Name:

IN THIS LESSON, YOU WILL:

- Distinguish between theoretical and experimental probability
- Explain how the number of trials impacts the accuracy of a prediction
- Apply the addition rule
- Use the theoretical probability of an event to calculate its expected value
- Evaluate and compare strategies using expected values
- Use expected value to calculate the value of an insurance policy
- Analyze age as a factor that impacts auto insurance premiums

INTRO

AMPLIFY: Chance Experiments
Let's explore probability using a game of chance. Follow your teacher's instructions to complete this activity.

LEARN IT

VIDEO: Probability Part 1: Rules and Patterns
You likely hear about probability in everyday life - maybe looking at a weather prediction, hearing about the risks of texting while driving, or studying the stats on your favorite athlete. But what is probability? Watch the video through 3:34 to learn some basic probability terms, notation, and rules. Then, answer the questions.

1. **After watching the video, complete the missing cells in the table below with either an explanation or example for each vocabulary word.**

Vocab	Explanation	Example
Empirical Probability (also called Experimental Probability)	The probability of an event that we observe in actual data.	
Theoretical Probability	The true probability of an event. We can estimate the theoretical probability using the empirical probability.	

Mutually Exclusive		A skittle can't be two colors at once. So if you only choose one skittle, then choosing a purple skittle and choosing a red skittle are mutually exclusive.
Addition Rule		Choosing a red or purple skittle: P(red or purple) = P(red) + P(purple) P(red or purple) = 0.2 + 0.2 = 0.4

2. **You flip a fair coin 4 times and get tails once. Which answer correctly identifies both the empirical probability and theoretical probability of getting tails on a single coin flip?**
    a. Empirical = 0.25; Theoretical = 0.25
    b. Empirical = 0.25; Theoretical = 0.5
    c. Empirical = 0.5; Theoretical = 0.25
    d. Empirical = 0.5; Theoretical = 0.5

PRACTICE IT

Pick-2 Practice: Intro to Probability
Choose any two of the problems below and complete them.

1. **Imagine your teacher has a grab bag with an equal number of pens, pencils, highlighters, and markers. You get to choose one at random.**
    a. What is P(highlighter)?

    b. What is P(marker)?

    c. What is P(highlighter or marker)?

2. **You have a bowl of gummy bears: 5 are blue, 15 are red, 15 are green, and 15 are yellow.**
    a. How many total gummy bears are there?

    b. What is the probability of getting a blue gummy bear?

    c. What is the probability that you do NOT get a blue gummy bear? This is called the complement and can be represented with the symbol '.
    P(blue') =

3. **Imagine you roll a fair 6-sided die.**
    a. What is the probability of rolling a 1 or a 5?

    b. What is the probability of rolling a number that is NOT a 1 or a 5? This is called the complement and can be represented with the symbol '.
    P((1 or 5)')=

4. **Imagine you roll a fair 10-sided die 5 times. Here are your results: 2, 8, 9, 10, 5.**
    a. What is the theoretical probability of rolling a number less than or equal to 3?

    b. What is the experimental probability (also called empirical probability) of rolling a number less than or equal to 3?

    c. If you rolled the die 100 more times, what would you expect to happen to the experimental probability?

LEARN IT

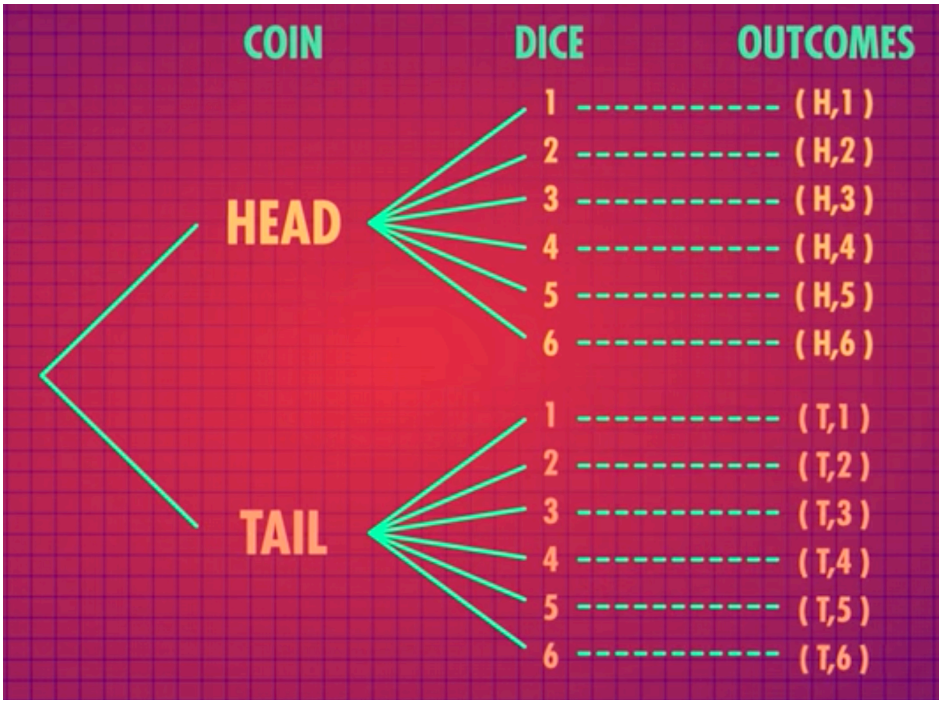
VIDEO: Probability Part 1: Rules and Patterns

Now that you've practiced the addition rule, let's look at a slightly trickier example: what happens when the events are NOT mutually exclusive? Resume the video and answer the questions.

1. **Which of the following events are mutually exclusive?**
    a. Picking a 4 and picking a 4 of clubs from a deck of cards
    b. Picking any color of candy and picking a red candy
    c. Rolling a 3 and rolling a 5 on a 6-sided die
    d. Rolling a 2 on a 6-sided die and getting tails on a coin flip

2. **Consider the example from the video where you flip a coin and roll a 6-sided die. Which equation correctly represents the probability of getting a tails or rolling a 6?**
    a. P(tails or 6) = P(tails) + P(6)
    b. P(tails or 6) = P(tails) - P(6)
    c. P(tails or 6) = P(tails) + P(6) + P(tails and 6)
    d. P(tails or 6) = P(tails) + P(6) - P(tails and 6)

3. **The image below shows the sample space for flipping a coin and rolling a 6-sided die. Answer the questions to find the probability of getting tails or an even number.**



a. Circle all the possible outcomes where you get tails.

b. Using a different color or shape, circle all the possible outcomes where you get an even number.

c. Define the following probabilities:
P(tails) =

P(even number) =

P(tails AND even number) =

d. What is the probability of getting tails OR an even number?

PRACTICE IT

Pick-2 Practice: Addition Rule
Choose any two of the problems below and complete them.

1. **There are 120 9th graders at Mountain Day High School. They all get to choose one of three possible electives: choir, computer science, or student council. 72 students choose choir, 27 choose computer science, and 21 choose student council. If you chose one student randomly...**
   a. What is P(computer science)?

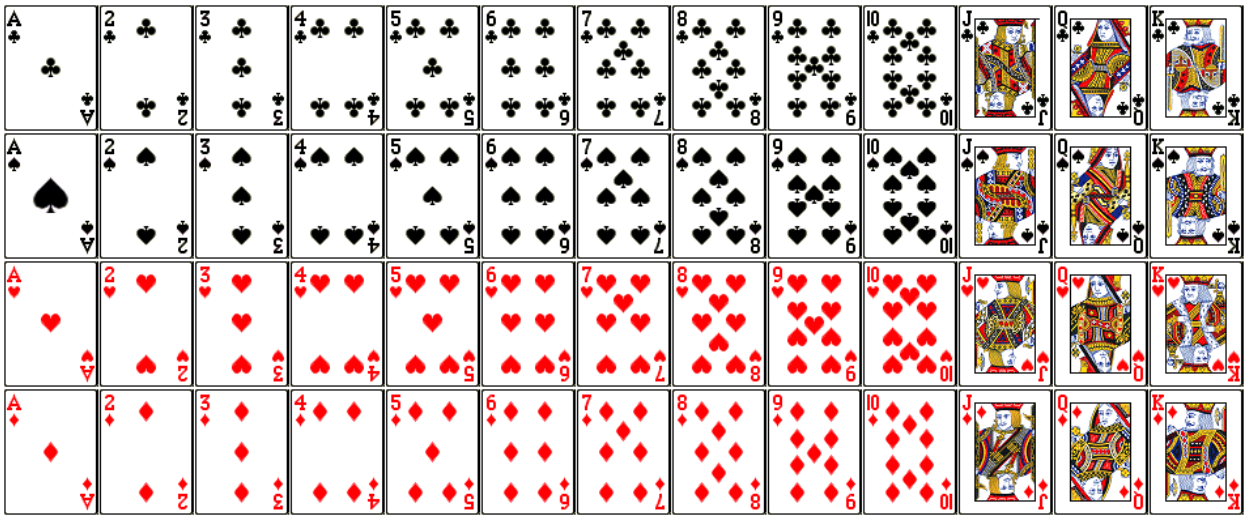
   b. What is P(choir)?

   c. What is P(computer science or choir)?

2. **If P(A) = 0.43, P(B) = 0.09, and P(A and B) = 0.02, what is P(A or B)?**

3. **In a group of 48 students, 30 play video games and 36 have a pet. 27 students both play video games and have a pet. If you randomly choose one student, what is the probability that they play video games or have a pet?**

4. **Imagine you are picking one card from a standard deck of playing cards, like the one shown below. What is the probability that you pick either a King or a Club?**
   Note: A standard deck of playing cards has 52 total cards. It is split into four different groups of cards, called "suits": clubs, spades, hearts, and diamonds. Each suit has 13 cards, including the numbers 1-10, one Jack, one Queen, and one King.



EXPLORE IT

AMPLIFY: Prize Wheel Puzzle

Once we start talking about probability, it can seem like nothing is certain! So how do you make decisions when you don't know what will happen? Let's play a game that's all about weighing the odds to see what strategies can be helpful. Follow your teacher's directions to complete this activity.

LEARN IT

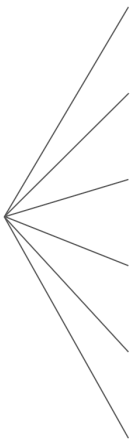
Expected Value

We've been learning about events with uncertain outcomes. Expected value is one tool we can use to make sense of probability and to make decisions when the outcome is uncertain. Expected value is a way to think about all the possible future events using a single number. It includes both the likelihood of each outcome and the value.

1. **Review the completed example below.**

Your friend proposes a bet: he'll roll a fair six-sided die. If it's an odd number, he'll give you that many dollars. If it's an odd number, you have to pay him that number of dollars. Should you accept?

1 **Define the Sample Space:** Write out the possible outcomes, including their probabilities and values.



Outcome	Probability	Value
1	1/6	+ $1
2	1/6	- $2
3	1/6	+ $3
4	1/6	- $4
5	1/6	+ $5
6	1/6	- $6

2 **Multiply:** Multiply each outcome's probability by its value. Then, add up those values.

$$\left(\frac{1}{6}\right)(1)+\left(\frac{1}{6}\right)(-2)+\left(\frac{1}{6}\right)(3)+\left(\frac{1}{6}\right)(-4)+\left(\frac{1}{6}\right)(5)+\left(\frac{1}{6}\right)(-6)=$$

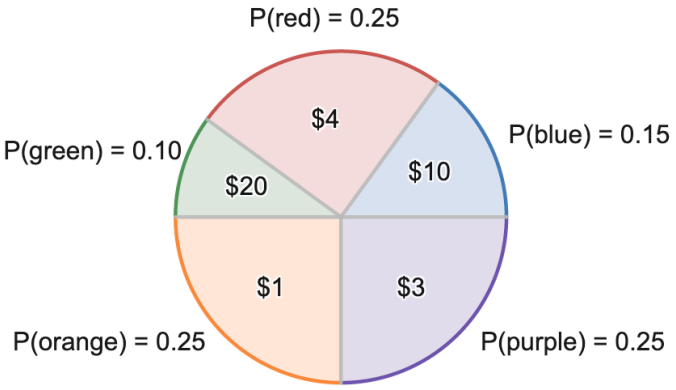
3 **Simplify:** Write expected value as E(X)=

E(X) = -0.5

4 **Contextualize:** What does this expected value tell you in context?

Since the expected value is negative, this bet is NOT a good deal for you. On average, you would expect to lose $0.50 per round if you played numerous rounds.

2. **Here is the prize wheel from the previous activity. Calculate the expected value of spinning the wheel once.**



1	**Define the Sample Space:** Write out the possible outcomes, including their probabilities and values.
2	**Multiply:** Multiply each outcome's probability by its value. Then, add up those values.
3	**Simplify:** Write expected value as E(X)=
4	**Contextualize:** What does this expected value tell you in context?

3. **Your school is holding a fundraising raffle. They are giving away one prize worth $100 and four prizes worth $25. You buy one ticket for $2 and calculate that you have a 0.00125 chance of winning $100 and a 0.005 chance of winning $25. What is the expected value of your ticket?**

1	**Define the Sample Space:** Write out the possible outcomes, including their probabilities and values.
2	**Multiply:** Multiply each outcome's probability by its value. Then, add up those values.
3	**Simplify:** Write expected value as E(X)=
4	**Contextualize:** What does this expected value tell you in context?

APPLY IT

Follow your teacher's directions to complete the Application Problems.