Machine Tool Technology (48.0501) T-Chart

Calculate mixture amounts	=	Use units as a way to understand problems and to guide the solution of multi-step problems

Program Task: Use cutting fluids.

Program Associated Vocabulary:
LEAN, MIXTURE, PROPORTION, RATIO, RATE, RICH

Program Formulas and Procedures:
Mixing cutting fluid concentrates is common in the machining field. Correct mixture rates ensure proper performance characteristics. Lean mixtures can cause damage to equipment and machined parts. Rich mixtures waste expensive coolant concentrates.

Mixture rates or ratios can exist in different formats:

- 50:1 means add 1 unit concentrate to 50 units of water.
- Add 1 ounce concentrate to 1 quart water.

Example 1:
For a 25:1 (water:concentrate) mixture rate how many *ounces* of concentrate must be added to 2 *gallons* of water?

$$\frac{2\,\text{gal. water}}{1} \times \frac{128\,\text{oz.}}{1\,\text{gal.}} \times \frac{1}{25} = 10.24\,\text{ounces of concentrate}$$

The first part converts the gallons to ounces and then the second step utilizes the mixing ratio.

Example 2:
How many ounces of coolant concentrate needs to be added to 10 gallons of water if the mixture rate is 2 ounces of concentrate per 1 quart water?

$$\frac{10\,\text{gal. water}}{1} \times \frac{4\,\text{qt.}}{1\,\text{gal.}} \times \frac{2\,\text{ounces}}{1\,\text{qt. water}} = 80\,\text{ounces of concentrate}$$

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 to answer the question.
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: 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. $\frac{240\,\text{min.}}{1} \text{ x } \frac{1\text{hr.}}{60\,\text{min.}} \text{ x } \frac{13\,\text{feet}}{2.5\,\text{hrs.}}$ = feet
4. $\frac{240\,\cancel{\text{min.}}}{1} \text{ x } \frac{1\,\cancel{\text{hr.}}}{60\,\cancel{\text{min.}}} \text{ x } \frac{13\,\text{feet}}{2.5\,\cancel{\text{hrs.}}}$ = feet
5. $\frac{240(1)(13)\text{ft.}}{(1)(60)(2.5)} = 20.8\,\text{ft.}$

Instructor's Script – Comparing and Contrasting
It is important to use unit analysis to determine how to do conversions. Often students ask what operation to use. If you understand unit analysis you do not need to ask that question. You can set the problem up and be able to determine the correct operation by looking at the units.

Once you understand how to set up and solve unit analysis problems, there are thousands of applications. There are examples of unit analysis in every trade area.

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.

What is 60 miles per hour in feet per second?

$$\frac{60\text{ miles}}{1\text{ hour}} \text{ x } \frac{5280\text{ feet}}{1\text{ mile}} \text{ x } \frac{1\text{ minute}}{60\text{ seconds}}$$

Incorrectly setting up the problem:
For instance, in the problem shown below, the problem has been set up incorrectly. Instead of starting with the 60 miles per hour, the solution begins with the conversion factor.

What is 60 miles per hour in feet per second?

$$\frac{1\text{ mile}}{5280\text{ feet}} \text{ x } \frac{1\text{ hour}}{60\text{ miles}} \text{ x } \frac{60\text{ minutes}}{1\text{ hour}} \text{ x } \frac{60\text{ seconds}}{1\text{ minute}} = \frac{1}{88}\text{ feet}$$

CTE Instructor's Extended Discussion
Mixture ratios or rates can be listed in different formats including:
- Ratio form such as 20:1, 40:1, 50:1
- Ounces per quart
- Ounces per gallon

Desired output units can vary as well, and may include ounces, quarts, or gallons depending on the application.

Care must be taken to use the proper conversion factor because if coolant mixtures are grossly incorrect, expensive damage to equipment and product can result and/or great waste of expensive concentrates can occur. For example, if an ounce to gallon conversion error is made, the mixture may be either 128 times too rich or too lean.

In other topical areas it may be required to use more than one conversion factor to gain desired output units.

Example: The formula for calculating machining time on the lathe is $T\text{ (in minutes)} = \frac{\text{Length (in inches)}}{\left(\frac{\text{Revolutions}}{\text{Minute}} \text{ x } \frac{\text{Inches}}{\text{Revolution}}\right)}$

Cut a 3' diameter 2 ***feet*** long at 50 RPM using a feedrate of .005 IPR. How many ***hours*** will it take to perform the cut?

$$T = \frac{2\text{ feet}}{50\text{ RPM x }.005\text{ IPR}} \rightarrow T = \frac{2\text{ feet}}{\frac{50\text{ rev.}}{1\text{ min.}} \text{ x } \frac{.005\text{ in.}}{1\text{ rev.}}} \rightarrow T = \frac{2\text{ feet}}{\frac{.25\text{ in.}}{1\text{ min.}}} \rightarrow \frac{2\text{ ft.}}{1} \div \frac{.25\text{ in.}}{1\text{ min.}} \rightarrow T = \frac{2\text{ ft.}}{1} \text{ x } \frac{1\text{ min.}}{.25\text{ in.}}$$

Use conversion factors to convert feet to inches and minutes to hours.

$$T = \frac{2\text{ ft.}}{1} \text{ x } \frac{1\text{ min.}}{.25\text{ in.}} \text{ x } \frac{12\text{ in.}}{1\text{ ft.}} \text{ x } \frac{1\text{ hr.}}{60\text{ min.}} = \frac{24}{15} = 1.6\text{ Hours}$$

Problems	Career and Technical Math Concepts	Solutions
1. The surface grinder coolant concentrate is to be mixed at a rate of 1 ounce per 1 quart of water. How many ounces of concentrate are needed for 3 gallons of water?		
2. 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?		
3. You are turning an 8' diameter shaft that is 24' long at 16 RPM using a feed rate of .015 IPR. Machining time can be calculated by the formula $$T \text{ (in minutes)} = \frac{\text{Length (in inches)}}{\left(\frac{\text{Revolutions}}{\text{Minute}} \text{ x} \frac{\text{Inches}}{\text{Revolution}}\right)}$$ How many hours will it take to complete this cutting pass?		
Problems	**Related, Generic Math Concepts**	**Solutions**
4. One milliliter of ink can print 50 pages of text. If you have 10 gallons, how many pages can you print? (1 gallon = 3.79 L)		
5. Sandy is traveling at 97 km. on 102 minutes. What is her speed in miles per hour if 1 mile = 1.6 km.?		
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 John 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?		

Machine Tool Technology (48.0501) T-Chart

Problems	Career and Technical Math Concepts	Solutions
1. The surface grinder coolant concentrate is to be mixed at a rate of 1 ounce per 1 quart of water. How many ounces of concentrate are needed for 3 gallons of water?		$\frac{3\,\text{gal.}}{1} \times \frac{4\,\text{qt.}}{1\,\text{gal.}} \times \frac{1\,\text{oz.}}{1\,\text{qt.}} = 12\,\text{oz.}$ 12 oz. of concentrate, 3 gallons of water
2. The mixing rate for cutting fluid concentrate for the CNC lathe is 50:1(water:concentrate). How many ounces of the concentrate must be added to 20 quarts of water?		$\frac{20\,\text{qt.}}{1} \times \frac{32\,\text{oz.}}{1\,\text{qt.}} \times \frac{1}{50} = 12.8\,\text{oz.}$ 12.8 oz. of concentrate, 20 quarts of water
3. You are turning an 8' diameter shaft that is 24' long at 16 RPM using a feed rate of .015 IPR. Machining time can be calculated by the formula $\text{T (in minutes)} = \frac{\text{Length (in inches)}}{\left(\frac{\text{Revolutions}}{\text{Minute}} \text{ x } \frac{\text{Inches}}{\text{Revolution}}\right)}$ How many hours will it take to complete this cutting pass?		$\frac{24\,\text{ft.}}{1} \times \frac{12\,\text{in.}}{1\,\text{ft.}} \times \frac{1\,\text{revolution}}{0.015\,\text{in.}} \times \frac{1\,\text{min.}}{16\,\text{revolutions}} = 1200\,\text{min.}$ $\frac{1200\,\text{min.}}{1} \times \frac{1\,\text{hour}}{60\,\text{min.}} = \frac{1200}{60} = 20\,\text{hours}$
Problems	**Related, Generic Math Concepts**	**Solutions**
4. One milliliter of ink can print 50 pages of text. If you have 10 gallons, how many pages can you print? (1 gallon = 3.79 L)		$\frac{10\,\text{gallons}}{1} \text{ x } \frac{3.79\,\text{liters}}{1\,\text{gallon}} \text{ x } \frac{1000\,\text{ml.}}{1\,\text{liter}} \text{ x } \frac{50\,\text{pages}}{1\,\text{ml.}} =$ 1,895,000 pages
5. Sandy is traveling at 97 km. on 102 minutes. What is her speed in miles per hour if 1 mile = 1.6 km.?		$\frac{97\,\text{km.}}{102\,\text{min.}} \text{ x } \frac{1\,\text{mile}}{1.6\,\text{km.}} \text{ x } \frac{60\,\text{min.}}{1\,\text{hr.}} = 35\,\text{miles per hour}$
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?		$\frac{8\,\text{hrs.}}{1} \text{ x } \frac{60\,\text{min.}}{1\text{hr.}} \text{ x } \frac{9\,\text{crates}}{36\,\text{min.}} \text{ x } \frac{\$2}{1\text{crate}} = \$240$
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 John can create 40 in two hours. At that rate, how long will it take to create 500 party favors?		$\frac{40\,\text{pf}}{2\,\text{hr.}} = \frac{20\,\text{pf}}{1\,\text{hr.}}$ total rate $= \frac{20\,\text{pf}}{1\text{hr.}} + \frac{30\,\text{pf}}{1\text{hr.}} = \frac{50\,\text{pf}}{1\text{hr.}}$ $\frac{500\,\text{pf}}{1} \text{ x } \frac{1\text{hr.}}{50\,\text{pf}} = 10\,\text{hrs.}$
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 $\frac{200\,\text{miles}}{1} \text{ x } \frac{1\text{hour}}{40\,\text{miles}} = 5 \text{ hours}$
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?		$\frac{485\,\text{miles}}{1} \text{ x } \frac{1\,\text{gallon}}{35\,\text{miles}} \text{ x } \frac{\$3.97}{1\,\text{gallon}} = \$55.01$