
SECTION 5.1 – Probability Rules

Probability

The measure of the likelihood of a random phenomenon or chance behavior occurring.

Experiment

Any process with uncertain results that can be repeated.

The Law of Large Numbers

As the number of repetitions of a probability experiment increases, the proportion with which a certain outcome is observed gets closer to the probability of the outcome.

Sample Space

The collection of all possible outcomes for an experiment, usually labeled S .

Event

Any collection of outcomes from a probability experiment, that is, any subset of the sample space.

Rules of Probabilities

1. The probability of any event E , $P(E)$, must be greater than or equal to 0 and less than or equal to 1. That is, $0 \leq P(E) \leq 1$
2. The sum of the probabilities of all outcomes must equal 1. That is, if the sample space $S = \{e_1, e_2, \dots, e_n\}$, then

$$P(e_1) + P(e_2) + \dots + P(e_n)$$

Unusual Event

An event that has a low probability of occurring, usually at 5% or less.

Approximating Probabilities Using the Empirical Approach

The probability of an event E is approximately the number of times event E is observed divided by the number of repetitions of the experiment.

$$P(E) \approx \text{relative frequency of } E = \frac{\text{frequency of } E}{\text{number of trials of experiment}}$$

Computing Probability Using the Classical Method

If an experiment has n equally likely outcomes and if the number of ways that an event E can occur is m , then the probability of E , $P(E)$ is

$$P(E) = \frac{\text{number of ways that } E \text{ can occur}}{\text{number of possible outcomes}} = \frac{m}{n}$$

So, if S is the sample space of this experiment,

$$P(E) = \frac{n(E)}{n(S)}$$

where $n(E)$ is the number of outcomes in E , and $n(S)$ is the number of outcomes in the sample space S .

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☺ **Exercises:**

For exercise 1 & 2, verify whether or not the following are probability models. Each model represents the colors obtained in a single bag of Skittles candies.

1)

Color	Probability
Green	0.167
Orange	0.233
Purple	0.217
Red	0.133
Yellow	0.25

2)

Color	Probability
Green	0.210
Orange	0.113
Purple	0.258
Red	0.223
Yellow	0.161

- 3) According to the American Veterinary Medical Association the proportion of households owning a dog is 0.372. What is the probability that a randomly selected household owns a dog?
- 4) A ‘significant’ earthquake is classified as one that meets at least one of the following criteria: At least one death, caused moderate damage (approximately \$1 million or more), a magnitude 7.5 or greater, a Modified Mercalli Intensity (MMI) X or greater, or an earthquake that generated a tsunami. According to the Southern California Earthquake Data Center (SCEDC) along with the United States Geology Survey (USGS), the frequency distribution of all ‘significant’ earthquakes with a magnitude of 4.0 or higher in Southern California that have occurred roughly within the last 100 years is shown below. (This does not include earthquakes that were created by nuclear explosions, quarry blasts, or sonic booms.)

Descriptor	Magnitude	Frequency
Great	8 and higher	0
Major	7 – 7.9	6
Strong	6 – 6.9	22
Moderate	5 – 5.9	22
Light	4 – 4.9	6

Source (As of 9/24/2020): <https://scedc.caltech.edu/significant/index.html#>

- a) Construct a probability model for all Southern California significant earthquakes with a magnitude of at least 4.0.
- b) Based off the probability model, if a significant earthquake with a magnitude of at least 4.0 occurred, what is the (estimated) probability that it is a major earthquake?

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☺ **Exercises:**

For exercise 5 through 15, roll a pair of standard dice.

- 5) List all the possible outcomes in the grid below.

D1 \ D2	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

- 6) What is the probability that you roll a sum of 7?
- 7) What is the probability that you roll a sum of 3?
- 8) What is the probability that you roll a sum of 8?
- 9) What is the probability that you roll a sum of 13?
- 10) What is the probability that you roll a sum of at least 11?
- 11) What is the probability that you roll a sum of at most 5?
- 12) What is the probability that you observe a '4' on at least one of the dies?
- 13) What is the probability that both dice are the same (or doubles)?

For exercises 14 and 15: In the game of Craps, there are "Hardway Bets". The Hard Way is when you have a sum of either 4, 6, 8, or 10, yet both dice are the same values. The Easy Way is when you have a sum of either 4, 6, 8, or 10, yet both dice show two different values.

- 14) What is the probability that you roll an easy '10'?
- 15) What is the probability that you roll a sum that is a hard '8'?

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☺ Extra Practice Exercises:***For problems #16 through #29, roll a pair of standard dice.***

- 16) What is the probability that you roll a sum of 4? _____
- 17) What is the probability that you roll a sum of 9? _____
- 18) What is the probability that you roll a sum of at least 3? _____
- 19) What is the probability that you roll a sum of 6? _____
- 20) What is the probability that you roll a sum of at most 4? _____
- 21) What is the probability that you roll a sum of 12? _____
- 22) What is the probability that you roll a sum of 5? _____
- 23) What is the probability that you roll a sum of 11? _____
- 24) What is the probability that you roll a sum of at least 9? _____
- 25) What is the probability that you roll a sum of at most 2? _____
- 26) What is the probability that you roll a sum of 1? _____
- 27) What is the probability that you roll a sum greater than 9? _____
- 28) What is the probability that you roll an easy '6'? _____
- 29) What is the probability that you roll a sum that is a hard '4'? _____
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☺ Answers to Extra Practice Exercises:

- 16) $\frac{3}{36} = \frac{1}{12}$; 17) $\frac{4}{36} = \frac{1}{9}$; 18) $\frac{35}{36}$; 19) $\frac{5}{36}$; 20) $\frac{6}{36} = \frac{1}{6}$; 21) $\frac{1}{36}$; 22) $\frac{4}{36} = \frac{1}{9}$; 23) $\frac{2}{36} = \frac{1}{18}$;
24) $\frac{10}{36} = \frac{5}{18}$; 25) $\frac{1}{36}$; 26) $\frac{0}{36} = 0$; 27) $\frac{6}{36} = \frac{1}{6}$; 28) $\frac{4}{36} = \frac{1}{9}$; 29) $\frac{1}{36}$.
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