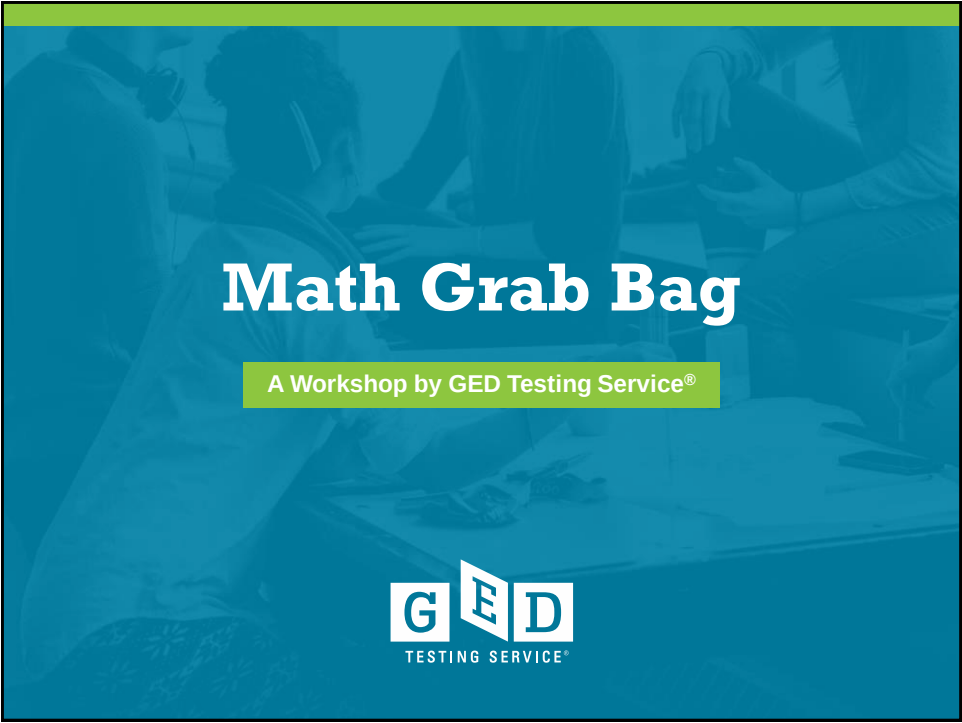




Session Objectives

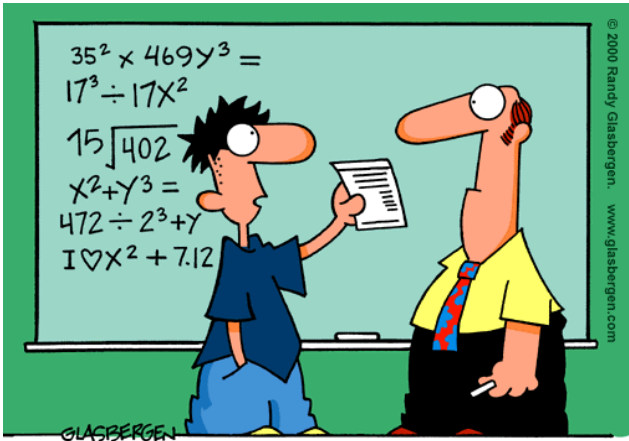


- Discuss the challenges students have with key concepts in math
- Focus on the foundational “must haves” in mathematical reasoning
- Review tips and strategies for helping students build consistency in math
- Share resources

3



It Really Isn't Genetic



"I HAD MY DOCTOR DO A D.N.A. BLOOD ANALYSIS.
AS I SUSPECTED, I'M MISSING THE MATH GENE."

4



What's the Problem?

- Students at Level 1
- Have limited, but developing proficiency
 - Perform some math skills at a basic level, such as
 - Putting fractions/decimals on a number line
 - Solving two-step arithmetic problems
 - Are inconsistent in the application of skills
 - Lack fluency in basic operations and mathematical properties



GED® Test: Mathematical Reasoning Performance Level Descriptors What Your Score Means: Level 1 — Below Passing

Test-takers who score at this level typically have a limited but developing proficiency in demonstrating skills in the following categories: number sense and computation, geometric measurement, data analysis and statistics, and algebraic expressions and functions.

Test-takers at the Below Passing level typically demonstrate the following skills:

Quantitative Problem Solving with Rational Numbers

- Apply number properties involving multiples and factors at a limited and inconsistent level
- Solve real-world problems using rational numbers at a limited and inconsistent level
- Compute unit rates at a limited and inconsistent level

Quantitative Problem Solving in Measurement

- Compute the area and perimeter of triangles and rectangles at a limited and inconsistent level
- Determine side lengths of triangles and rectangles when given area or perimeter at a limited and inconsistent level
- Represent, display, and interpret categorical data in circle and bar graphs
- Represent, display, and interpret categorical data in tables and scatter plots

Algebraic Problem Solving with Expressions and Equations

- Evaluate linear expressions
- Write linear expressions to represent context at a limited and inconsistent level
- Evaluate polynomial expressions at a limited and inconsistent level
- Write rational expressions to represent context at a limited and inconsistent level
- Solve real-world problems involving linear equations at a limited and inconsistent level
- Solve algebraic and real-world problems involving systems of equations

Algebraic Problem Solving with Graphs and Functions

- Locate and plot points in the coordinate plane

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Performance Level Descriptors (PLDs)

- Helpful tool for the classroom
- Explain in detail the skills students need to demonstrate to pass the test



How to Use PLDs in the Classroom

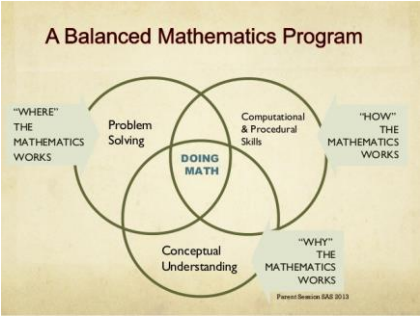
Use PLDs to:

- Tip 1: Assess student’s current skill level
- Tip 2: Determine when students are ready to test
- Tip 3: Shape learning activities
- Tip 4: Add perspective to lesson plans

9



Our Students Need...



10



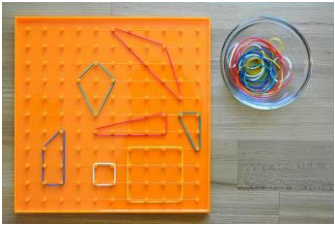
Understanding Skills Students Have

Low Intermediate Basic Education (4-5.9 GLE)	High Intermediate Basic Education (6-8.9 GLE)	Low Adult Secondary Education (9-10.9 GLE)
Students can perform with high accuracy all four basic math operations using whole numbers up to three digits and can identify and use all basic mathematical symbols.	Students can perform all four basic math operations with whole numbers and fractions; can determine correct math operations for solving narrative math problems and can convert fractions to decimals and decimals to fractions; and can perform basic operations on fractions.	Students can perform all basic math functions with whole numbers, decimals, and fractions; can interpret and solve simple algebraic equations, tables, and graphs and can develop own tables and graphs; and can use math in business transactions.

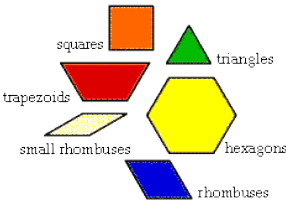
11



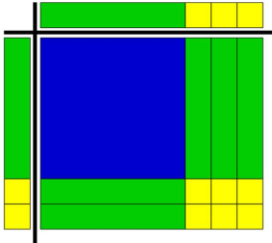
Best Practice for Building Skills



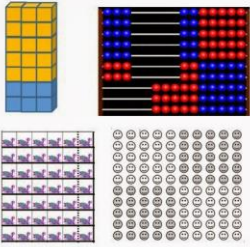
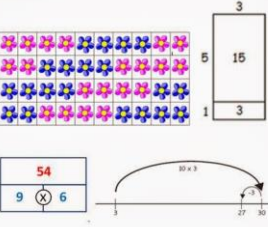
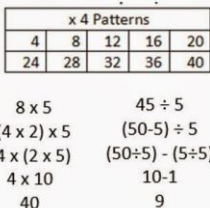
12



$(X+2)(X+3) = X^2 + 5X + 6$



C-R-A – Essential for Understanding

Concrete	Representational	Abstract
Students manipulate hands-on, concrete materials	Students draw and observe diagrams, or watch the teacher touching and moving hands-on materials	Students use numbers and mathematical symbols
		

13



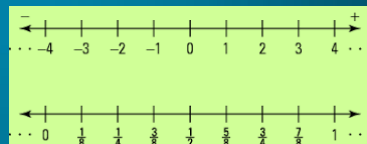
What are the Foundational “Must-Haves” in Mathematical Reasoning



14

Building Number Sense

Use a Number Line



15



Students with Number Sense...

- Think and reason flexibly with numbers
- Use numbers to solve problems
- Spot unreasonable answers
- Understand how to put numbers together and take them apart
- Understand number relationships

16



But they are just numbers...

Type of Number	Quick Description
Counting Numbers	{1, 2, 3, ...}
Whole Numbers	{0, 1, 2, 3, ...}
Integers	{..., -3, -2, -1, 0, 1, 2, 3, ...}
Rational Numbers	p/q – p and q are integers, q is not zero
Irrational Numbers	π – 3.14159265358979323856... cannot be written as a simple fraction $\sqrt{3}, \sqrt{99}$
Real Numbers	Rational and Irrational

17



Defining Numbers

Choose a Number Set:

☒ Counting ☒ Integers ☒ Rationals ☐ Real

zoom +

-3.5

-2.5

-1.5

-0.5

0.5

1.5

2.5

3.5

-7/2

-3

-5/2

-2

-3/2

-1

-1/2

0

1/2

1

3/2

2

5/2

3

7/2

Rational numbers are numbers that can be written as the ratio of two integers.

Example: $5/2$ (2.5), $-1/4$ (-.25), etc.

Open Instructions

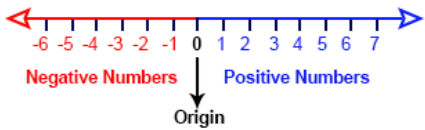
<https://unctv.pbslearningmedia.org/resource/mgbh.math.ns.numblne/builing-a-number-line/#.WU1B-IWcHnM>

18



The Number Line

- Provides a model for basic operations for all rational numbers
- Is a spatial object
- Allows students to situate themselves spatially in mathematics
- Permits students to conceptualize mathematics



19



Just a Sample

Formula Sheet

Calculator Reference

Julia wants to spend \$100 or less ordering shirts from an online company. The company charges a \$5 shipping fee for any order. The inequality $5 + 15n \leq 100$ represents the number of shirts, n , Julia can order from the online company. Graph all possible numbers of shirts that Julia can buy.

Click on the number line to plot the point(s).

(NOTE: To remove a point, place the arrow over the point and click the left mouse button.)

12345678910

Previous

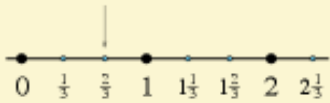
Next

20

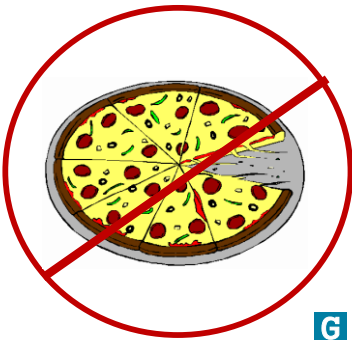


Fractions

Students need to learn to *locate* a fraction on a number line.



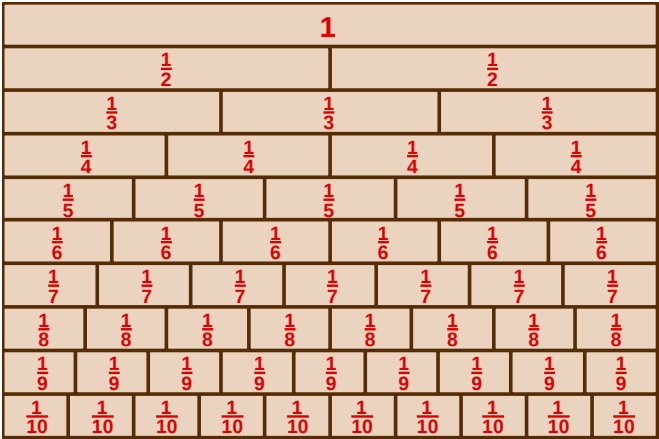
Use the number line so students understand that fractions are numbers and not just part of a pizza.



21



Fraction Tiles

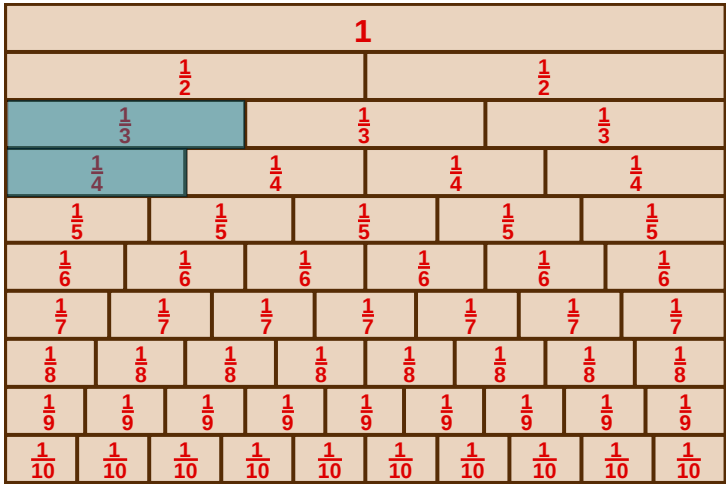


A linear model gives an overview and shows relationships.

22



Fraction Tiles



What is more, 1/4 or 1/3? What is more, 1/9 or 1/10?

23



Can students identify the problem?

- a) $\frac{2}{5} + \frac{1}{3} = \frac{3}{8}$

b) $\frac{2}{7} + \frac{1}{3} = \frac{2}{21} + \frac{1}{21} = \frac{3}{21}$

c) $\frac{3}{8} + \frac{1}{4} = \frac{9}{32} + \frac{8}{32} = \frac{17}{32}$

d) $\frac{8}{9} + \frac{1}{4} = \frac{32}{36} + \frac{9}{36} = \frac{41}{72}$

e) $\frac{7}{12} + \frac{5}{6} = \frac{14}{24} + \frac{20}{24} = \frac{34}{24} = \frac{17}{12}$
- f) $6\frac{1}{2} - 4\frac{2}{3} = 6 - 4 + \frac{1}{2} - \frac{2}{3} = 2 + \frac{3}{6} - \frac{4}{6} = 2\frac{1}{6}$

g) $5\frac{2}{5} + 1\frac{3}{4} = 5\frac{8}{20} + 1\frac{15}{20} = 6\frac{23}{20} = 7\frac{3}{20}$

h) $\frac{1}{2} \times \frac{1}{5} = \frac{5}{10} \times \frac{2}{10} = \frac{10}{100} = \frac{1}{10}$

i) $2\frac{1}{2} \div 1\frac{3}{4} = \frac{5}{2} \times \frac{4}{7} = \frac{35}{8} = 4\frac{3}{8}$

j) $\frac{17}{20} - \frac{4}{5} \times \frac{3}{8} = \frac{17}{20} - \frac{16}{20} \times \frac{3}{8} = \frac{1}{20} \times \frac{3}{8} = \frac{4}{160} = \frac{1}{40}$

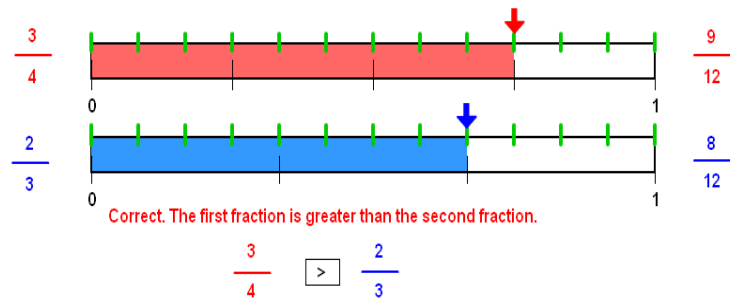
"Five out of four people have trouble with fractions."
-- Steven Wright

24



Can Students Use a Number Line?

The fractions 3/4 and 2/3 are pictured with number lines below:



25



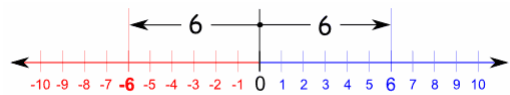
Absolute Value

Absolute Value means how far a number is from 0.

- Remove any negative sign and think of all numbers as positive
- Recognize symbol used to represent absolute value

$$|-5| = 5$$

$$|7| = 7$$



"6" is 6 away from zero,
and "-6" is **also** 6 away from zero.

So the absolute value of 6 is **6**,
and the absolute value of -6 is also **6**

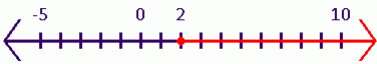
26



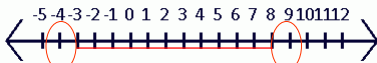
Inequalities

An inequality is a math statement that defines a range of values.

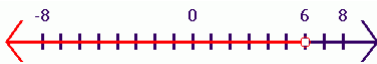
Jeffrey runs at least two miles every day.



On November 28, the temperature in North Pole, Alaska is expected to be greater than -4° and less than 9°



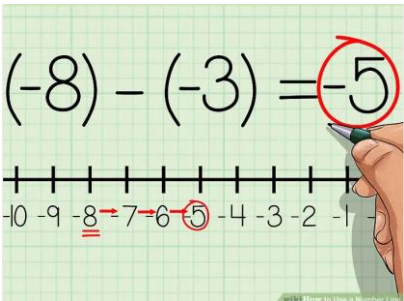
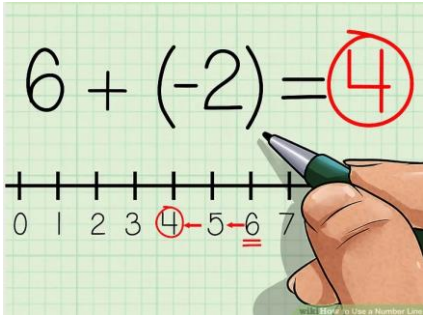
$T < 6$



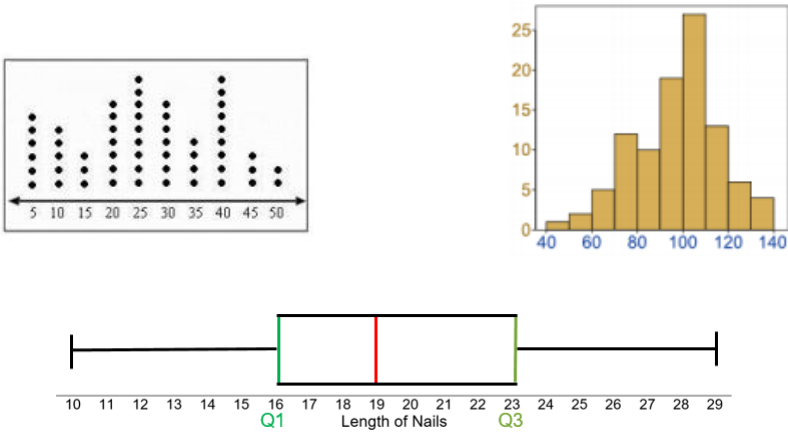
<https://www.gedtestingservice.com/educators/exploring-the-2014-ged-test-webinar-archive>



Operations with Positive and Negative Integers



Data Displays

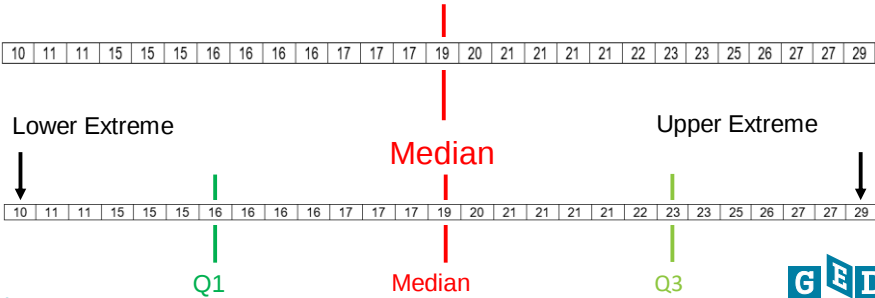


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Essential Skills for Box Plots

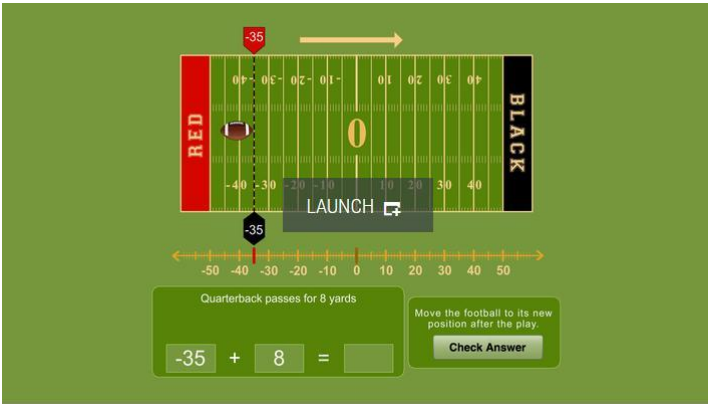
- Arrange data in order
- Find median for all data
- Find median for lower quartile
- Find median for upper quartile
- Find the range of the extreme values



30



Number Lines and the NFL



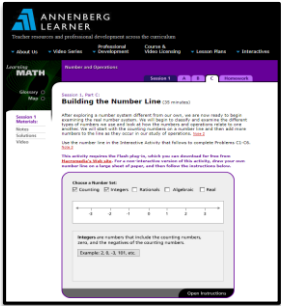
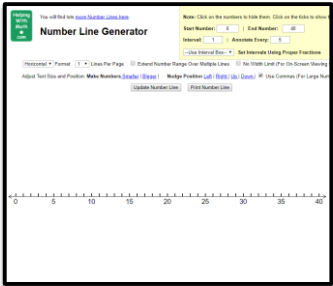
<https://unctv.pbslearningmedia.org/resource/mket-math-ns-ratnumb/football/#.WU0tDGgrKUk>

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Resources

- Helping with Math - Number Line Generator**
<http://www.helpingwithmath.com/printables/others/NumberLineGenerator01.htm>
- Math Warehouse – Number Line Graph Maker**
<http://www.mathwarehouse.com/number-lines/number-line-maker.php>
- Math is Fun – Number Lines (Inequalities, Operations, etc.)**
<http://www.mathsisfun.com/number-line.html>
- Annenberg Learner – Building the Number Line**
http://www.learner.org/courses/learningmath/number/session1/part_c/index.html



32



The Importance of Understanding the Order of Operations



Is the answer 18 or 10?

- Avoid confusion in how problems are solved
- Set up rules of precedence or rank of operations
- Is critical to simplifying and solving different algebra problems



Answer the Why

Subjects + Search KHANACADEMY New user / Sign up

PRE-ALGEBRA > ARITHMETIC PROPERTIES

Order of operations

Intro to order of operations

Order of operations example

Worked example: Order of operations (PEMDAS)

Practice: Order of operations

Next tutorial Arithmetic properties

$7 + 3 \times 5$

$7 + 3 \times 5 \div$
 10×5
50

$7 + 3 \times 5$
 $7 + 15$
22

because two people interpreted it a different way or another

YouTube

<https://www.khanacademy.org/math/pre-algebra/pre-algebra-arith-prop/pre-algebra-order-of-operations/v/introduction-to-order-of-operations>

35



Get Rid of Misconceptions about Order of Operations

Misconception 1 - All multiplication should happen before division.

Incorrect	Correct
$12 \div 3 \times 4$	$12 \div 3 \times 4$
$12 \div 12$	4×4
1	16

Misconception 2 – All addition comes before subtraction.

Incorrect	Correct
$4 + 10 - 5 + 8$	$4 + 10 - 5 + 8$
$14 - 13$	$14 - 5 + 8$
1	9 + 8
	17

GROUPINGS $() \{ \} []$
EXPONENTS N^2
MULTIPLY/DIVIDE $\div / \times$
(LEFT TO RIGHT)
SUBTRACT/ADD $+ / -$
(LEFT TO RIGHT)

Parenthesis
Exponents
Multiply / **D**ivide
Add + **S**ubtract

Essential Understanding

1. **Parentheses and Brackets**
from the inside out
2. **Exponents**
of numbers or parentheses
3. **Multiplication and Division**
in the order they appear
4. **Addition and Subtraction**
in the order they appear



37

Your Turn

What is the value of $6 \div 3 + 4 \times 2$?

So we do the division and multiplication before any addition or subtraction:

$$\begin{aligned} 6 \div 3 + 4 \times 2 \\ = 2 + 4 \times 2 \\ = 2 + 8 \\ = 10 \end{aligned}$$

38



Your Turn

What is the value of $6 \times 4 - 12 \div 3 - 8$?

We do 6×4 and $12 \div 3$ first, then the subtractions:

$$\begin{aligned} 6 \times 4 - 12 \div 3 - 8 \\ = 24 - 12 \div 3 - 8 \\ = 24 - 4 - 8 \\ = 20 - 8 \\ = 12 \end{aligned}$$

39



Your Turn

What is the value of $20 - (3 \times 2^3 - 5)$?

We start inside the **P**arentheses, and then use "**E**xponents" first:

$$20 - (3 \times 2^3 - 5) = 20 - (3 \times 8 - 5)$$

[Because 2^3 means $2 \times 2 \times 2 = 8$, **not** $2 \times 3 = 6$]

Next **M**ultiply:

$$20 - (3 \times 8 - 5) = 20 - (24 - 5)$$

Next **S**ubtract (still working inside the parentheses):

$$20 - (24 - 5) = 20 - 19$$

Now the **P**arentheses are completed, the last operation is **S**ubtract:

$$20 - 19 = 1$$

40



Your Turn

What is the value of $(12 \div 3 + 4) - (4^2 - 6 \times 2)$?

$$\begin{aligned}
 &(12/3+4)-(4^2-6 \times 2) \\
 &= (4+4)-(4^2-6 \times 2) \\
 &= 8-(4^2-6 \times 2) \\
 &= 8-(16-6 \times 2) \\
 &= 8-(16-12) \\
 &= 8-4 \\
 &= 4
 \end{aligned}$$

41



What's Your Sign?

In the equation below, replace each question mark with one of the four mathematical signs: +, -, $\times$, or $\div$. Each sign can be used only once. Fill in the blanks to solve the equation. (Hint: the first sign is +.)

$$7 \ ? \ 5 \ ? \ 4 \ ? \ 7 \ ? \ 6 = 15$$

What is the first step that you need to take in order to solve the equation? Write your answer in the question box.

$$(7 + 5) \div 4 \times 7 - 6 = 15$$



Do your students know the vocabulary?

Ratio – a comparison between two different values

Percent of change – ratio of the amount of change to the original amount

Percent increase – how much original amount increases

Percent decrease – how much original amount decreases



$$\text{percent change} = \frac{\text{amount of change}}{\text{original amount}}$$

45



What do students need to know?

- An understanding of percent
- Part and whole
- Increase
- Decrease
- Original number
- Difference between percentage of and percent of change

46



Do they understand increase vs. decrease?

- If you buy a brand new car for \$15,999, drive it off the lot, and get into an accident, the car will be worth \$11,499. Does the car's value increase or decrease?
- The temperature at sunrise is 71 degrees Fahrenheit . At noon, the temperature is 84 degrees Fahrenheit. At sunset, it is 69 degrees Fahrenheit. Has the temperature had an increase or decrease from sunrise to sunset?
- A scuba diver jumps off a dive boat into the water and descends 30 feet below sea level. He rises 10 feet to swim above a coral head, then swims back down 8 feet to the top of a submerged wreck. Has his depth shown an increase or decrease from his initial descent?

47



Percent of Increase

- Tips
- Sales Tax
- Increase in Population



To calculate percent of increase

percent change = $\frac{\text{amount of increase}}{\text{original amount}}$

48



Calculating a Percent of Increase

In 1981, there were 25 endangered and threatened species of reptiles in the U. S. In 2015, there were 45 species. By what percent did the number of these reptile species change from 1981 to 2016?

80%

20

amount of increase

original amount

25

percent change =

Is the amount of change an increase or a decrease? (increase)
What is the amount of change from 1981 to 2015? ($45 - 25 = 20$)
What is the original amount? (25)
Divide the amount of change by the original amount ($20/25 = .8$)
Write the quotient as a percent ($.8 = 80\%$ increase)

49



Calculating a Percent of Increase

198,000 people attended a concert in 2007. The number of attendees increase by 12% from 2007 to 2017. How many attendees attended in 2017?

Attendees in 2017

=

Attendees in 2007

+

Amount of increase

= $198,000 + 198,000 \times 12\%$ x (Substitute)
= $198,000 + 198,000 \times 0.12$ (write percent as a decimal)
= $198,000 +$
= $221,760$ (Evaluate)

50



Percent of Decrease

- Discounts
- Sales
- Reduction in Population



To calculate percent of decrease

percent change = $\frac{\text{amount of decrease}}{\text{original amount}}$

51



Calculating a Percent of Decrease

A stock was worth \$18.00 a share in 2000. In 2016, the same stock was worth \$7.60 a share. What was the percent of change?

58%	10.40
	18.00

- Is the amount of change an increase or a decrease? (decrease)
- What is the amount of change from 2000 to 2016? (\$10.40)
- What is the original amount? (\$18.00)
- Divide the amount of change by the original amount (10.40/18)
- Write the quotient as a percent (.57777 . . . = 58% decrease)

52



Laptop Computer

You can now buy a laptop for 14% of the cost of a 1981 laptop. What was the cost in 1981?



Now and Then – NCTM: <https://illuminations.nctm.org/Lesson.aspx?id=3121>



Common Errors

- Using the wrong base when calculating change
- Not being able to differentiate between a quantity change and a percentage change
- Incorrectly changing a decimal to a percent
- Confusing "percentage **of**" situations with percent increase/decrease situations
- Not reading the situation (word problem) carefully



Resources

- Art of Problem Solving: Percent Increase and Decrease Part 1
https://www.youtube.com/watch?v=vTPQV_M6tfI
- Art of Problem Solving: Percent Increase and Decrease Part 2
<https://www.youtube.com/watch?v=TbUifWJ9Ohw>
- How to Find the Percent Change Increase: The Easy Way
<https://www.youtube.com/watch?v=YWOeN7hDD3E>
- How To Find Percent Change Decrease: The Easy Way
<https://www.youtube.com/watch?v=fwhZ8ITiReY>



55



Exponents and Roots

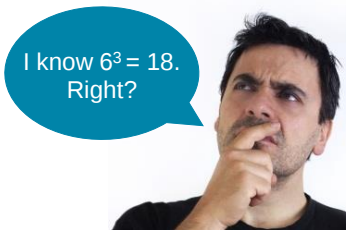
Oh My!



56

A Continuing Problem

Students think an exponent is the same as multiplication.



Multiplication =
Repeated Addition

$6 \times 3 = 18$
 $6 + 6 + 6 = 18$

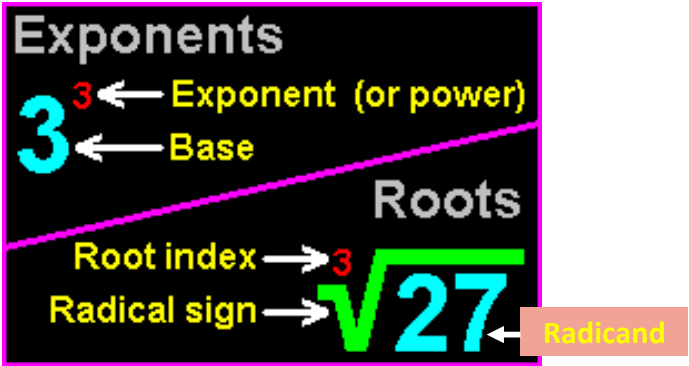
Exponents = Repeated
Multiplication

$6^3 = 18$
 $6 \times 6 \times 6 = 216$

57



Do your students know the vocabulary?



58



Rules of Exponents Made Easier



The Math Dude – Law of Exponents - <https://www.youtube.com/watch?v=g4bKGsC2IoY>



59

Rules of Exponents

	Rule	Example
1	$x^1 = x$	$5^1 = 5$
2	$x^0 = 1$	$5^0 = 1$
3	$x^{-1} = \frac{1}{x^1}$	$5^{-1} = \frac{1}{5}$
4	$(x^m)(x^n) = x^{m+n}$	$(x^2)(x^3) = x^{2+3} = x^5$
5	$\frac{x^m}{x^n} = x^{m-n}$	$\frac{x^3}{x^2} = x^{3-2} = x^1$
6	$(x^m)^n = x^{(m)(n)}$	$(x^3)^2 = x^{(3)(2)} = x^6$
7	$(xy)^n = x^ny^n$	$(xy)^3 = x^3y^3$
8	$\left(\frac{x}{y}\right)^n = \frac{x^n}{y^n}$	$\left(\frac{x}{y}\right)^3 = \frac{x^3}{y^3}$
9	$x^{-n} = \frac{1}{x^n}$	$x^{-2} = \frac{1}{x^2}$



60

Squares and Square Roots of Positive Rational Numbers

Recommendations for Test-Takers

- Memorize the first 12 perfect squares (1, 4, 9, ..., 144)
- Understand inverse relationships between pairs of squares and square roots ($12^2 = \sqrt{144}$ and $\sqrt{144} = 12$)
- Understand difference in squaring a negative number and the negative of a square number, i.e., $(-3)^2 = 9$ and $-(-3)^2 = -9$
- Practice computing with square and square roots that include fractions and decimals



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Simplifying Radical Expressions

- $\sqrt{9}$
- Find the prime factors = $\sqrt{3 \cdot 3}$
- Bring any pairs outside the radical = 3

$$\begin{aligned} &\sqrt{9xy^2} \\ &\sqrt{3 \cdot 3 \cdot x \cdot y \cdot y} \\ &3y\sqrt{x} \end{aligned}$$

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Why do students need to know this?

Mathematical Reasoning - Candidate Name

Question 5 of 16

Answer Explanation

Symbol

Flag for Review

Formula Sheet

Type your answer in the box. You may use numbers, symbols, and/or text in your answer.

An expression is shown.

$$\sqrt{15} \cdot \sqrt{12}$$

Simplify the expression completely. Leave your answer in radical form.

(NOTE: Click the symbol selector when you need to enter the radical sign.)

Previous

Next



Last, but not least

The incredible zero



The Incredible Zero

- It is unique in representing nothingness.
- As a placeholder it gives our number system its power.
- It acquires different meaning based on its location. Think 30 versus 3,000.



The Origin of the Number Zero

<http://www.smithsonianmag.com/history/origin-number-zero-180953392/#qagAYijydW3RXhkh.99>

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Properties of Zero

Property	Example
$a + 0 = a$	$4 + 0 = 4$
$a - 0 = a$	$4 - 0 = 4$
$a \times 0 = 0$	$6 \times 0 = 0$
$0 \div a = 0$	$0/3 = 0$
$a \div 0 = \text{undefined}$ (dividing by zero is undefined)	$7/0 = \text{undefined}$
$0^a = 0$ (a is positive)	$0^4 = 0$

<http://www.mathsisfun.com/numbers/zero.html>



The Problem with Zero

$\frac{a}{0}$

$\frac{7}{0}$

You can express a fraction with 0 in the denominator, but it has no meaning.

Division by zero is undefined. Mathematicians have never defined the meaning because there is no good definition.

How many times can you throw nothing into no baskets?

As many times as you want. It's just not a real number.

To learn more: <https://www.khanacademy.org/math/algebra/introduction-to-algebra/division-by-zero/v/why-dividing-by-zero-is-undefined>

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Calculator-Prohibited Items



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Calculator-Prohibited Indicators



**TEST-TAKER RECOMMENDATIONS FOR
CALCULATOR-PROHIBITED INDICATORS**

The first several questions of the GED® Mathematical Reasoning test assess eight indicators covering various concepts in number sense and computation (Q.1.a through Q.1.d and Q.2.a through Q.2.d) that prohibit the use of the calculator. GED Testing Service has analyzed data on these calculator-prohibited items, resulting in the following comments and recommendations:

Indicator	Background	Recommendations for Test-takers
Q.1.a Order fractions and decimals, including on a number line.	These questions may require • comparing or ordering positive numbers, or negative numbers, or both, • with or without a number line. Test takers generally do very well on this indicator, with the exception of questions that require test takers to compare or order a set consisting entirely of negative numbers.	• Leverage skills in comparing and ordering positive fractions and decimals toward similar skills comparing and ordering negative fractions and decimals. • Understand the difference in how negative numbers are compared and ordered: ◦ For instance, while 0.7 is greater than 0.2, -0.7 is actually less than -0.2. ◦ Since positives and negatives are essentially opposites, the rules for ordering each type of number are applied in a similarly opposite manner.
Q.1.b Apply number properties involving multiples and factors, such as using the least common multiple, greatest common factor, or distributive property to rewrite numeric expressions.	Test takers generally perform very well on this indicator, which includes questions that include both context or pure computation (no context) and which test factors of a number, multiples of a number, least common multiple, greatest common factor, etc.	No specific recommendations are provided, as the general population of GED® test takers performs well on this indicator.

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Sample Items

- Order Fractions and Decimals

Place the following numbers in order from greatest to least: 0.2, -1/2, 0.6, 1/3, 1, 0, 1/6
- Factors and Multiples

Find the LCM that is necessary to perform the indicated operation. $\frac{7}{6} - \frac{1}{4} =$
- Rules of Exponents

Simplify the following: $(x^3)^5$
- Distance on a Number Line

Find the distance between two points -9 and -3 on a number line



Sample Items

Operations on Rational
Numbers

Solve: $3 \frac{1}{2} \div 3 \frac{1}{2} =$

Squares and Square Roots of
Positive Rational Numbers

Find $\sqrt{9}$ Find $\sqrt{24}$

Cubes and Cube Roots of
Rational Numbers

Find $(-4)^3$

Undefined Value Over the Set
of Real Numbers

Solve $(2x - 3)(x + 2) = 0$

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Tips for Building Foundational Skills

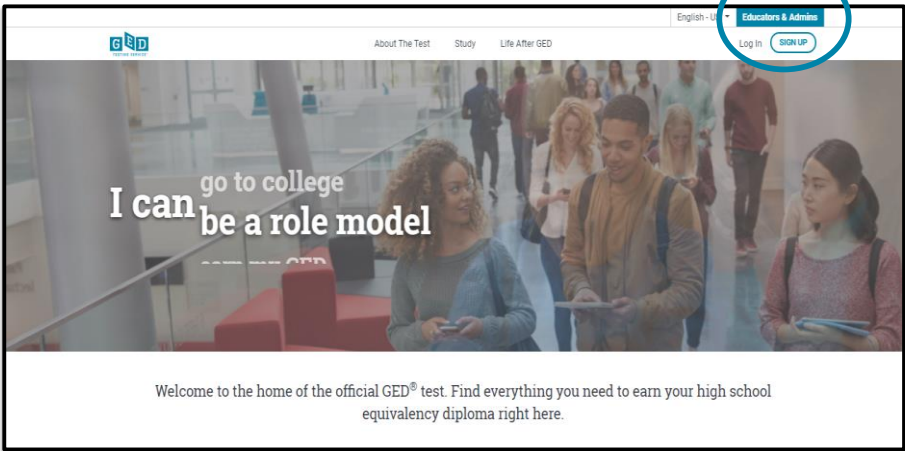


- Help students build their number sense
- Include opportunities for students to work together
- Provide plenty of practice with real-life situations included
- Set high expectations

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<https://ged.com>



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Thank you!

*Communicate with GED Testing Service®
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