

MATH 1070Q: Mathematics for Business and Economics

Lecture Slides

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Topic 10: General Probability and Odds

Reminders and To-Do

- Quiz (Topic 9) at the beginning of class.
- Topic 10 will cover sections 7.5 & 7.7 in the text.
- Worksheet 10 at the end of class.

Review: Idea of Probability

Recall:

Definition

Let S be a sample space for some scenario. A **random event** is any subset $E \subseteq S$. The **probability** of E occurring is defined by

$$P(E) = \frac{|E|}{|S|} \quad \left(\text{or } \frac{n(E)}{n(S)} \right).$$

Example

A sample space for rolling a 6-sided die is $\{1, 2, 3, 4, 5, 6\}$. The event in which we roll an odd number is $\{1, 3, 5\}$. Random events are sets that contain all possible ways to do the event (in this case, rolling an odd number). The probability for this event to occur is then $3/6$ or 0.5 .

Complement of Random Events

Let S be a sample space and $E \subseteq S$ any random event. Recall the **complement of E** is the set $S - E$ containing all elements in S that are not in E .

Notation

Since we will always work with sample spaces, we will use the shorthand E' to denote the complement $S - E$ of E in the sample space S . In other words:

$$E' = S - E = \{\text{all elements in } S \text{ not in } E\}.$$

Interpretation of E'

We think of E' as the event in which E **does not happen**.

Complements and Probability

Formula

The probability of E' occurring is given by

$$P(E') = 1 - P(E).$$

Note this equation implies also that $P(E) = 1 - P(E')$.

Examples

What is the probability of getting anything except the number 5 when rolling a 6-sided die?

Example of Complement Probability

Sometimes it is easier to find $P(E')$ first, and then use $P(E) = 1 - P(E')$.

Example

A coin is tossed 6 times. What is the probability that at least 2 heads is obtained?

Thought Process:

- 1 First, find $|S|$: the total number of outcomes in 6 coin tosses.
- 2 We want to find $P(E)$, where E is the event in which at least 2 heads is obtained.
- 3 Instead, we will find $P(E')$. Remember E' is the event in which E does not happen. It is easier to count $|E'|$ instead of $|E|$.

Question

Question: A group of 5 friends line up for a photo. Two of the friends, Bob and Alice, do not want to stand next to each other. Assuming the 5 friends line up randomly, what is the probability that Bob and Alice won't stand together?

Things to Think About

- If E is the event in which Bob and Alice won't stand together, what event does E' represent?
- Count $|E'|$ and use that to find $P(E')$.
- Use $P(E) = 1 - P(E')$ to finish the problem.

Another Example of Complement Probability

Example: Two 6-sided dice are rolled. What is the probability that the sum of the numbers obtained is less than 10?

Things to Think About

- Once again, it may be easier to find the probability of the given event not happening.
- If E is the event of rolling a sum less than 10, then what is E' ?

What are the Odds?

A common way of *presenting* probabilities is by using *odds*.

Example

In a horse race, an announcer may say “The odds against that horse winning are 5 to 1.” This means that, on average, for every 1 win the horse has, it has 5 losses.

Definition

Let E be some random event.

- If the **odds in favor** of E are $a : b$, then for every a -many occurrences of E , there are b -many occurrences of E' .
- If the **odds against** E are $a : b$, then for every a -many occurrences of E' , there are b -many occurrences of E .

Examples of Statements about Odds

Example

Suppose that a baseball player gets a hit 3 times during a game, and strikes out 2 times.

- What are the odds in favor of the player getting a hit?
- What are the odds against the player getting a hit?

Question

During a hockey game, a player scores 2 shots during a game and misses 4 times. What are the odds against the player scoring a shot?

(A) 2 : 4 (B) 4 : 2

(C) 2 : 6 (D) 6 : 2

Odds and Probability

Statements involving *odds* are really statements about *probability*. We can translate between the two:

Formulas: Converting Between Probability and Odds

- **Odds $\rightarrow$ Probability.** If the odds in favor of an event E are $a : b$, the probability of event E occurring is:

$$P(E) = \frac{a}{a + b}.$$

- **Probability $\rightarrow$ Odds.** If the probability of an event E is $P(E)$, the odds in favor of E are

$$P(E) : 1 - P(E)$$

Careful! These formulas assume odds are stated as “in favor.”

Example: Converting between Odds and Probability

Example 1

The odds against a team winning their next game are 6 : 5. What is the probability they will win their next game?

Example 2

The probability of a team winning their next game is $P(E) = 0.2$. What are the odds in favor of them winning?

Question

The odds in favor of a horse winning a race are $5 : 3$. What is the probability the horse will win?

- (A) $3/8$
- (B) $3/5$
- (C) $5/8$
- (D) $5/3$