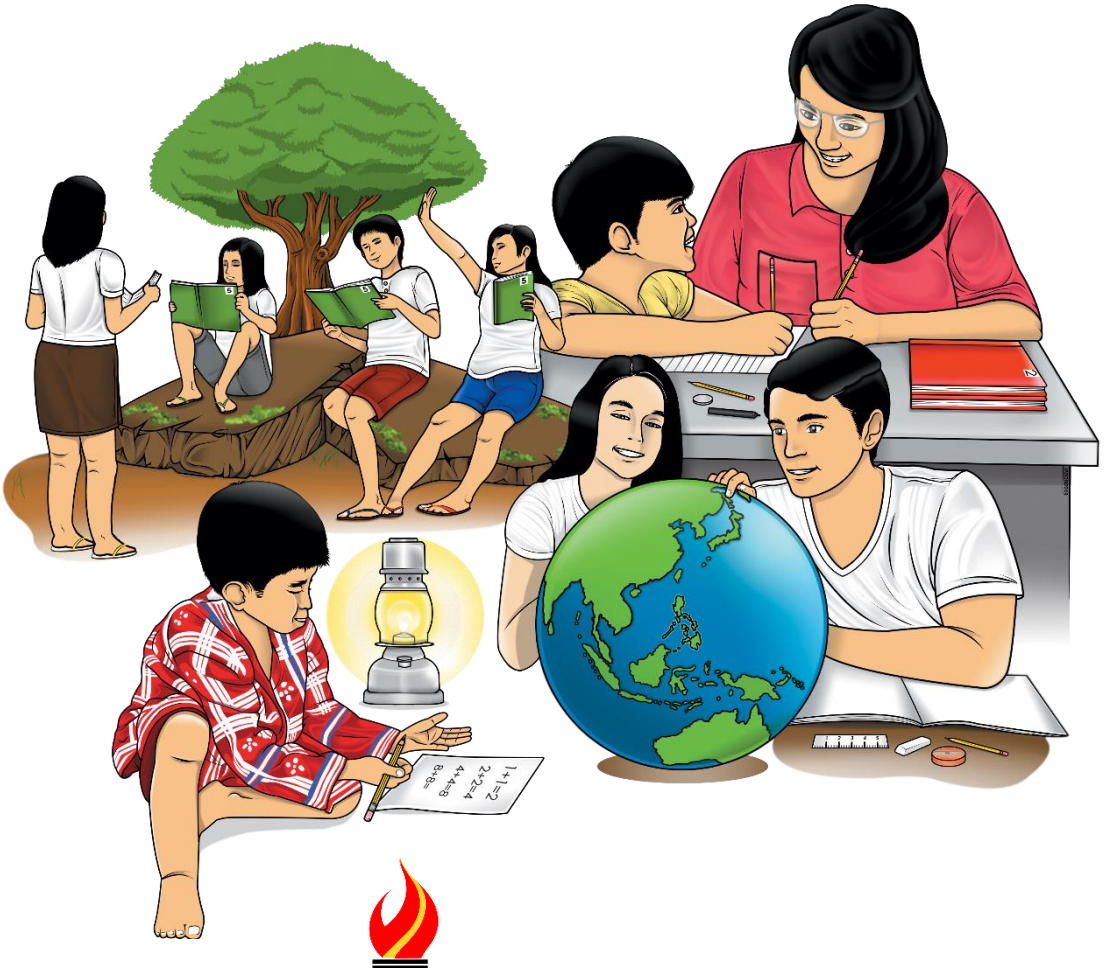
Senior High School

DepED
DEPARTMENT OF EDUCATION

General Mathematics
Quarter 2 – Module 16:
Truth Values of Propositions



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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

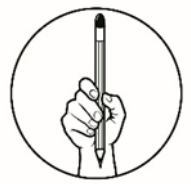
This module will guide you go beyond the surface of propositions. To further enhance your knowledge on logical operators, we will explore their truth values through this module. To help you do this, you will learn how to prepare a table of values given a proposition or a combination of propositions. In turn, this will help you in determining the truth values.

The module is composed of one lesson, namely:

- Lesson 1 – Truth Values of Propositions

After going through this module, you are expected to:

1. construct truth tables of propositions;
2. determine the truth values of propositions; and
3. distinguish the proposition as tautology or contradiction.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. What is a proposition that is always false?
   a. absolute
   b. contradiction
   c. negation
   d. tautology

For numbers 2 to 4, refer to the following problem:
p and q are both true propositions and r is a false proposition.

2. What is the truth value of $\sim r$?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

3. What is the truth value of $q \wedge (\sim r)$?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

4. What is the truth value of $p \vee (q \wedge (\sim r))$?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

For numbers 5 to 7, refer to the following problem: p and q are false and r is true.

5. What is the truth value of $\sim p$?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

6. What is the truth value of $q \leftrightarrow r$?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

7. What is the truth value of $(\sim p) \wedge (q \leftrightarrow r)$?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

For numbers 8 to 10, determine the truth values of the propositions p, q and r that will make the following statements false.

8. $p \wedge (q \vee r)$
   a. p and r are false, while q is true.
   b. p, q and r are all true or all false.
   c. If p is true, then q and r are both false. If p is false, then each of q and r may either be true or false.
   d. If p is true, then q and r are both true. If p is false, then each of q and r may either be true or false.

9. $(p \wedge q) \vee r$
   a. p and q should be false. r may be true or false.
   b. q should be false. p and r may either be both true or both false.
   c. p should be false. Either q is true and r is false, or vice versa, or both are true.
   d. r should be false. p and q may take any truth value except for both are true.

10. $\sim(p \wedge (\sim q))$
   a. p and r should be false, while q should be true.
   b. p and q should be false, while r should be true.
   c. q should be false, while p and r should be true.
   d. q and r should be false, while p should be true.

11. What is the truth value of the conjunction $p \wedge q \wedge (\sim r)$ if p and q are both false propositions and r is a true proposition?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

12. What is the truth value of the conjunction $\sim(q \wedge p) \wedge r$ if p and q are both false propositions and r is a true proposition?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

13. What is the truth value of the disjunction $p \vee (\sim r)$ if p and q are both true propositions *and* r is a false proposition?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

14. What is the truth value of the disjunction $(p \vee r) \vee (\sim q)$ if p and q are both true propositions and r is a false proposition?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

15. What is the truth value of the conditional $p \rightarrow (q \wedge r)$ if p, q and r are true, false and true propositions, respectively?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

Lesson 1 Truth Values of Propositions

Aside from performing operations on propositions, determining their truth values is also possible. Given some truth values of its component propositions, the truth value of a compound proposition may be known. The truth table will systematically guide you to determine the truth value of a compound proposition.
In the first place, logical operators may be defined by using truth tables. Truth values of compound propositions will be built on these. To understand the details of this lesson gradually, read on, dear learner.

What's In

Complete the following truth tables of logical operators.

1.

p	$\sim p$
T	
F	

2.

p	q	$p \wedge q$
T	T	
T	F	
F	T	
F	F	

3.

p	q	$p \vee q$
T	T	
T	F	
F	T	
F	F	

4.

p	q	$p \rightarrow q$
T	T	
T	F	
F	T	
F	F	

5.

p	q	$p \leftrightarrow q$
T	T	
T	F	
F	T	
F	F	

Take note that the knowledge of truth tables of logical operators is very important to be successful in this module. As a learner, you should be familiar with the truth value of each logical connector.

Notes to the Teacher

Enable learners to perform each task or activity in this module. Remind them to review the truth values of logical operators introduced in the previous lesson.

What's New

Hey there! Before you continue reading a new lesson, pause for a while. Have a seat. Take a deep breath. Now, read the poem word for word silently.

TRUTH THAT VALUES MOST

by: Azalea A. Gallano

Life can teach us good and bad,
While others feel the heat before they see the light,
As for some, a word is enough
And they make it a guide.

Even if one keeps the entire law,
But disobeys one commandment
That person shall be charged guilty
And shall be considered unworthy.

Life can best be spent on service
No one can serve two at the same time, however,
You'll satisfy and be satisfied with an endeavor you're in,
But the other will surely be forsaken.

While opportunity lies on your doorsteps, study well
Not all have this opportunity to fondle,
Others give up, yet some chase for their dreams
But you, you have no reason to surrender.

Take time to ponder, however, above all
The main purpose of life is service to the Creator
We fulfill our mission if and only if we serve Him
No more, no less, it is everybody's calling.

I guess you are done reflecting the message of the poem. Today or later, you will understand the lines on and in it. For the meantime, can you spot which stanzas deal with concepts of the logical operators negation, conjunction, disjunction, conditional and biconditional?

If you analyze the poem, you will identify and understand the differences of these logical operators. You'll be able to discover concepts behind each of them.

What is It

Truth Value and Truth Table Defined

Every proposition has two possible truth values. That is, the truth value of a proposition, be it simple or compound, is either true or false. The **TRUTH VALUE**, therefore, refers to the truthfulness of a proposition that may either be true or false. These can be represented in tabular form. The table that shows the complete possible truth values of a proposition is called **TRUTH TABLE**.
A proposition p has the following truth table:

p
T
F

Suppose we are given two propositions p and q. Since there are four possible combinations of truth values (TT, TF, FT, FF), then their truth table is:

p	q
T	T
T	F
F	T
F	F

It follows therefore that if there are three propositions *p, q* and *r* for example, their truth table is:

p	*q*	*r*
T	T	T
T	T	F
T	F	T
T	F	F
F	T	T
F	T	F
F	F	T
F	F	F

How many possible combinations of truth values do we have if there are three propositions? Can you name them? Notice that the number of truth-value combinations increases geometrically as the number of propositions increase. That is, there are $2^1 = 2$, $2^2 = 4$, $2^3 = 8$ and $2^4 = 16$ such combinations if there are 1, 2, 3 and 4 propositions, respectively. How many truth value combinations shall we expect if there are n propositions?

In the earlier module, the truth value of logical operators was introduced, but in this module, you will learn how to find truth table for the compound proposition.

Example 1

Given the statement "A diabetic either takes conventional drugs, natural medicine or both", determine the truth value of $p \vee (\sim q \wedge r)$ in each scenario. Let *p*: A diabetic takes conventional drugs. Let *q*: A diabetic takes natural medicine. And let *r*: A diabetic takes both conventional and natural medicines.

Scenario 1: Patient A only eats leaves of his insulin plant to control his sugar level.

Scenario 2: Patient B consults his doctor and buys diligently the prescribed conventional drugs.

Scenario 3: Patient C supplements conventional drugs with natural medicine he reads is effective as well for diabetics.

Solution:

Scenario 1: Patient A only eats leaves of his insulin plant to control his sugar level.

The negation of q denoted by $\sim q$ states that a diabetic does not take natural medicine which is false in Scenario 1. Its conjunction with proposition r which is also false is false as we've learned. On the other hand, p is false since Patient A takes natural medicine only. The disjunction of a false proposition and another false disjunct is false. Its truth table is illustrated as follows:

p	q	r	$\sim q$	$\sim q \wedge r$	$p \vee (\sim q \wedge r)$
F	T	F	F	F	F

Scenario 2: Patient B consults his doctor and buys diligently the prescribed conventional drugs.

Since $\sim q$ is true in this scenario and r is false, then their conjunction is false. And, since p is true and $(\sim q \wedge r)$ is false as we have said, then their disjunction is true. Simply put, since the proposition involves disjunction and one disjunct p is true, without further analysis we may conclude that the disjunction is true. That is because disjunction can only be false if both disjuncts are false. Its truth table is illustrated as follows:

p	q	r	$\sim q$	$\sim q \wedge r$	$p \vee (\sim q \wedge r)$
T	F	F	T	F	T

Scenario 3: Patient C supplements conventional drugs with natural medicine he reads is effective as well for diabetics.

Both $\sim q$ and r are true because Patient C is not taking conventional drugs only, but instead he takes both, conventional and natural. Thus, the conjunction of these two propositions is true. Then, although p is false, but since one of the disjuncts is true, then the disjunction $p \vee (\sim q \wedge r)$ is true. Its truth table is illustrated as follows:

p	q	r	$\sim q$	$\sim q \wedge r$	$p \vee (\sim q \wedge r)$
F	F	T	T	T	T

Example 2

Let p and q be propositions. Determine the truth value of $(p \rightarrow q) \rightarrow ((\sim p) \vee q)$. Construct its truth table.

Solution:

Since there are two propositions p and q. Thus, the truth table will contain four rows, the first two columns of which are

p	q
T	T
T	F
F	T
F	F

Using the truth table for the definition of the conditional, negation and disjunction statements $p \rightarrow q, \sim p$ and $\sim p \vee q$ respectively. You need to add three more columns to indicate the truth values for each statement.

$p \rightarrow q$	$\sim p$	$\sim p \vee q$
T	F	T
F	F	F
T	T	T
T	T	T

Lastly, you need to consider the truth value of the proposition $(p \rightarrow q) \rightarrow (\sim p \vee q)$. The truth table of $(p \rightarrow q) \rightarrow \sim p \vee q)$ is as follows:

p	q	$p \rightarrow q$	$\sim p$	$\sim p \vee q$	$(p \rightarrow q) \rightarrow (\sim p \vee q)$
T	T	T	F	T	T
T	F	F	F	F	T
F	T	T	T	T	T
F	F	T	T	T	T

Notice that the proposition $(p \rightarrow q) \rightarrow ((\sim p) \vee q)$ is always **TRUE**. Such is called **TAUTOLOGY** and is denoted by τ. It is the opposite of contradiction.

Example 3

Let p and q be propositions. Determine the truth values of $(p \wedge (\sim q)) \wedge (p \wedge q)$. Construct its truth table.

Solution:

Since there are two propositions p and q. Thus, the truth table will contain four rows, the first two columns of which are

p	q
T	T
T	F
F	T
F	F

Using the truth table for the definition of the negation and conjunction statements $\sim q$, $p \wedge (\sim q)$ and $p \wedge q$ respectively. You need to add three more columns to indicate the truth values for each statement.

$\sim q$	$p \wedge \sim q$	$p \wedge q$
F	F	T
T	T	F
F	F	F
T	F	F

Lastly, you need to consider the truth value of the proposition $(p \wedge (\sim q)) \wedge (p \wedge q)$. The truth table of $(p \wedge (\sim q)) \wedge (p \wedge q)$ is as follows:

p	q	$\sim q$	$p \wedge (\sim q)$	$p \wedge q$	$(p \wedge (\sim q)) \wedge (p \wedge q)$
T	T	F	F	T	F
T	F	T	T	F	F
F	T	F	F	F	F
F	F	T	F	F	F

Notice that the proposition $(p \wedge (\sim q)) \wedge (p \wedge q)$ is always **FALSE**. Such is called **CONTRADICTION**. Other resources call it a **FALLACY**. It is denoted by $\emptyset$.

What's More

Activity 1

Determine the truth value of each of the following propositions. Show the truth table of each as well.

1. $\sim p \wedge q$ where p and q are both false propositions
2. $(p \wedge r) \wedge \sim q$ where p and q are both false and r is true
3. $\sim(q \vee p) \wedge r$ where p and q are both true and r is false
4. $\sim p \rightarrow (q \leftrightarrow r)$ where p is true and q and r are both false
5. $p \rightarrow (q \vee r)$ where p and q are both false and r is true

Activity 2

Consider the statement "Lito saves money for organic and natural products and he buys paraben-free items". Suppose *p:* Lito saves money for organic and natural products. And *q:* He buys paraben-free items. Decide on the truth value of $p \wedge q$ in each of the following scenarios.

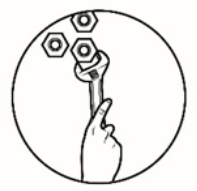
1. *Scenario A:* Lito was not able to save much money to buy natural products. He was able to purchase items some of which contain parabens.
2. *Scenario B:* The money that Lito has saved was more than enough for paying paraben-free items. He even was able to buy organic food.
3. *Scenario C:* Though Lito has not saved for natural items, he prioritized buying paraben-free products. He is decided to change his lifestyle.

What I Have Learned

Fill in each blank with "true" or "false".

1. The truth value of every proposition may be _____ or _____.
2. Given that p is true, the truth value of the negation of p $(\sim p)$ is _____.
3. The truth value of all conjunction of p and q $(p \wedge q)$ is _____ except for case where p and q are both _____.
4. The truth value of all disjunction of p and q $(p \vee q)$ is _____ except for case where p and q are both _____.
5. The truth value of all conditional of p and q $(p \rightarrow q)$ is _____ except for conditional where p is _____ and q is _____.

6. The truth value of the biconditional of p and q ($p \leftrightarrow q$) is _____ if p and q are both _____ or both _____. Otherwise, its truth value is _____.
7. A proposition is a tautology if the truth value is always _____. Meanwhile, a proposition is a contradiction or a fallacy if the truth value is always _____.



What I Can Do

Make three simple propositions out of things that matter to you most. What compound proposition involving logical operators shall represent your plan regarding these three propositions? Express it in symbols and construct a truth table. What reflection can you make out of the possible combinations of truth values as you can see from the truth table? Use a separate sheet of paper for your output.

You may improve your output by checking against the following rubric:

Criteria	**4**	**3**	**2**	**1**
Propositions **(score x 2)**	*All meaningful and realistic*	*Two are meaningful and realistic*	*Only one is meaningful and realistic*	*Not meaningful and realistic*
Truth table **(score x 3)**	*Complete with component propositions which gradually complicate from simple to compound proposition being asked; truth table with all correct truth values*	*Incomplete component propositions but gradually complicate from simple to compound proposition being asked; truth table with all correct truth values*	*Complete with component propositions which gradually complicate from simple to compound proposition being asked; truth table with 1-3 incorrect truth values*	*Incomplete with component propositions; truth table with more than 3 incorrect truth values*

Proof statement **(score x 3)**	*Consistently logical; aids clear and easy understanding of the solution*	*Somewhat logical; somewhat aids clear or easy understanding of the solution*	*Somewhat illogical; tends to complicate understanding of the solution*	*No textual explanation of solution or answer*
Reflection **(score x 2)**	*Very consistent with truth values; uses clear, rich and detailed imaginative language*	*Consistent with truth values; uses imaginative language*	*Somewhat inconsistent with truth values; uses imaginative language*	*Inconsistent with truth values; uses pure everyday language*

Assessment

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. What is a proposition that is always true?
   a. absolute
   b. contradiction
   c. negation
   d. tautology

For numbers 2 to 8, consider the following:

In the minutes of the meeting, it is recorded that "All ten members agreed that there will be a monthly contribution of ₱50.00. Let p be the statement "The collection for February is ₱500.00". Decide on the truth value of the negation $\sim p$ given the following scenarios.

2. What is the verbal equivalent of $\sim p$?
   a. The collection for February is not ₱500.00.
   b. The collection not for February is ₱500.00.
   c. All ten members agreed that there will be a monthly contribution of ₱50.00 and the collection for February is ₱500.00.
   d. If all ten members agreed that there will be a monthly contribution of ₱50.00, then the collection for February is ₱500.00.

Scenario A: All members of the group paid the monthly contribution.

3. What is the truth value of the negation $\sim p$ given Scenario A?
   a. true
   b. false
   c. neither true nor false
   d. information is insufficient

4. Which explains the reason behind the truth value of $\sim p$ given Scenario A?
    a. Despite all members contributed, each may have contributed any amount.
    b. Scenario A makes no mention about the contribution of each of ten members.
    c. Given that all ten members of the group contributed, the total collection for February is ₱500.00.
    d. Given that there are ten members of the group, the total collection for February just like in any month should be ₱500.00.

Scenario B: The treasurer lost the payment of the three members.

5. What is the truth value of the negation $\sim p$ given Scenario B?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

6. Which explains the reason behind the truth value of $\sim p$ given Scenario B?
    a. Scenario B lacks information.
    b. Since three payments were lost, the total collection for February is ₱350.00 only.
    c. The other seven members may or may not have paid more than ₱50.00 each.
    d. Three payments were lost, but it is a thumbs rule that the one keeping the collection should make up the lost money.

Scenario C: One member left the group.

7. What is the truth value of the negation $\sim p$ given Scenario C?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

8. Which explains the reason behind the truth value of $\sim p$ given Scenario C?
    a. Leaving the group does not relate to the total amount collected.
    b. Scenario C does not mention whether the member contributed or not before leaving the group.
    c. The remaining nine members divided ₱500.00 equally among themselves to meet the target amount.
    d. With one member withdrawing his/her connection to the group, the collection shall be lower than ₱500.00.

For numbers 9 to 11, determine all truth values of the propositions p and q that will make the following statements true.

9. $p \wedge \sim q$
    a. p and q are both true.
    b. p and q are both false.
    c. p and q are true and false, respectively.
    d. p and q are false and true, respectively.

10. $\sim(p \wedge q)$
    a. not p and q are false.
    b. Both p and q are true.
    c. p is true and q is true.
    d. At least one of p and q is false.

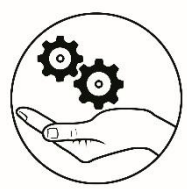
11. $\sim(p \wedge \sim q)$
    a. If p is true, then q should be true. If p is false, then q may either be true or false.
    b. If p is false, then q should be true. If p is true, then q may either be true or false.
    c. If p is true, then q should be false. If p is false, then q may either be true or false.
    d. If p is false, then q should be false. If p is true, then q may either be true or false.

12. What is the truth value of the conjunction $\sim p \wedge (q \vee r)$ if p and q are both true propositions and r is a false proposition?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

13. What is the truth value of the conditional $[p \wedge (q \vee r)] \rightarrow [(p \wedge q) \vee (p \wedge r)]$ if p and r are both true propositions and q is a false proposition?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

14. What is the truth value of the biconditional $p \leftrightarrow (q \wedge r)$ if p is a true proposition and both q and r are false propositions?
    a. true
    b. false
    c. neither true nor false
    d. information is insufficient

15. Which of the following propositions has a truth value of false if p is false and q is true?
    a. $p \leftrightarrow (\sim q)$
    b. $(q \rightarrow p) \vee (p \wedge q)$
    c. $(p \wedge q) \rightarrow (q \vee p)$
    d. $(\sim p \wedge q) \vee (q \leftrightarrow p)$



Additional Activities

Assume the propositions

p: Behind Bruce Lee was his wing chun teacher Ip Man.
q: Wing chun boils down to math.
r: It is strength and ability to avoid fight that matter.
s: Wing chun can be learned.

A. Determine the truth value of each proposition below.

Proposition A: If behind Bruce Lee was his wing chun teacher Ip Man, then he must have lived in simplicity and humility.

Proposition B: If Ip Man is good in math, then wing chun boils down to math.

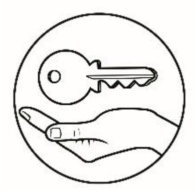
B. Considering the statement "Wing chun which is about strength and where ability to avoid fight matters, boils down to math and can be learned", determine the truth value of the proposition $q \rightarrow (r \wedge s)$ given each scenario:

Scenario A: Matthew upon reading much and correlating wing chun to math in his research has gradually understood that wing chun is about strength and not fight and that he can learn it in due time.

Scenario B: Ruth sees math in wing chun. Because of this, she is optimistic that she can learn it. However, since it is math, she believes it cannot be a good sport in promoting strength.

The following rubric will be used to rate your work for each of the four problems:

Criteria	**4**	**3**	**2**	**1**
Truth table **(score x 3)**	*Complete with component propositions which gradually complicate from simple to compound proposition being asked; truth table with all correct truth values*	*incomplete component propositions but gradually complicate from simple to compound proposition being asked; truth table with all correct truth values*	*Complete with component propositions which gradually complicate from simple to compound proposition being asked; truth table with 1-3 incorrect truth values*	*Incomplete with component propositions; truth table with more than 3 incorrect truth values*
Proof statement **(score x 2)**	*Consistently logical; aids clear and easy understanding of the solution*	*Somewhat logical; somewhat aids clear or easy understanding of the solution*	*Somewhat illogical; tends to complicate understanding of the solution*	*No textual explanation of solution or answer*



Answer Key

What I Know

1. b
2. a
3. a
4. a
5. a
6. b
7. b
8. c
9. d
10. a
11. b
12. a
13. a
14. a
15. b

What's More

Activity 1

1. false
2. false
3. false
4. true
5. true

Activity 2

1. false
2. true
3. false

Assessment

1. d
2. a
3. b
4. c
5. a
6. b
7. a
8. d
9. c
10. d
11. c
12. b
13. a
14. b
15. b

References

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*DepED Material: General Mathematics Learner's Material

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