Making Equivalents With Exponent Rules

Teacher		**Class**	Grade 8
Subject	Math	**Topic**	Exponents
Date		**Room**	
Lesson length	60 minutes	**Country**	United States

Students learn product, quotient, power, zero and negative rules. They play a team relay to make equivalent numerical expressions.

Curriculum links

- Know and apply the properties of integer exponents to generate equivalent numerical expressions.

Learning objectives

- Students will rewrite same-base products, quotients and powers as single powers.
- Students will use zero and negative exponents to generate equivalent expressions.

Success criteria

- I can add exponents to multiply same-base powers.
- I can subtract or multiply exponents to divide or power a power.
- I can rewrite zero and negative exponents as 1 or fractions.

What students already know

Ask: What does 2^3 mean? Listen for 2 x 2 x 2 = 8. Ask: Is 2^3 x 2^2 = 2^6? Listen for no.

Key words

base	the number that is multiplied by itself again and again [3]
exponent	the little raised number that shows how many copies to multiply [3]
power	a base raised with a count, like 2^3 which equals 8 [3]
equivalent	different on paper but equal in value
reciprocal	one over a number, like 1 over 2 cubed for 2 to the negative 3 [18]

Materials

- Slides 1, 2, 4, 5, 6, 8, 10, 11 and projector
- Video clip 1 (0:00-4:00) ready on Slide 5
- Relay task cards
- Answer sheets
- Pencils
- Rule strips for support
- Worksheet Task C copies

Before the lesson

- Print relay task cards, one chain per team
- Print answer sheets and rule strips, one per team
- Print Worksheet Task C copies, one per student
- Test Slides 1, 2, 4, 5, 6, 8, 10, 11 and Video clip 1 (0:00-4:00)
- Set up clear lanes to the board and clear aisles and backpacks

Lesson outline

0–7 min **Starter** 7 min · Whole class

Recall what exponents mean and hook students into making equivalent forms.

YOU DO

1. Show Slide 1 title and read the goal: make equivalent expressions with exponent rules.
2. Show Slide 2 question and have students think, then tell a partner what 2^3 means.
3. Expand 2^3 as 2 x 2 x 2, which equals 8 [3], and ask if 2^3 x 2^2 equals 2^6.
4. Introduce the relay challenge to the class.

STUDENTS DO

1. Think what 2^3 means, then tell a partner in 30 seconds.
2. Vote thumbs up or down on whether 2^3 x 2^2 = 2^6 and listen to the expansion.
3. Repeat the relay hook goal back to a partner.

Say: Your team gets points only if every step is equivalent. One sloppy exponent rule and the baton stops. First, prove you know what 2^3 means and why 2^3 times 2^2 is not 2 to the 6th.

Worked example: 2^3 = 2 x 2 x 2 = 8 [3]. 2^3 x 2^2 = (2x2x2) x (2x2) = five 2s = 2^5. An exponent tells how many times you multiply the base [11].

Ask: What does 2^3 mean in expanded form? (2 x 2 x 2, which equals 8) · Why is 2^3 x 2^2 not 2^6? (Count factors: three 2s plus two 2s is five 2s, so 2^5)

Check understanding: Quick show with fingers: hold up 5 for 2^5. If many show 6, re-expand (2x2x2) x (2x2) and count factors together.

Support: Let students write 2 x 2 x 2 on mini whiteboards and count the 2s before answering. **Stretch:** Ask students to predict x^5 times x^3 in expanded form to get x^8 [13].

Use: Slides 1–2

7–20 min **Teaching** 13 min · Whole class

Show why we add, subtract and multiply exponents to make equivalent powers.

YOU DO

1. Show Slide 4 chain and expand 2^3 x 2^2 as (2x2x2) x (2x2) to get 2^5, so add exponents when bases match [6].
2. Show Slide 5 and play Video clip 1, telling students to listen for when to add, when to subtract, and power to a power.
3. Expand x^5 over x^3 and cancel shared factors to leave x squared [8], so for non-zero x subtract exponents [4].
4. Show Slide 6 three moves and add that any non-zero number to the zero power is 1 [3] and x to the negative n equals 1 over x to the n [13].

STUDENTS DO

1. Chant the three moves with the teacher and copy one line for each rule.
2. Talk to a partner to explain one cancellation step in x^5 over x^3.
3. Write 5^4 divided by 5^2 = 5^2 = 25 [18] and check by expansion.

Say: Same base multiply means add the counts. Same base divide means subtract the counts after you cancel. A power raised again means multiply the counts. We fix zero and negatives last.

Worked example: 5^2 x 5^3 divided by 5^4: first use product rule to get 5^5 divided by 5^4, then use quotient rule to get 5^1, which is 5 [18]. Each step is equivalent.

Ask: Why do we add exponents for 2^3 x 2^2? (Three factors plus two factors makes five factors, so 2^5) · Why do we subtract for x^5 over x^3? (Three shared factors cancel, leaving x times x, so x^2) · What does (x^2)^3 equal and why? (x^2 times x^2 times x^2 is six xs, so x^6, multiply 2x3 [6])

Check understanding: Mini whiteboards: write single power for 3^2 x 3^4. Look for 3^6. If split, re-expand and recount.

Support: Project the cancellation with strike-throughs so students see shared factors cancel to leave x times x [8]. **Stretch:** Ask what 5^3 divided by 5^3 gives and how that connects to zero exponent equaling 1 [16].

Use: Slides 4–6, Video clip 1 (0:00–4:00)

20–40 min **Main Activity** 20 min · Groups

Apply two or more rules in teams to generate equivalent numerical expressions.

YOU DO

1. Set clear lanes, hand each team relay task cards, answer sheet, pencils and a rule strip.
2. Model the first card: 5^2 x 5^3 divided by 5^4 becomes 5^5 divided by 5^4, then 5^1, which is 5 [18].
3. Run the relay: one writer at a time, each step must be equivalent, next runner continues.
4. Stop the baton for a non-equivalent step, have the team fix it by expanding, then continue.

STUDENTS DO

1. In teams of 4, take turns to write one equivalent step on the answer sheet.
2. Check each step by asking: same base, correct add, subtract or multiply?
3. Turn in step-by-step sheet showing two equivalent forms for each expression.

Say: Work the chain in order. Show each equivalent form and name the rule. Walk fast, pass the marker hand to hand, and keep every exponent exact so the chain stays equivalent.

Worked example: Card: 5^2 x 5^3 / 5^4 = 5^(2+3) / 5^4 = 5^5 / 5^4 = 5^(5-4) = 5^1 = 5. Later cards mix in zero and negative powers rewritten with positive exponents [6].

Ask: After 5^2 x 5^3, what is the next equivalent single power? (5^5, add 2+3 for same-base multiply) · After 5^5 divided by 5^4, what is the single power and value? (5^1, which is 5, subtract 5-4)

Check understanding: Collect answer sheets after 2 cards and check that both steps are equivalent. If not, send team back to expand factors and recount.

Support: Give each team a rule strip that lists adding exponents when multiplying powers with the same base and subtracting when dividing [18]. **Stretch:** Add a bonus card that requires simplifying 14x^6 divided by x^5 to get 14x [20].

40–52 min **Practice** 12 min · Pairs

Practice writing single-power equivalents and naming the rule used.

YOU DO

1. Show Slide 8 task and read the four problems: 5^3x5^4, 10^7/10^5, (2^3)^2, 3^-2.
2. Model one: 4^2 x 4^1 as 4^(2+1), which is 4^3 [20], and 4^3 divided by 4^1 as 4^(3-1), which is 4^2 [20].
3. Hand out Worksheet Task C and have pairs rewrite each expression with the rules, then find the value.
4. Circulate, ask for rule names, and remind students to finish with positive exponents.

STUDENTS DO

1. Solve the four Slide 8 problems with a partner, writing one equivalent power and rule name.
2. Complete Worksheet Task C: rewrite each expression with the rules, then find the value.
3. Swap papers and check that each step kept the same value.

Say: In pairs, rewrite each expression as one power. Write the rule you used: add, subtract, multiply, zero, or negative flip. Expand if you are stuck.

Worked example: 10^7 / 10^5 = 10^(7-5) = 10^2 = 100. (2^3)^2 = 2^(3x2) = 2^6 = 64. 3^-2 = 1 over 3^2 = 1/9 [16]. Same base divide subtract, power to power multiply.

Ask: What is 5^3 x 5^4 as one power and which rule? (5^7, product rule, add 3+4) · What is 3^-2 as a fraction and why? (1 over 3^2, which equals 1/9, negative means reciprocal [16])

Check understanding: Hinge question on whiteboards: 3^-2 equals what? Look for 1/9. If many write -9 or -6, re-teach flip with 2^-3 = 1/8 [18].

Support: Let students first write expanded multiplication, like 4 x 4 x 4, to count factors before adding or subtracting exponents [21]. **Stretch:** Have students roll or choose a zero or negative exponent and rewrite the result with positive exponents.

Use: Slide 8, Worksheet Task C

52–60 min **Plenary** 8 min · Whole class

Return to objectives and clear up the trickiest exponent rule.

YOU DO

1. Show Slide 10 vote and have students vote which rule trips them up most.
2. Show Slide 11 true or false and work each: 3^4x3^2=3^6 true, (2^3)^2=2^5 false, 7^0=1 true, 4^-1=-4 false.
3. Fix the two false ones: (2^3)^2 = 2^6, multiply 3x2, and 4^-1 = 1 over 4, not -4.
4. Restate success lines and preview exit check.

STUDENTS DO

1. Vote for trickiest rule and explain choice to a neighbor in one sentence.
2. Answer true or false with thumbs and correct the false statements.
3. Say which success line they can now do.

Say: Vote now, then defend your answer. Power to a power needs multiply, not add. Negative exponent needs a flip to a fraction, not a minus sign. Zero power of a non-zero number is 1.

Ask: Is (2^3)^2 = 2^5 true or false, and what is correct? (False, power to power multiply 3x2, so 2^6 = 64) · Is 4^-1 = -4 true or false, and what is correct? (False, flip to 1 over 4, not negative)

Check understanding: Count votes and true-false thumbs. If zero and negative still weak, redo 5^3 divided by 5^3 = 5^0 = 1 [16] on the board.

Support: Give the rule strip again and point to add, subtract, multiply lines while reworking one vote example.
Stretch: Ask students to explain why the class leaves 0 to the zero as undefined for now.

Use: Slides 10–11

Common mistakes

Mistake	How to spot it	How to fix it
Adding exponents when adding powers, like 2^3 + 2^3 = 2^6	Student writes 2^6 for a plus problem	Expand to 8 + 8, which is 16, not 64 [16]. Add means compute values first.
Using rules with different bases, like 3^2 x 4^2 = 12^4	Student multiplies bases and adds or multiplies exponents	Compute 9 x 16, which is 144 [16]. Rules need the same base.
Reading 2^-3 as -8 instead of a fraction	Student keeps a minus sign in the answer	Flip first: 2^-3 = 1 over 2^3 = 1/8 or 0.125 [16]. Negative exponent means reciprocal [16].

Support

- Give each team a rule strip that lists adding exponents when multiplying powers with the same base and subtracting when dividing [18].
- Provide half-filled expansions with blanks for each factor to count total factors [8].
- Let students use calculator tables for powers of 2 to see the divide-by-base pattern to 1.

Stretch

- Add a bonus card that requires simplifying 14x^6 divided by x^5 to get 14x [20].
- Challenge students to expand and simplify 2^4 times 2^3 to get 2^7, which equals 128 [16].
- Ask students to mix rules, like (x^2)^3 times x^4, and show both add and multiply steps.

For the LSE or teaching assistant

Stay with the relay teams that need counting support. Prompt them to expand factors, point to the rule strip, and check each handoff is equivalent.

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Safety

- Clear lanes to the board, walk fast instead of running, and pass the marker hand to hand with no grabbing.

Check for understanding

Question	Answer
Simplify 3^4 x 3^2 as one power.	3^6
Simplify (2^3)^2 as one power and value.	2^6 = 64
Write 4^-1 and 7^0 as values.	1/4 and 1

Homework

Finish Worksheet Task C corrections and write one equivalent form for 10^7/10^5 and 3^-2.

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