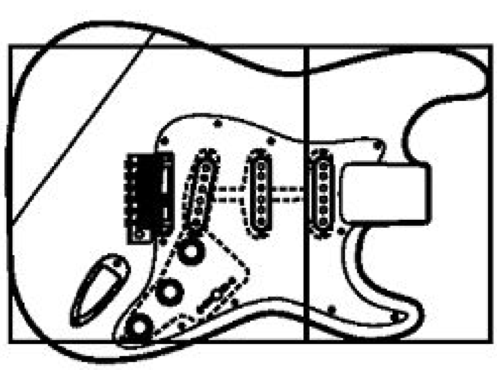
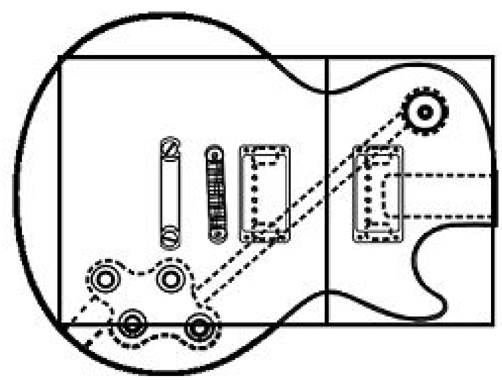
Guitar Body Geometry

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 Paul™ and the Stratocaster™ fit into the golden rectangle. Notice the position of the bridge in the Les Paul™ and the precise golden relation between the width at the upper bout and the length of the Stratocaster™ body.

Diagram: Leo Lospennato, Luthier





Learning Objectives:

Although mathematically defined as an irregular shape, a guitar body design is based on the golden ratio. It 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. By measuring, calculating, and combining the individual areas, the total area is determined. Knowing the surface area of your guitar is helpful in determining the amount of paint needed for full coverage.

1. Students will apply polygon properties and scale by creating a scaled 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 solve real-world mathematical problems involving the surface area of two-dimensional objects by determining the total surface area of a guitar body.

Standards:

CCSS.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 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 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 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 Solve real-world and mathematical problems involving surface area of two-dimensional objects composed of polygons and circles.

Materials Required:

1. Graph paper, pencil, ruler, geometrical compass, basic calculator
2. A guitar body to use for determining surface area

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). Retrieved 6 January 2014 from http://www.guitarengineer.com/index_files/Page1353.htm

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.

<u>Exercise #1: Determine Surface Area of a Guitar Body</u>

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.

<u>Exercise #2: Convert Units and Calculate Paint Quantity</u>

Humbrol™ enamel paint coverage: 50-ml tin covers approximately 1.0 m^2 depending on thickness of application.

Convert the total surface area of your guitar into m^2. 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 in^2 = 6.4516 cm^2
- 100-cm = 1-meter
- 1 m^2 = 10,000 cm^2

Name ______________________________

Assessment
Guitar Geometry

1. The "Golden Ratio" is also known as:

   A. The divine proportion
   B. A ratio of 1:1.618
   C. Phi (or ϕ)
   D. A naturally occurring relationship found in all structures life, nature, and the universe.
   E. All of these

2. All guitar designs are based on the Golden Ratio.

   True -or- False

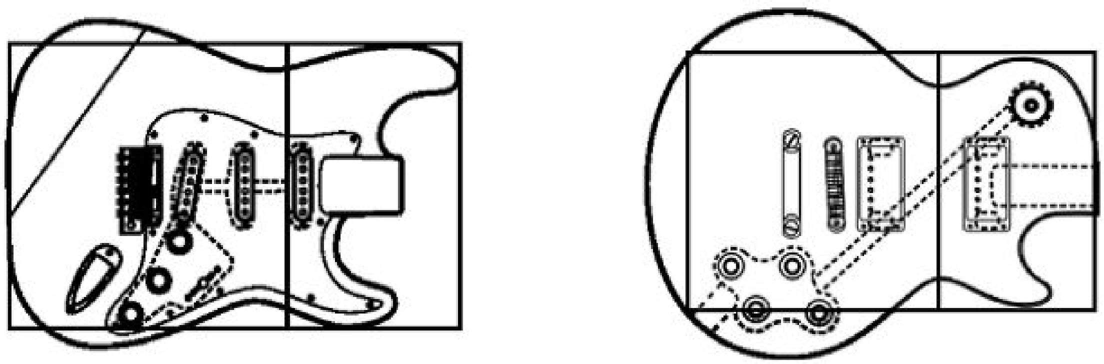
3. The total surface area of an irregular shape is determined by dividing the shape into known geometrical shapes, such as triangles, rectangles, and circles, then measuring, calculating, and combining the individual areas.

   True -or- False

4. Knowing the surface area of an object may be useful for which reason?

   A. To determine the weight of the object
   B. To determine or convert the unit scale
   C. To determine the overall size of the object
   D. To determine the quantity of material needed to cover the object
   E. No real reason- it's just as a math exercise

A. Stratocaster™ B. Les Paul™



[Diagram: Leo Lospennato, Luthier]

5. Consider the two diagrams above. Then, match each guitar body type to the corresponding description given below.

____ *Stratocaster*™ body ____ *Les Paul*™ body

A. Illustrates a golden relation between the width of the top of the guitar and the total length of the guitar

B. Illustrates a golden relation between the width and height of the top of the guitar and the position of the bridge.

6. If 1 inch is equal to 2.54 centimeters, then 1 in squared is equal to:

   A. 6.4516 square cm
   B. 25.4 square cm
   C. 2.54 square cm
   D. 100 square cm
   E. None of these

7. Match the area formulas with the correct geometrical shape. (1 point)

____	Rectangle		
____	Square		
____	Triangle	a.	pi * r^2 (r = radius)
____	Circular sector	b.	½ rl (r = radius; l = arc length)
____	Circle	c.	s^2 (s = side length)
		d.	l * w (l = length; w = width)
		e.	½ b * h (b = base; h = height

8. On a scale drawing of a guitar body, with a maximum width of 12-inches and a maximum length of 18-inches, using a scale ratio of 1:3, determine the measurements (in inches) of the scale drawing.

A. 2 x 3
B. 4 x 6
C. 6 x 9
D. 24 x 36
E. 36 x 354

9. A guitar body can be described using geometric shapes, their measures, and their properties.

True -or- False

10. If a guitar has an approximate surface area of 500-square inches, how many coats of paint is possible from a 50-ml tin of paint that covers approximately 1.0 square meters of surface area? (Hint: 1-square inch = 6.4516 square cm; 1-square meter = 10,000 square cm).

A. 1
B. 2
C. 3
D. 4
E. A 50-ml tin is not enough for 1 full coat

Assessment Key:

1. E - All of these
2. False
3. True
4. D - To determine the quantity of material needed to cover the object
5. A , B
6. A - 6.4516 square cm
7. d, c, e, b, a
8. B - 4 x 6
9. True
10. C - 3

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