

Probability and Compound Events: math lesson, Grade 7 – download the PDF

Will it rain on Saturday? Will your next free throw go in? Will the card you draw win the game? We cannot know for sure, but we can measure how likely each event is with a single number. In Grade 7 you learn to compute that number, to test it with experiments and simulations, and to handle events made of several steps.

1. Probability is a number from 0 to 1

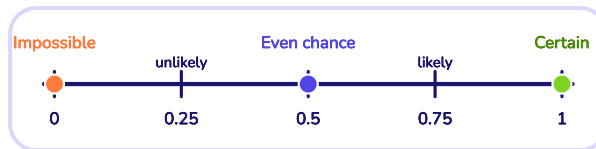
An **outcome** is one possible result of a chance process, such as rolling a 4. An **event** is a set of outcomes you care about, such as “rolling an even number”. The **probability** of an event, written $P(\text{event})$, tells how likely it is.

D

Probability scale

Every probability is a number between 0 and 1, including 0 and 1. It can be written as a fraction, a decimal or a percent.

- $P = 0$: the event is **impossible**.
- $P = \frac{1}{2}$: the event is **equally likely** to happen or not.
- $P = 1$: the event is **certain**.



The closer a probability is to 1, the more likely the event. A probability of 0.9 means “very likely”, and 0.1 means “unlikely”. A negative number or a number greater than 1 can never be a probability.

P Complement rule

The **complement** of an event is “the event does not happen”. Since something always happens, $P(\text{not } A) = 1 - P(A)$.

I 2. Theoretical probability and probability models

When all outcomes are **equally likely** (a fair coin, a fair die, a well-mixed bag), we can count:

P Theoretical probability

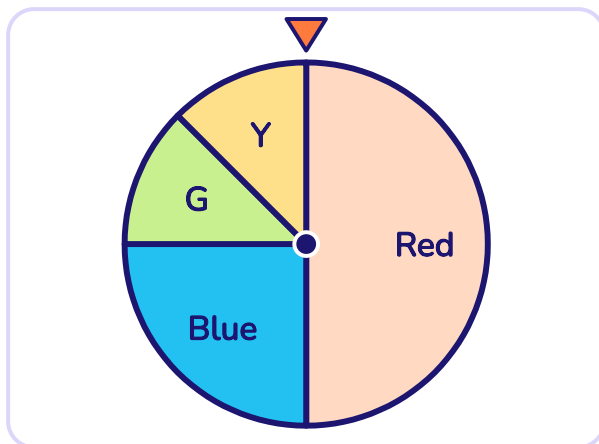
$$P(A) = \frac{\text{number of outcomes in } A}{\text{total number of outcomes}}$$

E Example 1: marbles in a bag

A bag holds 5 red, 3 blue and 2 yellow marbles, so there are 10 marbles. You pick one without looking.

$P(\text{blue}) = \frac{3}{10} = 0.3$. $P(\text{not red}) = \frac{5}{10} = \frac{1}{2}$, or $1 - \frac{5}{10}$. $P(\text{green}) = \frac{0}{10} = 0$ because no marble is green.

A **probability model** lists every outcome with its probability. In any model, **the probabilities add up to 1**. If the outcomes are equally likely the model is **uniform**. Otherwise it is not: the spinner below has a red half, a blue quarter, and green and yellow eighths.



Color	Red	Blue	Green	Yellow	Total
Probability	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	1



Careful

“There are two colors, so each has probability $\frac{1}{2}$ ” is only true when the colors take up equal parts. A bag with 2 red and 8 blue marbles gives $P(\text{red}) = \frac{2}{10} = \frac{1}{5}$.

3. Experimental probability

When you cannot count equally likely outcomes, or when you want to test a claim, you run an experiment and record the results.

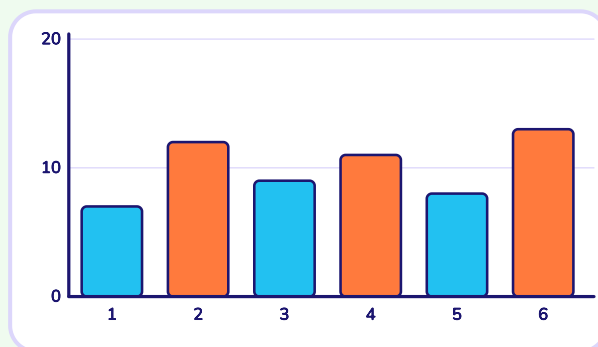
D Experimental probability

$$\text{experimental probability} = \frac{\text{number of times the event happened}}{\text{total number of trials}}$$

This is also called the **relative frequency**.

E Example 2: a die rolled 60 times

The bar chart shows how many times each face came up in 60 rolls.



The face 6 came up 13 times, so the experimental probability is $\frac{13}{60} \approx 0.217$. The theoretical probability is $\frac{1}{6} \approx 0.167$. The two numbers are close but not equal, which is normal.

The more trials you run, the closer the experimental probability usually gets to the theoretical one. This is why one short experiment can be surprising, while thousands of trials are reliable. Past results never “change” the next outcome: a fair coin has no memory.

4. Sample spaces and tables

The **sample space** is the list of all possible outcomes. For two coin flips it is HH, HT, TH, TT. For two steps with many outcomes, a **table** keeps the list organized. Here are all 36 sums when you roll two dice:

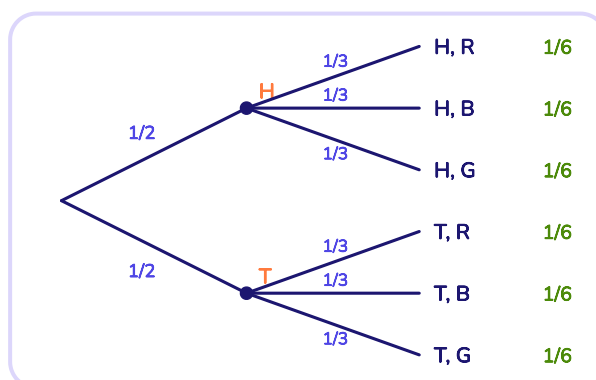
		Die 1					
		1	2	3	4	5	6
Die 2	1	2	3	4	5	6	7
	2	3	4	5	6	7	8
	3	4	5	6	7	8	9
	4	5	6	7	8	9	10
	5	6	7	8	9	10	11
	6	7	8	9	10	11	12

E Example 3: sum of two dice

Six cells in the table show a sum of 7, so $P(\text{sum is 7}) = \frac{6}{36} = \frac{1}{6}$. Only one cell shows a 2, so $P(\text{sum is 2}) = \frac{1}{36}$.

5. Tree diagrams and compound events

A **compound event** combines two or more steps or conditions, such as “flip a coin *and* spin a spinner”. A **tree diagram** shows each step as a set of branches, and each path from left to right is one outcome.



There are $2 \times 3 = 6$ paths, and they are equally likely, each with probability $\frac{1}{6}$. Notice that $\frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$: along a path, you multiply the probabilities of the branches.

P Counting principle

If one step has m outcomes and the next has n outcomes, the compound process has $m \times n$ outcomes.

I 6. Finding the probability of a compound event

M Method

1. Build the sample space with a list, a table or a tree diagram.
2. Count the total number of equally likely outcomes.
3. Circle the outcomes that match the event. Watch the words: **and** means both conditions at once, **or** means at least one of them (do not count an outcome twice).
4. Write the fraction and simplify it.

E Example 4: sandwich combinations

A deli lets you pick one bread (white, wheat or rye) and one filling (turkey, cheese, hummus or egg). There are $3 \times 4 = 12$ sandwiches. A sandwich is made at random.

$P(\text{wheat and cheese}) = \frac{1}{12}$. $P(\text{rye or hummus})$: rye gives 4 sandwiches, hummus gives 3, but rye with hummus is counted twice, so $4 + 3 - 1 = 6$ and the probability is $\frac{6}{12} = \frac{1}{2}$.

I 7. Simulations

Some situations are hard to test for real. A **simulation** uses a chance device that behaves like the real situation: coins, dice, cards, spinners or random digits.

M**How to design a simulation**

1. Choose a device whose outcomes match the real probabilities.
2. Decide what a “success” looks like.
3. Run many trials and record them.
4. Compute the experimental probability.

E**Example 5: free throws**

A player makes 60% of her free throws. Use the digits 0 to 9: the digits 0, 1, 2, 3, 4, 5 mean “made” (6 out of 10 digits, 60%) and 6, 7, 8, 9 mean “missed”. Read ten pairs of digits as ten pairs of shots: 47, 83, 12, 69, 05, 98, 34, 71, 50, 26.

Both shots are made when both digits are between 0 and 5: 12, 05, 34, 50 and 26. That is 5 pairs out of 10, so the simulated probability is 0.5. The exact value is $0.6 \times 0.6 = 0.36$. Ten trials is too few, and more trials would land closer to 0.36.

8. Predicting how often an event will happen

Probability lets you predict a frequency. If an event has probability p and you repeat the process n times, you expect it about $p \times n$ times. It is an estimate, not a promise.

E**Example 6: a prediction**

A spinner lands on blue with probability 0.2. In 300 spins, we expect $0.2 \times 300 = 60$ blues. We would not be surprised by 55 or 66, but 150 would be a reason to doubt that the spinner is fair.

You can also use an experimental probability to predict. A player who made 52 of 80 shots has an experimental probability of $\frac{52}{80} = 0.65$, so she is expected to make about $0.65 \times 200 = 130$ of the next 200 shots.



Zyro's tip

On my planet we say: “count first, divide second”. Write the total in the denominator before you look for the favorable outcomes, and you will never forget it!

Key takeaways

- A probability is a number from 0 (impossible) to 1 (certain), and $P(\text{not } A) = 1 - P(A)$.
- With equally likely outcomes, $P(A) = \frac{\text{favorable outcomes}}{\text{total outcomes}}$.
- In a probability model, all the probabilities add up to 1.
- Experimental probability = relative frequency; it gets closer to the theoretical value as the number of trials grows.
- Lists, tables and tree diagrams show every outcome of a compound event; $m \times n$ counts the outcomes of two steps.
- A simulation uses a chance device with the same probabilities as the real situation.
- Expected frequency $\approx$ probability $\times$ number of trials.



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