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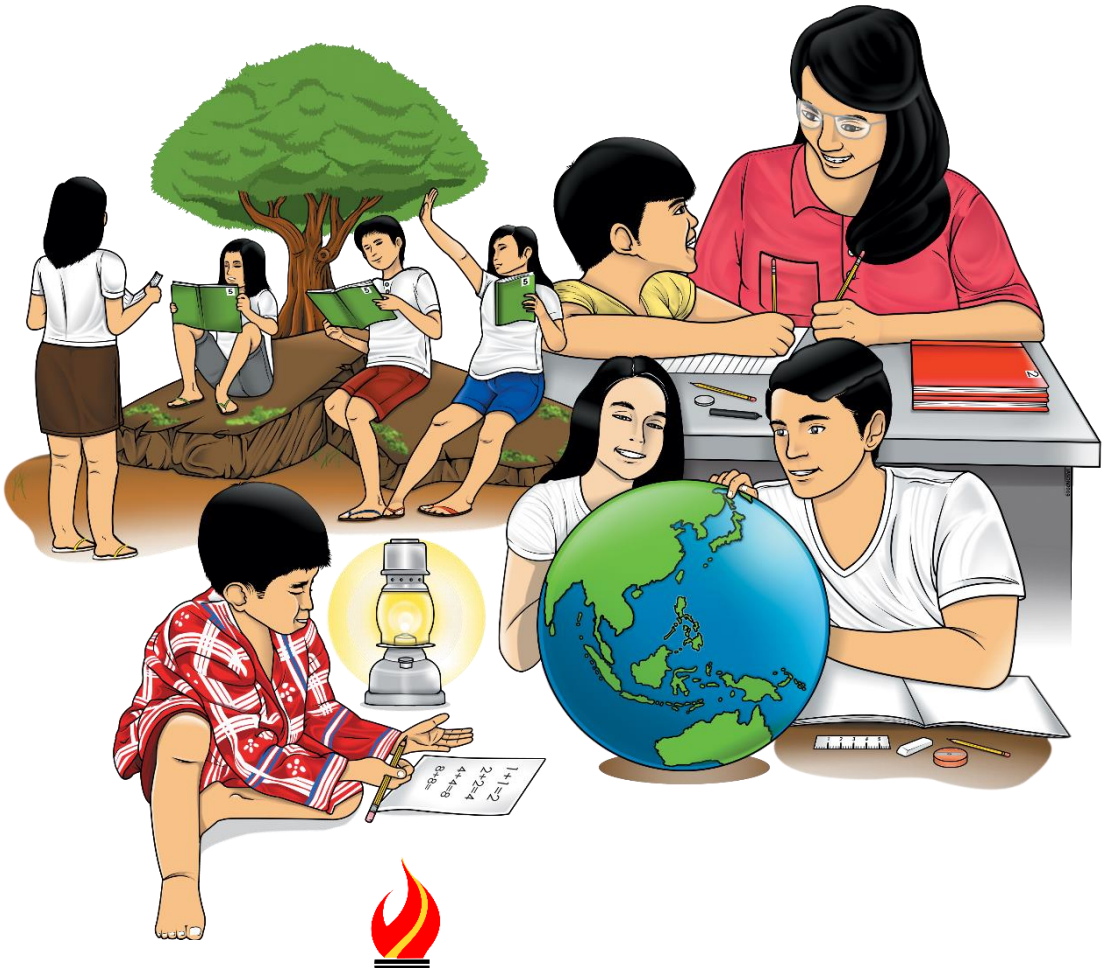
Mathematics

Quarter 3 – Module 32:
Conditional Probability



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Mathematics

Quarter 3 – Module 32:
Conditional Probability

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

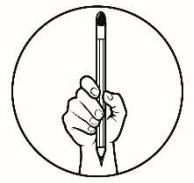
Thank you.

What I Need To Know

This module was designed and written with you in mind. It is here to help you find the probability of conditional events. The scope of this module permits it to be used in many different learning situations. The lessons are arranged to follow the standard sequence of the course but the pacing in which you read and comprehend the contents and answer the exercises in this module will depend on your ability.

After going through this module, you are expected to be able to demonstrate understanding of key concepts of conditional probability. Specifically, you should be able to:

1) recall multiplication rule of probability,
2) identify events which involves conditional probability,
3) solve problems involving conditional probability.



What I Know

Are you ready? You are task to answer the following questions before we proceed with our lesson. Do not worry, we only want to know how knowledgeable are you with the topics that we will be discussing in this module.

DIRECTION: Read and analyze each item carefully. Write the letter of the correct answer on a separate sheet of paper.

1) The probability that an event will occur given that another event has already occurred is called _____.

   A) Probability of Mutually Exclusive Events
   B) Probability of Independent Events
   C) Conditional Probability
   D) Simple Probability

2) How is the notation P(A|B) read?

A) The probability of A given B.
B) The probability of B given A.
C) The probability of A and B.
D) The probability of B and A.

3) Which of the following is a formula for conditional probability?

A) $P(A|B)=\frac{P(A\cap B)}{P(B)}$
B) $P(A|B)=\frac{P(A\cap B)}{P(A)}$
C) $P(B|A)=\frac{P(A\cap B)}{P(B)}$
D) $P(B|A)=\frac{P(A\cap B)}{P(B)}$

For items 4 to 6.

A number is selected at random from the set {1,2,3,4,5,6,7,8,9}.

4) Find *P(odd number).*

A) $\frac{4}{9}$ B) $\frac{7}{9}$ C) $\frac{5}{9}$ D) $\frac{8}{9}$

5) Find *P(prime number |odd number)*

A) $\frac{1}{5}$ B) $\frac{2}{5}$ C) $\frac{3}{5}$ D) $\frac{4}{5}$

6) Find *P(odd number |prime number)*

A) $\frac{5}{9}$ B) $\frac{8}{9}$ C) $\frac{1}{4}$ D) $\frac{3}{4}$

7) A card is drawn from a standard deck of 52 cards, what is the probability that the card is an ace given that it is a heart.

A) $\frac{4}{13}$ B) $\frac{2}{13}$ C) $\frac{3}{13}$ D) $\frac{1}{13}$

8) A card is drawn from a deck of cards, what is the probability that it is heart given that it is an ace?

A) $\frac{5}{9}$ B) $\frac{8}{9}$ C) $\frac{1}{4}$ D) $\frac{3}{4}$

9) Each letter of the word 'POLICY' is written on a strip of paper, rolled and placed in a fishbowl. If one letter is drawn and it is a consonant, what is the probability that it is a Y?

A) $\frac{1}{4}$ B) $\frac{1}{5}$ C) $\frac{3}{4}$ D) $\frac{2}{5}$

10) A pair of dice is tossed once. If it is known that the sum is 10, find the probability that one of the dice shows a 5.

A) $\frac{1}{2}$ B) $\frac{1}{3}$ C) $\frac{1}{4}$ D) $\frac{1}{5}$

11) If it is known that one of the dice in number 10 shows a 5, find the probability that the sum is 10.

A) $\frac{1}{9}$ B) $\frac{1}{10}$ C) $\frac{1}{11}$ D) $\frac{1}{12}$

12) The probability that Janice studies and passes her exam is 0.55. If the probability that she studies is 0.75, what is the probability that she passes the test given that she has studied?

A) 66.67% B) 73.33% C) 71.43% D) 85.71%

13) The probability that Clifford goes home late is 95%. The probability that he goes home late and his father scolds him is 80%. What is the probability that his father scolds him given that he goes home late?

A) 93.75% B) 94.12% C) 84.21% D) 85%

14) A die is tossed once. Find *P(number greater than 4 | even).*

A) $\frac{1}{3}$ B) $\frac{2}{3}$ C) $\frac{1}{4}$ D) $\frac{2}{5}$

15) A box contains four green balls, six red balls, and five pink balls. If one marble is drawn at random find *P(green | not pink).*

A) $\frac{1}{3}$ B) $\frac{2}{3}$ C) $\frac{1}{4}$ D) $\frac{2}{5}$

Lesson 1 Conditional Probability

What's In

Let us recall that if the outcome of one event has no effect on the outcome of a second event, then the two events are called **independent events**. If the outcome of one event has effect on the outcome of a second event, then the two events are called **dependent events**.

Let's review our previous lesson on multiplication rule of probability by answering the following activity:

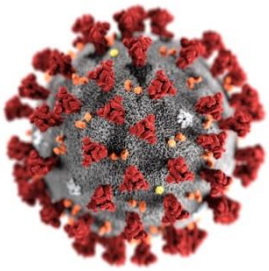
Activity 1

1. A pharmacy buys one box each of 50 thermal scanners from four different companies. There are 8 defective scanners in the box from the first company, 4 defective scanners from the second company, 3 defective scanners from the third company, and 5 defective scanners from the fourth company. If one scanner is taken from each box, what is the probability that the scanners from the first and second companies are defective and the scanners from the third and fourth companies are not?

2. An urn contains 5 red, 2 green, 3 blue and 7 yellow marbles. A marble is chosen at random from the urn. After replacing it, a second marble is chosen. What is the probability of choosing a red and then a yellow marble?

3. A standard die is rolled 4 times. What is the probability of getting a prime number on the first roll, an even number on the second roll, a multiple of 3 on the third roll, and a number greater than 2 on the fourth roll?

What's New

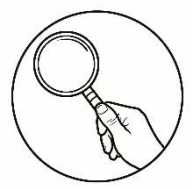


A nurse works in a hospital located in a city with a population of 3.8 million. Because of the pandemic caused by COVID-19, he assumes that approximately 0.8% of the city is infected since the citizens do not practice any precautionary measures like physical distancing, wearing of masks, and frequent washing/sanitizing of hands.

A man walks into the hospital for consultation, what is the probability that the man is infected with the virus? Upon consultation, it was found out that he has fever and dry cough, very common symptoms of the virus infection. With this additional information, do you think that the probability that the man has COVID-19 is higher than 0.8%?

When the man walked into the hospital, the probability that he had the virus was 0.8%. However, with the occurrence of another event (the symptoms) the probability now of the man having COVID-19 could be changed.

This would show that the probability of events could occur conditionally.



What Is It

The probability of an event occurring given that another event has already occurred is called **CONDITIONAL PROBABILITY**.

The conditional probability of an event B is the probability that the event will occur given that event A has already occurred.

In general, the conditional probability of B **given that** A has occurred is

$$P(B|A) = \frac{P(A \cap B)}{P(A)} \quad or \quad P(B|A) = \frac{n(A \cap B)}{n(A)}$$

or

the conditional probability of A **given that** B has occurred is

$$P(A|B) = \frac{P(A \cap B)}{P(B)} \quad or \quad P(A|B) = \frac{n(A \cap B)}{n(B)}$$

Let us look at some examples:

Notice how the formula is used depending on how each event is represented.

Example 1. A pair of dice is rolled once, find the probability that:

a) one of the dice shows a 3 if it is known that the sum is 7.
b) the sum is 7 if it is known that one of the dice shows a 3.

Solutions:

Let us show the sample space when 2 dice are rolled.

Dice 1 / **Dice 2**	**1**	**2**	**3**	**4**	**5**	**6**
1	1,1	2,1	**3**,1	4,1	5,1	6,1
2	1,2	2,2	**3**,2	4,2	5,2	6,2
3	1,**3**	2,**3**	**3,3**	4,**3**	5,**3**	6,**3**
4	1,4	2,4	**3**,4	4,4	5,4	6,4
5	1,5	2,5	**3**,5	4,5	5,5	6,5
6	1,6	2,6	**3**,6	4,6	5,6	6,6

a) Let *A* be the event that the sum of the numbers is 7.
Let *B* be the event that a 3 appears on one of the dice.

A = { (1,6), (2,5), (3,4), (4,3), (5,2), (6,1) }
n(A) = 6

B = { (1,3), (2,3), (3,3), (4,3), (5,3), (6,3), (3,1), (3,2), (3,4), (3,5), (3,6) }
n(B) = 11

$A \cap B = \{ (3,4), (4,3) \}$
$n(A \cap B) = 2$

Therefore, the probability that 3 will appear given that the sum is 7, denoted by $P(B|A)$ is

$$P(B|A) = \frac{n(A \cap B)}{n(A)}$$

we make use of this formula instead of $P(B|A) = \frac{P(A \cap B)}{P(A)}$ *since it is relatively easy to count the sample space of each event.*

$$P(B|A) = \frac{2}{6}$$

$$P(B|A) = \frac{1}{3}$$

b) In this case, the events are interchanged so we simply rewrite the formula to denote the probability that the sum is 7 given that one of the numbers is 3.

$$P(A|B) = \frac{n(A \cap B)}{n(B)}$$

$$P(A|B) = \frac{2}{11}$$

Example 2: Three hundred fifty returning OFW's were quarantined in two different locations, Nova Hotel and Diplomat Lodge. After the mandatory 14-day quarantine, they were interviewed whether they were satisfied or dissatisfied on the services available during the quarantine. The following table summarizes their responses.

LOCATION	SATISFIED	DISSATISFIED	TOTAL
NOVA HOTEL	143	54	197
DIPLOMAT LODGE	127	26	153
TOTAL	270	80	350

If one person from the 350 OFW's is chosen at random, find the probability that the person

a) is not satisfied given that he stayed at Diplomat Lodge.
b) stayed at Nova Hotel given that he is satisfied.
c) is known to have stayed at Diplomat Lodge and was satisfied.

Solutions:

a) probability that the person is not satisfied given that he stayed at Diplomat Lodge.

Let *A* be the event that the person is not satisfied.
Let *B* be the event that the person stayed at Diplomat Lodge

Hence, if written symbolically, it would be $P(A|B)$.

Next, find the number of OFW's who were not satisfied and stayed at Diplomat Hotel or $n(A \cap B)$ and the number of event *A* and *B*.

$n(A) = 80$ $n(B) = 153$ $n(A \cap B) = 26$

Then substitute the given values to the formula

$$P(A|B) = \frac{n(A \cap B)}{n(B)}$$

$$P(A|B) = \frac{26}{153}$$

Therefore, the probability that the person is not satisfied given that he stayed at Diplomat Hotel is $\frac{26}{153}$.

b) probability that the person stayed at Nova Hotel given that he is satisfied.

Let *A* be the event that the person stayed at Nova Hotel.
Let *B* be the event that the person is satisfied.

Hence, if written symbolically, it would be $P(A|B)$.

Next, find the number of OFW's who stayed at Nova Hotel and is satisfied or $n(A \cap B)$ and the number of event *A* and *B*.

$n(A) = 197$ $n(B) = 270$ $n(A \cap B) = 143$

Then substitute the given values to the formula

$$P(A|B) = \frac{n(A \cap B)}{n(B)}$$

$$P(A|B) = \frac{143}{270}$$

Therefore, the probability that the person stayed at Nova Hotel given that he is satisfied is $\frac{143}{270}$.

c) probability that the person is known to have stayed at Diplomat Lodge was satisfied.

Let *A* be the event that the person stayed at Diplomat Hotel.
Let *B* be the event that the person was satisfied.

Hence, if written symbolically, it would be $P(B|A)$.

Next, find the number of OFW's who stayed at Diplomat Hotel was satisfied or $n(A \cap B)$ and the number of event *A* and *B*.

$n(A) = 153$ $n(B) = 270$ $n(A \cap B) = 127$

Then substitute the given values to the formula

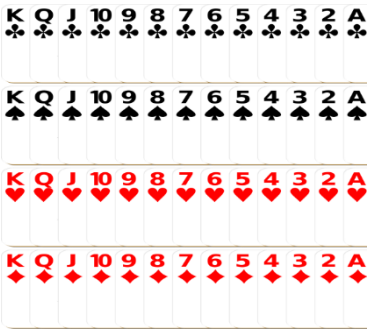
$$P(B|A) = \frac{n(A \cap B)}{n(A)}$$

$$P(B|A) = \frac{127}{153}$$

Therefore, the probability that the person is known to have stayed at Diplomat Lodge and was satisfied is $\frac{127}{153}$.

Example 3: One card is drawn from a standard deck of cards. What is the probability that: (*use the illustration at the right.)*

a) it is a Jack if it is known to be a face card?
b) it is an Ace given that it is a heart?
c) it is a number card given that it is a red card?
d) it is a face card given that it is black?



Solutions:

a) Let A be face card event.
Let B be Jack card event.

$A = \{$  $\}$

$n(A) = 12$

$B = \{$  $\}$

$n(B) = 4$

$(A \cap B) = \{$  $\}$

$n(A \cap B) = 4$

Therefore, the probability that it is a Jack if its known to be a face card is

$$P(B|A) = \frac{n(A \cap B)}{n(A)}$$

$$P(B|A) = \frac{4}{12} = \mathbf{\frac{1}{3}}$$

b) Let A be the event that it is an ace.
Let B be the event that is a heart.

$A =$ 
$n(A) = 4$

$B =$ 
$n(B) = 13$

$(A \cap B) =$ 
$n(A \cap B) = 1$

Therefore, the probability that it is an ace given that it is a heart is

$$P(A|B) = \frac{n(A \cap B)}{n(B)}$$

$$P(A|B) = \mathbf{\frac{1}{13}}$$

c) Let A be the event that it is a number card.
Let B be the event that it is a red card.

$A =$ 

$n(A) = 40$

$B =$ 

$n(B) = 26$

$(A \cap B) =$ 

$n(A \cap B) = 20$

Therefore, the probability that it is a number card given that it is a red card is

$$P(A|B) = \frac{20}{26} = \mathbf{\frac{10}{13}}$$

d) Let A be the event that it is a face card.
Let B be the event that it is a black card.

$A =$ 
$n(A) = 12$
$B =$ 

$n(B) = 26$

(A ∩ B) = 

$n(A \cap B) = 6$

Therefore, the probability that it is a face card given that it is black is

$$P(B|A) = \frac{6}{26} = \mathbf{\frac{3}{13}}$$

Example 4: In a survey among Grade 10 parents, 68% have smartphones. 22% have basic phones and smart phones. What is the probability that a parent has a basic phone given that he/she has a smart phone?

Solution:

$$P(basic\ phone|smart\ phone) = \frac{P(basic\ phone\ and\ smart\ phone)}{P(smart\ phone)}$$

$$P(basic\ phone|smart\ phone) = \frac{0.22}{0.68} = \mathbf{\frac{11}{34}}\ \boldsymbol{or}\ \mathbf{32.35\%}$$

Therefore, the probability that a parent has a basic phone given that he/she has a smart phone is 32.35%.

Example 5: The probability that it is Monday and that a teacher will give a quiz is 2%. Since there are 5 school days in a week, the probability that it is Monday is 0.2. What is the probability that a teacher will give a quiz given that today is Monday?

Solution:

$$P(quiz|Monday) = \frac{P(Monday\ and\ have\ a\ quiz)}{P(Monday)}$$

$$P(quiz|Monday) = \frac{0.02}{0.20} = \mathbf{\frac{1}{10}}\ \boldsymbol{or}\ \mathbf{10\%}$$

Therefore, the probability that a teacher will give a quiz given that today is a Monday is 10%.

What's More

Now, your turn.

Activity 2. Read and analyze each problem then solve for the probability of each event. Write your answers as a reduced fraction.

1. A six-sided die with A, B, C, D, E and F written on it is rolled once. Determine the probability that a D turned up, given that a consonant has been turned up.

2. Twenty-five balls numbered from 1 to 25 are placed in a jar, and one ball is randomly selected. What is the probability that the numbered ball chosen is

a. prime, given that it is odd-numbered ball?
b. odd, given that it is a multiple of 3?
c. divisible by 5, given that the numbered ball is even?

3. A pink die and a green die are thrown once. What is the probability that:
   a. the sum of the dice is less than 8 if the pink die shows a number less than 4?
   b. the sum is at most 7 given that the green die shows a 4?
   c. the sum of the dice is 10 given that a 5 turns up in at least one die?

4. A survey was conducted among junior and senior high students. They were asked which modality of learning they preferred for the first semester of the school year. The results of the survey is as follows:

	Modular	Online	Both	Total
Junior High	290	85	75	450
Senior High	217	125	88	430
Total	507	210	163	880

   If one student who was in the survey is selected at random, find the probability of each of the following:
   a. The student is from junior high given that he prefers online learning.
   b. The student prefers both modalities if he/she is from senior high.
   c. The student chose modular given that he/she is a junior high student.

5. At a local high school, the probability that a student speaks Kankanaey and Ilocano is 40%. The probability that a student speaks Kankanaey is 70%. What is the probability that a student speaks Ilocano given that he speaks Kankanaey?

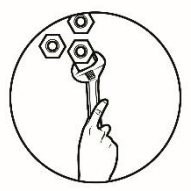
6. In one section of tenth graders, 28% are good in declamation and 15% are good in both oration and declamation. Find the probability that when a student is chosen at random, he is good in oration given that he is also good in declamation.

What I Have Learned

Let us check on what we have learned from the discussions and examples that have been presented.

Activity 3. Answer what is being asked in each question.

1. What are some of the key phrases used to determine conditional probabilities?
   _____, _____
2. What difficulties have you encountered in the lesson about Conditional Probability?
   _____
   _____
   _____
   _____.
3. In what situations could you apply the concepts you have learned?
   _____
   _____
   _____
   _____.



What I Can Do

Let us solve more problems about conditional probability.

Activity 4. Read and understand each problem then solve for the probability in each item.

1. In a certain community, 28% are SAP (Social Amelioration Program) beneficiaries, 12% are members of 4P's (Pantawid Pamilyang Pilipino Program), and somehow 2% are beneficiaries of both SAP and 4P's.

    a. If a citizen from the community is a SAP beneficiary, what is the probability that he also is a beneficiary of 4P's?

    b. If a person from that community is not a 4P's beneficiary, what is the probability that he also is not a SAP beneficiary?

2) It is commonly said that those who are good in Mathematics are not good in English. A teacher tried to observe 4 sections of grade 10 students. She recorded that 40% of the surveyed students were good in Mathematics, 65% were not good in English, and 15% were good in Mathematics but not in English. What is the probability that a student chosen at random from the respondents was not good in English, given that he/she was good in Mathematics?

Assessment

DIRECTION: Let us determine how much you have learned from this module. Read and answer each item carefully. Write the letter of the correct answer on a separate sheet of paper

1) The probability that an event will occur given that another event has already occurred is called _____.

   A) Probability of Mutually Exclusive Events
   B) Probability of Independent Events
   C) Conditional Probability
   D) Simple Probability

2) How is the symbol P(B|A) read?

   A) The probability of A given B.
   B) The probability of B given A.
   C) The probability of A and B.
   D) The probability of B and A.

3) Which of the following is a formula for conditional probability?

   A) $P(A|B)=\frac{P(A\cap B)}{P(A)}$
   B) $P(B|A)=\frac{P(B)}{P(A)}$
   C) $P(B|A)=\frac{P(A\cap B)}{P(B)}$
   D) $P(B|A)=\frac{P(A\cap B)}{P(A)}$

For items 4 to 6.

A number is selected at random from the set $\{9,10,11,12,13,14,15,16,17,18,19\}$.

4) Find *P(odd).*

   A) $\frac{5}{11}$ B) $\frac{6}{11}$ C) $\frac{7}{11}$ D) $\frac{8}{11}$

5) Find *P(prime|odd)*

   A) 1 B) $\frac{2}{3}$ C) $\frac{1}{3}$ D) 0

6) Find *P(odd|prime)*

   A) 1 B) $\frac{2}{3}$ C) $\frac{1}{3}$ D) 0

7) A card is drawn from a standard deck of 52 cards, what is the probability that the card is an eight given that it is a black suit.

A) $\frac{2}{13}$ B) $\frac{1}{13}$ C) $\frac{1}{4}$ D) $\frac{1}{2}$

8) A card is drawn from a deck of cards, what is the probability that it is a red suit given that it is a five?

A) $\frac{2}{13}$ B) $\frac{1}{13}$ C) $\frac{1}{4}$ D) $\frac{1}{2}$

9) Each of the letters of the word POLICY is written on a strip of paper, rolled and placed in a fish bowl. If one letter is drawn and it is a vowel, what is the probability that it is an O?

A) $\frac{1}{5}$ B) $\frac{1}{4}$ C) $\frac{1}{3}$ D) $\frac{1}{2}$

10) A pair of dice is tossed once. If it is known that the sum is 8, find the probability that one of the die shows a 5.

A) $\frac{1}{2}$ B) $\frac{1}{3}$ C) $\frac{2}{5}$ D) $\frac{3}{5}$

11) If it is known that one of the dice in item number 10 shows a 5, find the probability that the sum is 8.

A) $\frac{2}{5}$ B) $\frac{2}{11}$ C) $\frac{5}{36}$ D) $\frac{11}{36}$

12) The probability that Janice studies and passes her exam is 0.45. If the probability that she passes is 0.70, what is the probability that she studied given that she passed the test?

A) 85.71% B) 71.43% C) 64.29% D) 42.86%

13) The probability that Clifford goes home early is 21%. The probability that he goes home early and makes his father happy is 9%. What is the probability that Clifford's father becomes happy given that Clifford goes home early?

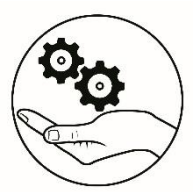
A) 85.71% B) 71.43% C) 64.29% D) 42.86%

14) A die is tossed once. Find *P(number less than 5|even).*

A) $\frac{1}{3}$ B) $\frac{2}{3}$ C) $\frac{1}{4}$ D) $\frac{2}{5}$

15) A box contains four green balls, six red balls, and five pink balls. If one marble is drawn at random find *P(pink|not green).*

A) $\frac{1}{3}$ B) $\frac{2}{3}$ C) $\frac{4}{11}$ D) $\frac{5}{11}$

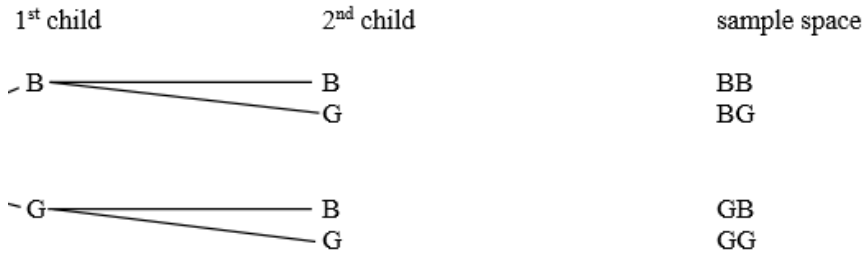


Additional Activity

Let us solve some more problems on conditional probability. Consider the problem below.

Problem: A family has two children. Assuming that boys and girls are equally likely, determine the probability that the family has one boy and one girl given that the first child is a girl.

Solution: We start by listing down the elements of the sample space since there are just a few.



The condition is the first child must be a girl. Hence, we will reduce our sample space by selecting the elements with a girl as the first child. That is,

Reduced sample space = {GB, GG}

From the reduced sample space, the number of favorable outcome which is to have one boy and one girl is one. That is the element {G,B}.

Therefore, the probability that the family has one boy and one girl given that the first child is a girl is

$$P(E) = \frac{number\ of\ elements\ in\ reduced\ sample\ space\ with\ one\ boy\ and\ one\ girl}{number\ of\ elements\ from\ the\ reduced\ sample\ space}$$

$$P(one\ boy\ and\ one\ girl\ given\ that\ the\ first\ child\ is\ a\ girl) = \mathbf{\frac{1}{2}}$$

Your Turn! A family has three children. Assuming that boys and girls are equally likely, determine the probability that the family has exactly two boys given that the first child is a boy.

Answer Key

What I Know

1) C
2) A
3) A
4) C
5) C
6) D
7) D
8) C
9) A
10) B
11) C
12) B
13) C
14) A
15) D

Activity 1

1) $\frac{846}{78125}$
2) $\frac{35}{289}$
3) $\frac{1}{18}$

Activity 2

1. $\frac{1}{4}$

2. a. $\frac{8}{13}$
   b. $\frac{1}{2}$
   c. $\frac{1}{6}$

3. a. $\frac{5}{6}$
   b. $\frac{1}{2}$
   c. $\frac{1}{11}$

4.a. $\frac{17}{42}$
   b. $\frac{44}{215}$
   c. $\frac{29}{45}$

5.57.14%

6. 53.47%

Activity 3

1. given that, if it is known that

2 and 3. Answers may vary

Activity 4

1. a. 7.14%
   b. 70.45%
2. 37.50%

Additional Activity

Your Turn! $\frac{1}{2}$

Assessment

1) C
2) B
3) D
4) B
5) B
6) A
7) B
8) D
9) D
10) C
11) B
12) C
13) D
14) B
15) D

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