Mathematics

Planning Guide

Grade 9

Exponents

Number

Specific Outcomes 1 and 2

This Planning Guide can be accessed online at:
http://www.learnalberta.ca/content/mepg9/html/pg9_exponents/index.html

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Planning Guide: *Grade 9 Exponents*

Strand: Number
Specific Outcomes: 1 and 2

This *Planning Guide* addresses the following outcomes from the program of studies:

Strand: Number	
Specific Outcomes:	1. Demonstrate an understanding of powers with integral bases (excluding base 0) and whole number exponents by: • representing repeated multiplication, using powers • using patterns to show that a power with an exponent of zero is equal to one • solving problems involving powers. 2. Demonstrate an understanding of operations on powers with integral bases (excluding base 0) and whole number exponents: • $(a^m)(a^n)=a^{m+n}$ • $a^m \div a^n = a^{m-n}$, $m > n$ • $(a^m)^n = a^{mn}$ • $(ab)^m = a^m b^m$ • $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}, b \neq 0$

Curriculum Focus

This sample targets the following changes to the curriculum:

- There is a change from integral exponents in the previous program of studies to whole number exponents in the revised program of studies, so students are no longer working with negative exponents in Grade 9.
- This outcome has an increased focus on connections, communication and technology.

What Is a Planning Guide?

Planning Guides are a tool for teachers to use in designing instruction and assessment that focuses on developing and deepening students' understanding of mathematical concepts. This tool is based on the process outlined in *Understanding by Design* by Grant Wiggins and Jay McTighe.

Planning Steps

The following steps will help you through the Planning Guide:

Step 1: Identify Outcomes to Address

Guiding Questions

- What do I want my students to learn?
- What can my students currently understand and do?
- What do I want my students to understand and be able to do based on the Big Ideas and specific outcomes in the program of studies?

Big Ideas

- Exponential notation, which is a way to represent very large or very small numbers and to show repeated products (Van de Walle 2001, p. 453).
- Exponents that can be represented in a variety of ways including standard and expanded forms as well as forms that are specific when using technology.
- Operations on exponents, which are subject to conventions that are connected to the order of operations.

Sequence of Outcomes from the Program of Studies

See http://www.education.alberta.ca/teachers/program/math/educator/progstudy.aspx for the complete program of studies.

Grade 8	Grade 9	Grade 10
Number	**Number**	**Algebra and Number**
Specific Outcomes	**Specific Outcomes**	**Specific Outcomes**
	1. Demonstrate an understanding of powers with integral bases (excluding base 0) and whole number exponents by: • representing repeated multiplication, using powers • using patterns to show that a power with an exponent of zero is equal to one • solving problems involving powers. 2. Demonstrate an understanding of operations on powers with integral bases (excluding base 0) and whole number exponents: • $(a^m)(a^n) = a^{m+n}$ • $a^m \div a^n = a^{m-n}$, $m > n$ • $(a^m)^n = a^{mn}$ • $(ab)^m = a^m b^m$ • $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n} \cdot b \neq 0.$	3. Demonstrate an understanding of powers with integral and rational exponents.

Step 2: Determine Evidence of Student Learning

Guiding Questions

- What evidence will I look for to know that learning has occurred?
- What should students demonstrate to show their understanding of the mathematical concepts, skills and Big Ideas?

Using Achievement Indicators

As you begin planning lessons and learning activities, keep in mind ongoing ways to monitor and assess student learning. One starting point for this planning is to consider the achievement indicators listed in *The Alberta K–9 Mathematics Program of Studies with Achievement Indicators*. You may also generate your own indicators and use them to guide your observation of the students.

The following indicators may be used to determine whether or not students have met specific outcomes 1 and 2. Can students:

- demonstrate the differences between the exponent and the base by building models of a given power, such as 2^3 and 3^2?
- explain, using repeated multiplication, the difference between two given powers in which the exponent and base are interchanged; e.g., 10^3 and 3^{10}?
- express a given power as a repeated multiplication?
- express a given repeated multiplication as a power?
- explain the role of parentheses in powers by evaluating a given set of powers; e.g., $(-2)^4$, (-2^4) and -2^4?
- demonstrate, using patterns, that a^0 is equal to 1 for a given value of a ($a \neq 0$)?
- evaluate powers with integral bases (excluding base 0) and whole number exponents?
- explain, using examples, the exponent laws of powers with integral bases (excluding base 0) and whole number exponents?
- evaluate a given expression by applying the exponent laws?
- determine the sum of two given powers, e.g., $5^2 + 5^3$, and record the process?
- determine the difference of two given powers, e.g., $4^3 - 4^2$, and record the process?
- identify the error(s) in a given simplification of an expression involving powers?

Sample behaviours to look for related to these indicators are suggested for some of the activities listed in **Step 3, Section C: Choosing Learning Activities** (p. 9).

Step 3: Plan for Instruction

Guiding Questions

- What learning opportunities and experiences should I provide to promote learning of the outcomes and permit students to demonstrate their learning?
- What teaching strategies and resources should I use?
- How will I meet the diverse learning needs of my students?

A. Assessing Prior Knowledge and Skills

Before introducing new material, consider ways to assess and build on students' knowledge and skills related to patterns. For example:

- Ask students to draw a variety of squares on graph paper and ask them to label the area and side lengths on the squares. Ask them how these measures relate to the concepts of square and square roots.
- Use achievement indicators from prior grades to determine student readiness. Allow students to use calculators and graph paper to demonstrate multiple solutions.

If a student appears to have difficulties with these tasks, consider further individual assessment, such as a structured interview, to determine the student's level of skill and understanding. See the **Sample Structured Interview: Assessing Prior Knowledge and Skills** (p. 8).

Sample Structured Interview: Assessing Prior Knowledge and Skills

<table>
<tr><td rowspan="2">Directions</td><td colspan="2">Date:</td></tr>
<tr><td>Not quite there</td><td>Ready to apply</td></tr>
<tr><td>Ask the student to represent the following in at least two ways:

2^2, 3^2, 4^2 and 5^2.</td><td>The student is unable to state that each expression means the base multiplied by itself.

The student makes errors like $3^2 = 6$, $4^2 = 8$ and $5^2 = 10$.

The student cannot translate the numerical expressions into a diagram.</td><td>The student is able to state that a square is a number multiplied by itself and can expand each expression.

The student can provide standard solutions like 4, 9, 16 and 25.

The student is able to represent each value as a square on graph paper.</td></tr>
<tr><td>Ask the student to indicate if the following values have a whole number square root (principal square root) and, if so, what the solution is:

12
16
20
24
25
30
36.</td><td>The student does not correctly identify the answer of 16, 25 and 36.

The student incorrectly identifies the square roots of some of the numbers as half of the number; e.g., the square root of 12 is 6 or the square root of 16 is 8.</td><td>The student is able to identify 16, 25 and 36 as having whole number square roots of 4, 5 and 6.</td></tr>
<tr><td>Ask the student to find the approximate square root to the following numbers:

8
15
24.</td><td>The student is unable to identify perfect squares like 9, 16 and 25 to help find an answer.

The student may divide the numbers in half stating answers like 4, 7.5 and 12 as square roots.</td><td>The student is able to approximate a value by using benchmarks like 9, 16 and 25.

The student is able to use "guess and check" to try different numbers multiplied by themselves to arrive at solutions.</td></tr>
</table>

B. Choosing Instructional Strategies

Consider the following guidelines for teaching patterns in Grade 9.

- Students should be engaged in conversations and discussion of open-ended questions to build confidence and competence with mathematics.
- When students are given opportunities to communicate their thinking (either orally or in writing), explain their reasoning and listen to the strategies used by other students, there are more opportunities to deepen their understanding.
- Have students model patterns using hands-on materials or drawings to help them understand the connections between different representations.

C. Choosing Learning Activities

The following learning activities are examples of activities that could be used to develop student understanding of the concepts identified in Step 1.

Sample Activities:

Sample Activity 1: Building Student Understanding of Mathematics Language

Determining student understanding of important terms used in this unit will help you assess prior knowledge and understanding.

1. Ask students to work with a partner to write a definition for *base, exponent* and *power*. Encourage them to represent their definitions with examples, pictures and manipulatives.

Sample Solution:

Power 2^3: The entire expression represents the power. This power can be represented by expanding the power to $2 \times 2 \times 2 = 8$ or can be shown as a cube that measures two units in length by two units in width by two units in height. Having students build the 3-D representations with interlocking tiles often helps them make the connection between the term *cubed* and the *representation with a cube.*

Look For …

Do students:

- ☐ read 5^3 as 5 to the power 3 rather than exponent 3 (they may not understand that a power refers to the entire expression)?
- ☐ calculate a power by multiplying the base and exponent $2^3 \neq 6$?

2. Have students compare the term *cubed* to the term *squared* and ask them how they would show the difference between 3^2 and 3^3.

Sample Solution:

If the term *cubed* can be shown on a cube that measures 3 cm by 3 cm by 3 cm, then 3 *squared* can be represented on graph paper or by drawing a square that measures 3 cm by 3 cm.

Sample Activity 2: Open-ended Questions and Starters

Open-ended questions and starters help build a culture of discussing, listening, sharing and questioning. Developing a community of respectful inquiry where students are encouraged to formulate and critique explanations is important in building thinking skills and understanding concepts. It is important that the teacher listens and probes through further questioning to facilitate students' expression of thinking.

Look For …

Do students:

- ☐ write the exponent as 2 rather than the base when asked to write number as a power of 2? [The expression 4^2 is a power of 4. It is critical to emphasize the exponent is not the power.]

Using calculators, have students explore the patterns for powers that have a base from 1 through 10 and an exponent value from 1 through 7. Have students explore and compare the key sequences on different calculators for entering n^m.

Provide a graphic organizer like the one below:

Power / Exponent	1^n	2^n	3^n	4^n	5^n	6^n	7^n	8^n	9^n	10^n
1	1	2	3							
2	1	4	9							
3	1	8	27							
4	1	16								
5	1	32								
6	1	64								
7	1	128								

- What patterns do you see on the chart?
- How do different calculators display answers for very large numbers? What does the display mean?
- What are the similarities and differences between 2^3 and 2(3)? Show your answer in more than one way.
- What are the similarities and differences between 2^3 and 3^2? Show your answer in more than one way.
- What are the similarities and differences between 5^3 and 3^5? Show your answer in more than one way.
- What are the similarities and differences between 10^2 and 2^{10}? Show your answer in more than one way.
- Can a number be both a power of 4 and a power of 2? Show your answer in more than one way. Find other instances in the chart where the value of a power are equal.

For the first three starters, you may want to put students in groups of two or three and provide larger size paper, such as chart paper or 11" by 17" paper, so that, when students share, their solutions are easy for the rest of the class to see. If students cannot think of first or second representations, then suggest that they consider expanding the number and/or using a diagram, calculator, interlocking cubes and/or tiles.

Sample Activity 3: The Negative Sign

Students often have difficulty with negative values and coefficients when solving expressions with exponents. Have them explore the following example.

Solve the following: What are the similarities and differences between the expressions shown in a) and in b)? Ask students what the negative sign in front of the expression means. You may need to explain that the negative sign is the same as multiplying by –1 and show several examples. Students are often unsure of what to apply the exponent to in the given expressions. This investigation should begin to clarify some of the differences that they will encounter.

> **Look For …**
> Do students:
> ☐ have trouble determining if the base is a negative value or if the power is negative? [The base is the quantity immediately to the left of the exponent.]

a. -2^3, $(-2)^3$, $-(2^3)$, (-2^3)
b. -2^4, $(-2)^4$, $-(2^4)$, (-2^4)

If students are unable to begin or show their solution, suggest that they use a graphic organizer such as the one below. Sample solutions might include:

Expression	Expanded Form	Answer
$\mathbf{-2^3}$	(–1)(2)(2)(2)	–8
$\mathbf{(-2)^3}$	(–2)(–2)(–2)	–8
$\mathbf{-(2^3)}$	– ((2)(2)(2))	–8
$\mathbf{(-2^3)}$	((–1)(2)(2)(2))	–8
$\mathbf{-2^4}$	(–1)(2)(2)(2)(2)	–16
$\mathbf{(-2)^4}$	(–2)(–2)(–2)(–2)	16 or +16
$\mathbf{-(2^4)}$	–((2)(2)(2)(2))	–16
$\mathbf{(-2^4)}$	((–1)(2)(2)(2)(2))	–16

There is often more than one way to represent a solution and different perspectives are shown in the graphic organizer above. Students may suggest other methods that may or may not be correct and it is important to have discussions to deepen understanding and aid students in moving from simply memorizing a rule (that is often easily forgotten or confused) to having a strategy for finding the solution.

Although using the expanded form may not be as efficient as using a rule, this process helps students arrive at a correct answer using a process. This process should help students develop a rule that makes sense to them. In addition, if they forget the rule, they can go back to the process to help them recall and prove the shortcut.

Sample Activity 4: Using Order of Operations to Solve Expressions

Put students in pairs. Have one person from each pair solve questions from Column A and then have the second person solve Column B. Ask students to verify the solution to their partner's answers and then try their questions. Have students discuss what the differences are between the questions and answers in Column A and Column B. Have students solve expressions like the ones below:

Look For …

Do students:

- ☐ raise the coefficient in algebraic terms to the exponent? [Must reinforce the concept of what the base is in an exponential expression $(4x)^2$ $= (4x)\,(4x) = 16x^2$ $4x^2 = 4(x)(x)$.]
- ☐ remember the order of operations?

Column A	Column B
$3^2 + (-2)^3 + 5^2 =$	$-3^2 + (-2)^3 + 5^2 =$
$5^3 + -2^3 - 3^2 =$	$-5^3 + -2^3 - (-3^2) =$
$4^3 - (-2)^3 =$	$(-4^3) - (-2)^3 =$
$4x^2 - 3x,\ x = 5$	$4x^2 - 3x,\ \ x = -5$
$(6^2 + 2^6)^2 =$	$(-6^2 + 2^6)^2 =$

Sample Activity 5: Product of Powers and Quotient of Powers

Put students in pairs. Have one person from each pair solve the questions from Column A and have the second person solve Column B. Ask students to verify the solution to their partner's answers and then try their questions. Have students discuss what the differences in their strategies are for solving questions in Column A and Column B. Have students solve expressions like the ones below:

> **Look For …**
> Do students:
> ☐ attempt to create a simplified power form when the quantities have different bases?

Column A	Expanded Form	Power Form	Standard Form (Answer)
$2^4 \times 2^3 =$			
$3^4 \times 2^3 =$			
$5^4 \times 5^2 =$			
$-3^4 \times -3^2 =$			
$-3^4 \times -5^2 =$			
$2^5 \times 2^3 \div 2^2 =$			

Column B	Expanded Form	Power Form	Standard Form (Answer)
$2^4 \div 2^3 =$			
$3^4 \div 2^3 =$			
$5^4 \div 5^2 =$			
$-3^4 \div -3^2 =$			
$-3^4 \div -5^2 =$			
$-2^5 \times -2^3 \div -2^2 =$			

The questions in Column A and Column B are the same, with the exception of the operation sign. Ask questions to help students understand that the base must be the same to apply power laws. If the bases are different, the order of operations applies.

Ask students to generalize their findings into the Product Law of Powers ($n^a \times n^b = n^{a+b}$) and Quotient Law of Powers ($n^a \div n^b = n^{a-b}$) by posing the following question: *"What shortcuts or rules could you use in the examples above to save time in solving these questions?"*

Sample Activity 6: Zero as an Exponent

Students should have familiarity with using the Quotient Law when exploring the Zero Property for Exponents. Ask students to evaluate or solve the following expressions:

- 10^0
- 2^0
- 5^0
- 12^0
- x^0
- y^0.

If they know that all of the values below are equal to 1, ask them to show how they can prove their answer.

If students are having difficulty proving their answers, suggest that they look at using a pattern like $10^3 =$ ___, $10^2 =$ ___, $10^1 =$ ___, $10^0 =$ ___.

Students may still give an incorrect value such as zero rather than the correct value of 1, so using the Quotient Law is another way to help students use a process rather than a rule to deepen understanding.

Look For …
Do students:
☐ calculate single terms raised to the exponent zero equal zero because they cannot write an expanded form? [Patterns and division of a value by itself must be used to develop understanding of the zero property.]

Expanding a question and then applying the Quotient Law will tell students that the answer is x^0, so, in addition, have them expand the numerator and denominator and then divide by common factors to show that the answer is 1.

- $\frac{10^3}{10^3} = 10^{3-3} = 10^0$, better to go $\frac{10\times10\times10}{10\times10\times10}$.

Sample Activity 7: Power of a Power

If students demonstrate that they can explain differences between the exponent laws, they will be more likely to remember the process rather than memorizing rules. Comparing and contrasting is an excellent strategy for connecting new information to prior learning.

Ask students to compare and contrast the following questions. Encourage them to use a variety of representations to demonstrate their solution.

- $2^4 \times 2^3 =$ and $(2^4)^3 =$
- $5^3 \times 5^2 =$ and $(5^3)^2 =$

Sample Solution:

Expression	**Expanded Form**	**Power Form**	**Standard Form (Answer)**
$2^4 \times 2^3 =$	$2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$	2^7	128
$(2^4)^3 =$	$(2 \times 2 \times 2 \times 2) \times (2 \times 2 \times 2 \times 2) \times (2 \times 2 \times 2 \times 2)$	$2^4 \times 2^4 \times 2^4 = 2^{12}$	4096
$5^3 \times 5^2 =$	$5 \times 5 \times 5 \times 5 \times 5$	5^5	3125
$(5^4)^2 =$	$(5 \times 5 \times 5 \times 5) \times (5 \times 5 \times 5 \times 5)$	$5^4 \times 5^4 = 5^8$	390 625

Sample Activity 8: Power Two-ways
(Wheatley and Abshire 2002)

Two-ways are a puzzle type activity and provide practice in a way that allows students to use a variety of strategies to solve for the missing values. Horizontal rows have a product that is displayed in the far right column. Column products are recorded in the bottom row. Students need to apply both addition and subtraction strategies to solve these type of problems.

×

2^2		2^3
	2^3	
2^5		

×

b^3		
	b	b^3
		b^{10}

Adapted from G. H. Wheatley and G. E. Abshire. *Developing Mathematical Fluency: Activities for Grades 5–8* (Tallahassee, FL: Mathematics Learning.org). Copyright © 2002.

Sample Activity 9: Power of a Product and Power of a Quotient

Ask students to solve the following questions and then compare and contrast the solutions:

- $(2 \times 5)^3$ and $(2^3 \times 5^3)$
- $(8 \div 2)^3$ and $(8^3 \div 2^3)$
- $(2^2 \times 5^3)^3$ and $(2^2)^3 \times (5^3)^3$.

Look For …

Do students:

- ☐ ignore the order of operations?
- ☐ try to combine terms with different bases?

Sample Activity 10: Variables as Exponents

To further reinforce exponent laws, ask students to solve for *n* in each of the expressions below:

- $5^n \times 5^6 = 5^{12}$
- $4^6 = (4^n)^3$
- $2^n \div 2^6 = 2^2$.

Look For …

Do students:

- ☐ create simple equations to help them find the unknown value?

Step 4: Assess Student Learning

Guiding Questions

- Look back at what you determined as acceptable evidence in Step 2.
- What are the most appropriate methods and activities for assessing student learning?
- How will I align my assessment strategies with my teaching strategies?

In addition to ongoing assessment throughout the lessons, consider the following sample activities to evaluate students' learning at key milestones. Suggestions are given for assessing all students as a class or in groups, individual students in need of further evaluation, and individuals or groups of students in a variety of contexts.

A. Whole Class/Group Assessment

Grading is not essential in teaching and learning and may inhibit learning (Black & Wiliam 1998). Formative assessment or assessment for learning focuses on student learning and understanding during the instruction process and occurs naturally in learning activities. Formative assessment does not require grading; instead, it helps teachers better understand student thinking and determine the:

- ways in which a student understands
- degree to which a student understands a mathematics problem or concept.

A research study conducted by Ruth Butler* (1988) examined the results of three different means of providing feedback to students about their work. The table below summarizes the feedback method and results:

Feedback Method	Gain in Student Achievement	Impact on Student Interest
Comments only	30%	1. all positive
Grades only	no gain	1. positive for top students only 2. negative for lower students
Combination of comments and grades	no gain	1. positive for top students only 2. negative for lower students

As summarized by Black and Wiliam; *Butler, R. "Enhancing and Undermining Intrinsic Motivation." *British Journal of Educational Psychology* 58 (1988): 1–14. (Alberta Assessment Consortium: http://www.aac.ab.ca)

Teachers should consider the following questions when looking to increase the use of formative assessment:

- Do my assessment strategies and tools promote student learning?
- Are my assessment strategies and tools adaptable to diverse student needs?
- Do I use information from my assessments to adjust instruction for individual students and for the class?

The following section suggests ideas for engaging students in assessments that may improve understanding, learning and student participation.

Partner Practice and Quizzes
Consider using a process like the one below to help students see quizzes and tests as opportunities to improve their learning.

- Provide students with the activities or questions that are similar to ones that will appear on the quiz and discuss an outline of the types of questions they may see on the quiz.
- Have students write the quiz individually or in partners.
- Mark the quiz with check marks for correct answers and circle incorrect responses. Do not put a grade or mark on the quiz.
- Return the quiz. Students go over their quiz and work with a partner or group to correct their errors.
- Circulate among the groups and ask questions to clarify student understanding. Ask students to resubmit their quiz.
- If the quiz is formative, readjust and report the mark to the student. If the quiz is summative, release the mark to the student.
- Use the data from the group discussions and quiz to identify students who need extra assistance or practice.

Feedback and Grading
Research from Black & Wiliam (1998) found that specific descriptive feedback enhances learning. This research found that when students are given feedback with a grade, they looked for the grade and left the feedback unread. Providing feedback without a grade encourages students to address the comments.

Provide an exit question during the last five to 19 minutes of a class period and assess student responses by making comments about their responses. These comments should be specific and targeted at improving student performance on the particular task. For sample activities 1 through 5, use the last five minutes of the period for students to summarize their learning by responding to the following:

- using the terms *base*, *exponent* and *power*, explain the differences between a number that is squared and a number that is cubed
- evaluate -5^4 and $(-5)^4$; explain your solution
- explain how adding a negative sign or brackets can change the value of $3 + 4^2$.

These exit questions will provide accurate information about a student's understanding of the day's work and give the teacher an opportunity to review or provide an opening question the next day to clarify misunderstandings.

Open-ended Problems or Questions
Use of open-ended problems helps students move away from memorization-based drill and practice toward developing strategies for solving problems in non-routine manners. This process often presents a struggle for both students and teachers, but with persistence, students often develop enough confidence so that they do not want to be told the steps or the rules. Developing a culture of open discussion and risk taking is important for both teachers and students as they begin to solve open-ended questions. Use of starter activities is an effective way to help teachers focus on observing student conversations, pose appropriate questions to help students move forward in their thinking and listen to student explanations and viewpoints. For example:

- What would you say when you are explaining the easiest method for remembering how to multiply powers and divide powers?
- What makes a solution efficient? Are some of our solutions more efficient than others?
- Can you classify your solutions into categories or types of strategies?
- Can you make up a similar problem to solve?

Checklists
Consider using a checklist of student names and indicators that you may be looking for during an activity. For the sample activities, you may want to develop a specific checklist or use the generic one shown below:
Yes (✓) or Not Yet (×)

Student name	Communicates with group or makes suggestions about the solution	Justifies solution and can show process and result	Contributes alternate solutions or strategies	Understands the concept

Student Self-assessment Rating Scale
Student self-assessment can be one of the most effective assessment strategies. The most effective methods of self-assessment involve four stages:

1. Students and the teacher negotiate and co-create the criteria for assessing the work.
2. The teacher assists students in defining levels of performance through the development of a rubric or rating scale.
3. The teacher coaches students in applying the measures.
4. The teacher provides specific feedback to students about their self-assessment.

Consider using descriptors instead of a numerical scale. For example:

- novice or not yet there
- proficient or on target
- advanced or above and beyond.

Here is a possible example of a self-assessment that might be developed for sample activities 6 through 9.

Have students select one of the three following categories for each of the criteria and comment on why their learning best fits into that category:

I am able to:	Novice	Proficient	Advanced	Example(s) to show understanding
use order of operations with exponents and powers				
solve power questions that involve multiplication				
show how brackets and a negative sign can change the solution to a power expression				
use the quotient of powers to prove that x^0 is equal to 1				
solve power questions that use quotients				

B. One-on-one Assessment

Error analysis provides questions to students either as quiz, starter or exit questions to see if they are able to articulate errors in questions like the following:

- $3^2 + 2^3 = 6^{2+3} = 6^5$
- $5^3 \times 5^4 = 5^{12}$
- $5^4 - 5^3 = 5$.

Step 5: Follow-up on Assessment

Guiding Questions

- What conclusions can be made from assessment information?
- How effective have instructional approaches been?
- What are the next steps in instruction?

A. Addressing Gaps in Learning

If students are having difficulty solving the basic facts using strategies, consider the following:

- Help students understand the nature of a negative in a power expression by reviewing multiplication by –1.
- Have students outline the power laws on study cards or posters that can be displayed in the classroom.
- Encourage students to expand the questions and use the order of operations if they have difficulty recalling the rules for exponents.

B. Reinforcing and Extending Learning

Students who have achieved or exceeded the outcomes will benefit from ongoing opportunities to apply and extend their learning. These activities should support students in developing a deeper understanding of the concept and should not progress to the outcomes in subsequent grades.

Activity 1
Students can research where and why scientific notation is used. They should explore some of the conventions for writing numbers in scientific notation such a 5.81×10^8 and then translate these values into equivalent expressions like 0.581×10^9 or 58.1×10^7. Students may want to look at how these values are used in astronomy, in chemistry, and in biology for bacteria or population growth.

Activity 2
What are the last two digits of 7^{100}?

This type of question is an extension from Sample Activity 2 and allows students to look at patterns that emerge from evaluating powers.

Activity 3
Extend learning with questions like:

- $n^5 = 248\ 832$
- $(n^3)^2 = 4096$
- $n^7 \div n^2 = 7776$
- $(2^3 \times 2^5)^4$
- $(2^3 \times 2^5)^4 \div (2^2 \times 2^4)^3$.

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