

Grade Level 7-12	Black Holes	Lesson Length- 3 to 4- 90 Minutes classes
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Lesson Objects and Standards

Students will:

- become familiar with the formation of black holes and new discoveries.
- read and analyze four different articles about *NuSTAR* black hole discoveries.
- gain a better understanding of black holes, their masses, and their X-ray emissions.
- receive real experience with the topic.
- make observations, record results, and make connections.
- will learn how black holes form.
- demonstrate their understanding of black hole through the creation of a presentation of their choice.

Missouri Learning Standards:

- 9-12.ESS1.A.1 Develop a model based on evidence to illustrate the lifespan of the sun and the role of nuclear fusion in the Sun's core to release energy in the form of radiation.
- 9-12.ESS1.A.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.
- 9-12.ESS1.A.3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.
- 11-12.W.1.A
b. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation
- 11 -12.SL.1.A Work with peers to promote civil, democratic discussions and decision making; set clear goals and deadlines; and establish individual roles as needed.

Materials:

- 1 internet-connected device per group
- Chart Paper
- Markers
- Student handouts/online resources
- Round balloons
- Aluminum foil
- Balance or scales (measure to at least 0.1 gram)
- Cloth tape measure
- Poster paper (optional)

<p><u>Engagement Phase</u> Video: Black Holes 101 National Geographic - YouTube- This video gives a brief explanation of a black hole.</p> <ul style="list-style-type: none"> • Before watch the video, have the students complete a quick write of what they know about a black hole. • During the video students can take notes over facts they learn about a black hole to have for later class discussion. • After watching the video, have a class discussion about what the students learn. <p>Teacher Notes:</p> <ul style="list-style-type: none"> • The video is a little over three minutes long. • If using Google Classroom, prepare a google document for the students to complete their quick in. <p>Source: 8 ways we know that black holes really do exist Space</p>	<p>Duration: 10-15 minutes</p> <p>Teacher Role-</p> <ul style="list-style-type: none"> • Facilitate learning and guide student understanding <p style="text-align: center;"><u>Goals</u></p> <ul style="list-style-type: none"> • Connect student’s experiences • Create interest • Ask questions • Understand the objectives of the lesson
<p><u>Exploration Phase</u></p> <ul style="list-style-type: none"> • Have the students work in pairs or small groups (depending on class size) and go to NASA’s site on Black holes (Black Holes NASA) • Have students click on the link in the middle of the pages “Find out more about black holes”. This link will take them to 	<p>Duration: 30-40 minutes</p> <p>Teacher Role-</p> <ul style="list-style-type: none"> • Introduce students to the NASA website over black holes.

<p>a page with seven current articles on the topic of blackholes.</p> <ul style="list-style-type: none">• Have each group pick one article to read and summarize to later share with the class. There are also videos embedded in many of the articles.• Have the groups write their key findings on large sheets of poster paper to share with the class. <p>Teacher Notes:</p> <ul style="list-style-type: none">• Depending on your class dynamics the teacher might want to assign certain articles for each group.• There are many ways to have the students share their finds such as, make a sharable Google Document, but I have found that my students enjoy using my large chart paper that can be posted around the room. Which allow for the information to stay posted in the classroom during the entire lesson. <p>Source: Black Holes NASA</p>	<p style="text-align: center;">Goals</p> <ul style="list-style-type: none">• Students become familiar with the formation of black holes and new discoveries.
<p><u>Explanation Phase</u></p> <ul style="list-style-type: none">• The students will read and analyze four different articles about <i>NuSTAR</i> discoveries regarding black holes.• Have the students work in small groups to read <u>Lesson 3: Black Holes in the News</u>, pages 25-32 from the <i>NuSTAR Educator’s Guide X-rays on Earth and from Space</i>.• After reading the article have each group complete the student handout on page 32.• Students will complete a short presentation about what their group found interesting from the articles. <p>Teachers Notes:</p> <ul style="list-style-type: none">• Depending on the class, you could assign one article to each group to read and make their presentation over. <p>Sources: NustarGuide14b508.pdf (caltech.edu)</p>	<p>Duration: 60 minutes</p> <p>Teacher Role-</p> <ul style="list-style-type: none">• Encourages students to explain concepts in their own words• Asks for clarification from students• Builds on student explanations• Provides time for students to compare their ideas with others and revise their ideas <p style="text-align: center;">Goals</p> <ul style="list-style-type: none">• Students will read and analyze four different articles about <i>NuSTAR</i> black hole discoveries

	<ul style="list-style-type: none"> Students will gain a better understanding of black holes, their masses, and their X-ray emissions
<p>Elaborate Phase – The Formation of Black Holes Activity</p> <ul style="list-style-type: none"> The students will learn what happens when a star collapses and forms a black hole. The student will complete the Black Hole activity four times collecting data Upon completion of the activity the students should notice that the mass of the aluminum ball is not changing as it size is getting smaller <p>Teacher Notes:</p> <ul style="list-style-type: none"> The procedure of this activity is easy to follow and help explain what the students need to understand prior to beginning the activity. Before beginning the activity review the life cycle of a massive star with the students: Background: Life Cycles of Stars (sonoma.edu) <p>Source:</p> <p>bhguide06.pdf (sonoma.edu)</p> <p>Background: Life Cycles of Stars (sonoma.edu)</p>	<p>Duration: 40-60 minutes</p> <p>Teacher Role-</p> <ul style="list-style-type: none"> Provide an explanation, and information through text. Builds on student explanations Provides time for students to construct their black hole to gain an understanding of what happens to a str when it collapses. <p>Goal</p> <ul style="list-style-type: none"> Students receive real experience with the topic. Students make observations, record results, and make connections. Students will learn how black holes form.
<p>Evaluate Phase</p> <ul style="list-style-type: none"> The students will create a presentation of their choice over one of the following topics and present it to the class. <ol style="list-style-type: none"> Describe one or more of the black hole missions or observations. Make a poster that explains the past or future black 	<p>Duration 120-180 minutes</p> <p>Teacher Role-</p> <ul style="list-style-type: none"> Asks open-ended questions Uses a variety of

hole missions or observations.

C. Write an essay about the NASA science missions or any other observational project.

- The students will need to do extra research online, however this handout does give many resources for them to start with. The Other Side of Infinity: Black Holes pages 18-21. [bhguide06.pdf \(sonoma.edu\)](#)

Teacher Notes:

- Before beginning this activity, you might want to make a list of sites for the students to use. I have listed the sources at the end of each document and the attached activities have many sites also available for the students.

Teacher Sources:

[bhguide06.pdf \(sonoma.edu\)](#)

Sources for Student Use:

[The Uhuru Satellite \(nasa.gov\)](#)

[The High Energy Astrophysics Observatory 2 \(Einstein\) \(nasa.gov\)](#)

[Home \(hubblesite.org\)](#)

[Chandra X-ray Center \(harvard.edu\)](#)

[Chandra X-ray Observatory - NASA's flagship X-ray telescope \(harvard.edu\)](#)

[ESA Science & Technology - XMM-Newton](#)

[XMM-Newton Guest Observer Facility \(nasa.gov\)](#)

[The Neil Gehrels Swift Observatory \(nasa.gov\)](#)

[The Fermi Gamma-ray Space Telescope \(nasa.gov\)](#)

[Fermi Gamma-ray Space Telescope \(sonoma.edu\)](#)

assessments to gather evidence of student understanding

- Provides opportunities for students to assess their progress

Goal

- Students are given the opportunity to demonstrate their understanding of black hole through the creation of a presentation of their choice.

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Space/Astronomy Lesson Plan
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[The Fermi Large Area Telescope \(stanford.edu\)](http://stanford.edu)

[Gamma Ray Astrophysics at the NSSTC \(nasa.gov\)](http://nasa.gov)

[Chandra :: Chronicles :: Major Milestones In X-ray Astronomy :: June 6, 2002 \(harvard.edu\)](http://harvard.edu)

[High-Energy Missions \(nasa.gov\)](http://nasa.gov)

[Chandra :: Field Guide to X-ray Astronomy :: History of X-Ray Astronomy \(harvard.edu\)](http://harvard.edu)

Work Cited

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Black hole Educator Guide. <https://glast.sonoma.edu/teachers/blackholes/bhguide06.pdf>. (n.d.). Retrieved September 21, 2021, from <https://glast.sonoma.edu/teachers/blackholes/bhguide06.pdf>.

Dunbar, B. (2017, November 15). *Black holes*. NASA. Retrieved September 22, 2021, from <https://www.nasa.gov/black-holes>.

For teachers. NuSTAR. (n.d.). Retrieved September 22, 2021, from <https://www.nustar.caltech.edu/page/teachers>.

May, A. (2021, August 28). *8 ways we know that black holes really do exist*. Space.com. Retrieved September 22, 2021, from <https://www.space.com/how-we-know-black-holes-exist>.

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NuSTAR Educator Guide. https://www.nustar.caltech.edu/system/media_files/binaries/34/original/NustarGuide14b508.pdf?1442355944. (n.d.).