Near-Earth Object
High School Science Lesson

Lesson Overview	Career Highlight
Students learn how near-Earth objects (NEOs) can threaten the planet. After identifying and categorizing NEOs through a citizen science exercise, students enter a simulation to save Earth from an incoming asteroid. Students work in teams to divert the asteroid through an interactive app that features critical thinking, mathematics modeling, and competitive team building.	Aerospace Engineer Computer Scientist Planetary Scientist

STEM Course Connections	21st Century Skills	CTE Alignment
High School Earth Science High School Engineering High School Environmental Science	Collaboration Communication Critical Thinking	Engineering and Design Industry Sector (ED)

Engineering Activity	
Science and Engineering Practice #6	Students work in teams to model the most economical solution to intercept a near-Earth object (NEO) threatening Earth based on specific parameters of velocity, density, diameter, and intercept mode.

Materials
• Access for students to use computers/ tablets • Google Slides/Powerpoint • YouTube Access for class videos • Access to Nasa.gov • Scientist Visitor Slide Deck - *share with scientist before class* • Teacher Slide Deck • NEO App Teacher Resource Guide • Student Handout

Essential Questions
1. Why does curiosity lead us to space? 2. How do we get to space? 3. How do we study and track objects in space?

4. How do we protect our planet from objects in space?

Prerequisite Knowledge

- Students understand Earth's position in the solar system
- Students understand the relationship of the position of the Moon, the Sun, and Earth
- Students understand that gravity is constant on Earth and always acting on object
- Students understand that velocity is speed with direction

Mission Prep - Day 1
Why Does Curiosity Lead Us to Space?

ENGAGE (10 mins) - *Thinking About Space*

- Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section A):
  - When were you first **curious** about space?
  - How often do you **think Earth connects/ interacts** with Space?
  - How do you **think** space can affect your life today?
- Students share their answers with a partner, then to the class.

ELABORATE (10 mins) - *The Aerospace Corporation*

- The Aerospace Corporation began in 1960 and the science and engineering they began decades ago is still relevant today. Students watch We Are Aerospace on YouTube.
- Teacher poses the following question to the class and allows students a few minutes to respond to each in their Student Handout (section B):
  - What you **notice** or **observe** about the The Aerospace Corporation message?
- Students share their answers with a partner, then to the class.
- Teacher makes the connection that *space is for everyone, all people and cultures have looked up and wondered about the possibilities. Space is active, changing, and has* ***not*** *been completely explored*.

EXPLORE (45 mins) - *Citizen Science Application*

- Students use computers to log onto the citizen science site, Zooniverse.
- Students learn how to identify asteroids through the citizen science project, Hubble Asteroid Hunters.
- Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section C):
  - What did you learn about identifying asteroids?
  - How might citizen science be useful in other research projects?
  - How does this connect to our idea of science being discovered daily and that everyone can be a scientist?
- Students share their answers with a partner, then to the class.

EXPLAIN (45 - 60 mins) - *Vocabulary Development*

- Following the Student Handout (section D), students should use words and images to define words in their own way.
- Students share their definitions with the class, as this vocabulary is central to the NEO Deflection App and understanding the science behind hunting asteroids.

Launch - Day 2

How do Scientists Identify Near-Earth Objects?

ENGAGE (10 mins) - *Near-Earth Objects*

- Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section E):
  - What do you think a near-Earth object is?
  - What do you think a fireball is?
- Students share their answers with a partner, then to the class.
- Opportunity for The Aerospace Corporation volunteer to use the Scientist Visitor Slide Deck to talk about how scientists find near-Earth objects and how The Aerospace Corporation is a **team of people with diverse careers** impacting space.

ELABORATE (20 mins) - *Near-Earth Object Careers*

- Teacher shows CNEOS video on YouTube. Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section F):
  - List out three things from the video that you find interesting, new, or have a question about.
- Students share their answers with a partner, then to the class.
- Opportunity for The Aerospace Corporation volunteer to talk about the difference between near-Earth objects and fireballs.
- **Career Connection:** Review the slides (8-11) with students and discuss the many types of careers that work together to identify and combat near-Earth objects.
- Opportunity for The Aerospace Corporation volunteer to talk about their specific job and career path.

EXPLORE (20 mins) - *Fireballs*

- Students use computers to log onto the NASA Fireball event site.
- Students investigate what all the buttons and zoom features do and highlight on the Student Handout (section G) which area the teacher assigns from the list:
  - Date ranges
  - Impact size ranges in kt
  - Latitude and Longitude ranges
  - Energy ranges
  - Velocity ranges
  - Planetary defense, launch the initial them and call to arms
- Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section G):
  - Change the dates to be the most recent. Then zoom in and take a **screenshot** of your observations of fireballs. Insert your screenshot here.
  - What are **two** specific things you notice or observe about the fireballs for your section? Explain in detail.
  - What do you **think** you could do if you could **alter**/ **change** and keep the objects from hitting Earth? What would you do/ change and why?
- Students share their answers with a partner, then to the class.

EVALUATE (10 mins) - *Defending Earth*

- Teacher revisits Vocabulary Development in the Student Handout (section D) with the class.
- Teacher poses the following questions to the class and allows students a few minutes to respond to each in their Student Handout (section H):
    - What keywords/ vocabulary do you think will help scientists and engineering investigate NEOs and keep Earth safe?
    - What if we could change whether a NEO becomes a fireball, what would you do to keep a NEO from hitting Earth? Tell your story in detail.
- Students share their answers with a partner, then to the class.

EXPLORE (25 mins) - *NEO Deflection App*

- Students watch NEO app video #1 (*coming soon*)
- Students use computers to log onto the NEO App
- Students investigate what happens when they change each of the constraints listed on the Student Handout (section I):
    - Delta-V Mode
    - Intercept Mode
    - Time of Deflection
    - Simulated Near-Earth Objects
    - Density (Intercept Mode)
    - Beta (Intercept Mode)
    - B-Plane
- Students share their answers with a partner, then to the class

Exploration - Day 3
How Do Launching Constraints Impact NEO Interception?

EVALUATE (45-60 mins) - *NEO Deflection App Competition*

- Students watch NEO app video #2 (*coming soon*)
- Teacher asks students to navigate to the NEO Deflection App from the previous day.
- Teacher assigns students to work in groups of three with each student selecting a different role:
    1. Lead Planetary Scientist: records all of the groups' ideas and presents it to the class for the competition
    2. Lead Aerospace Engineer: calculates the different sets of experiments to try based on orbital configuration and rocket constraints
    3. Lead Computer Scientist: uses the computer to enter the team's data and calculates the cost and density of the mission
- Option 1: Teacher assigns parameters for the competition (examples):
    - Set budget of ___x millions of dollars
    - Number of vehicles for launching
    - Time of year to launch
    - Number of launches/ velocity
- Option 2: Teacher uses the NEO App Teacher Reference Guide to set up missions. Criteria are suggested for mission set up, solutions, and winner outcomes.

Distance Learning Suggestions

Teachers can use Google Slides, Google Docs, Zoom breakout rooms, Menti, Jamboards, Padlet, or Pear Deck to collect responses, or create visuals for lessons. Turn on Closed Captions for YouTube videos.

CA NGSS Standards

HS-ESS1-6 Earth's Place in the Universe: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

HS-ESS2-2 Earth's Systems: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS3-1 Earth and Human Activity: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-PS2-3 Motion and Stability: Forces and Interactions Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

HS-ETS1-1 Engineering Design: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-3 Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

CTE Alignment

2.2 Identify barriers to accurate and appropriate communication

3.2 Evaluate personal character traits, such as trust, respect, and responsibility, and understand the impact they can have on career success
3.3 Explore how information and communication technologies are used in career planning and decision making

5.0 Conduct short, as well as more sustained, research projects to create alternative solutions to answer a question or solve a problem unique to the Engineering and Architecture sector using critical and creative thinking; logical reasoning, analysis, inquiry, and problem-solving techniques. (Direct alignment with WS 11-12.7)
5.1 Identify and ask significant questions that clarify various points of view to solve problems
5.2 Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate
5.3 Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment
5.4 Interpret information and draw conclusions, based on the best analysis, to make informed decisions

7.2 Explain the importance of accountability and responsibility in fulfilling personal, community, and workplace roles. 7.3 Understand the need to adapt to changing and varied roles and responsibilities
7.8 Explore issues of global significance and document the impact on the Engineering and Architecture sector

9.1 Define leadership and identify the responsibilities, competencies, and behaviors of successful leaders
9.2 Identify the characteristics of successful teams, including leadership, cooperation, collaboration, and effective decision-making skills, as applied in groups, teams, and career technical student organization activities
9.3 Understand the characteristics and benefits
9.6 Respect individual and cultural differences and recognize the importance of diversity in the workplace
9.7 Participate in interactive teamwork to solve real Engineering and Architecture sector issues and problems

B6.0 Employ the design process to solve analysis and design problems
C1.0 Understand historical and current events related to engineering design and their effects on society
D3.0 Understand the fundamentals of earth science as they relate to environmental engineering

Resources

The Aerospace Corporation. (2018, January 15). *The Aerospace Corporation* [Video]. Youtube. https://www.youtube.com/watch?v=vpKVjwKMs-A.

Flipgrid. (n.d.). Microsoft. Retrieved August 3, 2020, from https://info.flipgrid.com/

Google Drawings. (n.d.). Google. Retrieved August 3, 2020, from https://docs.google.com/drawings.

Google Slides. (n.d.) Google. Retrieved August 3, 2020, from https://www.google.com/slides/about/.

Hubble Asteroid Hunter. (n.d.). Zooniverse. Retrieved November 7, 2020, from https://www.zooniverse.org/projects/sandorkruk/hubble-asteroid-hunter/about/research.

Jamboard. (n.d.). Google Suite. Retrieved August 3, 2020, from https://gsuite.google.com/products/jamboard/.

JPLraw. (2020, April 27). *Web Tutorial: How to Navigate the CNEOS Website* [Video]. Youtube. https://www.youtube.com/watch?time_continue=17&v=UA6voCyCW1g&feature=emb_logo.

Microsoft Powerpoint. (n.d.). Microsoft. Retrieved November 7, 2020, from https://www.microsoft.com/en-us/microsoft-365/powerpoint.

Nasa. (n.d.). National Aeronautics and Space Administration. Retrieved November 7, 2020, from https://www.nasa.gov/.

NASA Jet Propulsion Laboratory. (n.d.). *Fireballs.* Center for Near-Earth Object Studies. https://cneos.jpl.nasa.gov/fireballs/.

NASA Jet Propulsion Laboratory. (n.d.). *NASA/JPL NEO Deflection App.* Center for Near Earth Object Studies. https://cneos.jpl.nasa.gov/nda/nda.html.

NASA Jet Propulsion Laboratory. (n.d.). *NEO Earth Close Approaches.* Center for Near-Earth Object Studies. https://cneos.jpl.nasa.gov/ca/.

Pear Deck for Google Slides. (n.d.). Pear Deck. Retrieved August 3, 2020, from https://www.peardeck.com/googleslides.

San Diego County Office of Education. (2020). *Next Generation Science Standards.* San Diego County Office of Education Science Resource Center. https://ngss.sdcoe.net/,

Seesaw. (n.d.). Seesaw. Retrieved August 3, 2020, from https://web.seesaw.me/.

Youtube. (n.d.). Youtube. Retrieved November 7, 2020, from https://www.youtube.com/.

Zoom. (n.d.). Zoom Video Communications. Retrieved November 7, 2020, from https://zoom.us/.

Zooniverse. (n.d.). Retrieved September 27, 2020, from https://www.zooniverse.org/project.