GRADES: 8–9
(students in Pre-Algebra or Algebra 1)

Getting Power Through Positive Exponents

OVERVIEW:

This program introduces students to exponents using positive integers and scientific notation; it leads students to discover the rules of using positive exponents; and it illustrates how useful exponents are, especially in computing square and cubic measures and in expressing large numbers using scientific notation.

ITV SERIES:

The Power of Algebra: Program #5: Using Positive Exponents

LEARNING OBJECTIVES:

In this lesson students will:

- ❖ define exponents using positive integers
- ❖ make physical models of numbers raised to thesecond and third powers.
- ❖ write numbers in exponential form and scientific notation
- ❖ evaluate numbers written in exponential form and scientific notation
- ❖ discover and use the rules for multiplying and dividingwith positive exponents
- ❖ appreciate the usefulness of exponents and scientificnotation
- ❖ use calculators to evaluate numbers written inexponential form

MATERIALS:

Student Materials:

(for each group of 2-4 students)

- 1 scientific calculator
- 2-4 sheets of 1 cm graph paper
- 65 snap-together cubes (like multi-link)in a zip-top plastic bag

(for each student)

- 2 sheets of paper
- pencil/penpractice sheet for exponents and scientific notation

Teacher Materials:

- transparent grid paper
- overhead marking pens
- scientific calculator for the overhead projector
- transparencies of the practice sheet
- 9 foam cubes or wooden cubes or cardboard cubes

VOCABULARY:

variable	factor
base	
exponent	square
power	
scientific notation	

PRE-VIEWING ACTIVITIES

Introduce the concept of exponents by discussing the terms “variable” (a symbol that is a placeholder for some numbers) and “factor” (a number of variables that are used in multiplication to yield a product). What does “variable” mean? How have you used variables in mathematics? What do you mean when you say “2 is a factor of 12? How have you used factors in math?

Ask the class to factor 72; continue to breakdown the first set of factors given until you have the prime factors of 36 ($2 \cdot 2 \cdot 3 \cdot 3$). Make observations about the repeated use of 2 and 3 as factors and introduce exponents as a short-hand way to indicate this ($2^2 . 3^2$). Emphasize that the exponent indicates the number of times the base is used as a factor. The video says it’s how

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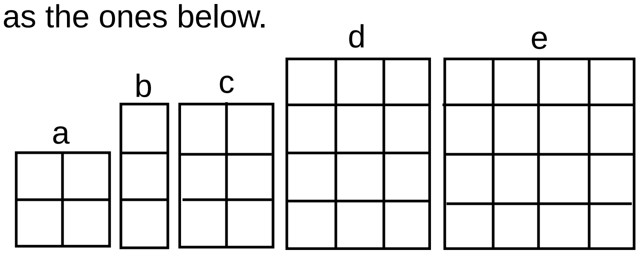
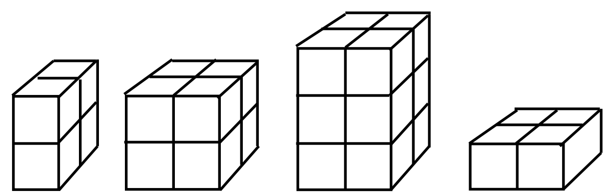
many times the base is multiplied by itself. This explanation may be misleading because 4^2 does not mean multiply 4 by itself 2 times or $4(4 \cdot 4)$.

Place the students in groups of 2–4. Ask them to draw a square on their graph paper that has sides of length 2. (Do the same at the overhead or blackboard). Have them count the non-overlapping small squares within the one they drew (4). Write $2^2=2 \cdot 2=4$ and discuss this with them. Continue this development with 2^2, 4^2, 5^2 and 6^2. Then ask them to explain what 1^2 would be, using the graph paper. Culminate this concrete explanation of the meaning of squared numbers by showing them square grids such as the ones below.



Have the groups discuss these questions:
1) Do these grids show square numbers?
2) If so, what number is squared? If not, why not? Groups should discuss their answers with the whole class.
4) To concretely develop the concept of cubic numbers,use the snap-together cubes. First, ask the groups tobuild a cube 2 blocks long, 2 blocks wide, and 2 blockstall. (Do the same with the blocks which you have.) Ask them how many blocks they used to build thelarge cube (8); write $2^3=2 \cdot 2 \cdot 2=8$ and check for theircomprehension. Now have the groups use the blocks to build and evaluate 3^3 and 4^3. Then ask them to explainwhat 1^3 is. How many blocks would be needed to build 5^3? Finish this development by showing them the figures below and having the groups decide:

1) which show cubic numbers;
2) if so, what number is cubed; if not, why not?



FOCUS FOR VIEWING:

Encourage the students active involvement in viewing this segment by telling them they should
1) list any distances or expressions involving exponents that are mentioned and
2) be able to summarize the situation presented by the characters.

VIEWING ACTIVITIES:

Start the tape after the titles, with the green space ship on the monitor. Stop after Holmes says he put 2 and 4 together. Have the students list the distances/exponential expressions from the segment (47,000.000 miles in space; 27,000 miles between the 2 space shapes; multiply the distance by 10^2; what does 10^2 mean? If the distance between ships is multiplied by 10^2, what will the new distance be? (2,700,000 mi.).

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Fast forward to the close-up of the male narrator where he says "Astronauts also have to use another concept..." Ask students to listen for the following:

1) How does the narrator describe "exponent?"
2) When is using exponents particularly useful?;
3) What is scientific notation?

Pause the video after "It can be written as 10^6." Ask for answers to the three questions:

1) number of times base is multiplied by itself;
2) when using large numbers;
3) using exponents to write large numbers.

Reinforce thinking of an exponent as the number of times the base is used as a factor. How would you write 1 billion in scientific notation? ($1 \cdot 10^9$). Resume until he says "How much easier to write $8 \cdot 10^{22}$". Stop and ask them to write these numbers in scientific notation:

1) 500,000 ($5 \cdot 10^5$)
2) 73,500,000 ($7.35 \cdot 10^7$)

Fast forward to the start of the space shuttle launch beginning with rocket ignition. Play with the sound off (because the narration is not particularly relevant to the topic) and ask students to listen for large numbers mentioned by the NASA physicist when the sound is on again. Resume at normal volume as the NASA spokesman appears, standing by the rocket model.

Pause after "Math is the key to getting into and out of orbit." What were the numbers he mentioned? List these on the overhead/blackboard:

- $4^1/_2$ million lbs. of vehicle
- 61/2 million lbs. of thrust
- Earth's rotation at equator 1000 mph
- Earth's rotation at Florida 800 mph
- altitude 150-200 miles
- nose temperature 2200-2500 degrees

Students should list these in their notes for later work.

In this segment, students should note the two rules of exponents explained by the narrator. Resume viewing as the narrator explains how to multiply and divide with scientific notation/ exponent expressions. Pause after the second rule, when he says "equals A^{m-n}. Ask students to explain the two rules; check for understanding by having them work these problems:

1) $10^4 \times 10^3$ (10^7)
2) $10^4 \div 10^3$ (10^1 or 10)

In this last segment students will find out why Moriarity's missile overshot Holmes and Watson. Ask students to refer to the list of distances from the first viewing activity and tell them that, if they listen carefully, they will find a discrepancy between that list and the distances given in this segment; they will be asked what that difference is. Resume viewing the program until Holmes says "...light years ahead Moriarity".

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Stop and ask if they noticed the discrepancy (the first segment says the distance between ships is 27,000 miles but this segment says 17,000). Make sure they can explain why the distance was miscalculated. (New distance between ships is $1.7.10^6$ miles, but Moriarity multiplied the exponents to get $1 \cdot 7 \cdot 10^8$ miles.)

POST-VIEWING ACTIVITIES:

Have groups use the list of 6 numbers from Viewing Activity 3 and rewrite each of those in scientific notation.

Have students fold a piece of paper in half. Write 2^1 on the overhead/board and explain this means you folded the paper into 2 parts 1 time. How many parts are there? (2). Have them fold the paper in half again; write 2^2 and ask them how many parts there are ($2^2=4$). Have them fold a third and fourth time to evaluate 2^3 (8) and 2^4 (16). Ask them to fold another sheet of paper into thirds to evaluate 3^1 (3), 3^2 (9), and 3^3 (27).

Have groups explain why 2^3 is not equal to 3^2 using snap-together blocks, graph paper and a written explanation. Then they explain why 5^2 is not equal to 2^5: Include a physics model of these numbers, if possible, and a written explanation.

The teacher should demonstrate that the rules for exponents apply to base other than 10 by using examples like the following; emphasize that the bases must be the same.

$$4^2 \bullet 4^5 = (4 \cdot 4) \bullet (4 \cdot 4 \cdot 4 \cdot 4 \cdot 4) = 4^{2+5} = 4^7 \text{ or } 16,384$$

$$9^5 \div 9^3 = \frac{9 \bullet 9 \bullet 9 \bullet 9 \bullet 9}{9 \bullet 9 \bullet 9} = 9^{5 \text{-} 3} = 9^2 \text{ or } 81$$

The teacher should lead the class in using their scientific calculators to evaluate numbers written in exponential form. (Instructions aren't given here because this varies between calculator models, but numbers from pre-viewing and viewing activities could be used.) Then show how calculators convert large number answers to scientific notation by having the students multiply 2 numbers large enough to force the answer to be converted to scientific notation.

Have students complete Practice Sheet for Exponents and Scientific Notation (derived from The Power of Algebra lesson guide).
Have students write journal entries responding to these questions:

a) What is the largest square number that can be modeled on your piece of graph paper. Explain your answer.
b) What is the largest cubic number you can model if you have 200 snap-together cubes? Explain how you got your answer.

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ACTION PLAN:

Invite a guest speaker whose occupation requires working with large numbers and scientific notation. Ask him/her to explain the part these numbers play in their work, what determines when they'll use scientific notation, specific problems in which they would use it, etc.

Have students read the sections from the local paper which contain national and local news. Have them write a report/make a presentation which lists any uses of exponents or scientific notation; numbers larger than 5 decimal places and their corresponding scientific notation; the types/subjects of articles which contained these numbers.

EXTENSIONS:

SCIENCE: Use science textbooks as a resource to determine how scientists use scientific notation, how the concept is developed in those books, and how scientific notation is used to represent very small numbers

Students can also read articles from science-related magazines to find out which branches of science tend to use notation the most. Make a list of "famous" numbers (ex Avogadro's number). Have students research their significance and determine what their equivalent number/exponential form is.

SOCIAL STUDIES: Have students find examples of large numbers in their textbook, class discussions, or magazines related to social studies. Rewrite them in scientific notation. Explain which form is more useful in dealing with these numbers.

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Student Worksheet

Name: ______________________

1. Complete this chart

Exponent Form	Read	Number
	One Million or Ten to the Sixth Power	1,000,000
10^5		
		10,000
	Ten Squared or	
10^1	or	

2. Write in exponential form

a. 6•6•6•6 ______ b. 8•8•8•8•8 ______

c. 1•1•1•1•1•1•1 ______ d. y•y•y ______

3. Write the number represented

a. 6^2 ______ b. 2^6 ______

c. 29^1 ______ d. 1^{25} ______

4. Complete by writing the number in scientific notation

a. 20,000 = ______ x 10^4 b. 320 = ______ x 10^2

c. 450,000 = 4.5 x ______ d. 5280 = 5.28 x ______

e. 89,000 = ______ x ______ f. 400 = 4 x 10______

g. 186,000,000 = ______ x ______ h. 102,000 = ______ x ______

i. 6,000,000 = ______ x ______ j. 1100 = ______ x ______