Stanford NGSS Integrated Curriculum

An Exploration of a Multidimensional World

UNIT 1

Colossal Collisions

What are the effects of an asteroid collision and how can we prevent a future one?

SCALE

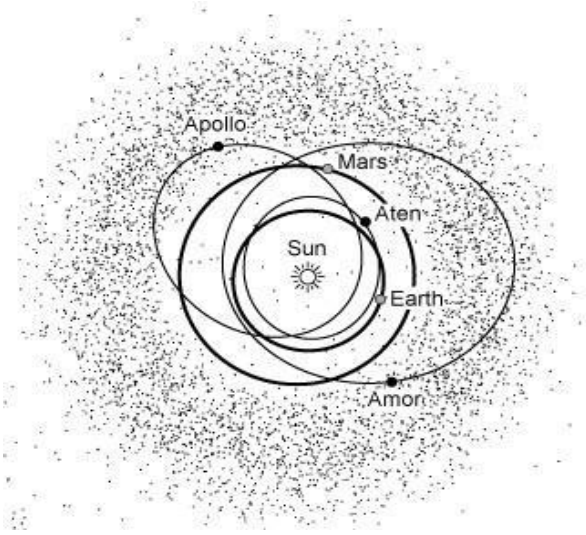
Stanford Center for Assessment, Learning & Equity

8th Grade Science Unit 1: Colossal Collisions
Culminating Project

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

Challenge

A very large asteroid (called *Etiam*) that is capable of destroying most life on Earth is headed our way. You and your team are going to work together on preventing the impending collision of *Etiam* with Earth. There are many different solutions to this problem—each one has its own challenges and benefits. How you decide to protect the Earth will depend on decisions that your group makes using the information and concepts you develop over the course of this unit. Once your group makes a decision on what your solution to save Earth is, your group will create a video news segment that describes how you plan to prevent this impending collision. As individuals, you 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.



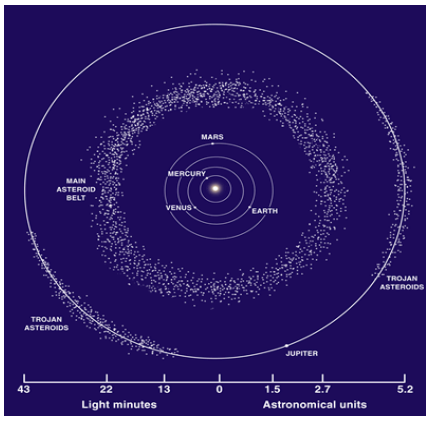
Background Data on Etiam

Shape:
Etiam has been described as having an irregular bone-shape.
Length at longest point: 78 km
Width at thickest point: 20 km
Width at thinnest point: 12 km

Mass:
6,890,000,000,000,000 or 6.89 x 10^{15} kg

Speed:
Etiam is travelling at 103,450 km/h.
This speed is relative to the Earth.

Location:
Etiam is 104.7 million km from Earth and about 84 million km from the edge of the asteroid belt. When triangulating with the sun, *Etiam* forms the point furthest from the Sun and the Earth in what appears to be - roughly - a right triangle (90° from the Earth, when compared to the Sun).



http://astronomy.swin.edu.au/cosmos/A/Asteroid+Belt

8th Grade Science Unit 1: Colossal Collisions
Culminating Project

Group Project Criteria for Success

Your news segment should:

- ☐ Explain the situation to the public
- ☐ Propose a Solution
  - ☐ How does your group plan to prevent a collision between *Etiam* and the Earth?
    - ☐ Show in a diagram and/or video
    - ☐ Explain the science concepts you used to help create your plan
  - ☐ Why did your group decide on this strategy instead of other strategies?
  - ☐ What are problems/concerns with your solution?
- ☐ Have High Video News Segment Quality
  - ☐ Includes a visual model that shows how your solution works
  - ☐ Is organized logically
  - ☐ Is interesting to the audience
  - ☐ Practices good oral presentation skills

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Individual Project Criteria for Success

Your news article should:

- Explain the problem of how *Etiam* is on a trajectory to hit the Earth.
  - What are the criteria for success in solving this problem?
  - What constraints exist that limit possible solutions?

- Convince your audience why it is important we protect Earth from an asteroid collision.
  - Cite data from the fossil record as evidence of past effects of asteroid collisions.
  - The public is familiar with another recent asteroid collision from February 2013. An asteroid known as *Chelyabinsk*, hit Russia. Its mass was 10,000,000 or 1 x 10^7 kg and its speed was 60,000-69,000 km/hr. How can you compare the force of *Chelyabinsk's* collision with the force of *Etiam*'s collision? Explain why the impact of one of these asteroids will be greater by describing the specific relationships between mass and kinetic energy and speed and kinetic energy.

- Describe and diagram all possible solutions for the public. These solutions must collectively use and explain all the following scientific concepts:
  - Gravity and mass
  - Newton's first law
  - Newton's second law
  - Newton's third law

  *You do not have to create a separate solution for each scientific concept. Some solutions may use many of these concepts within one solution.

- Propose a best solution.
  - Explain the investigation of solutions:
    - Describe the experiment you ran to evaluate all the potential design solutions. Include: independent variable, dependent variable, controls, procedure, and data collected.
    - Evaluate the different solutions: According to the test data, how well did each design meet the criteria of the problem?
  - What is your final design solution to prevent a collision between *Etiam* and the Earth?
    - How did you combine best characteristics of different designs to come up with the best possible design?
    - Show diagram of final design solution (and any calculations, if applicable).

8th Grade Science Unit 1: Colossal Collisions
Culminating Project

News Article Peer Review Feedback

Complete after you have a full first draft of your news article.

News Article Owner's Name	
News Article Reviewer's Name	

Review the following sections of the News Article:

- Explain the problem of how *Etiam* is on a trajectory to hit the Earth.
  - What are the criteria for success in solving this problem?
  - What constraints exist that limit possible solutions?

  - Positive Comment:

  - Constructive Comment:

- Convince your audience why it is important we protect Earth from an asteroid collision.
  - Cite data from the fossil record as evidence of past effects of asteroid collisions.
  - The public is familiar with another recent asteroid collision from February 2013. An asteroid known as *Chelyabinsk*, hit Russia. Its mass was 10,000,000 or 1 x 10^7 kg and its speed was 60,000-69,000 km/hr. How can you compare the force of *Chelyabinsk's* collision with the force of *Etiam*'s collision? Explain why the impact of one of these asteroids will be greater by describing the specific relationships between mass and kinetic energy and speed and kinetic energy.

  - Positive Comment:

  - Constructive Comment:

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- Describe and diagram all possible solutions for the public. These solutions must collectively use and explain all the following scientific concepts:
  - Gravity and mass
  - Newton's first law
  - Newton's second law
  - Newton's third law

  - Positive Comment:

  - Constructive Comment:

- Propose a best solution
  - Explain the investigation of solutions:
    - Describe the experiment you ran to evaluate all the potential design solutions. Include: independent variable, dependent variable, controls, procedure, and data collected.
    - According to the test data, how well did each design meet the criteria of the problem?
  - What is your final design solution to prevent a collision between *Etiam* and the Earth?
    - How did you combine best characteristics of different designs to come up with the best possible design?
    - Show diagram of final design solution (and any calculations, if applicable).

  - Positive Comment:

  - Constructive Comment:

8th Grade Science Unit 1: Colossal Collisions
3-Dimensional Individual Project Rubric

Overview: The following rubrics can be used to assess the individual project: a news article detailing background and solutions to the *Etiam* collision. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on your Culminating Project Student Instructions. Use these rubrics to see if you are doing your best work on your individual project.

Rubric 1: Student defines the problem of an asteroid collision, including criteria of success and constraints that might limit possible solutions.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **does not** define the problem of an asteroid collision **and/or** includes **inaccurate or irrelevant** criteria of success and constraints that might limit possible solutions.	Student **accurately** defines the problem of an asteroid collision, including **accurate** criteria of success **OR** constraints that might limit possible solutions.	Student **accurately** defines the problem of an asteroid collision, including **accurate, but partial** criteria of success **and** constraints that might limit possible solutions.	Student **accurately** defines the problem of an asteroid collision, including **accurate and complete** criteria of success and constraints that might limit possible solutions.

Rubric 2: Student explains the importance of protecting Earth from an asteroid collision by citing similar patterns in the fossil record data as evidence.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **irrelevantly** explains the importance of protecting Earth from an asteroid collision.	Student **accurately** explains the importance of protecting Earth from an asteroid collision but cites **no specific** patterns in the fossil record data as evidence.	Student **accurately** explains the importance of protecting Earth from an asteroid collision by citing **one** similar pattern in the fossil record data as evidence.	Student **accurately** explains the importance of protecting Earth from an asteroid collision by citing **multiple** similar patterns in the fossil record data as evidence.

Rubric 3: Student describes the relationships between mass, kinetic energy, and speed, and uses these relationships to provide information about the potential magnitude of the *Etiam* collision.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student describes **no** relationships between mass, kinetic energy, and speed, **and/or** uses relationships to provide **inaccurate** information about the potential magnitude of the *Etiam* collision.	Student describes **partial** relationships between mass, kinetic energy, and speed, and uses this relationship to provide **accurate** information about the potential magnitude of the *Etiam* collision.	Student describes **complete but general** relationships between mass, kinetic energy, and speed, and uses these relationships to provide accurate information about the potential magnitude of the *Etiam* collision.	Student describes complete **and specific** relationships between mass, kinetic energy, and speed, and uses these relationships to provide accurate information about the potential magnitude of the *Etiam* collision.

8th Grade Science Unit 1: Colossal Collisions

3-Dimensional Individual Project Rubric

Rubric 4: Student draws a model to represent a potential deflection strategy and explains how mass and gravity could affect *Etiam*'s trajectory using this solution.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student draws an **irrelevant** model to represent a potential deflection strategy that **does not** use the effect of mass on gravitational attraction.	Student draws a **relevant** model to represent a potential deflection strategy but **does not accurately** explain how mass and gravity could affect *Etiam*'s trajectory using this solution.	Student draws a **relevant** model to represent a potential deflection strategy and **accurately, but partially** explains how mass and gravity could affect *Etiam*'s trajectory using this solution.	Student draws a **relevant** model to represent a potential deflection strategy and accurately **and completely** explains how mass and gravity could affect *Etiam*'s trajectory using this solution.

Rubric 5: Student develops models of potential design solution(s) to prevent a collision and uses Newton's laws to explain why the solution(s) work.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student develops models of **irrelevant** potential design solution(s) to prevent a collision **that do not use** Newton's laws.	Student develops models of **relevant** potential design solution(s) to prevent a collision that uses Newton's law(s) **but does not use** Newton's laws to accurately explain why the solution(s) work.	Student develops models of relevant potential design solution(s) to prevent a collision **and uses some of** Newton's laws to accurately explain why the solution(s) work.	Student develops models of relevant potential design solution(s) to prevent a collision and uses **all of** Newton's laws to accurately explain why the solution(s) work.

Rubric 6: Student describes the experiment conducted to test potential solutions and uses test data to evaluate how well each met the design criteria.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student describes an **inaccurate or irrelevant** experiment conducted to evaluate potential solutions **and/or does not use** test data to evaluate how well each met the design criteria.	Student **generally** describes the experiment conducted to test potential solutions **and** uses test data to **incompletely** evaluate how well each met the design criteria.	Student **partially** describes the experiment conducted to test potential solutions **and/or** uses test data to **partially** evaluate how well each met the design criteria.	Student **completely** describes the experiment conducted to test potential solutions **and** uses test data to **completely** evaluate how well each met the design criteria.

Rubric 7: Student draws and describes a final design solution and explains how it combines best characteristics of different designs.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student draws and describes a final design solution that **does not combine** best characteristics of different designs.	Student draws and describes a **relevant** final design solution but **does not explain** how it combines best characteristics of different designs.	Student draws and describes a **relevant** final design solution and **partially** explains how it combines best characteristics of different designs.	Student draws and describes a **relevant** final design solution and **completely** explains how it combines best characteristics of different designs.

8th Grade Science Unit 1: Colossal Collisions
Project Organizer

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

You will be designing a solution to prevent the impending collision of the asteroid *Etiam* with Earth. After each task, you will return to the table below to organize what you learn as you go through the unit. By the end of the four tasks, you will have all this information to use for your culminating project. For each activity, be sure to include answers to **ALL** the questions provided.

Lift-Off Task: Asteroid Collisions	In order to develop a solution to an impending collision with the asteroid *Etiam*, we need to learn everything we can about the impacts of an asteroid collision. ❑ Summarize what you already know about collisions, including: ○ Possible negative consequences. ○ The types of methods humans use to prevent every-day collisions.
Task 1: An Ancient Collision	Today we learned that there has already been an asteroid collision in the past that had huge consequences. Use this ancient collision to justify your design solution: ❑ 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?

8th Grade Science Unit 1: Colossal Collisions

Project Organizer

Task 2: Contact Forces	In this task, you explored and studied how different contact forces and factors like mass help predict the motion of objects. Now, let's use these ideas to start deciding how to deflect *Etiam* from its path towards Earth. ❒ How will *Etiam's* large mass affect Earth? Use experimental evidence from the task as well as scientific ideas of mass, kinetic energy, and speed to back up your response. ❒ How can Newton's three laws help us predict and explain 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?

8th Grade Science Unit 1: Colossal Collisions

Project Organizer

Task 3: Gravity – A Non-Contact Force	In this task, you learned about another, less tangible force that also affects the motion of *Etiam*. Look back at the trajectory of *Etiam* from your Culminating Project handout and brainstorm where this force may help you prevent *Etiam's* collision with Earth. ❒ Draw a diagram showing how gravity is currently influencing *Etiam.* ❒ What other objects in our solar system might influence *Etiam's* movements as it travels through space? Why? ❒ Illustrate moments in *Etiam's* trajectory where the asteroid might be impacted by other gravitational forces in a way that changes its trajectory. ○ Explain how this works.

8th Grade Science Unit 1: Colossal Collisions

Lift-Off Task: Asteroid Collisions

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

The picture above is a pretend illustration of a possible asteroid collision with Earth 65 million years ago.

Part A: If you wanted to know more about this historical asteroid collision, what questions would you ask? Individually, record any questions that you would need to ask to get a better understanding of this event.

8th Grade Science Unit 1: Colossal Collisions

Lift-Off Task: Asteroid Collisions

Part B: As a group,

- Discuss what questions each member wrote on his or her list.
- On a large piece of poster paper:
  - Write the phrase "Asteroid Collisions" in the middle of your poster and draw a circle around it.
  - Around the circle, record the questions that were similar across your group members.
  - Draw lines to link together questions that relate to each other.
  - Draft possible answers to the questions, using your prior knowledge. Connect these to the questions on your poster.
- Post your group poster on the wall.
- Walk around and look at each groups' ideas.

Part C: As a whole class,

- Construct a class concept map with the phenomenon in the middle: "Asteroid Collisions".
  - Decide which key questions you want to have on the concept map.
  - Draw lines with arrows between two key questions to show that there is a relationship.
  - Make as many connections as you can between the questions on the concept map.
- It's important for everyone to share their ideas and it's okay if you don't agree.
- You will revise and add new questions and information to this concept map as you learn more about asteroid collisions.

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

Connecting to the Culminating Project

You will be designing a solution to prevent the impending collision of the asteroid *Etiam* with Earth. In order to develop a solution to an impending collision with ~~a~~steroid *Etiam*, we need to learn everything we can about the impacts of an asteroid collision.

- ❑ Summarize what you already know about collisions, including:
  - Possible negative consequences.
  - The types of methods humans use to prevent every-day collisions.

This should be completed individually in your Project Organizer.

8th Grade Science Unit 1: Colossal Collisions
Lift-Off Task: Asteroid Collisions

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

Reflection

Individually reflect on the Lift-Off Task, using the questions provided:

1. At the beginning of this task, you made a list of all the questions you have about an asteroid collision 65 million years ago. Look back at your list: think about the questions your peers asked that you did not initially write down. How are those questions different from the ones you originally asked?

2. In this unit, we will be focusing on four crosscutting concepts:
    - **Patterns:** Graphs, charts, and images can be used to identify patterns in data.
    - **Scale, Proportion, and Quantity**: There are proportional relationships between different types of quantities.
    - **Systems and System Models**: Models can be used to represent systems and their interactions.
    - **Stability and Change:** We can examine forces at different scales to explain stability and change.

    Looking at your class concept map, give one example of how a crosscutting concept came up in today's task.

3. Now that you understand what project you'll be working on over the course of this unit, what else do you need to know? What additional questions do you have?

8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

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

Engage

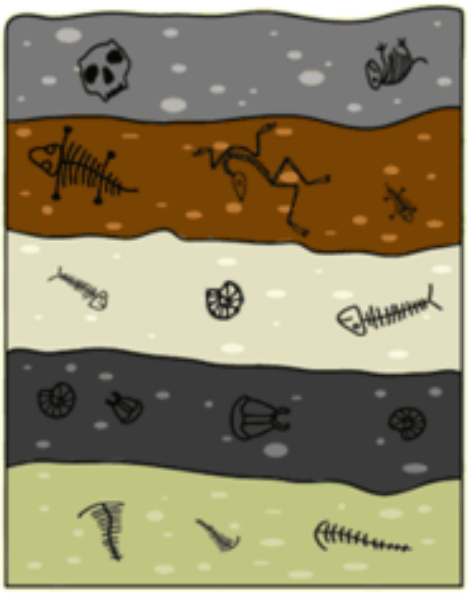
In the Culminating Project Challenge, we found out that an asteroid, called *Etiam*, is headed towards Earth, so we need to learn everything we can to help prevent this. There is a theory that a large asteroid hit Earth 65 million years ago. What might be the consequences of an asteroid colliding with Earth?

In groups, pull together all of your prior knowledge and see if you can guess what asteroid collision this refers to. Record below:

In order to learn about the history of life on Earth, scientists examine the ground to study the soil and the fossils of ancient organisms that are stored within each layer. They call this the "fossil record." Before we look at data from the fossil record, let's practice how to read it in pairs:

1. Which do you think are the oldest fossils and the youngest fossils? Label on the diagram and explain why.

2. How do you see species changing over time? Pick one example species and circle it in the layers on the diagram. Explain what anatomical changes you see over time and make a prediction for why you think these changes happened.



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8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

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

Explore

Analyzing and Interpreting Data: The fossil record documents the existence of a large variety of life forms, chronicling how they have changed over time and even how many have become extinct. However, today we are going to focus on looking for evidence of one type of event in the fossil record—an asteroid collision. By the end of this activity, you should be able to conclude whether a large asteroid collision has happened in the past and identify any consequences.

As a group, explore the stations and record your analysis in the chart below:

	Type of Data (Graph, image, description, etc)	**Observations: What do you see?**	**Responses to the Discussion Questions**
Resource Card 1			
Resource Card 2			

8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

	Type of Data (Graph, image, description, etc)	Observations: What do you see?	Responses to the Discussion Questions
Resource Card 3			
Resource Card 4			
Resource Card 5			

8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

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

Explain

Constructing Explanations: Now that you have collected evidence from fossil and soil data, individually write a CER (Claim-Evidence-Reasoning) paragraph concluding whether a large asteroid has hit Earth before and what the effects were. In your explanation, use **patterns** from the *Explore* data as evidence to help support your claim.

Claim	
Evidence	
Reasoning	

8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

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

Elaborate

The following activity is to help you and your peers strengthen and clarify your CER paragraph. Each time you talk to a new partner, you can build from their ideas and borrow the language of previous partners.

Instructions:

1. Record ideas and language you liked from your own CER paragraph in the chart below to help you think about what you will say to your partner (1 minute)
2. Stand in front of your assigned partner. Turn your papers upside down, so that you are not looking at it while speaking. Take turns sharing your argument aloud (1 minute per person).
    a. After each partner shares, the listener may ask clarifying questions. Have a discussion about strengths and suggestions (1 minute per person).
3. You will then have time to record any ideas or language that will make your CER paragraph stronger and clearer (1 minute).
4. When your teacher calls time, each of you in the inner circle will move one space to the right, so you have a new partner. Repeat Steps 2 and 3.

	Ideas and Language I like from the CER
Me	
Partner 1	
Partner 2	

8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

Individually, use the space below to write a revised version of your CER paragraph, borrowing from the ideas and language of your peers. Remember that while it is encouraged to learn from others, it is not okay to copy directly!

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

Evaluate: Connecting to the Culminating Project

You will be designing a solution to prevent the impending collision of the asteroid *Etiam* with Earth. Today we learned that there has already been an asteroid collision in the past that had huge consequences. Use this ancient collision to justify your design solution:

- ❑ 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?

This should be completed individually in your Project Organizer.

8th Grade Science Unit 1: Colossal Collisions

Task 1: An Ancient Collision

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

Reflection

Individually reflect on Task 1, using the questions provided:

1. At the beginning of this task, you were asked to guess what asteroid collision occurred 65 million years ago. Look back at your prediction: after collecting all the evidence today, how would you change or add to your prediction?

2. In this task, we focused on the crosscutting concept of:
   - **Patterns:** Graphs, charts, and images can be used to identify patterns in data and these patterns can be used to identify cause-and-effect relationships.

   Where did you see examples of **Patterns** in this task?

3. Now that you have learned more about the fossil record and what it tells us about asteroid collisions, what questions do you still have?

8th Grade Science Unit 1: Colossal Collisions
Task 2: Contact Forces

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

Engage

Now that you know why it's so important we protect against another asteroid collision, it's time to figure out how we might design a solution to this problem. To do this, let's look more closely at what might happen when other things collide.

You will be given a series of scenarios (situations) to examine. For each scenario, use your own knowledge to explain why they happen as best you can.

For each scenario:

- With your partner, discuss the scenario.
- Below, describe the scenario with words and with pictures.
- As best you can, write an explanation for *why* you think the scenario happens the way it does.

Description of scenario, in words	**Systems and System Models: Description of scenario, in drawings**	**Describe why you think this happens**
A.		
B.		

8th Grade Science Unit 1: Colossal Collisions

Task 2: Contact Forces

Description of scenario, in words	Systems and System Models: Description of scenario, in drawings	Describe why you think this happens
C.		
D.		
E.		
F.		

8th Grade Science Unit 1: Colossal Collisions

Task 2: Contact Forces

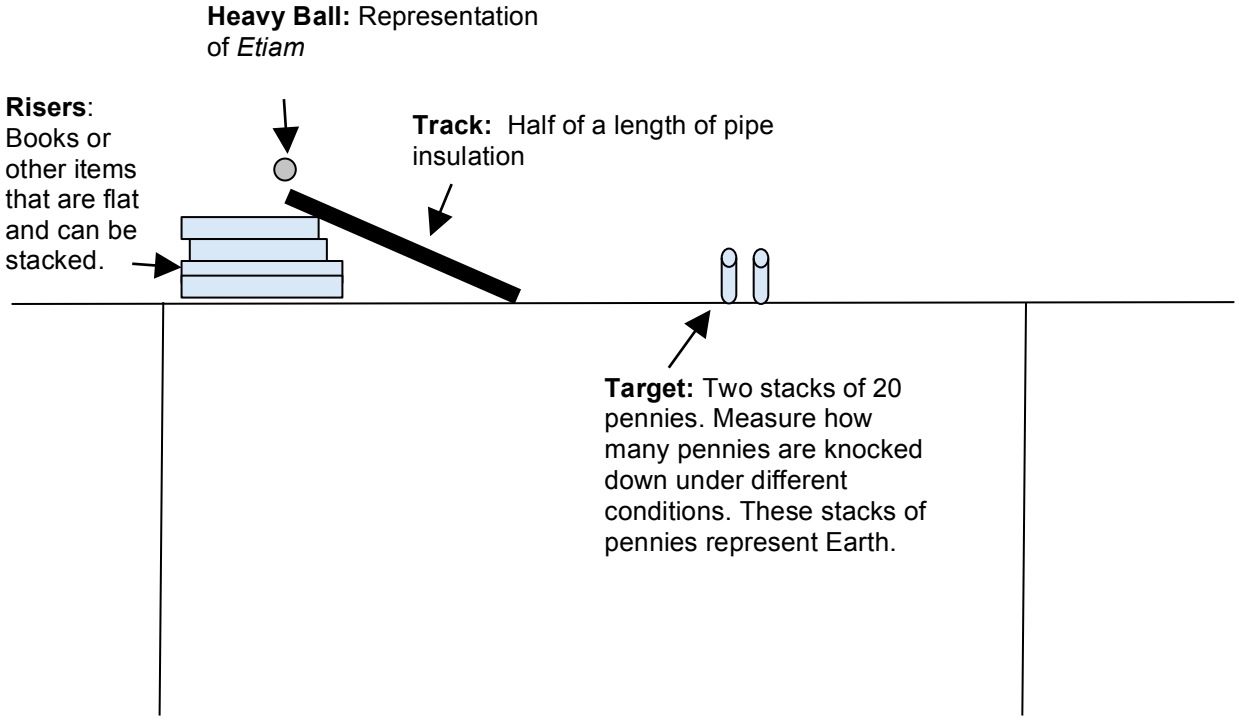
Unit Essential Question: *What are the effects of an asteroid collision and how can we prevent a future one?*

Explore

Experimental Question: *How can we stop a rolling ball from knocking down a stack pennies?*

While it is difficult to investigate how you might save the Earth from an impending asteroid collision, you can use a model to examine the forces involved at a much smaller scale, which will help inform your solution. In your model, a stack of pennies will represent Earth and a ball rolling down a track will represent *Etiam*. As the ball rolls down, your group wants to prevent the ball from knocking any pennies from the stack. Your group will have the following materials to help you come up with solutions to deflect *Etiam* from Earth.

Materials for ramp set-up	Materials for deflecting *Etiam*
• Stack of 40 pennies (Earth) • Heavy ball or large marble (asteroid *Etiam*) • A track for *Etiam's* trajectory (pipe insulation tubing, cut in half lengthwise) • Risers (4 textbooks)	• String • Balls of varying mass • Foam • Rubberbands • Popsicle sticks • Plastic spoons • Tape



8th Grade Science Unit 1: Colossal Collisions

Task 2: Contact Forces

Designing Solutions: As a group, use any scientific ideas you know or experiences you've had to design different ways to deflect the asteroid *Etiam* from its collision course with Earth. Record and explain all attempts in the table below.

Attempts to Deflect *Etiam*			
Trial	**Setup (Draw/describe)**	**Observations (How did the objects move?)**	**Reasoning (Why do you think the objects moved the way they did?)**
1			
2			
3			

8th Grade Science Unit 1: Colossal Collisions

Task 2: Contact Forces

Attempts to Deflect *Etiam*			
Trial	**Setup (Draw/describe)**	**Observations (How did the objects move?)**	**Reasoning (Why do you think the objects moved the way they did?)**
4			
5			
6			

Systems and System Models: As a group, make a poster that shows your best deflection strategy. Draw a model to represent how it works to prevent the collision and prepare to share it with the class.

8th Grade Science Unit 1: Colossal Collisions

Task 2: Contact Forces

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

Explain

We are starting to understand how forces make things move (or not move). You will now learn more about the scientific ideas behind contact forces so that you can explain why things move, what a push/pull is, and what happens when objects collide. Pair up with a partner and watch the videos provided by your teacher. Complete the graphic organizer below, recording definitions, examples, and diagrams.

Topic we are learning	Definition and Example	Diagrams
Forces		
Newton's 1st law		
Newton's 2nd law		

8th Grade Science Unit 1: Colossal Collisions

Task 2: Contact Forces

Newton's 3rd law		

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

Elaborate

Experimental Question: *How can I knock over the most/least amount of pennies?*

Planning and Carrying Out Investigations: To better understand the damage that an asteroid can do to Earth, you will be investigating different kinds of "asteroids" and their impact on "Earth". During your investigation, a stack of pennies will represent Earth and a set of rolling objects will represent *Etiam*. Your group will be using this model to test different conditions of an asteroid hitting Earth. You have the following materials available to you:

- Stack of 40 pennies (Earth)
- A track for *Etiam's* trajectory (pipe insulation tubing, cut in half lengthwise)
- Risers (4 textbooks)
- Ruler
- Marbles of varying mass

In groups, complete the planning questions below to help you plan your experiment:

Planning Questions

1. Identify the Dependent Variable: What are you trying to measure or observe at the end of the experiment?

2. Identify the Independent Variable: What will you need to manipulate (change) in order to measure this?

3. What should you keep the same so that you only measure what you want to?

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Task 2: Contact Forces

4. Describe your experiment: What are you testing? How are you going to test it? What materials will you use?

Lab Set-Up

Materials

-
-
-
-
-
-
-
-

Procedure

1.
2.
3.
4.
5.
6.

Once your teacher has approved your experimental design, run your experiment and record data in the table below. *Optional* - slow motion record your marble collisions to share with the class later!

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Task 2: Contact Forces

Data Table: I changed _____

I controlled _____

	_____					
_____	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	_____
_____						
_____						
_____						
_____						
_____						

In pairs, use your experimental results and scientific knowledge to answer the following questions:

1. **Stability and Change:** The stacks of pennies that represent "Earth" are not moving at the beginning of the experiment. What causes this to change? Which of Newton's laws does this represent?

2. What happened to the balls ("Etiam") after they hit the pennies ("Earth")? How does this relate to Newton's third law of motion?

3. What happened to the stack of pennies when the mass of the ball was changed?

4. **Analyzing and Interpreting Data:** To understand why more pennies fell down with certain balls, you need to understand the relationships between the mass of an object, its kinetic energy, and its speed. Imagine you are able to go to a physics lab where you can conduct this experiment with balls of more mass and you can actually measure the kinetic energy and speed of each ball, rather than just how many pennies it knocks over. The data is shown below:

Asteroid Ball	Mass of Ball (In kilograms)	Kinetic Energy (In Joules)	Speed (In meters per second)
Ball A	0	0 J	0
Ball B	0.5	100 J	10
Ball C	1.0	200 J	14.2
Ball D	1.5	300 J	17.3
Ball E	2.0	400 J	20
Ball F	2.5	500 J	22.4
Ball G	3.0	600 J	24.5

a. Make line graphs of the data to help you identify the relationships between mass and kinetic energy and speed and kinetic energy. Fill out the table below:

Relationship Between Mass and Kinetic Energy	**Relationship Between Kinetic Energy and Speed**
Make a line graph of the data in the table above to show the relationship between mass and kinetic energy:	Make a line graph of the data in the table above to show the relationship between speed and kinetic energy:

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Describe the mathematical relationship between mass and kinetic energy:	Describe the mathematical relationship between speed and kinetic energy:

b. **Scale, Proportion, and Quantity:** What do these relationships tell you about why the balls with more mass knock over more pennies? What does this mean for Earth if *Etiam* has a lot of mass?

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

Evaluate: Connecting to the Culminating Project

You will be designing a solution to prevent the impending collision of the asteroid *Etiam* with Earth. In this task, you explored and studied how different contact forces and factors like mass help predict the motion of objects. Now, let's use these ideas to start deciding how to deflect *Etiam* from its path towards Earth.

- ✓ How will *Etiam's* large mass affect Earth? Use experimental evidence from the task as well as scientific ideas of mass, kinetic energy, and speed to back up your response.
- ✓ How can Newton's three laws help us predict and explain 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?

This should be individually completed in your Project Organizer.

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Task 2: Contact Forces

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

Reflection

Individually reflect on Task 2, using the questions provided:

1. At the beginning of this task, you attempted to explain why different scenarios happen the way they do. Look back at your responses: after learning everything you have about contact forces, how can you add to or revise your explanations? Use information from the task to better explain these scenarios with the new scientific ideas we learned today.

2. In this task, we focused on the crosscutting concepts of:
    - **Scale, Proportion, and Quantity**: There are proportional relationships between different types of quantities.
    - **Systems and System Models**: Models can be used to represent systems and their interactions.
    - **Stability and Change:** We can examine forces at different scales to explain stability and change.

    Where did you see examples of **Scale, Proportion, and Quantity, Systems and System Models**, and **Stability and Change** in this task?

3. Now that you have learned more about the contact forces that are involved in an asteroid collision and preventing an asteroid collision, what questions do you still have?

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

Engage

In the last task, you explored the obvious forces acting on objects as they move, don't move, and collide. Today, you will look at a less tangible force that also affects the collision course of the asteroid, *Etiam*.

https://www.scientificamerican.com/article/make-craters-with-mini-meteors-bring-science-home/

To better understand this invisible force and its effect on *Etiam*, we can make a model using sand and a ball. In our model, the sand will represent Earth and the ball will represent *Etiam.* After the teacher demonstrates the model, discuss your observations and analyses with a partner and answer the questions below:

1. What happened when your teacher dropped the balls (models of *Etiam*)? Record your observations.

2. Why do the balls move in that direction? What force is affecting the balls?

3. When both balls were dropped at the same time and from the same height, did they reach the ground at the same time? Why do you think this is?

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4. What is the difference between the two balls?

    a. How did this difference affect the crater size in the sand (Earth)?

5. Can you think of other examples of this invisible force from your daily life? Discuss with the rest of your group members and record a few below:

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

Explore

Systems and System Models: We know that gravity is a force acting on objects, but we need to learn more about gravity so maybe we can use it to prevent the collision of *Etiam* and Earth. Today you will receive three resources on gravity: a video model, a data set, and a computer simulation model. All of these will help you decide how gravity works and what factors affect the pull gravity has on objects.

In groups, follow the instructions on the resource cards provided by your teacher and fill out the chart below:

	Draw pictures to show what the resource tells/shows you about gravity	**Discussion Questions**
Resource 1: Video Model		1. What force keeps the pink and blue alien attracted to the planet he is first sitting on?

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		2. When he first tries to jump to the other planet, what happens? Why do you think this happens? 3. Why do you think he is finally able to move to the other planet? What keeps him on the other planet?
Resource 2: Data Set		1. Which body has the largest mass? a. How does the time it takes for a rock to reach that body's surface compare to others? 2. Take a look at the right-hand column. If the time is shorter, does that mean the gravitational pull is stronger or weaker?

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		3. Now compare the two right-hand columns. Write a rule that compares mass of the body and gravitational pull. Optional sentence stem: The _____ the mass of the body, the ____ the gravitational pull.
Resource 3: Computer Simulation Model		Part 1: 1. How does the mass of the Sun impact the orbit of Earth? 2. What would happen if the mass of the Sun increased? 3. What would happen if the mass of the Sun decreased? Part 2: 1. How would you describe the Moon's movement?

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		2. What would happen to the Moon if the Earth's mass decreased? 3. What would happen to the Moon if the Earth's mass increased?

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

Explain

Individually, fill in the KNOW and WANT TO KNOW sections of the KWL chart below, keeping in mind what you already know or have learned from the Explore.

K (KNOW)	W (WANT TO KNOW)	L (LEARNED)

As a class, watch this video about gravity: https://www.youtube.com/watch?v=EwY6p-r_hyU ? (until 10:25) and fill in the LEARNED section of the KWL chart. After the video, share what you learned with your group members and add at least one new thing you learned from your discussion to the LEARNED section.

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Lastly, with your group, draw some conclusions about gravity:

1. In your own words, how would you describe gravity? Use an example from the Explore resources to back up your description.

2. In your own words, explain how the *mass* of an object affects its *gravitational force*. Use an example from the Explore resources to back up your description.

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

Elaborate

You have two friends from another school that haven't learned about gravity, like you have. They are having an intense argument about how astronauts on the moon avoid floating away into space.

- Friend 1 says the astronauts must have a cord tied to them at all times in order to avoid floating away into space.
- Friend 2 says the astronauts must always wear heavy boots to avoid floating away into space.

Engaging in Argument From Evidence: Help your friends out by individually explaining why both of them are wrong. Cite specific evidence from previous sections of this task to back up your argument.

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Task 3: Gravity – A Non-Contact Force

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

Evaluate: Connecting to the Culminating Project

You will be designing a solution to prevent the impending collision of the asteroid *Etiam* with Earth. In this task, you learned about another, less tangible force that also affects the motion of *Etiam*. Look back at the trajectory of *Etiam* from your Culminating Project handout and brainstorm how this force may help you prevent *Etiam's* collision with Earth.

- ❒ Draw a diagram showing how gravity is currently influencing *Etiam.*
- ❒ What other objects in our solar system might influence *Etiam's* movements as it travels through space? Why?
- ❒ Illustrate moments in *Etiam's* trajectory where the asteroid might be impacted by other gravitational forces in a way that changes its trajectory.
    - Explain how this works.

This should be completed individually in your Project Organizer.

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

Reflection

Individually reflect on Task 3, using the questions provided:

1. At the beginning of this task, you predicted why objects fall down towards Earth. Look back at your initial response: after learning everything you have about gravity, how can you make your response more specific? What other details have you learned about gravity?

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Task 3: Gravity – A Non-Contact Force

2. In this task, we focused on the crosscutting concept of:
    - **Systems and System Models**: Models can be used to represent systems and their interactions.

   Where did you see examples of **Systems and System Models** in this task?

3. Now that you have learned more about how gravity may be involved in an asteroid collision and preventing an asteroid collision, what questions do you still have?