Math-in-CTE Lesson Plan Template

Lesson Title: Calculating FEEDS and SPEEDS for machine tools.		Lesson # 0001
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Occupational Area: Manufacturing Engineering		
CTE Concept(s): Recognize and understand the formula for calculating feeds and speeds that are used for calculating proper operation of machine tools in a machine shop/Engineering environment.		
CTE Standard: MNPA10.02.05.08 - Set up equipment or process in a timely way.		
Math Concepts: Radius, Diameter, Circumference, Pi, the use of formulas, charts and graphs.		

Common Core SS Math Standard:

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; ~~choose and interpret the scale and the origin in graphs and data displays.~~

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A-REI.3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

G.MG.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

7th Grade Common Core Standards

7.RP.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; ~~give an informal derivation of the relationship between the circumference and area of a circle.~~

Lesson Objective: To help the students learn the procedures to obtain proper cutting speeds and the calculations for determining cutting feeds for various materials and cutting tool material types.

Materials: Material hardness charts. Pocket references.

FEED is generally specified as tangential feed per tooth in inches (FPT). For practical use FPT must be converted to table travel in terms of inches per minute (IPM). See conversion formula below.

SPEED is generally specified as the rate of peripheral speed of a tool in terms of surface feet per minute (SFM). For practical use SFM must be converted to revolutions per minute (RPM). See formula below.

Feed and Speed rates affect many things including machining time, surface finish, and tool life. Calculated speed and feed rates give us a useful reference in determining what rates should be used for our purposes. The following demonstrates how to calculate Speeds and Feeds for a surface milling operation.

Definitions:

- SFPM (ft/min) : (Surface Feet per Minute)- Also called *Cutter speed*. Speed of a point on the outside diameter of the tool. Value depends on material - see chart below.
- FPT (in) : (Feed Per Tooth)- Also called *Chip Load*. Amount of stock removed by each tooth during a single revolution. Value depends on stock material, tool size, and tool material.

Variables:

- D (in) : Diameter of tool
- N : Number of teeth or flutes
- RPM : (Rotations Per Minute) *Spindle Speed*
- IPM (in/min) : (Inches Per Minute) Also called *Feed Rate*. Rate at which the work piece is moved into the tool.

Formulas:

- $RPM = SFPM*12/(\pi*D) \approx SFPM*4/D$
- $IPM = FPT*N*RPM$

THE "7 ELEMENTS"	TEACHER NOTES (and answer key)
1. Introduce the CTE lesson.	My aim is to describe all the times when the machinist will need to make calculations by him/her self to adjusting the machine tool to work properly in the specified materials and the cutting tool configuration and material being used.
2. Assess students' math awareness as it relates to the CTE lesson. **The students will understand the need to adjust the machine tool speed to compensate for various types of materials and different diameters of materials.**	*Definitions:* • SFM (ft/min) : (Surface Feet per Minute • FPT (in) : (Feed Per Tooth *Variables:* • D (in) : Diameter of tool • N : Number of teeth or flutes • RPM : (Rotations Per Minute) *Spindle Speed* • IPM (in/min) : (Inches Per Minute) Also called *Feed Rate*. Rate at which the work piece is moved into the tool. *Formulas:* • RPM = SFPM*12/(π*D) ≈ SFPM*4/D • IPM = FSPT*N*RPM
3. Work through the math example *embedded* in the CTE lesson.	The instructor should explain the need to know the information that is being sought. Go over all the pertinent definitions. Including : ➢ Materials ➢ Feed ➢ Speed ➢ SFPM ➢ FPT ➢ IPM

	➢ RPM ➢ RPM = SFM*12/(π*D) ≈ SFM*4/D ➢ IPM = FPT*N*RPM Use the formulas above to demonstrate the processes. (Maybe three examples of each.)
4. Work through *related, contextual* math-in-CTE examples.	At this point I would offer a set of variables and allow the students to work the formulas and convert the sfpm specs. To RPMs. Also I would offer opportunities for the learners to calculate RPMs, Cutter teeth and chip load into IPM.
5. Work through *traditional math* examples.	At this point I will review the basic principles of math. How PI relates with diameter and circumference. Also, how decimals and multiplication interact to determine inches per minute.
6. Students demonstrate their understanding.	The students will demonstrate an understanding of the processes using a handout with variables. They will be able to solve several problems using the formulas.
7. Formal assessment.	An on going assessment would be the practical application of the students working in the machine shop. Each time the student runs a lathe or a milling machine they will need these calculations to effectively use the machine tool.

Threading Calculations Math Standards

High School Common Core Standards

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; ~~choose and interpret the scale and the origin in graphs and data displays.~~

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

6th Grade Standards

6.EE.2c Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations). For example, use the formulas V = s3 and A = 6 s2 to find the volume and surface area of a cube with sides of length s = 1/2.

4th Grade Standards

4.NF.6. Use decimal notation for fractions with denominators 10 or 100. *For example, rewrite 0.62 as 62/100; describe a length as 0.62 meters; locate 0.62 on a number line diagram.*

Feed and Speed worksheet
Levels 1-4.

Use the formulas and charts provided to solve the following problems, use the information supplied.

Variables:

- D (in) : Diameter of tool
- N : Number of teeth or flutes
- RPM : (Rotations Per Minute) *Spindle Speed*
- IPM (in/min) : (Inches Per Minute) Also called *Feed Rate*. Rate at which the work piece is moved into the tool.

Formulas:

- $RPM = SFPM*12/(\pi*D) \approx SFM*4/D$
- $IPM = FPT*N*RPM$

Don't let all the letters fool you. The formulas are simple and follow logically if you take the time to think about it.

Type of Material		**Speed (SFM) for HSS**	**Feed (FPT) for HSS**
Aluminum and Magnesium		400 & 600	.005 - .025
Brass and Bronze	- Soft	250 – 300	.005 - .020
	- Hard	150 – 200	.003 - .010
Copper		150 – 200	.005 - .015
Cast Iron	- Soft	75 – 100	.005 - .015
	- Hard	50 – 75	.003 - .007
Steel	100BHN	125 – 175	.004 - .010
	200BHN	70 – 90	.004 - .010
	300BHN	40 - 50	.003 - .005
	400BHN	20 - 30	.001 - .003
	500BHN	10 - 15	.001 - .003
Stainless Steel	- Hard	35 – 70	.003 - .005
	- Free Machining	70 – 105	.003 - .005
Titanium	under 100K PSI	35 – 55	.003 - .005
	100K – 135K PSI	25 – 35	.002 - .005
	135K PSI & over	15 – 25	.001 - .005

1) What is the proper R.P.M. for the lathe when turning a piece of aluminum at 500 SFPM? The work diameter is 6.375 and you are using High Speed steel (HSS) for a cutting tool. The calculated RPM is? _____

2) What would be the correct feed rate in Inches per minute, (IPM) if you are cutting steel at 45 SFPM? The end mill is 1.5 inches in dia., and the cutter has 8 flutes (cutting edges). You want a chip load of .0025 per tooth. The calculated IPM should be_____

3) What is the proper feed and speed for a piece of Brass? You will want to cut it at 150 SFPM, and you will use a .5 inch dia. 2 flute end mill. The chip load should be calculated at .005 per tooth. The calculated I.P.M. is?
_____

4) Calculate the correct R.P.M. range for a lathe project when you are using HSS for a cutter material, and are machining titanium that is (100K to 135K PSI). The titanium has a working dia. of .25. The calculated R.P.M. range is? _____ to _____

5) As a change up, you are turning a job where the material is steel and the dia. is .75 dia. The job is running really well. The machine is running at a spindle speed of 870 RPM. You want to solve for the SFPM so that you can make a note on the job traveler. What is the new SFPM you want to record?_____

Single point threading on a lathe.

Materials and terminology used:

- Thread relief
- Thread Pitch
- Major Diameter
- Minor Diameter
- Pitch Diameter
- Compound rest in feed
- Threads per inch

The three basic functions in O.D. single point threading

Part 1 Determining the major diameter of a thread. First you must establish the OD size (the major dia. of the thread) this is accomplished by the first number or fraction part of the thread title (.75-18 thread)
The .75 is the thread major dia., 18 is the quantity of threads per inch. Also called the Thread pitch. For an example, a ¾ dia. thread would not have a dia. of .75, it simply Would not fit. It needs to be cut smaller than the .75 hole it must fit into. A rule of thumb could be specification dia. minus .005.

Part 2. Figuring the compound rest movement. Based on a 60 deg. Thread form, set your compound rest at 29.5 degrees, Perpendicular to the lathe axis of rotation. The formula for calculating the in-feed is .708/N. it means that you take the number of threads per inch, (TPI, or thread pitch)
And divide it by .708 (Multiply). The Then take the last passes at about .001 per pass. Another example, a 3/8 16 thread= .708 divided by 16 (.708/16) =.0443. the compound Rest works .001 dial movement =.002 off the part diameter. Depending on your lathe, and materials and experience, you should start with larger cuts then gradually diminish the Depth of cuts to finish, make the finish cuts at only about .001 depths.

Part 3. Sometimes a thread relief is required to make the ending point for the thread. The calculations for a thread relief is major diameter of the thread, minus depth of the Thread -.005. or The minor diameter of the thread -.005, .613/ N +.005. The .613/N is actually the thread height calculation for the thread. The .005 is so that the tool does not cut the into the bottom of the groove.

Apply the before mentioned formulas and information to give the important dimensions for the thread sizes listed below. Needed dimensions are:

- Major Diameter
- Compound rest feed in
- Thread relief depth.

1. $\frac{1}{4}$-20 thread
   - A. Major dia. _____
   - B. Compound rest feed in _____
   - C. Thread relief depth _____

2. 5/16-18 thread
   - A. Major dia. _____
   - B. Compound rest feed in _____
   - C. Thread relief depth _____

3. 3/8-16 thread
   - A. Major dia. _____
   - B. Compound rest feed in _____
   - C. Thread relief depth _____

4. 1/2-13 thread
   - A. Major dia. _____
   - B. Compound rest feed in _____
   - C. Thread relief depth _____

5. 5/8-11 thread
   - A. Major dia. _____
   - B. Compound rest feed in _____
   - C. Thread relief depth _____

Name: _____ Date: _____

Feeds and Speeds—Math Connection

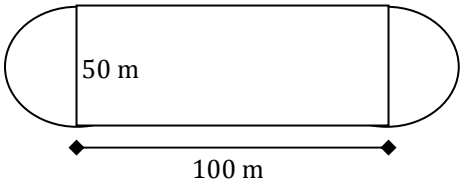
Below are some math topics (that you have seen/will see) and skills that are related to the math you are using to calculate "Feeds and Speeds."

1. Find the EXACT circumference of a circle if the radius of the circle is 6 meters.

A. $6\pi\ m$
B. $72\pi\ m$
C. $12\pi\ m$
D. $36\pi\ m$

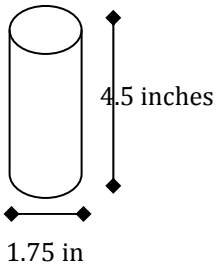
2. Find the approximate distance around this track.

A. 414 m
B. 357 m
C. 514 m
D. 278.5 m



3. Find the real-life diameter of this water tower that is drawn to scale.
Key: 0.5 inch = 9 feet

A. 15.75 feet
B. 40.5 feet
C. 5.14 feet
D. 31.5 feet



4. A parking garage uses the formula $C = 4 + 0.5h$ to determine the cost, C, for parking in their garage for h hours. How much will someone have to pay if they parked in this garage for 5 hours?

A. $4.25 B. $29 C. $2 D. $6.50

5. Meredith owns a coffee shop. She can calculate the total profits, P, of the shop by using the formula $P = -250 + 2x$ where x is the number of cups of coffee she has sold. What will her total profit be after she sells 1,000 cups of coffee?

A. $1750 B. $625 C. $375 D. $2250

6. Evaluate the expression when $x = 2$ and $y = -1$.

$$6x + 5y - 2$$

A. 111 B. 5 C. 55 D. 15

7. Evaluate the expression when $x = 1$, $y = 2$ and $z = -3$.

$$2x - 3y + 7z$$

A. -6 B. -84 C. 62 D. -25

8. Use the equation $F = 1.8C + 32$ to convert between the Fahrenheit (F) and Celsius (C) temperature systems. If it is 30° C outside, what is the temperature in Fahrenheit?

A. 37° F B. 25° F C. -1° F D. 86° F

9. Joe the Plumber charges $75 for just showing up and then $60 per hour of work. If Joe's visit to a house cost the customer $165, how long was Joe at this customer's house?

A. 1 hour
B. 1 hour 15 minutes
C. 1 hour 30 minutes
D. 1 hour 45 minutes

10. The cost of a taxi ride is an initial fee plus $1.50 for each mile traveled. Your fare to travel 9 miles is $15.50. How much is the initial fee?

A. $13.50
B. $2.00
C. $4.00
D. $9.00

11. A car rental company charges $25 plus $0.25 per mile. If the rental company charges you $60, how many miles did you drive?

A. 140 miles
B. 15 miles
C. 40 miles
D. 375 miles

12. Solve the following equation for p.

$4p + 7 = 31$

A. 6
B. 0.75
C. 9.5
D. 59

Engineering Formulas Row Game

Person A: _____ Person B: _____

OBJECTIVE: Practice using a formula

TASK: Complete only the problems in your column. Your numerical answer (not necessarily units) should match your partner's, who is completing the other column. If your answers don't match, work together to find the error. Show your work on a separate sheet of paper, which you will turn in with this sheet.

Person A Column	**Person B Column**
1) Area of a circle: $A = \pi \cdot r^2$ r = 3in	1) Circumference of a circle: $C = \pi \cdot d$ r=4.5in (first find d)
2) Mechanical Advantage = R/E R = load/resistance = 30lbs E = effort = 5lbs	2) Mechanical Advantage (lever) = LE/LR LE = length to effort = 42in LR = length to load/resistance = 7in
3) deformation $\delta = (P \cdot L)/(A \cdot E)$ P = force = 20lbs L = length = 24in A = area = $0.01in^2$ E = modulus of elasticity = 480,000 lbs/in^2	3) deformation $\delta = (P \cdot L)/(A \cdot E)$ P = force = 100lbs L = length = 30in A = area = $0.03in^2$ E = modulus of elasticity = 1,000,000 lbs/in^2
4) Initial Velocity $V_i = \sqrt{\frac{-gX}{\sin(2\theta)}}$ g = grav. acceleration = $-32.2ft/s^2$ X = range = 12ft θ = trajectory angle = 15°	4) Initial Velocity $V_i = \sqrt{\frac{-gX}{\sin(2\theta)}}$ g = grav. acceleration = $-32.2ft/s^2$ X = range = 24ft θ = trajectory angle = 45°
5) Find the **deformation** if a 24in long circular rod with cross-sectional area $0.05in^2$ is stretched by a tensile force of 300lbs. (E = 7,200,000 psi.)	5) Find the **mechanical advantage** of a lever where you exert an effort of 200lbs force to move a load of 4lbs.

Threading Formulas Lesson Name_____

Math Connection--Using a Formula

Date_____ Period____

Evaluate each using the values given. This is just like substituting values into a formula!

1) $y^2 \div x$; use $x = 2$, and $y = 9.6$

2) $y + x - 10$; use $x = 8.27$, and $y = 5.2$

3) $7 - (q - r)$; use $q = 8.336$, and $r = 3.8$

4) $x \div (x + z)$; use $x = 9.6$, and $z = 2.2$

5) $a(c + b)$; use $a = 2.5$, $b = 8.73$, and $c = 9.8$

6) $h + j - k$; use $h = 5.3$, $j = 6.4$, and $k = 1.6$

7) $(m - p)^2$; use $m = 9.4$, and $p = 5.3$

8) $m(m - q)$; use $m = 9.25$, and $q = 3.7$

9) $p + n^2$; use $n = 6.982$, and $p = 9.8$

10) $5(z + x)$; use $x = 5.1$, and $z = 9$

Threading Formulas Lesson Name_____

Math Connection--Using a Formula

Date_____ Period____

Evaluate each using the values given. This is just like substituting values into a formula!

1) $y^2 \div x$; use $x = 2$, and $y = 9.6$

46.08

2) $y + x - 10$; use $x = 8.27$, and $y = 5.2$

3.47

3) $7 - (q - r)$; use $q = 8.336$, and $r = 3.8$

2.464

4) $x \div (x + z)$; use $x = 9.6$, and $z = 2.2$

0.813559322034

5) $a(c + b)$; use $a = 2.5$, $b = 8.73$, and $c = 9.8$

46.325

6) $h + j - k$; use $h = 5.3$, $j = 6.4$, and $k = 1.6$

10.1

7) $(m - p)^2$; use $m = 9.4$, and $p = 5.3$

16.81

8) $m(m - q)$; use $m = 9.25$, and $q = 3.7$

51.3375

9) $p + n^2$; use $n = 6.982$, and $p = 9.8$

58.548324

10) $5(z + x)$; use $x = 5.1$, and $z = 9$

70.5