Name:_________________
Date:___________________

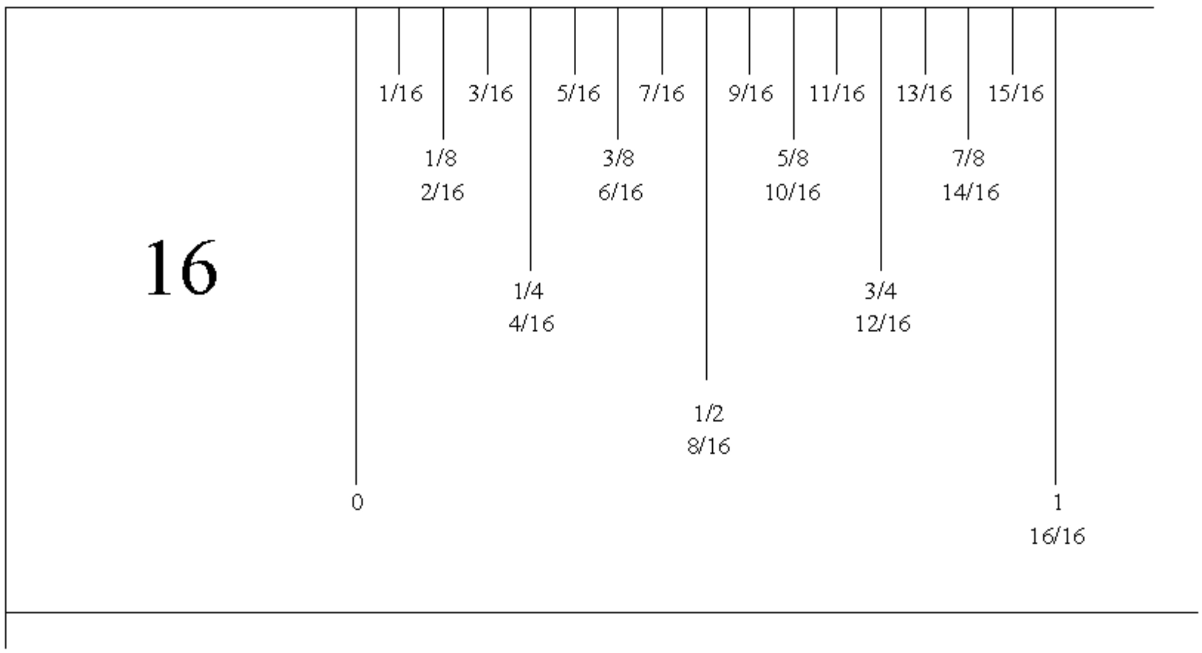
The 16th Scale

(1 Point Each)

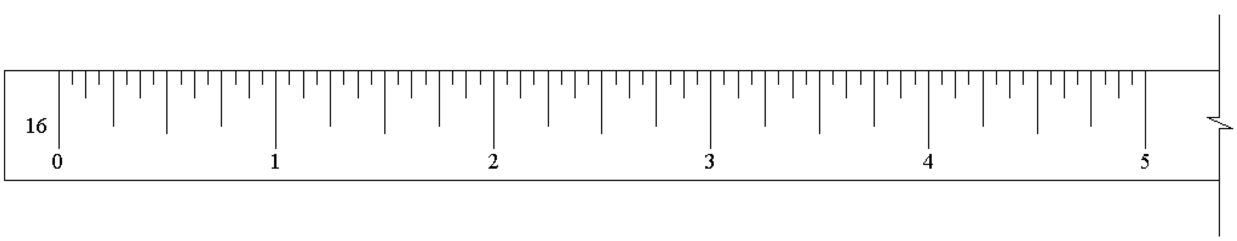
Directions: *Shown are various lines of different lengths. Use a 16th Scale Ruler to measure each line and indicate the dimension it represents in the space provided.*

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______

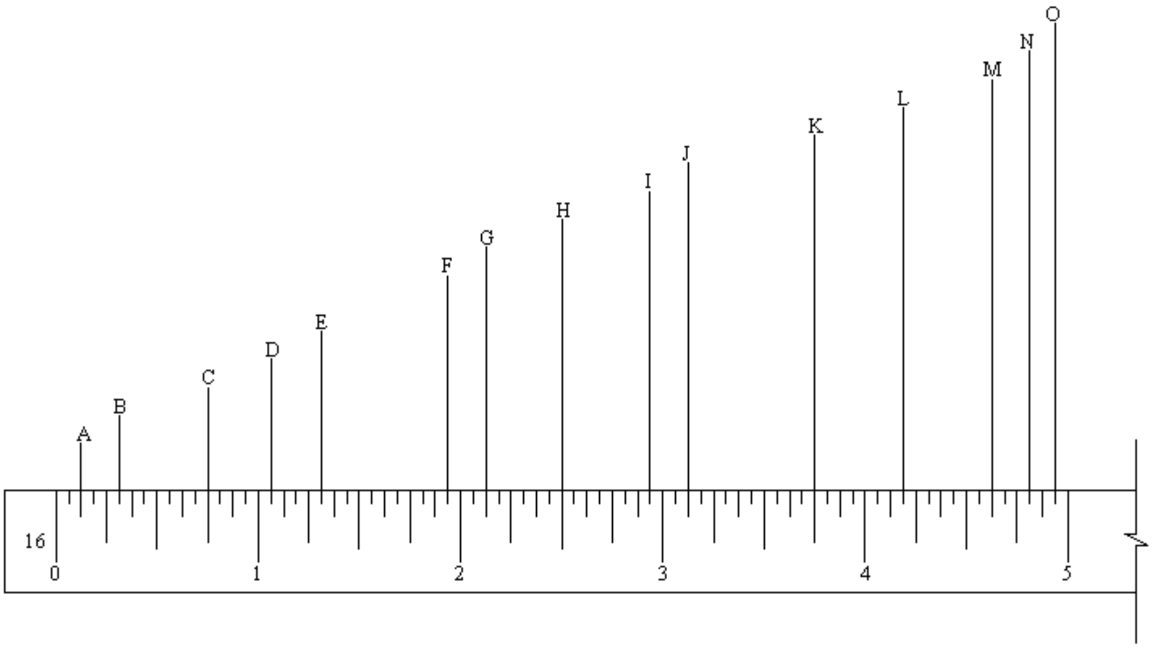
16^{th} Scale Work Sheets



16^{th} Scale Work Sheets



16th Scale Work Sheets



A ________ D ________ G ________ J ________ M________

B ________ E ________ H ________ K ________ N ________

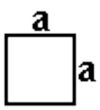
C ________ F ________ I ________ L ________ O ________

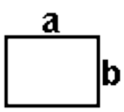
MCTE Lesson Plan: Create a Mind-Challenging Game

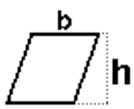
Mathematics Formulas

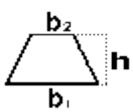
pi: (pi = π= 3.141592...)

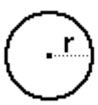
Area: (Note: "ab" means "a" multiplied by "b". "a^2" means "a squared," which is the same as "a times a." *Be careful, units count. Use the same units for all measurements.*

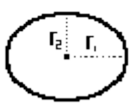
square = a^2 

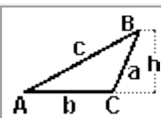
rectangle = ab 

parallelogram = bh 

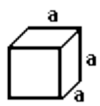
trapezoid = $h/2\ (b_1 + b_2)$ 

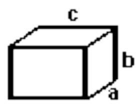
circle = *pi* r^2 

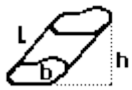
ellipse = *pi* $r_1\ r_2$ 

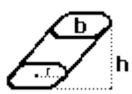
triangle =	$\frac{1}{2}(bh)$		one half times the base length times the height of the triangle

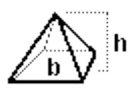
Volume: Note: "ab" means "a" multiplied by "b." "a^2" means "a squared" (the same as "a" times "a.") "b^3" means "b cubed" (the same as "b" times "b" times "b"). *Be careful, units count. Use the same units for all measurements.*

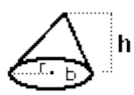
cube = a^3 

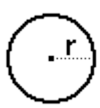
rectangular prism = a b c 

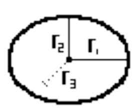
irregular prism = **b** h 

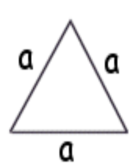
cylinder = **b** h = *pi* r^2 h 

pyramid = (1/3) **b** h 

cone = (1/3) **b** h = 1/3 *pi* r^2 h 

sphere = (4/3) *pi* r^3 

ellipsoid = (4/3) *pi* r_1 r_2 r_3 

equilateral triangle =	$\frac{\sqrt{3}}{4}(a^2)$ 

Math-in-CTE Lesson Plan

Lesson Title: Conversions in Automotive Applications	Lesson # AT01

Occupational Area: Automotive Technology
CTE Concept(s): Conversions in automotive applications
Math Concept(s): Equivalent forms; computation; computation in context.

Lesson Objective:	Required conversions techniques needed in automotive technology
Supplies Needed:	Visuals such as meter stick/yard stick, ruler with inches and centimeters, dual unit measuring cups, quarts, etc. These items may be used in the introduction as well as in step 6.
Link to Accompanying Materials:	Auto AT01 Downloads

THE "7 ELEMENTS"	TEACHER NOTES (and answer key)
1. Introduce the CTE lesson. Let's list all the automotive-related conversions you can think of. Why are these conversions needed in the automotive field? In this lesson we will learn how to perform various conversions on mathematical quantities used in the automotive field. In our first example we will show in detail how to perform a cubic inch to liter conversion of the 302 cubic inch engine.	*NOTE: This lesson can be reviewed throughout the year, and concepts should be reinforced as they appear in other lessons.* Keep the students focused on the automotive field as much as possible. Too many non-related examples at this point may lose the interest of the students. To pull the students in better have each student work on making a list of conversions as well as describe how the conversion is needed. See who can come up with the longest list. Give students a copy of the automotive-related Conversion Factors Handout and have them describe why or how each conversion is used in the automotive field. Remember to have them keep it automotive related.
2. Assess students' math awareness as it relates to the CTE lesson. Most of you probably know that a 305 cubic inch engine is considered to be equivalent to a 5 liter engine. Is a 302 cubic inch engine close enough	Have the students try to convert the 302 in^3 to liters to see how many already understand the procedure involved in solving the question.

in size to also be equivalent to a 5 liter engine? How would you set up this problem in order to see if a 302 in^3 can be called a 5.0 liter? Can you show how you would set up any type of basic conversion? Can problems with different units all be done the same way?	See the next topic below for a detailed procedure of how a problem of this type is set up. Students who understand the setup well enough will understand that the same procedure can be used regardless of what units are being used.
3. Work through the math example *embedded* in the CTE lesson. How big, in liters to the nearest tenth of a cubic inch, is a 302 in^3 engine? A. Write the number that you are trying to convert (302 in^3) on the left side of an equal sign and leave enough space for your conversion factor. **Include the unit with the number.** Place the number 1 underneath this number. This helps to organize the math steps we will take. Write the unit of the number you are trying to convert to on the right side of the equal sign. Leave space for the answer. Example: $\frac{302\ in^3}{1} = \qquad liters$ B. Look up the conversion factor for liters to cubic inches (or cubic inches to liters) in the appendix. Example: 1 liter = 61.024 in^3 C. Make a fraction out of your conversion by putting the number with the unit you are trying to find on top and the number with unit you are trying to convert from on the bottom. Example: $\frac{1\ liter}{61.024\ in^3}$	Before you begin you may want to physically show the students some conversions such as how big in inches 100 mm in on a ruler, or how big a cubic centimeter is physically, etc. *NOTE: This way of setting up the problems is effective with special needs students who need a clear and repetitious method of solving problems.* You may want to point out to the students that since this is a volume type of unit, they can find it quicker by going to the volume conversions. It has also been suggested that you might want to make a wall poster of the conversion factors listed in the appendix. You may want to point out that this is why it is called a conversion **factor**. You will recall that a factor is one number divided by another. You also may want to start to use the terms **numerator** for the top of the fraction and **denominator** for the bottom of the fraction.

D. Write the conversion factor to the right of the number you are trying to convert (i.e. to the left of the equal sign). Place a multiplication sign between the number and your conversion factor. Example: $\frac{302\ in^3}{1} \times \frac{1\ liter}{61.024\ in^3} = \qquad liters$	Point out that we can do this since **1 liter** divided by **61.024 in^3** is equal to 1. Remember that these two quantities are equal to each other and that anything divided by something equal to itself is one. Anything multiplied by 1 doesn't change. This concept forms the basis for all conversion factors that can be created.
E. One of the reasons we include the units with our number is that it allows us to see if the units cancel out properly and leave us with the unit we want. Example: $\frac{302\ \cancel{in}^3}{1} \times \frac{1\ liter}{61.024\ \cancel{in}^3} = \qquad liters$	Point out that units cancel just like numbers do. Also show them that if the conversion factor is upside down, nothing will cancel. The answer will be wrong as well as the units. Example:
F. After the units have been canceled this is what we have left to work with. $\frac{302}{1} \times \frac{1\ liter}{61.024} = \qquad liters$	$\frac{302\ in^3}{1} \times \frac{61.024 in^3}{1 liter} =$ The answer to this problem would be 21358 in^6/liter. Notice how unrealistically large the answer is and that the units do not make any sense. (Rules of mathematics requires us to multiply in^3 times in^3 which equals in^6)
G. Complete the problem by multiplying the two numerators by each other and the two denominators by each other. $\frac{302 \times 1}{1 \times 61.024} liters = \frac{302}{61.024} liters$	Point out that all that is left are liters (which are what we were looking for all along).
H. Finally divide the numerator by the denominator. $\frac{302}{61.024} = 4.948 \approx 4.9$ liters (Rounded to the nearest 10th) Therefore a 302 in^3 should not be called a 5.0 liter engine.	Some might argue that 4.948 liters is close enough to 5 that a 302 can be called a 5 liter. That's fine if that is your position but speaking from a purely mathematical position you would be required to call it a 5 liter not a 5.0 liter.

4. Work through *related, contextual* math-in-CTE examples.	
1. How many cubic inches are in a 600 cc (cubic centimeter) motorcycle?	$\frac{600cc}{1} \times \frac{.06102 in^3}{1cc} = 36.612 in^3$
2. In hybrid technology, motors that are electrically based are generally rated in watts. What is the horsepower rating of a hybrid electric motor that is rated at 25,000 watts?	$\frac{25000\ watts}{1} \times \frac{1\ hp}{746\ watts} = 33.51\ hp$
3. If 1 mile/hour is equal to 0.447 meter/sec, how many miles/hour is 50 meters per second?	$\frac{50 \frac{meters}{\sec}}{1} \times \frac{1 \frac{mile}{hour}}{.447 \frac{meters}{\sec}} = 111.86 \frac{miles}{hour}$
4. Which metric wrench is closest in size to a 7/16 inch wrench? (hint: change 7/16 to it's decimal form and then do the conversion)	(7/16 inch = .4375 inch) $\frac{.4375 in}{1} \times \frac{25.4 mm}{1 in} = 11.1 mm$
5. The lowest recommended caster setting on a Nissan is 45 minutes. What would this be in a fraction of a degree?	$\frac{45 \min}{1} \times \frac{1 \text{degrees}}{60 \min} = \frac{3}{4} = .75 \text{degrees}$
5. Work through *traditional math* examples.	
1. How many feet is the 100 meter dash?	$\frac{100\ meters}{1} \times \frac{1\ ft}{.3048\ meters} = 328\ ft$
2. If your backyard is 37,560 square feet, what part of an acre is this?	$\frac{37{,}560\ ft^2}{1} \times \frac{1\ acre}{43{,}560\ ft^2} = .862\ acres$

3. You determine that you need 295 cubic feet of concrete to pour a driveway, how many cubic yards should you order?	$\frac{295\ ft^3}{1} \times \frac{1\ cubic\ yard}{27\ ft^3} = 10.9\ cubic\ yards$
4. A load of gravel weighs 3,500 pounds, how many tons is this?	$\frac{3{,}500\ pounds}{1} \times \frac{1\ ton}{2{,}000\ pounds} = 1.75\ tons$
5. How many hours are in 560 minutes?	$\frac{560 \min}{1} \times \frac{1\ hour}{60 \min} = 9.33\ hours$
6. Sometimes it is necessary to use two or more different conversion factors to get the answer you are looking for. Let's try this for example: A car travels a city block (about 700 feet) in 16 seconds. How fast is this in mile per hour (mph)?	$\frac{700\ feet}{16 \sec} \times \frac{60 \sec}{1 \min} \times \frac{60 \min}{hour} \times \frac{1\ mile}{5{,}280\ feet}$ $= 29.8\ mph$
6. Students demonstrate their understanding. Have students perform a volume or length conversion mathematically and then verify that their calculation was correct by physically making the measurement using related measuring devices.	
7. Formal assessment. See attached test and key for assessment.	

Math-in-CTE Lesson Plan

Lesson Title: Create a Mind-Challenging Game	Lesson #01

Occupational Area: Industrial Technology
CTE Concept(s): Measure accurately, use measurement tools, use problem-solving techniques
Math Concept(s): Use U.S. customary and metric measurement systems, use problem-solving techniques
Writers: Sebastian Kapala, Bolingbrook HS & Mark Morrey, Joliet Central HS

Lesson Objectives:	1. Define measurement and other key terms. 2. Use measurement systems: U.S customary and metric. 3. Use common measurement tools to calculate linear distances, diameters, and angles. 4. Measure major physical qualities of objects and structures. 5. Use problem solving techniques in the creation of products. 6. Explain how accurate measurement relates to quality control. 7. Analyze fabrication processes. 8. Evaluate fabrication processes.
Supplies Needed:	44" X 4" square of soft wood 15 golf teas or wooden pegs Tapemeasure Sand paper Paint, poly, stain finish Masking tape (12 inches) 2 Styrofoam cups String (12 inches) 1 Straw 2 Large paper clips 10 pieces Size A paper 1 Ping-pong ball 2 Rubber bands 2 Mouse traps 1 manila folder 1 12-inch ruler 1 Large envelope
Key Terms:	Area Capacity Distance Length Mass Measurement Measuring tools (direct- and indirect-read) Metric System Micrometer Precision measurement Quality Control (QC) Ruler Square Standard measurement Temperature Time U.S. Customary System Volume Weight

THE “7 ELEMENTS”	TEACHER NOTES (and answer key)
1. Introduce the CTE lesson. When you travel from your home to school, how far is the trip? How long does the journey take? Do you travel by car or bus? If so, how much fuel does that vehicle’s fuel tank hold? A book has some physical qualities. What is its weight? What size are the pages? How thick is the book? Think about how you compare with your classmates. How much do you weigh? How tall are you? How fast can you run the one-hundred-yard dash? Provide the attached **Mathematical Formulas** to all students.	These questions ask you to describe physical qualities. ***Physical qualities are*** the ***characteristics*** of an object or event that can be described. If we say a tree is tall, but have nothing to compare it to, saying the tree is tall has no meaning. The tree could be a dwarf apple tree variety or a giant redwood. If it takes a long time to do something, what is meant by a long time? Hours? Weeks? Years? Centuries? To accurately describe something to others, we must have a common reference or standard. We use measurement to describe objectively the physical qualities of an item. ***Measurement*** is the practice of comparing the qualities of an object to a standard. To describe objects using measurements, we have systems of standards for comparison.

2. Assess students' math awareness as it relates to the CTE lesson.	
Display the measuring devices students are going to be studying in this measurement lesson or unit.	EXAMPLE: Fabrication measurement devices such as ensuring each student has a 16th Scale for use in the lesson/unit
Write these key terms on the board and have the students define them 1. Area 2. Length 3. Mass 4. Metric System 5. Temperature 6. Volume 7. Weight 8. NOTE: Add more terms as needed. Evaluate students' definitions individually. Common definitions of some of the key terms essential to lesson activities are shown.	1. **Area** is a quantity expressing the extent of a 2D surface or shape in the plane. Area can be the amount of material with a given thickness needed to fashion a model of the shape, or the amount of paint needed to cover the surface with a single coat. 2. **Length**, in certain contexts, is reserved for the specific dimension of an object where length is measured. 3. **Mass** is the quantity of matter present in a object. 4. The **metric system** is an international decimalised measurement system. 5. **Temperature** is a physical property of matter that quantitatively expresses the common notions of hot and cold. 6. **Volume** is the quantity of 3-D space enclosed by a boundary. For example, the space that a substance (solid, liquid, gas, or plasma) or shape occupies or contains. 7. **Weight**, in science and engineering contexts, is the name for the force placed on an object due to gravity.

3. **Work through the math example embedded in the CTE lesson.**

Review the process to complete the the **"16th Scale Worksheets."** Summarize overall and individual measurement results with students as needed.

Assign the 16th Scale Worksheets attached.

FABRICATION: We live in a material world. All the products around us have been developed using material processing technology.

TASK: Make a game using the measurements shown in the game figure layout below. The game would be given to a local charity.

DEMONSTRATE: Demonstrate the safe and proper use of tools and machines (drills, saws, etc.) to construct the game.

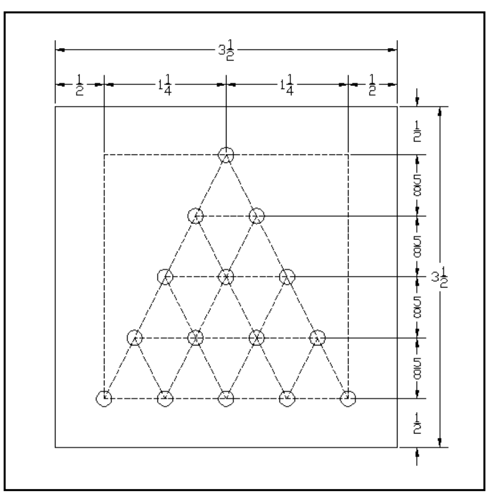
Watch the demonstration and follow the rules for the *safe and proper use of tools and machines* to make the game.

MATERIALS:

1. One piece ¾" x 3-1/2" x 3-1/2" clear pine, redwood, or western red cedar.
2. Fifteen 1/8" diameter x 1" wooden pegs or golf tees.

Collect the MATERIALS to construct the game.

GAME LAYOUT: Use the dimensions shown in the figure to layout the game.



Construct the game by following the GAME LAYOUT figure and the details in this Operation Process Chart:

Game Board	Pegs
¾ x 3-1/2 x RL Pine	1/8: Dia. X 1" Dowel
Cut to length	Cut to length
Layout Block	Sand ends
Drill 15-5/32" dia. holes	Inspect
Sand faces	Apply Stain
Sand edges and ends	Apply finish
Soften arrises (sharp edges)	Count out 15 pegs
Inspect	
Apply finish	
Package w/ directions	

Proposed GAME and SCORING DIRECTIONS: 1. Place a peg in all but one hole. 2. Select one peg and jump another adjacent peg, ending in an empty hole. 3. Remove the jumped peg. 4. Continue jumping pegs until only one remains or no other jumps are possible. ***Scoring:*** 1. Terrific: 1 peg remains = 30 points 2. Good: 2 pegs remain = 20 points 3. Fair: 3 pegs remain = 10 points 4. Try Again: 4 pegs remain = 0 points	Play a game or two with the game and scoring and directions provided. Then, revise the game directions and the scoring as needed.
	Analysis: Meet as a class to analyze the material processing activities. 1. Which material processing tools did you use? 2. Which measuring tools did you use? 3. How could you increase the speed of the manufacturing/fabrication process? 4. What changes in the material processing actions would you make to improve the product quality? 5. What did you learn about problem solving from this activity 6. How could what you learned about problem solving and fabrication relate to other courses you are taking? 7. How does this activity relate to other projects and information you've learned in this course so far? 8. How would you redesign the activity for the students next year?
NOTE: Consider referencing **Bloom's Cognitive Taxonomy** as you and the students analyze and evaluate the game project.	**Evaluate** the project for accuracy based on the game figure layout and the shown and operation process chart.

4. **Work through *related, contextual* math-in-CTE examples.**

TASK: Develop a working model of a device to move a ping pong ball 18 inches into the air and back to the origin.

Assign teams of 2 to develop a working model.

MATERIALS:

Tapemeasure	2 Mousetraps
Masking tape (12-in.)	1 Manila folder
2 Styrofoam cups	One 12-inch ruler
String (12 in.)	1 Large envelope
1 Straw	2 Rubber bands
2 Large paperclips	1 Ping-pong ball
10 pieces A-size paper	

TASK: You and your partner are to develop a working model of a device that must move a ping-pong ball 18 inches into the air and back to the origin. *[NOTE: The ball must come back to the starting point without any human help. In addition it must remain where it started at the end of the device's cycle.]* KEY: Your device must repeat the cycle accurately twice.

GATHER MATERIALS: To make the problem solving experience a bit more interesting, you are only allowed to use the materials provided by your instructor. So, if you and your partner "use up" any of the materials provided, you are not allowed to replenish those supplies. In short, be very careful how you decide to use your materials.

Create and test your device.

ANALYSIS:
1. Provide a sketch of your ideas and final solution to the problem.
2. Provide an activity summary sheet as required by your instructor including any follow-up questions.

5. **Work through the *traditional math* examples.**

a. Ethan adds liquid soap to the cylindrical fill cup of his parents' laundry machine. The cup is 5 centimeters deep with a radius of 5 centimeters. How many cubic centimeters of soap did he need to fill half of it?

Solutions

a.

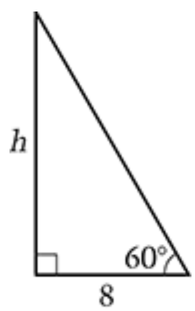
$V = \Pi * r^2 * h * 1/2$

$V = \Pi * 5^2 * 5 * 1/2$

$V = 196.3495$

b. Logan receives a rubber ball as a birthday gift. The ball has a radius of 4 centimeters, how many cubic centimeters is in the ball?	**b.** $V = 4/3 * \Pi * r^3$ $V = 4/3 * \Pi * 4^3$ $V = 268.0826$
c. Ethan draws a circle on paper using a drafting compass. The radius of the circle was 8 centimeters. How many square centimeters are inside the circle?	**c.** $A = \Pi * r^2$ $A = \Pi * 8^2$ $A = 201.0619$
d. Natalie rides a horse down a straight slope from the top to the bottom of a hill. The hill is 8 meters tall and the slope makes a 49-degree angle to the flat ground. How many meters wide is the hill? (Assume the peak of the hill is in the middle and the slopes are the same on both sides of the peak.)	**d.** *adjacent* = 2 * *opposite* / tangent(A) *adjacent* = 2 * 8 / tangent(49) *adjacent* = 13.9086
6. Students demonstrate their understanding.	Students complete the fabrication tasks and traditional mathematics problems in the lesson plus any additional tasks assigned by the instructor. In addition, during the completion of the tasks, students: 1. Complete handouts/worksheets provided by the instructor. 2. Accurately add and subtract fractions and simplify fractions. 3. Measure accurately. 4. Use drawing scales accurately. 5. Use conversion charts (U.S. customary to metric and vice versa).

7. **Formal assessment.** Students may use the attached **Mathematical Formulas** for these formal assessment problems.	**Solutions**
1. Emily must measure the length of a table. She has a dollar bill that is about 6-inches long. It fits, end to end, 10 times along the length of the table. Which is the best estimate for the length of the table? A. 5 feet B. 6 feet C. 10 feet D. 12 feet	**1. A**
2. A loaded trailer truck weighs 26,643 kilograms. When the trailer truck is empty, it weighs 10,547 kilograms. About how much does the load weigh? A. 14,000 kilograms B. 16,000 kilograms C. 18,000 kilograms D. 36,000 kilograms	**2. B**
3. It takes Ms. Wylie 15 minutes to drive from her house to a store. Which is the best estimate of the distance from her house to the store? A. 5 feet B. 5 miles C. 20 feet D. 200 miles	**3. B**

4. Megan drew a rectangle that has an area of 24 square centimeters. Which of the following is likely the dimensions of her rectangle? A. 2 centimeters (cm) by 12 cm B. 3 cm by 9 cm C. 4 cm by 20 cm D. 6 cm by 6 cm E. 12 cm by 12 cm	**4. A**
5.  What is the value of *h* in the figure above? A. $4\sqrt{3}$ B. $8\sqrt{2}$ C. $8\sqrt{3}$ D. $12\sqrt{2}$ E. $12\sqrt{3}$	**5. C**
6. Which of the following containers has the greatest liquid capacity? (1 gal. = 4 qts. = 8 pts. = 128 oz.) A. 64-ounces of orange juice B. 16-pint water jug C. 5-quart punch bowl D. 2-quart cola bottle E. 1-gallon milk bottle	**6. B**

7. Mr. Elkins plans to buy a refrigerator. He can choose from five different refrigerators whose interior dimensions, in inches, are given below. Which refrigerator has the greatest capacity (volume)? A. 42 x 34 x 30 B. 42 x 30 x 32 C. 42 x 28 x 32 D. 40 x 34 x 30 E. 40 x 30 x 28	**7. A**

Math-in-CTE Lesson Plan

Technical Mathematics: Math-in-CTE

Lesson Title: Auto Racing Calculations **Writer:** D. Oldham, Coal City High School as adapted from thehenryford.org/education website at https://www.thehenryford.org/education/	Lesson #1

Technical Area: Engineering Technology
CTE Concept(s): Problem solving, speed, distance, design
Math Concept(s): Trigonometry, conversions, physics, motion and energy
CCSS Math Practices & Standards: CC.9-12.A.CED.2 CC.9-12.A.CED.4 CC.K-12.MP.5 CC.K-12.MP.1 CC.K-12.MP.4 CC.K-12.MP.7 **NGSS Standards:** Physics: motion and energy

Lesson Objective:	Design a car that is fast and travels further than the others during a race using the concepts of distance, velocity, acceleration.
Supplies Needed:	• Computers with access to the Internet • Digital projector and screen (preferred) OR printed handouts of Background Information Sheet, Student Activity Sheet and digitized artifacts' images and descriptions [SEE The Henry Ford website PDF: Physics, Technology and Engineering in AUTO RACING at https://www.thehenryford.org/docs/default-source/default-document-library/default-document-library/physics-auto-racing-digikit.pdf?sfvrsn=a072c01_0. • Background Information Sheet for Students 3A: The Study of Motion Using Artifacts [SEE link above.] • Student Activity Sheet 3B: Motion and Energy–Answer Key 3B: Motion and Energy [SEE link above.]

THE "7 ELEMENTS"	TEACHER NOTES (Answer Key)
1. Introduce the CTE lesson. How many people are interested in NASCAR? How about Formula 1 or drag racing? Anyone interested in just plain going fast?	
2. Assess students' math awareness as it relates to the CTE lesson. A. Review/do conversion problems.	A. To convert all values to the same units, multiply by an appropriate factor that is equal to 1. Either of the equivalent units can be numerator or denominator to cancel units. **Example: Convert 25 minutes to seconds.** 25 minutes * 60 seconds = 1,500 seconds 1 minute
B. Review/do simple multiplication and division problems.	B. Show a multiplication problem. 6 * 2 = 12
C. Review/do a simple algebra problem.	C. Sample Algebra multiple choice problem: When $x = 3$ and $y = 5$, by how much does the value of $3x^2 - 2y$ exceed the value of $2x2 - 3y$? **a.** 4 **b.** 14 **c.** 16 **d.** 20 **e.** 50

3. Work through the math example *embedded* in the CTE lesson. 1. Show the formula for Velocity. 2. Calculate distance, speed, & velocity.	1. V=d/t 2. DEFINITIONS: a) Speed is the distance traveled per time. b) Velocity is the displacement per time. **Sample Problem:** A velocity calculation for 8.0 meters north, 8.0 meters east, and 8.0 meters south for a trip lasting 4.0 seconds is: v = d / t = 8 meters/ 4 seconds = 2 meters/second east A car averages 27 miles per gallon. If gas costs $4.04 per gallon, which of the following is closest to how much the gas would cost for this car to travel 2,727 typical miles? **a.** $ 44.44 **b.** $109.08 **c.** $118.80 **d.** $408.04 **e.** $444.40
4. Work through *related, contextual* math-in-CTE examples. A. Car A travels 190 mph and Car B, travels slower racing at 180 mph. How many more seconds will it take Car B than Car A to travel one lap of the 2.5-mile track?	*A. d=v*tort=d/v CarA) t=d/v=2.5miles/190mph=.01316hour Car B) t = 2.5 miles/180 mph =* ***0.01389 hour*** *Time difference = .01389 hr – .01316hr = .00073 hr .00073 hr * 3,600 sec/hr =* ***2.263 seconds and Car A wins.***
B. What is the average velocity of an Indianapolis 500 race car if it takes 2 hours and 40 minutes to complete the 500 miles of the Indianapolis race?	*B. v(ave) = d(total) / t(total) = 500 miles/2.67 hours =* ***187.3 mph***

5. Work through the *traditional math* examples. A. A drag race car travels the quarter mile (402 meters), increasing its velocity from 0 meters/second to 60 meters/second. Calculate its acceleration. D= rate *time B. In an early 1900's race, the pit crew took 10 minutes to get Car A ready to head back onto the track. If the lead car is traveling at 50 mph, what distance would the lead Car B travel while the pit crew worked on Car A?	*d = 30 laps * 1.5 mile/lap = 45 miles* *t=d/v=45miles/65mph=.692hr* 60min/hr = **41.5 minutes*** *d = v * t = 50 mph * 10 min * 1hr /60 min = **8.3 miles***
6. Students demonstrate their understanding. Explain the relationships between velocity, speed and distance in your own words.	Assign this reflective writing task.
7. Formal assessment. A **maximum 3-person team** will design, construct, and test a car that will run faster and farther than any other car in the class and consistently travels that distance. The majority of the points are earned on how far the car moves, how fast the car moves and how close it comes to a wall that you will place at the end of the car's run. You must know in advance how far your car will travel in order to place the wall. The reference point for all measurements is the front edge of the car. **ASSESSMENT TASK:** Calculate the distance and velocity of the car you built and tested.	**The project is worth 200 points:** 50 points for your pretest data tables, weekly reports, and design note books. The race score is calculated using the following formula: • **10 points** if your car moves one full car length • **50 points** come from the distance your car travels. The car that goes the farthest receives all 50 points and each car is scaled from there. The last car will receive 30 points. • **40 points** for being the fastest car. The car that is the fastest will receive all 40 points and each car thereafter is scaled from there. The slowest car will receive 25 points. • **50 points** come from stopping the closest to the wall. The perpendicular

	distance your car comes to rest from the wall will be measured in centimeters. Your predicted distance versus the actual distance your car traveled will be calculated and points will be awarded based upon the percentage you were off. • **50 points** for a well-maintained design notebook. The design notebook reflects the evolution of possible designs you considered, an accurate drawing of the chosen design, discussions of problems your team encountered and how you solved them. NOTE: The **design notebook** must include data from your trials accompanied by interpretation of your comprehensive testing.

Math-in-CTE Lesson Plan

Technical Mathematics

Lesson Title: Machining Rotors Using Math Concepts **Writers:** John Barber, Joliet Township HS-West Math Teachers: Mr. Peterson, Edna Bazik, Kim O'Malley	Lesson # 3 Vocabulary: micrometer, measurement, decimal, inches, fractions, absolute value, ruler, lathe, rotor, spindle, sleeve, thimble, anvil, ratchet, frame

Technical Area: Auto Technology
CTE Concept(s): Rotor Thickness Variation and Lateral Runout
Math Concept(s): Decimals, Add/Subtract, Fractions, Absolute Value
CCSS Math Standards: CC.6.NS.1 Interpret and compute quotients of fractions. CC.6.NS.3 Fluently add, subtract, multiply and divide multi-digit decimals using the standard algorithm for each operation. CC.6.EE.1 Write and evaluate numerical expressions involving whole-number exponents. CC.7.RP.3 and CC.9-12. N.Q.1 Reason quantitatively and use units to solve multi-step problems. CC.9-12.S.MD.5 Use probability to evaluate outcomes of decisions. CC.9-12.S.MD.1-2 Calculate expected values and use them to solve problems.

Lesson Objective:	Learn when and how to machine a vehicle's rotor.
Supplies Needed:	Micrometer, Brake Rotor, ALLDATA (for Manufacturer's Specifications), Brake Lathe

THE "7 ELEMENTS"	TEACHER NOTES (Answer Key)
1. Introduce the CTE lesson. Why is cutting a rotor important? How do you determine when a rotor needs to be cut? Have you ever machined anything?	We have already discussed how to diagnose brake problems. If you **suspect problems with a brake rotor**, then that rotor is measured to determine if it's out of specification and/or if it's able to be machined or must be replaced. Next, look up the manufacturer's specifications for **rotor thickness** for the vehicle being working on. Then, measure the rotor in six different places on its circular surface. To spread measurement points equally around the rotor, and a circular rotor surface is 360 degrees, how far apart would each measurement be? Now, use a **micrometer** to measure the rotor thickness to the nearest thousandth of an inch, and record in a decimal format. First, look at the smallest of the six measurements and make sure that this measurement is greater than the minimum required thickness. If the rotors pass this test, you then must determine how much to machine off the rotor so that it is "true."
2. Assess students' math awareness as it relates to the CTE lesson. A. Who knows how to write one thousandth as a decimal? B. Who can tell me how to compare decimals? For example, which is greater: 0.4 or 0.39? Any numbers to the RIGHT of a decimal point are smaller than one, and each place value further to the right of the decimal point is ten times less than the place value to its left. C. Note the different place values on the place value chart at the top of the worksheet I am passing out. To compare	A. 0.001 B. 0.4 is greater C. Brake Rotors: The Math Within!

decimals, we compare the values in each place until we find two different digits in the same place value. At that point, we can tell that the number with the higher digit in that place is the great number, even if the other number is longer.	

3. Work through the math example *embedded* in the CTE lesson.	
A. Suppose the original thickness of a brake rotor is 1.27”. The discard thickness (when the rotor is no longer usable) is 1.21”. We have taken six measurements as follows: 1.223, 1.261, 1.238, 1.229, 1.26, and 1.251. We need to put these **in order from least to greatest**, and see if the least value is acceptable and can be machined. Who can put these numbers in order from least to greatest?	A. 1.223, 1.229, 1.238, 1.251, 1.26, 1.261
B. **The smallest value is 1.223**. Now we have to figure out how much needs to be machined from the rotor to make it “true.” This amount is the difference between the highest measurement and the lowest measurement.	B. 1.261 - 1.233 = ? We need to line up the decimal points so we will be subtracting the correct digits from each other: 1.261 - 1.233 **0.028**
So, we have 0.028 (twenty-eight thousandths) that must be machined from the rotor. However, we do not want to machine more than five-thousandths at a time, in order to avoid what is called **the “record effect,”** which is grooves in the rotor. How many times would we need to machine the rotor in order to meet this requirement? We will also use a dial indicator to measure **lateral runout** (a term to describe the wobble of the brake rotor). Maximum allowable lateral runout is usually between 0.10 and 0.13 mm. If the dial indicator registers more than 0.13 mm at any point during on rotation of the rotor, the rotor must be discarded.	**Six cuts:** Five cuts of five-thousandths, and one cut of three-thousandths. **NOTE:** A good automotive tech weighs the cost of machining the existing rotor against the cost of replacing the rotor. It is also important to look at how close to minimum thickness the rotor would be after machining and how long it could be expected to last.

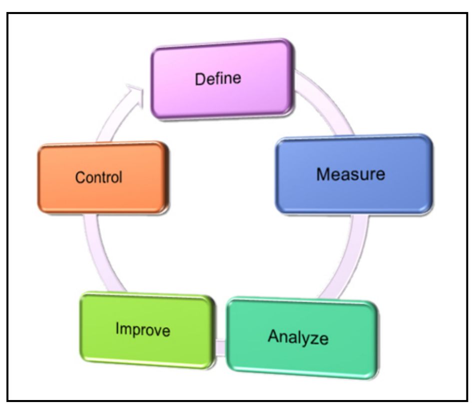
4. Work through the related contextual math examples. A. You look at the **right front brake** and take the following measurements: 32.140 mm, 32.135 mm, 32.140 mm, 32.138 mm, 32.139 mm, 32.140 mm. Lateral runout is 0.015 mm. If the discard thickness is 30.700 mm and maximum lateral runout is 0.080 mm, what should you do? B. A disc brake rotor has a diameter of 7.550" and a minimum allowable thickness of 0.468". Your measurements from around the rotor are 0.463", 0.462", 0.460", and 0.458". **What would you recommend to the customer**?	A. The largest measurement is 32.140 and the smallest is 32.135, with a difference of 0.005 mm. The lateral runout is less than 0.080. Therefore, the rotor should be machined by 0.005 mm. B. Each measurement is less than 0.468, so the rotor should be replaced.
5. Work through the *traditional math* examples.	See Brake Rotor: The Math Within! Worksheet
6. Students demonstrate their understanding.	A. Set up the rotor to be machined and take multiple measurements on the rotor surface. B. Then, check the manufacturer's specifications for minimum thickness a rotor can be machined. C. Compare your measurements to the manufacturer's specification values and determine how much metal needs to be machined from the rotor to make it functional. (NOTE: Some rotors are warped, too thin, or cracked and cannot be machined so they will have to be replaced with a new one.]
7. **Formal assessment**. **Source of Formal Assessment Items:** Sample release and retired items from ACT, ACT COMPASS, SAT, ACT Explore, ACT WorkKeys, Illustrative Mathematics, NATEF, NAEP, PARCC, TIMSS, and teacher-constructed test items.	**Performance Assessment:** Students machine a rotor to the proper specifications.

Math-in-CTE Lesson Plan

Lesson Title: **Spaghetti Bridge**	Lesson #02

Occupational Area: Technology
CTE Concept(s): Problem Solving Model
Math Concept(s): Order of Operations
Writers: Sebastian Kapala, Bolingbrook HS & Mark Morrey, Joliet Central HS

Lesson Objectives:	1. Describe the general problem-solving/design process. 2. Define a technological problem or opportunity. 3. Describe the technological problem-solving/design process. 4. List the major steps in solving technological problems and meeting technological opportunities. 5. List the steps to identify a technological problem or opportunity. 6. List the criteria and constraints in the problem-solving design process. 7. List general methods of gathering information for the problem-solving/design process. 8. Describe the foundational information that must be gathered to solve technical development projects. 9. Design a bridge using 1 pound of noodles. 10. Build the bridge. 11. Test the bridge's efficiency by first weighing the bridge, then placing a load on the structure. 12. Record the amount of weight your bridge can support.
Supplies Needed:	Glue (for paper) Paper Utility knife Straight pins Spaghetti noodles Cardboard
Key Terms:	Constraints Criteria Descriptive methods Design Process Scientific information Technological knowledge Technological Opportunity Technological problem Order of Operations Human information Legal information Problem solving Descriptive methods Ethical information Experimental methods History Information Historical methods Mechanical Advantage

THE “7 ELEMENTS”	TEACHER NOTES (and answer key)
1. **Introduce the CTE lesson**. All technology is created for purpose. It is designed to meet human needs or wants. All technology was developed by people who wanted to solve a problem or address an opportunity. **Discussion:** Ask students to: 1. Provide an example of problem solving. 2. Provide an example of the design process.	Evaluate each answer individually. (You may substitute these discussion topics based personal experience and comfort level of discussion.) Problem Solving EXAMPLES: 1. Getting ready for school 2. Designing a home and/or any product.
2. Assess students’ math awareness as it relates to the CTE lesson. Write the following key terms on the board. Have students define them. 1. Order of operations 2. Problem Solving (graphically) 3. Design Process (graphically) 4. Mechanical Advantage	**Order of operations** Do you ever get confused about which part of a math problem to solve first? REMIND students of the phrase “**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally.” How does that help? It’s an acronym or mnemonic device for *order of operations*. **P**=Parenthesis **E**=Exponents **M**=Multiplication **D**=Division **A**=Addition **S**=Subtraction **Problem solving** 

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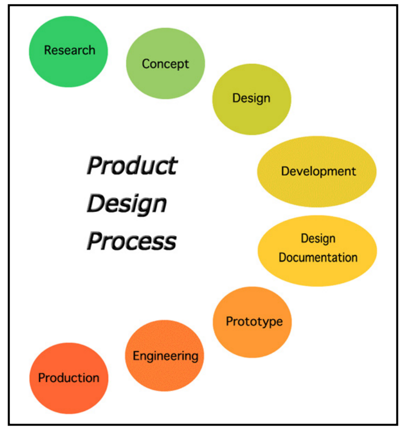
Design Process



Mechanical advantage is a measure of how much a simple machine multiplies the input of force put into the machine.

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3. **Work through the math example embedded in the CTE lesson.**

The Law of Equilibrium:
A Greek mathematician who lived more than two thousand years ago actually proved the law behind the workings of the LEVER. Archimedes observed how a small force can move a great weight. From this observation, the following law of equilibrium was created: A lever is in equilibrium when the product of the weight (W1) and distance (D1) on one side of the fulcrum [the center of gravity] is equal to the product of the weight (W2) and distance (D2) on the other side of the fulcrum. The formula is **W1 x D1=W2 x D2**.

1. So, if Roberto, who weighs 150 pounds, is 2 feet from the fulcrum of a seesaw, how far from the fulcrum would Becky, who is 60 pounds have to sit to achieve equilibrium?

2. If Isaac, who weighs 120 pounds, is 3 feet from the fulcrum how far from the fulcrum would Josie who is 90 pounds have to sit to achieve equilibrium.?

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Solution using the law of equilibrium formula:

1. Using W1=150, D1=2 and W2=60 we can calculate the distance (D2) as follows:
   a. 60 x D2=150 x 2
   b. 60 x D2=300
   c. D2=300/60
   d. D2=5

So, Becky would need to sit 5 feet from the fulcrum.

2. Using W1=120, D1=3 and W2=90 we can calculate the distance (D2) as follows:
   a. 90 x D2=120 x 3
   b. 90 x D2=360
   c. D2=360/90
   d. D2=4

Thus Josie would need to sit 4 feet from the fulcrum.

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4. **Work through *related, contextual* math-in-CTE examples.**

Problem Statement:
The objective of this activity is to design and build the lightest bridge possible, capable of supporting the heaviest load when weight is hung, or placed on a given span, using specified materials and guidelines. In addition, the students create a PowerPoint or other presentation describing what they learned about bridge design and function.

PARAMETERS:
1. Bridge must span an opening of 6” (minimum). (The distance between the center-most pillars.)
2. Roadbed width must be 4” (minimum) and there must be at least 3” above the road of empty space. (This is where the wooden block is placed.)
3. Roadbed base must be 3” above the ground (minimum).
4. Length 6” to 18” and Width 4” to 8”.
5. Roadbed height 3 1/2” (minimum)
6. Complete order of operations Khan Academy examples at https://www.khanacademy.org/math/pre-algebra/pre-algebra-arith-prop/pre-algebra-order-of-operations/v/order-of-operations.
7. Create a 10-slide PowerPoint about Bridge Design at the conclusion of the project. (cover slide, objective slide, vocabulary, photos, body of the presentation (including statistics and insights), conclusion slide, source slide)

MATERIALS & SUPPLIES:

Noodles	One pound
Glue	Elmer’s or Super Glue

Evaluate the projects individually.

Analysis: Meet as a class and analyze the material processing activities using the following questions for each student/student team:

1. Which material processing tools were used?
2. Which measuring tools were used?
3. How could the speed of the manufacturing process have been increased?
4. What changes in the material processing actions would be made to improve the quality of the product?
5. What has this activity taught you about the problem solving method?
6. How can you relate this information to your other courses?
7. Describe how this activity relates to the information we covered in class so far.
8. Given the opportunity how would you redesign this activity?

BRIDGE Data:
1. Width = ______
2. Height = ______
3. Length = ______
4. Weight = ______
5. Load Carried = ______
6. Bridge Efficiency (Bridge Weight / Load Carried) = ______

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SUGGESTED PROCEDURES:
1. **Read and analyze the problem statement** carefully prior to formulating the procedures and techniques necessary to construct a solution.

2. **Review the accepted steps in the problem solving process.**
a. Identifying
b. Developing
c. Evaluating
d. Applying

3. **Be creative.** Do not be limited by the drawing above. There are unlimited possibilities for solving the problem.

4. **Prepare to discuss** your solution with the class. (Student reports may contain working drawings, description of problem solution, etc.)

TESTING:
1. Center the bridge on the platform.

2. Place a wooden or metal block 4” by 6” on the roadbed.

3. Add weights in a continuous fashion until the bridge fails. [NOTE: A fail is the inability of the bridge to carry any additional load without breaking, or with any part of the bridge extending more than 2 cm.

4. Check all construction requirements and dimensions prior to testing.

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5. Work through the *traditional math* examples.

1. Which of the following expressions is equal to $\frac{1}{x+2} - \frac{2}{x+1}$?

A. $\frac{-1}{2x+3}$
B. $\frac{-x-3}{x^2+2}$

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Solutions

1. D

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C. $\frac{-1}{x^2+3x+2}$

D. $\frac{-x-3}{x^2+3x+2}$

E. $\frac{-x+5}{x^2+3x+2}$

2. What is the solution to the system of equations $\begin{cases} 3x - 2y = -7 \\ x + y = 11 \end{cases}$?

Answer: x = ____________________

y = ____________________

2. X=3, y=8

3x-2y=-7

x+y=11

3x+-2(11-x)=-7

3x-22+2x=-7

5x-22=-7

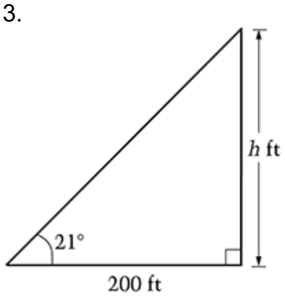
5x=15

X=3

3+y=11

y=8

3.



Note: Figure not drawn to scale.

On level ground from a distance of 200 feet, the angle of elevation to the top of a building is 21°, as shown in the figure above. What is the height h of the building, to the nearest foot?

A. 72
B. 77
C. 187
D. 201
E. 521

3. B

4. In a certain restaurant a whole pie has been sliced into 8 equal wedges. Only 2 slices of the pie remain. Three people would each like an equal portion from the remaining slices of pie. What fraction of the original pie should each person receive?

Answer: __________________________

4. 1/12

5. The remainder when a number *n* is divided by 7 is 2. Which of the following is the remainder when 2 *n* + 1 is divided by 7 ?

A. 1
B. 2
C. 3
D. 4
E. 5

5. E

6. A cat lies crouched on level ground 50 feet away from the base of a tree. The cat can see a bird's nest directly above the base of the tree. The angle of elevation from the cat to the bird's nest is 40°. To the nearest foot, how far above the base of the tree is the bird's nest?

A. 32
B. 38
C. 42
D. 60
E. 65

6. C

6. Students *demonstrate their understanding.*

1. Students complete the handouts provided by the instructor and complete any other projects being created in class.
2. Student find solutions to their problems using *order of operations*.
3. Student complete the hands-on activities provided by the instructor.

Projects similar to the Spaghetti Bridge task. For example:
a. Spaghetti Bridge at http://techedchs.weebly.com/uploads/3/8/4/4/38449457/bridge-designs.pdf.
b. Spaghetti Bridge at https://www.teachengineering.org/activities/view/wpi_spag_act_joy.
c. Spaghetti Bridge at http://me.utep.edu/cmstewart/documents/ME1321/Project%20Overview.pdf.
d. Other teacher-selected handouts, tasks/ worksheets, and/or projects.

7. Formal assessment.	**Solutions**
1. Rosa is twice as old as Byron. Fred is one year older than Byron. If Fred's age is represented by *F*, which of the following represents the ages of Rosa and Byron, respectively? A. ½ (*F* - 1) and *F* - 1 B. ½ (*F* + 1) and *F* + 1 C. 2 (*F* - 1) and *F* - 1 D. 2 (*F* + 1) and *F* + 1 E. 2 *F* and *F* - 1	**1. C**
2. It takes 28 minutes for a certain bacteria population to double. If there are 5,241,763 bacteria in this population at 1:00 p.m., which of the following is closest to the number of bacteria in millions at 2:30 p.m. on the same day? A. 80 B. 40 C. 20 D. 15 E. 10	**2. B**
3. $$\sqrt{8}\,N = 3^5$$ In the equation above, what is the value of *N*, rounded to the nearest tenth? Answer:____________________	**3. 85.90**
4. $3^3 + 4(8-5) \div 6 =$ A. 6.5 B. 11 C. 27.5 D. 29 E. 34.16	**4. D**

Math-in-CTE Lesson Plan

Technical Mathematics

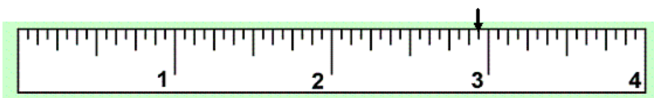
Lesson Title: Reading a Ruler **Writers:** Adam Yakush: Minooka Community High School Kim O'Malley: Morris Community High School	Lesson # 2 **Vocabulary** Ruler Fractions Numerator Denominator Common denominator Reduce Greatest common factor

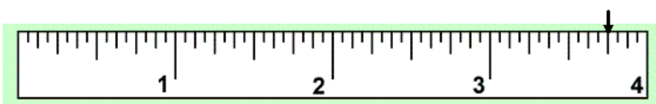
Technical Area: Woods 1
CTE Concept(s): Reading a ruler, accurate measurement
Math Concept(s): Fraction operations, measurement
CCSS Math Practices & Standards: G.CO.1 G.CO.12 MP 4

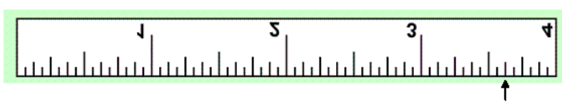
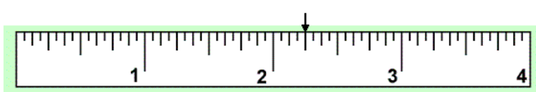
Lesson Objectives:	1. Read a 16th-inch scale ruler 2. Measure within a 16th of an inch 3. Add fractions 4. Subtract fractions 5. Multiply fractions 6. Divide fractions
Supplies Needed:	1. Pencil 2. Tape measure- 16th-inch scale 3. Various shop objects 4. Dry erase board

<table>
<tr><th>THE "7 ELEMENTS"</th><th>TEACHER NOTES
(Plus Answer Key)</th></tr>
<tr><td>1. Introduce the CTE lesson.
How important is measurement? Measurement is necessary for everything that is produced.</td><td>Show students different objects to compare how important measurement is.
Examples: Space shuttle, pencil</td></tr>
<tr><td>2. Assess students' math awareness as it relates to the CTE lesson.

A. Give students Pre-test on different measurements such as the following examples:





B. Pretest will also include simple addition and subtraction of fractions.
5½ – ¾ =
¾ – 1/8 =
4-3/8 – 2¼ =
5/8 – ½ =
2- 5/16 – 1- 1/8 =

¼ + 1/8 =
¾ + 5/8 =
1½ + 1/16 =
5- 3/8 + ½ =
3/8 + 7/16 =

C. Provide students answers to the pre-test to self-assess how well they have done.</td><td>Create a worksheet that includes the ruler, addition, and subtraction problems shown.

• 2- 15/16
• 3- 3/4
• 3- 5/8
• 2-1/4

• 4¾
• 5/8
• 2-1/8
• 1/8
• 1- 3/16

• 3/8
• 1-3/8
• 1-9/16
• 5- 7/8
• 13/16</td></tr>
</table>

3. Work through the math example *embedded* in the CTE lesson.	
Parts of a tape measure: A. 16th-inch scale B. Foot marks C. Inch marks	Tape measures are handed to students.
Students are given blank inch to fill in. (See attached file) **Parts of an inch:** A. Inch Marks: Longest line and marks were an inch starts and stops B. ½″ mark: 2nd Longest line in an inch. Have students fill in the blank inch. C. ¼″ marks: 3rd longest line in an inch. Have students fill in 1/4″ and 3/4″ marks D. 1/8″ marks: 4th longest line in an inch. Have students fill in 1/8″, 3/8″, 5/8″, and 7/8″ marks E. 1/16″ marks: 5th longest and shortest line. Have students fill in 1/16″, 3/16″, 5/16″, 7/16″, 9/16″, 11/16″, 13/16″, and 15/16″ marks.	Students fill out the worksheet as it is simultaneously being filled in on the dry erase board. Once filled out, students can keep it for reference.

4. Work through *related, contextual* math-in-CTE examples. Examples of different line lengths/segments for students to measure. 1. ___________ 2. ___ 3. ________________ 4. ____________________ 5. _______ 6. _ 7. ____________ 8. ____ 9. ___________________________ 10. _______________ Complete the following task with each line. 11. Add lines 2 and 9 12. Subtract line 6 from line 8 13. Multiply lines 1 and 10 14. Divide line 4 from 5	Give each student a tape measure to find the length of the different lines. They will find it the length to the nearest 16th of an inch. Students use the individual line/segment measurements, from lines 1 through 10, to answer questions 11 through 14.

5. Work through the *traditional math* examples. Addition: 1. 3/16 + 5/8= 2. 1/2 + 3/8 +1/16= 3. 5/16 + 1/2 + 1+ 3/4= Subtraction: 4. 7/8 – 5/16= 5. 15/16 – 1/2= 6. 3/4 – 3/8= Multiplication: 7. 3/16 x 7/8= 8. 5/16 x 1/8= 9. 3/8 x 3/8=	Following are typical math problems. Addition HINT: Common Denominator Subtraction HINT: Common Denominator Multiplication HINT: Straight Across

<table>
<tr><td>Division:
10. 3/4 ÷ 3/8=
11. 1/8 ÷1/16=
12. 1/2 ÷ 1/8=</td><td>Division HINT: Flip and multiply</td></tr>
<tr><td>6. Students demonstrate their understanding.

Students complete the following “Measurement Activity” assessment individually. They use tape measures and must find sizes of different objects around the classroom and shop.

1. Book thickness = _____
2. Drain diameter = _____
3. Screwdriver length = _____
4. Elec. Box Opening Diameter = _____
5. T- Square Width = _____
6. Whiteboard marker length = _____
7. Desk thickness = _____
8. Broom handle diameter = _____
9. Wall clock diameter = _____
10. An item of your choosing = _____</td><td>Print and distribute the “Measurement Activity” assessment.

Make a key before giving the assessment.</td></tr>
<tr><td>7. Formal assessment.

Students complete a post-test assessment on reading a ruler. The test contains several different rulers and markings to test the students.

Source of Formal Assessment Items: Sample release and retired items from ACT, ACT COMPASS (including Joliet Junior College (JJC) Sample Release Items), ACT Explore, ACT WorkKeys, Illustrative Mathematics, JJC CAD Dual Credit proprietary test items, Career Cruising, National Automotive Technicians Education Foundation (NATEF), National Assessment of Educational Progress (NAEP), Partnership for Assessment of Readiness for College and Careers (PARCC), Trends in International Mathematics and Science Study (TIMSS), and teacher-constructed test items.</td><td>Print and distribute the post-test assessment.

Make a test key before giving the assessment.</td></tr>
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