

Diagnose electrical system problems = Use reasoning to solve equations and justify the solution method

Program Task: Diagnose electrical system problems.

Program Associated Vocabulary:

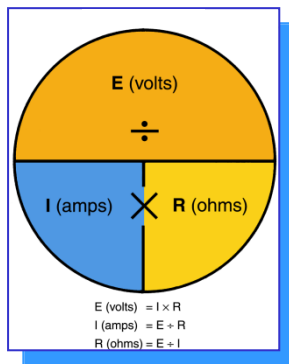
OHMS LAW, OHMS, VOLTS, RESISTANCE, AMPS, CURRENT OR INDUCTIVE FORCE

Program Formulas and Procedures:

Ohm's law states that the electrical current (I) flowing in a circuit is proportional to the voltage (E) and inversely proportional to the resistance (R). The formula can be reorganized so that the relationship can easily be seen for all of the three variables. It takes one Volt to push one Amp through one Ohm of Resistance.

Ohm's Law: $E = I \times R$
 E = Voltage
 I = Current (Amps)
 R = Resistance (Ohms)

$E \text{ (volts)} = I \times R$
 $I \text{ (amps)} = E \div R$
 $R \text{ (ohms)} = E \div I$



Example 1: $6V = 3A \times 2\Omega$

Resistance is inversely proportional to the amperage, and while one goes up, the other must go down (if the voltage stays the same):

$$6V = 2A \times 3\Omega \text{ and } 6V = 3A \times 2\Omega$$

$$\text{and } 2A \times 3\Omega = 3A \times 2\Omega$$

Example 2: How many Amps are pushed through 1.8Ω by 12V?

$$I = \frac{E}{R}$$

$$I = \frac{12V}{1.8\Omega}$$

$$I = 6.67 \text{ A}$$

Example 3: What is the resistance if voltage = 200V and 13 Amps?

$$R = \frac{E}{I}$$

$$R = \frac{200V}{13A}$$

$$R = 15.38\Omega$$

PA Core Standard: CC.2.2.HS.D.9

Description: Use reasoning to solve equations and justify the solution method.

Math Associated Vocabulary:

INVERSE, RECIPROCAL, PROPORTION, CROSS MULTIPLICATION, RATIO, CONSTANT

Formulas and Procedures:

Direct Proportions:

Two quantities, A and B, are directly proportional if by whatever factor A changes, B changes by the same factor.

Example 1: Take the formula, distance = rate x time. If the rate remains constant, at 30 miles per hour, then the time and distance are directly proportional.

$d = 30t$
 when $t = 2$, $d = 60$
 when $t = 4$, $d = 120$

*Note that when the time doubles, so does the distance.

Example 2: If speed is directly proportional to distance, and a car can travel 100 miles at 50 miles per hour, how far can that car travel during the same time if it travels at 70 mph?

Step 1: Set up proportion.

$$\frac{50 \text{ mph}}{70 \text{ mph}} = \frac{100 \text{ mi.}}{x}$$

Step 2: Cross multiply and divide to solve.

$$50x = 70(100) \rightarrow 50x = 7000 \rightarrow x = 140 \text{ miles}$$

Inverse Proportions:

Two quantities, A and B, are inversely proportional if by whatever factor A changes, B changes by the multiplicative inverse, or reciprocal of that factor.

Example 1: Take the formula, distance = rate x time. If the distance, 100 miles is constant, then as the rate increases, the time decreases.

$100 = rt$
 When $r = 100$, $t = 1$
 When $r = 50$, $t = 2$

*Note that when the rate doubles, the time is halved.

Example 2: The time needed to complete a job is inversely proportional to the number of people working. If it takes one person 8 hours to paint the room alone, how long would it take 4 people to paint a room?

Step 1: Set up the proportion. Step 2: Invert (flip) one ratio.

$$\frac{1 \text{ person}}{4 \text{ people}} = \frac{8 \text{ hours}}{x \text{ hours}} \qquad \frac{1 \text{ person}}{4 \text{ people}} = \frac{x \text{ hours}}{8 \text{ hours}}$$

Step 3: Cross-multiply and divide to solve.

$$4x = 8, x = 2$$

4 people can paint the room in 2 hours.

Instructor's Script – Comparing and Contrasting

Understanding direct vs. inverse proportions can be very useful when students are making quick decisions as to how a change in a system may affect the result. For example, knowing that fuel mileage and miles driven are directly proportional means that an increase in miles driven with a single tank of fuel means the fuel mileage must also increase.

Within technical applications, proportional math comes from problems based on a given formula where a value is held steady and two other values are allowed to adjust (in the example above, voltage is being held steady at 6V while amperage rises from 2A to 3A and resistance drops from 3Ω to 2Ω).

It's important that students understand the distinction between direct and inverse. Direct indicates that the 2 values allowed to change in the proportion will go up together or go down together. An inverse proportion indicates the 2 values will change in opposite directions (one higher, one lower).

Common Mistakes Made By Students

When students compare direct and inverse proportional relationships, they may become confused and have difficulty differentiating one from the other. One way to keep them straight is to:

1. Set up one pair of values on the same line, e.g., $\frac{12}{24} = \frac{100 \text{ lbs.}}{x \text{ lbs.}}$
2. Beneath that line, place the other pair of values, $\frac{12}{24} = \frac{100 \text{ lbs.}}{x \text{ lbs.}}$
3. Students need to be aware that direct proportions mean that as one variable increases so does the other variable. An inverse proportion means that one variable increases when the other one decreases. Students struggle with this concept.
4. If the problem is a direct proportion, students should cross multiply (24 times 100) and (12 times x) and then divide to solve the problem.
5. If an inverse relationship exists, then students should first invert one ratio before cross multiplying and dividing to solve the problem.
6. If need be, have the student set up the problem and do it both ways to see which answer makes sense! We know in problem #9, for example, that it won't take 5 rabbits more time than it took 1 rabbit to eat 20 carrots, so it must be an inverse proportion.

CTE Instructor's Extended Discussion

This T-chart focuses on Inverse Proportional relationships; however, there are many examples of Direct Proportional Relationships in Automotive Technology. Other direct and inverse proportion formulas, such as Watt's Law, Pascal's Law, determining HorsePower, etc., are used to aid diagnosis of numerous vehicle systems. However, it is essential, especially when repairing today's sophisticated electrical systems, to understand the properties and how to apply Ohm's Law.

It is important that technical instructors demonstrate to students how these math concepts are relevant in their technical training and that the math is presented in a way which shows a relationship to the math CTE students use in their academic school settings.

Automotive Technology (47.0604) T-Chart

Problems	Career and Technical Math Concepts	Solutions
1. What is the minimum fuse rating needed to protect a circuit with .8 ohms of resistance in a 12V circuit? What fuse rating would be needed if E was changed to 24 volts?		
2. If the current in a circuit is 15 amps and the resistance is 0.4 ohms, what is the voltage? What would be the voltage if the amperage was changed to 45 amps?		
3. Find R when E = 15 volts and I = .2 amps. What would the resistance be if the amperage was changed to 0.4 amps?		
Problems	Related, Generic Math Concepts	Solutions
4. If you need 5 pounds of chicken to serve 20 people, how many pounds will you need to serve 50 people?		
5. The pressure of a gas and its corresponding volume are inversely proportional. If the pressure of 0.24 m ³ is 0.5 atm, what would the pressure be of 0.060 m ³ of the same gas at the same temperature?		
6. If it takes 26 lbs. of metal to make 10 castings, how many pounds of metal will be needed to make 14 castings?		
Problems	PA Core Math Look	Solutions
7. Given that y and x are directly proportional, and y = 2 when x = 5, find the value of y when x = 15.		
8. Given that y and x are inversely proportional, and y = 2 when x = 5, find the value of y when x = 15.		
9. If one rabbit can chew 20 carrots in 15 hours, how long will it take 5 rabbits to chew the same number of carrots?		

Problems	Career and Technical Math Concepts	Solutions
1. What is the minimum fuse rating needed to protect a circuit with .8 ohms of resistance in a 12V circuit? What fuse rating would be needed if E was changed to 24 volts?	$A = E/R$	(Direct: Voltage increase = Amps Increase) $\frac{24}{.8} = \frac{A}{1} = \frac{A \cdot 8}{.8} = A = 30$ $A = 15 \text{ amps}$
2. If the current in a circuit is 15 amps and the resistance is 0.4 ohms, what is the voltage? What would be the voltage if the amperage was changed to 45 amps?	$E = I \times R$	(Direct: Amps Increase = Voltage Increase) $\frac{6V}{15A} = \frac{E}{45A} = \frac{15E}{15} = 18\text{volts}$ $E = 6 \text{ volts}$
3. Find R when E = 15 volts and I = .2 amps. What would the resistance be if the amperage was changed to 0.4 amps?	$R = E/I$	(Inverse: Resistance Decrease = Amps Increase) $\frac{75\text{ohms}}{.4\text{amps}} = \frac{R}{.2\text{amps}} = \frac{.4R}{.4} = 37.5\text{ohms}$ $R = 75 \text{ ohms}$
Problems	Related, Generic Math Concepts	Solutions
4. If you need 5 pounds of chicken to serve 20 people, how many pounds will you need to serve 50 people?		(Direct) $\frac{5 \text{ pounds}}{20 \text{ people}} = \frac{x \text{ pounds}}{50 \text{ people}} \rightarrow 20x = 5(50) \rightarrow 20x = 250$ $x = 12.5 \text{ pounds}$
5. The pressure of a gas and its corresponding volume are inversely proportional. If the pressure of 0.24 m ³ is 0.5 atm, what would the pressure be of 0.060 m ³ of the same gas at the same temperature?		(Inverse) $\frac{0.24 \text{ m}^3}{0.060 \text{ m}^3} = \frac{0.5 \text{ atm}}{x \text{ atm}}$ (Invert one ratio since it is an inverse proportion.) $\frac{0.24 \text{ m}^3}{0.060 \text{ m}^3} = \frac{x \text{ atm}}{0.5 \text{ atm}} \rightarrow 0.060x = (0.24)(0.5) \rightarrow x = 2 \text{ atm}$
6. If it takes 26 lbs. of metal to make 10 castings, how many pounds of metal will be needed to make 14 castings?		(Direct) $\frac{10 \text{ castings}}{14 \text{ castings}} = \frac{26 \text{ lbs.}}{x \text{ lbs.}} \rightarrow 10x = 26(14) \rightarrow x = 36.4 \text{ lbs.}$
Problems	PA Core Math Look	Solutions
7. Given that y and x are directly proportional, and y = 2 when x = 5, find the value of y when x = 15.		(Direct) $\frac{5}{15} = \frac{2}{y} \rightarrow 5y = 2(15) \rightarrow y = 6$
8. Given that y and x are inversely proportional, and y = 2 when x = 5, find the value of y when x = 15.		(Inverse) $\frac{5}{15} = \frac{y}{2} \rightarrow 15y = 2(5) \rightarrow y = 0.667$
9. If one rabbit can chew 20 carrots in 15 hours, how long will it take 5 rabbits to chew the same number of carrots?		(Inverse) $\frac{1}{5} = \frac{x}{15} \rightarrow 5x = 1(15) \rightarrow x = 3 \text{ hours}$