

## Lesson #1 – The Effect of Increasing Sides of Polygons

### *Opening discussion*

- 1) What types of lodges have been used by Native Americans in the past?
- 2) Which tribes used each of the lodges?
- 3) What factors usually determined the type of home used by various tribes?
- 4) What were the geometric shapes of the bases and the dimensions of the lodges?

The following passage is taken from SIMMS Integrated Mathematics (see references). This may be helpful in the discussion.

Traditional American Indian lodges vary from tribe to tribe and from region to region. Those who lived in what is now South Dakota used tipis, the tribes of the American Southwest chose pueblos, while the people of the Far north build igloos (also called illuliaqs). Differences in climate, terrain, building materials, and cultures were all important factors in the development of appropriate housing designs.

The design of a house affects such practical considerations as the amount of building material needed, the amount of space enclosed, and the relative heating or cooling efficiency of the dwelling. As the end of the 20<sup>th</sup> century approaches, both building materials and heating fuels are growing scarce. Houses of the future must make efficient use of our resources.

Examining some traditional American Indian housing designs may help suggest possible designs for efficient homes into the next century. In this module, you examine several types of structures, the geometric shapes that represent them and the properties that help make buildings efficient.

Types of homes used included tipis, longhouses, pueblos, caves and igloos. Tribes in the American Southwest used pueblos, while those in the Far North used igloos. Factors that affected the selection of homes were weather and resources available. Circles, horseshoes, rectangles, and other polygons were among some of the geometric shapes that were used.

### *Activity*

The amount of floor space is important to the comfort of its owners. Many colonial houses had rectangular floors. In this case, the area of the floor is relatively easy to determine. The floor of a large tipi, however, could be a regular polygon with as many as 18 sides. In this activity you will determine the areas of regular polygons inscribed in a circle with a given radius.

For each polygon below:

- 1) Record the side length ( $s$ ) and the length of the apothem ( $a$ ).
- 2) Calculate the perimeter and area and record them in the table following the polygons.

Regular Polygon	Perimeter (cm)	Area (cm <sup>2</sup> )
Triangle		
Square		
Pentagon		
Hexagon		
Octagon		
18-gon		
CIRCLE		

- 3) What happens to the shape of the polygons as the number of sides increases?
- 4) What happens to the area of the polygons as the number of sides increases?
- 5) What happens to the perimeter of the polygons as the number of sides increases?
- 6) Describe the method or formulas used for finding the area of regular polygons.

## *Lesson #2 – Surface Area and Volume*

### *Opening Discussion*

- 1) Describe what a prism looks like.
- 2) What types of prisms are used for traditional houses?
- 3) What other solid shapes are used for houses?
- 4) Are silos prisms? Explain.

In designing a house, the available building materials played a big role in determining an appropriate design. The Cheyenne Indians used 12-15 buffalo hides to make a tipi. Indian families in the Yukon region of Alaska and Canada often built double lean-tos. In this activity, you will determine surface areas for different lodges.

### *Activity*

To estimate the amount of material needed to build a lodge, it is helpful to see what the building would look like on one plane. A net is a pattern without tabs that can be folded to resemble a prism or cylinder on one plane.

- 1) Draw a net that would resemble the materials needed to build the lodges in the shapes shown below.



*Lesson #3 – Heating Considerations/Studying Surface Area and Volume*

*Opening Discussion*

- 1) How do you find the volume of a prism?
- 2) Describe the difference between surface area and volume.
- 3) What important factors need to be considered when designing a house in the
  - A) Northern regions?
  - B) Southern regions?
  - C) Plains regions?
- 4) What factor needs to be considered when designing an energy efficient house?

The following paragraph is from SIMMS Integrated Mathematics:

Efficient heating and cooling were major considerations when choosing a design for a dwelling. Since you heat the space inside a home (volume) and lose heat through the outside walls, roofs, and floor (surface area), you must consider both surface area and volume when estimating its efficiency. One way to do this involves calculating the ratio of a building's surface area to its volume. Although this rule of thumb is not always applicable, it does give one potential efficiency.

In this activity, you will determine the ratio between volume and surface area of different prisms.

*Activity*

For each arrangement of 8 cubes below:

- 1) Find the volume and surface area.
- 2) Calculate the ratio of surface area to volume.
- 3) Record all information in the table provided.

Arrangement Number	Surface Area $\text{Cm}^2$	Volume $\text{Cm}^3$	Ratio S.A./Vol

- 4) Sketch at least three other arrangements that are possible for the 8 cubes and calculate the corresponding surface area and volumes of each.
  
- 5) Compare and contrast the figure with the greatest surface area/volume ratio to the figure with the smallest surface area/volume ratio.
  
- 6) If you were building a house in a cold climate and needed to conserve heating fuel, which figure would you choose? Explain.
  
- 7) If you were building a house that collects and stores solar energy, which shape would you choose? Explain.

#### *Lesson #4 – Building a Pyramid and Tipi*

Students will build a classroom size pyramid using crepe paper or flagging tape, and then use meter sticks to measure the slant height, height, and edge lengths.

Divide students into groups to do the following tasks:

Group 1: Measure out 4 pieces of crepe paper or flagging material. Each piece should be 3 meters in length.

Group 2: Make a perfect square using the 4 pieces of paper measured by Group 1.

Group 3: Find the center of the square. Use whatever tools necessary, and be able to justify the method used mathematically.

Group 4: Connect the center of the square to a point on the ceiling directly above the center. (Connect with another piece of crepe paper.)

Group 5: Define the four edges of the pyramid by connecting crepe paper from the point on the ceiling to each corner of the base.

*Questions to work on in groups:*

- 1) Find the area of the base.
- 2) Find the area of the sides.
- 3) Find the total surface area of the pyramid.
- 4) Develop a general formula for finding the surface area of a pyramid.

The formula for the volume of a pyramid is  $(1/3)Bh$ , where B is the base area and h is the height of the pyramid.

- 5) What is the difference between the height of a pyramid and the slant height of a pyramid?
- 6) Find the volume of the pyramid constructed by the class.

Change the shape of the base to a circle with a diameter of 2 meters. Answer questions 1-6 for the cone instead of the pyramid.

*Lesson #5 – Assessment Research Project*

Choose one Native American tribe, or several tribes for a single region, and study their traditional lodges. Describe each lodge's practical seasonal and cultural uses. Then describe each lodge from a mathematical point of view. Include its shape, geometric properties and typical dimensions. Include a diagram and mathematical formulas to show surface area and volume of the lodge.

The grade for this project will be based on:

Presentation: Neatness, typed summary, color and organization

Mathematics: Diagrams, corresponding formulas, correct calculations.

Bibliography: Sources in correct bibliographic format

You may want to build a model of the dwelling or include a computer sketch.

This project is due: \_\_\_\_\_.

The rough draft is due: \_\_\_\_\_.