MBF3C Date: _____

Theoretical Probability

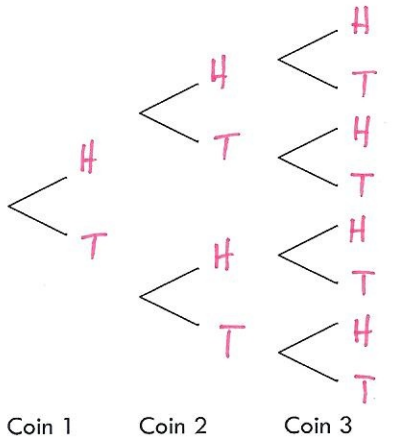
Theoretical Probability is another measure of the likelihood of an event. Without performing experiments, theoretical probability measures possible outcomes

Theoretical Probability Formula: $P(\text{event}) = \frac{\#\text{ of successful outcomes}}{\text{total \# possible outcomes}}$

To calculate theoretical probability, all outcomes must be equally likely, meaning each event has the same chance of occurring because the conditions are fair.

Again, the probability of an event is a value between 0 and 1.

Recall the coin flipping experiment. Use a tree diagram to help determine the possible outcomes.



Now the 8 possible outcomes can be grouped into specific events

Possible Outcomes

1) H H H
2) H H T
3) H T H
4) H T T
5) T H H
6) T H T
7) T T H
8) T T T

Event A (earning 3 points) is outcome # 8 (3 tails)

Event B (earning 1 point) is outcome # 4, 6, 7 (2 tails)

Event C (earning 0 points) is outcome #1, 2, 3, 5 (0 or 1 tail)

Listing the outcomes and the events gives a more clear indication of the chances of having a particular event occur. In this case you can calculate the theoretical probability for each of the events.

Probability for Event A

$P(A) = \frac{\#\text{ successful outcome}}{\text{total possible outcomes}}$

$= \frac{1}{8}$

$= 0.125$

$= 12.5\%$

Probability for Event B

$P(B) = \frac{\#\text{ successes}}{\#\text{ possibilities}}$

$= \frac{3}{8}$

$= 0.375$

$= 37.5\%$

Probability for Event C

$P(C) = \frac{\#\text{ successes}}{\#\text{ possibilities}}$

$= \frac{4}{8} = \frac{1}{2}$ (reduce to lowest terms)

$= 0.5$

$= 50\%$

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Remember $P(\text{event}) = \dfrac{\#\text{ successful outcomes}}{\#\text{ possible outcomes}}$

Date: _____

EXAMPLE 1

A standard deck of playing cards has 52 cards, 13 of each suit. If one card is drawn from the deck, find the probability of each event.

a) a heart $P(\text{heart}) = \dfrac{\#\text{ hearts}}{\#\text{ total cards}} = \dfrac{13}{52} = \dfrac{1}{4}$

b) an ace $P(\text{ace}) = \dfrac{\#\text{ aces}}{\#\text{ cards}} = \dfrac{4}{52} = \dfrac{1}{13}$

c) a heart, a club, or a jack

be careful not to count jacks twice; two are already included with the hearts and clubs

$P(\text{heart, club, or jack}) = \dfrac{\#\text{ hearts} + \#\text{ clubs} + \#\text{ jacks}}{\#\text{ cards}} = \dfrac{13+13+2}{52} = \dfrac{28}{52} = \dfrac{7}{13}$

d) a heart, a club, a spade, or a diamond

$P(\text{heart, club, spade, diamond}) = \dfrac{\#\text{hearts} + \#\text{clubs} + \#\text{ spades} + \#\text{ diamonds}}{\#\text{ cards}} = \dfrac{13+13+13+13}{52} = \dfrac{52}{52} = 1$

EXAMPLE 2

Jason rolls a regular six-sided die. Find the theoretical probability of each event. Express your answer as a fraction in lowest terms and as a percent.

a) rolling a 6 $P(\text{roll a 6}) = \dfrac{\#\text{ sixes}}{\#\text{ sides}} = \dfrac{1}{6} = 16.7\%$

b) rolling a number greater than 2 $P(\text{roll} > 2) = \dfrac{\#\text{ sides} > 2}{\#\text{ sides}} = \dfrac{4}{6} = \dfrac{2}{3} = 66.7\%$

c) rolling an 8 $P(\text{roll 8}) = \dfrac{\#\text{ sides w/ 8}}{\#\text{ sides}} = \dfrac{0}{6} = 0\%$

d) rolling an even number

$P(\text{roll even}) = \dfrac{\#\text{ sides that are even}}{\#\text{ sides}}$

$= \dfrac{3}{6}$

$= \dfrac{1}{2} = 50\%$