**Barron’s Let’s Review Regents – Algebra II**

# Chapter 9: Probability

## Chapter 9.1 Sample Spaces

**Key Ideas**

A *sample space* is a list of all possible *outcomes* of some experiment. When it is possible to create an accurate sample space, calculating the *probability* of different types of outcomes can be found by counting. The probability of something happening can range from as low as 0% = 0.00 (if it is impossible) to as high as 100% = 1.00 (if it must happen). Most probabilities are somewhere between 0 and 1.

When a fair coin is flipped, there are two possible outcomes: heads and tails. Since each outcome is equally likely, the two outcomes can be written as a set called the sample space.

{ Heads, Tails }

Anything you can try to calculate the probability of is known as an *event*. The sample space can be used to calculate the probability of different events that can happen with the coin.

To calculate the probability of the coin landing on heads, first count the number of possible outcomes in the sample space. Make that the denominator in your answer. Then count the number of *favorable* outcomes, meaning outcomes in the sample space that are heads. Make that the numerator of your answer. Since there are 2 possible outcomes and 1 outcome with heads, the probability of the coin landing on heads is .

**Math Facts**

If there is a sample space, the probability of some event happening can be calculated with the fraction .

Below is a picture of a circle divided into 6 equal slices, numbered 1 through 6. A spinner is put into the middle and spun. A circular chart with numbers and a arrow

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The sample space for one spin is { 1, 2, 3, 4, 5, 6 }.

With this sample space, various question can be answered.

**Basic Probability Questions**

The most basic question is one like: What is the probability that the spinner will land on the number 4? This question is abbreviated as P(4).

Since there is one 4 in the sample space and there are 6 total numbers in the sample space, .

**Probability Questions Involving the Word “Not”**

If the question is to find the probability that the spinner will not land on the number 4, or P(not 4), count the number of outcomes in the sample space that are not 4. Since 5 of the numbers in the sample space are not the number 4, .

**Probability Questions Involving the Word “And”**

Questions involving the word “and” require you to analyze each element in the sample space to see if it meets two different conditions. Here’s a typical question involving the spinner with 6 equal slices, numbered 1 through 6.

“On one spin, what is the probability that the spinner will land on a number that is greater than 3 and even, or (P greater than 3 and even)?”

The denominator of the solution is still 6. For the number, examine all 6 numbers in the sample space to see how many of them are both greater than 3 and also even.

Exactly two of the numbers, 4 and 6, satisfy both conditions. So the numerator of the probability fraction is 2, and the solution is .

**Probability questions Involving the Word “Or”**

Imagine there is a game where you spin the spinner and you win a prize if the spinner lands on an even number or on a number that is greater than 3. To find the probability of winning this game, go through the 6 outcomes to find how many of them are either even, greater than 3, or both.

Of the 6 numbers, the numbers 2,4, 5 and 6 all are either even, greater than 3, or both. The probability of getting a number that is even or greater than 3 is .

Probability Questions Involving the Word “Given”

Imagine the spinner is spun. Somebody looks at it before you get a chance to and tells you a hint about the number it landed on, such as “It landed on an even number.” Then a question is asked like, “What is the probability that it landed on a number greater than 3?” Had you not known about the hint, the solution would since 3 of the 6 numbers (4, 5 and 6) are greater than 3. With the hint, though, you can get a more accurate answer.

This question could be described as “What is the probability of getting a number greater than 3 given that it landed on an even number?” or . You can instead use the given symbol, |, to write .

**Example 1**

A fair coin is flipped, and a fair 6-sided die is rolled. The sample space has 12 outcomes { H1, H2, H3, H4, H5, H6, T1, T2, T3, T4, T5, T6 }. Using this sample space, calculate the probability of getting:

A) An outcome with tails on the coin

B) An outcome with tails on the coin and 2 on the die

C) An outcome with tails on the coin or 2 on the die

D) An outcome with tails on the coin given that there is a 2 on the die.

E) An outcome with a 2 on the die given that there is a tails on the coin

*Solution*:

A) Since 6 out of the 12 outcomes have a T in them, the probability is .

B) Only one of the 12 outcomes has a T and a 2, so the probability is .

C) The outcomes H2, T1, T2, T3, T4, T5, T6 each have a 2 or a T (T2 has both). This is 7 out of the 12 outcomes in the sample space, so the probability is .

D) Since it is given that 2 is on the die, the sample space gets reduced to {H2, T2}. Only one of the two outcomes has a T, so the probability is .

E) Since it is given that tails is on the coin, the sample space set gets reduced to {T1, T2, T3, T4, T5, T6}. Of the 6 possible outcomes in this reduced sample space, only one has a 2 on the die. So the probability is .

**Sample Spaces Represented as Tables**

For certain surveys, the results can be represented in a table. This table can serve as a sample space for probability questions.

Imagine that 100 people are surveyed and asked two questions “Are you more than 14 years old?” and “Are you more than 5 feet fall?” The results of the survey can be shown with a table like this.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Under 14 Years** | **Over 14 Years** | **Total** |
| Under 5 feet | 21 | 12 | 33 |
| Over 5 feet | 9 | 58 | 67 |
| Total | 30 | 70 | 100 |

A probability question that can be answered with this table is “If one person is taken from the 100 at random, hat is the probability the person will be both under 14 years old and over 5 feet tall?”

The denominator of the fraction will be 100 since there are 100 people in total. For the numerator, the number of people who are both under 14 years old and over 5 feet tall, based on the information in the table, who are both under 14 years old and over 5 feet tall, based on information in the table, is 9.

So, the solution is .

**Example 2**

Using the above table, what is the probability that a randomly chosen person will be under 14 years old?

*Solution*: The denominator of the solution is 100. The numerator is since there are 21 people under 14 years old who are under 5 feet tall and 9 people under 14 years old who are over 5 feet tall. The solution is .

**Example 3**

Using the above table, find the probability that a randomly chosen person is over 5 feet tall or over 14 years old.

Solution: The total number of people is 100, which will be the denominator for the solution. For the numerator, look at the four possibilities and which count people who are either over 5 feet tall, over 14 years old, or both. Three of the four possibilities have at least one of those characteristics. The only one that doesn’t is the people are both under 14 years old and 5 feet tall. Add , and make that the numerator. The solution is .

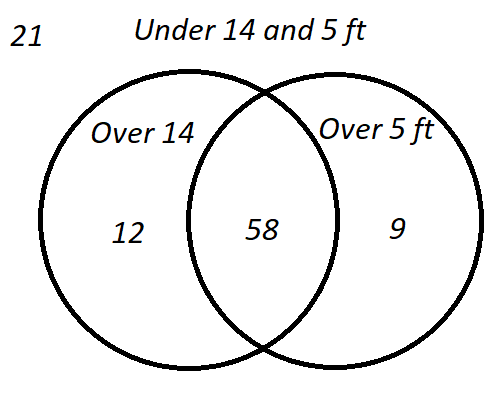
**Example 4**

Using the above table, find the probability of a randomly chosen person being over 5 feet tall given that the person is over 14 years old.

Solution: Because of the word “given,” the denominator of the fraction is no longer going to be 100. Since it is known that the person is over 14 years old, the 30 people under 14 years old are no longer relevant. The number of people over 14 years old is 70, and this will be the denominator of the solution. Of those 70 people, 58 of them are over 5 feet tall. So the solution is .

**Sample Spaces Represented as Venn Diagrams**

Another way to represent the data from the age/height survey is with a Venn diagram.

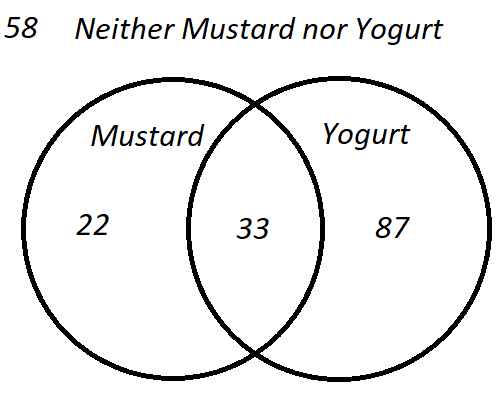


The two circles represent the people who are over 14 years old and the people who are over 5 feet tall. Just as there are four different categories of people in the table (both under 14 and under 5 feet, under 14 but over 5 feet, over 14 but under 5 feet, and both over 14 and over 5 feet), this Venn diagram has 4 regions (in neither circle, in the circle on the left, but not in the circle on the right, in the circle on the right but not in the circle on the left, and in both circles.

Use the Ven diagram to answer a question like “If a person is chosen randomly from the 100 surveyed, what is the probability that the person is under 14 years old but over 5 feet tall?” The circle on the right represents people who are over 5 feet tall. This is composed of the 58, which are the people who are both over 5 feet and over 14 years old, and of the 9, which are people who are over 5 feet but not over 14 years old (since they are not inside the over 14 years old circle on the right). The solution is .

**Example 5**

The Venn diagram below is based on two survey questions “Do you like frozen yogurt?” and “Do you like mustard?”



Use this Venn diagram to answer the following questions:

A) What is the probability that a person chosen randomly among those surveyed likes frozen yogurt but does not like mustard?

B) What is the probability that a person chosen randomly among those surveyed likes mustard?

C) Given that a randomly person likes mustard, what is the probability that the person also likes frozen yogurt?

*Solution*:

There are people in the survey.

A) The number of people who like yogurt is 87 but not mustard out of 200 people. The solution is .

B) There are people who like mustard out of 200 people. So the solution is .

C) Since it is given that the person likes mustard, the denominator is the number of people who like mustard (. The number of people who like mustard and yogurt is the intersection of the Venn diagram which has 33 people. The solution is then .