# HVAC (47.0201) T-Chart

**Work with very large/small numbers = Apply and extend the properties of exponents to solve problems with rational exponents**

**Program Task:** Read and interpret technical data.

**Program Associated Vocabulary:**
KILO, MICRO, MEGA, MILLI, TERA

**Program Formulas and Procedures:**
HVAC technicians are required to work with very large and very small numbers. Not only is it inconvenient and impractical to write these numbers out in long strings of digits, the opportunity for error is greatly increased in doing so. At times, HVAC professionals use prefixes such as kilo-, mega-, or tera- to describe moderately large numbers, or prefixes such as milli- or micro- to describe moderately small numbers.

In some cases, engineering specifications, which must be understood by the field technician, will reflect very large and very small numbers using scientific notation. Regardless of how the number is represented in technical data and writing, the technician must be accurate and proficient in interpreting and applying the values.

**Some Examples of Scientific Notation in HVAC:**

- One ampere of electrical current is defined as 6,241,509,629,152,650,000 electrons moving past a given point per second. A rough estimate of this number in scientific notation form is $6.24\times10^{18}$.
- 1 micro amp = .000001 amps = $1 \times 10^{6}$ or 1E-6 amps
- 1,200 tons of cooling = 14,400,000 btu/h = 1.4E+7 btu/h or $1.4 \times 10^{7}$

Students may find the following chart helpful.

| Term | Number | Sc.Not. | Definition |
|---|---|---|---|
| Tera (T) | 1,000,000,000,000 | $10^{12}$ | Trillion |
| Giga (G) | 1,000,000,000 | $10^{9}$ | Billion |
| Mega(M) | 1,000,000 | $10^{6}$ | Million |
| Kilo (k) | 1,000 | $10^{3}$ | Thousand |
| Hecto(h) | 100 | $10^{2}$ | Hundred |
| Deca(da) | 10 | $10^{1}$ | Ten |
| | 1 | $10^{0}$ | One |
| Deci (d) | 0.1 | $10^{-1}$ | Tenth |
| Centi (c) | 0.01 | $10^{-2}$ | Hundredth |
| Milli (m) | 0.001 | $10^{-3}$ | Thousandth |
| Micro(µ) | 0.000001 | $10^{-6}$ | Millionth |
| Nano (n) | 0.000000001 | $10^{-9}$ | Billionth |

**PA Core Standard: CC.2.1.HS.F.1**

**Description:** Apply and extend the properties of exponents to solve problems with rational exponents.

**Math Associated Vocabulary:**
EXPONENT, INTEGER, STANDARD FORM

**Formulas and Procedures:**
**Scientific Notation**:
A number in the form $\mathbf{a} \times \mathbf{10^{n}}$, where $1 \leq \mathbf{a} < 10$ and **n** is an integer.

Example: $2.3 \times 10^{5}$ Not an example: $.23 \times 10^{5}$

Expressing numbers in scientific notation from standard form:

1. Identify where the decimal point must be placed. Remember that the number must have one single digit in front of the decimal.
2. Count the number of places the decimal point must move to get to the desired location (from 1). This is the exponent, **n.**

   *Note: If the original number has no decimal, then place the original decimal at the far right of the number. Ex. 100 would become 100.
3. If the decimal place must move left, the exponent is positive. If the decimal place must move right, the exponent is negative.
4. Write the number in scientific notation.

**Example 1**: Write 2,400,000 in scientific notation.

1. The decimal must go between the 2 and 4. 2.400000, so a = 2.4
2. The original decimal 2,400,000. had to move 6 places to the left, so n = 6
3. The decimal moved left so n = 6

   The answer is $2.4 \times 10^{6}$ or 2.4E+06.

**Example 2**: Write 0.00435 in scientific notation.

1. The decimal must go between the 4 and 3, so a = 4.35
2. The original decimal had to move 3 places so n = 3.
3. Since the decimal moved 3 places to the right, n = -3

   The answer is $4.35 \times 10^{-3}$ or 4.35E-03.

**Instructor's Script - Comparing and Contrasting**
HVAC technicians need to simplify expressions in practical ways that may be expressed in scientific notation or through the use of convenient prefixes, such as milli, kilo, and micro.

Being able to write numbers in scientific notation allows us to multiply and divide very large numbers or very small numbers that our calculators would otherwise not be able to compute. For example:

$$\frac{(4.5 \times 10^{8})(6.1 \times 10^{-5})}{3.5 \times 10^{-4}} \quad \text{can be re-written as} \quad \frac{(4.5 \times 6.1)(10^{8} \times 10^{-5})}{3.5 \times 10^{-4}}$$

Multiply the numbers in the first parenthesis. To multiply the numbers in the second parenthesis you add the exponents. Be careful with negative exponents (8 + (-5) = 3):

$$\frac{27.45 \times 10^{3}}{3.5 \times 10^{-4}}$$

To finish the division problem, divide 27.45 by 3.5. To divide the powers you subtract the exponents. Be careful with negatives. (3 − (-4) = 3+ 4 = 7)

Answer: $7.84 \times 10^{7}$

**Common Mistakes Made By Students**
**Students will incorrectly place the decimal**. Students forget that once the number is in scientific notation, the number in front of the decimal must be a single digit.

**Students either move the decimal in the wrong direction or incorrectly identify the sign of the exponent**, making it negative when it should be positive and vice-versa.

**Students may forget to enter parenthesis into the calculator when simplifying expressions in scientific notation**.

**CTE Instructor's Extended Discussion**
HVAC instructors should help their students become proficient in working with numbers in as many aspects as possible. The most proficient and successful technicians, engineers and HVAC business owners will be those who are comfortable working with and communicating using numbers and formulas.

Help your students to understand that there is more than one format for displaying scientific notation.

**Examples:**

$3.16 \times 10^{6}$ = 3.16E+06

$2.54 \times 10^{-9}$ = 2.54E-09

| Problems | Occupational (Contextual) Math Concepts | Solutions |
|---|---|---|
| 1. A hospital boiler has a maximum firing rate of 100 gallons per hour (gph) of #2 oil. Each gallon contains 140,000 British Thermal Units (btu's) of energy. How many btu's of heat energy are released if the burner operates on high fire for a full 8 hour shift? Show the btu value using scientific notation. | | |
| 2. One ampere of electrical current is defined as 6,241,509,629,152,650,000 electrons moving past a given point per second. A rough estimate of this number in scientific notation form is $6.24 \times 10^{18}$. If a fan motor amperage is measured at 10 amps, about how many electrons, per second, are flowing through the motor windings? | | |
| 3. Flame rod circuits measure electrical current flowing through a flame. During normal operating conditions, the current will be between 3 and 5 micro-amps (3-5 millionths of an amp). How would that range be written in scientific notation? | | |
| **Problems** | **Related, Generic Math Concepts** | **Solutions** |
| 4. Light travels at a rate of 186,000 miles per second; how far will light travel in one day? | | |
| 5. Express $9.3 \times 10^{7}$ as a number in standard form (this is also the distance between the Sun and the Earth in miles). | | |
| 6. Scientists estimate that there are 326,000,000,000,000,000,000 gallons of water on Earth. Express that number in scientific notation. | | |
| **Problems** | **PA Core Math Look** | **Solutions** |
| 7. Express 3,345,000,000 in scientific notation. | | |
| 8. Express 0.00045 in scientific notation. | | |
| 9. Evaluate the following expression (write your answer in scientific notation): $\frac{(3.25 \times 10^{6})(4.2 \times 10^{-4})}{(2.5 \times 10^{-3})}$ | | |

| Problems | Occupational (Contextual) Math Concepts | Solutions |
|---|---|---|
| 1. | A hospital boiler has a maximum firing rate of 100 gallons per hour (gph) of #2 oil. Each gallon contains 140,000 British Thermal Units (btu's) of energy. How many btu's of heat energy are released if the burner operates on high fire for a full 8 hour shift? Show the btu value using scientific notation. | Total BTU's = btu/hour × hours of operation<br>Total BTU's = 140,000 btu's × 100 × 8<br>Total BTU's = 112,000,000 btu's<br>Total BTU's = 1.12E+08 btu's or $1.12 \times 10^{8}$ btu's |
| 2. | One ampere of electrical current is defined as 6,241,509,629,152,650,000 electrons moving past a given point per second. A rough estimate of this number in scientific notation form is 6.24E+18. If a fan motor amperage is measured at 10 amps, about how many electrons, per second, are flowing through the motor windings? | 10 amps = (6.24E+18) × 10<br>10 amps = 6.24E+19 or $6.24 \times 10^{19}$ electrons/second |
| 3. | Flame rod circuits measure electrical current flowing through a flame. During normal operating conditions, the current will be between 3 and 5 micro-amps (3-5 millionths of an amp). How would that range be written in Scientific Notation? | 3E-6 to 5E-06 amps or $3 \times 10^{-6}$ to $5 \times 10^{-6}$ amps |
| **Problems** | **Related, Generic Math Concepts** | **Solutions** |
| 4. | Light travels at a rate of 186,000 miles per second; how far will light travel in one day? | Miles = 186,000 mps x 60 sec. × 60 min. × 24 hrs.<br>Miles = 16,070,400,000<br>Miles = 1.607E+10 or Miles = $1.607 \times 10^{10}$ |
| 5. | Express $9.3 \times 10^{7}$ as a number in standard form (this is also the distance between the Sun and the Earth in miles). | $9.3 \times 10^{7}$ = 93,000,000 |
| 6. | Scientists estimate that there are 326,000,000,000,000,000,000 gallons of water on Earth. Express that number in Scientific Notation. | 326,000,000,000,000,000,000 = 3.26E+20 or $3.26 \times 10^{20}$ |
| **Problems** | **PA Core Math Look** | **Solutions** |
| 7. | Express 3,345,000,000 in scientific notation. | $3.345 \times 10^{9}$ or 3.345E+09 |
| 8. | Express 0.00045 in scientific notation. | $4.5 \times 10^{-4}$ or 4.5E-04 |
| 9. | Evaluate the following expression (write your answer in scientific notation):<br>$\frac{(3.25 \times 10^{6})(4.2 \times 10^{-4})}{(2.5 \times 10^{-3})}$ | $5.46 \times 10^{5}$ or 5.46E+05 |