COMMON CORE MATHEMATICS

Integration Activity

Pathway: Animal, Plant, and Soil Science

Lesson: APSR D3–3: Fertilizer Formulations

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 be able to convert between units of weight, cost, and area to determine the proper amount of fertilizer to apply on a certain area using the formulation of the fertilizer and the nutrient requirements of the site.

BACKGROUND KNOWLEDGE for Teachers and Students

Math Concepts:

Units 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:

A fertilizer is an organic or inorganic material applied to soil or water to provide nutrients that increase plant growth, yield, and nutritional quality. Bags of fertilizer will show the fertilizer grade. The grade lists the content of the three primary macronutrients—the percentage, in order, of nitrogen (N), phosphate (P_2O_5) (also called phosphoric acid), and potash (K_2O). For example 25-50-10 will be 25% N, 50% P_2O_5, and 10% K_2O. Fertilizer grades never total 100 percent; the remaining percentage is taken up by fillers and carrier compounds that do not directly provide nutrition to plants. To convert between the amounts of phosphorus / phosphoric acid (P_2O_5) and potassium/potash (K_2O), the following formulas are used: $P_2O_5 \times 0.44 = P$ and $K_2O \times 0.83 = K$. Soil testing is done to determine optimal fertilizer rates to be applied. Overfertilization leads to wasted fertilizer and money as well as pollution.

Guided Practice Exercises: ANSWER KEY

1. a. 6,500
   b. 3
   c. 10
   d. 45
   e. 10
   f. 10
   g. 0.83
   h. 0.44

2. $56 \text{ lawns} \times \frac{6{,}500 \text{ ft}^2}{1 \text{ lawn}} \times \frac{3 \text{ lb N}}{1{,}000 \text{ ft}^2} = 1{,}092 \text{ lb N}$

3. 10-10-10

$$1 \text{ lb N} \times \frac{100 \text{ lb fert}}{10 \text{ lb N}} \times \frac{\$18.00}{100 \text{ lb fert}} = \$1.80$$

45-0-0

$$1 \text{ lb N} \times \frac{100 \text{ lb fert}}{45 \text{ lb N}} \times \frac{\$38.00}{100 \text{ lb fert}} = \$0.84$$

45-0-0 is the better value. It costs only $0.84 for each lb N, while 10-10-10 costs $1.80 for each lb N.

4. $$1{,}092 \text{ lb N} \times \frac{100 \text{ lb fert}}{45 \text{ lb N}} = 2{,}426.67 \text{ lb fert}$$

   $$2{,}426.67 \text{ lb fert} \times \frac{\$38.00}{100 \text{ lb fert}} = \$922.13$$

5. JP Enterprises will need to purchase 130 lb of 10-10-10 and 14.44 lb of 45-0-0 to meet this demand. The total cost will be $28.89.

   $$\frac{1.66 \text{ lb K}}{1{,}000 \text{ ft}^2} \times \frac{1 \text{ lb } K_2O}{0.83 \text{ lb K}} \times \frac{100 \text{ lb}^{10\text{-}10\text{-}10}}{10 \text{ lb } K_2O} \times 6{,}500 \text{ ft}^2 = 130 \text{ lb}^{10\text{-}10\text{-}10}$$

   $$\frac{0.88 \text{ lb P}}{1{,}000 \text{ ft}^2} \times \frac{1 \text{ lb } P_2O_2}{0.44 \text{ lb P}} \times \frac{100 \text{ lb}^{10\text{-}10\text{-}10}}{10 \text{ lb } P_2O_2} \times 6{,}500 \text{ ft}^2 = 130 \text{ lb}^{10\text{-}10\text{-}10}$$

   $$6{,}500 \text{ ft}^2 \times \frac{3 \text{ lb N}}{1{,}000 \text{ ft}^2} = 19.5 \text{ lb N total needed}$$

   $$130 \text{ lb}^{10\text{-}10\text{-}10} \times \frac{10 \text{ lb N}}{100 \text{ lb}^{10\text{-}10\text{-}10}} = 13 \text{ lb N applied}$$

   $$19.5 - 13 = 6.5 \text{ lb N needed} \times \frac{100 \text{ lb}^{45\text{-}0\text{-}0}}{45 \text{ lb N}} = 14.44 \text{ lb}^{45\text{-}0\text{-}0}$$

   $$130 \text{ lb}^{10\text{-}10\text{-}10} \times \frac{\$18.00}{100 \text{ lb}^{10\text{-}10\text{-}10}} = \$23.40$$

   $$14.44 \text{ lb}^{45\text{-}0\text{-}0} \times \frac{\$38.00}{100 \text{ lb}^{45\text{-}0\text{-}0}} = \$5.49$$

   $$\$23.40 + 5.49 = \$28.89$$

Independent Practice Exercises: ANSWER KEY

1. a. 24,000

   b. 10

   c. 20

d. 20

e. 20

f. 0.83

g. 0.44

2. Total needed $= 24{,}000\ ft^2 \times \frac{10\ lb\ N}{1{,}000\ ft^2} = 240\ lb\ N$

$$\text{Total applied} = 1\ \text{property} \times \frac{24{,}000\ ft^2}{1\ \text{property}} \times \frac{30\ lb^{20\text{-}20\text{-}20}}{1{,}000\ ft^2} \times \frac{20\ lb\ N}{100\ lb^{20\text{-}20\text{-}20}} = 144\ lb\ N$$

$240 - 144 = 96\ lb\ N$

3. No additional P or K should be added this year.

$$\frac{30\ lb\ fert^{20\text{-}20\text{-}20}}{1{,}000\ ft^2} \times \frac{20\ lb\ K_2O}{100\ lb\ fert^{20\text{-}20\text{-}20}} \times \frac{0.83\ lb\ K}{1\ lb\ K_2O} = 4.98\ lb\ K/1{,}000\ ft^2$$

$$\frac{30\ lb\ fert^{20\text{-}20\text{-}20}}{1{,}000\ ft^2} \times \frac{20\ lb\ P_2O_5}{100\ lb\ fert^{20\text{-}20\text{-}20}} \times \frac{0.44\ lb\ K}{1\ lb\ P_2O_5} = 2.64\ lb\ P/1{,}000\ ft^2$$

4. 45-0-0 should be used to apply all the remaining fertilizer for two reasons: (a) applying it is cheaper, and (b) using 45-0-0 will avoid overfertilizing the soil with P and K.

5. JP Enterprises should apply a total of 213.33 lb of 45-0-0 to the 24,000 ft^2.

$$96\ lb\ N\ needed \times \frac{100\ lb^{45\text{-}0\text{-}0}}{45\ lb\ N} = 213.33\ lb^{45\text{-}0\text{-}0}$$

$$213.33\ lb^{45\text{-}0\text{-}0} \times \frac{\$38.00}{100\ lb^{45\text{-}0\text{-}0}} = \$81.07$$

Name: _____

Guided Practice Exercises:

Jan and Pete run a successful lawn care business, JP Enterprises. They care for 56 residential properties, averaging 6,500 ft^2 each, providing fertilization, mowing, minor landscaping, and aeration. They have an opportunity to buy bulk amounts of fertilizer with formulations 10-10-10 and 45-0-0. How much of each fertilizer will they need to buy to cover all their lawns with 3 lb N per 1,000 ft^2?

1. Write equality relationships between the following units.

   a. 1 lawn = _____ ft^2

   b. 1,000 ft^2 = _____ lb N

   c. 100 lb 10-10-10 = _____ lb N

   d. 100 lb 45-0-0 = _____ lb N

   e. 100 lb 10-10-10 = _____ lb K_2O

   f. 100 lb 10-10-10 = _____ lb P_2O_5

   g. 1 lb K_2O = _____ lb K

   h. 1 lb P_2O_5 = _____ lb P

2. Using the relationships above, how many total pounds of nitrogen are needed by JP Enterprises?

   56 lawns × _____ × _____ = _____ N

3. 10-10-10 costs $18 per 100 lb, and 45-0-0 costs $38 per 100 lb. Determine the cost of each pound of nitrogen. Which fertilizer would be the better value in terms of lb N?

4. Assuming JP Enterprises goes with the better value, how many pounds of fertilizer would it need to buy to satisfy its needs? How much will the fertilizer cost?

5. The average 6,500 ft^2 lawn that JP Enterprises cares for requires 1.66 lb K and 0.88 lb P to be applied, as well as 3 lb N per 1,000 ft^2. How many pounds of 10-10-10 and 45-0-0 will be needed to meet this demand? How much will it cost?

Name: _____

Independent Practice Exercises:

JP Enterprises has just acquired another customer with 24,000 ft^2 of property that was being cared for by another business. That business applied 20-20-20 at a rate of 15 lb/1,000 ft^2 in March and again in late May. How much of each fertilizer (10-10-10 and 45-0-0) should JP Enterprises apply in the fall to reach a total of 10 lb N/1,000 ft^2 for the year?

1. Write equality relationships between the following units.

   a. 1 property = _____ ft^2

   b. 1,000 ft^2 = _____ lb N

   c. 100 lb 20-20-20 = _____ lb N

   d. 100 lb 20-20-20 = _____ lb K_2O

   e. 100 lb 20-20-20 = _____ lb P_2O_5

   f. 1 lb K_2O = _____ lb K

   g. 1 lb P_2O_5 = _____ lb P

2. Using the relationships above, how many total pounds of nitrogen should JP Enterprises apply (Total needed – Total applied)?

   $$\text{Total needed} = \_\_\_\_\_\ ft^2 \times \frac{\text{lb N}}{ft^2} = \_\_\_\_\_\ \text{lb N}$$

   $$\text{Total applied} = 1 \text{ property} \times \frac{\text{lb}^{20\text{-}20\text{-}20}}{\_\_\ \text{property}} \times \frac{\text{lb}^{20\text{-}20\text{-}20}}{ft^2} \times \frac{\text{lb N}}{\text{lb}^{20\text{-}20\text{-}20}} = \_\_\_\_\_\ \text{lb N}$$

3. If 2.5 lb P and 4.5 lb K were recommended to be applied per 1,000 ft^2 for the whole year, should any additional phosphorus or potassium be added to the new lawn?

4. Determine the best way for JP Enterprises to apply the remaining fertilizer using 10-10-10 ($18/100 lb) and 45-0-0 ($38/100 lb). Give two reasons to support your conclusion.

5. How much will JP Enterprises need? How much will it cost?