COMMON CORE MATHEMATICS

Integration Activity

Pathway: Animal, Plant, and Soil Science

Lesson: APSR E4–10: Irrigation

Common Core State Standards for Mathematics: 9-12.N-Q.1

Domain: Quantities N-Q

Cluster: Reason quantitatively and use units to solve problems.

Standard: 1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

Student Objective: Students will use relationships between units of area, volume, and time to calculate water application rates for irrigation systems and compute densities of crop production per unit of area.

BACKGROUND KNOWLEDGE for Teachers and Students

Math Concepts:

Unit of Measurement: A standardized quantity of measurement of a physical quantity.

Equality: A statement of two equal quantities. When used in conjunction with the identity a $\times$ 1 = a, it becomes possible to change the units of a quantity without changing the quantity. For example if x = x, then x/x = 1. In the same way, if x = y, then x/y = 1 or y/x = 1. Different number quantities can be equal when expressed in different units.

Ex: If 1 foot = 12 inches, then $\frac{1 \text{ foot}}{12 \text{ inches}} = \frac{12 \text{ inches}}{1 \text{ foot}} = 1$

Unit Conversion:

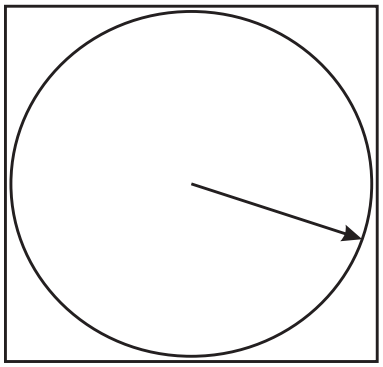
Khan Academy—Video

(https://www.khanacademy.org/math/arithmetic/rates-and-ratios/unit_conversion/v/converting-units-of-length)

Agriculture Concepts:

Irrigation is used in crop production and horticulture settings to promote plant growth by the artificial application of water. Irrigation is an important part of soil moisture management. Water deficiency can cause poor plant growth and low yields, among other things. Fertilizers, growth regulators, and other chemicals can easily be added to irrigation water for increased benefits. There are many types of irrigation practices. Two of them are center-pivot irrigation and furrow irrigation. Center-pivot irrigation involves an elevated watering line that slowly turns around a pivot point. Furrow irrigation distributes water through furrows, with crops planted in the ridge between two furrows.

Guided Practice Exercises: ANSWER KEY



1. $\sqrt{(43{,}560 \times 2)} = 295.16$ ft

   Length and width are each 295 ft.

2. $A_{circle} = \pi r^2 h$

   $A_{cpirrigation} = \pi(147.5 \text{ ft})^2$

   $A_{cpirrigation} = 68{,}314.63 \text{ ft}^2 \times (1 \text{ acre} / 43{,}560 \text{ ft}^2) = 1.57$ acres

3. 1.57 acres × (27,000 gal / 1 acre × week) × (1 hr / 60 min) × (1 week / 10 hr) = 70.65 gal per min

4. 1.57 acres × (27,000 gal/acre) × (1 min / 35 gal) × (1 hr / 60 min) = 20.19 hr

5. Irrigated tomatoes: 1.57 acres / 2 = 0.785 acre × (1.5 lb/ft^2) × (43,560 ft^2/1 acre) = 51,291.9 lb

   Nonirrigated tomatoes: 0.43 acre / 2 = 0.215 acre × (0.5 lb/ft^2) × (43,560 ft^2/1 acre) = 4,682.7 lb

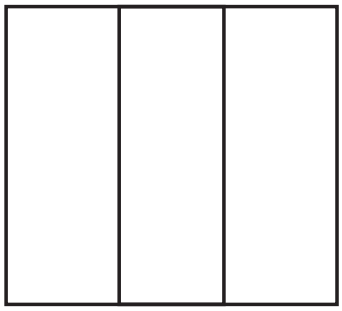
   Total tomatoes: 51,291.9 + 4,682.7 = 55,974.6 lb tomatoes

   Irrigated green beans: 1.57 acres / 2 = 0.785 acre × (1 lb/ft^2) × (43,560 ft^2/1 acre) = 34,194.6 lb

Nonirrigated green beans: 0.43 acre / 2 = 0.215 acre × (0.5 lb/ft^2) × (43,560 ft^2/1 acre) = 4,682.7 lb

Total green beans: 34,194.6 + 4,682.7 = 38,877.3 lb green beans

Independent Practice Exercises: ANSWER KEY



1. Length = $\sqrt{\text{Total area}}$ = $\sqrt{(43{,}560 \times 2)}$ = 295.16 ft

   Length for each plot: 295 ft

   Width for each plot: 295 ft / 3 = 98.33 ft

2. V_{furrow} = Length × width × height

   V_{furrow} = 295 ft × 1 ft × 1 ft = 295 ft^3

   41 furrows × Volume of each furrow = 12,095 ft^3

   12,095 ft^3 × (1 gal H_2O/7.48 ft^3) = 1,616.98 gal per section

3. 2 acres × (1 in of water / acre) × (27,000 gal / 1 inch of water) × (1 fill / (3 × 1,616.98 gal) = 11.13 ≈ 11 fills

4. Each fill: 3 × 1,616.98 gal × (1 min / 35 gal) × (1 hr / 60 min) = 2.31 hr

   Total: (2.31 hr/fill) × 11 fills = 25.41 hr

5. Eggplant: (1.25 lb/ft^2) × (295 ft × 98.33 ft) = 36,259.19 lb

   Snap peas: (1 lb/ft^2) × (295 ft × 98.33 ft) = 29,007.35 lb

   Onions: (0.75 lb/ft^2) × (295 ft × 98.33 ft) = 21,755.51 lb

   Total produce: 36,259.19 + 29,007.35 + 21,755.51 = 87,022.05 lb

6. The overall time commitment each week was less for the center-pivot system. Also, that system would be less labor intensive because you would need only to turn on the center-pivot valve once and wait. With the furrow system, you would need to move the hose to each furrow. The water usage is less with the center-pivot system because less area is being irrigated at the same rate as with the furrow system.

Name: _____

Guided Practice Exercises:

You plan on planting a square 2-acre community garden to provide fresh tomatoes and green beans for your local food pantry. The crops will require irrigation.

1. Draw a diagram of the plot, and indicate the length and the width. (43,560 ft^2 per acre)

2. A 147.5-foot center-pivot irrigation system can be installed to water the garden. Draw it into your diagram above. How much area (in acres) will it irrigate? (1 acre = 43,560 ft^2)

3. You need to irrigate the garden with 1 inch of water per acre each week for peak crop growth. How many gallons per minute are required if you water the garden for 10 hours each week and each inch of water per acre requires about 27,000 gallons?

4. Your water well can handle only 35 gallons per minute. Can the garden be irrigated in the 10 hours? If not, how many hours will it take to irrigate the garden properly?

5. Irrigated tomatoes produced 1.5 pounds per square foot throughout the season, and irrigated green beans produced 1 pound per square foot. Nonirrigated tomatoes produced 0.5 pound per square foot, and nonirrigated green beans produced 0.5 pound per square foot. Assuming the plants were planted in equal amounts, how many pounds of tomatoes and how many pounds of green beans were harvested from the garden?

Name: _____

Independent Practice Exercises:

Next year you plan to grow eggplant, snap peas, and onions in the 2-acre community garden.

1. Draw a diagram of the square garden divided into three equal plots for eggplant, snap peas, and onions. What are the length and the width of each section?

2. The plan is to irrigate each section by flooding furrows between the rows of crops going the length of the garden. You intend to plant 40 rows of each crop and have 41 furrows in each section. Each furrow is 1 foot wide and will be flooded to a depth of 12 inches. How much water will it take to fill each section of the garden each time you flood? (1 gal H_2O = 7.48 ft^3)

3. If the crops require the equivalent of 1 inch of water per week, how many times will you need to fill the furrows each week? (1 in of water/acre = 27,000 gal/acre)

4. The well can pump 35 gallons per minute. How many hours will it take to fill every furrow in the garden? To apply an inch of water?

5. With irrigation, eggplant, snap peas, and onions will yield 1.25 pounds per square foot, 1 pound per square foot, and 0.75 pound per square foot, respectively. How many pounds of produce will you collect this year?

6. In a few sentences, compare the time commitment and water usage each week for the garden with center-pivot irrigation and with furrow irrigation.