Space Junk

Science Performance Assessment

Middle School

Task Table of Contents

About This Task

Task Name	Space Junk	Grade Level or Course	Middle School
Phenomenon or Phenomenon Based Problem Description	We pollute Earth orbit just like we pollute land, air, and ocean. How do space junk collisions affect other things in orbit?	**What instruction or experiences should learners have before completing this task?**	Students should have experience with investigations and analyzing data to apply ideas about Newton's third law in the context of real world objects colliding.
Time Required & Materials	**Time:** 45 minutes **Materials Needed:** ● Copies of the task worksheet for each student.		
Considerations and Adaptation Suggestion(s)	Part 3 of this task could be augmented by asking students to share their invention ideas in a gallery walk, by having them make a 3D model of their invention physically or digitally, and/or by facilitating a round of peer feedback and revision.		

Standards Emphasis

Assessment is a balancing act involving multiple tradeoffs. No one task can do everything, and often good design carefully considers what *not* to assess. The targeted NGSS Performance Expectation and supporting dimensions are shown below. The parts of the standard not addressed in the task are ~~struck through~~. Each item in the task may target one or more of the dimensions - not every item has to assess every dimension. What matters is that the task as a whole addresses all three dimensions.

NGSS Performance Expectations • **MS-PS2-1:** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Construct an explanation using models or representations.	**PS2.A: Forces and Motion** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).	**Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

PADI Design Principles Emphasis

The PADI design principles are present in varying ways and to different degrees across these teacher-created science performance tasks. The design principles highlighted for each task represent those that are intentionally emphasized in the task. Educators utilizing these tasks may develop their own interpretations of the application of the design principles, and modifications to the tasks could naturally influence the extent to which each principle manifests.

The PADI Design Principles are:
Student Voice & Agency. Task or activity ensures that the students can make choices within and have agency over some aspects of the learning and assessment experience.

Relationships. Task or activity provides opportunities for students to make connections with others both within and beyond the classroom.

Identity and Inclusion. Task or activity ensures that each student can bring a sense of joy and pride around their identity and individuality to the task. Students should feel safe to be vulnerable and should feel supported by their classroom community (teachers and students).

Groundedness. Task or activity ensures that students can complete the task in their current environment using their current context to apply real-world knowledge to the place where they live. All participants should have awareness of self, others, and surroundings. Task or activity should prioritize presence over productivity. Students should feel like they can answer the question: “Where are my feet planted? What can I do from here?”

This task foregrounds:

- **Identity and Inclusion** by introducing a scientist of color who is working on the issue of space junk and the space ecosystem and asking students to think about the relationship between the value of Āina (our responsibility to the land) and the space environment.
- **Student Voice & Agency** by asking students to invent an idea to clean up space junk.

Teacher Facilitation Guidance

Often performance assessments are new to students. They usually require some degree of transfer from their classroom learning experience and students will need support to share all their ideas in the task.

1. **Review the Task.** Complete the performance assessment acting as a student in your classroom. Think about the unit you have taught/are teaching. Where might your learners need additional support? What additional activities might you need to do before the Performance Assessment? What adjustments do you need to make to the assessment (e.g., a classroom discussion of the phenomenon) before you send students to complete the task.
    a. Decide how you want to group students for part 3 of the task.
    b. If there is time, part 3 of this task could be augmented by asking students to share their invention ideas through a gallery walk and/or by facilitating peer feedback and revision.

2. **Orient to the Transfer Task Routine.** Refer to the "During–" and "After the Transfer Task Implementation" guidance in the "Transfer Task Routine" document on how to support students in their experience. Consider what additional support your students may need as they work to apply science ideas they have developed to a new scenario.

3. **Introduce the task context.** Introduce Moriba Jah. He is an Astrodynamicist from the University of Texas who studies the near-Earth space environment and sustainability.
    a. First play the video about his research: https://www.youtube.com/watch?v=qFVs_mXllWs
    b. Hand out the student task worksheet.

4. **Review the Wayfinder tool in partners.** Ask students to explore the Wayfinder Tool (https://wayfinder.privateer.com/) with a partner and complete questions 1 and 2 together.

5. **Clarify the Relevance.** After students have time to reflect on the video and explore the Wayfinder tool, make sure to clarify the idea that satellites provide people with many services like internet, TV, GPS, and phone service. Functional satellites orbit the Earth alongside nonfunctional space junk. Space junk varies in size, though most space junk is smaller than a few centimeters.

6. **Complete Part 2 Individually.** Give students 10-15 minutes to complete part 2 individually.

7. **Introduce Part 3.** Introduce the invention component of this task and review what needs to be included in their explanation. Offer ideas like a net, tether, magnetic tug, or laser if needed. Remember to add additional details for how you plan to facilitate this in class, how students will be sharing their ideas, and if you choose to extend this.

8. **Wrap up.** Ask students to reflect on their experience with this assessment and share where they felt confident and where they struggled.

Student Task Worksheet

A student version of the task worksheet is linked here.

Feedback and Scoring Guidance

Sample student responses are shown below in purple text or in purple diagrams. In some cases different elements of a response are identified with a + symbol. These + elements are not meant to be all inclusive, but are suggestions for different ideas your students might include.

The following scoring guidance can help you identify different elements that students should (or could) include in their responses.

- If several of the elements marked with a + are missing from a student's response, this may indicate that the student has not mastered the science ideas or that the student may be struggling to bring those ideas together in a written explanation or model. Additional probing of their thinking can provide insight about whether the student is struggling with a science practice or science idea, or both.
- If all or almost all of the elements marked with a + are present in a student's response, this may indicate that the student has mastered the science ideas and is able to use them in a written explanation or explanatory model.
- If the elements marked with a ++ are present in a student's response, this indicates that the student is bringing a deeper understanding of the science ideas or a deeper engagement with the practice to their response. Students should not be penalized if ideas marked with a ++ are not present in their response.

Part I. Learn about Space Junk

1. According to the information in the video and your exploration of the Wayfinder, what is the problem that needs to be solved?

Accept all student responses that are relevant to the idea that space junk, which is nonfunctional pieces of debris from broken satellites and other things in space, is abundant in near-Earth orbit and is causing or threatening to damage satellites and other technologies that provide us services here on Earth.

Moriba Jah said "We pollute Earth orbit just like we pollute land, air, and ocean. How can we behave as stewards of the space environment, which is a finite resource and do so in a way where we can use it as long as we can."

2. Consider Āina (our responsibility to the land) and the space environment. Think about how we consider the space environment in the same ways we think about Āina. What is one action you think people should take to be stewards of the space environment?

Accept all student responses that are related to taking care of the space environment. Students may also say that it isn't as important as the land and therefore less necessary to take action.

Part II. How can something as small as a paint chip cause damage in space?

Using the data in Tables 1 and 2 and what you know about forces, motion, and collisions, explain how a

very small piece of space junk can damage something like a satellite or space station.

In your explanation:

- Use **both words and pictures** (for example, labeled diagrams, arrows showing motion, or before-and-after drawings).
- Describe **how the forces** on the satellite and the space junk **compare** when they collide.
- Explain **how the total kinetic energy** in a collision in space **compares** to collisions you know about on Earth.
- Describe **what happens to the energy** of the space junk when it strikes the satellite or space station window.
- Use evidence or examples from the tables to support your ideas.

+ The force on the space junk is equal and opposite the force on the satellite at the moment of collision.
+ Uses evidence from table 1 and table two to support their explanation. For example, the speed of space junk in near-Earth orbit is 270x the speed of a fast car on the highway.
+ Even though the space junk is small, its huge speed means it has a lot of kinetic energy.
+ Compared to Earth collisions (e.g., baseballs or car crashes), collisions in space involve much greater speeds, so much greater kinetic energy in the system at the time of collision.
+ The kinetic energy transfers to the satellite or window. That energy becomes heat, sound, light, and deformation (e.g., cracks, holes, melting).

Part III. How can we clean up space?

Engineers are working on ways to remove **space junk**, the tiny pieces of debris that zip around Earth at thousands of miles per hour. Your job is to **invent and explain** a creative way to clean up space!

Your Task

Design and explain a method to remove space junk from near-Earth orbit. Be imaginative — your idea doesn't have to be totally realistic, but it should show how science ideas help it work.

In your explanation of your invention:

1. **Describe your idea.**
   - What is your device or system?
   - How does it work to capture, move, or destroy space junk?
2. **Draw and label a model.**
   - Show how your device interacts with the debris.
   - Use arrows or labels to show the **forces** between your remover and the space junk.
3. **Explain how your design deals with forces.**
   - When your remover pushes, pulls, or catches the debris, how does it handle the **equal and opposite reaction force**?
4. **Identify a trade-off or challenge.**
   - What's a possible **constraint** your idea might face — like mass, cost, energy use, or the risk of collisions?
   - How might engineers have to **balance** that challenge?

Look-fors in Student Responses:

Understanding and Application of Core Science Ideas

Student correctly describes how forces act in pairs (equal and opposite) between debris and remover.

Student recognizes that when one object exerts a force, the other experiences an equal and opposite force; larger-mass objects respond less (smaller acceleration).

Student connects speed and mass to energy or momentum — e.g., acknowledges that even small

debris can carry large energy due to high velocity.
The explanation shows awareness of design trade-offs (e.g., mass, cost, fuel, safety, new debris).
Mentions conservation or transfer of energy when junk is captured or slowed down.

Modeling and Representation

Model (drawing or diagram) clearly shows:

Both the removal system and space debris.
Arrows for forces (labeled with direction and relative size).
Interaction points (where the remover pushes, pulls, or captures)

The model connects directly to the written explanation (consistent cause/effect).
Arrows or labels show action–reaction pairs.
Student can explain how the model illustrates motion changes or energy transfer.

Explanation and Reasoning

The student's explanation includes cause-and-effect reasoning (e.g., "When the magnet pulls the debris in, it must also push back, so the collector needs thrusters to balance the force")
The explanation connects science concepts to design features (how/why it works).
Includes logical sequence: problem → mechanism → outcome.

Systems and Interactions Thinking

Recognizes that the remover–debris system interacts within a larger Earth–orbit system.
Shows understanding that changing one part (e.g., applying a force, capturing junk) affects the whole system (e.g., satellite motion, orbital path).
Identifies causes and effects of forces and design trade-offs.
Mentions possible unintended effects (e.g., "catcher might create more small pieces if it hits too hard").

Engineering Design Thinking

- Student identifies a constraint or trade-off (mass, energy use, cost, safety, feasibility).
- Describes how the design manages or reduces reaction forces or risks.
- Provides a rationale for why the design might be effective or safer.
- Shows iterative or problem-solving thinking ("To prevent spinning, my robot uses opposite thrusters…").