how many do you now know the locations of, and how many masses are you still looking for?

__________________________________________________________________
__________________________________________________________________

11. Use your extra quarters and your table of possibilities for the number of masses at each location to reveal the hidden mass(es). How will you know when you have discovered the missing mass distribution?

__________________________________________________________________
__________________________________________________________________
12. Draw the locations and original mass distribution at each location in the diagram below.

**Analyze and Reflect:**

Similar to this lab investigation, astronomy involves indirect measures and investigations. It would have been very easy for us to tear apart the paper plate in order to discover how much "hidden matter" there was and where it was located. So when we study a subject such as dark matter, it is important to understand the tools at hand to probe its nature

- When you took a total mass measurement of the "hidden matter" in the paper plates, it was just like you were a scientist at NASA who had taken total mass measurements from gravitational binding of clusters.

- When the light was shone through the paper plate to locate the "hidden matter", it was as if you were applying the concept of gravitational lensing to locate dark matter as at Bell Labs scientists have done.

- Lastly, you can think of balancing torques in paper plates as analogous to the rotational curve observations of galaxies that is being done now to reveal even more about dark matter.

**Reflect:**

Think about this lab and the studies that are being done right now on dark matter. What has this lab investigation taught you about the scientific approach to revealing the nature of dark matter? Discuss below.
Construct an explanation of Dark Matter:

__________________________________________________________________
__________________________________________________________________
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Compare and Contrast Dark Matter and Dark Energy:

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<table>
<thead>
<tr>
<th>Dark Energy Summative Assessment - Extended Writing Response Rubric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Unsatisfactory 0 points</td>
</tr>
<tr>
<td>1. Evidence to Support the Existence of Dark Matter and Dark Energy</td>
</tr>
<tr>
<td>2. Effect of gravitational force on the distribution of matter in our Universe</td>
</tr>
<tr>
<td>3. Effect of Dark Energy on the distribution of matter in our Universe</td>
</tr>
<tr>
<td>4. Prediction if gravitational force proves stronger than Dark Energy</td>
</tr>
<tr>
<td>Overall</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
Supernova and Heavy Elements
Student Worksheet

Purpose:
In the movie “Seeing the beginning of time” scientist explain that supernovae literals the universe with heavy metals. In this lesson, you will learn the basic physical and chemical processes that the stars undergo before the explosion to create metals up to Iron.

Essential Questions:

*How does the atomic emission spectrum is used to identify elements in a gas?*

*Why does the nuclear reactions in supernovae only create elements no heavier than Iron?*

Demo: Implosion

*Why does the soda can collapse?*

*How is this demonstration similar to the implosion of a supernova?*

*Draw a force diagram of the soda can and of a star.*
Using the interactive simulation “Build an Atom” from Phet
https://phet.colorado.edu/en/simulation/build-an-atom

*Explain why in the nuclear process in supernovae atoms are not conserved but the total number of protons plus neutrons is conserved.*

https://webhome.phy.duke.edu/~kolena/snrspectra.html

In the spectrum of supernovae 1987A, you can see the presence of the atoms of O, Ni, Fe, Mg, Si, and S.

Explain how scientist can use the light of a star to determine its chemical composition.
In your small research team, select one of the following guiding questions:

**Guiding Question 1:** Is there empirical evidence that dust clouds collapse to become a star?

**Guiding Question 2:** Is there empirical evidence that supernovae produce elements heavier than Iron?

**Data Collection:**

**Develop a tentative argument**

**Argumentation:**

**Explicit and Reflective Discussion:**

**Write an Investigation Report:**

**Double-Blind Group Peer Review:**

**Revise and Submit the Report:**
Supernovae 1987A:

The article “The Dawn of a New Era for Supernova 1987a” by Hille (2017) provide a wealth of information about an event that took place only thirty years ago. For the first time in about four hundred years, astronomers have been able to observe and study the explosion of a supernova in detail.

Create a power point presentation that includes:

- Images of the supernova before and after the explosion
- Describe the astronomer’s description of the rings around the remnants of the star
- Explain the relationship between the models of the explosion of supernovae 1987A and the actual observations in the last thirsty years
- Analyze the multicolor observations conducted by astronomers and explain why is necessary to make observations in different ranges of the electromagnetic spectrum
- Compare and contrast the spectra of supernova 1987a with the fusion reaction that took place in the star
- Present your views about the relationship between models and observations of supernovae. What are the strengths and limitations of the model?

Create a model, 3D printing, of the supernovae remnant using the models published by NASA 3D printing resources at https://nasa3d.arc.nasa.gov/detail/sn1987a