Electrical Power & Transmission Installers (46.0399) T-Chart

Multiple Use of Power Formula –Inverse and Direct Applications	=	Use units as a way to understand and solve problems

Program Task: Using various power formulas, solve for missing variables based on known values and show metric conversions into similar units of power. The power formula is a great example of indirect and direct proportional relationships.

Program Associated Vocabulary
CIRCUIT, VOLTAGE(V), RESISTANCE(R), OHMS(Ω), WATTS, METRIC UNITS, CURRENT-AMPS(I)

Program Formulas and Procedures
It is important for students to learn how to determine what items in an electrical scenario are necessary for electricians to obtain valid information for themselves and for any questions that arise from superiors or customers. Electricians must be able to pull power formula information from a real world application and determine quickly the equation needed to obtain the information required by the asking party.

Example:

A heating coil in a DC circuit dissipates 1.2 kW of power. The circuit that runs through the heating coil is 10 amps. As an electrician, you need to determine the resistance of the coil and also solve for the voltage drop across the coil. The customer would also like to know the energy consumption in a 4 hour time period (kWh). Round your answer to the nearest whole number.

Step 1: Determine the formula needed for Resistance of coil

Given: 1.2 kW = Power (P) ------ 10 Amps (I)

Need to find: Resistance (R) of coil.

Formula: $R=\frac{P}{I^2}$

Step 2: Solve for Resistance (Remember to first convert to all same units.)

$1.2\text{ kW} = 1200\text{W}\left(\text{kW to W you need to multiply by 1000}\right)$

$R=\frac{P}{I^2} \rightarrow R=\frac{1200W}{(10)^2}=12\,\Omega$

Step 3: Determine the formula and solve for the voltage drop.

Given: Resistance = 12Ω Power = 1200W

Need to find: Voltage Drop(V)

$V=\sqrt{PR} \quad (\mathit{Formula})$

$\sqrt{1200(12)}=\sqrt{14400}=120\,V$

Step 4: Find the energy consumption in 4 hours.

Energy = PT = (1.2kW)(4 hours) = 4.8 kWh

PA Core Standard: CC.2.1.HS.F.4 Use units to understand and solve multi-step problems.

Description: Use units as a way to understand problems and to guide the solution of multi-step problems.

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, 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 70 mph?

Step 1: Set up proportion.

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

Step 2: Cross multiply and divide to solve.

50x=70(100) → 50x = 7000 → x = 140 miles

Indirect 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 is constant, 100 miles, 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: If the time needed to complete a job is inversely proportional to the number of people working, how long would it take 4 people to paint a room if 1 person needs 8 hours?

Step 1: Set up the proportion.

$$\frac{1person}{4people}=\frac{8hours}{xhours}$$

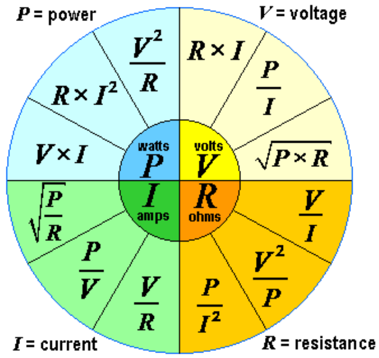
Step 2: Invert (flipA) one ratio

$$\frac{1person}{4people}=\frac{xhours}{8hours}$$

Step 3: Cross-multiply and divide to solve
4x=8, x = 2 4 people can paint the room in 2 hours.

Teacher's Script - Comparing and Contrasting

Indirect and direct proportional relationships are important when working with all forms of equations, both in the electrical environment and in other real world applications. The Power Equation is an integral part of an electrical program. Knowledge of how to read a chart such as this one is important in solving key equations in the program. Not only is it important mathematically to solve the equations, but it is important to know how to obtain the information from what is given in the problem/situation and be able to choose the correct formula/application needed to solve the problem.



Direct proportions basically mean that when one factor changes (increases) the other factor does the same (increases). It relates directly to the others actions.

Indirect proportions basically mean that when one factor changes (increases) the other factor does the opposite (decreases). It relates indirectly to the way the other one reacts.

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.

<u>Students don’t set up the relation correctly and compare and analyze the results.</u>

Example: If you have an electrician working on a job for 6 hours, how long will it take for 2 electricians to work on this same job?

You choose: $\frac{1\text{ electrician}}{2\text{ electricians}}=\frac{6\text{ hours}}{x\text{ hours}}$ 12=x hours x=12 hours

Now – ask yourself, “Does this make sense?” The answer should be, “If I add an electrician to help work at this job, then the hours should <u>decrease</u>. In this problem they <u>increased</u>. It is an indirect proportion, so I need to flip and solve:

$\frac{1\text{ electrician}}{2\text{ electricians}}=\frac{x\text{ hours}}{6\text{ hours}}$ 6=2x hours x=3 hours Now say, “One electrician takes 6 hours, if I add a second electrician it takes 3 hours.” This makes sense.

<u>Choosing information from a written situation:</u>

Many students do not read and “pull out” information from the problem correctly. This is something that every teacher could work on with any situation. Many students know how to “do the math”, but if the problem is not set up properly or the information is not correct, the math is irrelevant.

Lab Teacher's Extended Discussion

The Power Equation is the basis for many of electrical applications, from circuits to transformers to basic energy efficiency. Students need to be aware of practical common sense answers if the mathamatical answer does not make sense to them. By being aware of this, students will learn to use their judgement and avoid costly, as well as life threatening errors.

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Problems	Occupational (Contextual) Math Concepts Solutions
1. In 2011, the average household used 940 kilowatt-hours (kWh) per month. What would this be in terms of joules (J)? (1 kWh = 3.600×10^6)	
2. The voltage in a circuit is measured at 3.8 kV. The current is at 4.2 A. What is the power in the circuit in kW?	
3. There is a DC circuit with a battery and a bulb whose resistance is 70 Ω and whose power if 12 W. Find the current of this circuit in milliamps.	
Problems	**Related Generic Math Concepts Solutions**
4. If it takes 12 eggs to make 1 dozen, how many eggs will be needed to make 9 dozen?	
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 20 carrots?	

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Problems	Occupational (Contextual) Math Concepts Solutions
1. In 2011, the average household used 940 kilowatt-hours (kWh) per month. What would this be in terms of joules (J)? (1 kWh = 3.600 x 10^6)	$940k\cancel{Wh}\left(\frac{3.600x10^6}{1k\cancel{Wh}}\right) = 3.384x10^9 J$ (Direct)
2. The voltage in a circuit is measured at 3.8 kV. The current is at 4.2 A. What is the power in the circuit in kW?	$\frac{3.8\text{ kV}}{1} \text{ x } \frac{1000V}{1kV}$ =3800V Must have similar units. $\text{Power}(W) = \text{Volts}(V) \text{ x Current } (I)$ Power(W)= 3800 x 4.2=15,960W ≈ 16kW (1,000W per kW)
3. There is a DC circuit with a battery and a bulb whose resistance is 70 Ω and whose power if 12 W. Find the current of this circuit in milliamps.	$I(\text{Current})=\sqrt{\frac{P}{R}} = \sqrt{\frac{12}{70}}$ » .4140 amps» 414mA Direct-As power increases, current increases. Indirect-As resistance increases, current decreases.
Problems	**Related, Generic Math Concepts Solutions**
4. If it takes 12 eggs to make 1 dozen, how many eggs will be needed to make 9 dozen?	**(Direct)** $\frac{12eggs}{xeggs} = \frac{1dozen.}{9dozen} \rightarrow 1x = 12(9) \rightarrow x = 108eggs$
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)** $\frac{0.24m^3}{0.060m^3} = \frac{0.5atm}{xatm}$ (Invert one ratio since it's an inverse proportion.) $\frac{0.24m^3}{0.060m^3} = \frac{xatm}{0.5atm} \rightarrow 0.24(0.5) = 0.060x \rightarrow x = 2atm.$
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)** $\frac{10castings}{14castings} = \frac{26lbs.}{xlbs.} \rightarrow 10x = 26(14) \rightarrow x = 36.4lbs.$
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 20 carrots?	**(Inverse)** $\frac{1}{5} = \frac{x}{15} \rightarrow 5x = 1(15) \rightarrow x = 3$ hours