Near-Earth Object
Student Handout

Name:		Date:	

Directions: Students read the prompts and answer in complete sentences in the box to the right.

Part 1: Why Does Curiosity Lead Us to Space?

Section A: Thinking About Space	
1. When do you **think** were you first curious about space? Explain in detail as much as you remember.	
2. How often do you **think** space **connects/ interacts** with Earth? Explain in detail.	
3. How do you **think** space can specifically affect your life today? Explain your thinking.	

Section B: The Aerospace Corporation	
What do you **notice** or **observe** about The Aerospace Corporation message?	

Section C: Citizen Science Application Students get a computer/tablet and go to the link, Zooniverse Asteroid Hunters	
1. What did you learn about identifying asteroids?	
2. How might citizen science be useful in other research projects?	
3. How does this connect to our idea of science being discovered daily and that everyone can be a scientist?	

AEROSPACE

Part 2: How Do Scientists Identify Near-Earth Objects?

Section D: Vocabulary Development		
Vocab	Official Definition	Image: Draw a picture to represent the vocab word
1. **Object:** The thing	Main item (object primary designation).	
2. **Close-Approach (CA):** Path next to Earth	Pathway that is near Earth.	
3. **Close-Approach (CA) Date:** When is the object going to arrive closest to Earth	Date and time (TDB) of closest Earth approach. "Nominal Date" is given to appropriate precision. The 3-sigma uncertainty in the time is given in the +/- column in days_hours:minutes format (for example, "2_15:23" is 2 days, 15 hours, 23 minutes; "< 00:01" is less than 1 minute).	
4. **CA Distance Nominal (LD | au:** How close is the object to Earth compared to the distance of Earth to the Moon	The most likely (Nominal) close-approach distance (Earth center to NEO center), in LD (Lunar Distance) and au.	
5. **CA Distance Minimum (LD | au):** The closest the object to get to Earth with possible error added in	The minimum possible close-approach distance (Earth center to NEO center), in LD (Lunar Distance) and au. The minimum possible distance is based on the 3-sigma Earth target-plane error ellipse.	
6. **V relative (km/s):** How fast is it going compared to Earth	Object velocity relative to Earth at close-approach.	
7. **V infinity (km/s):** How fast is the object going compared to empty space	Object velocity relative to a massless Earth at close-approach.	

8. **H (mag):** How big is the asteroid	Asteroid absolute magnitude (in general, smaller H implies larger asteroid diameter). **Undefined for comets**.	
9. **Estimated Diameter:** How big is the estimated diameter of the asteroid	Diameter range (min - max) estimated from the asteroid's absolute magnitude (H) and limiting albedos of 0.25 and 0.05.	
10. **Au:** The distance between the Earth and the sun.	One Astronomical Unit (au) is approximately 150 million kilometers (see glossary for definition).	
11. **LD:** The distance between Earth and the moon.	One Lunar Distance (LD) is approximately 384,000 kilometers (see glossary for definition).	

Section E: Near-Earth Objects	
1. What do you **think** a near-Earth object is?	
2. What do you **think** a fireball is?	

Section F: Near-Earth Object Careers		
List out three things from the video that you find interesting, new, or have a question about.	1.	
	2.	
	3.	

Section G: Fireballs
1. Students get a computer/tablet and go to NASA Fireballs. Play and investigate what all the buttons and zoom features do. Then highlight which area your teacher is having you focus on from the list: a. Date ranges b. Impact size ranges in kt c. Latitude and longitude ranges d. Energy ranges e. Velocity ranges

2. Change the dates to be the most recent. Then zoom in and take a **screenshot** of your observations of fireballs. Insert your screenshot here.	
3. What are **two** specific things you notice or observe about the fireballs for your section? Explain in detail.	
4. 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?	
Section H: Defending Earth	
1. What keywords/vocabulary do you think will help scientists and engineering investigate NEO and keep Earth safe?	
2. 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.	

Section I: NEO Deflection App Students get a computer/tablet and go to the link: https://aerospace.org/asteroids	
Experiment with all the following options. Write what **happens** when you change each of these:	
1. Delta-V Mode	
2. Intercept Mode	
3. Time of Deflection	
4. Simulated near-Earth objects	
5. Density (Intercept Mode)	
6. Beta (Intercept Mode)	
7. B-Plane	

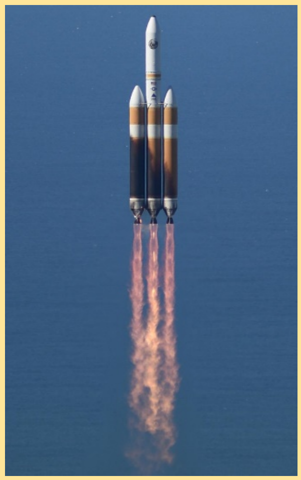
Section J: NEO Deflection App Team Time

Directions: You will need to figure out how to use your tools to protect Earth from NEOs. You will begin with experimenting on a few scenarios to learn how to use your resources. Remember, there are many ways to save Earth, but will you be able to do it with the least resources, or be the first to arrive, or the smallest budget? You decide!

Mission Resources:

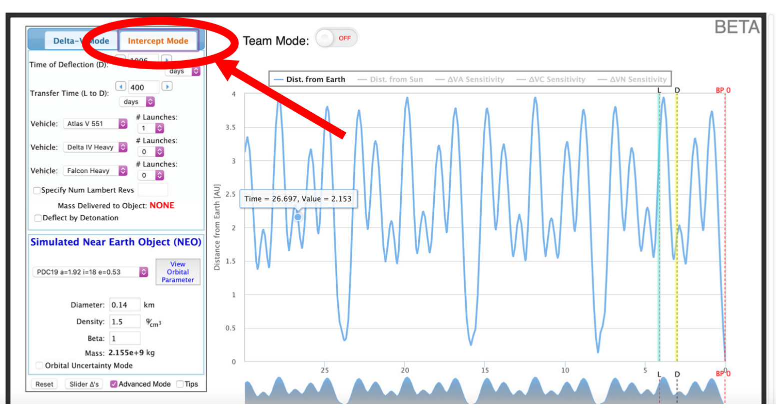
- The App Usage Guide the 2019 Scenario https://cneos.jpl.nasa.gov/pd/cs/pdc19/
- Press Release https://cneos.jpl.nasa.gov/pd/cs/pdc19/pdc19_pr1.pdf

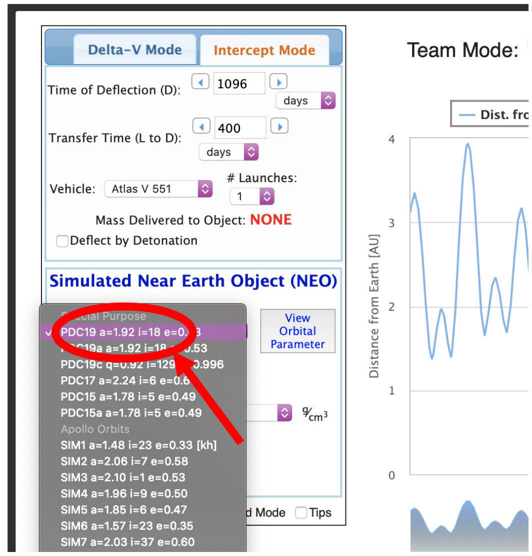
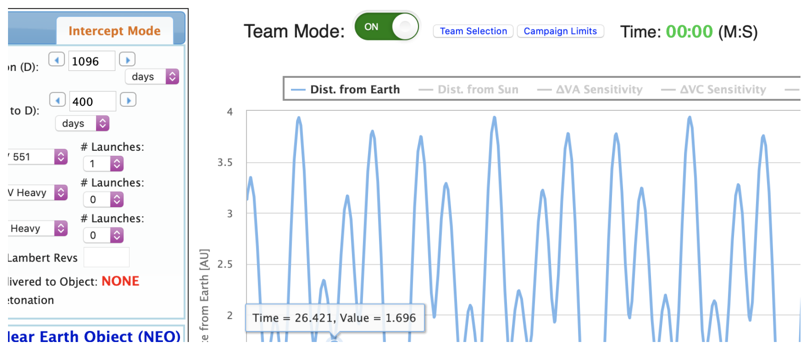
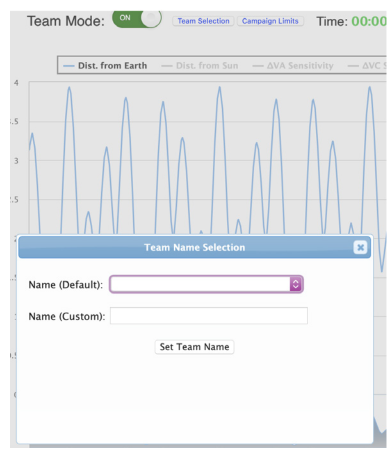
Mission Vehicles

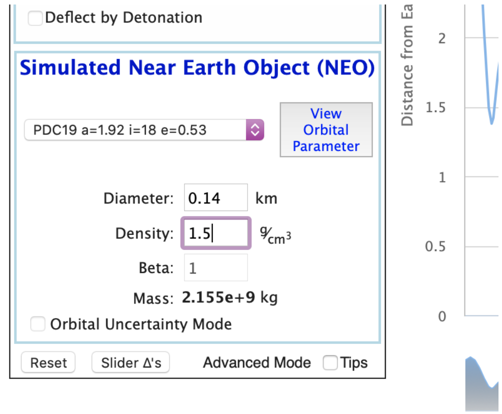
Atlas V551	Delta IV Heavy	Falcon
		

Mission Scenario 1: Find the ***shortest number of days*** from discovery of the asteroid and the least number of days from launch to impact that would give the smallest missed distance. (How close can you launch to the potential Earth impact day, with moving the asteroid the smallest amount necessary to protect Earth?)

Setting up the Values for Round 1. In the app, select the Intercept Mode, so it turns orange.

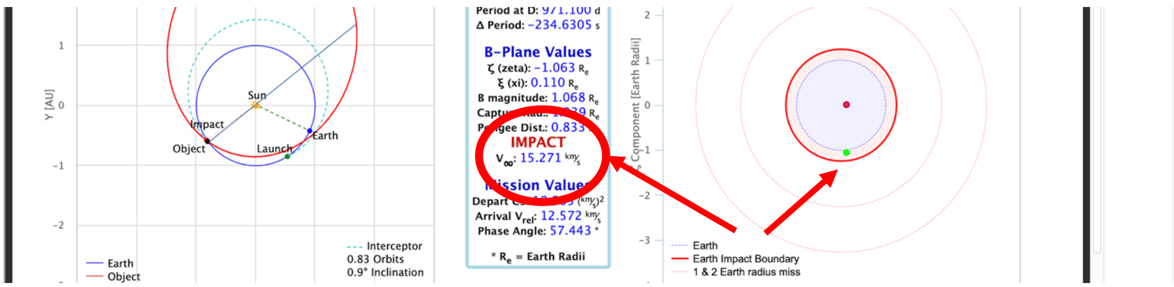


<table>
<tr><td>Select simulated NEO PDC19 from the dropdown menu.</td><td>
</td></tr>
<tr><td>Turn on the Team Mode button.</td><td>
</td></tr>
<tr><td>Type in your team name.</td><td>
</td></tr>
</table>

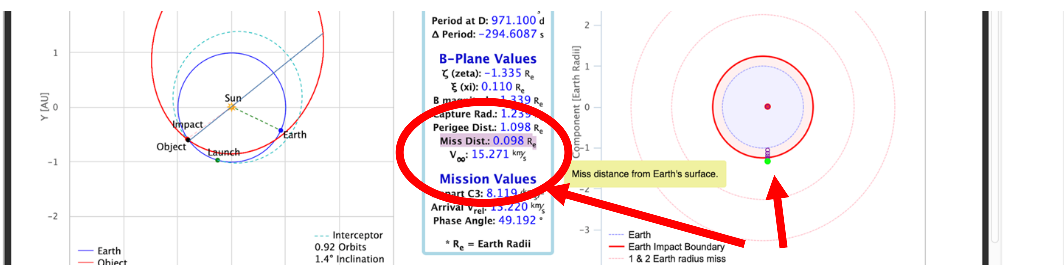
Use the NEO diameter and density default values (140 meters, 1.5 g/cm³).	

Find solutions that save Earth!

This is an unsuccessful mission = Earth is hit!



This is a successful completion = Earth is saved!



	$B	Performance Metric	R_e (Earth Radii away)	Time of Deflection (D)	Transfer Time (L - D)
Your Team's Solutions					

	Atlas V551	Delta IV Heavy	Falcon
Total Number of Launches			

1. What is your total $B?	
2. What is your Performance Metric?	
3. Write 5 to 6 sentences about your team's solution and performance. Explain why your group found the best solution and saved Earth.	