Precision Machining (48.0599) T-Chart

Mixing Rates = Use units as a way to understand and solve problems

Program Task: Mix cutting fluid for the CNC lathe

Program Associated Vocabulary
RATIO, CONCENTRATE, MIXING RATE

Program Formulas and Procedures
Learning how to mix cutting fluid for a CNC lathe is part of learning how to use the machine. The concentrates are often expensive so it's important not to use too much. Using too little can cause damage to equipment and machined parts. Rich mixtures waste expensive coolant concentrates.

Example of a CNC lathe

Directions for mixing these concentrates come in the form of ratios like 50:1, which means add 1 unit concentrate to 50 units water.

Example:
The mixing rate for cutting fluid concentrate for the CNC lathe is 50:1. How many ounces of the concentrate must be added to 20 quarts of water?

Step 1: Identify conversion you need in the problem.

32 oz. = 1 qt.

Step 2: Set up the equation and solve.

$$\frac{20\ qt.water}{1} \times \frac{1\ qt.conc.}{50\ qt.water} \times \frac{32\ oz.conc.}{1\ qt.conc.} = 12.8\ oz.conc.$$

PA Core Standard: CC.2.1.HS.F.4

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

Math Associated Vocabulary
RATE, PERCENT, DECIMAL, PROPORTION, RATIO, DIMENSIONAL/UNIT ANALYSIS

Formulas and Procedures
Dimensional or Unit Analysis can be used to solve problems using operations because by analyzing the units, one can determine whether or not the equation was set up correctly.

Basic Steps:
1. Determine the unit given and the unit needed (answer).
2. Write the number with the unit you are given as a fraction over one on the left hand side and write an equal sign followed by the unit you need on the far right hand side.
3. Multiply by the rates you are given or conversion factors (write as fractions), making sure that the unit that was given (in numerator) is also on the bottom (denominator) of the given rate or conversion factor.
4. Remember, units cancel out just like numbers do! Continue to multiply by rates or conversion factors until the unit needed is the only unit that does not cancel.
5. Perform the indicated operations.

Example 1: A snail can crawl 13 feet in 2.5 hours. How far can it crawl in 240 minutes?

1. unit given = 240 minutes, unit needed = feet
2. $\frac{240\,\text{min}}{1}$ = feet
3. $\frac{240\,\text{min}}{1} \bullet \frac{1hr}{60\,\text{min}} \bullet \frac{13\,feet}{2.5hrs}$ = feet
4. $\frac{240\,\cancel{\text{min}}}{1} \bullet \frac{1\cancel{hr}}{60\,\cancel{\text{min}}} \bullet \frac{13\,feet}{2.5\cancel{hrs}}$ = feet
5. $\frac{240(1)(13)\,ft}{(1)(60)(2.5)} = 20.8\,ft$

Example 2: A savings account earns a simple interest rate of 3% per year over 12 years. If $3,000 is invested, how much interest will the account earn?

$$\frac{\$3{,}000}{1} \bullet \frac{.03}{1yr} \bullet \frac{12\,yrs}{1} = \$1{,}080$$

Teacher's Script - Comparing and Contrasting

The example shown on the Machining side of the T-chart demonstrates how dimensional (or unit) analysis is used to complete calculations and conversions. This problem can also be completed by breaking the process into two steps: finding the amount of concentrate in quarts and then converting that to ounces.

The eligible content item appears to be similar to CC.2.1.HS.F.3 but there is a slight difference. Although this eligible content item can include proportional relationships, because the ratio itself is often a "rate", this eligible content item includes any operation using a rate or multiple rates and is often more complex.

Common Mistakes Made By Students

Use of incorrect conversion factors or omission of essential conversion factors.

For instance, in the problem shown below, a conversion factor (60 minutes = 1 hour) was omitted from the solution.

If you have 500 tasks to complete and each task takes 3 minutes, how many hours will it take to complete all of the tasks?

$$\frac{500\ tasks}{\mathbf{1}} \times \frac{3\ minutes}{1\ task} = 1500\ minutes$$

Incorrectly setting up the problem.

For instance, in the problem shown below, the problem has been set up incorrectly. Instead of starting with the 500 tasks, the solution begins with the conversion factor.

If you have 500 tasks to complete and each task takes 3 minutes, how many hours will it take to complete all of the tasks?

$$\frac{1\ tasks}{3\ min} \times \frac{\mathbf{1}}{500\ tasks} = \frac{\mathbf{1}}{1500\ minutes}$$

Lab Teacher's Extended Discussion

The primary functions of cutting fluids in machining are:

- Lubricating the cutting process primarily at low cutting speeds
- Cooling the work piece primarily at high cutting speeds
- Flushing chips away from the cutting zone

A machinist must mix these fluids accurately in order to save the employer money and time. Also, since fluids relate to the overall machine performance, any error on the mixing ratio could result in major machine maintenance or even irreparable damage. Environmental hazards may result if the fluid is over-concentrated. The application of proper mathematical ratios is important. Any machinist who wants to become a manager or supervisor in his field must apply the basic concepts of ratios and proportions.

Precision Machining (48.0599) T-Chart

Problems	Occupational (Contextual) Math Concepts	Solutions
1. The mixing rate for cutting fluid concentrate for the CNC lathe is 50:1. How many ounces of the concentrate must be added to 10 quarts of water?		
2. A new kind of cutting fluid concentrate requires only a 45:1 ratio of water to concentrate. How many ounces of the concentrate must be added to 5 quarts of water?		
3. The mixing rate for cutting fluid concentrate for the CNC lathe is 45:1. How many quarts of water should be added to 8 ounces of concentrate?		
Problems	**Related, Generic Math Concepts**	**Solutions**
4. Since work equals force times distance, lifting 4 pounds (force) 5 feet off the ground (distance) equals 20 foot-pounds of work. If the same amount of work is applied to 10 pounds, how many feet off the ground will it be lifted?		
5. A worker has 6 gallons of a solution that is 50% water. If she adds one gallon of water, what is the new percentage of water in the solution?		
6. A worker unloads 9 crates every 36 minutes and is paid $2 per crate. How much money does he make in an 8 hour shift?		
Problems	**PA Core Math Look**	**Solutions**
7. Kathy and John are helping to create party favors for the school dance. Kathy can create 30 in one hour and Joe can create 40 in two hours. At that rate, how long will it take to create 500 party favors?		
8. Two trucks are plowing snow and moving in opposite directions. The first truck can plow snow at 23 mph and the other can plow at 17 mph. How long will it take them to plow 200 miles of road?		
9. A fuel-efficient car can drive 35 miles per gallon of gas. If the cost of gas is $3.97 per gallon, how much will it cost to make a 485-mile trip?		

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Problems	Occupational (Contextual) Math Concepts	Solutions
1. The mixing rate for cutting fluid concentrate for the CNC lathe is 50:1. How many ounces of the concentrate must be added to 10 quarts of water?	$\frac{10\ qt.water}{1} \times \frac{1\ qt.conc.}{50\ qt.water} \times \frac{32\ oz.conc.}{1\ qt.conc.} = 6.4\ oz.conc.$ Note: 32 oz. = 1 qt.	
2. A new kind of cutting fluid concentrate requires only a 45:1 ratio of water to concentrate. How many ounces of the concentrate must be added to 5 quarts of water?	$\frac{5\ qt.water}{1} \times \frac{1\ qt.conc.}{45\ qt.water} \times \frac{32\ oz.conc.}{1\ qt.conc.} = 3.6\ oz.conc.$ Note: 32 oz. = 1 qt.	
3. The mixing rate for cutting fluid concentrate for the CNC lathe is 45:1. How many quarts of water should be added to 8 ounces of concentrate?	$\frac{8\ oz.conc.}{1} x \frac{45\ oz.water}{1\ oz.conc.} x \frac{1\ qt.water}{32\ oz.water} = 11.25\ qts\ of\ water$ Note: 32 oz. = 1 qt.	
Problems	**Related, Generic Math Concepts**	**Solutions**
4. Since work equals force times distance, lifting 4 pounds (force) 5 feet off the ground (distance) equals 20 foot-pounds of work. If the same amount of work is applied to 10 pounds, how many feet off the ground will it be lifted?	20 foot-pounds / 10 pounds = 2 feet (distance)	
5. A worker has 6 gallons of a solution that is 50% water. If she adds one gallon of water, what is the new percentage of water in the solution?	6 * 0.5 = 3 gallons of water in original solution 6 + 1 = 7 total gallons in new solution 3 + 1 = 4 known gallons of water in new solution 4 / 7 = 57% water in new solution	
6. A worker unloads 9 crates every 36 minutes and is paid $2 per crate. How much money does he make in an 8 hour shift?	$\frac{8hrs}{1} \bullet \frac{60\min}{1hr} \bullet \frac{9crates}{36\min} \bullet \frac{\$2}{1crate} = \$240$	
Problems	**PA Core Math Look**	**Solutions**
7. Kathy and John are helping to create party favors for the school dance. Kathy can create 30 in one hour and Joe can create 40 in two hours. At that rate, how long will it take to create 500 party favors?	$\frac{40\,pf}{2hr} = \frac{20\,pf}{1hr}$, total rate = $\frac{20\,pf}{1hr} + \frac{30\,pf}{1hr} = \frac{50\,pf}{1hr}$ $\frac{500\,pf}{1} \bullet \frac{1hr}{50\,pf} = 10hrs$	
8. Two trucks are plowing snow and moving in opposite directions. The first truck can plow snow at 23 mph and the other can plow at 17 mph. How long will it take them to plow 200 miles of road?	Rate 1 + rate 2 = 23mph + 17mph = 40 mph $\frac{200miles}{1} \bullet \frac{1hour}{40miles} = 5hours$	
9. A fuel-efficient car can drive 35 miles per gallon of gas. If the cost of gas is $3.97 per gallon, how much will it cost to make a 485-mile trip?	$\frac{485miles}{1} \bullet \frac{1gallon}{35miles} \bullet \frac{\$3.97}{1gallon} = \$55.01$	