Guitar Geometry

The golden ratio can be used as a basic guide for guitar design. The Golden Ratio, also known as the divine proportion, is a design resource used for millennia, since ancient Greece times. It describes a relation between two segments, one of which is 1.618 times larger than the other. This relationship is found in an astonishing number of instances in culture and the universe, clearly more frequently than pure chance would suggest. So, a guitar designed using this principle would be perceived as consistent with proportions found in art and nature. The figures below illustrate how the Les PaulTM and the StratocasterTM fit into the golden rectangle. Notice the position of the bridge in the Les PaulTM and the precise golden relation between the width at the upper bout and the length of the StratocasterTM body.

**Diagram: Leo Lospennato, Luthier**



**Learning Objectives:**

Although mathematically defined as an irregular shape, a guitar design based on the golden ratio is divinely proportioned and harmonious with nature and the universe. The total surface area of an irregular shape is determined by dividing the shape into known geometrical shapes, such as triangles, rectangles, and circles, then measuring, calculating, and combining the individual areas. Knowing the surface area of your guitar is necessary to determine how much paint is needed for full coverage.

1. Students will demonstrate understanding of polygon properties and scale by creating a scale drawing of a guitar shape, dividing the irregular guitar shape into polygons and circle sectors, then measuring, calculating, and combining the individual areas.
2. Students will demonstrate understanding of real-world and mathematical problems involving the surface area of two-dimensional objects by determining the total surface area of a guitar body.

**Materials Required:**

Graph paper, pencil, ruler, geometrical compass, basic calculator

A guitar to use for determining surface area

**Safety:**

**Safety:**

N/A

**References:**

Lospennato, L. (2010). *Designing the electric guitar body: A guest post.* guitarmakersonline.com. Retrived 6 January 2014 from http://guitarmakersonline.com/desiging-the-electric-guitar-body/

GuitarEngineer.com. (2005). *Finite element model.* (Chapter 3).

**Standards:**

**Common Core State Standards for Mathematics aligned with this activity:**

[CCSS.Math.Content.HSG.MG.A.1](http://www.corestandards.org/Math/Content/HSG/MG/A/1/) Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

[CCSS.Math.Content.HSG.MG.A.3](http://www.corestandards.org/Math/Content/HSG/MG/A/3/) Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

[CCSS.Math.Content.HSG.GPE.B.7](http://www.corestandards.org/Math/Content/HSG/GPE/B/7/) Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.

[CCSS.Math.Content.7.G.A.1](http://www.corestandards.org/Math/Content/7/G/A/1/) Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

[CCSS.Math.Content.7.G.B.6](http://www.corestandards.org/Math/Content/7/G/B/6/) Solve real-world and mathematical problems involving surface area of two-dimensional objects composed of polygons and circles.

[CCSS.Math.Practice.MP1](http://www.corestandards.org/Math/Practice/MP1) **Make sense of problems and persevere in solving them.**

[CCSS.Math.Practice.MP4](http://www.corestandards.org/Math/Practice/MP4) **Model with mathematics.**

[CCSS.Math.Practice.MP5](http://www.corestandards.org/Math/Practice/MP5) **Use appropriate tools strategically.**

[CCSS.Math.Practice.MP6](http://www.corestandards.org/Math/Practice/MP6) **Attend to precision.**

**Activity**

To determine the ***total surface area*** of a guitar body, create a scale drawing of a guitar shape, divide the irregular guitar shape into polygons and circle sectors, then measure, calculate, and combine the individual areas.

**Exercise #1: Determine Surface Area of a Guitar Body**

Measure the length of the guitar body at the longest point and use this measurement and the graph paper units to determine the scale factor for your scale drawing. As accurately as possible, create a scale drawing of the guitar body onto the graph paper. Make sure your drawings are detailed representations of the front, back, and sides of the guitar body, including details, such as cutouts for the pickups and knobs.

Using a straightedge and compass, divide the guitar body drawing into circle sectors and polygons, such as triangles and rectangles. Determine and label the lengths of the geometric shapes using the graph paper units or a ruler. Using what you know about polygons and circle sectors, calculate the individual areas of the geometric shapes within the guitar body drawing, and then combine these areas to determine the total surface area.

**Exercise #2: Convert Units and Calculate Paint Quantity**

*HumbrolTM enamel paint coverage: 50-ml tin covers approximately 1.0-m² depending on thickness of application.*

Convert the total surface area of your guitar into m2. Based on the above information, how many milliliters of paint are needed to cover the entire surface of your guitar?

* ***Hint:***
* 1-inch = 2.54 centimeter
* 1-in2 = 6.4516 cm2
* 100-cm = 1-meter
* 1-m2 = 10,000 cm2