Pascal's Law & Surface Area of a Piston

Lessons 2 and 3

Remember:
Pretty **P**lease **M**y **D**ear **A**unt **S**ally
(From left to right; **P**arentheses; **P**ower; **M**ultiply; **D**ivide; **A**dd, **S**ubtract)

We have learned how to measure a brake drum to determine if we can resurface it, there charging only a labor fee, or, if the drum is worn or scored beyond it's discard limit. Today, we're going to discuss how a 100-pound person can stop a 4000-pound car. Or how a 1" servo piston inside an automatic transmission can increase fluid pressure enough to stop an input drum connected to the torque converter from spinning.

By using the brake system's ability to multiply force, we can use a math formula to calculate the applied force on the brake pad pressing on the rotor. You can also calculate the surface area of a piston using the formula for finding the area of a circle.

Some of the math and math terms we'll be using to today are:

Algebraic Expressions - variables and numbers that can be combined with the operations of arithmetic.

Formulas - Equations with several variables.

Variables - letters or symbols that can represent real numbers

Piston - container that transfers pressure into motion.

Pascal - scientist who worked with atmospheric pressure. Pressure decreases with height and a vacuum existed above the atmosphere.

The formula we'll be using to determine Pressure, Force and Area:

$$P = \frac{F}{A}$$

$$F = P * A$$

$$A = \frac{F}{P}$$

Area = $\prod r^2$ (r = radius) Diameter = 2r

Pressure - (pounds per square inch [psi]) A = area (square inches) F = force (pounds)

Surface area - the area of the face of the object. In this instance, surface area would be the face of the top of the piston, $\prod$ (Pi) = 3.14 X r X r = area of a circle

∏ (Pi) - 3.14 approx.

Radius - the distance from the center of the circle to any point on the circle. (Half of the diameter)

Diameter - the line that passes through the center point and ends at two points on the circumference.

Center - point in a circle that is equidistant from the all points around the circumference of the circle.

Define Pascal's Law. Use the formulas to calculate pressures. Use the formula to calculate surface area. Area = r2 (r = radius), Diameter = 2r

Example:

1. If a force of 100 pounds is applied to a piston in a hydraulic cylinder of 4 square inches in area, what is the pressure?

$$P = \frac{F}{A}$$

$$P = \frac{100\,pounds}{4in^2}$$

$$P = 25\,psi(\frac{pounds}{in^2})$$

2. If 80 pounds per square inch of pressure is applied to a 2 square inch area. What is the total force?

3. If total force is 120 pounds per square inch and pressure is 30 pounds per square inch, what is the area?

4. If we have 50 pounds of force applied to an area of .5 square inches, what would be the pressure?

5. A master cylinder piston has 100 pounds per square inch of force applied to a 1.5 square inch piston. What is the pressure?

      5A. If the force stays the same, but the diameter of the piston is increased to 4.50 inches, what is the pressure?

      5B. What is the surface area of the 4.50" diameter piston in square inches?

      5C. How much how force is being applied to the 4.50" piston if the pressure is 1000 psi?

6. If the diameter of a wheel cylinder cup is 23/32 inches, determine the force applied to the piston if 1700psi is produced.
Remember to convert!

7. Find the area of a piston with a 7-inch diameter.

8. Find the area of a circle with a 20 mm (millimeters) diameter.

9. Find the diameter of a piston with an area of 32.75 square inches.

10. Find the radius of a circle with an area of 25 square centimeters.

Larry's Truck Worksheet

Name: _____ AM-1: _____ PM _____ Date: _____

This can be a team project.

You've just seen that Larry put a 6" lift kit on his Ford F-150 and a set of 33's Super Swamper Thornbird Tires. The Suspension System has been modified to handle the oversized tires, however, Larry cheaped out and didn't modify the Brake System. Larry now has a problem stopping his "Big Foot" whannabe.

Congratulations! You've just been promoted to head braking system engineer. Based on our lessons on Pascal's Law and your knowledge of automotive braking systems, you've been assigned the task of developing a plan to fix Larry's truck.

Remember: Larry doubled the size of the original tires. The truck's stock brake system parts sizes are: 1/4 in brake lines; 1/2 in bore master cylinder; 7/8 in bore wheel cylinders and 2 in caliper pistons.

Your task: Now, you must:

1. Determine what parts should be replaced on Larry's truck that will make it stop better.

2. We know it is possible to replace all the parts that could affect the trucks stopping ability, but is it physically possible to bolt them to the truck? For example, can we purchase a replacement master cylinder that has a different size bore and is the same physical size as the stock master cylinder that came standard on the truck, and still be bolted to the truck without modifications?

3. List the parts you would replace, and why. *You must show all calculations and justify your solution in a 200-300 word essay.* NOTE: There is no one "right" answer.

The written paper will account for one of your required marking period essays. If this was a team effort, each team member must turn in a separate essay on his or her portion of the project. Good luck and have fun!

North Montco Technical Career Center

Math-In-CTE

Lessons 2 and 3 Worksheet – Pascal's Law

Name: _____ AM-1: _____ PM _____ Date: _____

Work through traditional math examples.

1. Find the time traveled for a distance of 150 miles at a rate of 55miles per hour. Remember: T = d/r

2. Find the diameter of a circle that has a circumference of 36 in. Remember: C =πd

3. If a force of 120 pounds is applied to a piston in a hydraulic cylinder of 8 square inches in area, what is the pressure?

4. If 95 pounds per square-inch of pressure is applied to a 3 square in area, what is the total force?

5. Solve for the value of x. 15 =x /3

6. Find the value of r when 3 =57/r

7. Find the value of R in terms of E and I from the formula, E =IR

Lessons 2 and 3 Homework – Pascal's Law

Name: _____ AM-1: _____ PM _____ Date: _____

1. If we have 50 pounds of force applied to an area of .75 square inches, what would be the pressure?

2. If total force is 110 pounds per square inch and pressure is 45 pounds per square inch, what is the area?

3. A master cylinder has 200 pounds per square inch of force applied to a 2 square inch piston. If the diameter of the caliper piston is 4 inches, find the area of the caliper piston in square inches. Determine the force of the caliper piston.

4. Find the area of a piston with a 5-inch diameter.

5. Find the radius of a circle with an area of 18 square centimeters.

6. Find the diameter of a circle with an area of 25 square centimeters.

7. Find the average rate traveled when the distance from point A to point B was 92 miles and the time of travel was 2 hours and 15 minutes.

8. Find the value of x when 36 =4 /x 2