**Program Task:** Identify the relationship between primary and secondary turns, primary and secondary voltage, and primary and secondary currents.

**Program Associated Vocabulary**
PRIMARY WINDING, SECONDARY WINDING, 
TURNS, CURRENT (or AMPERAGE), RATIO, 
VOLTAGE, VOLTAMPS (VA) RATING

**Program Formulas and Procedures**
A transformer is an electrical device that transforms an applied voltage to a higher or lower output voltage. The voltage in:out ratio is equal to the ratio of turns in the windings (primary:secondary).

\[ V_2 = V_1 \left(\frac{N_2}{N_1}\right) \]

**Math Associated Vocabulary**
INVERSE, RECIPROCAL, PROPORTION, CROSS MULTIPLICATION, RATIO, CONSTANT

**Program 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.

\[ d = 30t \]

\[ \text{when } t = 2, d = 60 \]
\[ \text{when } t = 4, d = 120 \]

**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?

**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.

**Example 2:** 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?

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<table>
<thead>
<tr>
<th>Determine transformer calculations</th>
<th>Use reasoning to solve equations and justify the solution method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PA Core Standard:</strong> CC.2.2.HS.D.9</td>
<td><strong>Description:</strong> Use reasoning to solve equations and justify the solution method.</td>
</tr>
<tr>
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</tr>
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<td></td>
</tr>
</tbody>
</table>

**Program Formulas and Procedures**

**Example 1:** A transformer has 300 turns in the primary, 50 turns in the secondary, and 120 volts applied to the primary. What is the voltage of the secondary?

**Example 2:** A transformer has 300 turns in the primary, 50 turns in the secondary, and 1.2 amperes applied to the primary. What is the current of the secondary?

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**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 \( t = 4, d = 120 \)

**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.

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

**Step 2:** Cross multiply and divide to solve.

\[ 50x = 7000 \rightarrow x = 140 \text{ miles} \]

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

**Example 2:** 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 proportion.

\[ \frac{1\text{ person}}{4\text{ people}} = \frac{8\text{ hours}}{x \text{ hours}} \]

**Step 2:** Invert (flip) one ratio.

\[ \frac{1\text{ person}}{4\text{ people}} = \frac{x \text{ hours}}{8\text{ hours}} \]

**Step 3:** Cross multiply and divide to solve.

\[ 4x = 8, x = 2 \]

4 people can paint the room in 2 hours.
Teacher's Script - Comparing and Contrasting
Transformers provide a real-world example of direct and inverse proportional relationships at work.

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., \(12'' = 100 \text{ lbs}\) (from problem #1)
2. Beneath that line, place the other pair of values, \(24'' \times x \text{ lbs}\).
3. Cross multiply (24 times 100) and (12 times x), but first determine if you have to invert one ratio.
4. If you have to invert one ratio, then it is an inverse proportion.
5. If need be, 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.

Lab Teacher's Extended Discussion
None
### Electro Mechanical Mechatronics (15.0403) T-Chart

#### Problems | Occupational (Contextual) Math Concepts | Solutions
---|---|---
1. I have a primary input of 120v and 161 turns; the secondary is 88 turns. What is the secondary voltage?  
2. Given a primary voltage of 120 volts, a primary current of 7.5 Amperes, and a secondary voltage of 16, find the current.  
3. Given a primary voltage of 120 volts, a primary current of 7.5 Amperes, and secondary amperage of 45 amps, find the secondary voltage.

#### 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 (atmospheres), 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?
### Problems | Occupational (Contextual) Math Concepts | Solutions
--- | --- | ---
1. I have a primary input of 120v and 161 turns; the secondary is 88 turns. What is the secondary voltage? | *turns and voltage are directly proportional<br>Step 1: Set up the proportion<br>\[
\frac{120 \text{ volts}}{x} = \frac{161 \text{ turns}}{88 \text{ turns}}
\] <br>Step 2: Cross-multiply and divide to solve<br>\[
120(88) = 161x \quad \rightarrow \quad x = 65.6 \text{ Volts}
\] | 
2. Given a primary voltage of 120 volts, a primary current of 7.5 Amperes, and a secondary voltage of 16, find the current. | *voltage and current are inversely proportional<br>Step 1: Set up the proportion<br>Step 2: Invert one ratio<br>Step 3: Cross-multiply and divide to solve<br>\[
\frac{120 \text{ volts}}{16 \text{ volts}} = \frac{7.5 \text{ Amps}}{x \text{ Amps}}
\] <br>\[
120(7.5) = 16x \quad \rightarrow \quad x = 56.25 \text{ Amps}
\] | 
3. Given a primary voltage of 120 volts, a primary current of 7.5 Amperes, and secondary amperage of 45 amps, find the secondary voltage. | *voltage and current are inversely proportional<br>Step 1: Set up the proportion<br>Step 2: Invert one ratio<br>Step 3: Cross-multiply and divide to solve<br>\[
\frac{120 \text{ volts}}{45 \text{ Amps}} = \frac{7.5 \text{ Amps}}{x \text{ Amps}}
\] <br>\[
120(7.5) = 45x \quad \rightarrow \quad x = 20 \text{ volts}
\] | 
4. If it takes 12 eggs to make 1 dozen, how many eggs will be needed to make 9 dozen? | (Direct)<br>\[
\frac{12 \text{ eggs}}{x \text{ eggs}} = \frac{1 \text{ dozen}}{9 \text{ dozen}} \quad \rightarrow \quad 1x = 12(9) \quad \rightarrow \quad x = 108 \text{ eggs}
\] | 
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 (atmospheres), what would the pressure be of 0.060 m\(^3\) of the same gas at the same temperature? | (Inverse)<br>\[
\frac{0.24 \text{ m}^3}{0.060 \text{ m}^3} = \frac{0.5 \text{ atm}}{x \text{ atm}}
\] <br>\[
0.24(0.5) = 0.060x \quad \rightarrow \quad x = 2 \text{ atm}
\] | 
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)<br>\[
\frac{10 \text{ castings}}{14 \text{ castings}} = \frac{26 \text{ lbs.}}{x \text{ lbs.}} \quad \rightarrow \quad 10x = 26(14) \quad \rightarrow \quad x = 36.4 \text{ lbs}
\] | 
7. Given that y and x are directly proportional and y = 2 when x = 5, find the value of y when x = 15. | (Direct)<br>\[
\frac{5}{15} = \frac{2}{y} \quad \rightarrow \quad 5y = 2(15) \quad \rightarrow \quad y = 6
\] | 
8. Given that y and x are inversely proportional and y = 2 when x = 5, find the value of y when x = 15. | (Inverse)<br>\[
\frac{5}{15} = \frac{y}{2} \quad \rightarrow \quad 15y = 2(5) \quad \rightarrow \quad y = 0.667
\] | 
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)<br>\[
\frac{1}{5} = \frac{x}{15} \quad \rightarrow \quad 5x = 1(15) \quad \rightarrow \quad x = 3 \text{ hours}
\] |