WATER WISE FARMS: GRAVITY IN ACTION

One-Week Challenge Guide

Table of Contents

Challenge Rationale

Farmers need water to grow crops, but getting water to the right place isn’t always easy. On sloped land, gravity pulls water downhill. This means some areas can get too much water, while others don’t get enough. When that happens, plants might not grow well, and water can be wasted. In fact, farmers around the world are already working to fix this problem. According to the Food and Agriculture Organization (FAO), about 70% of all freshwater used by humans goes to agriculture. Even small improvements in how we move water on farms can make a big difference for people and the planet.

By learning how gravity affects water flow, we can design better irrigation systems that help farmers use water wisely. Whether it's building small channels, using drip lines, or changing the slope of the land, understanding gravity helps farmers get water exactly where it's needed without wasting a drop.

Source: Food and Agriculture Organization of the United Nations. (2017). Water for Sustainable Food and Agriculture. Retrieved from: https://openknowledge.fao.org/server/api/core/bitstreams/b48cb758-48bc-4dc5-a508-e5a0d61fb365/content

Establishing The Challenge

Identify a Challenge

In this challenge, you'll use simulations or models to explore how gravity affects the way water moves across sloped farmland. Your job is to figure out how changing the mass of objects or the distance between them affects gravitational force, then use that knowledge to design a better irrigation system. Your final product could be a simple prototype, a simulation-based solution, or a creative plan that shows how farmers can use gravity to help water flow exactly where it's needed. The goal is to use science and design to solve a real farming problem, making sure crops get the right amount of water without wasting any.

Establishing The Challenge

CHALLENGE QUESTION

How does gravitational force affect water flow on sloped farmland, and how can farmers use this understanding to design better irrigation systems?

THIS SOLUTION MUST ADDRESS THE FOLLOWING NEEDS:

The simulation or model must allow students to manipulate mass and distance between objects to observe how these factors affect gravitational force. Students should record data on gravitational force at different mass and distance values, identifying any patterns. The findings must be presented in a way that shows clear relationships between mass, distance, and gravitational force (e.g. , graphs, tables) and the impact of their findings on a specific example in the agriculture industry.

SUCCESS WILL BE DETERMINED BY:

Students provide accurate data showing how gravitational force changes with varying mass and distance. Graphs or other mathematical representations clearly illustrate the observed patterns. Students can explain the relationship between mass, distance, and gravitational force based on their observations and simulations. Students accurately present their findings about the implications of this experimental evidence on an agricultural example.

Standards Addressed

Next Generation Science Standards

nextgenscience.org

- MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- MS-ETS1-1 / MS-ETS1-2 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the environment.
  Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- Optional Connection – MS-ESS3-3

Standards Addressed

COMMON CORE STANDARDS

corestandards.org/mathematics-standards

- EE.B.6 Use variables to represent numbers and write expressions when solving real-world or mathematical problems.
- RP.A.3 Use proportional relationships to solve multistep ratio and percent problems.
- SP.C.5 Summarize numerical data sets in relation to their context.
- SP.B.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

corestandards.org/english-language-arts-standards

- RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
- RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- RST.6-8.7 Integrate quantitative or technical information expressed in words with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- WHST.6-8.1 Write arguments focused on discipline-specific content.
- WHST.6-8.2 Write informative/explanatory texts, including scientific procedures/experiments or technical processes.
- SL.6-8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details.

Guiding The Challenge

Each Purple Plow Challenge can be implemented in a variety of methods, time frames, and programs. Follow the steps below to help determine how this challenge will best fit the current situation and educational environment.

1. **REVIEW** the Purple Plow "Design Process" (next page) and the "Lesson Packet" documents.
   Note that the lessons are encouraged but not required.

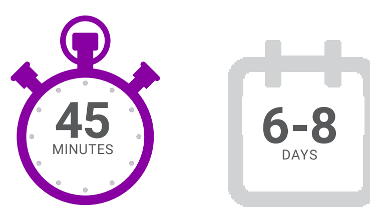
2. **EXAMINE** the suggested timeline to determine ways to integrate the challenge and lessons to fit your needs.

3. With the time frame in mind, **USE THE GUIDANCE PROVIDED** in this section to help students progress through the challenge. This guidance includes suggested student prompts, guiding questions for students, signs of step completion, and journaling opportunities. The student prompts, guiding questions, and journal prompts are found in the "Student Guide." Facilitators or students may determine the method by which they record their research and discoveries found for these prompts and journal reflection questions.

SUGGESTED TIMELINE

This sample pacing guide is created for a 90-day calendar with a 45-minute class. It is important to remember that timing may vary on student's pace, as well as how much time you dedicate to each of the steps listed below. Your students may return to certain steps and repeat the process, no journey is the same!

DESIGN PROCESS STEP	TIMELINE
Identify	1 day
Imagine	1 day
Design	1-2 days
Create	1-2 days
Test & Improve	1 day
Share	1 day



You may need time beyond the allotted program time estimates above to fulfill the challenge's requirements. Possible options for competing include:
Sending the related materials home with students wishing to compete (participating in regular progress monitoring of the project with the facilitator).
Developing continuation options in an after-school or extracurricular club with the facilitator.
Including parents in the process of continuing the investigation (with an option of providing space at school to keep project materials).

Challenge Design Process

purple PLOW

STEP ONE

IDENTIFY

Define the problem and how it is affecting life globally, nationally, and locally. Research and consider how others have approached solving the problem. Describe why this problem needs a solution. Determine constraints (e.g., time, space, resources, etc.).

STEP TWO

IMAGINE

Brainstorm solutions to the problem. List all ideas – don't hold back! Discuss and select the best possible solution.

STEP THREE

DESIGN

Diagram the prototype. Identify the materials needed to build the prototype. Write out the steps to take. Describe the expected outcomes.

STEP FOUR

CREATE

Follow the design plan and build the prototype.

STEP FIVE

TEST & IMPROVE

Test the design and collect quantitative and qualitative data. Discuss results and compare with the expected outcomes. Seek areas of improvement and make changes where needed.

STEP SIX

SHARE

Communicate what was learned. Share the design, data, and conclusions. Present results.

Materials List

Suggested Materials List

The items listed below are suggested materials needed to conduct the challenge. Facilitators and students are encouraged to be creative and inventive in acquiring the materials needed to complete the challenge (e.g., purchased, recycled, donated, etc.).

FOR SIMULATIONS:

- Internet-connected device (laptop, tablet or desktop)
- Access to a gravitational force simulation (e.g., PhET "Gravity Force Lab", NASA Gravity Explorer, or similar)
- Student notebooks or digital data recording sheets
- Graph paper or graphing software (e.g., Google Sheets, Excel)
- Rulers or measuring tools (for scaled diagrams or prototype measurements)
- Pencils, erasers, markers

FOR HANDS-ON PROTOTYPES OR MODELS:

- Cardboard or foam board (for building slopes and models)
- Plastic tubing or straws (to simulate irrigation channels)
- Small containers or cups (to hold water)
- Water (colored with food coloring for visibility)
- Soil, sand, or pebbles (to simulate farmland surfaces)
- Measuring spoons or droppers (to control water flow)
- Toy figures or marbles (to represent mass and simulate gravitational effects)

FOR ENHANCED PRESENTATIONS:

- Poster board or trifold boards (for presenting findings)
- Colored paper, glue sticks, scissors (for visuals and models)
- Digital presentation tools (e.g., Canva, Google Slides)
- Stopwatches (for timing water flow if testing physical models)

STEP ONE

1 IDENTIFY

Purpose of Step

Define the problem and how it is affecting life globally, nationally, and locally. Research and consider how others have approached solving the problem including how people have addressed this problem historically. Describe why this problem needs a solution. Determine constraints (e.g., time, space, resources, etc.).

Student Prompts and Guiding Questions:

- What is gravitational force?
- How does it affect objects of different masses and at different distances?
- How might gravity affect how water flows on sloped land?
- Why might this matter to farmers?
- What do you already know about irrigation systems?

Signs of Step Completion

Students can explain gravitational force in their own words. Students can describe a possible connection between gravity and water movement on farmland. They should generate a list of questions they want to investigate.

AT THE COMPLETION OF THIS STEP, DIRECT STUDENTS TO THE REFLECTION QUESTIONS IN THE STUDENT GUIDE.

STEP TWO

2 | IMAGINE

Purpose of Step

Brainstorm how they might use simulations or models that explore gravitational interactions and water flow to provide possible solutions to the challenge. Discuss the tools available and how they might be the best solution.

Student Prompts and Guiding Questions:

- What do you already know about gravity and how it affects moving objects?
- What kind of model or simulation could help you explore how mass and distance affect gravity?
- How could you simulate water movement down a slope?
- How do you think increasing or decreasing mass or distance will affect gravitational force?
- How might gravity influence how water moves across farmland with different slopes?
- If you were a farmer, what problems might you face with water flow?
- What would happen to water if the mass of water increased or the flow changed?
- What would an ideal irrigation system look like if gravity were used to help water flow?
- What kind of data do you think we'll need to collect to understand the relationship between gravity and water flow?

Signs of Step Completion

Students sketch or describe possible ways to test or simulate gravitational interactions and have proposed at least one simulation or tool to use (e.g., online PhET gravity simulation, simple 3D model of a hill and water flow).

AT THE COMPLETION OF THIS STEP, DIRECT STUDENTS TO THE REFLECTION QUESTIONS IN THE STUDENT GUIDE.

STEP THREE

3 | DESIGN

Purpose of Step

Plan the investigation or simulation setup, including how to collect and organize data on mass, distance, and gravitational force.

Student Prompts and Guiding Questions:

- What variables will you change (mass? distance?) and which will you keep the same?
- How will you record and compare your results? Will you use a table, chart, or graph?
- What tools (graph paper, spreadsheet, digital tools) will you use?
- How will you make sure your design can be tested more than once to determine accuracy?
- How can your design connect back to a real-world farming scenario?

Signs of Step Completion

Students should present a clear plan for running the simulation or creating a model and have prepared a data collection table to record force values, mass, distance, etc., along with an outline of how they'll represent the data (e.g., graphs or tables).

AT THE COMPLETION OF THIS STEP, DIRECT STUDENTS TO THE REFLECTION QUESTIONS IN THE STUDENT GUIDE.

STEP FOUR

4 | CREATE

Purpose of Step

Run the simulation or create a basic model/prototype and begin recording data.

Student Prompts and Guiding Questions:

- What patterns do you notice as mass or distance changes?
- What data are you collecting and how are you organizing it?
- Do your results match your expectations?
- How does your model or simulation represent a real farm landscape or irrigation system?
- What farming challenge are you simulating (e.g., too much water at the bottom of a hill, erosion, dry patches)?
- If a farmer saw your model, what could they learn about how to manage water on their land?
- How might different crops or soil types be affected by the water movement you observed?
- Are there any real irrigation tools or farming methods your model is like (e.g., terracing, drip irrigation)?

Signs of Step Completion

Students have recorded their initial observations and have a complete data set showing how gravitational force changes. They will begin to recognize trends or patterns.

AT THE COMPLETION OF THIS STEP, DIRECT STUDENTS TO THE REFLECTION QUESTIONS IN THE STUDENT GUIDE.

STEP FIVE

5 | TEST & IMPROVE

Purpose of Step

Collect quantitative and qualitative data. Analyze data, discuss the results, and compare them with your expected outcomes. Consider any inconsistencies, errors, or ideas for improvement in their model or data collection and make changes where needed.

Student Prompts and Guiding Questions:

- Are your results consistent? If not, why might that be?
- What could you change or improve in your model or how you collected data?
- How do your results connect back to our challenge question?
- Does your model help solve a real farming issue, like water pooling in one area or not reaching certain crops?
- If this were a real farm, would your system help conserve water or prevent erosion? Why or why not?
- How would changes in slope, soil type, or crop placement affect the success of your irrigation model?
- What improvements could make your model more helpful for farmers dealing with uneven land?
- If a farmer tested your idea in real life, what feedback might they give?
- What would you change if your farm were in a very dry area? A rainy one?

Signs of Step Completion

Students can explain their results about gravity's role in irrigation on sloped farmland and connect their findings to real-world farming examples. They revise data collection methods or repeat trials if needed.

AT THE COMPLETION OF THIS STEP, DIRECT STUDENTS TO THE REFLECTION QUESTIONS IN THE STUDENT GUIDE.

STEP SIX

6 | SHARE

Purpose of Step

Students communicate their findings, using evidence to explain the relationship between mass, distance, and gravitational force, and their agricultural relevance.

Student Prompts and Guiding Questions:

- What patterns did you find in your data?
- Were your findings what you expected? Why or why not?
- How does gravitational force affect water flow in farming?
- How can farmers use this knowledge to design better irrigation systems?
- What would you recommend to a farmer designing a gravity-fed system?

Signs of Step Completion

Students create a visual representation - a graph/chart with an explanation, a brief report, a poster, a video, or a presentation. Their explanation clearly ties gravitational interactions to agricultural decision-making and explains the impact of using water to move water efficiently across farmland, supporting responsible management practices like reducing runoff, conserving water, and improving crop health.

AT THE COMPLETION OF THIS STEP, DIRECT STUDENTS TO THE REFLECTION QUESTIONS IN THE STUDENT GUIDE.

EXTENSION POSSIBILITIES:

- Compare irrigation systems from around the world that use gravity.
- Build a small-scale gravity irrigation model with tubes, funnels, and water.
- Explore how soil type or plant spacing might interact with water flow patterns.
- Research or interview local farmers or agricultural extension agents to learn how irrigation and slope impact water management in real-world settings.
- Research the costs and benefits of various gravity-based irrigation methods
- Compare solutions that are sustainable for different farm sizes and climates.
- Investigate how farmers in other parts of the world develop innovative solutions in places with limited resources, steep slopes, or rough terrain, and consider how those solutions could be adapted locally.

THIS RESOURCE IS BROUGHT TO YOU BY

American Farm Bureau Foundation for Agriculture®

THANKS TO GENEROUS SUPPORT FROM

Corteva agriscience™