

# PRE-ALGEBRA

## NUMBER SYSTEMS

The following sets are infinite; that is, there are no last numbers.  
The three dots indicate continuing or never-ending patterns.

- Counting or natural numbers =  $\{1, 2, 3, 4, \dots, 78, 79, \dots\}$ .
- Whole numbers =  $\{0, 1, 2, 3, 4, \dots, 296, 297, \dots\}$ .
- Integers =  $\{\dots, -4, -3, -2, -1, 0, 1, 2, 3, 4, \dots\}$ .
- Rational numbers =  $\{\text{all numbers that can be written as fractions, } p/q, \text{ where } p \text{ and } q \text{ are integers and } q \text{ is not zero}\}$ . Rational numbers include all counting numbers, whole numbers, and integers, in addition to all proper and improper fraction numbers, and ending or repeating decimal numbers.  
Ex:  $4/9, 3, -18.75, \sqrt{16}, -\sqrt{25}$ .
- Irrational numbers =  $\{\text{all numbers that cannot be expressed as rational numbers}\}$ . As decimal numbers, irrational numbers do not end nor repeat.  
Ex:  $3.171171117\dots, \sqrt{2}, -\sqrt{2}, \pi$ .
- Real numbers =  $\{\text{all rational and all irrational numbers}\}$ .

## OPERATIONS

## ABSOLUTE VALUE

**Absolute value** is the distance (always positive) between a number and zero on the number line; the positive value of a number. Ex:  $|3| = 3$ ;  $|-3| = 3$ ;  $|-5| = 5$

### ADDITION

1. **Integers:** When adding integers follow these rules:
- If both numbers are positive, add them; the sign of the answer will be positive.
  - If both numbers are negative, add them; the sign of the answer will be negative.
  - If one number is negative and the other is positive (in any order), subtract the two numbers (even though they are joined by a plus sign); the sign of the answer will be the same sign as the sign of the number that has the larger absolute value.
- EX:  $4 + (-9) = -5$ ;  $(-32) + (-2) = -34$ ;  $(-12) + 14 = 2$ .
2. **Rational numbers:**
- When adding two mixed numbers, fractions, or decimal numbers, follow the same sign rules that are used for integers (above), but also follow the rules of operations for each type of number.
  - For mixed numbers and fractions, make sure the fractions have a common denominator, then add the numbers. Mixed numbers and fractions can also be changed to decimal numbers and then added.
  - For decimal numbers, line the decimal points up, then add the numbers bringing the decimal point straight down.
- EX:  $(-4 \frac{1}{2}) + (5 \frac{1}{2}) = (-4 \frac{1}{2}) + (5 \frac{1}{2}) = 1 \frac{1}{2}$ ;  $5.667 + (-8.777) = -3.11$
3. **Irrational numbers:**
- When adding irrational numbers, exact decimal values cannot be used. If decimal values are used, then they are rounded and the answer is only an approximation. Instead, if the two irrational numbers are multiples of the same square root, radical expression, or pi (π), then simply add the coefficients (numbers in front of the roots or pi (π)).
- EX:  $4\sqrt{3} + 5\sqrt{3} = 9\sqrt{3}$ ;  $(-6\pi) + 9\pi = 3\pi$ ;  $3\sqrt{7} + 3\sqrt{2}$  cannot be added any further because the two square roots are different.

## SUBTRACTION

1. Subtraction of an integer or a number can be accomplished by adding the opposite of the number to be subtracted.
2. When changing the sign of the number in back of the minus sign, follow the rules of addition as stated above. Thus:  $8 - (-2) = 8 + 2 = 10$ ;  $6 - 2 = 4$ ;  $-1 - (-5) = -1 + 5 = 4$ ;  $-1 - 5 = -6$ ;  $-1 - (-9) = -1 + 9 = 8$ .

### MULTIPLICATION

1. **Integers:** When multiplying integers, follow these rules:
- a. If the signs of the numbers are the same, multiply and make the answer positive.
  - b. If the signs of the numbers are different, multiply and make the answer negative.
- NOTE:** The sign of the answer does not come from the number with the larger absolute value as it does in addition.  $\text{Ex: } (-4)(5) = -20$ ;  $(-3)(-2) = 6$ ;  $(7)(-10) = -70$ .
2. **Rational numbers:**
- a. When multiplying rational numbers, follow the sign rules that are used for multiplying integers (above) and the rules for multiplying each type of number.
  - b. For mixed numbers, change each mixed number to an improper fraction, and then multiply the resulting fractions.
  - c. For fractions, multiply the numerators and the denominators, then reduce the answer.
  - d. For decimal numbers, multiply them as though they were integers, then put the decimal point in the answer so there is the same number of digits behind the decimal point in the answer as there are behind both decimal points in the problem.
3. **Irrational numbers:**
- a. When multiplying irrational numbers, follow the same sign rules that are used for integers (listed above).
  - b. If radical expressions are multiplied and they have the same indices, then the numbers (radicands) under the root symbols (radicals) can be multiplied.
- $\text{Ex: } (-\sqrt{3})(-\sqrt{7}) = +\sqrt{3 \cdot 7} = +\sqrt{21}$ ;  $(2\sqrt{7})(-\sqrt{6}) = -12\sqrt{7}$

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- 1. Integers:** When dividing integers, follow these rules:
- If the signs of the numbers are the same, divide them and make the answer positive.
  - If the signs of the numbers are different, divide them and make the answer negative.
  - The sign of the answer does not come from the number with the larger absolute value as it does in addition.
- Ex:**  $(-30) \div (5) = -6$ ;  $(-22) \div (-2) = 11$ ;  $(70) \div (-10) = -7$
- 2. Rational numbers:**
- When dividing rational numbers, follow the sign rules that are used for dividing integers (listed above) and the rules for dividing each type of number.
  - For mixed numbers, change each mixed number to an improper fraction, invert or flip the number behind the division sign and follow the rules for multiplying fractions.
  - For decimal numbers, first move the decimal point in the divisor to the back of the number, then, move the decimal point the same number of positions to the right in the dividend. Divide the numbers, then bring the decimal point straight up into the quotient (answer). Additional zeros can be written after the last digit behind the decimal point in the dividend so the division process can continue if needed.
- 3. Irrational numbers:**
- When dividing irrational numbers, follow the same sign rules that are used for dividing integers (listed above).
  - If radical expressions are divided and they have the same indices, then the numbers (radicands) under the root symbols (radicals) can be divided.
- Ex:**  $(-\sqrt{15}) \div (\sqrt{3}) = -\sqrt{5}$ ;  $(\sqrt{30}) \div (-\sqrt{6}) = -\sqrt{5}$ ;  $\frac{3}{4} \div \sqrt{2}$  cannot be divided, only simplified as demonstrated in the *Quick Study® Algebra Part One* study guide.

## EXPONENTS / POWERS

1. Definition:  $a^b = \underbrace{a \cdot a \cdot a \cdots a}_b$ , that is, the number written in the upper right-hand corner is called the exponent or power, and it tells how many times the other number (called the base) is multiplied times itself. If an exponent cannot be seen, it equals 1. Ex:  $5^0 = 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5 = 5 \cdot 5 \cdot 5 = 15,625$ , notice that the base, 5, was multiplied times itself 6 times because the exponent was 6.
2. Rule:  $a^m \cdot a^n = a^{m+n}$ ; that is, when multiplying the same base, the new exponent can be found quickly by adding the exponents of the bases that are multiplied.  
Ex:  $(5^2)(5^3) = 5^7$ ;  $(3^4)(7^5)(7^2)(3^8) = (3^4)(3^8)(7^5)(7^2)$
3. Rule:  $a^m / a^n = a^{m-n}$ ; that is, when dividing the same base the new exponent can be found quickly by subtracting the exponents of the bases that are divided. The new base and exponent go either in the numerator or in the denominator, depending on whether the original one is located in the original problem. Ex:  $(3^4)(7^2)/(7^5) = 7^3$ ;  $(3^8)/(3^4) = 3/(3^4)$ .
4. Rule:  $a^{-n} = 1/a^n$ ; and  $1/a^{-n} = a^n$ ; that is, a negative exponent can be changed to a positive exponent by moving the base to the other section of the fraction; numerator goes to denominator or denominator goes to numerator.  
Ex:  $7^{-3} = 1/(7^3)$ ;  $1/(5^{-2}) = 5^2$ ;  $3(2^{-4}) = 3/(2^4)$  notice the 3 stayed in the numerator because the invisible exponent is always positive 1.
5. Rule:  $(a^m)^n = a^{mn}$ ; that is, when there is a base with an exponent raised to another exponent, then the short cut is to multiply the exponents.  
Ex:  $(-3x^2)^3 = (-3)^3(x^2)^3 = -27x^6$

### ORDER OF OPERATIONS

When a problem has many operations, the order in which the operations are completed will give different answers. So there is an order of operations rule.

1. Do the operations in the parentheses (or any enclosure symbols) first.
  2. Do any exponents or powers next.
  3. Do any multiplication and division, going left to right in the order they appear (this means division is done before multiplication if it comes first in the problem).
  4. Do the addition and subtraction, going left to right in the order they appear (this means subtraction is done before addition if it comes first in the problem).
- Ex.  $4 + 2(3 + 5) - 4 + 2(10) = 4 + 20 - 4 + 20 = 24 - 4 + 20 = 20 + 20 = 40$

### SCIENTIFIC NOTATION

*A form of a decimal number where the decimal point is always behind exactly one non-zero digit and the number is multiplied by a power of ten.*

1. It is a method for representing very large or very small numbers without writing a lot of digits. E.g.:  $2.437 \times 10^6$ ,  $9.882 \times 10^{-5}$  would be written as  $2.437 \times 10^{+6}$ ,  $.000009882$  would be written as  $9.882 \times 10^{-5}$ .
2. A positive or zero exponent on the 10 means the number value is more than or equal to one. A negative exponent on the 10 means the number value is less than one. E.g.:  $5.29 \times 10^3 = .00000000529$  and  $5.29 \times 10^{-3} = 529,000,000,000,000$ .
3. Operations with very large or very small numbers are much easier if you use scientific notation.
4. The scientific notation is used by scientists, astronomers, mathematicians, etc.

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**Roman Wölfel**



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