

Grow Stand Math

Teacher Resources

Summary

In this standards-aligned, 5-E lesson, students will learn about artificial lighting and its use in agricultural production, they will use engineering design principles and mathematics to design a model using plastic straws and tape and build a grow light stand out of PVC piping and connectors.

Grade Level

6-8

Contents address the following Next Generation Science Standards

- MS-ETA1-1. 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 natural environment that may limit possible solutions

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Background

Standards

Next Generation Science Standards

- MS-ETA1-1. 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 natural environment that may limit possible solutions

Common Core

CCSS.Math.Content.6.RP.A.3.c

- Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

Estimated Time

2, 60-minute class periods

Student Materials

Each student will need:

- 1 – Grow Stand Math worksheet
- 1 – plastic straw (10“ Jumbo Straw)
- 1 - pair of scissors
- 1 – ruler
- roll of tape

Building the grow light stand (per group of 2 or more)

- 1 – 1-1/2” X 10 foot PVC Pipe
- 1 – PVC Pipe Cutter
- 2 – 1-1/2” elbow joint
- 2 – 1-1/2” T-Joints
- 4 – 1-1/2” end caps
- 1 – 2 – 3-foot grow lamp (optional)
- Chain and hooks for hanging (optional)

Anticipated cost for materials (including grow light and chains and hooks for hanging) is \$47.00. Estimate courtesy of University of Maryland Extension found here: <https://extension.umd.edu/growit/food-gardening-101/pvc-light-stand>

Vocabulary

- engineer** - is a professional practitioner of engineering, concerned with applying scientific knowledge, mathematics, and ingenuity to develop solutions for technical, societal and commercial problems. (6th Grade)
- percentage** - a rate, number, or amount in each hundred. (6th Grade)
- grow light** - an artificial light source, generally an electric light, designed to stimulate plant growth by emitting an electromagnetic spectrum appropriate for photosynthesis. (7th Grade)
- scale model** - a representation or copy of an object that is proportionally smaller or larger than the actual size of the object being represented

Key STEM Ideas

Math and engineering can be applied to solve real-world problems outside of the classroom setting. Students will learn about steps taken in the engineering process to produce a usable product. Building a model is an important step which requires students to take measurements and make calculations to build a successful scale model. Scale model measurements and calculations can be applied to the life-size product.

Students' Prior Knowledge

Students will need a basic knowledge of percentages and how to find a percentage of fixed number.

Connections to Agriculture

According to “A Historical Background of Plant Lighting: An Introduction to the Workshop,” Raymond Wheeler states, “Electric lamps have been used to grow plants for nearly 150 years.” This dates back to the origin of the light bulb. With the production of the light bulb, humans were not only brought out of the dark, but also provided with a tool to move farming into other realms. With artificial lighting, plants could be grown during times of the year with usually short photoperiods and photosynthesis was no longer limited to daylight hours. This greatly expanded the growing seasons of various vegetables.

Growing plants under lights also gives growers the ability to control the growing conditions. Growers are able to regulate the type, intensity, and duration of the light for whatever plant they are trying to grow. In a classroom setting using grow lights will help control variables or establish a control that your students might come in contact with in their experiments.

Essential Links

- What is Agricultural Engineering? Video - <https://www.youtube.com/watch?v=SEZWXytGnnI>
- The Economist “The light fantastic” article: <http://www.economist.com/node/21602194/print>

Sources/Credits

- A historical background of plant lighting by Raymond M. Wheeler: <http://hortsci.ashspublications.org/content/43/7/1942.full>
- Image of commercial grow light stand: <http://www.greenhousecatalog.com/grow-lights>
- Image of PVC pipe grow light stand: <https://extension.umd.edu/growit/food-gardening-101/pvc-light-stand>

Lesson Procedures

Engage

Introduction to Growing Plants with Lights

1. Hand out the Grow Stand Math student worksheets to the class.
2. Read the introduction as a class and explain that this lesson will allow them to build a scale model of a grow light stand, and later to build an actual grow light stand with a group.
3. Explain that this product is developed using engineering design principles and the grow stand could be used in classroom experiments in which light is manipulated to observe changes in plant growth or development.
4. Have students brainstorm possible variables that could be tested in such an experiment.

Explore

Activity 1 – Engineering a Grow Light Stand

5. Introduce the steps of the engineering design process. Answer the first three questions as a class. Provide students guidance in verbalizing what the problem or need is, what might be pertinent information to collect, and field student ideas for solutions to this problem. Some students may come up with an idea other than building a grow light stand for holding the artificial light. Discuss how this one solution isn't the only solution. Engineers often come up with different solutions to the same problem.
6. Explain the importance of developing a model. Ask students why it is a good idea to test out a model before diving into the final product. (A model helps in avoiding mistakes to ensure safety and testing early prototypes before the final product is constructed.)
7. Discuss examples of scale models and that they are proportional to the final product. Have students sketch a design for a grow light stand built from 10 feet of PVC pipe. Later, students will have access to PVC connectors, but keep the design sketch simple for now.

Explore and Explain

Activity 2 – Making Calculations

8. Have students share their designs and discuss differences or similarities.
9. Read the instructions together, and discuss how many different designs could work, but for today's project we will be building a scale model of the grow light stand pictured on the worksheet. Ask students if the final product looks even and well-constructed. (It does.) Explain that this is the result of careful calculation and measurements taken before constructing the stand.
10. Explain that they will be using a plastic straw, scissors, a ruler, and tape to conduct these calculations and measurements for a scale model first.
11. Pass out a pair of scissors, a normal size straw, and a ruler to each student. Give access to tape when constructing the model.
12. Once all the materials are handed out have the students brainstorm how they could cut the straw to make a model of a grow light stand.
13. Explain that if we were to build the grow light stand pictured on their worksheet we would need to calculate the following percentages of the construction material.
 - a. 1 piece – 43%
 - b. 2 pieces – 20%

- c. 4 Pieces – 4%
14. Have students calculate the percentages above for the large straw. Students should write their answers down on their worksheet and show their calculations.
15. Once the students have the measurements for the straw they may use the ruler and the scissors to cut the straw to the documented measurements.
16. Students can assemble their straw pieces into a feasible design for a grow light stand.

Extend

Building the Actual Grow Light

17. Construction of the grow light stands can be done by groups of 2 or more. Alternatively, if cost is prohibitive, the entire class can work together to construct a single grow light stand.
18. Handout the following materials for each grow light stand:
 - a. 1 – 1-1/2” X 10 foot PVC Pipe
 - b. 1 – PVC Pipe Cutter
 - c. 2 – 1-1/2” elbow joint
 - d. 2 – 1-1/2” T-Joints
 - e. 4 – 1-1/2” end caps
 - f. 1 – 2 – 3-foot grow lamp (optional)
19. Students should take what they learned from cutting the straw and upscale it to a 10-foot PVC pipe.
 - a. Have students calculate and measure the appropriate number of pieces needing to be 43% (1 piece), 20% (2 pieces), and 4% (4 pieces) of the total length. Mark these lengths with a pencil or sharpie on the PVC pipe.
 - b. Before cutting, demonstrate safe use of the PVC pipe cutters (Note: PVC pipe cutters are extremely sharp and appropriate safety gear should be worn).
 - c. Students should construct grow light from the pieces of the PVC pipe they cut.

Optional – Hand out grow lights and have students use chains and hooks to place the grow lights onto the stands.

Extend and Evaluate

Activity #3- How can grow lights be applied to modern agriculture?

20. Have students read the short article “The light fantastic” (<http://www.economist.com/node/21602194/print>) from the Economist. Students can access this article online or be given a PDF paper copy.
21. Working individually or in groups, have students discuss the article and answer the follow-up questions.
22. Review with students how engineering grow lights can be used to further indoor agriculture production.

Grow Stand Math: TEACHER NOTES

Introduction to Growing Plants with Lights

Prior to the invention of the light bulb, plants were limited to producing energy through photosynthesis only during daylight hours. For farmers and gardeners, this meant the typical growing season for plants and crops was limited to times of year with a long photoperiod. A photoperiod is the amount of time in a single day that a plant or animal is exposed to light. However, once lightbulbs became readily available, plant researchers began to test if artificial light could be used to grow plants during times of the year with short photoperiods. By combining artificial lighting technology with the use of greenhouse space, researchers observed elongated stem growth in plants exposed to artificial light.

In the years since the first artificial lighting was developed, improved technology and design has impacted the quality, intensity, longevity, and safety of lights. Currently, gardeners use grow lights indoors to sprout seeds well before spring arrives. In addition, indoor farming operations use grow lights to produce crops such as lettuce, tomatoes, basil, kale, and chives during the winter season.

In this lesson, we will be using engineering principles to design and construct an artificial lighting set-up that could be used to grow plants indoors under controlled conditions. The product you construct could be used to help set up controlled experiments testing the effects of artificial light on plant growth.

If you were allowed to manipulate light in a variety of ways to test how environmental conditions affect plant growth, what are some of the variables that you might want to test?

Answers may vary.

- Light intensity
- Length of exposure (photoperiod)
- Wavelength
- Type of light used (florescent, LED, etc.)
- Light color

Remember, in an experiment, you would select only ONE of these variables to test.



An artificial lighting set-up including grow light and a stand.

Activity #1: Engineering a Grow Light Stand

The following steps are taken by engineering when they are designing a solution to a particular problem.

1. Identify a need or problem
2. Collect information
3. Brainstorm ideas to fix problem or satisfy need
4. Develop a model (or prototype)
5. Test and analyze the model
6. Make improvements on design
7. Present results

As a class, answer the following questions.

1. What is the need or problem?
We need to build a structure to hold a grow light in order to conduct science experiments.
2. What information should you collect before you begin?
Answers will vary. What is my budget? What materials can we use? How big does it have to be? How heavy can it be? How large is the light it needs to hold? What tools do we have to work with?
3. How might you fix this problem?
I will work with a group to design a model and build a stand from a 10' PVC pipe and connectors that will safely hold a 3' grow light.

Now, we will be focusing on step 4, developing a model. Modeling is an important step in the engineering process because engineers need to brainstorm what the finished product should look like and how it should function before they begin building it. A scale model is a representation or copy of an object that is usually smaller than the actual size of the object being represented. Scale models are useful to both the developer and the consumer because it can show what the finished product will look like and how it can be constructed.

4. Can you think of anything that could be described as a “scale model”?
Answers will vary. Model boats, trains, cars, etc., Matchbox cars, action figures, architecture models, train sets, etc.
5. Sketch a design for a grow light stand that you could build from a 10-foot piece of PVC pipe.
Answers will vary.

Activity #2: Making Calculations

Materials Needed:

- 1 plastic drinking straw
- 1 pair of scissors
- 1 ruler
- tape

A grow light stand could be constructed in many different ways. We are going to work in groups to build a grow light that looks similar the image to the right. Using the materials listed above, you can build a scale model of this grow light. Before we begin building the model, we need to calculate how long each of the pieces needs to be. Use your understanding of calculating



percentages to complete the following questions. Be sure to show your work!

6. What is the length of your straw? (in inches)

10 inches

7. How long is 43% of the straw? (in inches)

4.3 inches

8. How long is 20% of the straw? (in inches)

2 inches

9. How long is 4% of the straw? (in inches)

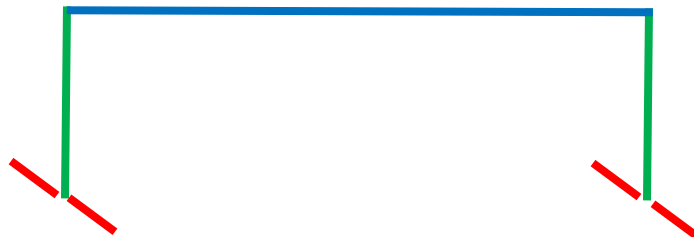
0.4 inches

10. How would you cut your straw in order to construct your model?

Student may provide a drawing or simply indicate number of cuts and sizes of pieces.

1 piece – 4.3 inches, 2 pieces – 2 inches, 4 Pieces – 0.4 inches

11. Draw a sketch of how you would put these pieces together to create a grow light stand.



Activity #3: How can grow lights be applied to modern agriculture?

Read the article “The light fantastic” (<http://www.economist.com/node/21602194/print>) from The Economist, May 17, 2014 for an example of how grow lights are being used to impact indoor agriculture in Indiana. The article showed how technology and science can be applied to impact agriculture; this is the job of agricultural engineers.

Answer the following questions.

12. Briefly explain the lighting technology being used in this indoor farming example.

Thousands of blue and red light-emitting diodes (LEDs)

13. What crops are being grown in this facility?

Lettuce, kale, basil, chives

14. What are three benefits that can result from moving crops into indoor growing facilities?

- Reduced water use because of recycled water
- Precise application of necessary nutrients using sensors
- Energy efficient (light itself is more energy efficient AND give off less heat = reduced air conditioning)
- More space efficiency (Increased plant density)
- Better produce (crisper or softer lettuce)
- Faster growing time
- Meeting high demand for locally grown produce

15. What are two problems that are solved by moving agriculture into a warehouse?

- Avoidance of insect pests
- Avoidance of bad weather