Teacher Training Module:
Mathematics
Learning Cycle Fifteen

Laws of Exponents

Sindh Technical Assistance –
Development through
Enhanced Education Programme
(STA-DEEP)

School Education & Literacy Department (SE&LD)

Government of Sindh.

Dear Teachers!

Welcome to the new phase of the Continuous Professional Development (CPD) Program. In the previous phase, we had focused on pedagogical skills that helped you to develop your skills to make classroom more interactive, participative, and joyful for our students. In the new phase, we will continue practicing those pedagogical skills and also learn about the introduced content knowledge and skills in Mathematics, Science, English, Urdu, and Sindhi. As a result, you will be better prepared to deal classroom situation using modern teaching strategies integrated with subject knowledge.

Our vision

Our common goal is to improve the quality of teaching in schools all over Sindh. We want students to become active and collaborative learners, problem solvers, and critical thinkers who approach tasks with creativity and confidence. They are conceptually clear about the subject content and have the skills to link this content with the world around them. To make this possible, we, as teachers, must be better prepared for the classroom demands in pedagogy and the subject content. Moreover, we aim to professionalize these trainings so that the CPD teacher training courses make an impact and substantially change student performance.

Our Teaching Philosophy

The CPD training sessions, including this training, follow a participatory teaching philosophy that engages teachers to apply and practice active and collaborative learning, as well as engage in self and peer reflection to become community of practice. The objective is not only to improve the teaching practices but to help you understand the theory of the subject content and the strategies that help students apply the content in daily life with confidence and mastery.
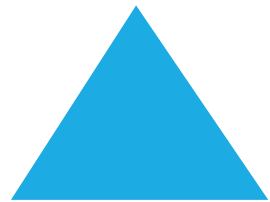
Supporting You

The training module is designed to support you in your classroom teaching. It will introduce you to the subject content and some approaches for use in the classroom. This will make your teaching more manageable and help you grow as a skillful teacher.

Acknowledgement

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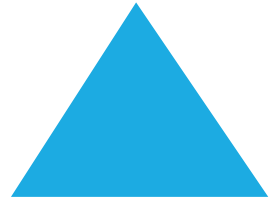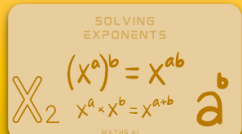
Learning Objectives: By the end of the session, the teachers will be able to:
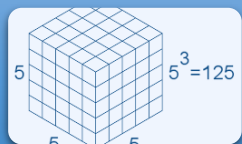
5^3 exponent base — Identify base, exponent and value

$3 = 4 \times 4 \times x$ exponent or power, base — Derive laws of exponents

SOLVING EXPONENTS $(x^a)^b = x^{ab}$ $x^a \times x^b = x^{a+b}$ X_2 a^b MATHS AI — Simplify and compute the values of expressions with exponents by using laws of exponent.

$5^3 = 125$ — Explain and use exponents in real life problems

120 mins

Session Plan

Instructional strategies/activities

Time	Objective/purpose of the activity	Activities/learning experiences	Materials/resources
30 mins	**Activity 1:** **Exponential Growth- Paper Folding Activity**	- Ask teachers to take A4 size paper. - Instructions for Paper Folding Activity Step-by-Step Process: **First Fold:** • Take the sheet of A4 paper and fold it vertically to make it two equal parts. • Open the folded paper and lay it flat. • Count the number of regions created by the first fold. • Record this number in the designated table in Handout-15.1 under the "First Fold" column. **Second Fold:** • Now, fold the paper in half again, but this time in the opposite direction (if the first fold was vertical, make this fold horizontal, or vice versa). • Open the folded paper and lay it flat once more.	A-4 paper Handout-15.1A

- Count the number of regions created by this second fold.
- Record this new number in the same table in Handout 15.1A under the "Second Fold" column.

Note: Ensure each fold is neat and precise to accurately count the regions.

If you have any questions or need clarification, please ask your instructor before proceeding.

- Ask the teachers the following questions to reflect on the activity and connect it with the concept of exponents:

1) What would happen if you folded the paper into thirds, fourths, fifths, etc.? Ask them to complete the table based on continuing the paper folding activity
2) What generalizations can be made based on entries in the table?

- Collect random responses and connect the activity with exponents such as folding the paper multiple times and increasing the number of regions, which are related to the concept of exponents such as

Number of regions/rectangles=$2^{\text{Number of folds}}$

Facilitator will help teachers to read exponents with its base as

EXPONENT

5^4
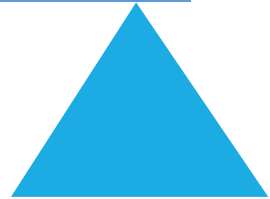
BASE

- The number 5 is the base, while the number 4 is the exponent or power.
- Ask teachers to do the activity given in handout-15.1B

		Activity 2: **Exploring Exponential and Expanded Forms for laws of exponents**	**Product Laws of Exponents:** In this section, we will explore two different cases of the generalized form of multiplying two exponents. (a) When two exponents with same bases but different powers are multiplied. For example ……., (see handout 15.2A) (b) When two exponents with different bases but same powers are multiplied. Let's explore Product Laws of Exponents using the Handouts 15.2A and 15.2B Read thoroughly the first row of the Handout 15.2A and then complete the remaining rows of the Handout 15.2A. Generalized form of the Product law of Exponent when bases are the same but exponents are different is: $$a^m \times a^n = a^{m+n}$$ Similarly complete the Handout 15.2B	Handout 15.2A Handout 15.2B Handout 15.2C Handout 15.2D Handout 15.23
🕐 40 mins				

Generalized form of the Product law of Exponent when bases are different but exponents are same is:

$$a^m \times b^m = (ab)^m$$

Quotient Laws of Exponents:

Now we explore the generalized form of Laws of Quotients

    (a) When two exponents with same bases but different powers are divided,

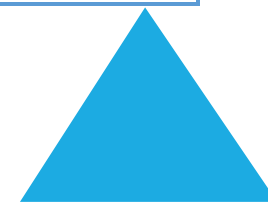   (b) When two exponents with different bases but same powers are divided.

Let's explore Quotient Laws of Exponents by using the Handouts 15.2C and 15.2D

Read thoroughly the first row of the Handout 15.2C and then complete the remaining rows of the Handout 15.2C.

Generalized form of the Quotient law of Exponent when bases are the same but exponents are different is:
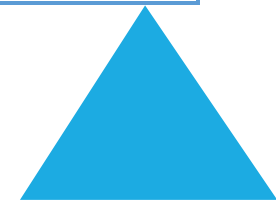
$$a^m \div a^n = a^{m-n}$$

Similarly complete the Handout 15.2D

Generalized form of the Quotient law of Exponent

when bases are different but exponents are same is:

$$a^m \div b^m = (a/b)^m$$

The Power Law of Exponents.

Now, let's explore the generalized form of the power law of exponents by using the Handouts 15.2E. Read thoroughly the first row of the Handout 15.2E and then complete the remaining rows of the Handout 15.2E.

The generalized form of the **power law** is

$$(a^m)^n = a^{mn}$$

At the end of the activity, ask teachers to briefly reflect on the activities they have just completed. Ask teachers for any questions or ambiguities they have in understanding laws of exponents. Then the facilitator will sum up the activity by providing feedback.

		Activity 3:	**Activity 3A:** - Ask teachers "Where do you see numbers written in exponential form?" - Collect random responses and conclude the activity by discussing the	https://passyworldofmathematics.com/exponents-in-the-real-world/

**35 mins**

key information shared in the website.

Activity 3B:

- Divide teachers into four equal groups

- Give the following application problems to the teachers to solve within their respective groups.

1. Find the area of the rectangle with a length of $2m^3$ and a width of $7x^3m^5$

2. Find the volume of cube with side measures of $-9kx^3$

3. The total number of bacteria on a door handle is given by the expression $3b^5$ where b is the number of bacteria on your hand when you touched the door handle. If you had 9 bacteria on your hand when you touched the door handle, how many total bacteria are on the door handle?

4. When a caterpillar larvae hatches, it weighs only 10^{-2} grams. However, each day it is able to eat 10^4 times its body weight. How many grams of food can the larvae eat each day?

5. Ajmal has to wrap two gifts. He gets two boxes for the gifts. The smaller box has all edges equal to 30 cm, and the larger box has all edges equal to 45 cm. Write a numerical expression with exponents that describes how much more volume the larger box

		has. - Call two volunteers from each group to present any one of the problems and discuss its solution with the whole class - Give feedback and address the challenges teachers faced during the solution of the above problems.	

15 mins	**Activity 5:**
	Assessment
		-Teachers will be asked to complete the assessment related to the learning cycle.
		
		1. Simplify $(x^2 \cdot x^3)^2$
		
		   A) x^{10}
		
		   B) x^7
		
		   C) x^{12}
		
		2. Simplify $(3x^3)(3x^4)(-3x^2)$
		
		   A) $-27x^9$
		
		   B) $27x^9$
		
		   C) $-27x^{24}$
		
		3. A certain type of bacteria doubles every hour. If you start with 1 bacterium,
		
		    how many bacteria will there be after 6 hours?
		
		4. The population of a small town is growing exponentially. If the population is 5^3 today, and it triples every year, what will the	

		population be in 2 years? 5. The side length of a cube is doubled. How does the volume of the cube change?	
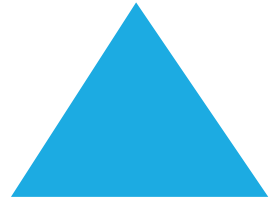
Paper Folding Activity

Instructions: Complete the table using paper folding.

| No of folds	No of regions/rectangles
0	1
1st	
2nd	
3rd	
4th	
5th	
6th	
.	
.	
.	
.	
N	
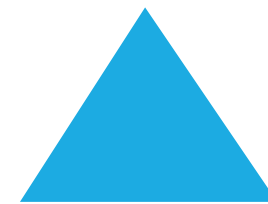
Instructions: Complete the given table to explore exponential and expanded form

Product Law of Exponent (Case a)

1. Product Law of Exponents (When the bases are same)

Task	Expanded Form	Exponential Form
$2^2 \times 2^4$	$2 \times 2 \times 2 \times 2 \times 2 \times 2$	2^6
$4^3 \times 4^4$		
$5^2 \times 5^5$		
$6^3 \times 6^3$		
$5^4 \times 5^4$		
$4^5 \times 4^4$		
--		
$a^m \times a^n$		

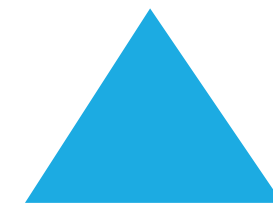When bases are the same but exponents are different, then **product law** is: $a^m \times a^n = a^{m+n}$
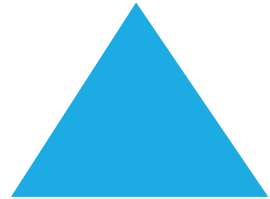
Product Law of Exponent (Case b)

2. Product Law of Exponents (When the bases are different)

Task	Expanded Form	Exponential Form
$3^2 \times 4^2$	$3 \times 3 \times 4 \times 4 = (3 \times 4)(3 \times 4)$	$(3 \times 4)^2$
$4^3 \times 6^3$		
$5^5 \times 4^5$		
$4^3 \times 7^3$		
$2^4 \times 5^4$		
$3^5 \times 5^5$		
--		
$a^m \times b^m$		

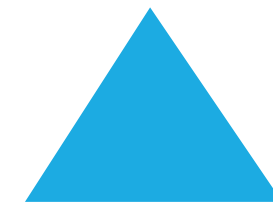When bases are different but exponents are same, then product law is: $a^m \times b^m = (ab)^m$

Quotient Law of Exponent (Case a)

3. Quotient Law of Exponents (When the bases are same)

Task	Expanded Form	Exponential Form
$3^4 \div 3^2$	$(3 \times 3 \times 3 \times 3) \div (3 \times 3)$	3^2
$2^5 \div 2^3$		
$5^5 \div 5^3$		
$4^6 \div 4^3$		
$6^4 \div 6^4$		
$7^4 \div 7$		
--		
$a^m \div a^n$		

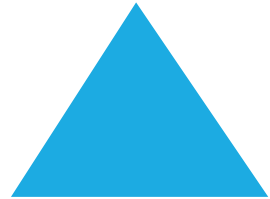When bases are the same, but the exponents are different, then **quotient law** is: $a^m \div a^n = a^{m-n}$

Quotient Law of Exponent (Case b)

4. Quotient Law of Exponents (When the bases are different)

Task	Expanded Form	Exponential Form
$3^3 \div 4^3$	$(3 \times 3 \times 3) \div (4 \times 4 \times 4)$	$(3/4)^3$
$4^5 \div 6^5$		
$5^4 \div 4^4$		
$4^2 \div 5^2$		
$2^3 \div 5^3$		
$3^5 \div 5^5$		
--		
$a^m \div b^m$		

When bases are different but the exponents are different, then **quotient law** is: $a^m \div b^m = (a/b)^m$

Power Law of Exponent (Case a)

5.   Power Law of Exponents

Task	Expanded Form	Exponential Form
$(3^3)^2$	$(3^3) \times (3^3)$	3^6
$(4^2)^4$		
$(6^4)^3$		
$(2^2)^2$		
$(3^3)^3$		
$(5^5)^2$		
--		
$(a^m)^n$		

The **power law** is: $(a^m)^n = a^{mn}$
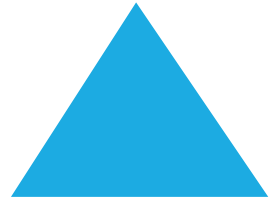
For reference:

List of 1-20 LCs topics

Learning Cycles (LCs)	Topics
LC-1	Developing Number Sense
LC-2	Fractions
LC-3	Decimal and Percentage
LC-4	Ratio and Proportion
LC-5	Introduction to Algebra
LC-6	Algebraic Identities
LC-7	Angle and its Constructions
LC-8	Area and Perimeter
LC-9	Three Dimensional Shapes
LC-10	Information Handling
LC-11	Place Value
LC-12	Highest Common Factor (HCF) and Least Common Multiple (LCM)
LC-13	Fraction Addition and Subtraction
LC-14	Fraction Multiplication
LC-15	**Laws of Exponents**
LC-16	Square Roots
LC-17	Simultaneous Linear Equations
LC-18	Unit Conversion
LC-19	Pythagoras Theorem
LC-20	Construction of Different Types of Triangles
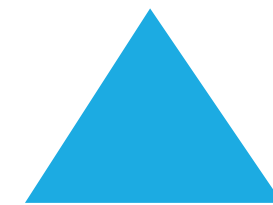
For reference:

List of Resource Items for LCs (11-20)

Items	No. of items	LC-11	LC-12	LC-13	LC-14	LC-15	LC-16	LC-17	LC-18	LC-19	LC-20
Dice	8	✓							✓		
Pair of scissors	8	✓	✓								
Paper Plate	18		✓								
Red beans	½ kg	✓	✓								
Counters (Red/Black)	10								✓		
Counters (Blue/White)	10								✓		
Color pencil box	4			✓	✓						
Measuring tape	8								✓		
Geometry Box	8									✓	✓
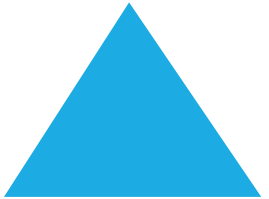
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