

# Population Density

*Fast Track GRASP Math Packet*



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## Table of Contents

<b>Welcome!</b>	<b>4</b>
Vocabulary	5
Introduction	7
<b>What is Area?</b>	<b>8</b>
Introduction to Area - Answer Key	16
<b>What is Density?</b>	<b>17</b>
Beans and Density	17
Density of Foxes in a State Park	20
Introduction to Density - Answer Key	22
Finding Density from Area and Population	23
Finding Density from Area and Population - Answer Key	27
<b>Reviewing What We Have Learned about Population Density</b>	<b>28</b>
<b>What Does the Word “Per” Mean?</b>	<b>31</b>
What Does the Word “Per” Mean? - Answer Key	35
<b>Chickens and Eggs</b>	<b>36</b>
Two Chicken Coops	37
Chickens and Eggs - Answer Key	40
<b>Looking at the Population of the United States</b>	<b>41</b>
Population of U.S. Regions (Chart)	42
Area and Population of U.S. States and Territories (Table)	46
Questions about the Area and Population of U.S. States & Territories	47
A Practice Question	48
Looking at the Population of the United States - Answer Key	49
<b>Population, Area and Density Practice</b>	<b>51</b>

Your Own Population and Area Data	55
How Crowded is New York City?	56
Public Libraries in NYC	57
Population, Area and Density Practice - Answer Key	58
<b>Practice Questions</b>	<b>60</b>
Practice Questions - Answer Key and Explanations	68
<b>Key Ideas to Remember</b>	<b>70</b>
<b>The Language of Population Density</b>	<b>71</b>
How Math is Written	71
Using Graphic Organizers to Learn Vocabulary	73
Concept Circle	76
Fill in the Blanks	77
Where You Live	79
The Language of Population Density - Answer Key	81
Vocabulary Review	82

## Welcome!

Congratulations on deciding to continue your studies! We are happy to share this study packet on the topic of population density. We hope that that these materials are helpful in your efforts to earn your high school equivalency diploma. This group of math study packets will cover mathematics topics that we often see on high school equivalency exams. If you study these topics carefully, while also practicing other basic math skills, you will increase your chances of passing the exam.

Please take your time as you go through the packet. You will find plenty of practice here, but it's useful to make extra notes for yourself to help you remember. You will probably want to have a separate notebook where you can recopy problems, write questions and include information that you want to remember. Writing is thinking and will help you learn the math.

After each section, you will find an answer key. Try to answer all the questions and then look at the answer key. It's not cheating to look at the answer key, but do your best on your own first. If you find that you got the right answer, congratulations! If you didn't, it's okay. This is how we learn. Look back and try to understand the reason for the answer. Please read the answer key even if you feel confident. We added some extra explanation and examples that may be helpful. If you see a word that you don't understand, try looking at the *Vocabulary Review* at the end of the pack.

We also hope you will share what you learn with your friends and family. If you find something interesting in here, tell someone about it! If you find a section challenging, look for support. If you are in a class, talk to your teacher and your classmates. If you are studying on your own, talk to people you know or try searching for a phrase online. Your local library should have information about adult education classes or other support. You can also find classes listed here: <http://www.acces.nysed.gov/hse/hse-prep-programs-maps>

You are doing a wonderful thing by investing in your own education right now. You have our utmost respect for continuing to learn as an adult.

Please feel free to contact us with questions or suggestions.

Best of luck!

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## Vocabulary

It is important to understand mathematical words when you are learning new topics. The following vocabulary will be used a lot in this study packet:

area · density · per · product · rate · rectangle · square · unit

In this first activity, you will think about each word and decide how familiar you are with it. To start, think about the word “area.” Which of these statements is true for you?

- I know the word “area” and use it in conversation or writing.
- I know the word “area,” but I don’t use it.
- I have heard the word “area,” but I’m not sure what it means.
- I have never heard the word “area” at all.

In the chart on the next page, read each word and then choose one of the four categories and mark your answer with a ✓ (checkmark). Then write your best guess at the meaning of the word in the right column. If it’s easier, you can also just use the word in a sentence.

Here’s an example of how the row for “area” might look when you’re done:

Word	I know the word and use the word	I know the word but don’t use it	I have heard the word, but I’m not sure what it means	I have never heard the word	My best guess at the meaning of the word (or use the word in a sentence)
area	✓				A place or location, like a neighborhood or town

Complete the table on the next page.

Complete the table based on your knowledge of the words in the left column. It's okay if you don't know the meaning of a word. Make your best guess or write where you have heard it.

Word	I know the word and use the word	I know the word but don't use it	I have heard the word, but I'm not sure what it means	I have never heard the word	My best guess at the meaning of the word (or use the word in a sentence)
area					
density					
per					
product					
rate					
rectangle					
square					
unit					

## Introduction

Consider these two housing situations:

2 people living in a 3-room apartment

3 people living in a 4-room house

Imagine that you have the choice of living as a roommate in one of the two homes above. Which would you choose? You probably want to live in the home that has more space. The apartment has less people, but it also has fewer rooms. The house has more rooms, but it also has more people.

Imagine you were given some additional information:

The apartment is 600 square feet in size.

The house is 1,000 square feet in size.

How would you decide which home would be less crowded?

You could use the idea of density to make a decision about which home to live in. Density can help us understand how crowded a place is.

Density is an idea that is used to measure many different things. For example, how many people live in a place, the number of animals that can survive in the wild, and the weight of gold are all related to density. This packet combines social studies, science and math. You will use the concepts of area and volume to understand important topics on the high school equivalency math and science exams. You will also practice interpreting graphs, a crucial skill for high school equivalency success.

Population density is a way of describing how crowded a place is with people. Places where people are spread out, like the country, have low population density. Places where people live close together, like cities, have high population density. Population density is also used to describe how many animals or plants (living organisms) are in an area. For example, you might talk about the population density of pigeons in New York City. How crowded do you think New York City is with pigeons?

In science, density is a measure of how heavy something is for its size. For example, the metal steel is denser than foam rubber. If you hold a piece of foam rubber in one hand and a piece of steel the same size in the other hand, the steel would be heavier. Steel has a higher

density which makes it heavier for its size. (A separate math packet on the **Density of Matter** will be available.)

**Answer:** You can compare how crowded two homes are by measuring their density. You might measure the number of people per room or the number of rooms per person. Before you move in as a roommate, both the apartment and the house have the same population density. In both the apartment and the house, there are 2 rooms or 300 square feet for each person.

In this math learning module, you will get lots of practice comparing how crowded different places are, based on their size and population. The questions and answers you see in this module will help you check your understanding of exercises and explanations as you read.

## What is Area?

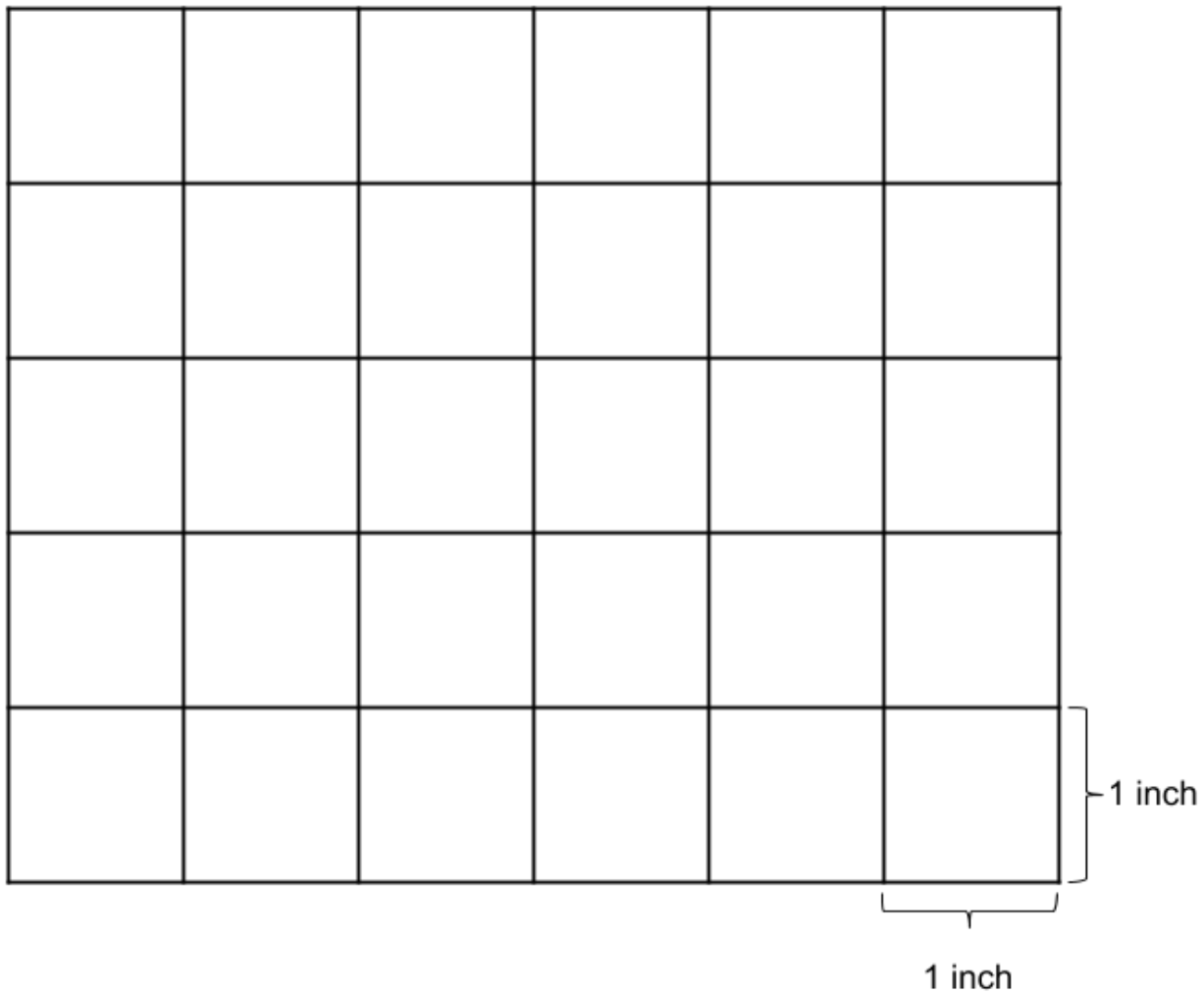
In order to understand population density, it's important to understand area, an idea from geometry. In everyday English, "area" means a place. A neighborhood could be an area, for example. A town could be an area. We might talk about the urban areas of New York State where a lot of people live or the rural areas of the state where fewer people live.

In mathematics, the definition of area is more specific. Area means the size of a surface. Examples of surfaces include a chalkboard, a table, a wall or a field. In mathematics, if you talk about the area of a city, you might ask, "What is the size of the surface the city covers?"

We measure surfaces by imagining how many squares it would take to cover the surface completely. For example, you might measure the area of a piece of paper in square inches. To do this, you can imagine lots of squares, each with a width and length of 1 inch, covering the paper.



Let's think about the area of the figure below. It's made of squares that are 1 inch on each side.



How many squares are there in total? \_\_\_\_\_

What is the area of the rectangular grid? \_\_\_\_\_ square inches

The answer to both of these questions is the same: 30.

How did you know there were 30 square inches in that figure?

**Ways of finding the number of squares:**

- Counting the number of squares is a perfectly good way to find out the area.

- Another way to find the number of squares in the grid is to think about the number of rows and columns. There are 5 rows and each row has 6 squares. If you add 6's for each of the 5 rows, you end up with 30:

$$6 + 6 + 6 + 6 + 6 = 30$$

- Another way is to multiply the height by the length. The height is 5 squares and the length is 6 squares. The area of the grid = 5 inches  $\times$  6 inches = 30 square inches.

When we use the word *area*, we're talking about how many squares it takes to cover a surface. The question, *What is the area?* means the same as *How many squares would you need to cover the entire surface?*

Now we need to know the size of the squares we're using to measure the surface. That's why it is important to include a measurement in your answer. When you write the number of squares in the area, always include a measurement: square inches, square centimeters, square feet, square meters, etc.

You can measure area with squares of many different sizes. For example, the area of an apartment might be measured with square feet or square meters, and the area of a city with square miles or square kilometers. We use the word *unit* to refer to the size of the squares we're using to measure. In the United States, our units for area are square inches, square feet and square miles for measuring area. In the rest of the world, people use square centimeters, square meters and square kilometers as part of the International System (SI) of measurement, which is related to the metric system. American scientists, health care workers, and others also use SI measurements.

Here are some examples of possible area measurements:

The size of a...	is about...	and is also about...
postage stamp	1/2 square inch	3 square centimeters
playing card	9 square inches	56 square centimeters
football field	57,000 square feet	53,000 square meters
New York State	55,000 square miles	142,000 square kilometers

**Check Your Understanding:** If you look at real estate listings, you will see that the size of homes isn't usually measured in square inches. Why not? What unit is normally used?

To measure in different situations, you will use squares of different sizes. For example, if you measure the size of a table, you would probably use square inches or square centimeters. To measure the size of a house or apartment, you would probably use square feet or square meters. If you measure the size of a country, you would use square miles or square kilometers.

Square units can be written in at least three different ways:

*square inches*

*sq. in.*

*in<sup>2</sup>*

*square feet*

*sq. ft.*

*ft<sup>2</sup>*

*square miles*

*sq. mi.*

*mi<sup>2</sup>*

**Answer:** The truth is, we *could* measure the size of homes in square inches though it probably wouldn't be practical. Usually, you will see that real estate ads describe the size of homes in square feet.

Let's say a 3-bedroom home has an area of 2,000 square feet. You could also say that the area is 288,000 square inches. This is correct since there are 144 square inches in a square foot, but 2,000 square feet is an easier measurement to remember. You could even say the area of the house is .00007 square miles!

The measurement in square inches and the measurement in square miles are both true, but I doubt you will ever hear someone measure a house that way. The measurement in square inches is a really big number and the measurement in square miles is a really small number. The number 2,000 in square feet is an easier number to talk about with other people. When we measure area, we usually choose the unit that gives us numbers that are easiest to use.

Find the area of the following figures:

1) Area = 42 square inches

How do you know the area is 42 in<sup>2</sup>?

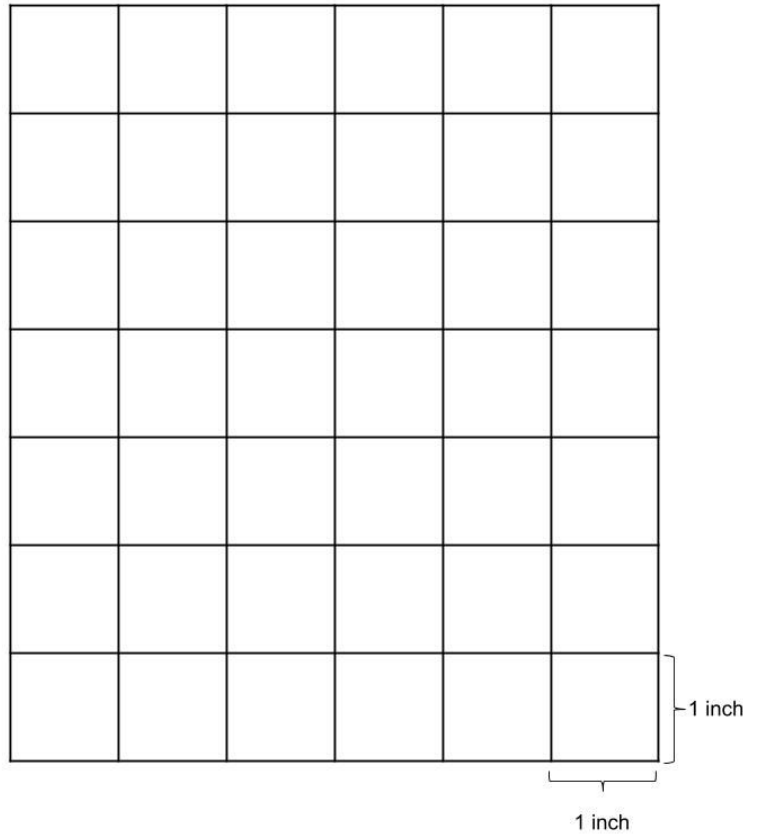
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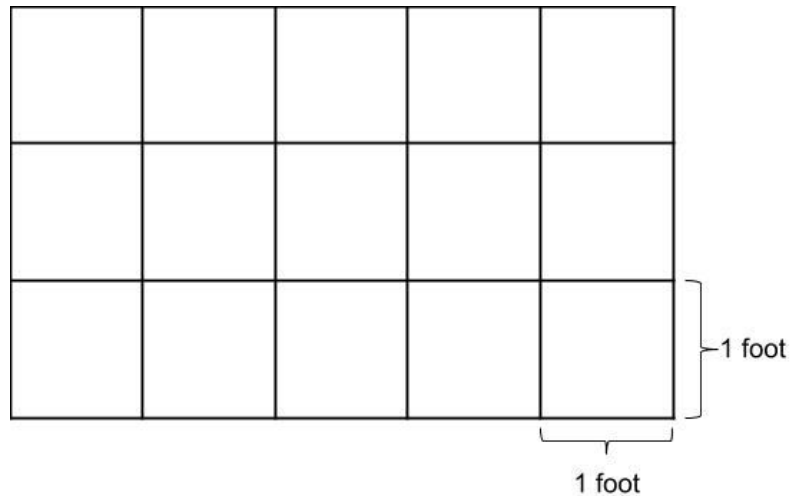
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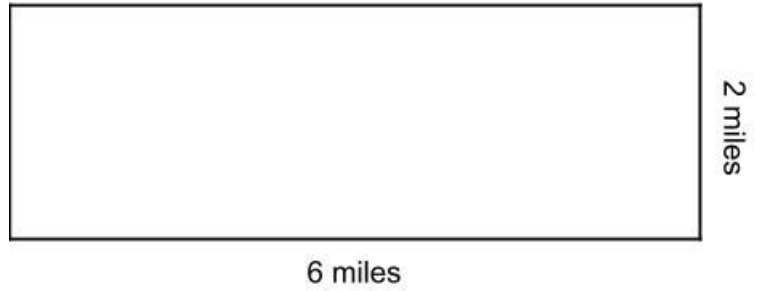


2) Area = \_\_\_\_\_ square feet

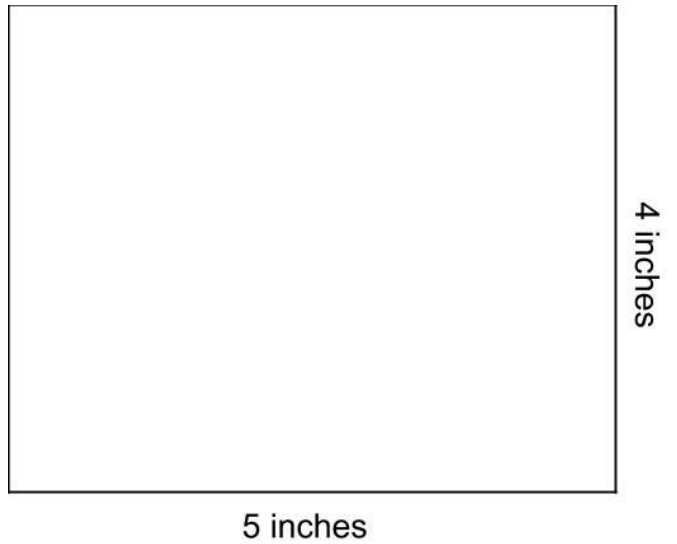


Find the area of the following figures:

3) Area = \_\_\_\_\_ sq. mi.

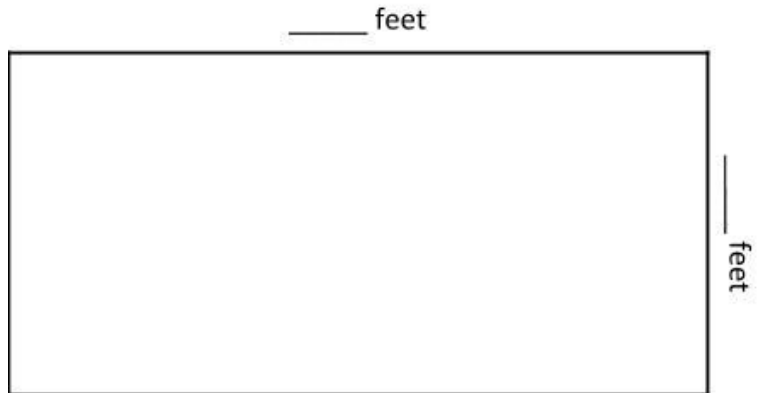


4) Area =



5) The area of the rectangle on the right is 15 square feet.

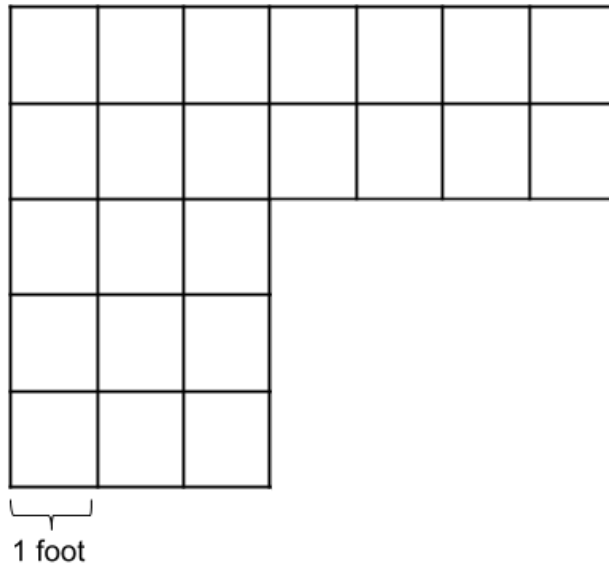
What do you think the length and width of the rectangle could be?



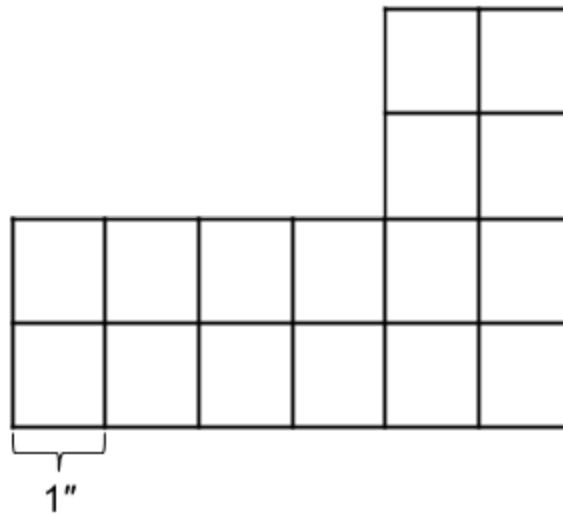
You can also find the area of shapes other than rectangles.

What are the areas of these figures?

6) Area = \_\_\_\_\_ sq. ft.

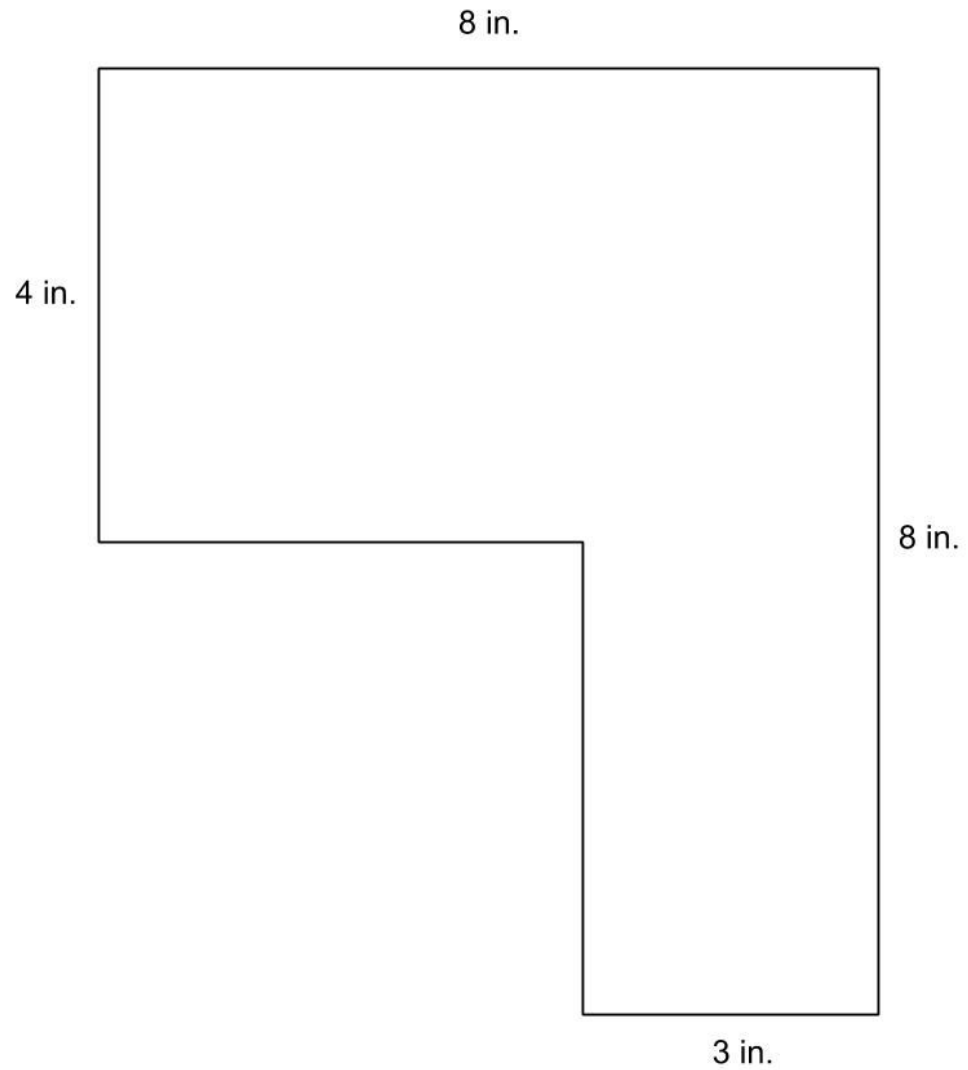


7) Area =



(Note: The symbol ' means *feet* and " means *inches*.)

8) Area =



**Question:** What is the area of a standard piece of  $8\frac{1}{2}$ " by 11" piece of paper?

## Introduction to Area - Answer Key

- 1) 42 square inches. You could count 42 squares or multiply 6 by 7 to get 42.
- 2) 15 square feet
- 3) 12 square miles
- 4) 20 square inches
- 5) There are many possible correct answers. The dimensions of the rectangle could be 3 feet by 5 feet. The measurements could also be 2 feet by  $7\frac{1}{2}$  feet.
- 6) 23 square feet
- 7) 16 square feet
- 8) 44 square inches



# What is Density?

## Beans and Density

Now that we've explored area, let's consider density. When we calculate the density of a population, we need to divide the population over a certain area. For this activity, you will need about 100 beans (rice grains or other items about the same size are fine as well) and the grid paper on the next page.

- 1) On grid paper, color or fill in an area of 18 square inches.
- 2) Count out 54 beans and pour them on to your 18 square-inch area.
- 3) Spread the beans out equally so that there is the same number of beans in each of the 18 squares.
- 4) You should be able to put an equal amount of beans on each square. Once you divide up all 54 beans equally, how many are there in each square? \_\_\_\_\_
- 5) This grid has a density of \_\_\_\_\_ beans per square inch. (In other words: *How many beans are in each square?*)

*How we write measurements of density:*

If you had 18 beans to spread out on the rectangular grid, the density is *1 bean per square inch*, since you can put 1 bean on each of the 18 squares in the grid. Try it on your grid.

If you had 36 beans, you could put 2 beans on each of the 18 squares. So, if the population is 36 beans and the area is 18 square inches, then the density is *2 beans per square inch*. This means there will be 2 beans for every square inch. Try it.

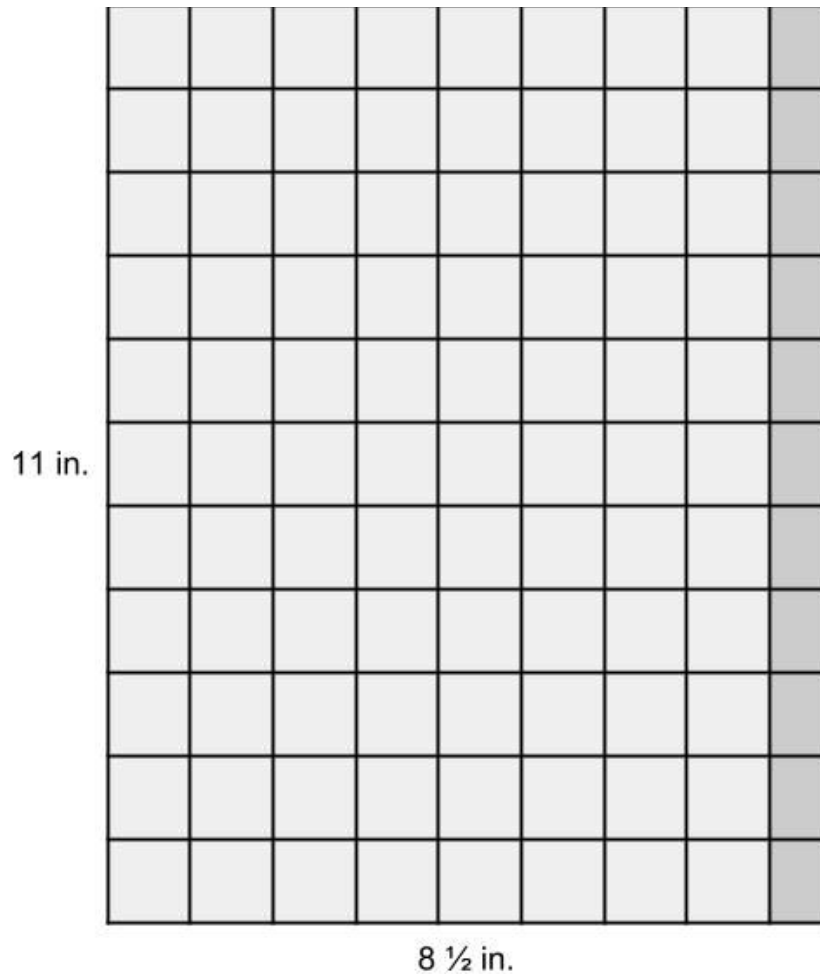
Density measurements can be written in different ways. Each of the following means the same thing and should be read as "*2 beans per square inch*:"

*2 beans/square inch*

*2 beans/sq. in.*

*2 beans/in<sup>2</sup>*


**Answer:** What is the area of a standard piece of  $8\frac{1}{2}$ " by 11" piece of paper? In other words, how many squares would cover the paper? The image below shows the paper covered with light grey 1-inch squares.



There are 88 light grey 1-inch squares. The dark grey pieces are actually each half of a square, since the paper is  $8\frac{1}{2}$  inches wide. There are 11 half-squares, which equals  $5\frac{1}{2}$  light grey square inches.

$$88 + 5\frac{1}{2} = 93\frac{1}{2} \text{ square inches}$$

Another way to figure out the area is to multiply the length and the width of the paper:

$$8.5 \text{ inches} \times 11 \text{ inches} = 93.5 \text{ in}^2 \quad \leftarrow \text{ Try this with a calculator.}$$

## Density of Foxes in a State Park



*In the last exercise, you filled in an area of 18 square inches. Imagine that this grid now represents a state park with an area of 18 square miles. There is a population of 54 foxes living in the park (represented by the beans). The population density of foxes is 3 foxes per square mile.*

In the life sciences, the word **population** refers to all the organisms of a species living in a specific area. A **species** is a group of similar living things which interbreed among themselves.

*In the spring, the fox population increased when 36 baby foxes were born.*

6) Count out beans to represent the additional foxes and add them to the grid.

7) What is the total population of foxes now? \_\_\_\_\_

8) Can you put the same number of beans in each square? \_\_\_\_\_

If so, how many beans are there in each square? \_\_\_\_\_

9) The density after the population increase is \_\_\_\_\_ foxes per \_\_\_\_\_ .

*The next winter was really cold and, unfortunately, 27 foxes died.*

10) Remove 27 beans. What is the total population of foxes now? \_\_\_\_\_

11) You won't be able to divide an equal amount of whole beans into each square, but what if you could cut some beans in half?  
\_\_\_\_\_

12) The fox population density after the winter is \_\_\_\_\_ foxes/sq. \_\_\_\_\_ .



- 13) Take a look at Tayshawn's work on the fox population problem. Can you help him find the fox population density after the winter?

$$\begin{array}{r} 54 \text{ foxes} \\ + 36 \text{ baby foxes} \\ \hline 90 \text{ foxes after the spring} \\ - 27 \text{ foxes died} \\ \hline 63 \text{ foxes after the winter} \end{array}$$

I found the fox density by dividing the fox population by the area.

$$54 \div 18 \text{ mi}^2 = 3 \text{ foxes / mi}^2$$

$$90 \div 18 \text{ mi}^2 = 5 \text{ foxes / mi}^2$$

$$63 \div 18 \text{ mi}^2 = ?$$

63 doesn't divide evenly by 18, so I don't know the fox density after the winter.

## Introduction to Density - Answer Key

- 1) The 18 square inch area could be different shapes on the grid paper. You might have a 2 by 9 rectangle or a 3 by 6 rectangle. You could even have an L shape as long as there are 18 squares outlined.
- 2) Count to make sure you have exactly 54 beans.
- 3) Each square should have the same number of beans.
- 4) 3
- 5) 3
- 6) You should count out 36 more beans.
- 7) 90
- 8) Yes, 5
- 9) 5, square mile
- 10) 63
- 11) There would be 3 and  $\frac{1}{2}$  beans on each square.
- 12) 3.5, mile
- 13) You might have a different explanation.  $63 \div 18 = 3.5$ . The fox population density after the winter is 3  $\frac{1}{2}$  foxes per square mile.

## Finding Density from Area and Population

In order to find the density, you can *distribute* (spread out evenly) the population to each square in the area. Once you have distributed the population, the density is the number of things left in each square.

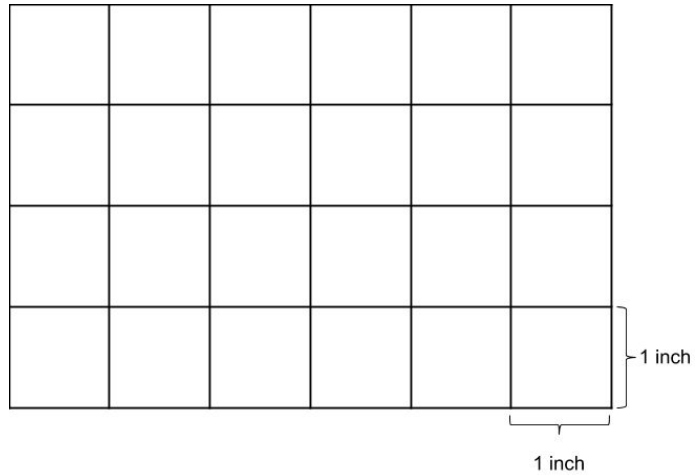
Try these practice exercises. Fill in the missing information.

1) Population = 144 beans

Area = 24 square inches

Density = \_\_\_\_\_ per sq. in.

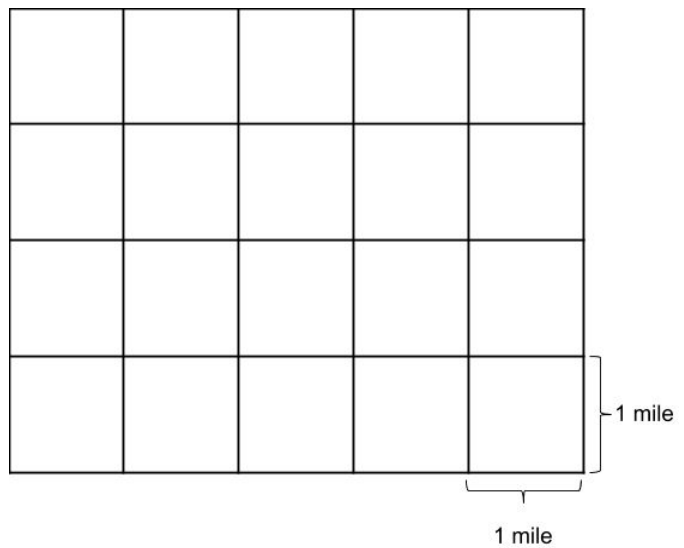
*\* Remember that you can find the density by dividing the number of beans by the number of squares.*



2) Population = 180 foxes

Area = \_\_\_\_\_ sq. \_\_\_\_\_

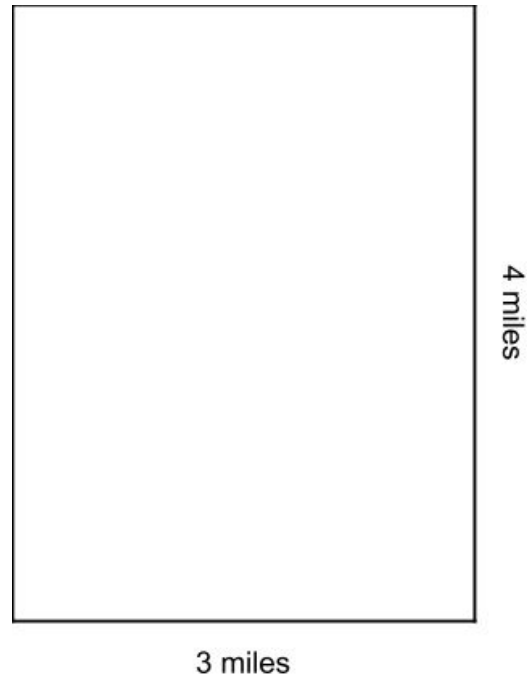
Density = \_\_\_\_\_ / sq. \_\_\_\_\_



3) Population = 132 squirrels

Area = \_\_\_\_\_ square \_\_\_\_\_

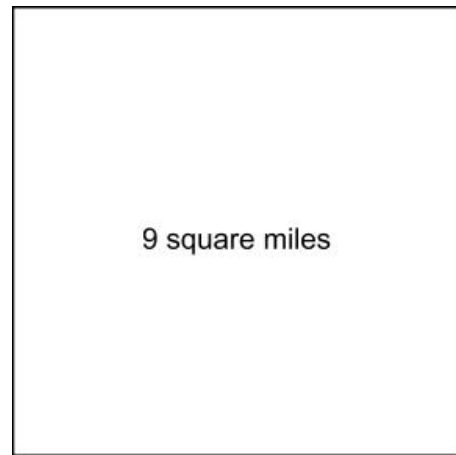
Density = \_\_\_\_\_ squirrels/sq. mi.



4) Population = 27,000 pigeons

Area = \_\_\_\_\_

Density = \_\_\_\_\_





Fill in the missing blanks.

5)

Population = 350 people

Area = 14 square miles

Density = \_\_\_\_\_ people/\_\_\_\_\_

6)

Population = 100 rabbits

Area = 40 sq. mi.

Density = \_\_\_\_\_ / \_\_\_\_\_

7)

Population = 1,035 pigeons

Area = 60 mi<sup>2</sup>

Density = \_\_\_\_\_ pigeons/\_\_\_\_\_

8)

Population = 5,000 chickens

Area = 10,000 square \_\_\_\_\_

Density = \_\_\_\_\_ chickens/ft<sup>2</sup>

9)

Population = 2000 people

Area = \_\_\_\_\_ mi<sup>2</sup>

Density = 200 people/mi<sup>2</sup>

10)

Population = \_\_\_\_\_ people

Area = 7 mi<sup>2</sup>

Density = 5,000 people/mi<sup>2</sup>

Answer the questions below.

- 11) If a population of 200 cows lives on 5 square miles of land, what does it mean that there is a density of 40 cows/mile<sup>2</sup>?
  
  
  
  
  
  
  
  
  
  
- 12) Imagine a population of deer in a forest. In the winter, animals compete for fewer and fewer resources. Many deer don't survive and the population decreases while the area of the forest stays the same. What happens to the population density of deer?
  
  
  
  
  
  
  
  
  
  
- 13) If parts of the forest are cut down to make room for houses, but the population stays the same, what happens to the population density of deer?

**Challenge Question:** There are about 2 million rats in New York City, which has a land area of about 300 square miles. What is the population density of rats in New York City?

## Finding Density from Area and Population - Answer Key

- |  |  |   |
|--|--|---|
| 1) 24, inches, 6, in                         | 9) 10  | there are fewer deer with the same amount of space.   |
| 2) 20, mi., 9, mi.                           | 10) 35,000   |   |
| 3) 12, miles, 13                             | 11) Different answers are possible. It means that if 200 cows were distributed evenly across 5 square miles of land, every square mile would have 40 cows on it. | 13) The population density goes up because there are the same number of deer with less space. |
| 4) 9 square miles, 3,000 pigeons/square mile |  |   |
| 5) 25, square mile                           |  |   |
| 6) 2.5 rabbits/sq. mi.                       |  |   |
| 7) 17.25, mi <sup>2</sup>                    | 12) The population density goes down because   |   |
| 8) miles, .5                                 |  |   |

## Reviewing What We Have Learned about Population Density

Population density tells you how crowded a population is over a particular area. It shows the relationship between the population and the area. 500 people at the Department of Motor Vehicles would be really crowded, but a football stadium with 500 people would seem empty. This is because the area of a football stadium is much larger than the DMV's offices.

The *population density* of foxes in the state park is a measure of how crowded the park is with foxes. To find out the population density of foxes, we imagine the foxes spread around the park and distributed equally in each square mile.

We can divide the total number of foxes by the total area to find the population density.

***54 foxes divided by 18 square miles equals 3 foxes per square mile.***

Also written as:

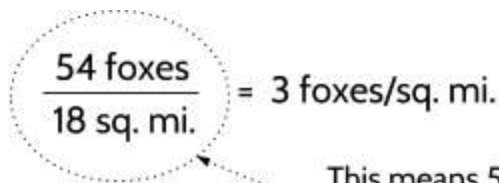
***Population divided by area equals population density.***

You can write this as a formula:

$$\frac{\text{population}}{\text{area}} = \text{population density}$$

or  $\frac{p}{a} = d$

If you insert numbers, you get:


$$\frac{54 \text{ foxes}}{18 \text{ sq. mi.}} = 3 \text{ foxes/sq. mi.}$$

This means 54 divided by 18. The horizontal line means the top number is divided by the bottom number, so the whole equation means  $54 \div 18 = 3$ .

This calculation confirms that 3 foxes would live in each square mile if they were distributed evenly around the park. (Of course, this is not how foxes actually live, but it's a way for us to understand how crowded the state park is with foxes.)

Sometimes the population can't be divided evenly by the area. In that case, your answer will have a decimal remainder.

$$\frac{63 \text{ foxes}}{18 \text{ sq. mi.}} = 3.5 \text{ foxes/sq. mi.}$$

*You can find the population density by dividing the population (number of people, animals, plants or things) by the area.*

If you know the population and the population density, you can find out the area by dividing the population by the density:  $\frac{p}{d} = a$

*A population of 2,000 people with a population density of 200 people per square mile means that the area is \_\_\_\_\_ square miles.*

$$\frac{2000 \text{ people}}{200 \text{ people/sq. mi.}} = 10 \text{ sq. mi.}$$

There must be a total of 10 square miles, because 2,000 divided by 200 equals 10.

And if you know the area and the population density, you can find out the population by multiplying the area by the density:  $a \times d = p$

*An area of 7 square miles with a density of 5,000 people per square mile means that the total population is \_\_\_\_\_ people.*

$$7 \text{ sq. mi.} \times 5000 \text{ people/sq. mi.} = 35,000 \text{ people}$$

There must be a total of 35,000 people, because 35,000 divided by 5,000 equals 7.

**Answer:** There are about 2 million rats living in New York City. New York City has an area of about 300 square miles. We can use these numbers to find the population density of rats in New York City, using the formula:

$$\frac{\textit{population}}{\textit{area}} = \textit{population density}$$

Don't forget that *2 million* can be written as 2,000,000 before doing calculations.

$$\frac{2,000,000 \textit{ rats}}{300 \textit{ sq. mi.}} \cong 6,667 \textit{ rats/sq. mi.}$$

We are dealing with bigger numbers now, but our bean model still works. Imagine trying to fit 2 million beans into 300 squares. Each square would have about 6,667 beans on it.

Note: The symbol  $\cong$  means "approximately equal to". 2,000,000 divided by 300 equals 6,666.66... (The 6 after the decimal point repeats forever, so we can round off the number to 6,667 per square mile.)

## What Does the Word “Per” Mean?

Here are some examples of measurements of density we have used so far:

3 beans *per* square inch

5 foxes *per* square mile

200 people *per* square mile.

Notice that “per” is used in all of these measurements. The word “per” means “for each,” so the phrases above could also be written like this:

3 beans *for each* square inch

5 foxes *for each* square mile

200 people *for each* square mile

When you first spread out the 54 beans on the grid paper, there were 3 beans *for each* square inch. In the state park example, after the new foxes were born in the spring, there were 5 foxes *for each* square mile in the state park. *Per* is just a faster way to say *for each*.

We use *per* a lot when we talk about driving.

Question: How fast was the car moving?

Answer: 65 miles *per* hour. This means the car went 65 miles *for each* hour of driving.

Question: How much did the gas cost?

Answer: \$3.00 *per* gallon. This means you have to pay \$3.00 *for each* gallon of gas you put in your car.

Question: What is your car’s gas mileage?

Answer: 25 miles *per* gallon. This means your car travels 25 miles *for each* gallon in the tank.



**Note:** People often say “a” or “an” instead of “per.” They might say “65 miles **an** hour,” “3 dollars **a** gallon” or “25 miles **a** gallon.” When used this way, the words “a” and “an” also mean *for each*.

Each of the answers above use a *rate* to compare two quantities. A rate compares two related quantities. The rate, “65 miles per hour,” is the same thing as saying, “65 miles for each 1 hour.” For each 1 hour that passes, the car travels 65 miles.

The rates for driving speed, cost and gas mileage above can be written in many ways:

<b>speed</b>	<b>cost</b>	<b>gas mileage</b>
<i>65 miles per hour</i>	<i>\$3.00 per gallon</i>	<i>25 miles per gallon</i>
<i>65 miles/hour</i>	<i>3 dollars/gallon</i>	<i>25 miles/gallon</i>
<i>65 mph</i>	<i>\$3.00/gallon</i>	<i>25 mpg</i>

The slash symbol / also means “per” or “for each.” *65 miles/hour* is another way to write “65 miles per hour.”

- 1) Complete the following tables.

Rate: *65 Miles/Hour*

<b>Hours Driving</b>	<b>Distance Traveled</b>
1	<i>65 miles/1 hour</i>
2	<i>130 miles/2 hours</i>
3	
5	
10	

Rate: *\$3.00/gallon*      *25 miles/gallon*

<b>Number of Gallons</b>	<b>Cost</b>	<b>Gas Mileage</b>
1	<i>\$3.00/1 gallon</i>	<i>25 miles/1 gallon</i>
2	<i>\$6.00/2 gallons</i>	
3		
5		
10		



A rate like 25 miles/gallon is called a *unit rate* because it connects 25 miles to 1 gallon. This answers the question, “How many miles can you drive on 1 gallon of gas?” The speed 65 miles/hour is also a unit rate since it answers the question, “How far did the car travel in 1 hour?” Unit rates answer the question, “How much (or how many) for 1?”

You can make a unit rate from other kinds of rates. For example, if you were told oranges cost \$2 for 4 oranges, you could figure out that the unit rate is \$.50 for 1 orange, which can be written as \$.50/orange. This answers the question, “How much money is it for 1 orange?”

2) Complete the following tables.

How many miles for 1 hour?                          45     mph

Hours Driving	Distance Traveled
1	
2	
3	135 miles/3 hours
5	
10	

How much for 1 gallon?                      \_\_\_\_\_ /gallon                      \_\_\_\_\_ mpg

Number of Gallons	Cost	Gas Mileage
1		
2	\$5.40/2 gallons	
3		
5		90 miles/5 gallons
10		

3) Look up the words *per diem* and *percent*. What these words mean?

Complete the following matching activity. Connect the quantity on the left with the unit rate on the right.

190 heartbeats	per	person
19 students		pound
\$15.00		hour
\$2.00		mile
\$3.00		class
270 eggs		gallon
1.6 kilometers		minute

Complete the following sentences, using units from the matching activity.

- 4) The doctor measured the patient's heart rate at 190 heartbeats per minute .
- 5) Kindergarten in Albany has an average of 19 \_\_\_\_\_ .
- 6) Starting in 2018, large employers in New York City will pay a minimum wage of 15 \_\_\_\_\_ .
- 7) The average cost of apples is about 2 \_\_\_\_\_ .
- 8) At many grocery stores, milk costs about 3 \_\_\_\_\_ .
- 9) In the United States, \_\_\_\_\_ are consumed each year.
- 10) To understand driving distances in other countries, you can use the conversion rate of 1.6 \_\_\_\_\_ .

## What Does the Word “Per” Mean? - Answer Key

- 1) *Distance Traveled*  
 65 miles/1 hour  
 130 miles/2 hours  
 195 miles/3 hours  
 325 miles/5 hours  
 650 miles/10 hours

*Cost*

- \$3.00/1 gallon  
 \$6.00/2 gallons  
 \$9.00/3 gallons  
 \$15.00/5 gallons  
 \$30.00/10 gallons

*Gas Mileage*

- 25 miles/1 gallon  
 50 miles/2 gallons  
 75 miles/2 gallons  
 125 miles/2 gallons  
 250 miles/2 gallons

- 2) 45 mph

*Distance Traveled*

- 65 miles/1 hour  
 130 miles/2 hours  
 195 miles/3 hours  
 325 miles/5 hours  
 650 miles/10 hours

\$2.70 dollars/gallon

*Cost*

- \$3.00/1 gallon  
 \$6.00/2 gallons  
 \$9.00/3 gallons  
 \$15.00/5 gallons  
 \$30.00/10 gallons

18 mpg

*Gas Mileage*

- 18 miles/1 gallon  
 36 miles/2 gallons  
 54 miles/2 gallons  
 90 miles/2 gallons  
 180 miles/2 gallons

- 3) Some people get a *per diem* when they are traveling for work. A *per diem* is an amount of money that is given each day for expenses. “Diem” means *day* in Latin, so “per diem” literally means “for each day.”

*Percent* means something out of 100, so 50 percent means 50 out of 100. 25% means 25 out of 100. “Percent” literally means “for every

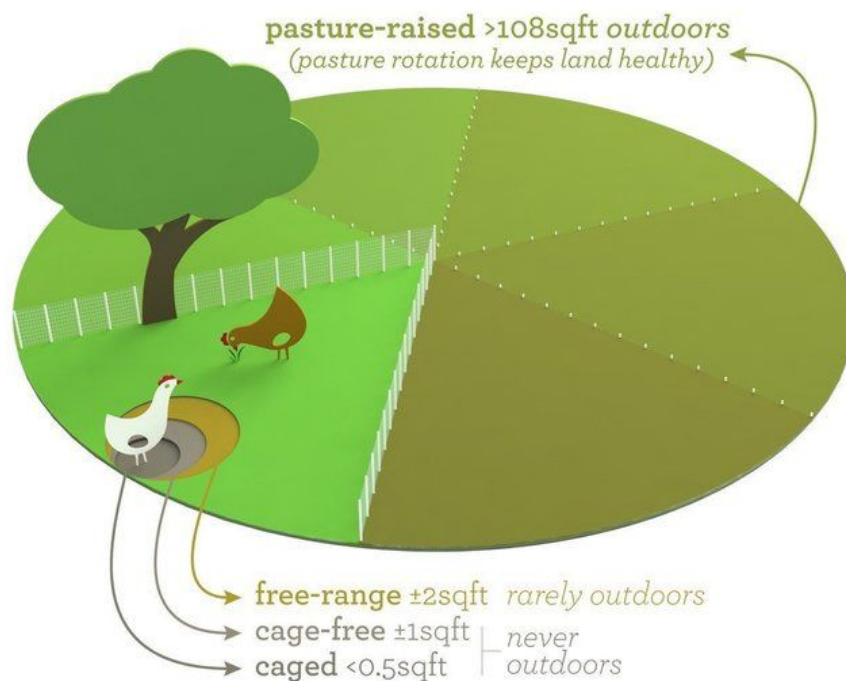
100.” By the way, you can find “cent” in many words that have to do with 100. A century is 100 years. A cent (penny) is  $\frac{1}{100}$  of a dollar. A centimeter is  $\frac{1}{100}$  of a meter. A centennial is the 100th anniversary of an important event. A centipede (supposedly) has 100 legs. A centenarian is a person who has lived to be 100 years old!

- 4) heartbeats per minute  
 5) students per class  
 6) dollars per hour  
 7) dollars per pound  
 8) dollars per gallon  
 9) eggs per person  
 10) kilometers per mile

## Chickens and Eggs

Have you ever noticed a big difference in prices of the eggs that are sold in grocery stores? Eggs can cost less than \$2 a dozen and as much as \$8 a dozen. There are several different factors that go into the pricing of the eggs, including population density. In your local store, you might see words like "cage free," "free range," or "pasture-raised". Each phrase has a specific meaning when it comes to how much space each chicken is given.

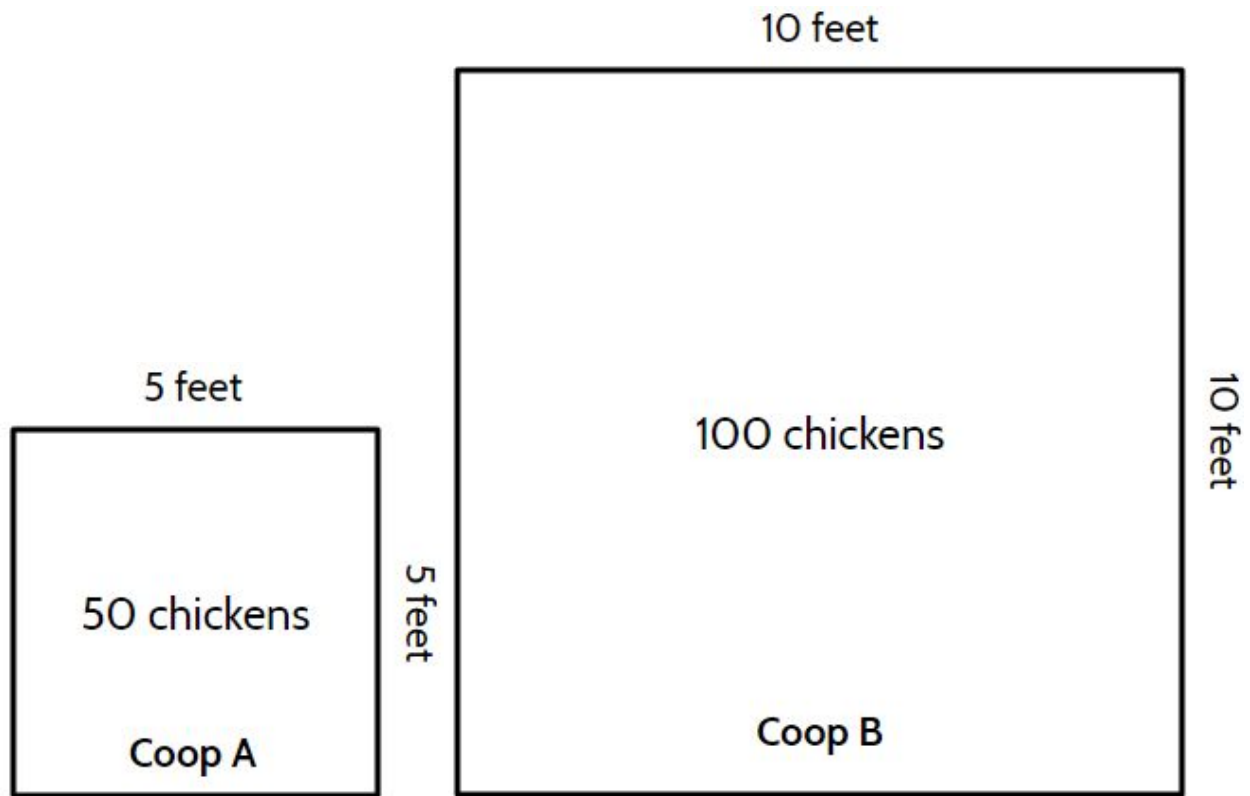
**Cage Free** means the chickens are raised with at least 1.5 square feet per hen (.67 chickens/ft<sup>2</sup>). **Free Range** means that each bird has a minimum of two square feet (.5 chickens/ft<sup>2</sup>). To earn the **Pasture-Raised** description means each bird is given 108 square feet (.01 chickens/ft<sup>2</sup>). If the egg carton doesn't say cage free, free range or pasture-raised, the eggs are from a large chicken farm where each chicken gets less than half of a square foot and never goes outside.



graphic from Vital Farms

- 1) As a consumer, which type of eggs would you prefer to buy? Why?
- 2) As a farmer, which eggs would you prefer to produce? Why?

## Two Chicken Coops



3) What do you notice about the two chicken coops?

4) Record the data for the two chicken coops in a table:

Coop	Number of Chickens	Area (square feet)	Population Density (chickens per sq. ft.)
A			
B			

5) Is Coop A or Coop B more crowded? How do you know?



For the next few questions, create your own chicken coops. Decide on the size and how many chickens it will hold. Add the information to the table above.

6) Create a coop that is less crowded than both Coop A and Coop B.

7) Create a coop that is more crowded than both A and B.

## Chicken Coop Practice Questions

- 8) If you added 25 square feet to Coop A, what would the new density be?
- 9) If you added 50 chickens to Coop B, what would the new density be?
- 10) What is the area of a chicken coop with a width of 4 feet and a length of 4.5 feet?
- A. .5 ft<sup>2</sup>
  - B. 8.5 ft<sup>2</sup>
  - C. 18 ft<sup>2</sup>
  - D. 180 ft<sup>2</sup>
- 11) If you were a farmer, how many chickens could you raise in Coop B...
- If you wanted to call the eggs *Cage-free*? \_\_\_\_\_
- If you wanted to call the eggs *Free Range*? \_\_\_\_\_
- If you wanted to call the eggs *Pasture-Raised*? \_\_\_\_\_
- 12) Chicken farmers sell eggs at a higher price when they have a lower population density because \_\_\_\_\_
- \_\_\_\_\_
- 13) Someone who buys eggs might be concerned about population density on poultry farms because \_\_\_\_\_
- \_\_\_\_\_
- 14) Challenge question: In many large chicken farms, each chicken has the space of an 8 ½" by 11" sheet of paper. What is this area in square feet? \_\_\_\_\_ sq. ft.

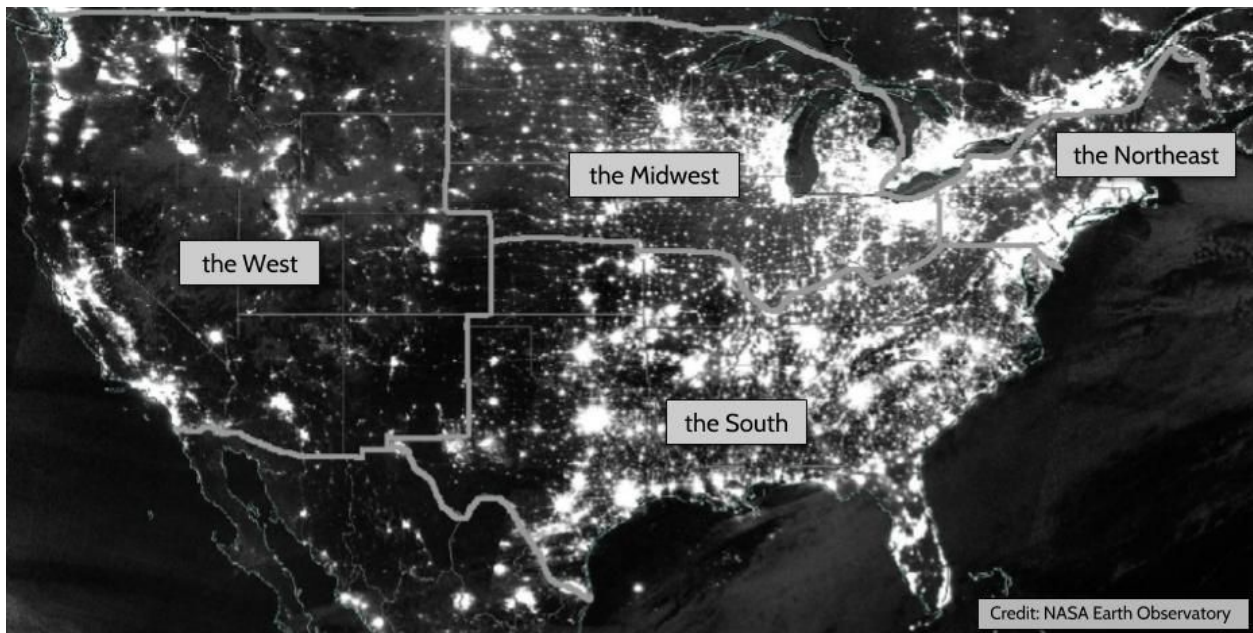
*Note: To convert square inches to square feet, divide by 144.*

## Chickens and Eggs - Answer Key

- |   |  |  |
|---|--|--|
| <p>1) This is your personal preference. Have you seen the prices of different kinds of eggs?</p>  | <p>B is 1 chicken/ft<sup>2</sup>. The density of Coop B is higher than Coop A.</p>   | <p>1<br/>(Actually, 100 ft<sup>2</sup> isn't quite enough for one chicken when it's pasture-raised. You would need 108 square feet to raise 1 chicken.)</p>  |
| <p>2) This probably depends on how much money you can make as a chicken farmer. Sometimes you can make money selling a high quantity at a low price for the consumer. You might also make money by selling few eggs at a higher price to the consumer.</p>  | <p>4) The data from the table should match the numbers on page 37.</p>   |  |
| <p>3) There are lots of things you might notice:</p> <ul style="list-style-type: none"> <li>● Coop A is 25 ft<sup>2</sup> in area. Coop B is 100 ft<sup>2</sup>.</li> <li>● Coop B is four times as big as Coop A. (At first, did you think it was twice as big?)</li> <li>● Coop B has twice as many chickens.</li> <li>● The density of Coop A is 2 chickens/ft<sup>2</sup>. The density of Coop</li> </ul> | <p>5) Coop A is more crowded. There are 2 chickens for every square foot. In Coop B, there is only 1 chicken for every square foot.</p> <p>6) There are many possibilities. Just make sure that the density of this coop is <b>less</b> than 1 chicken/ft<sup>2</sup>.</p> <p>7) There are many possibilities. Just make sure that the density of this coop is <b>more</b> than 1 chicken/ft<sup>2</sup>.</p> <p>8) 1 chicken/ft<sup>2</sup></p> <p>9) 1.5 chickens/ft<sup>2</sup></p> <p>10) C</p> <p>11) 66<br/>50</p> | <p>12) This answer should be based on your opinion, but think about how farmers can raise fewer chickens if they have a lower population density. Fewer chickens means fewer eggs.</p> <p>13) It might depend on whether you can spend a bit more so that you know that the chickens that laid the eggs have better lives. However, if you're on a budget, you might just need to get the cheapest eggs.</p> <p>14) About .65 or <math>\frac{2}{3}</math> ft<sup>2</sup></p> |



## Looking at the Population of the United States



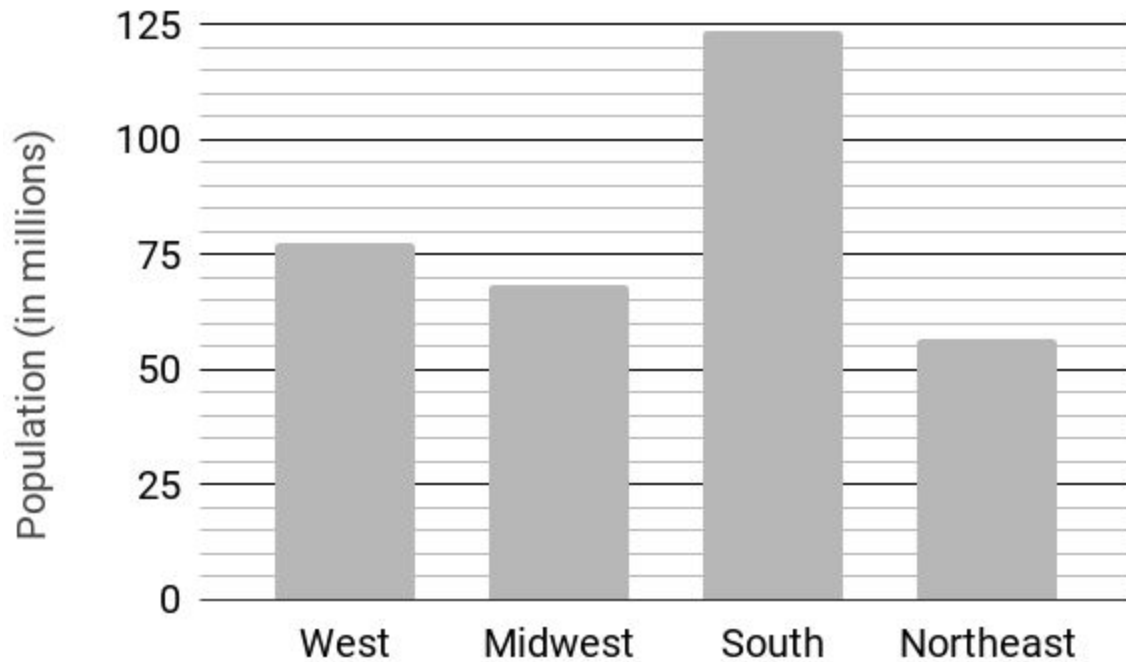
The United States can be separated into four regions: the West, the Midwest, the South, and the Northeast. This satellite image of the continental United States was taken in 2012. The photograph captures light at night.

- 1) What do you notice?

Answer these questions using the photograph of the United States at night.

- 2) Which region do you think has the biggest area?
- 3) Which region do you think has the most people? How do you know?
- 4) Which region do you think is the most crowded with people?
- 5) What U.S. states are not included in this satellite photo?

## Population of U.S. Regions (Chart)



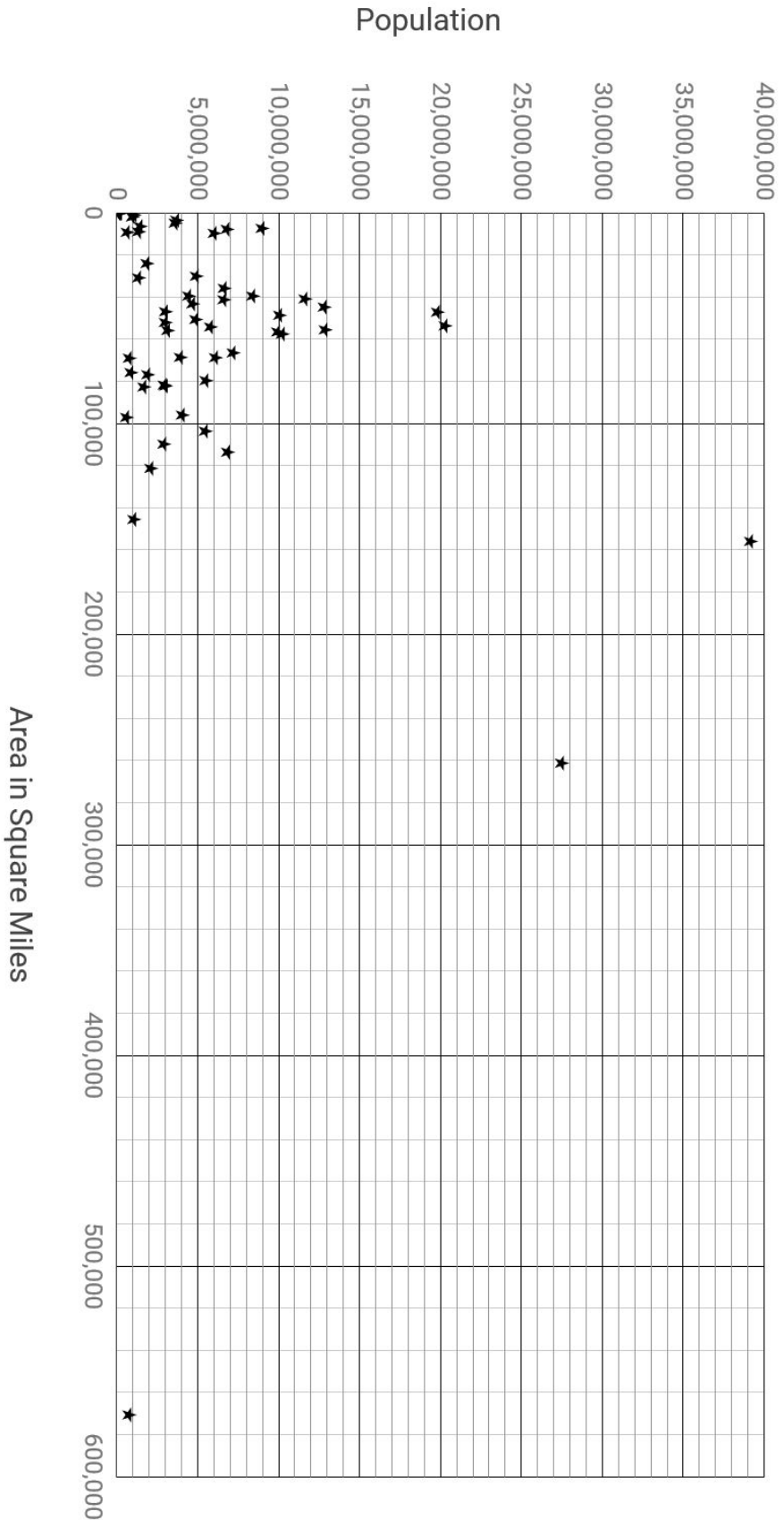
- 6) Based on the graph above, **estimate** the population of each region of the United States. Then calculate the population density of each region. (The symbol ~ also means that the number after is approximate, since it's an estimate.)

Region	Population	Approximate Area (sq. mi.)	Population Density (people per sq. mi.)
West	~ 77,000,000	1,900,000	
Midwest	~	600,000	
South	~	870,000	
Northeast	~	160,000	

Answer the following questions using the population table above.

- 7) The region of the US with the largest area is...
  
  
  
  
  
  
  
  
  
  
- 8) The South has the largest population. Why doesn't it also have the largest population density?
  
  
  
  
  
  
  
  
  
  
- 9) The Northeast has the smallest area. Does it also have the smallest population density? Why or why not?
  
  
  
  
  
  
  
  
  
  
- 10) Which region of the country has the most open space? Explain using your density calculations.
  
  
  
  
  
  
  
  
  
  
- 11) Which part of the country has the least open space? Explain using your density calculations.
  
  
  
  
  
  
  
  
  
  
- 12) The first European settlers who came to the United States came to the East coast across the Atlantic Ocean. Look back at the photo of the United States. What do you see in the photo that shows the history of European settlement?

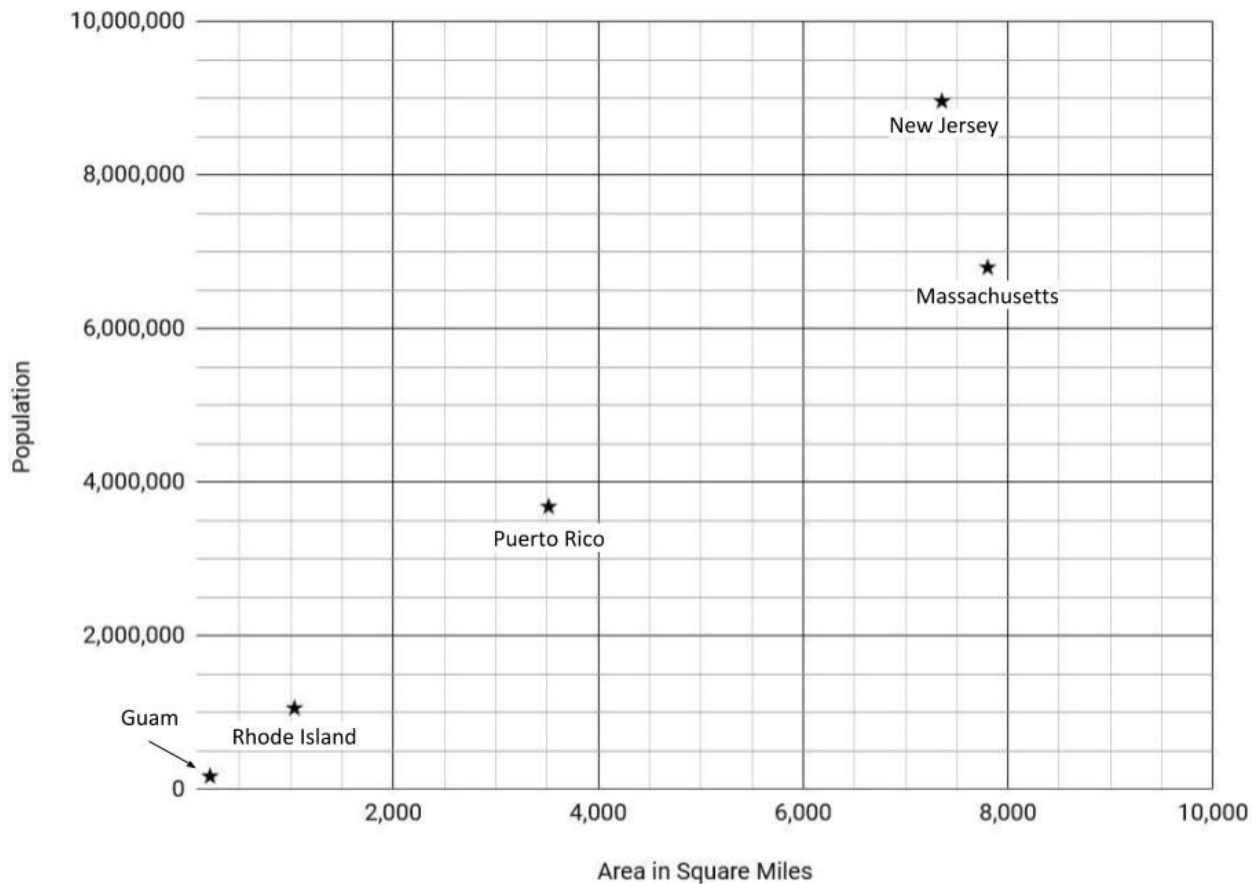
## Area and Population of U.S. States and Territories



13) Write three things you notice about this chart.

The chart on the previous page has a star for each of the 50 states and 5 territories of the United States. Did you try counting the stars? It might not seem possible, but there really are 55 stars on the chart. Some of the stars are very close or are overlapping, which makes it hard to count them all. A smaller version of the chart below shows a sample of places with high population density.

Five U.S. States and Territories with Highest Population Density



14) Use your best estimate of the population and area of each place to complete the table below. *Reminder:* The ~ symbol means that the numbers are approximate.

State or Territory	Guam	Massachusetts	New Jersey	Puerto Rico	Rhode Island
Population	~200,000	~6,800,000		~3,700,000	
Area (mi <sup>2</sup> )			~7,400		~1,000
Density (ppl/mi <sup>2</sup> )	~1,000			~1,050	

## Area and Population of U.S. States and Territories (Table)

Use the table to check your estimates on the previous page. How close were you to the actual population, area and density?

State/Territory	Area (mi <sup>2</sup> )	Population	Density (ppl/mi <sup>2</sup> )
Alabama	50,645	4,860,000	96
Alaska	570,641	740,000	1
American Samoa	77	60,000	721
Arizona	113,594	6,830,000	60
Arkansas	52,035	2,980,000	57
California	155,959	39,140,000	251
Colorado	103,642	5,460,000	53
Connecticut	4,842	3,590,000	742
Delaware	1,949	950,000	485
Florida	53,625	20,270,000	378
Georgia	57,513	10,210,000	178
Guam	210	170,000	809
Hawaii	6,423	1,430,000	223
Idaho	82,643	1,650,000	20
Illinois	55,519	12,860,000	232
Indiana	35,826	6,620,000	185
Iowa	55,857	3,120,000	56
Kansas	81,759	2,910,000	36
Kentucky	39,486	4,430,000	112
Louisiana	43,204	4,670,000	108
Maine	30,843	1,330,000	43
Maryland	9,707	6,010,000	619
Massachusetts	7,800	6,790,000	871
Michigan	56,539	9,920,000	175
Minnesota	79,627	5,490,000	69
Mississippi	46,923	2,990,000	64
Missouri	68,742	6,080,000	89
Montana	145,546	1,030,000	7

State/Territory	Area (mi <sup>2</sup> )	Population	Density (ppl/mi <sup>2</sup> )
Nebraska	76,824	1,896,190	25
Nevada	109,781	2,890,000	26
New Hampshire	8,953	1,330,000	149
New Jersey	7,354	8,960,000	1,218
New Mexico	121,298	2,090,000	17
New York	47,126	19,800,000	420
North Carolina	48,618	10,040,000	207
North Dakota	69,001	760,000	11
Northern Mariana Islands	179	60,000	308
Ohio	40,861	11,610,000	284
Oklahoma	68,595	3,910,000	57
Oregon	95,988	4,030,000	42
Pennsylvania	44,743	12,800,000	286
Puerto Rico	3,515	3,680,000	1,047
Rhode Island	1,034	1,060,000	1,022
South Carolina	30,061	4,900,000	163
South Dakota	75,811	860,000	11
Tennessee	41,235	6,600,000	160
Texas	261,232	27,470,000	105
Virgin Islands	134	110,000	799
Utah	82,170	3,000,000	36
Vermont	9,217	630,000	68
Virginia	39,490	8,380,000	212
Washington	66,456	7,170,000	108
West Virginia	24,038	1,840,000	77
Wisconsin	54,158	5,770,000	107
Wyoming	97,093	590,000	6

## Questions about the Area and Population of U.S. States & Territories

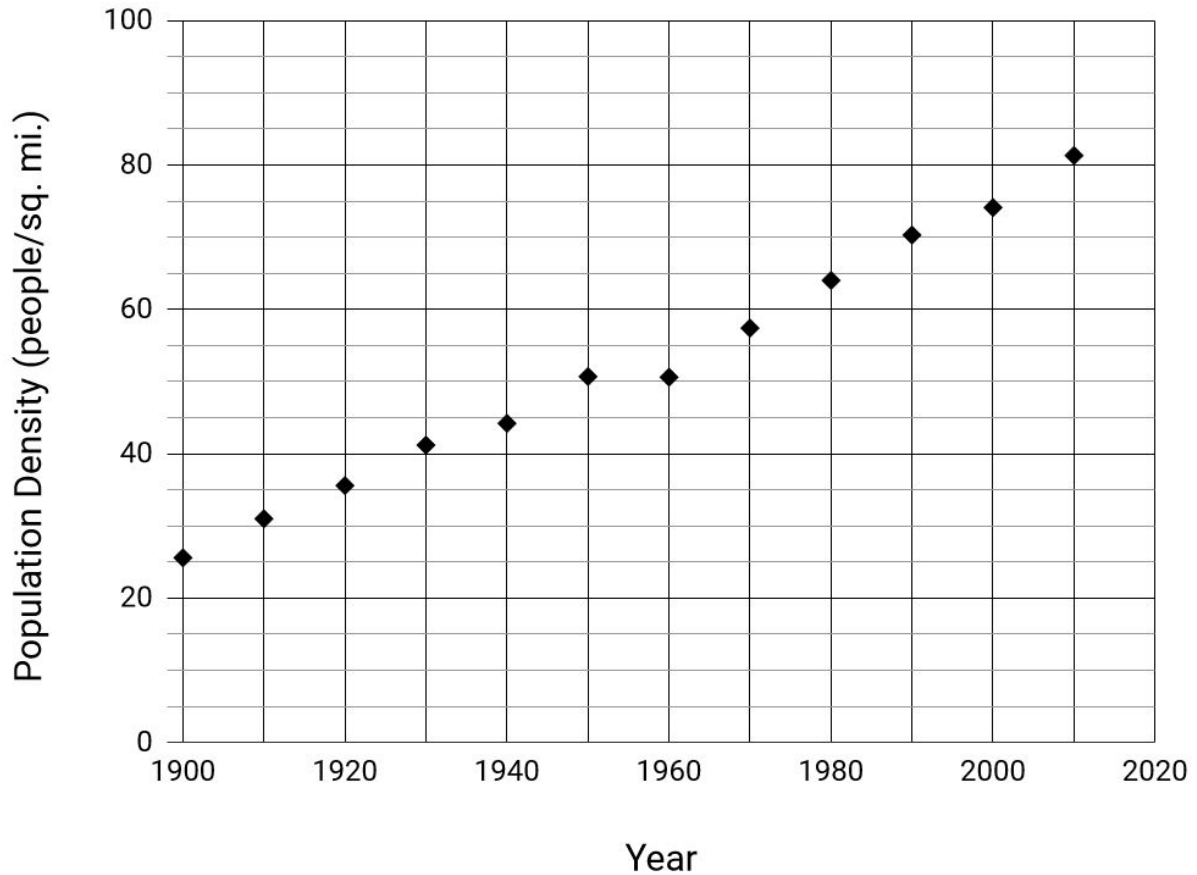
- 15) Which two states or territories have the largest population?
- 16) Which two states or territories have the smallest population?
- 17) Which two states or territories have the largest land area?
- 18) Which two states or territories have the smallest land area?
- 19) Which two states or territories have the highest population density?
- 20) Which two states or territories have the lowest population density?
- 21) Missouri and Oklahoma are both about 69,000 square miles in area. Which state is more crowded? Explain your answer.
- 22) Utah and Mississippi both have about 3,000,000 people. Which state is more crowded? Explain your answer.

## A Practice Question

This practice question

23) Look at the chart below and then answer the question below.

### The History of Population Density in the United States



Which of these answers is the best prediction of what the population density of the United States will be 2020, based on historical data?

- A. 81 people per square mile
- B. 87 people per square mile
- C. 92 people per square mile
- D. 100 people per square mile



## Looking at the Population of the United States - Answer Key

- |   |  |   |
|---|--|---|
| <p>1) There are lots of things you might notice:</p> <ul style="list-style-type: none"> <li>● The bright lights are heavily populated areas, like cities.</li> <li>● The West isn't as bright as the other regions.</li> <li>● The coast of the Northeast is really bright.</li> <li>● What else did you notice?</li> </ul>   | <p>South 143 ppl/mi<sup>2</sup><br/>Northeast 350 ppl/mi<sup>2</sup></p> <p>7) The West</p> <p>8) The South also has a large area so the population is spread out. The Northeast has a higher population density because more people live in a smaller area.</p> <p>9) The Northeast has a LOT of people living in a smaller area than the other regions, so its population density is high.</p> | <p>coast. Their population grew as the settlements became cities. European Americans moved west and took lands as part of Western Expansion. The eastern part of the United States is still more populated than the West.</p>   |
| <p>2-4) These are your predictions based on the photo. Were you right?</p> <p>5) Alaska &amp; Hawaii</p> <p>6) These are estimates based on the graph. Your answers don't have to be exactly the same, but they should be close.</p> <p><i>Population:</i><br/>West 77,000,000<br/>Midwest 68,000,000<br/>South 124,000,000<br/>Northeast 56,000,000</p> <p><i>Density:</i><br/>West 40 ppl/mi<sup>2</sup><br/>Midwest 113 ppl/mi<sup>2</sup></p> | <p>10) The West. There are only 40 people per square mile and each person has more space.</p> <p>11) The Northeast has the least open space. There are 350 people per square mile, which means each person gets less space than the other regions.</p> <p>12) The first Europeans sailed across the Atlantic and settled on the east</p>   | <p>13) There are lots of things you might notice:</p> <ul style="list-style-type: none"> <li>● There are many stars on the chart.</li> <li>● The stars represents U.S. states and territories</li> <li>● The star on the far right side has a large area and small population.</li> <li>● The star at the top represents the state with the highest population, about 39,000,000 people.</li> <li>● Most states have less than 15 million people.</li> <li>● Most states are less than 100,000 square miles in area.</li> </ul> <p>14) <i>Population:</i><br/>NJ ~9,000,000</p> |

RI ~1,000,000

*Area:*

Guam ~200 mi<sup>2</sup>

MA ~7,800 mi<sup>2</sup>

PR ~3,500 mi<sup>2</sup>

RI ~1,000 mi<sup>2</sup>

*Density:*

MA ~900 ppl/mi<sup>2</sup>

NJ ~1,200 ppl/mi<sup>2</sup>

RI ~1,000 ppl/mi<sup>2</sup>

15) California & Texas

16) Northern Mariana Islands  
& American Samoa

17) Alaska & Texas

18) American Samoa & the  
U.S. Virgin Islands

19) New Jersey & Puerto Rico

20) Alaska & Wyoming

21) Missouri is more  
crowded because it has a

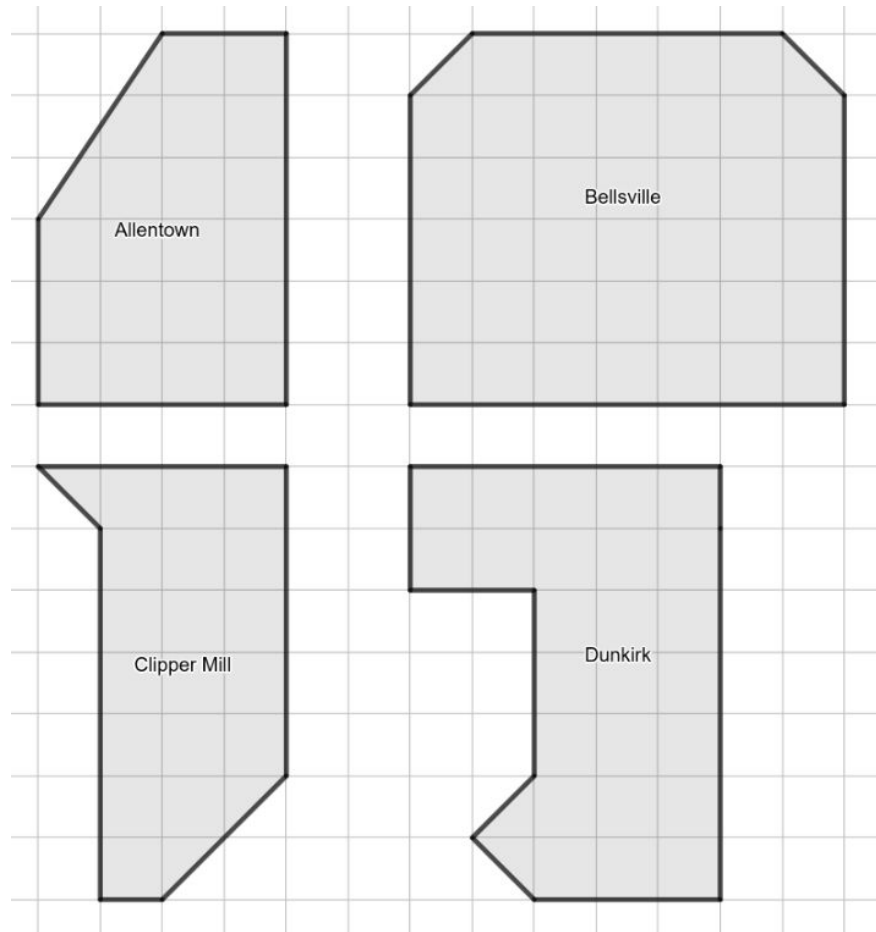
higher population in the  
same amount of space  
as Oklahoma.

22) Mississippi is more  
crowded because it has a  
smaller area, with the  
same number of people  
as Utah, but with less  
space.

23) B

## Population, Area and Density Practice

- 1) What is the area of each of the towns below? Notice that they aren't in the shape of rectangles. Each square in the grid is 1 square mile.



- 2) Complete the population, area and density table below. Round to the nearest person. For example, a density of 135.6 people/mi<sup>2</sup> would be rounded to 136 people/mi<sup>2</sup>.

	Allentown	Bellsville	Clipper Mill	Dunkirk
<b>Population</b>	17,000	24,000	16,000	20,000
<b>Area (mi<sup>2</sup>)</b>				
<b>Density (ppl/mi<sup>2</sup>)</b>				

- 3) Fill in the missing information. Refer to the review on page 28 if you need help.  
Round to the nearest person.

Place	Population	Area (sq. mi.)	Population Density
Adams, NY	3,000	2	1,500
Alfred, NY	4,000	1	
Buffalo, NY	936,000	380	
Champaign, IL	145,000		3,085
Jamestown, ND	15,000		1,500
Los Angeles Metro Area, CA		1736	7,000
Miami, FL		1239	4,441
Montauk, NY	3,000		600
New York City Metro Area, NY	18,351,000		5,319
Oswego, NY	39,000	21	
Palmyra, NY	5,000	5	
Portsmouth, OH	36,000		1,800
Potsdam, NY	9,000		3,000
Red Hook, NY		7	1,000
Snowflake, AZ		5	1,200
Utica, NY	117,000		1,887
Walsenburg, CO	3,000		1,500

Provide the correct answer and explain your answer.

4) For each pair of locations, underline the place that has more people.

A. Los Angeles Metropolitan Area, CA or New York City Metropolitan Area, NY

The NYC metro area has about 18,000,000 people and the LA metro area has about 12,000,000 people. I found out the LA population by multiplying the area (1736 mi<sup>2</sup>) by the density (6,999 ppl/mi<sup>2</sup>).

B. Alfred, NY or Red Hook, NY

5) For each pair of locations, underline the place that is bigger in land area.

A. Los Angeles Metropolitan Area, CA or New York City Metropolitan Area, NY

B. Oswego, NY or Portsmouth, OH

6) For each pair of locations, underline the place that is more crowded.

A. Champaign, IL or Buffalo, NY

B. Montauk, NY or Palmyra, NY

7) The density of \_\_\_\_\_ is about 2500 people/mi<sup>2</sup>.

- 8) The population of Concord, NY was 8,494 people in the 2010 Census. Its density was 121 people per square mile. How big is Concord?
- C. .014 sq. mi.
  - D. 70 sq. mi.
  - E. 8373 sq. mi.
  - F. 1,0327,774 sq. mi.
- 9) What are some reasons places become densely populated with people? Choose all that apply.
- A. economic opportunity
  - B. plentiful natural resources
  - C. temperate climate
  - D. extreme climate
- 10) What are some reasons places are less densely populated with people? Choose all that apply.
- A. economic opportunity
  - B. plentiful natural resources
  - C. temperate climate
  - D. extreme climate
- 11) Which of these would cause a place to become more densely populated?
- A. low birth rate, low death rate
  - B. low birth rate, high death rate
  - C. high birth rate, low death rate
  - D. high birth rate, high death rate

## Your Own Population and Area Data

You can use this New York State web site with population and area data about NYS counties:

<https://www.ny.gov/counties>

- 12) What is the name of the county where you live?
  
- 13) What year was your state founded?
  
- 14) What is the population of your county?
  
- 15) What is the area of your county?
  
- 16) What is the population density of your county?
  
- 17) Is your county more or less densely populated than Albany County? Explain your answer.

## How Crowded is New York City?

18) Fill in the table below. Round to the nearest person.

Borough	Population (2017)	Area (sq. mi.)	Density (ppl/mi <sup>2</sup> )
Bronx	1,471,160	42	
Brooklyn	2,648,771	71	
Manhattan	1,664,727	23	
Queens	2,358,582	109	
Staten Island	479,458	58	
Total			

19) \_\_\_\_\_ has the highest population.

20) \_\_\_\_\_ has the largest area.

21) With 72,379 people/sq. mi., \_\_\_\_\_ is the borough of NYC with the highest population density.

22) With \_\_\_\_\_ people/sq. mi., \_\_\_\_\_ is the borough of NYC with the lowest population density.

23) List the boroughs in order from least crowded to most crowded.



## Public Libraries in NYC

24) Fill in the table below. Round to the nearest tenth. For example, a density of .22 libraries/mi<sup>2</sup> would be rounded to .2 libraries/mi<sup>2</sup>.

Borough	Libraries	Area (mi <sup>2</sup> )	Density (libraries/mi <sup>2</sup> )
Bronx	35	42	
Brooklyn	59	71	
Manhattan	44	23	
Queens	65	109	
Staten Island	13	58	
Total			

25) There are about \_\_\_\_\_ libraries for every square mile in New York City.

26) \_\_\_\_\_ has the lowest density with \_\_\_\_\_ libraries/mi<sup>2</sup>.

27) Based on libraries/mi<sup>2</sup>, which borough is best for public libraries?

\_\_\_\_\_.

Why? \_\_\_\_\_

28) Based on libraries per 100,000 residents, which is best for libraries?

\_\_\_\_\_.

Why? \_\_\_\_\_

Borough	Libraries per 100,000 residents
Bronx	2.4
Brooklyn	2.2
Manhattan	2.6
Queens	2.8
Staten Island	2.7

29) Which do you think is a better way to measure the density of libraries, libraries/mi<sup>2</sup> or libraries/100,000 residents? \_\_\_\_\_

\_\_\_\_\_

## Population, Area and Density Practice - Answer Key

- |   |   |
|---|---|
| <p>1) Answers are in the next question.</p> <p>2) <i>Area:</i><br/>         21 mi<sup>2</sup><br/>         41 mi<sup>2</sup><br/>         19.5 mi<sup>2</sup><br/>         26 mi<sup>2</sup></p> <p><i>Density:</i><br/>         810 ppl/mi<sup>2</sup><br/>         585 ppl/mi<sup>2</sup><br/>         821 ppl/mi<sup>2</sup><br/>         769 ppl/mi<sup>2</sup></p> <p>3) Adams - 1,500 ppl/mi<sup>2</sup><br/>         Alfred - 4,000 ppl/mi<sup>2</sup><br/>         Buffalo - 2,463 ppl/mi<sup>2</sup><br/>         Champaign - 47 mi<sup>2</sup><br/>         Jamestown - 10 mi<sup>2</sup><br/>         LA - 12,152,000 ppl<br/>         Miami - 5,502,399 ppl<br/>         Montauk - 5 mi<sup>2</sup><br/>         NYC - 3,450 mi<sup>2</sup><br/>         Oswego - 1,857 ppl/mi<sup>2</sup><br/>         Palmyra - 1,000 ppl/mi<sup>2</sup><br/>         Portsmouth - 20 mi<sup>2</sup><br/>         Potsdam - 3 mi<sup>2</sup><br/>         Red Hook - 7,000 ppl<br/>         Snowflake - 6,000 ppl<br/>         Utica - 62 mi<sup>2</sup><br/>         Walsenburg - 2 mi<sup>2</sup></p> <p>4) A. NYC<br/>         B. Red Hook</p> | <p>5) A. NYC<br/>         B. Oswego</p> <p>6) A. Champaign<br/>         B. Palmyra</p> <p>7) Buffalo</p> <p>8) D</p> <p>9) A, B, C</p> <p>10) D</p> <p>11) C</p> <p>12-17) Answers will vary.</p> <p>18) <i>Density:</i><br/>         Bronx 35,028<br/>         Brooklyn 37,307<br/>         Manhattan 72,379<br/>         Queens 21,638<br/>         Staten Island 8,267</p> <p><i>Total Population:</i><br/>         8,622,698</p> <p><i>Total Area: 303</i></p> <p>19) Brooklyn</p> <p>20) Queens</p> <p>21) 72,379, Manhattan</p> <p>22) 8,267, Staten Island</p> |
|---|---|

- 23) Staten Island, Queens, Bronx, Brooklyn, Manhattan
- 24) *Density:*  
 Bronx .8  
 Brooklyn .8  
 Manhattan 1.9  
 Queens .6  
 Staten Island .2  
 Total Density .7  
*Total Libraries: 216*  
*Total Area: 303*
- 25) .7
- 26) Staten Island, .2
- 27) Manhattan. Based on the space, there are more libraries to spread around the borough.
- 28) Queens. Based on the population, there are more libraries for the people to share. By the way, the number of libraries for every 100,000 residents is an example of “per capita,” which means “for each person.” Queens has the most libraries per capita.
- 29) This answer should be based on your opinion, but someone could argue that libraries are created to serve people, so it’s better to measure how many libraries there are in comparison to the population. Other people could argue that in order use libraries, they have to be spread around the city, which requires measuring the density in comparison to the area of the city.

## Practice Questions

- 1) There are about 20 million people in New York State, with a total land area of about 47,000 square miles.

What is the population density of New York State?

- A. .0004 people per sq. mile
- B. 426 people per sq. mile
- C. 2,350 people per sq. mile
- D. 940,000 people per sq. mile

Explain your answer:

- 2) The following chart shows population and area of the five boroughs of New York City.

Borough	Population (2017)	Area (sq. miles)
Bronx	1,471,160	42
Brooklyn	2,648,771	71
Manhattan	1,664,727	23
Queens	2,358,582	109
Staten Island	479,458	59

Based on the chart, which answer choice lists the boroughs from greatest to least population density?

- A. Manhattan, Brooklyn, Bronx, Queens, Staten Island
- B. Brooklyn, Queens, Manhattan, Bronx, Staten Island
- C. Queens, Brooklyn, Staten Island, Bronx, Manhattan
- D. Manhattan, Queens, Brooklyn, Bronx, Staten Island

Explain your answer:

- 3) In 2017, the total New York City population was about 8.6 million people. The area of New York City is about 300 square miles. By 2040, the population of New York City is projected to grow by 400,000 people from the 2017 population level. If this happens, what will the population density be for New York City in 2040?
- A. 34.9 ppl/mi<sup>2</sup>
  - B. 1,333 ppl/mi<sup>2</sup>
  - C. 28,667 ppl/mi<sup>2</sup>
  - D. 30,000 ppl/mi<sup>2</sup>

Explain your answer:

- 4) Albany is about 22 square miles in area and has a population density of about 4,500 people/mi<sup>2</sup>. What is the population of Albany?
- A. .005 people per square mile
  - B. 205 people per square mile
  - C. 99,000 people
  - D. 205,000 people

Explain your answer:

- 5) Between 2000 and 2010 in New York State, the population density increased from 345 people per square mile to 352 people per square mile. The land area of New York State is about 55,000 square miles. What was the increase in population?
- A. 7 people
  - B. 156 people
  - C. 385,000 people
  - D. 19,360,000 people

Explain your answer:

- 6) A farmer did some calculations while planning an addition to her farm. What does the number 1,200 represent in her notes below?

$$\begin{array}{r}
 1200. \\
 \hline
 .25 \overline{) 300.00} \\
 \underline{25} \phantom{00} \\
 50 \phantom{00} \\
 \underline{50} \phantom{00} \\
 00
 \end{array}$$

$$300 \text{ chickens} \div .25 \text{ chickens/ft}^2$$

- A. How much land is needed to raise the chickens
- B. How many chickens will fit in each square foot of land
- C. How many chickens the farmer can raise
- D. The increase in the population of chickens

- 7) In New York City there are 7 libraries for every 10 square miles of area. New York City is about 300 square miles in size. About how many libraries are there in New York City?
- A. 30
  - B. 43
  - C. 70
  - D. 210

Explain your answer:

- 8) The approximate 2015 U.S. Census populations and population densities are shown in the table below.

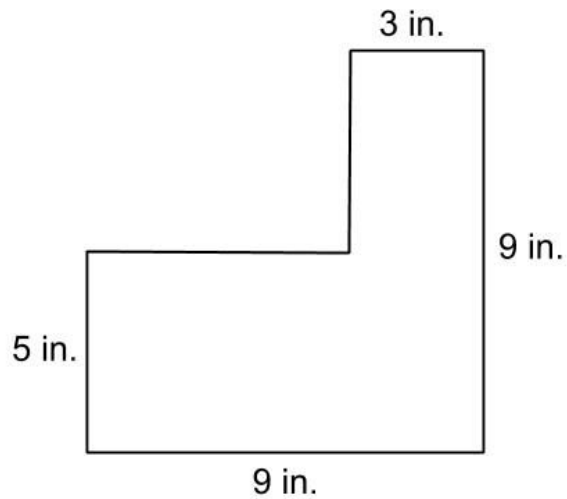
State	Population Density (people/sq. mi.)	Population in 2015
Florida	378	20,270,000
Illinois	232	12,860,000
New York	420	19,800,000
Pennsylvania	286	12,800,000

Based on the table above, which list shows the states' areas in order from largest to smallest?

- A. New York, Florida, Pennsylvania, Illinois
- B. Illinois, Florida, New York, Pennsylvania
- C. Florida, New York, Illinois, Pennsylvania
- D. Pennsylvania, New York, Florida, Illinois



9) What is the area of this figure?



- A. 26 square inches
- B. 57 square inches
- C. 81 square inches
- D. 1,215 square inches

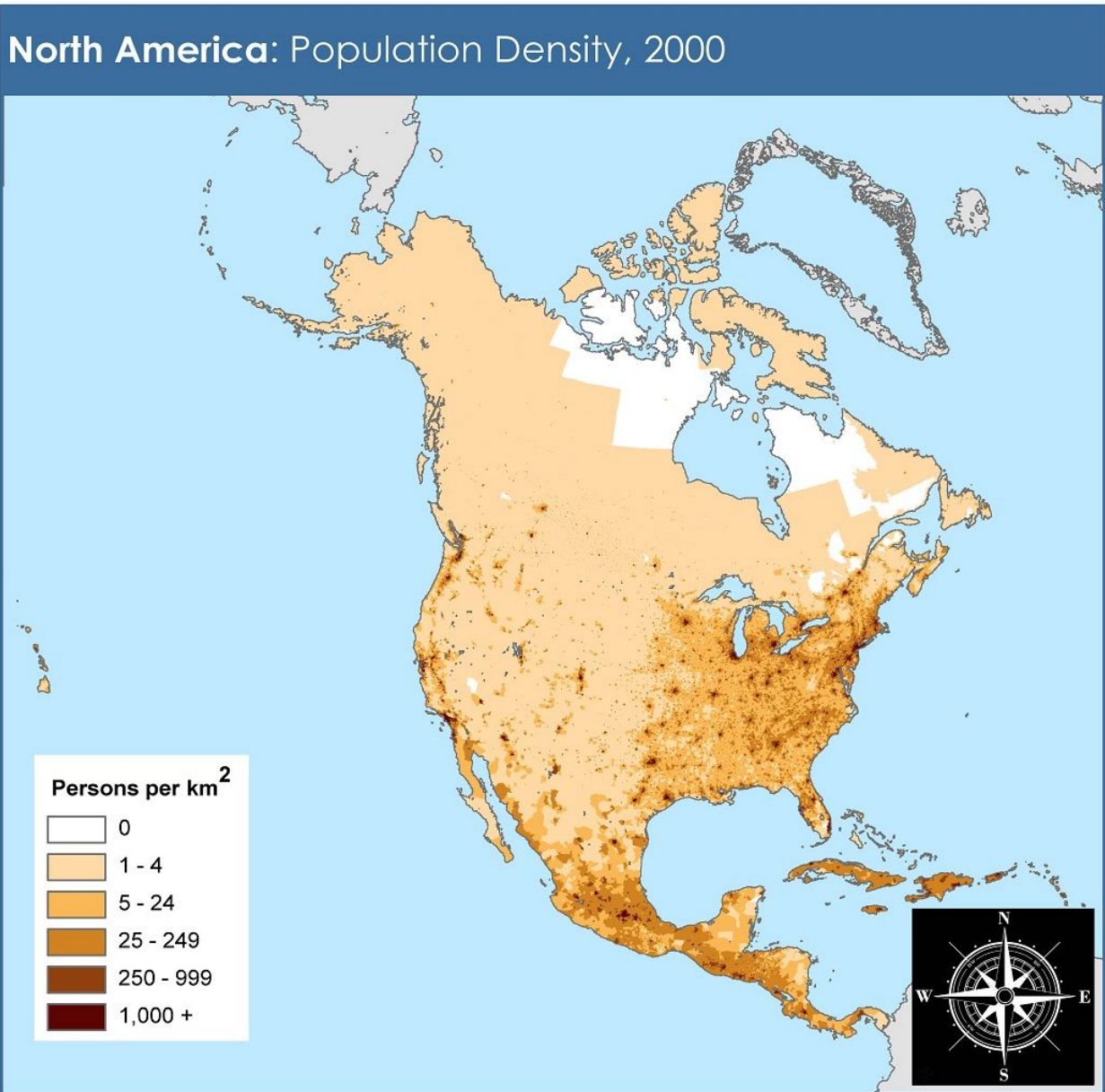
10) There are about 325 million people in the United States, with a total land area of about 3.8 million square miles.

What is the population density of the United States?

- A. .001 people per sq. mile
- B. 9 people per sq. mile
- C. 86 people per sq. mile
- D. 1,235 people per sq. mile

Explain your answer:

Look at the map below. You may want to also look at other maps online to identify countries in North America. Then answer the next three questions.



adapted from NASA Socioeconomic Data and Applications Center (<http://sedac.ciesin.columbia.edu>)



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<http://creativecommons.org/licenses/by/3.0/>

11) Which part of the United States is most densely populated?

- A. West
- B. Midwest
- C. South
- D. Northeast

Explain your answer:

12) What is the main reason the far northern part of North America is sparsely populated?

- A. low economic opportunities
- B. low birth rates
- C. extreme weather
- D. war and conflict

Explain your answer:

13) One characteristic common to the geographical regions below is that they all...

Siberian Plain  
Sahara Desert  
Amazon Basin  
Antarctica

- A. have a low population density
- B. are located between major river valleys
- C. are major religious centers
- D. have large areas of valuable farmland

14) If you know the density and the area, one way to find the population is to...

- A. Divide the area by the density
- B. Divide the density by the area
- C. Divide the population by the area
- D. Multiply the density and the area

## Practice Questions - Answer Key and Explanations

- 1) The correct answer is **B** (*426 people per sq. mile*). You can get this answer by imagining all the people in the state spread out evenly over each square mile. The population (20,000,000) divided by the area (47,000) is 425.53, which can be rounded to 426.

A, C and D are *distractors*, which are answers that look like they might be correct but are not. The people who wrote the test write distracting answers to make you prove you really understand. Don't feel bad if you choose one of these answers. The distractors are based on common mistakes that many people make.

Here is an explanation of the wrong answers:

**A** (*.0004 people per sq. mile*): A person might get this answer if they forget the zeros in 20 million. 20 divided by 47,000 equals .0004. We need to remember that 20 million means 20,000,000. That is the number that should be used in the calculation. We should also stop to think about what .0004 people per square mile would mean. That's much, much less than 1 person for every square mile in New York State. It would mean there were only 20 (twenty) people in the whole state. A population density of .0004 ppl/mi<sup>2</sup> would be similar to the population density of Antarctica, where only about 1,000 scientists live on 5.4 million square miles of land.

**C** (*2,350 people per sq. mile*): You will get 2,350 people per sq. mile as an answer if you divide 47,000 by 20. However, it's 20 million, not 20. When you calculate the density, you should use 20,000,000. Also, in calculating population density we usually divide the population by the area, instead of the other way around.

**D** (*940,000 people per sq. mile*): Sometimes, if we don't know what to do in a problem, we might grab a couple numbers from the problem and try something. 47,000 multiplied by 20 is 940,000 but this doesn't really make sense with the situation. Multiplying the population by the area doesn't give you the density. If there were 940,000 people per square mile all across New York State, the total population of the state would be 40 billion people. Since there are "only" 7.4 billion people on Earth, this isn't really possible.

- 2) The correct answer is **A** (*Manhattan, Brooklyn, Bronx, Queens, Staten Island*). To figure out the right answer, you should calculate the population density of each of the 5 boroughs and then see which borough has the most people per square mile. With 72,379 people per square mile, Manhattan has the highest population density of the 5 boroughs. You

can calculate the population density by dividing 1,664,727 (population) by 23 (area). If you live in New York City, you might already know that Manhattan is the most crowded borough from personal experience. It's the business center of the city and is a small island with lots of people crowded together. Brooklyn is the second most dense borough, with 37,307 people per square mile.

Here is an explanation of the wrong answers:

**B** (*Brooklyn, Queens, Manhattan, Bronx, Staten Island*): This lists the boroughs in order from greatest to least **population**, not population density. With 2.6 million people, Brooklyn has the highest population, but not the highest population density.

**C** (*Queens, Brooklyn, Staten Island, Bronx, Manhattan*): This lists the boroughs in order from greatest to least **area**, not population density. With 190 square miles in area, Queens is the biggest in land mass, but not in population density.

**D** (*Manhattan, Queens, Brooklyn, Bronx, Staten Island*): This list is almost correct, except Queens is out of order. The rest of the boroughs are in the right order. Someone might choose this answer if they figured out that Manhattan was the most densely populated, but didn't calculate the density of the other boroughs..

- |      |       |
|------|-------|
| 3) D | 9) B  |
| 4) C | 10) C |
| 5) C | 11) D |
| 6) A | 12) C |
| 7) D | 13) A |
| 8) B | 14) D |

## Key Ideas to Remember

- *Area* is the size of a surface measured by counting square units.
- *Density* is used to measure how crowded a space is.
- *Population density* is a measure of how crowded an area is with people or other living organisms. It is measured by the number per square unit. In the United States, this measure is often the number of people per square mile. The formula for *population density* is *population* divided by *area*:

$$\frac{p}{a} = d$$

When you see the words *population*, *area* and *density*, these questions should come to mind:

- *Population: How many are there?*
- *Area: How many square units are there?*
- *Population Density: How many are there in each square unit?*

Write notes for yourself so that you will remember the difference between population, area and population density. \_\_\_\_\_

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# The Language of Population Density

## How Math is Written

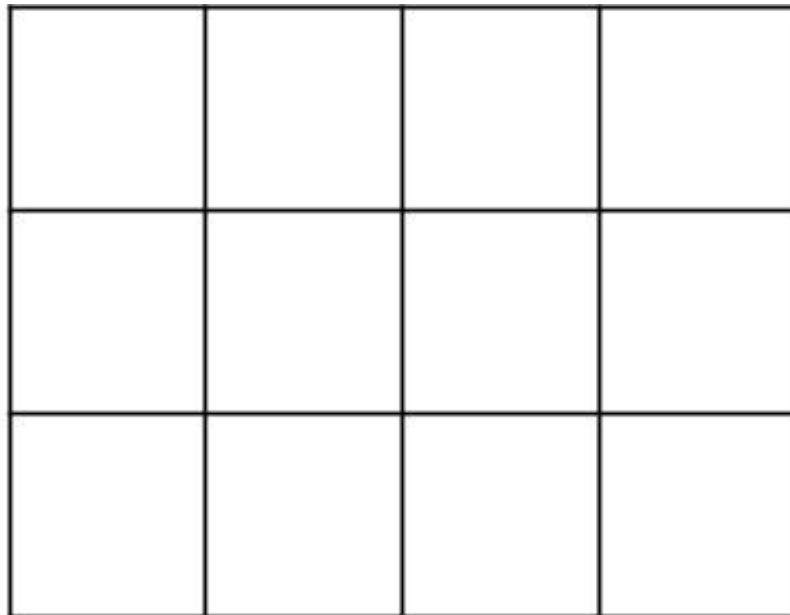
In learning mathematics, knowing how to write your answer is important so that other people understand what you mean. Mathematics *notation* is the way in which mathematicians write to communicate with other mathematicians. Learning this kind of notation is like learning a new language, but it's helpful so that you understand other people and they will understand you.

In this notation for writing distance measurements, ' means *feet* and " means *inches*. Look at the example below:

4"

This means 4 inches, like the width of the grid below.

What's the area  
of this grid?



- 1) Make sure you know the difference between ' and ". For example, what's the difference between 10' and 10"? Can you think of two things in the real world with these measurements?

10' \_\_\_\_\_ 10" \_\_\_\_\_



As you know, area is the size of a flat surface, measured in square units. When you write an area measurement, you can use any of the following ways of saying the area of the grid on the previous page:

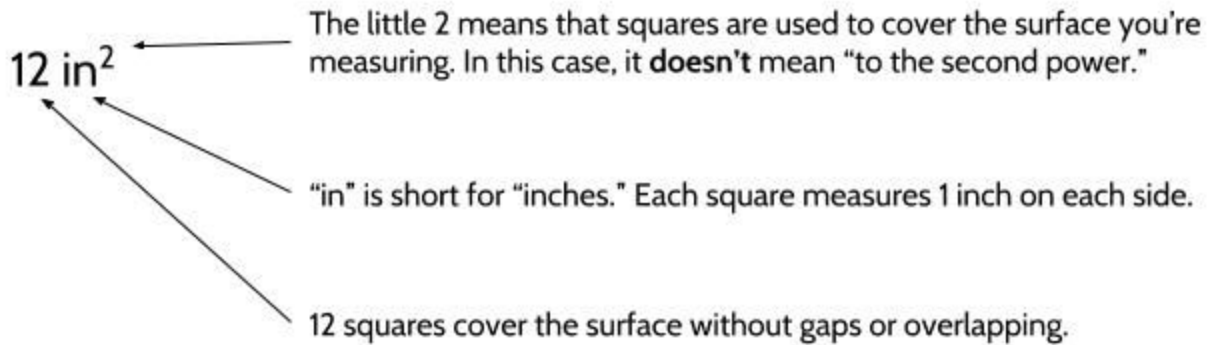
12 square inches

12 sq. in.

12 in<sup>2</sup>

Note: ' and " are normally used for regular feet and inches, not square feet and inches.

When you see a measurement like **12 in<sup>2</sup>**, this is what it means:



2) Fill in the missing boxes in this table.

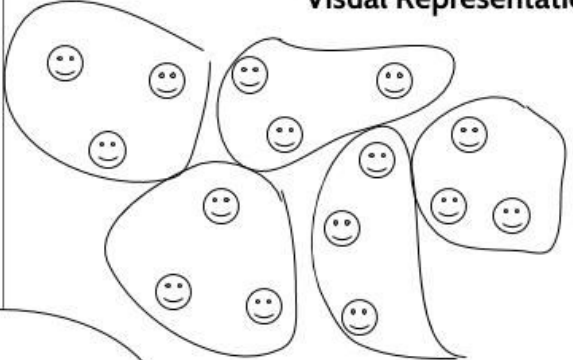
10 square inches →	10 sq. in.	10 in <sup>2</sup>
5 square feet →		
→		9 in <sup>2</sup>
→	7.5 sq. mi.	
1/2 square foot →		
25 square meters →		
→		12 cm <sup>2</sup>

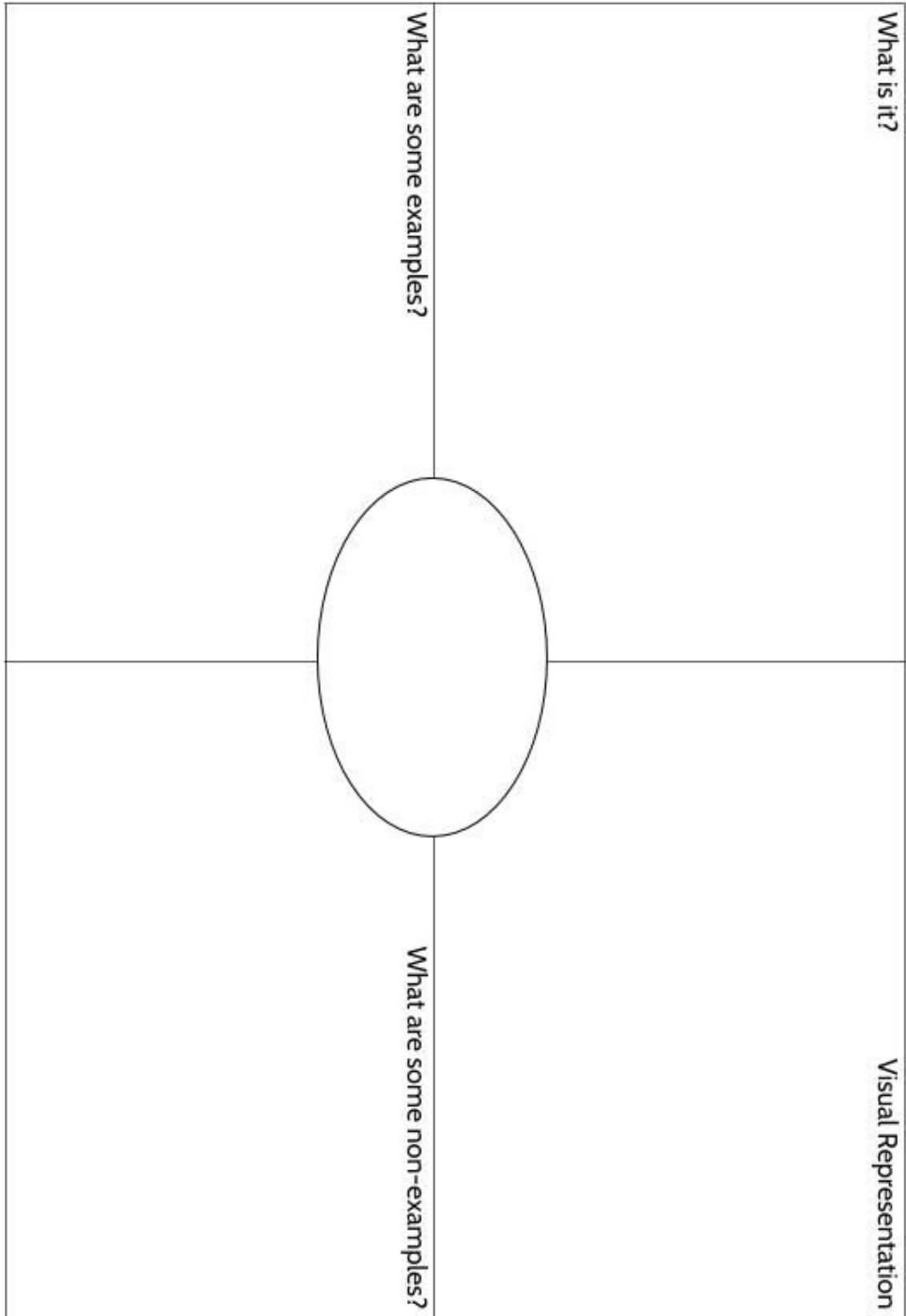
## Using Graphic Organizers to Learn Vocabulary

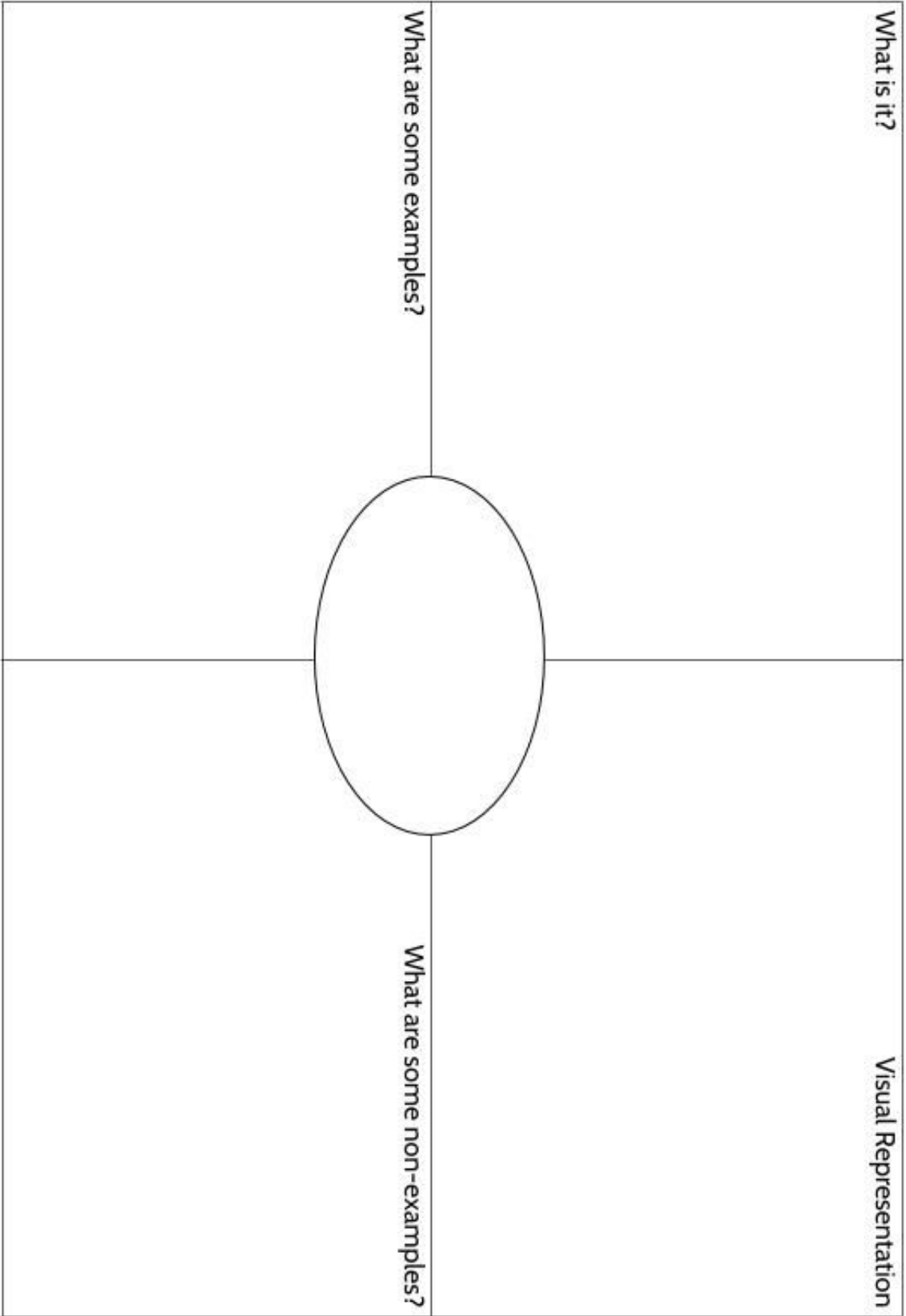
In order to learn math vocabulary, we need practice using it in different ways. In this activity, you will choose a few words from this packet that you want to practice, then you will complete a graphic organizer for each word. Look at the sample for the word *quotient* below.

To complete the graphic organizer, you will choose a word and then answer four questions:

- What is the definition of the word? You can look at the vocabulary review on page 82 for help. Try to write the definition in your own words to really make the word yours.
- Make a visual representation. You can make a drawing or diagram that will help you remember what the word means.
- What are some examples of the word you're studying? Below you can see that there are examples of *quotients*, which are the answers to division problems.
- What are some non-examples of this word? These are things that are **not** the word you're studying. For example, 24 is **not** the quotient of 4 divided by 6.

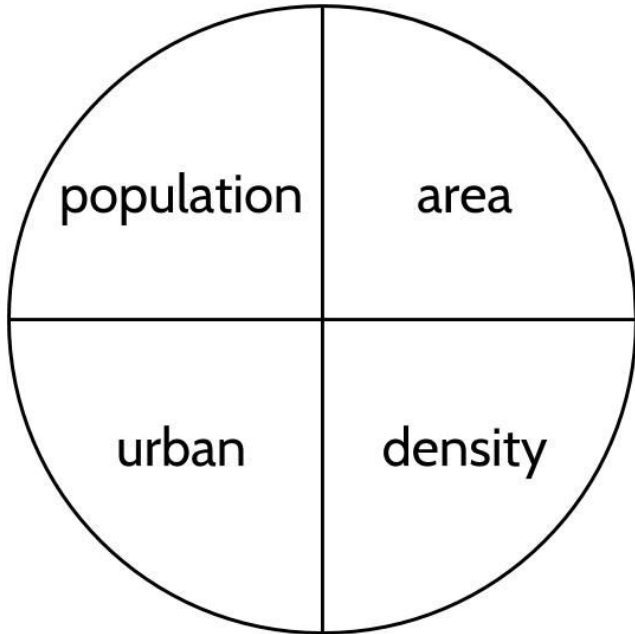
<p><b>What is it?</b></p> <p>A quotient is the result of dividing one number by another. It is the answer to a division question.</p>	<p><b>Visual Representation</b></p> 
<p><b>What are some examples?</b></p> <p>15 divided by 3 equals 5</p> <p><math>66 \div 6 = 11</math></p> <p><math>63/18 = 3.5</math></p> <p>5, 11 and 3.5 are quotients in these calculations.</p> <p>population <math>\div</math> area = <b>density</b></p>	<p><b>What are some non-examples?</b></p> <p>4 times 6 equals 24</p> <p><math>18 + 5 = 23</math></p> <p><math>17 - 2.5 = 14.5</math></p> <p><math>3.5 \times 18 = 63</math></p>





## Concept Circle

3) Explain these words and the connections you see between them.



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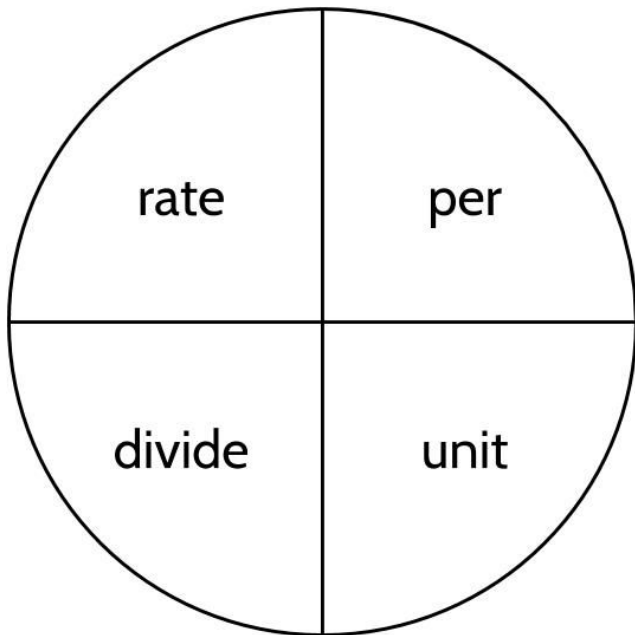
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## Fill in the Blanks

4) Use the words and numbers below to fill in the blanks in the article.

few population high  
square miles water 41 ppl/sq. mi. 21 million people  
crowded lowest per deserts climate  
~~population density~~ highest area distributed  
271 rural world's population 48,000 people/mi<sup>2</sup>  
urban

The population density of a country or a city or other place is a number that shows how crowded that place is. It is calculated by dividing the \_\_\_\_\_ by the \_\_\_\_\_. For example, France has a population of 67,000,000 people and an area of 247,368 square miles, so its population density is about \_\_\_\_\_ people per square mile.

A number of factors can affect population density. \_\_\_\_\_ is one of those factors. Greenland has a very low population density because it is very cold there, so not many people want to live there. Other places with harsh weather conditions such as \_\_\_\_\_ or mountainous areas usually also have low population density.

Many cities were built near rivers, because people need \_\_\_\_\_ for their daily needs, so places near rivers often have a \_\_\_\_\_ population density. People are not \_\_\_\_\_ equally around the world. In satellite

photos of Earth at night, you can see lights surrounding oceans, lakes and rivers. This shows that most of the \_\_\_\_\_ lives near water.

Many \_\_\_\_\_ places, such as cities, have high population densities and can be really \_\_\_\_\_. Mexico City is an example. With a population of about \_\_\_\_\_ people and an area of about 3,000 \_\_\_\_\_, the city has a population density of about 7,000 people/mi<sup>2</sup>. Other places with large \_\_\_\_\_ areas can have very low population densities. For example, the population density of Sonora, a northern state in Mexico, is only about \_\_\_\_\_ because much of the state is made up of mountains and deserts.

The country with the \_\_\_\_\_ population density in the world is Monaco, with \_\_\_\_\_. The whole country is less than 1 square mile! It's called a city-state because the country is the city. The country with the \_\_\_\_\_ population density is Greenland, which has only 0.07 people \_\_\_\_\_ square mile. Greenland is really big, but very \_\_\_\_\_ people live there because it's so cold.







## The Language of Population Density - Answer Key

- 1) Here are a couple possibilities:  
10' = 10 feet, the height of a basketball hoop  
10" = 10 inches, the length of a person's foot (maybe)
- 2) 10 square inches, 10 sq. in., 10 in<sup>2</sup>  
5 square inches, 5 sq. in., 5 in<sup>2</sup>  
9 square inches, 9 sq. in., 9 in<sup>2</sup>  
7.5 square inches, 7.5 sq. in., 7.5 in<sup>2</sup>  
1/2 square inches, 1/2 sq. in., 1/2 in<sup>2</sup>  
25 square inches, 25 sq. in., 25 in<sup>2</sup>  
12 square inches, 12 sq. in., 12 in<sup>2</sup>
- 3) Each paragraph should use the 4 vocabulary words in the circle on the left. Be creative. There is no right way to do this activity!
- 4) population density  
population  
area  
271  
climate (You should capitalize "C.")  
deserts  
water  
high  
distributed  
world's population  
urban  
crowded  
21 million  
square miles  
rural  
41 ppl/mi<sup>2</sup>  
highest  
48,000 people/mi<sup>2</sup>  
lowest  
per  
few
- 5) Take your time with this activity. Look at the window and describe what you see. Think about whether the place where you live is crowded or not. You might even do some research so that you have some numbers to include in your writing. This is an opportunity to practice all the vocabulary and math skills you have learned.

## Vocabulary Review

You can use this section to look up words used in this math packet.

**approximate** (adjective): close to the actual, but not completely accurate or exact

**area** (noun): The size of a flat surface, measured in square units

**convert** (verb): The change from one thing into another

- You can *convert* feet into inches by multiplying by 12.
- If you *convert* Euros into dollars today, you will get \$1.15 for every Euro you exchange.
- To understand distances in different races, runners can convert miles to kilometers because they know that 1 mile equals 1.6 kilometers.

**dense** (adjective): crowded closely together or packed together

- The population of Buffalo, NY is less *dense* than New York City.
- Manhattan is the most *dense* borough of New York City.

**density** (noun): A measure of how crowded or “pushed together” things are in a space

The word *dense* comes from the Greek word *dasus*, which means “compact.”

- The *density* of New York City is about 28,000 people per square mile.
- The *density* of libraries in Manhattan is about 2 per square mile.

*population density*: The average number of people or things per square unit of area

*density* in science: The amount of mass per unit of volume (This topic is covered in a separate student packet.)

**distribute** (verb): to spread out or divide evenly

- The fox population is *distributed* evenly throughout the state park.

**estimate** (verb): to make a rough guess at a number, usually without making written calculations

**per** (preposition): for each or for every

- The car was traveling 40 miles *per* hour.
- Manhattan has about 73,000 people *per* square mile.
- The subway costs \$2.75 *per* ride.

- The bicycle tire pressure should be 80 pounds *per square inch*.

**per capita** (adverb/adjective): for each person (“capita” means *head* in the language Latin)

- The *per capita* income, or average salary per person, in New York State is about \$40,000 per year.
- The New York State egg industry produces a total of 1.5 billion eggs per year, which works out to about 75 eggs *per capita*.

**population** (noun): all the organisms of a particular species living in a given area at the same time.

**product** (noun): the result of multiplication

- The product of 2 and 3 is 6.

**rate** (noun): a ratio with two different quantities that are being compared

- The train traveled at a *rate* of 80 miles per hour.
- On October 10, 2018, the exchange *rate* for Mexican to U.S. money was 19.15 pesos per dollar.

*unit rate*: How many (or much) of something for every **one** unit of another thing

- If the cost is \$2.00 for 4 apples, there are two possible *unit rates*. One unit rate is 50 cents for 1 apple, which tells us how much money you would need to spend for **one** apple. Another unit rate would be \$1.00 for 2 apples, which tells us how many apples you would get for **one** dollar.

**ratio** (noun): a relationship between two numbers that are in proportion to each other

- The *ratio* of students to teachers was 25 to 1.
- The recipe called for a *ratio* of 2 cups of water for 1 cup of rice.

**rectangle** (noun): A 4-sided flat shape with straight sides which has:

- Four sides
- Opposite sides of equal length
- Four right angles (90°)

**rural** (adjective): related to the countryside, not a town or city

**square** (noun): a 4-sided, flat shape which has:

- Four straight and equal sides
- Four right angles (90°)

**unit** (noun): a quantity of one used to measure other quantities

- Inches, feet, centimeters and meters are all *units* for measuring distance.
- Square inches, square feet, square centimeters, and square meters are all *units* for measuring area.
- The cost of apples can be measured in *units* of apples or *units* of dollars.

**urban** (adjective): related to a city or town