

A detailed illustration of the Inspector Detector spacecraft, a small satellite with a grey body, gold-colored solar panels, and various instruments. It is shown in orbit above a dark, cratered planetary surface.

INSPECTOR DETECTOR

LEADER NOTES

Photo credit: NASA/JPL

CHALLENGE: Design and build a device that can pass above a surface and detect magnetic fields.

LEARNING GOALS: *Science:* Magnetism, inverse square law; *NASA:* Magnetometers; *Engineering:* Design process

NASA CONNECTION: Many NASA spacecraft carry instruments to study magnetic fields. If a planet or moon has a magnetic field, it might have a molten core. Magnetic fields also deflect the damaging radiation of the sun and cosmic rays, so they could be important for protecting future astronauts.

GET READY AHEAD OF TIME

- **Tape the magnets.** Tape five to ten magnets to a sheet of newspaper. Make one of these “planetscapes” per four or five kids.
- **Draw the grid.** On a full sheet of newspaper, use a black marker to draw a 10 x 10 grid. Label the top 1–10 and the side A–J. Make an answer key, noting where the magnets are. Then lay the grid on the newspaper with the magnets.
- **Make the metal shards.** (Use scissors you don’t care about.) Cut #3 (coarse) steel wool in small pieces, between an eighth and a quarter of an inch long.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Inspector Detector*, Tracy Drain, and NASA videos. Be prepared to project them. If you’re unable to show videos, review the handout’s overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric.

MATERIALS (per magnetometer)

- 1 grid map
- Pieces of cardboard or small cardboard box
- 1–2 paper cups (6- to 8-ounce)
- 1 piece copier paper
- A small pile of metal shards (cut off a pad of coarse [i.e., #3 or 4] steel wool)
- String (50 centimeters [20 inches])
- Tape (clear or masking)
- 1 small magnet for testing
- Scissors
- 6–10 full sheets of newspaper per planetscape
- Black marker
- 8–10 strong magnets per planetscape (available at dollar, toy, office supply, and craft stores)

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage

- Tell kids that today they’ll be doing a different kind of treasure hunt—searching for something invisible. Ask: What kinds of invisible forces and energy can your body detect? (*Your senses can detect things like heat, sound, pressure, etc. Your sense of balance can detect gravity.*)
- Name some devices that deal with invisible energy. (*Cell phones, radios, GPS, thermometers, compass, metal detectors, airport screening devices, medical imaging devices, etc.*)
- Tell kids the challenge and show them the *Inspector Detector* video.

Relate it to NASA missions

Magnetism is one invisible force NASA is interested in because it can tell scientists a lot about how a planet or moon formed and has changed. Planets and moons with huge amounts of fluids circulating (e.g., a molten core) can produce a magnetic field. NASA's *Juno* and *Lunar Prospector* missions use magnetometers, devices that detect magnetic fields. Show one or both of the NASA video clips.

- **Juno** will orbit Jupiter, going just above the planet's cloud tops. Its magnetometers will measure the strength and direction of Jupiter's magnetic field.
- **Lunar Prospector** measured the strength of the moon's magnetic fields. Its magnetometer provided data about the location of minerals and helped determine the size and composition of the lunar core.

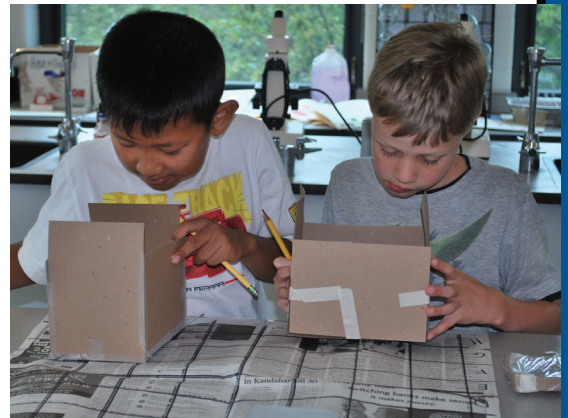
2 BRAINSTORM AND DESIGN (10 minutes)

Show kids a magnetic field. Sprinkle some metal shards onto a piece of white copier paper. Pass it over a magnet. Have kids describe how the magnetic field affects the shards. Is there a pattern?

Identify the problem. Have kids state the problem in their own words (e.g., build a tool that can find hidden magnets).

Offer final tips

- **Relate the planetscape to the map.** Explain how to use the grid's numbers and letters to mark the location of a magnet (similar to the game Battleship®). Point out that their map has the same grid. Tell them to mark their maps, not the newspaper. That way, other groups can use the planetscape.
- **Distributing shards.** Once kids have made a detector, tell them to call you over to sprinkle some shards on its window. Cover it lightly. It doesn't take a lot of shards to work effectively.
- **Keep shards away from magnets.** Cleaning them off a magnet is a nuisance.
- **Set up the room.** Have kids build in one area and test with the planetscapes in another area.



Explain how to use the grid's numbers and letters to mark the location of a magnet.

3 BUILD, TEST, EVALUATE, AND REDESIGN (30 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

- **If a detector doesn't respond...** Tell kids to hold the detector closer to the planetscape. Check that there are enough shards, that the cardboard isn't too thick, and that nothing is interfering with how the shards move. Have kids test their detectors with a small magnet.
- **If it's hard to see the shards move...** Design a window or remove parts that block the view.
- **If there's a spill...** Use a plastic bag with some magnets inside. To clean up an area, swish the bag over any loose shards. To dump the shards, hold the bag over a piece of paper and lift out the magnets. The shards will fall onto the paper.

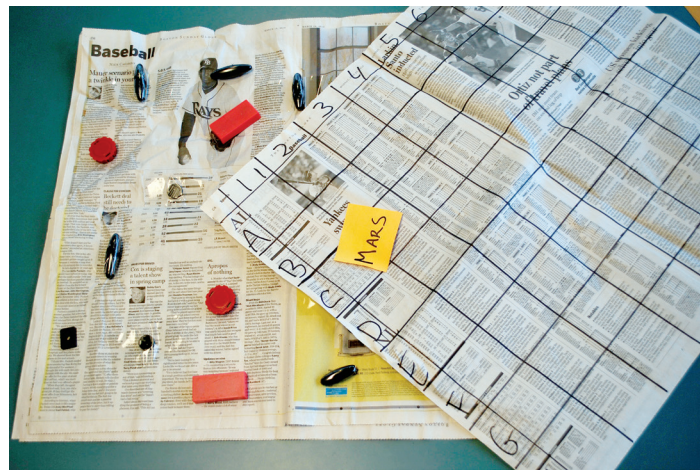


There are many designs that can contain the shards and let kids pass it over the grid. The simplest is a plain paper cup!

4 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

- **Math:** Gather kids around one of the planetscapes. Use a detector to locate each magnet. Have kids check off the ones they got. Point out the power of a grid system. Maps, touch screens, mouse pads, and interactive white boards use grid systems to keep track of a point.
- **Science:** Why are NASA scientists interested in magnetic fields? (*Magnetic fields are indicators of a planet's interior structure, which is important in learning if there is an active core and how the planet formed and evolved. Magnetic fields also deflect damaging radiation from solar wind and cosmic rays, so could help protect future astronauts.*)
- **NASA:** What kinds of missions use magnetometers? (*Magnetometers are typically used on spacecraft that fly past or orbit a planet or moon. It can take more than a thousand orbits to develop a comprehensive map of a magnetic field.*)
- **Career:** Show kids the engineer profile featuring Tracy Drain. As a flight systems engineer, Tracy makes sure a spacecraft's parts, instruments, and systems all work as intended. If even just one part fails, it can be catastrophic. Download the profile sheet for fun facts, discussion prompts, and extension ideas.



A planetscape has two parts: a sheet of newspaper with magnets taped to it that's covered by a second sheet of newspaper with a grid drawn on it.

EXTEND THE CHALLENGE

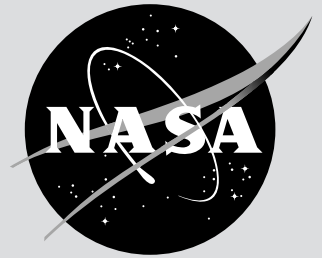
- **Sensitivity test.** Make two or more planetscapes with magnets of different strengths. Whose detector can accurately locate the magnets AND determine their strength?
- **Go on a treasure hunt.** Houses and schools are loaded with magnets. For example, electric motors, speakers, telephones, door-closers, TVs, etc. all have magnets. Use the detector to go prospecting for magnets and see how many invisible magnetic fields are around you.

CURRICULUM CONNECTIONS

Use *Inspector Detector* to engage, explain, and extend student understanding of the following topics:

- **Magnetism.** This activity uses permanent magnets. As with all materials, a magnet's atoms have electrons orbiting a nucleus. In an iron-rich material, when many electron orbits are aligned (i.e., spin in the same direction), these aligned spins produce a magnetic field.
- **Inverse square law.** Gravity, electric charges, light, and sound are all governed by an inverse-square relationship. Let's use light as an example. As you move away from a light source, it gets dimmer. But how much dimmer? If you double your distance from the source, the light you see will be $\frac{1}{4}$ as bright as before, not $\frac{1}{2}$ as bright (i.e., $\frac{1}{2}$ squared = $\frac{1}{4}$). Because the intensity of the light varies as the square of the distance, this relationship is called the inverse square law. With magnets, the drop in the magnetic force is even more extreme—it changes as the cube of the distance!

INSPECTOR DETECTOR



When huge amounts of fluids circulate in a planet or moon, such as a molten core, it can produce a magnetic field. Scientists can tell a lot about how the planet or moon formed and has changed by studying its magnetic field.

WE CHALLENGE YOU TO...

...build a device that you can pass above a surface to detect magnetic fields.

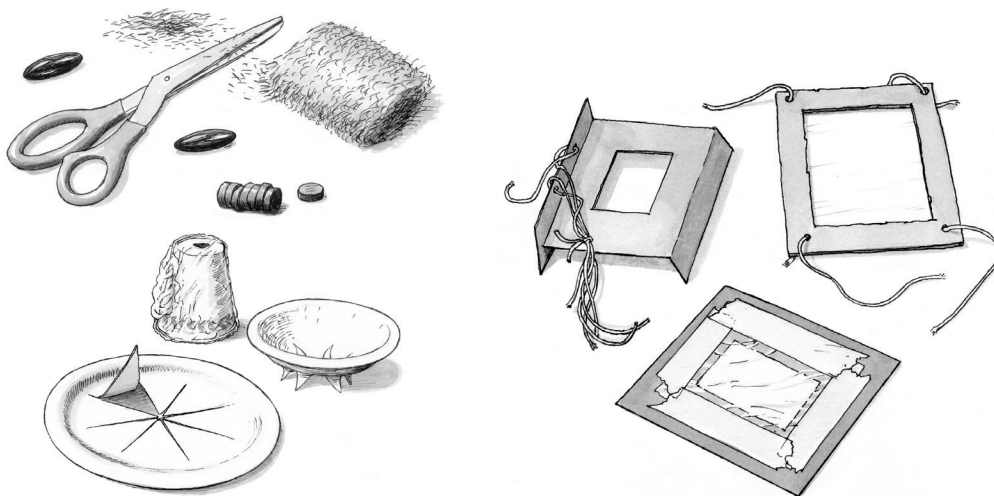
DESIGNsquad
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1. IDENTIFY THE PROBLEM AND BRAINSTORM

- How can you make sure that the metal shards stay in your detector and don't fall off?
- How can you make it easy to see when the metal shards move?
- How will you hold the detector as you move it above the surface?

2. DESIGN AND BUILD

Below are some ideas for detectors. Invent your own design or improve on one of these.



MATERIALS

- Pieces of cardboard or a small box
- 1–2 paper cups (6- to 8-ounce)
- 1 piece copier paper
- A small pile of metal shards (cut off a pad of coarse [# 3] steel wool)
- 1 small magnet for testing
- 8–10 strong magnets per planetscape
- Tape (clear or masking)
- String (50 centimeters [20 inches])
- Scissors
- 1 grid map

WORDS TO USE

- **magnetic field:** *The area around a magnet where a magnetic force can be detected*
- **magnetometer:** *A device that detects magnetic fields*

3. TEST

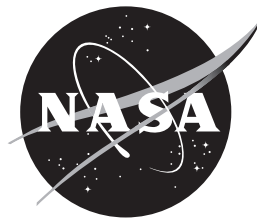
- **Try out your detector.** Use the small magnet to test how well your detector works.
- **Find the hidden magnets.** Slowly pass your detector over the grid, one section at a time.
- **Map the magnets.** Use the grid lines to identify the locations. Mark each magnet with a dot on your map (NOT on the newspaper).

4. EVALUATE AND REDESIGN

- **If it's hard to see the shards move...** Design a window or remove parts that block your view.
- **If your detector doesn't respond...** Check that you have enough metal shards and that nothing blocks how they move. Also check that you're not holding it too far above the surface.

5. TRY THIS NEXT!

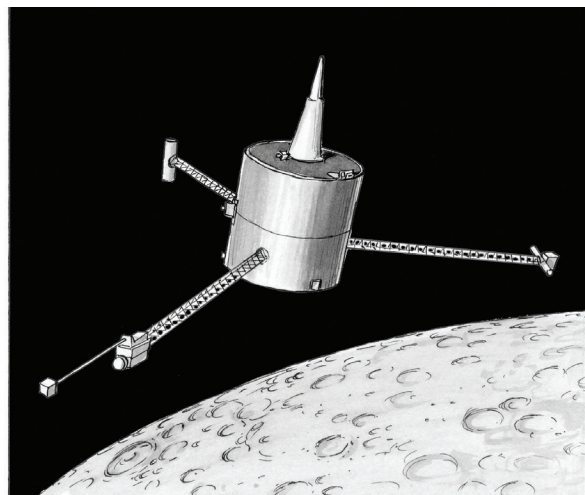
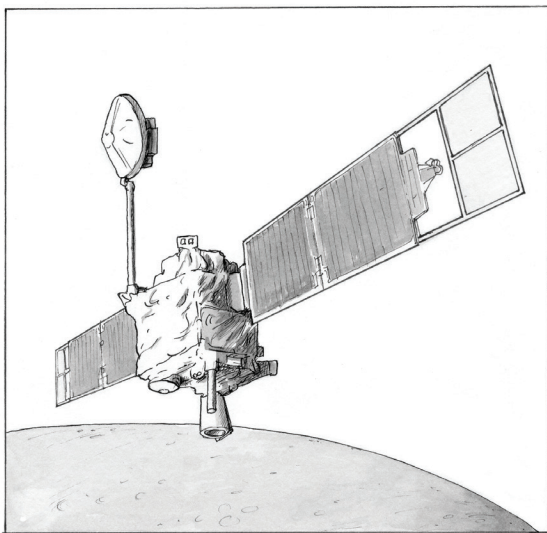
- **Magnet treasure hunt.** Use your detector and see how many invisible fields you can find. Check things like door closers, speakers, electric motors, and microphones.



Check out NASA's missions at nasa.gov

NASA EXPLORES SPACE

NASA's *Mars Global Surveyor* carries magnetometers on the ends of its solar panels. The mission determined that Mars no longer has a strong magnetic field, meaning that its interior has cooled.



NASA's *Lunar Prospector* measured the strength of the moon's magnetic fields. The mission also used magnetometers to find the location of minerals and to determine the size and makeup of the moon's core.

Visit the **Design Squad Nation** website at pbskids.org/designsquad.

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MAJOR FUNDING



PROJECT FUNDING

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MAP OF THE MAGNET LOCATIONS

Put an "X" where you think there is a magnet. (A big "X" = Strong and a small "x" = Weak.)

	1	2	3	4	5	6	7	8	9	10
A										
B										
C										
D										
E										
F										
G										
H										
I										
J										

Check the planet you mapped: ___Earth ___Mars ___Venus ___Team Members: _____

DESIGN CHALLENGE PERFORMANCE ASSESSMENT RUBRIC



Challenge name: _____

Names of team members: _____

Identifying the problem(s) and brainstorming solutions	Showed a clear understanding of the problem(s) to solve. Independently brainstormed solutions.	Needed some teacher direction to define the problem(s) and brainstorm possible solutions.	Needed lots of teacher direction to define the problem(s). Little if any independent brainstorming.	Points:
Working as a team member	Worked well together. All team members participated and stayed on task.	Some team members were occasionally off task.	Most team members were often off task and not cooperating or participating fully.	Points:
Using the design process	Team brainstormed many design ideas and tested and improved the design. Final design complete or nearly complete and shows creative problem solving.	Some team members were occasionally off task.	Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design idea(s).	Points:
Processing the science and engineering	Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process.	Team gave a basic presentation of its solution to the challenge and showed basic understanding of the science concepts and design process.	Team gave a weak presentation of its solution to the challenge and showed little understanding of the science concepts and design process.	Points:
				Total Points:

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ADDITIONAL FUNDING



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