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

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<tr><th>THE “7 ELEMENTS”</th><th>TEACHER NOTES
(Answer Key)</th></tr>
<tr><td>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?</td><td>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.”</td></tr>
<tr><td>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</td><td>A. 0.001

B. 0.4 is greater

C. Brake Rotors: The Math Within!</td></tr>
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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.