Design Principles for Guitars

**Description of Activity**

* Students will be exposed to a series of design considerations for guitar body design. Examples of things to avoid will be presented, as well as a few concepts that ought to be taken into account for creating an effective design.
* Purpose of this activity is to get students thinking about what makes for good design. Just because a thing could be drawn up and cut out, doesn’t mean that it will be the most ideal solution to a challenge. The challenge in this case would be to design a guitar body.
* Activity is intended for students grades 9-14 that might be using a CAD system, such as AutoDesk Fusion 360 or SolidWorks, to design a guitar body with the intention to cut the body on the CNC machine. Also suitable for students using “legacy technology” such as band saws or portable jig saws to cut body shape from a blank.

**Learning Objectives:**

**(List measureable objectives)**

Student will use paper and pencil to design several guitar bodies as rough drafts, observing principles of design. This will happen prior to using CAD software to design the body in the computer. Student should select the design he or she feels is most effective for approval by the teacher.

**Standards:**

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| --- | --- | --- | --- |
| **Student Performance Objective(s):** | | | |
| **HS-ETS1-2** | Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. | | |
| Science and Engineering Practices | | Disciplinary Core Ideas | Crosscutting Concepts |
| **Constructing Explanations and Designing Solutions**   * Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) | | **ETS1.C: Optimizing the Design Solution**  ▪ Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS- ETS1-2) | **Systems and System Models**  ▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows— within and between systems at different scales. |

Common Core State Standards for Mathematics:

**MP.4** Model with mathematics.

List The Common Core Math, Next Generation Science Standard and/or SME Competency Gaps. For example:

Need to find some standards. I’m thinking ITEEA STL, PLTW IED or PLTW CIM

**Materials Required:**

* Pencil
* Practice Guitar Body Design Worksheet

**Safety:**

**safetys:**

**References:**

<https://www.companyfolders.com/blog/rule-of-thirds-graphic-design>

**Activity:**

The shape of the guitar requires careful consideration. The shape of the guitar performs three important functions:

1) Serves as a foundation to attach all the hardware and the neck.

2) makes an artistic statement about the guitar or its designer.

3) a machine, and a tool for making music. How will you make the guitar ergonomic or comfortable to use? An uncomfortable guitar won’t get played. Remember, the guitar is a machine, or a system of components that together, make up a tool for creating music.

The guitar body is the foundation for the electric guitar. There must be enough material present to attach all the hardware. There also must be enough material to withstand string tension when the guitar is tuned. It might be possible to create a body that has minimal material, but it may not hold up well over time when the strings are tuned. Another thought to keep in mind: if you remove material from the interior of the guitar, do you want to sand all the surfaces? Can you apply finish to all those surfaces?



Source: <https://newatlas.com/david-flores-loredo-eagle-guitar/49659/>

This guitar, called Eagle Guitar, won a design award. Although the article at newatlas mentions it going in to production, no other information can be found. High labor costs from lots of sanding and difficulty in spraying paint into all the corners and crevices would have made this an expensive body to produce. If a design has limited appeal and high production costs, award or no award, it won’t sell many units. From a structural standpoint, the six strings anchor into a relatively thin piece of end grain. Shear failure where the six strings are attached would be a concern.



Source: <http://www.myrareguitars.com/vintage-1985-austin-hatchet-electric-guitar>

The shape of the body should in some way serve as an artistic statement. It should inspire a player to want to pick it up and play it, it should be unique, and not simply a copy of some well-known body shape. A visually appealing shape, color scheme, or both, is referred to as aesthetic.

Some shapes that you probably want to avoid:

A simple slab of wood. The Hatchet guitar pictured isn’t much more than a slab of wood. Even Bo Diddley’s well-known rectangular guitar featured high end appointments like binding and a highly polished paint job. Your teacher will not accept a simple rectangle. The powerful CAD design software is capable of so much more than a rectangle. You are not fully exploring the capabilities of this advanced software package if you simply draw four lines.

A round shape like an apple, a circle, Pac-Man, Millenium Falcon, an amoeba, or a butterfly. You may think you’d like a very rounded shape but these won’t be easy or comfortable to hold for making music.

Shapes with pointy, spikey features, or where the outer perimeter abruptly changes direction. It may be hard to sand and uncomfortable to hold. You may not be able to play it easily when sitting.



Source <https://www.musiciansfriend.com/guitars/bc-rich-it-beast-electric-guitar>

You should strive for a shape that is comfortable to sit or stand to hold and play. Generally, the guitar has a narrower middle portion to sit on the player’s knee. Ergononics should be considered in your design. Ergonomic means a thing is efficient to use, and discomfort is reduced. An area to conform to your knee when you sit would be a good idea. The arm relief and tummy relief on solid guitars like the Fender StratocasterTM help make the guitar more comfortable to play standing or seated.



Source: <https://usa.yamaha.com/products/musical_instruments/guitars_basses/silent_guitar/index.html>

While this Yamaha SILENTTM guitar appears to have a comfortable shape, and certainly would be lightweight to hold, the edges of the guitar might press into your arm or torso. Before you might be tempted to cut this much away from your block of wood, there are a few things to be aware of. This Yamaha guitar perimeter isn’t part of a solid block of wood. Instead, it is formed laminations of bent wood like many acoustic guitars. The grain is continuous for strength. If you were to cut this shape from a block of wood, the wood end grain would be weakened and the guitar perimeter would break easily. Again, consider how you might sand all the interior surfaces.

Guitars with very small bodies or lots of empty air spaces in the interior may suffer from being poorly balanced. A poorly balanced guitar may be what is known as “nose-heavy” where the weight of the truss rod, neck, and tuner machines outweighs the body. When this happens, the headstock always wants to fall towards the floor. This is nearly universal in a class of small-body guitars commonly referred to as travel guitars.

So, after seeing a long list of things to avoid, what *should* you do with your guitar design?

Consider a narrow waist. If you divide the body block up roughly into thirds, consider making the middle third narrower than the rest of the guitar body. The treble side portion can rest on your knee when sitting. The bass side portion provides some clearance for your torso.

Consider bouts. If you divide the body block up roughly into thirds, the upper bout would be the area of the body closest to where the neck mounts. The lower bout is the portion furthest from the neck mount.

Consider symmetry. Symmetry about the center axis of the guitar would be where the two halves of the guitar have a matching contour. If you could fold the guitar in half along its center line both halves would make the same profile. An exception: Leo Fender pioneered body shapes known as “offset waist” where the treble side thirds (smaller three strings) are shifted further from the neck than the bass side (larger three strings.) Examples are models such as the Jazzmaster, Jaguar, Duo-Sonic, and Mustang.

Above all, try to give your guitar body shape gentle curves and transitions. This will contribute to making the guitar more visually appealing and easier to hold and play in either standing or seated position. It will also be easier to sand and finish.

Lower Bout Waist Upper Bout



Treble Side cut away

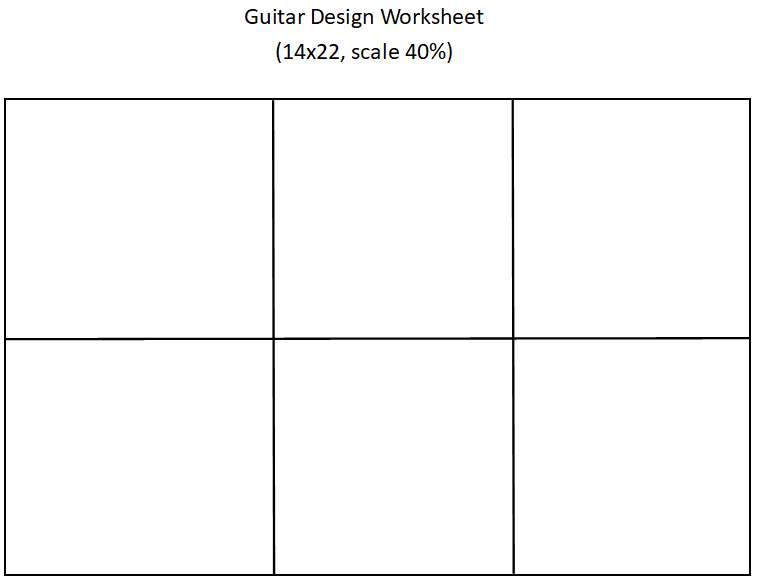
TelecasterTM shape. Symmetry about the center axis.



JaguarTM shape. Offset waist and bouts. Almost symmetrical about center axis.

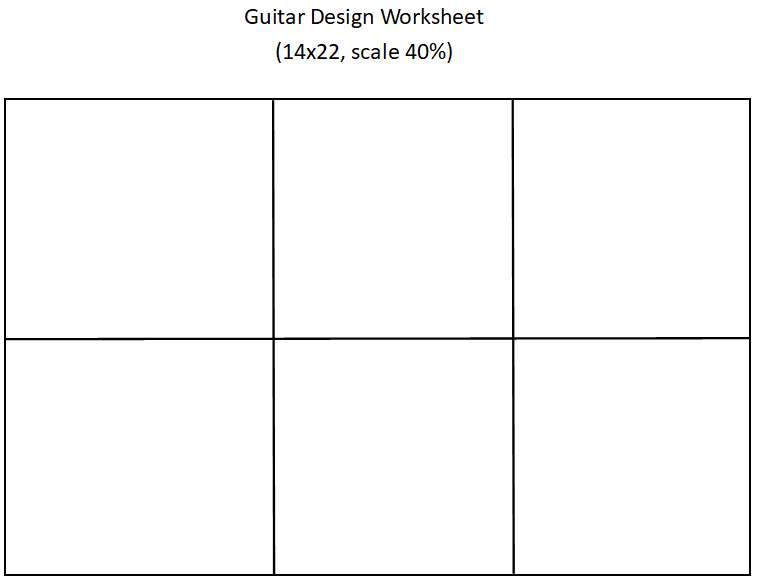
Bass and treble side cutaways on either side of the neck pocket. Notice how the waist is offset more than the bouts along the center axis.

Use the design worksheet (next page) to practice sketching a shape of a guitar body you might create in 3D CAD. The design approach here is adapted from a design principle called Rule of Thirds. Dividing an area into thirds helps guide where to place lines. On the worksheet, the thirds are equally divided, but you can tweak where the two vertical dividing lines are located. Often, the lower bout (left third) might be wider than the upper bout (right third.) Try to keep symmetry, or close to it, about the center axis.



Sample design practice sheet. You might consider moving the vertical

dividing lines between upper bout, waist and lower bout.



**Quiz:**

Match words in the word list with the description here.

1. \_\_\_\_\_ design principle with sections divided by three

2. \_\_\_\_\_ visually appealing

3. \_\_\_\_\_ narrow part of the guitar body

4. \_\_\_\_\_ efficient, comfortable to use

5. \_\_\_\_\_ area of body that allows access to higher notes

6. \_\_\_\_\_ rounded part of the body closer to the neck pocket

7. \_\_\_\_\_ object shape where halves are mirrored on axis

8. \_\_\_\_\_ body shape you really don’t want to make

9. \_\_\_\_\_ imbalanced guitar

10. \_\_\_\_\_ treble side bouts and waist shifted from bass side along center axis

Word List

1. Symmetry
2. Ergonomics
3. Offset-waist
4. Rule of Thirds
5. Aesthetics
6. Thirds
7. Nose-heavy
8. Half
9. Circle
10. Waist
11. Upper Bout
12. Cutaway

**Reviewing Faculty Cohort Members:**

* Include at least two names and schools of reviewing faculty cohort members (refer to email list for faculty cohort member email addresses). Why do reviewing faculty get named but not the author?