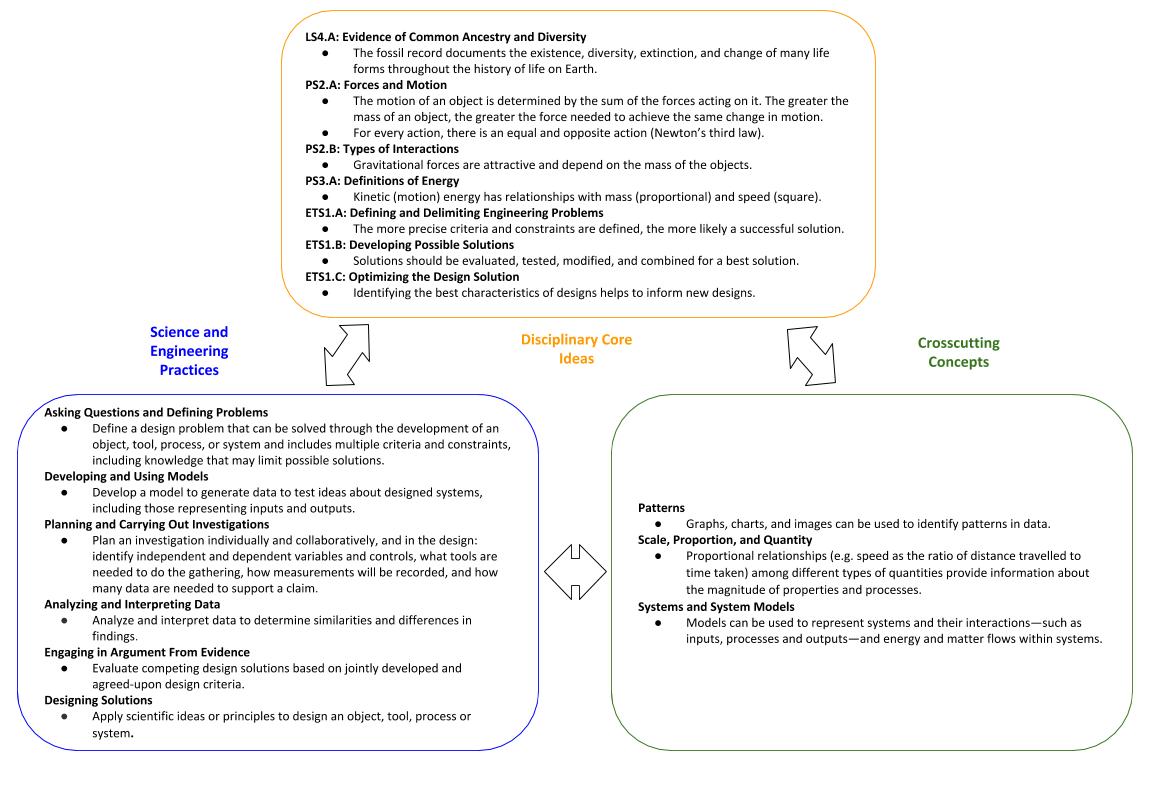
**Unit Essential Question:** *What are the effects of an asteroid collision and can we prevent a future one?*

**Introduction**

The area between Mars and Jupiter contains countless numbers of asteroids. This jostling asteroid belt orbits the sun and occasionally some asteroids slam into each other, knocking them out of regular orbit. This was the case for the asteroid that collided with Earth 65 million years ago—the phenomenon in the Lift-Off Task. In this unit’s project, another one of these asteroids (called *Etiam*), a very large one that is capable of destroying most life on Earth, is headed our way.

This culminating project is a design problem that asks students to demonstrate all four of the Engineering Design Performance Expectations at the middle school level. In doing so, students will work together to thwart the impending collision of *Etiam* with Earth. There are many different solutions to this problem—each one has its own challenges and benefits. How they decide to protect the Earth will depend on decisions that their group makes using the information and concepts they develop over the course of this unit. Once each group makes a decision on what their solution to save Earth is, each group will create a video news segment that describes how they plan to prevent this impending collision. As individuals, they will then write a detailed news article for people who want to know more about asteroid collisions with Earth and the science behind making this decision.

**3-Dimensional Assessment**



**Time Needed (Based on 45-Minute Periods)**

11 days at end of unit

* Group Project: 6 periods
  + Develop models of all possible design solutions (1 day)
  + Plan an experiment to test the design solutions (1 day)
  + Run experiment, collect data, and evaluate data (1 day)
  + Finalize solution and create news segment (2 days)
  + Presentation day (1 day)
* Individual Project: 5 periods
  + First draft: 3 periods
  + Feedback: 1 period
  + Revision: 1 period

**Materials**

News Segment

* Optional: Engineering and Design Process Graphic Organizer (provided at end of this teacher guide)
* Same materials from Task 2 to run tests of all solutions (Provide additional materials, as needed)
* Poster Paper or Computer Graphics Program (Ex: Google Drawing)
* Color pencils/pens or computer graphics
* Video camera or phone with recording capabilities
* Computers

News Article

* Optional: Newspaper Article Guide (provided at end of this teacher guide)
* Paper or Word Processing software for writing newspaper article
* Computers (Optional)

**Instructions for the Culminating Project**

1. Introduce the Culminating Project at the end of the Lift-Off task, including both group and individual components outlined in the Challenge.
2. Read over the Culminating Project Task Card with the students. We recommend only reading the Challenge, Background, and Group Project Criteria for Success at this time in order to not overwhelm students with information.
   * Take questions for clarification.
   * Make sure to emphasize the background data on the asteroid, *Etiam*, noting that students will need to return to this data and review it more thoroughly as they get closer to the project.
     + We recommend you draw a diagram of the trajectory of *Etiam* through space on the board, so students can visualize the context.
3. Remind students that as they go through the Project Organizer, they will be planning pieces of their design solution and recording scientific concepts they will likely need for their individual project. However, there is nothing wrong with going back and changing their ideas over the course of the unit. The students won’t fully design their solution and news segment until the end of the unit, so change during the imaginative and creative time is acceptable and often experienced.
4. Make sure the students fill out the Project Organizer after each task, which will help students think about different parts of their solution along the way. This process allows students to both apply and document relevant scientific concepts as they move throughout the unit. This will inform both their group and individual projects.

* We recommend that students complete the Project Organizer individually. They might discuss ideas first as a group, but should then respond individually. This allows students time to process concepts on their own and generate their own ideas, which can be used later when it comes to developing their group project.

1. The table below summarizes how the Project Organizer guides the students through developing different components of their design solution and corresponding news segment and news article.

|  |  |  |
| --- | --- | --- |
| **Task** | **Project Organizer** | **Group and Individual Culminating Project** |
| **Lift Off**  Asteroid Collisions | * What do you already know about collisions? * What are some negative consequences? * What are some methods humans use to prevent every-day collisions? | * None |
| **Task 1**  An Ancient Collision | * What evidence is there that this has happened before? * What were the effects last time? * How will you use the evidence to convince the public that it is important to protect Earth from another asteroid collision? | * News article cites data from the fossil record as evidence of the effects of past asteroid collisions. |
| **Task 2**  Contact Forces | * How will *Etiam’s* large mass affect Earth? Use experimental evidence as well as scientific ideas of mass, kinetic energy, and speed to back up your response. * How can Newton’s laws help us predict what will happen when *Etiam* hits Earth? * Record ideas you have on deflecting *Etiam*, using the following questions to help you: In the experiments, which solutions worked best? Based on the data, can you combine characteristics from the best solutions to create an even better one? How does each solution use contact forces and your understanding of mass and motion? | * News segment proposes a solution to prevent a collision between *Etiam* and Earth. This solution may be related to any of Newton’s laws. * News article compares the impact of a 2013 asteroid collision to the potential impact of the *Etiam* collision, using the relationships between mass, kinetic energy, and speed. Article also describes and diagrams solutions that use the science of Newton’s three laws to deflect *Etiam.* |
| **Task 3**  Gravity—A Non-Contact Force | * How does gravity currently influence *Etiam*? * What other objects in the solar system might influence *Etiam* as it travels through space and why? * How can other gravitational forces affect the trajectory of *Etiam*? | * News segment proposes a solution to prevent a collision between *Etiam* and Earth. This solution may be related to gravity and mass. * News article describes and diagrams a solution that uses the concepts of gravity and mass to deflect *Etiam*. |

1. After all the learning tasks are completed, and all the Project Organizers are completed, the students can start to design a potential solution to thwart the collision of Earth and *Etiam*.

* We highly recommend providing students with the Engineering and Design Process Graphic Organizer to guide them through this process. This allows students to engage with all the middle school Engineering and Design Performance Expectations, which not only helps students to design the best possible solution but also helps them write a news article that better meets the criteria of their individual project.
* Through this process, students are asked to develop models of all possible design solutions, plan and run an experiment to test the design solutions, collect and evaluate data, and then use the data to inform an improved design solution.

1. Students will then create a news segment that describes the situation to the public and explains why their chosen solution is the best option. Their news segment must meet all the criteria in the student handout. The Project Organizers should be used as reference for the students to remind them of all the components of the project.

* As always, we recommend the use of group roles for Culminating Project work time (See “How to Use This Curriculum” for details). We recommend changing the roles every work day.

1. Below are some possible strategies to stop the collision of *Etiam* and Earth (although students may come up with others).

* Blow up *Etiam* before it gets near the Earth so that not all pieces will come into contact with the Earth. Pieces with less mass will thus impact the Earth with less force.
* Use the gravity of another large object to change *Etiam’s* trajectory.
  + Ex: Use the Moon to intercept *Etiam* so that the Earth will be saved.
* Build a large cushion for *Etiam* to hit on Earth, preventing *Etiam* from doing too much damage on Earth.

1. Optional: Have groups show their news segment as a class. This is not only an opportunity for students to showcase their hard work, but also a time for students to see other solutions before they do their individual project.
2. Once the news segments are complete, students are ready to move on to their individual project. Students will create a news article for people who want to know more about asteroid collisions with Earth and the science behind making this decision. This should meet all the criteria in the student handout. You may wish to provide students with a guide to help them structure their article. An option is provided at the end of this teacher guide.
3. Conduct a peer review of the News Article after students have completed a first draft.

* Copy the News Article Peer Review Feedback form found in the Student Instructions. Another option is to use the Student 3-Dimensional Individual Project Rubric.
* Assign each student a partner, preferably a partner from a different group.
* Students switch drafts and assess them using the peer review feedback form or 3-Dimensional Rubric.
  + Remind each student to give one positive comment and one constructive comment for each section on the checklist.
  + Allow students time to present their feedback to their partner, so their partner may ask clarifying questions if needed.

1. After receiving feedback, allow students time to complete a final draft based on the feedback they received.

**Assessment**

The Project Organizer can be formatively assessed using:

* *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix from the Unit Overview to inform your criteria.

The Group Culminating Project will be summatively assessed using:

* The *Group Project Criteria for Success* Checklist

The Individual Culminating Project will be summatively assessed using:

* The *3-Dimensional Individual Project Rubric*.
* Keep in mind that the Proficient level indicates that the student has successfully demonstrated understanding of the criteria. Because we are in the early stages of NGSS adoption, it may take multiple opportunities throughout the course of the year for students to reach Proficient.
* If you wish to give students a numeric score, you could take the average score of all of their rubrics or add up rubric scores to give students a summation out of the total. Because of the note above, this scoring may not correlate to traditional grading systems.
* While we recommend scoring all of the project criteria with the rubrics for each student, we understand the burden of that level of scoring.
  + One option is to select the rubrics that you wish to focus on for this project and use those to assess each student’s individual project. For example, in this unit you may wish to assess students on Engineering and Design and thus would just focus on the rubrics pertaining to the Engineering and Design PEs.
  + Another option is to review the Proficient level of each of the project’s rubrics and use the descriptions to generally analyze all student work for trends.

**Engineering and Design Process Graphic Organizer**

**Step 1: Develop models of all possible solutions**

* Draw a model of each possible design solution below. You will use these models to generate data as you test all the solutions. In your models, label the materials you will use for the different parts.

|  |  |
| --- | --- |
| Design Solution 1 | Design Solution 2 |
| Design Solution 3 | Design Solution 4 |

**Step 2: Plan an experiment to test all your solutions**

|  |  |  |
| --- | --- | --- |
| Identify the Independent Variable: What are you changing each time you run the experiment? | Identify the Dependent Variable: What will you measure or observe at the end of the experiment to see how successful the design is? | Identify the Controls:  What should you keep the same so that you only measure what you want to? |
|  |  |  |

Lab Set-Up: Draw and describe below:

Materials



Procedure



**Step 3: Run experiment and collect data**

Data Table

* Complete the data table below or draw a new one to record your data, including any observations. You should run multiple trials for each of the design solutions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Dependent Variable:  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | Other Observations |
|  | Trial 1 | Trial 2 | Trial 3 |  | |
| Design Solution 1 |  |  |  |  | |
| Design Solution 2 |  |  |  |  | |
| Design Solution 3 |  |  |  |  | |
| Design Solution 4 |  |  |  |  | |

**Step 4: Evaluate the data and use to inform your final design solution**

1. According to the test data, how well did each design meet the criteria of the problem?
   * Design Solution 1:
   * Design Solution 2:
   * Design Solution 3:
   * Design Solution 4:
2. What are the best characteristics of each design solution and how can you combine them into one improved solution?

**Optional Guide for Article**: *This guide serves as both a guide for the article’s structure as well as a reminder of what students should include in their individual project. However, this does not replace the Individual Project Criteria for Success and both documents should be used in conjunction. This is best used as a digital template, so students can replace the wording, but you may also make hard copies to serve as guidelines if students are writing their articles by hand.*

**News Article Title**

1-2 catchy sentences summarizing your article.

By YOUR NAME Month, ##, 20##

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

NAME OF YOUR CITY – In this paragraph, explain the problem of how *Etiam* is on a trajectory to hit the Earth. Use the *Individual Project Criteria for Success Checklist* to make sure you include all parts.

In these next two paragraphs, convince your audience why it is important we protect Earth from an asteroid collision. One paragraph should cite data from the fossil record and the next paragraph should compare *Etiam* to *Chelyabinsk*. Use the *Individual Project Criteria for Success Checklist* to make sure you include all parts.

|  |  |  |  |
| --- | --- | --- | --- |
| Fig 1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Fig 2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Fig 3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Fig 4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

In this next set of paragraphs, describe all possible solutions to the public, including the science concepts behind them. For each solution, draw a diagram in the spaces above. As you describe these diagrams in the paragraphs, you can refer to them by using figure numbers in parentheses. For example, “… (see Fig. 1).” Use the *Individual Project Criteria for Success Checklist* to make sure you include all parts.

*Draw a diagram and/or report calculations here for your final proposed solution.*

In this next set of paragraphs, describe the experiment you ran and how you used the data to evaluate all the potential design solutions. Use the *Individual Project Criteria for Success Checklist* to make sure you include all parts.

In this paragraph, describe how you combined best characteristics of different designs in order to come up with the best solution to prevent a collision between *Etiam* and Earth. Use the *Individual Project Criteria for Success Checklist* to make sure you include all parts.

End with a brief conclusion of 1-2 catchy sentences. You may wish to look at some online articles as samples to inspire ideas.