

PART 1:

Engineering Challenge: Build a Better Antenna

In this activity, students will be creating an “antenna” or “receiver” out of re-used materials. After construction is complete, the students can test their design using the “data” (in this case, ping pong balls).

Objective

Students take on the role of communications engineers as they design, implement, and refine construction of a ‘receiver’ to capture ‘data.’ The activity demonstrates the challenging nature of space communications, and fosters both creative problem-solving and the engineering design process.

Refer to [Telepong Part 2](#) and [Telepong Part 3](#) for complete activity instructions.



NGS Standards

Performance Expectations

MS-PS4-1, *-ETS1

Science and Engineering Practices

- Planning and Carrying Out Investigations
- Constructing Explanations and Designing Solution

Disciplinary Core Ideas

- Information Technologies and Instrumentation
- Defining and Delimiting Engineering Problems
- Developing Possible Solutions
- Optimizing the Design Solution

Cross-Cutting Concepts

- Patterns
- Cause and Effect: Mechanism and Prediction
- Structure and Function



GRADES:

5+



DURATION:

30-45 minutes



PREP TIME:

60 minutes

MATERIALS

- 40-140¹ ping pong or other² small balls
- Sterilized plastic egg cartons or similar ‘trough’ style holder
- Permanent markers
- Paper and writing implements
- Tubes: Paper towel or plastic mailer tubes ~1.5” in diameter³
- Repurposed materials: cardboard boxes, plastic containers, card stock, etc.
- Ruler
- Masking tape or hot glue gun⁴
- Scissors, hobby knife, or box cutter
- Durable cutting surface

OPTIONAL MATERIALS

- 26-30 cups or other sorting containers
- Other craft supplies: pipe cleaners, floral wire, tongue depressors, etc.
- Disposable gloves

ADDITIONAL RESOURCES

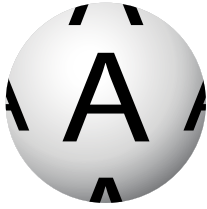
- [Space Communications: 7 Things You Need to Know](#)
- [New Ground Station Brings Laser Communications Closer to Reality](#)

¹ Small groups (3-8 learners) could complete the activity with as few as 20-40 balls. The larger number (140) is suggested for a full classroom of 30 learners split into four groups.

² The rest of this document assumes ping-pong balls; adjust dimensions accordingly if using others.

³ Cardboard tubes work well, but clear tubes are best (many packing-products vendors sell 1.5” diameter plastic mailing tubes). Ideal length is 12-16 inches

⁴ Adult supervision required for all activities which involve cutting or using hot glue. Use appropriate cutting implements on proper cutting surfaces.



Suggestion: Marking all six faces takes more preparation time but makes for a smoother activity experience.

VOCABULARY

Antenna: a device which changes “free-space” electromagnetic energy (energy moving through the atmosphere or the vacuum of space) into electrical signals in a wire, or vice-versa

Data: facts or information

Electromagnetic Spectrum: all the different colors and energies of light and radiation, even the ones humans cannot see

Ground Station: a facility on Earth designed to receive signals from space

Parabolic Reflector: a dish which is specially shaped to direct received signals to a precise focal point

Receive: to take in or ‘catch’ information

Satellite: anything that orbits a planet/ moon. Can be artificial or natural (moons, comets)

Spacecraft: anything made by humans that leaves Earth’s atmosphere and goes into space

Telescope: a device that gathers light and enable us to see things over larger distances; in space communications, telescopes can be used to receive or send information with laser light

Transmit: to send or ‘throw’ information

Teacher Preparation

1. Label balls in large block print on at least 3 ‘faces’ with letters of the alphabet. Resting the balls in upside-down egg cartons helps to prevent smearing while the ink dries.
2. Sort the balls alphabetically into individual containers.
3. Make a list of **core** and **bonus** requirements. Examples follow below.

Exploration

Student Activity

1. Discuss the engineering design process **generally**.

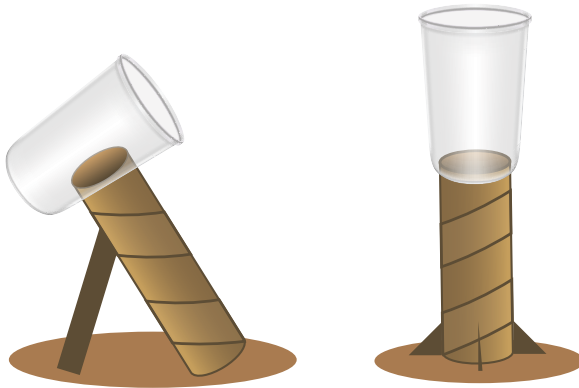


2. Discuss the engineering design process as it applies to this specific challenge. Check students’ understanding of the overall goal: **to make a durable device that catches and stores thrown balls**. Highlight the difference between “core” requirements and “bonus” requirements.

Example:

CORE REQUIREMENTS	BONUS REQUIREMENTS
<ul style="list-style-type: none"> Receiver is stable Receiver easily receives ping pong balls thrown a short distance Receiver can be easily emptied Receiver stores 8+ balls 	<ul style="list-style-type: none"> Users can read the lettered balls while they are still in the receiver Receiver is decorated to look like a NASA radio antenna dish or laser telescope

3. Have students apply the design process to building their receivers.



Two example receiver designs.

4. Have them test their devices periodically by stepping a few feet away and tossing balls into it.
5. Challenge students to improve their devices. This **iterative design process** is the core of the activity. Encourage them to make multiple observations before adjusting. In other words, throw at least 10-20 balls into the device before deciding on the next adjustment; this can help you introduce concepts of **sample size** and proper **experimental design**.
6. Ideally, the engineering iteration is self-driven. However, if students are getting frustrated, you might give them hints:
- How can you increase the target **size** of the dish?
NASA uses larger dishes to listen to fainter signals from far-off spacecraft, and to ease the high precision required to transmit across these vast distances.
 - How can you change the **shape** of the dish to better retain data that hits it?
NASA uses parabolic reflectors for radio communications and lenses for laser communications. Both of those methods focus signals into the receiver. How can you prevent balls from bouncing back out (without reducing the aperture size)?
 - How can you change the **material** of the dish to absorb some of the [kinetic] energy of the incoming data?
This is where the model starts to break down; NASA antennas seek to preserve as much energy as possible along the 'beam path' (i.e. the path that radio or infrared light takes when it travels between the source and the detector).

Suggestion: With physical balls as 'data' it can be helpful to put a soft or flexible material as a backstop (looseleaf paper, a tissue, bubble wrap, felt).

- d. How can you move the transmitter closer to the receiver?
Generally, we can't! The Moon, for example, isn't going to get dramatically closer anytime soon; we have to treat most of the vast distances as given. However, students can extend the distance of practical transmission by adding 'relay satellites' in between the transmitter and the receiver. What are your students' interpretations of a 'relay'?

Expansion

Continue your exploration of space communications and the NASA design process by building on this activity! Further learning possibilities include:

- Using the receivers in [Telepong Part 2](#).
- Having student groups test each other's systems. Encourage them to suggest improvements and share successful ideas.
- Discussing the ways in which their Telepong receivers are similar to a NASA radio antenna or laser telescope. What are the differences and similarities? Why are these significant? What is the purpose of these changes?

Telepong Receiver	Both	NASA Antenna/ Telescope
<ul style="list-style-type: none"> • Catches matter • Small • Made of recycled materials (reduces cost and weight) • Stationary • Relies on thrower's aim to catch balls 	<ul style="list-style-type: none"> • Receives data (information) in a central collector • Increase the distance over which information can reliably be sent 	<ul style="list-style-type: none"> • Catches electromagnetic energy • Very large! (3-70 meters in diameter) • Made of metal (weatherproof, reflects radio energy) • Pivots to track objects across sky • Parabolic shape focuses signals into receiver

FOR MORE SCAN ACTIVITIES, VISIT:

- [Exploration and Space Communications Activities](#)
- [NASA Kahoot! Quizzes](#)



Have feedback for us about any of these resources? Reach us at gsfc-scan-engagement@mail.nasa.gov. We especially love receiving pictures of your results in action!

Explanation

As you reflect on this activity with your students, we offer the following “core takeaways” that informed our design:

- The engineering design process helps refine solutions that efficiently and effectively address a need.
- *Data* that misses the *receiver* is lost; this can scramble messages or ruin them entirely.
- Accurate positioning, navigation, and timing is essential to communications.
- NASA relies on collaboration and teamwork to keep data flowing smoothly between Earth and space.