Electrical (46.0399) T-Chart

Determine square footage of areas	=	Apply geometric concepts to model and solve real-world problems

Program Task: Calculate lighting loads for single-family dwellings.

Program Associated Vocabulary:
SQUARE FOOT AREA, VOLT-AMPERE (VA), GENERAL LIGHTING LOAD

Program Formulas and Procedures:
When an electrician has to calculate a single-dwelling lighting load for a residence, the total square footage of the dwelling must be known. Most houses are not perfect squares, or rectangles. Therefore, all living space must be calculated.

General Lighting Load Calculation Formula is
General Lighting Load = # square feet x 3 Volt-Ampere per square foot

Volt-Ampere (VA) is the unit used for the apparent power in an electrical circuit.

Example:
If a house has a first floor measuring 50 feet wide by 35 feet deep, and has a second floor measuring 40 feet wide by 30 feet deep. What is the square footage of the house? Calculate the lighting load of the structure, and then provide the minimum number of 15 amp lighting branch-circuits required in a 120 volt house.

First Floor: A = lw   Second Floor: A = lw

A = 50 x 35   A = 40 x 30

A = 1750 sq.ft.   A = 1200 sq.ft.

Total Square Footage = 2950 sq.ft.

2950 sq. ft. x 3 Volt-Ampere per sq ft = 8850 VA

8850 VA/120 volts = 73.75 amps

73.75/15 = 4.91666 (round up to 5) 15-amp branch-circuits.

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

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

Math Associated Vocabulary:
LENGTH, HEIGHT, BASE, WIDTH, DIAMETER, RADIUS, HYPOTENUSE, AREA, PERIMETER, CIRCUMFERENCE

Formulas and Procedures:
Rectangle: $A = lw$ $P = 2l + 2w$

Trapezoid: $A = \dfrac{h(a + b)}{2}$

Circle: $A = \pi r^2$ $C = 2\pi r$ or πd
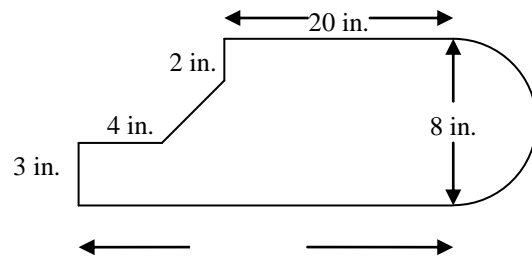   (Circumference = circle perimeter)

Triangle: $A = \dfrac{1}{2}bh$ $P = a + b + c$

Pythagorean Theorem: $c^2 = a^2 + b^2$

An irregular figure can be broken down into two or more regular shapes, such as triangles, circles, trapezoids or rectangles.

To find the **perimeter** around irregular figures, add the lengths of the sides. If the sides of the figures include circles, use the circumference formula to calculate the length of that portion of the figure and add it to the total of the other sides.

To find the **area** of an irregular figure, separate the figure into shapes for which you can calculate the area. The sum of the areas of each smaller figure is the area of the irregular figure.


To find the perimeter of the figure above, use the Pythagorean theorem and circumference formula to find the missing lengths.
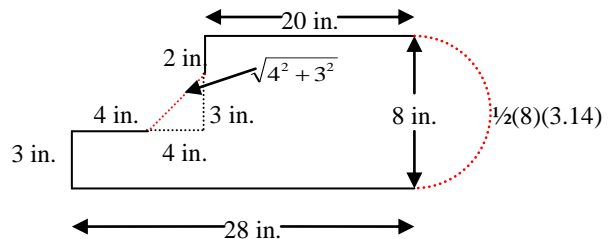
To find the area of the same figure, divide the figure into one triangle, two rectangles, and one semi-circle.

Instructor's Script – Comparing and Contrasting

The example shown on the Electrical Occupations side of the T-Chart requires that the student combine the area of two rectangles. To make these problems more difficult have a student estimate the area of a floor plan from a blueprint. Make the building layout so that it is not a basic rectangle. For instance, look at the floor plan shown below. The key skill required by this eligible content is the ability to break down complex shapes into simple shapes to find area and perimeter.

#1
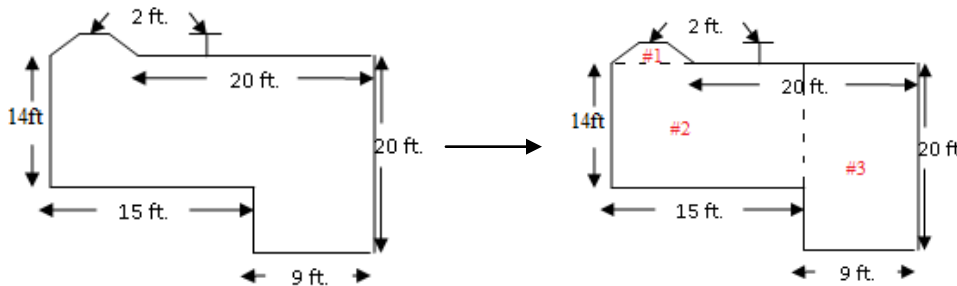
$$A = \frac{h(a+b)}{2} = \frac{2(2+4)}{2} = 6\,\text{sq.ft.}$$

#2

$$A = lw \quad A = 15 \times 14 = 210\,\text{sq.ft.}$$

#3

$$A = lw \quad A = 9 \times 20 = 180\,\text{sq.ft.}$$

Total Area is $6 + 210 + 180 = 398$ sq.ft.

Common Mistakes Made By Students

Mixing perimeter and area formulas or calculations: Perimeter formulas calculate the length of the outside edge of an object, while area formulas calculate the space taken up by the shape. Areas and perimeters should not be compared (apples and oranges) because perimeter is measured as a unit length while area is that same unit squared.

Perimeter calculations should <u>not</u> include inner edges: The perimeter of an irregular object should follow the outer edge of the figure. If you find the perimeter for basic shapes constructed within the irregularly shaped object, be sure to eliminate the auxiliary lines (inner edges) that don't follow the outside edge.

Finding basic shapes within irregular objects can be frustrating: Some irregular objects can be broken into basic shapes with only a couple of extra lines, while others seem to take a lot more. Don't feel locked in to your first attempt if it is too messy.

Empty shapes in the figure require subtracting the area of the "hole": If your plan includes areas that create holes in the object, you will be subtracting out that area to get a final answer (e.g., a deck plan that has a spot for a hot tub).

Final answer may include multiple parts: Don't forget to total all the various areas or perimeters to get your final answer.

Be sure to find all missing lengths before calculating the perimeter.

CTE Instructor's Extended Discussion

This process is completed for every type of home that is constructed today. The formulas that are needed to complete the problems on page 3 and 4 include:
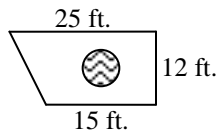
- Any or all of the area formulas on the right side of page 1 of this T-Chart
- General Lighting Load (VA) = sq. ft. x 3 VA per sq. ft.
- Min. Number of Lighting Branch-Circuits = VA / 120 volts, then divide that number by 15 (lighting branch circuit size).
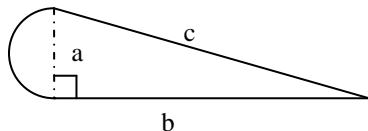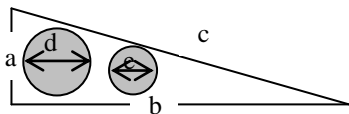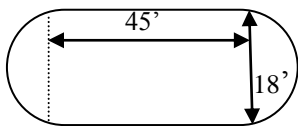
For problem #2

on page 3

Electrical (46.0399) T-Chart
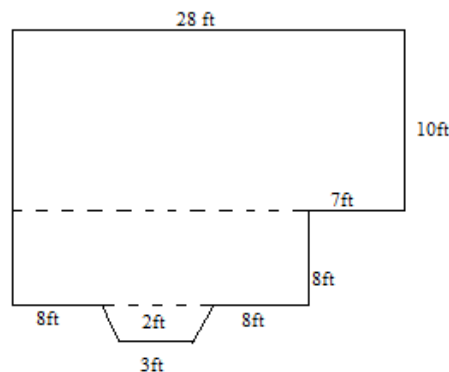
	Problems	Career and Technical Concepts	Solutions
1.	What is the area (square ft.) of a house's first floor that has a width of 70 feet and a length of 45 feet?		
2.	What is the area (square ft.) of the house shown on the bottom of page 2?		
3.	A ranch house has a width of 88 feet and a length of 43 feet. What is the area? Calculate the General Lighting Load, and the minimum number of 15 amp branch circuits for this dwelling.		

	Problems	Related, Generic Math Concepts	Solutions
4.	A health club has a circular jogging track with an outside diameter of 200 feet and the track is 15 feet wide. What is the area of the track?		
5.	Your goal is to paint a mural that depicts a large yellow image of the Sun, risen half-way above the eastern horizon. You buy a gallon of yellow paint and read that the manufacturer claims it will cover a 200 square foot wall. What is the diameter of the largest sun you can paint?		
6.	The installer plans to build a new patio with a 6 ft. (d) round hot tub in the center. What is the area of material needed around the hot tub pictured in the patio below? 25 ft. 12 ft. 15 ft.		

	Problems	PA Core Math Look	Solutions
7.	Find the area of the figure pictured. 45' 18'		
8.	Find the area of the unshaded area if a = 5, b = 18, d = 3, and e = 1. c a d b		
9.	Find the perimeter of the figure if c = 37 and b = 24. c a b		

Problems	Career and Technical Math Concepts	Solutions
1. What is the area (square ft.) of a house's first floor that has a width of 70 feet and a length of 45 feet?	$A = lw$ $A = 45 \times 70$ $A = 3150$ square feet	
2. What is the area (square ft.) of the house shown on the bottom of page 2?	#1 $A = lw = 28 \times 10 = 280$ sq.ft. #2 $\begin{array}{l}28 - 7 = 21\,\text{ft.}\\ A = lw = 21 \times 8 = 168\,\text{sq.ft.}\end{array}$ $21 - (8+8) = 5$ ft. #3 $A = \dfrac{h(a+b)}{2} = \dfrac{2(5+3)}{2} = 8$ sq.ft. Total Area $= 280 + 168 + 8 = 456$ sq. ft.	
3. A ranch house has a width of 88 feet and a length of 43 feet. What is the area? Calculate the General Lighting Load, and the minimum number of 15 amp branch circuits for this dwelling.	$A = lw$ 3784 @ 3 VA per = 11352 $A = 88 \times 43$ 11352 / 120 volts = 94.6 amps $A = 3784$ 94.6 / 15 = 6.306 (round up to 7) circuits	

Problems	Related, Generic Math Concepts	Solutions
4. A health club has a circular jogging track with an outside diameter of 200 feet and the track is 15 feet wide. What is the area of the track?	The diameter of the smaller circle is $(200 - (15+15))$ feet Large circle area $= \pi (100 \times 100)$ Large circle area $= 3.14 \times 10,000$, or $31,400$ ft.^{2} Small circle area $= 3.14 \times 85 \times 85$, or $22,687$ ft.^{2} Area of the track $=$ Large Circle Area $(31,400)$ - Small Circle Area $(22,687)$, or $8,718$ ft.^{2}	
5. Your goal is to paint a mural that depicts a large yellow image of the Sun, risen half-way above the eastern horizon. You buy a gallon of yellow paint and read that the manufacturer claims it will cover a 200 square foot wall. What is the diameter of the largest sun you can paint?	You base your estimations on a semi-circle whose area is 200 sq. ft. (full circle size would be 400 sq. ft.) Formula to use: Diameter $= (\text{Sqrt}(\text{Area}/\pi)) \times 2$ Diameter $= (\text{Sqrt}(400/3.14)) \times 2$ Diameter $= \text{Sqrt } 127 \times 2$ Diameter $= 11.27 \times 2$ Diameter $= 22.5$ feet	
6. The installer plans to build a new patio with a 6 ft. (d) round hot tub in the center. What is the area of material needed around the hot tub pictured in the patio below?	Area of patio $=$ area of a trapezoid (patio shape) – area of the circle (hot tub shape) Area $= \dfrac{h(a+b)}{2} - \pi r^2$ $A = \dfrac{12(15+25)}{2} - \pi 3^2$ $A = 240 - 28.26 = 211.74$ ft.^{2}	

Problems	PA Core Math Look	Solutions
7. Find the area of the figure pictured.	Area $=$ Area Rectangle $+$ Area one full circle $\quad = lw + \pi r^2$ ($l = 45$, $w = 18$, $r =$ radius $= \frac{1}{2} \times 18 = 9'$) $\quad = (45)(18) + \pi (9)^2$ $\quad = 810 + 254.3$ $\quad = 1064.3$ ft.^{2}	
8. Find the area of the unshaded area if $a = 5$, $b = 18$, $d = 3$, and $e = 1$.	Area $=$ Area triangle $-$ Area circle 1 $-$ Area circle 2 $\quad = \frac{1}{2} bh - \pi r^2 - \pi r^2$ (radius circle 1 $= \frac{1}{2} \times 3 = 1.5$, $\qquad\qquad\qquad\qquad\qquad$ radius circle 2 $= \frac{1}{2} \times 1 = 0.5$) $\quad = \frac{1}{2}(18)(5) - \pi (1.5)^2 - \pi (0.5)^2$ $\quad = 45 - 7.1 - .8$ $\quad = 37.1$ units^2	
9. Find the perimeter of the figure if $c = 37$ and $b = 24$.	Perimeter $= c + b +$ semicircle with diameter a. $a^2 + b^2 = c^2$ $a^2 + 24^2 = 37^2$ $a^2 + 576 = 1369$ $a^2 + 576 - 576 = 1369 - 576$ $a^2 = 793$ $\sqrt{a^2} = \sqrt{793}$ $a = 28.2 =$ diameter of semicircle circumference of semicircle $= \frac{1}{2} d\pi = \frac{1}{2}(28.2)(3.14) = 44.3$ Total perimeter $= 37 + 24 + 44.3 = 105.3$ units	