Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**How Odd?**

1. Roll your pair of dice 30 times, each time recording a success if one (or both) of the dice show an odd number and a failure if the dice do not show an odd number.

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| --- | --- |
| Number of Successes | Number of Failures |
|  |  |

1. Based on your trials, what would you estimate the probability of two dice showing at least one odd number? Explain your reasoning.
2. You have just calculated an experimental probability. 30 trials is generally sufficient to estimate the theoretical probability, the probability that you expect to happen based upon fair chance. For instance, if you flip a coin ten times you expect the coin to land heads and tails five times apiece; in reality, we know this does not happen every time you flip a coin ten times.

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| Dice Lattice | | | | | |
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* 1. A lattice diagram is useful in finding the theoretical probabilities for two dice thrown together. An incomplete lattice diagram is shown to the right. Each possible way the two dice can land, also known as an outcome, is represented as an ordered pair. (1, 1) represents each die landing on a 1, while (4, 5) would represent the first die landing on 4, the second on 5. Why does it have 36 spaces to be filled?
  2. Complete the lattice diagram for rolling two dice.  
       
     The 36 entries in your dice lattice represent the sample space for two dice thrown. The sample space for any probability model is all the possible outcomes.
  3. It is often necessary to list the sample space and/or the outcomes of a set using set notation. For the dice lattice above, the set of all outcomes where the first roll was a 1 can be listed as: {(1, 1), (1, 2), (1, 3), (1, 4), (1, 5), (1, 6)}. This set of outcomes is a **subset** of the set because all of the elements of the subset are also contained in the original set. Give the subset that contains all elements that sum to 9.
  4. What is the probability that the sum of two die rolled will be 9?
  5. Using your lattice, determine the probability of having at least one of the two dice show an odd number.

1. The different outcomes that determine the probability of rolling odd can be visualized using a Venn Diagram, the beginning of which is seen below. Each circle represents the possible ways that each die can land on an odd number. Circle A is for the first die landing on an odd number and circle B for the second die landing on odd. The circles overlap because some rolls of the two dice are successes for both dice. In each circle, the overlap, and the area outside the circles, one of the ordered pairs from the lattice has been placed. (1, 4) appears in circle A because the first die is odd, (6, 3) appears in circle B because the second die is odd, (5, 1) appears in both circles at the same time (the overlap) because each die is odd, and(2, 6)appears outside of the circles because neither dice is odd.
   1. Finish the Venn Diagram by placing the remaining 32 ordered pairs from the dice lattice in the appropriate place.



* 1. How many outcomes appear in circle A? (Remember, if ordered pairs appear in the overlap, they are still within circle A).
  2. How many outcomes appear in circle B?
  3. How many outcomes are in ?
  4. How many outcomes are in ?
  5. Record your answers to b, c, d, and e in the table below.

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| --- | --- | --- | --- |
| b. Circle A | c. Circle B | d. | e. |
|  |  |  |  |

* 1. How is your answer to e related to your answers to b, c, and d?
  2. Based on what you have seen, make a conjecture about the relationship of A, B, and using notation you just learned.
  3. What outcomes fall outside of (outcomes we have not yet used)? Why haven’t we used these outcomes yet?
  4. Which outcomes appear in ?
  5. Which outcomes appear in ?

1. The investigation of the Venn Diagram in question 4 should reveal a new way to see that the probability of rolling at least one odd number on two dice is 27/36 = 3/4. How does the Venn diagram show this probability?
2. Venn Diagrams can also be drawn using probabilities rather than outcomes. The Venn Diagram below represents the probabilities associated with throwing two dice together. In other words, we will now look at the same situation as we did before, but with a focus on probabilities instead of outcomes.



* 1. Fill in the remaining probabilities in the Venn Diagram.
  2. Find and explain how you can now use the probabilities in the Venn Diagram rather than counting outcomes.
  3. Use the probabilities in the Venn Diagram to find .
  4. What relationship do you notice between P(B) and ? Will this be true for any set and its complement?