## 9.6 Properties of Logarithms • Cal State LA
Time estimate to complete this assignment: 90 -- 120 minutes.

This is the sixth topic in Unit 9 - Exponential and Logarithmic Functions. Since a logarithm is an exponent, we would expect there to be properties of logarithms just as there are properties of exponents. In this section, we will introduce seven properties of logarithms and use them to simplify and expand logarithmic expressions.

Logarithmic functions and exponential functions are inverse of each other. Learning logarithmic functions is critical in learning the complete knowledge set of these two functions. Logarithms have important properties that students must learn in order to perform mathematical work involving logarithms in their future learning or work. Logarithms are used in earth sciences. For example, the Richter scale of earthquake measures use logarithm.

**Timeframe: Note how long will it take the learner to complete all of the activities from pre-class to post-class activities.**

| Pre-Class | In-Class | Post-Class | Total |
|-----------|----------|------------|-------|
| 100 min | 70 min | 150 min | 320 min |

## Overview
There are a few properties of logarithms that are important yet easy to learn by yourselves. They are

Four Basic Properties of Logarithms

For all positive numbers $b$, where $b \neq 1$,

1. $\log_b 1 = 0$     2. $\log_b b = 1$     3. $\log_b b^x = x$     4. $b^{\log_b x} = x$   $(x > 0)$

The Product Rule of Logarithms

The logarithm of a product equals the sum of the logarithms of the factors.
For all positive real numbers $M$, $N$, and $b$, where $b \neq 1$,

$$\log_b MN = \log_b M + \log_b N$$

Read as "the log base $b$ of $M$ times $N$ equals the log base $b$ of $M$ plus the log base $b$ of $N$."

The Quotient Rule of Logarithms

The logarithm of a quotient equals the difference of the logarithms of the numerator and denominator. For all positive real numbers $M$, $N$, and $b$, where $b \neq 1$,

$$\log_b \frac{M}{N} = \log_b M - \log_b N$$

Read as "the log base $b$ of $M$ divided by $N$ equals the log base $b$ of $M$ minus the log base $b$ of $N$."

The Power Rule for Logarithms

The logarithm of a number raised to a power equals the power times the logarithm of the number.

For all positive real numbers $M$ and $b$, where $b \neq 1$, and any real number $p$,

$$\log_b M^p = p \log_b M$$

*Read as "the log base b of M to the p power equals p times the log base b of M."*

## Learning Objectives

### Basic objectives (while preparing for workshop)

1. State and use the four basic properties of logarithms in simplifying logarithmic expressions.
2. State and use the product rule for logarithms in simplifying logarithmic expressions.
3. State and use the quotient rule for logarithms in simplifying logarithmic expressions.
4. State and use the power rule for logarithms in simplifying logarithmic expressions.

### Advanced objectives (in the workshop)

1. Write logarithmic expressions as a single logarithm.
2. State and use the change-of-the-base formula.
3. Use properties of logarithms to solve application problems.

## Preparatory Activities and Resources:

- Text: Read pages 814 – 819.
- Video: Watch the following videos.
    - Introduction to logarithm properties
      https://www.youtube.com/watch?v=PupNgv49_WY (9:16)
      https://www.youtube.com/watch?v=TMmxKZaCqe0 (10:05)

## Exercises:  Please complete by November 15th

The exercises for this pre-class guided practice are in worksheets #1-4 and they are available on Canvas, so if you don't have a copy of them, download a copy from Canvas.  Note that they are also distributed in the previous class meeting, so you can get a hard copy for free if you attend the previous class meeting.

## Submission Instructions:

Scan or take a picture of your work and email to me by the midnight of November 15th.

Math 80
Fall 2018
El Camino Community College


**Lesson:** Properties of Logarithms


**Timeframe: Note how long will it take the learner to complete all of the activities from pre-class to post-class activities.**

| Pre-Class | In-Class | Post-Class | Total |
| --- | --- | --- | --- |
| 100 min | 70 min | 150 min | 320 min |


**Materials needed: Describe what items will be needed to complete the in-class activities.**

1. Pre-class worksheet
2. In-class worksheet
3. Homework (post-class)

**Objectives: List out the basic objectives tied to pre-class activities and the advanced objectives tied to in-class and post-class activities.**

*Basic:*
   1. State and use the four basic properties of logarithms.
   2. State and use the product rule for logarithms.
   3. State and use the quotient rule for logarithms.
   4. State and use the power rule for logarithms.

*Advanced:*
   1. Write logarithmic expressions as a single logarithm.
   2. State and use the change-of-the-base formula.
   3. Use properties of logarithms to solve application problems.

**Background to the Lesson: Note the typical composition of learners in the class, how this lesson fits into the course design/schedule, prerequisite knowledge required, and typical challenges that learners face with this content area.**

This is the sixth topic in Unit 9 - Exponential and Logarithmic Functions.  Since a logarithm is an exponent, we would expect there to be properties of logarithms just as there are properties of exponents.  In this section, we will introduce seven properties of logarithms and use them to simplify and expand logarithmic expressions.

Prerequisite knowledge:
1. 9.3 Exponential Functions
2. 9.4 Logarithmic Functions
3. 9.5 Base-e Exponential and Logarithmic Functions

**Introduction to Lesson: Describe the purpose of this content area for learners and an overview of the activities and resources for the flipped lesson.**

Logarithmic functions and exponential functions are inverse of each other. Learning logarithmic functions is critical in learning the complete knowledge set of these two functions. Logarithms have important properties that students must learn in order to perform mathematical work involving logarithms in their future learning or work. Logarithms are used in earth sciences. For example, the Richter scale of earthquake measures use logarithm.

In this lesson, students will have worksheets that address the learning objectives. The worksheets contain logarithmic properties and explanations that students can refer to when they are participating in pre-class and in-class activities. There are practice problems in the worksheets as well.

The pre-class activity will be direct instructions by students learning from the worksheets and reading materials assigned from the textbook. The in-class activity will be done in a group with the instructor giving assistance.

**Procedure [Time needed, include additional steps if needed].**

*Pre-Class Individual Space Activities and Resources:* Outline the major steps for the preparatory activities and be sure to tie the steps to the basic learning objectives you have noted above. Note resources required for learner preparation.

| Steps | Purpose | Estimated Time | Learning Objective |
|---|---|---|---|
| **Step 1:**<br><br>Read Worksheet #1 and answer attached questions. | Let students getting to know the four basic logarithmic properties. | 25 min | State and use the four basic properties of logarithms. |

| Step 2: | | | |
|---|---|---|---|
| Read Worksheet #2 and answer attached questions. | Let students getting to know the product rule of logarithms. | 25 min | State and use the product rule of logarithms. |
| **Step 3:** | | | |
| Read Worksheet #3 and answer attached questions. | Let students getting to know the quotient rule of logarithms. | 25 min | State and use the quotient rule of logarithms. |
| **Step 4:** | | | |
| Read Worksheet #4 and answer attached questions. | Let students getting to know the power rule of logarithms. | 25 min | State and use the power rule of logarithms. |
| **Step 5:** | | | |
| Submit assignments of Steps 1 - 4 and give a pass/no pass grade. | Checking the learning outcomes of Steps #1 - 4. | 0 min | None. |

*In-Class Group Space Activities and Resources.* Outline the major steps for the in-class activities and be sure to tie the steps to the advanced learning objectives you have noted above. Also note any resources needed/developed to provide effective active learning activities within class.

| Steps | Purpose | Estimated Time | Learning Objective |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Step 1:**<br><br>Questions and answers for pre-class activities. | To answer any possible questions students may have the during pre-class activity. | 5 min | None |
| **Step 2:**<br><br>Group work of four students with worksheet #5. Groups are composed of 3-4 students mixed with high and low math skills | Let students learn to apply logarithmic properties by writing logarithmic a expression as a single logarithm. | 20 min | Write logarithmic expression as a single logarithm. |
| **Step 3:**<br><br>Group work with worksheet #6. | Let students learn change-of-the-base formula. | 20 min | State and use the change-of-the-base formula. |
| **Step 4:**<br><br>Group work with worksheet #7. | Let students learn applying logarithms and logarithmic functions in real-world problem solving. | 20 min | Applications of logarithms and logarithmic functions. |
| **Step 5:**<br><br>Kahoot quiz used to see the learning outcomes of the worksheets of the entire class session. | To check the learning outcomes of this section. | 5 min | None. |

***Post-Class Individual Space Activities and Resources.*** Outline the major steps for the post-class activities and be sure to tie the steps to the advanced learning objectives you have noted above. Also note any resources learners will need to complete any post-class activities assigned after the group space activities.

| Steps | Purpose | Estimated Time | Learning Objective |
|---|---|---|---|
| **Step 1:**<br><br>Homework: page 824, 61 - 101 odd, 107, 109. | Let students retain the learning outcomes from objectives #1 - 7. | 150 min | Post-class individual space activity. |
| **Step 2:** | | | |

**Evaluation:**

*Analysis.* In this section, note what you think will work, and what challenges you think you may face in implementation.

I think this lesson plan will work but with a few concerns. I do not worry about the in-class activities especially with the presence of the instructor.

The challenge I may have is likely to be in the pre-class activities. Some students may not want to do any work by themselves before the lecture time. According to the book of this workshop, I will have to assign a considerable percentage of grade to the pre-class activities.

*Connections to Future Lessons.* In this section, note how you think this lesson plan connects to your next topics in the course.

This lesson will prepare students for the next section in the textbook – 9.7 Exponential and Logarithmic Equations since this lesson concludes all the properties of logarithms and, together with previous lessons, will contributes the understanding of 9.7.