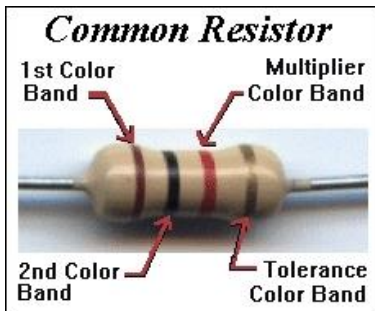


**Decode resistor values = Apply and extend the properties of exponents to solve problems with rational exponents**

**Program Task:** Decode resistor values to diagnosis electrical system problems.

**Program Associated Vocabulary:**  
AMPERES, VOLTS (VOLTAGE), RESISTANCE

**Program Formulas and Procedures:**  
It is important for automotive technicians to properly diagnose electrical system problems. Many devices are solid state and require no servicing, but they must be diagnosed to determine whether or not they are the root cause of a malfunction. Here we'll learn how to diagnose a resistor.



Resistors are electronic components that oppose the flow of electricity and this resistance is measured in ohms. "Color bands" are used to signify the resistance value with each color signifying a number.

The tolerance band must be on your right side when looking at the resistor. The first two bands are related as follows:

**Black 0, Brown 1, Red 2, Orange 3, Yellow 4, Green 5, Blue 6, Violet 7, Gray 8, White 9**

The third color band is the multiplier of the first 2 bands where **Black = 1, Brown = 10, Red = 10<sup>2</sup>, Orange = 10<sup>3</sup>, Yellow 10<sup>4</sup>** and so on.

The 4th color band is the tolerance of the resistor. It shows how precisely the resistor was manufactured.

**Gold = 5%, Silver = 10%.**

Resistor above:  $10 \times 10^2 = 1000$  ohms, 5% tolerances.

**Example 1:** What is resistance for this resistor?

Yellow 4, Violet 7, Orange 10<sup>3</sup>

$47 \times 10^3 = 47,000$  ohms w / 5% tolerance



**Example 2:** What is the total resistance of two resistors in the series:

R1= **Green, Blue, Orange, Gold** + R2= **Red, Violet, Green, Silver**

$$R_1 + R_2 = R_{\text{series}}$$

$$56 \times 10^3 \text{ ohms} + 27 \times 10^5 \text{ ohms} =$$

$$56,000 \text{ ohms} + 2,700,000 \text{ ohms} = 2,756,000 \text{ ohms}$$

$$= 2.756 \times 10^6 \text{ ohms}$$

**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  $a \times 10^n$ , where  $1 \leq a < 10$  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

One of the strengths of using scientific notation is it is a quick way of determining the magnitude of a number. Point out that the magnitude of the resistance value is based on the 3<sup>rd</sup> color band. This value is the power of 10 and can be used to determine if the resistance is small (black band means less than 100 ohms), or if the resistance is quite large (blue means a resistance of hundreds of thousands of ohms).

Resistance values are sometimes indicated with a **k** (4.7k ohms). Note that the k represents thousands of ohms and can be substituted with  $\times 10^3$  470k ohms =  $470 \times 10^3 = 470,000$  ohms =  $4.7 \times 10^5$  ohms

When performing calculations involving scientific notation, students should be encourage to either:

1. Use the scientific notation button on the calculator (often **EE** or **Exp**):

$$4.7 \times 10^3 \text{ TI-30II: } \boxed{4} \boxed{.} \boxed{7} \boxed{EE} \boxed{3}$$

2. Convert numbers to “normal” decimal form, perform calculations, and then convert back to scientific notation.

Calculate the total resistance of resistors **in a series** by adding the individual resistance values:

$$R_{\text{series}} = R_1 + R_2 + R_3 + \dots$$

Calculate the total resistance of resistors **in parallel** by the following formula:

$$R_{\text{parallel}} = \frac{R_1 \times R_2}{R_1 + R_2} \quad \text{This would be a good, advanced problem with scientific notation.}$$

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  $3 - (-4) = 3 + 4 = 7$ :

$$7.84 \times 10^7$$

### 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

The most proficient and successful technicians, engineers, and automotive repair/service business owners will be those who are comfortable working with and communicating using numbers and formulas. Automotive Technology instructors should help their students become proficient in working with numbers in as many aspects as possible

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

**Examples:**

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

$$2.54 \times 10^{-4} = 2.54E-04$$

# Automotive Technology (47.0604) T-Chart

Problems	Career and Technical Math Concepts	Solutions
1. Find the resistance in scientific notation of a resistor with: Band 1 <b>Violet 7</b> ; Band 2 <b>Green 5</b> ; Band 3 <b>Blue 6</b> with a <b>Gold</b> tolerance band.		
2. Find the total resistance in scientific notation of 2-resistors in series:  R1= <b>Orange, White, Gray, Gold</b> & R2 = <b>Blue, Violet, Orange, Silver</b>		
3. The maximum tailpipe emission of a particular exhaust gas is 5PPM. How is this 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? A year?		
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 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	Career and Technical Math Concepts	Solutions
1. Find the resistance in scientific notation of a resistor with: Band 1 <b>Violet 7</b> ; Band 2 <b>Green 5</b> ; Band 3 <b>Blue 6</b> with a <b>Gold</b> tolerance band.		$75 \times 10^6$ or 75,000,000 or 75M ohms w / 5% tolerance
2. Find the total resistance in scientific notation of 2-resistors in series: R1= <b>Orange, White, Gray, Gold</b> & R2 = <b>Blue, Violet, Orange, Silver</b>		$= 39 \times 10^8 + 67 \times 10^3$ $= 3,900,000,000 + 67,000$ $= 3,900,067,000$ $= 3.900067 \times 10^9$
3. The maximum tailpipe emission of a particular exhaust gas is 5PPM. How is this written in scientific notation?		PPM = parts per million $\frac{5}{1,000,000} = 0.000005$ $5 \times 10^{-6}$
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? A year?		Miles / day = $186,000 \text{ mps} \times 60 \text{ sec.} \times 60 \text{ min} \times 24 \text{ hours}$ $= 1.60704 \times 10^{10}$ or 16,070,400,000 miles per day Miles / year = $(1.60704 \times 10^{10}) \times 365$ $= 5.865696 \times 10^{12}$ or 5,865,696,000,000 That's 5 trillion miles!
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 gallons of water on Earth. Express that number in scientific notation.		$326,000,000,000,000,000 = 3.26 \times 10^{20}$ 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):  $\frac{(3.25 \times 10^6)(4.2 \times 10^{-4})}{(2.5 \times 10^{-3})}$		$5.46 \times 10^5$ or 5.46E+05 $\frac{(3.25 \times 10^6)(4.2 \times 10^{-4})}{2.5 \times 10^{-3}} = \frac{(3250000)(0.00042)}{0.0025}$ $= \frac{1365}{0.0025} = 546000 = 5.46 \times 10^5$