Machine Tool Technology (48.0501) T - Chart

Calculate measurement over wires for threading operations on the lathe	=	Apply and extend the properties of exponents to solve problems with rational exponents

Program Task: Perform threading on the lathe.

PA Core Standard: CC.2.1.HS.F.1

Description: Apply and extend the properties of exponents to solve problems with rational exponents.

Program Associated Vocabulary:
FORMULA, ORDER OF OPERATIONS

Math Associated Vocabulary:
SIMPLIFY NUMERICAL EXPRESSION, TERM

Program Formulas and Procedures:
Understanding how to use the order of operations is vital in the machining industry so that the many frequently used formulas will be calculated correctly. If formulas produce incorrect results due to math errors and those results are applied to machining operations, both time and money will be lost.

One example of using the order of operations is calculating the measurement over wires when using the three wire method to inspect external threads cut on the lathe.

$$M = PD + (3W - .86602P) \text{ where}$$

M = Measurement over wires
PD = Pitch Diameter
W = Wire size
P = Pitch

Example:
Calculate the measurement over wires (M) for a 7/8-9 UNC 3A when:
PD = .8028
W = .072
P = .1111

$$M = .8028 + (3 \times .072 - .86602 \times .1111)$$

First perform multiplication inside parentheses.

$$M = .8028 + (.216 - .0962)$$

Next perform subtraction inside parentheses.

$$M = .8028 + .1198$$

Finally perform addition from left to right.

$$M = .9226$$

Formulas and Procedures:

P Do all operations in **PARENTHESIS**. Start with the innermost set.

E Evaluate all **EXPONENTS**.

M
D Do **MULTIPLICATION** and **DIVISION** in order from left to right.

A
S Do **ADDITION** and **SUBTRACTION** in order from left to right.

One way to remember the order of operations is:

Please **E**xcuse **M**y **D**ear **A**unt **S**ally.

Remembering that <u>my</u> and <u>dear</u> go together since they both describe Aunt Sally who is one person.

Example:

$$(7 + 3)^2 - 21 \div 7 + 10(2)$$

$10^2 - 21 \div 7 + 10(2)$	Parentheses
$100 - 21 \div 7 + 10(2)$	Exponents
$100 - 3 + 20$	Multiplication and Division
$97 + 20$	Addition and Subtraction
$= 117$	

Instructor's Script – Comparing and Contrasting

Order of operations is an important skill to learn in any field. Whether it is in mathematics or any other procedure, the order in which skills are performed is important. In baseball you need to run to first base before you can run to third base. And if you are taking a CPR class you need to follow a procedure and the order of the steps you take are important.

Common Mistakes Made By Students

Improper use of calculators: Students are usually very quick to use calculators when faced with formulas but if they are not proficient in using the order of operations, they will not insert parentheses where needed or press "=" at the wrong points and arrive at incorrect answers.

Familiarity with the calculator: In some calculators, you must enter the radical sign first and in some calculators the radical sign is entered after the number is entered. Some calculators automatically do some of the correct order of operations. You need to know your calculator. Calculators are great tools, but you need to know the correct way to use them.

When entering the square of a negative number in a calculator it is important to put it in parentheses. You need to enter $(-2)^2$ not -2^2. For the latter the calculator thinks you are saying the negative of 2 squared or -4, and not (-2) (-2) = 4.
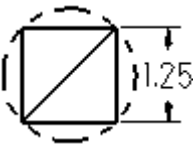
When dealing with fractions students often will forget to put the numerator of the fraction and the denominator of the fraction in parentheses. If you enter (3 + 6)/9 into the scientific calculator, it recognizes that 3 + 6 is in the numerator and does this operation first, giving the answer 9/9 or 1. If you put 3 + 6/9 (without the parentheses) into a scientific calculator, it will give you an answer of 3.66…
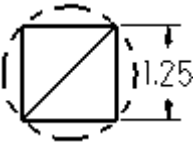
CTE Instructor's Extended Discussion

Not all formulas used in the machining industry are shown with parentheses. Some contain a fraction bar that indicates grouping which students often miss. They just start entering numbers on their calculators without proper grouping and end up with incorrect answers. Other formulas may have the form ab + cd. Some calculators will not automatically implement the order of operations so students must either use parentheses or track the correct order of operations on paper. Calculators that implement the order of operations can still give incorrect answers if students press the "=" key between the operations.

Example:

$(5+2)^2 + 7 + 3^2 + (5)(2) - (7)(3)$	Original Numerical Expression.
$(7)^2 + 7 + 3^2 + (5)(2) - (7)(3)$	Simplify within Parentheses.
$49 + 7 + 9 + (5)(2) - (7)(3)$	Evaluate Exponents.
$49 + 7 + 9 + (10) - (21)$	Multiplication (There is no division in this problem.)
$56 + 9 + (10) - (21)$	Addition and Subtraction in order from left to right.
$65 + (10) - (21)$	Addition and Subtraction in order from left to right.
$75 - 21$	Addition and Subtraction in order from left to right.
54	Addition and Subtraction in order from left to right.

	Problems Career and Technical Math Concepts	Solutions
1.	Calculate lathe machining time using the formula $\text{Time in minutes} = \dfrac{\text{Length in inches}}{\text{IPR x RPM}}$ when Length = 20", IPR = .002, and RPM = 375.	
2.	Determine what diameter round stock is required to machine a 1.25" square. Use the Pythagorean Theorem in the form $c = \sqrt{a^2 + b^2}$ to solve for the length of side c. (a and b are equal)	
3.	Use the formula $\text{TPI} = \dfrac{D - d}{L}$ to determine taper per inch when D = 2.375, d = 1.688, and L= 6.400.	

	Problems Related, Generic Math Concepts	Solutions
4.	Simplify: $3(5 + 7)^2 - 10/5$	
5.	Simplify: $5(8 + 2) + (-5 + (2 + 3)(7 - 4))$	
6.	Simplify: $(5 + 8)^2 - (7 + 5)^2$	

	Problems PA Core Math Look	Solutions
7.	Simplify $(5 + 7 + 3) \div (3 + 2)$	
8.	Simplify $5 + 7 + 3 \div 3 + 2$	
9.	Compare problem #7 with problem #8. Explain how someone may make the mistake of thinking they are the same problem.	

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	Problems	Career and Technical Math Concepts	Solutions
1.	Calculate lathe machining time using the formula $\text{Time in minutes} = \dfrac{\text{Length in inches}}{\text{IPR} \cdot \text{RPM}}$ when Length = 20", IPR = .002, and RPM = 375.		$\text{Time} = \dfrac{20}{.002 \text{ x } 375} = \dfrac{20}{.75} = 26.67$ minutes
2.	Determine what diameter round stock is required to machine a 1.25" square. Use the Pythagorean Theorem in the form $c = \sqrt{a^2 + b^2}$ to solve for the length of side c. (a and b are equal)		$c = \sqrt{a^2 + b^2}$ $c = \sqrt{1.25^2 + 1.25^2}$ $c = \sqrt{1.5625 + 1.5625}$ $c = \sqrt{3.125}$ $c = 1.7678$
3.	Use the formula $\text{TPI} = \dfrac{D - d}{L}$ to determine taper per inch when D=2.375, d=1.688, and L = 6.400.		$\text{TPI} = \dfrac{2.375 - 1.688}{6.400} = \dfrac{.687}{6.400} = .1073$

	Problems	Related, Generic Math Concepts	Solutions
4.	Simplify: $3(5 + 7)^2 - 10/5$		$3(5 +7)^2 - 10/5 = 3(12)^2 - 10/5 = 3(144) - 10/5 = 432 - 2 = 430$
5.	Simplify: $5(8 + 2) + (-5 + (2 + 3)(7 - 4))$		$5(8 +2) + (-5 +(2 + 3)(7 - 4)) =$ $5(8 +2) + (-5 +(5)(3)) =$ $5(10) + (-5 + 15) =$ $5(10) + (10) = 50 + 10 = 60$
6.	Simplify: $(5 + 8)^2 - (7 + 5)^2$		$(5 + 8)^2 - (7 + 5)^2 =$ $13^2 - 12^2 =$ $169 - 144 =$ 25

	Problems	PA Core Math Look	Solutions
7.	Simplify $(5 + 7 + 3) \div (3 + 2)$		Following the order of operations, $(5 + 7 + 3) \div (3 + 2) =$ Parenthesis $15 \div 5 =$ Division 3
8.	Simplify $5 + 7 + 3 \div 3 + 2$		Following the order of operations, $5 + 7 + (3 \div 3) + 2 =$ Division $5 + 7 + 1 + 2 =$ Addition 15
9.	Compare problem #7 with problem #8. Explain how someone may make the mistake of thinking they are the same problem.		In problem #7 you are asked to add $5 + 7 + 3$ first, then add $3 + 2$, and finally divide the two answers $(5 + 7 + 3)/(3 + 2)$. In problem #8, the first thing to do is divide 3 by 3 and then add $5 + 7 + 1 + 2$.