Automotive Technology (47.0604) T-Chart

Calculate surface area of a piston	=	Apply geometric concepts to model and solve real world problems

Program Task: Diagnose engine mechanical problems, perform precision measurements.

Program Associated Vocabulary:
AREA, DISPLACEMENT, COVERAGE, FRICTION SURFACE, DIAMETER

Program Formulas and Procedures:
Formula to find Surface Area:
Cylinder: $SA = 2\pi r^2 + 2\pi rh$
r = radius, h = height

diameter = 4”

h = 5”

Example: What is the surface area of this piston?
Radius is ½ of diameter = 0.5 x 4 = 2”
h(height) = 5”

Cylinder $SA = 2\pi r^2 + 2\pi rh$
$SA = 2\times\pi\times 2^2 + 2\times\pi\times 2\times 5$
$SA = 8\pi + 20\pi$
$SA = 28\times\pi$
$SA \approx 87.92$ sq. in.

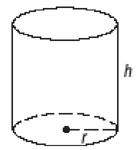
PA Core Standard: CC.2.3.HS.A.14

Description: Apply geometric concepts to model and solve real world problems.

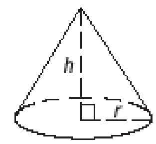
Math Associated Vocabulary:
AREA, CROSS SECTION, LENGTH, WIDTH, ROUND, BASE, HEIGHT, RADIUS, RECTANGULAR PRISM

Formulas and Procedures:
Surface Area:

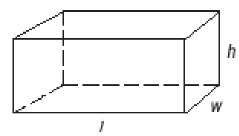
Cylinder:
$SA = 2\,\pi\,r^2 + 2\,\pi\,r\,h$



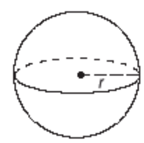
Cone:
$SA = \pi\,r^2 + \pi r\,\sqrt{(r^2+h^2)}$



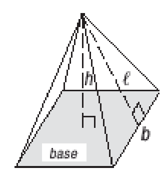
Rectangular Prism:
$SA = 2lw + 2wh + 2hl$

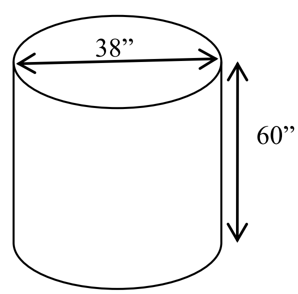


Sphere:
$SA = 4\,\pi\,r^2$



Pyramid:
SA = (area of the base) + ½ ℓ (perimeter of base)
h = height, b= base, ℓ = slant length





Example: Find the surface area of the cylinder above.
r = ½ • 38” = 19”   h = 60”
Cylinder $SA = 2\pi r^2 + 2\pi rh$
$SA = 2\pi(19)^2 + 2\pi(19)(60)$
$SA = 722\pi + 2{,}280\pi$
$SA = 3{,}002\pi$
$SA \approx 9{,}426.28\ in^2$

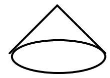
Instructor's Script – Comparing and Contrasting

Surface Area is the total area of all surfaces of a solid object. Unlike lateral area, it includes the area of the bases of the figure. The surface area formulas used in technical trades are the same as in mathematics:

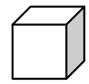
The formulas correspond to the areas of the individual surfaces of the objects:

Cylinder SA = $2\pi r^2 + 2\pi rh$ (r = radius, h = height/length)
Area of top & bottom (2 circles) + Area of sides

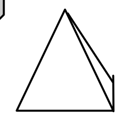
Cone SA = $\pi r^2 + \pi r\ell$ (r = radius, ℓ = slant height)
Area of bottom (circle) + Area of side



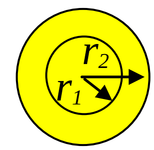
Cube SA = $6e^2$ (e = length of single edge of cube)
Area of 6 sides (6 squares)



Pyramid SA = $B + \frac{1}{2}\ell p$ (p = perimeter of base, ℓ = slant height)
Area of base + Area of sides



One additional surface area formula useful in some automotive applications (e.g., brakes) is the annulus:
Annulus SA = $\pi(r_2^2 - r_1^2)$ OR (using diameter): SA = $.7854(d_2^2 - d_1^2)$



**Remember when computing surface area of a brake rotor that it has 2 sides!
When using these surface area formulas for technical applications, the student must identify which parts of the formulas to use, as many applications will not be concerned with ALL surfaces of an object.

For example, cylinders include a top and bottom (**$2\pi rh$**), but if you are calculating a hemi cylinder, you will want to remove the top from the math formula and replace it with a specialized formula for the cap.

Common Mistakes Made By Students

Using incorrect formula: Students may use an incorrect formula to solve a problem. To rectify these errors have the students correctly identify the type of object they are dealing with and use the appropriate formula. Frequently two formulas may be needed for complex problems.

Not "removing" unnecessary surface areas from calculations: Depending on the problem, not all surface areas included in formula may be needed. Identify the areas that are required for the calculation and remove from formula as needed.

CTE Instructor's Extended Discussion

Technical tasks are usually not presented using this model. Therefore, it is important that technical instructors demonstrate to students how these math concepts link to and are relevant in their technical training and that the math is presented in a way which shows a relationship to the math CTE students use in their academic school settings.

Many shapes addressed in geometry books can be found in the automotive technology industry; cylindrical shapes being the most frequently utilized. This T-Chart focuses on determining the surface area of pistons. In addition to engine cylinders and pistons, other cylindrical parts may include pipes, tubes, hoses, conduits, ducts, tanks, and bottles, as well as integral parts of tools and other machines.

The cylindrical shape is probably most important for its inherent strength, but its surface area may also be a component of system performance. One frequent use of the cylinder is in engine pistons/engine block cylinders. These devices are critical to the amount of HP produced by an engine. Whatever the function of the cylinder may be, the formula for finding the surface area of a cylinder remains the same. When working with an engine cylinder, height typically refers to the length of pipe or tubing.

Variations of this formula can be used as the cylinder shape varies to fit the application.

Automotive Technology (47.0604) T-Chart

Problems **Career and Technical Math Concepts** **Solutions**	
1. What is the surface area of a disc brake rotor (braking surface) with an outside diameter d2 = 12" and an inside diameter d1 = 4.5"? Use the formula: SA = .7854(d22 – d12) $A = 2(.7854)(d^2 - f^2)$	
2. A wheel cylinder cup seal has a diameter which equals 7/8". The wheel cylinder cup is 3/4" deep. What is the area of the wheel cylinder cup seal and what is the surface area of the wheel cylinder cup?	
3. The eight orange traffic cones (Pyramid) used on a test track to measure brake stopping distance need to be painted bright orange. The height (h) = 36" & the diameter (d) is 15". What is the surface area of one cone; of all cones?	

Problems **Related, Generic Math Concepts** **Solutions**	
4. You need fabric to cover a 4-sided pyramid with base sides of 12' & slant length of 20'. How many square feet of fabric will you need to cover all sides of the pyramid? How many square yards? Note: $1yd^2 = 9\ ft^2$	
5. One soup can has a radius = 3" and height = 4". Another soup can has a radius = 4" and a height = 3". Which will have a greater total surface area?	
6. A size 7 regulation basketball has a d = 9.39". A size 6 regulation basketball has a d = 9.07". What is the surface area of each basketball?	

Problems **PA Core Math Look** **Solutions**	
7. Find the surface area of a cylinder with a diameter of 13.75' and a height of 28.45'.	
8. Find the surface area of a sphere that has a diameter of 27.75".	
9. Find the total surface area of a cone with base diameter of 15.50" and a height of 22".	

Problems	Career and Technical Math Concepts Solutions
1. What is the surface area of a disc brake rotor (braking surface) with an outside diameter d_2 = 12" and an inside diameter d_1 = 4.5"? Use the formula: $SA = .7854(d_2^2 - d_1^2)$ ~~A = 2(.7854)(d² - f²)~~	$SA = .7854(12^2 - 4.5^2)$ $SA = .7854(123.75)$ $SA \approx 97.19$ sq.in. 2 sides to a disc brake rotor, so **2 x** 97.08=194.16 sq. in.
2. A wheel cylinder cup seal has a diameter = 7/8". The wheel cylinder cup is 3/4" deep. What is the area of the wheel cylinder cup seal and what is the surface area of the wheel cylinder cup?	$A = \pi r^2 \quad A = \pi(.4375)^2 \quad A \approx 0.601\,\text{in.}^2$ $SA = 2\pi r^2 + 2\pi rh \quad SA = 2\pi(.4375^2) + 2\pi(.4375 \times .75)$ $SA \approx 1.203 + 2.061 \quad SA \approx 3.264\,\text{in.}^2$
3. The eight orange traffic cones (Pyramid) used on a test track to measure brake stopping distance need to be painted bright orange. The height (h) = 36" & the diameter (d) is 15". What is the surface area of one cone in sq. inches & of all the cones in sq. inches & sq. feet?	$SA = \pi r^2 + \pi r\sqrt{r^2 + h^2}$ $SA = \pi(7.5^2) + \pi(7.5)\sqrt{7.5^2 + 36^2}$ $SA \approx 176.715 + 866.442$ $SA \approx 1043.157\text{in}^2$ 1-cone, SA 8-cones = $8345.256\,\text{in.}^2$ SA in $\text{ft.}^2 \approx 8345.256 \div 144 \approx 57.953\,\text{ft.}^2$
Problems	**Related, Generic Math Concepts Solutions**
4. You need fabric to cover a 4-sided pyramid with base sides of 12' & slant length of 20'. How many square feet of fabric will you need to cover all sides of the pyramid? How many square yards? Note: 1yd2 = 27 ft2.	Pyramid: SA = (base area) + ½ ℓ (perimeter of base) SA = (12)(12) + ½ (20)(48) SA = 144 + 480 SA = 624 ft^2 SA = 624 $ft^2 \div 9 \approx 69.3\ yd^2$.
5. One soup can has a radius = 3" and height = 4". Another soup can has a radius = 4" and a height = 3". Which will have a greater total surface area?	Can 1: $SA = 2\pi(3^2) + 2\pi(3)(4)$; $SA \approx 57 + 75$; $SA \approx 132\ in^2$ Can 2: $SA = 2\pi(4^2) + 2\pi(4)(3)$; $SA \approx 101 + 75$; $SA \approx 176\ in^2$
6. A size 7 regulation basketball has a d = 9.39". A size 6 regulation basketball has a d = 9.07". What is the surface area of each basketball?	radius = ½ d Ball 1: r = 4.695 ; $SA = 4\pi(4.695^2)$; $SA \approx 4\pi(22.04)$; $SA \approx 277\ in^2$ Ball 2: r = 4.535 ; $SA = 4\pi(4.535^2)$; $SA \approx 4\pi(20.57)$; $SA \approx 258\ in^2$
Problems	**PA Core Math Look Solutions**
7. Find the surface area of a cylinder with a diameter of 13.75' and a height of 28.45'.	Cylinder $SA = 2\pi r^2 + 2\pi rh$ radius = ½ d = 6.875' $SA = 2\pi(6.875)^2 + 2\pi(6.875)(28.45)$ $SA = 94.53125\pi + 391.1875\pi$ $SA = 485.71875\pi$ SA = 1525.9 ft^2.
8. Find the surface area of a sphere that has a diameter of 27.75".	Sphere $SA = 4\pi r^2$ radius = 27.75/2 = 13.875" $SA = 4\pi(13.875)^2$ $SA = 770.0625\ \pi$ $SA \approx 2419.2\ in^2$
9. Find the total surface area of a cone with base diameter of 15.50" and a height of 22".	$SA = \pi r^2 + \pi r\sqrt{r^2 + h^2}$ $SA = \pi(7.75)^2 + \pi(7.75)\sqrt{(7.75)^2 + 22^2}$ $SA = 60.0625\pi + \pi(7.75)\sqrt{60.0625 + 484}$ $SA \approx 60.0625\pi + \pi(7.75)(23.325)$ $SA \approx 60.0625\pi + 180.769\pi$ $SA \approx 240.83\pi$ $SA \approx 756.590\,\text{in.}^2$