



# Guitars: Bringing Fun and STEM Education Back into the Classroom

*The Perfect Hook for Students from Any Background*

A close-up photograph of the body of an electric guitar. The guitar has a dark finish with a vibrant, multi-colored flame or "floyd rose" pattern in shades of yellow, orange, and blue. The image is partially obscured by text boxes.

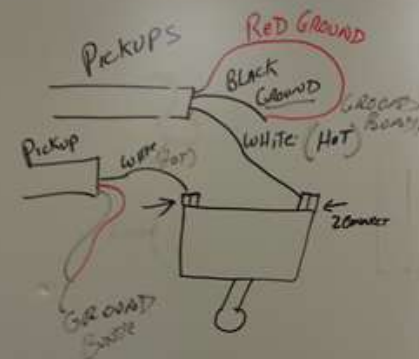
**Tom Singer**

Mechanical Engineering Technology Professor  
Sinclair Community College

A close-up photograph of the fretboard of an electric guitar. The fretboard is dark wood with light-colored fret markers. The strings are visible, and the image is partially obscured by text boxes.

# NSF Support Acknowledgement

- This material is based upon work supported by the National Science Foundation under Grant Number
- 1304405 LEAD with Guitars in STEM
- 0903336 Design, Construction, Assembly of a solid body electric guitar
- Other previous grants that assisted in the development 0802305, 04042023, 9550953, 9454571





# Your poll will show here

1



Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



When? -

*Aug 10, 1937:*  
First-ever electric guitar  
to the Electric

Versatile, inexpensive and relatively easy to play, the acoustic guitar was a staple of American rural music in the early 20th century, particularly black rural music such as the blues. But a significant physical limitation made it a poor fit in ensembles made up of brass, woodwind and orchestral string instruments: The acoustic guitar was simply too quiet. What transformed the guitar and its place in popular music, and eventually transformed popular music itself, was the development of a method for transforming the sound of a vibrating guitar string into an electrical signal that could be amplified and re-converted into audible sound at a much greater volume. The electric guitar—the instrument that revolutionized jazz, blues and country music and made the later rise of rock and roll possible—was recognized by the [United States Patent Office](#) on this day in 1937 with the award of Patent #2,089,171 to G.D. Beauchamp for an instrument known as the Rickenbacker Frying Pan.

Inventor G.D. Beauchamp, partner with Adolph Rickenbacher in the Electro String Instrument Corporation of Los Angeles, [California](#), spent more than five years pursuing his patent on the Frying Pan. It was a process delayed by several areas of concern, including the electric guitar's reliance on an engineering innovation that dated to the 19th century. When a vibrating string is placed within a magnetic field, it is possible to "pick up" the sound waves created by that string's vibrations and convert those waves into electric current. Replace the word "string" with the word "membrane" in that sentence, however, and you also have a description of how a telephone works. For this reason, Beauchamp's patent application had to be revised multiple times to clarify which of his individual claims were truly novel and which were merely new applications of existing patents.

On August 10, 1937, the Patent Office approved the majority of Beauchamp's claims—primarily those relating to the unique design of the Frying Pan's "pickup," a heavy electromagnet that surrounded the base of the steel strings like a bracelet rather than sitting below them as on a modern electric guitar. Unfortunately for the Electro String Corporation, Beauchamp's specific invention had long since been obsoleted by the innovations of various competitors, rendering the patent awarded on this day in 1937 an item of greater historical importance than economic value.



# NSF STEM Guitar Project

## Over view

- Started just over 3 years ago
  - 4 community colleges, 2 high Schools & a University
  - HS and community college faculty training
- Focus on the Math & Science of the guitar
  - “Technology of the guitar” by Mark French a Co-PI on the project



# Current Project Adopters

## High School and College adoptees states

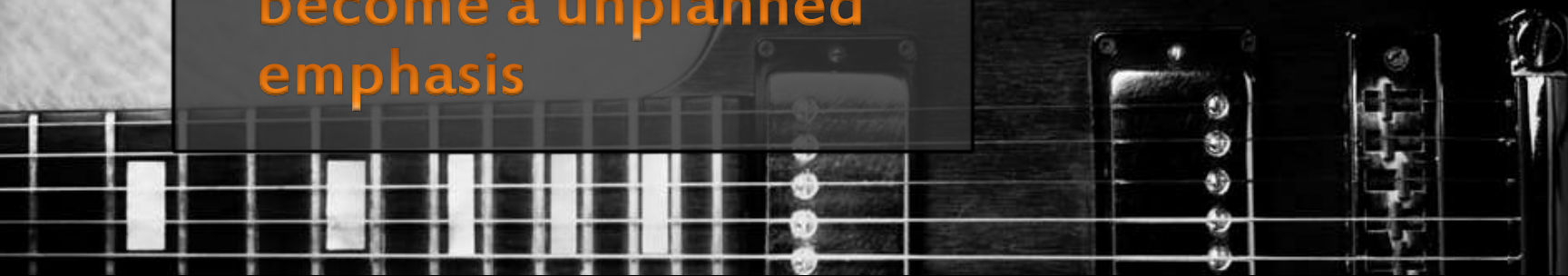
- 32 States now have schools that have adopted
  - Including Hawaii, Florida, New Hampshire, Ohio, Arizona, Washington .....





# Overarching Themes STEM Guitar Project

- Collaboration and Sharing
- Curriculum, guitar designs, build techniques, innovation
- Manufacturing and entrepreneurial business operations has become a unplanned emphasis



# Links to Employment

We have developed a cross walk to entry level Boeing manufacturing positions in Washington state





# Washington State Math Curriculum Credit

- The curriculum out of the workbook and our Modular learning activities have been approved by the State of Washington DOE as a framework for Tech Education math credit



# Book Format

## Fret Spacing Calculation

### Learning Objectives:

Student will demonstrate understanding of the concepts of string instrument scale length and how fret locations are determined by calculating the exact fret locations for the first five fret positions when given the scale length of the string instrument. The precise locations of frets on a fret board are essential to creating an instrument that plays in tune.

### References:

- From <http://www.cybozone.com/luthier/instruments/fretscale.html>

## INTRO

"Pythagoras was first to experiment with determining scalar intervals... and later, in the 16th century, Vincenzo Gallelei was credited with developing the "rule of 18"... used for centuries by instrument makers to determine the fret scale of their instruments. For any given vibrating string length they would simply divide the length of the string by 18... Yielding the distance from the nut to the first fret. By subtracting that figure from the original string length they arrived at a new shorter scale measurement which was then divided once again by 18 and resulted in the distance between the first and second frets. They continued in this manner until the entire scale was determined. Over the years several variations on this theme have been developed... The divisor has been refined, (based on a complex mathematical formula that utilizes the 12th root of 2) resulting in more accurate scales:

$$X_n = L \left( 1 - \frac{1}{r^n} \right)$$

Or written on one line, looks like

$$X_n = L (1 - 1 / r^n)$$

Where:

$X_n$  is the distance of the fret  $n$  to the string nut at the end of the fretboard  
 $n$  is the current fret  
 $L$  is the scale length

$$r = 2^{(1/12)} = 1.059463$$

Problems 1-5: Determine the first 5 fret locations for a stringed instrument with a 25.5 inch scale length

Problems 6-10: Determine the first 5 fret locations for a stringed instrument with a 32.125 inch scale length.

You must show all your work neatly, so that it flows in a straight line. Formulas, substitution, calculation, answer.

## BACKGROUND INFO

## Math Exercise 1

### Fret Spacing Calculation

Determine the first 3 fret locations for a stringed instrument with a 24" scale length.

### Fret Spacing Example calculation

#### Fret position #1

$$\begin{aligned} X_n &= L (1 - 1 / r^n) \\ &= 24" (1 - 1 / 1.059643^1) \\ &= 24" (1 - 1 / 1.059643) \\ &= 24" (1 - 0.943714) \\ &= 24" (0.056286) \\ &= 1.350" \end{aligned}$$

#### Fret position #2

$$\begin{aligned} X_n &= L (1 - 1 / r^n) \\ &= 24" (1 - 1 / 1.059643^2) = 24" (1 - 1 / 1.122843) \\ &= 24" (1 - 0.890596) = 24" (0.109404) = 2.625" \end{aligned}$$

#### Fret position #3

$$\begin{aligned} X_n &= L (1 - 1 / r^n) \\ &= 24" (1 - 1 / 1.059643^3) = 24" (1 - 1 / 1.18981) \\ &= 24" (1 - 0.840468) = 24" (0.159532) = 3.828" \end{aligned}$$

Problems 1-5: Determine the first 5 fret locations for a stringed instrument with a 25.5 inch scale length

Problems 6-10: Determine the first 5 fret locations for a stringed instrument with a 32.125 inch scale length. You must show all your work neatly, so that it flows in a straight line. Formula, substitution, calculation, answer.

## SAMPLE PROBLEMS

## INDEPENDENT WORK

# Guitarbuilding.org



LEARN ▼

BUILD ▼

SHARE ▼

Our Industry Partners ▼

## Welcome to The National STEM Guitar Project



The National STEM Guitar Project, in partnership with NSF Advanced Technological Education (ATE) Centers with funding provided through a grant from The National Science Foundation (#1304405), hosts innovative Guitar Building Institutes around the United States. The 5-day Institutes, combined with additional instructional activities comprising 80 hours, provide faculty training on science, technology, engineering and math (STEM) for middle, high school, and post-secondary faculty. The institutes present and teach participants hands-on, applied learning techniques to help engage students and spark excitement for learning STEM subject matter.

Nationwide, there are increasing concerns from businesses about the supply of science, technology, engineering, and mathematics trained workers. Science and math test scores in the U.S. are among the lowest around the world.

The goal and objective of the *STEM Guitar Building Institutes* is to showcase a new way to present learning for students with applied methods.

STEM educators take part in an intense five day electric guitar design/build project. Each faculty member will build his/her own custom electric guitar and will engage in student centered learning activities that relate the guitar design to specific math, science and engineering topics. Participants leave this weeklong experience with their custom-made guitars, curriculum modules with short term assessments that can be immediately integrated into the faculty team school curriculum.

Through the NSF grant, educators who applied and are selected receive free tuition and stipend to participate in the 5-day Guitar Building Institutes. Over the initial 4 year NSF grant period, the STEM Guitar Project has over delivered its objectives by recruiting 235 STEM faculty members to participate in Guitar Building Workshops around the country with an additional 335 faculty impacted via national education conferences. Thus far, this effort is impacting over 4600 students nationally as a result of faculty members adopting or adapting the curriculum developed through the project. At this rate, the project goal of reaching over 19,000 students by 2016 is highly realistic. [Click here to get involved in an upcoming institute.](#)

### Upcoming Events

Butler County Community College

June 22-26

Butler, PA

[Click Here to Apply](#)

Southern Maine Noble High School

June 22-26

North Berwick, ME

[Click Here to Apply](#)

Saddleback College

July 13-17

Mission Viejo, CA

[Full](#)

Wyoming/Laramie WY

July 27-31

Laramie, WY

[Click Here to Apply](#)

Hover to See *12 Core STEM Activities* Students Complete Through Building a Guitar



# Entrepreneurial Examples

- Southern Wells H.S., Poneto, IN
  - Fretboards
  - R&D for prototype instrument development
- Stebbins H.S., Dayton, OH
  - Fret wire rollers
  - Ferrule punches
- Sinclair C.C., Dayton, OH
  - Coordinates production
  - Orders bulk hardware
  - Produces bodies and necks
  - Packs and ships guitar kits
- Central Washington State University
  - Becoming a west coast manufacturing hub



# Student-centered

- Students take ownership of their work
  - See first-hand the creation of revenue
- Gain first-hand experience in Quality Control
  - Students are expected to have a hand in Q.C.
- We reject items that are not to spec
  - Students realize rejected items do not generate revenue




# Ties to innovation and the guitar industry

- Stewart Macdonald connection
  - Tools and product development
  - Global awareness
- Guitar String analysis
  - (Purdue - New Philadelphia HS)
  - D'Addario String Manufacturer
- Compensated Fretboard project for Fender
  - (Purdue – Southern Wells)





# Industry Partnerships



Everything for building and repairing stringed instruments!


[Your order](#) | [Account](#) | [Saved list](#)

[Chat is Offline](#) | [Email](#)

800-848-2273  
9AM-6PM EST, M-F

[Home](#)
[Free catalog](#)
[Quick order](#)
[International](#)
[Customer service](#)

[Home](#) : [Tools](#) : [Tool Kits](#) : Tool List for Sinclair Community College



DEPARTMENTS

- Accessories
- Bindings, trim
- Bodies, necks, wood
- Books, plans
- Bridges, tailpieces
- Electronics, pickups
- Finishing supplies
- Fretting supplies
- Glues, adhesives
- Hardware, parts
- Inlay, pearl
- Kits
- Knobs
- Nuts, saddles
- Pickguards
- Tools**
- Truss rods
- Tuners
- Video, DVD

## Tool List for Sinclair Community College

☆☆☆☆☆ Not yet rated | Be the first to [Write a Review](#)



Sinclair's program recommends StewMac tools for manufacturing accuracy: fret pressing, radiusing, string spacing, and more. You don't have to be enrolled to get them for your shop!

The Guitar Project at Sinclair uses the guitar to teach fundamental science and math principles and product lifecycle management concepts. Faculty members work together to write a curriculum to train high school and college instructors to bring the guitar project back to their classrooms. [More about Sinclair's STEM Guitar Project](#)


[See details below](#)


[Email to a friend](#)
[+1](#)
[0](#)
[Like](#)
[Send](#)


Item#	Description	In stock	Price	Quantity	
5643	<a href="#">Aluminum Radius-sanding Beam</a> 12" radius	Yes	\$132.15	<input type="text"/>	<input type="checkbox"/>
4366	<a href="#">Fret Press Caul</a> Caul only	Yes	\$39.42	<input type="text"/>	<input type="checkbox"/>

[ADD to order](#)







# Industry Partnerships



INDASA



# How to get involved

- Guitarbuilding.org Upcoming Workshops 2015 – Applications being accepted for the following events
- June 2015
  - Butler County C. C. Butler, PA
  - Southern Maine North Berwick High school
- July
  - Edmonds Community College, Edmonds, Washington **\*\* fee involved**
  - University of Wyoming, Laramie, WY





# How to get involved

- No cost for the institute (travel costs are not included)
- Fellowship funding provided
  - \$300 to attend + additional incentives
  - Opportunity to earn Graduate credit from the University of Wyoming
  - Receive curriculum and quizzing software for your classroom
  - Build a custom guitar
  - Over a \$1800 value



# Thank You

Tom Singer  
[thomas.singer@sinclair.edu](mailto:thomas.singer@sinclair.edu)

