Guitar Humidification, Humidifier Build and Lab

The purpose of this MLA is to help understand why guitar humidification is necessary and how to construct a simple, inexpensive humidifier that will humidify a guitar for a long time. Many believe that only acoustic guitars need humidification but wood is wood. Although to a lesser degree, electric guitar necks and bodies can develop problems in high or low humidity situations. Many commercial guitar humidification units available dry out quick leaving your valued instrument exposed to the elements. This MLA is suitable for any class for all grades and ages.

Learning Objectives:

1. Students will understand why wood humidification as it applies to wood of all types and specifically to guitars and guitar building is important.
2. Students will construct a guitar humidifier for their guitar case, keeping the guitar properly humidified.
3. Students shall conduct a lab experiment on wood samples subjected to 50% (normal), 90% (over-humidified) and 15% (under-humidified) conditions and analyzed for weight and size changes.

Standards:

https://www.nextgenscience.org/pe/hs-ps1-5-matter-and-its-interactions

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

HS-PS1-5. **Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration**

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Common Core Math Standards:

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-PS1-5)*

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-5)*

Materials Required:

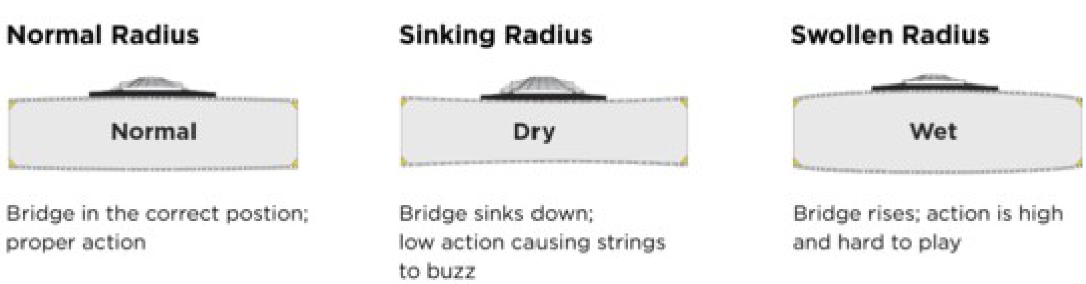
Quantity	**Materials**
1	Soap bar box 1 per person (rectangular): Walmart, $1. See photos in this article.
1	Sponge: Magic Sponge Eraser Melamine Cleaner Foam White, Ebay $5 or less for many sponge. (Large kitchen or car wash sponges work but Magic Sponge Eraser Melamine sponge hold more water, and for longer time, and fit perfect.
1	Drill
1/2”	Drill bit
As needed	Distilled water: preferred but regular water ok for experiment.
1	Safety Glasses
2	12” Zip lock bag
2	Velcro strips, two mating pieces
1	Hygrometer: Digital readout, EBAY

Introduction to Guitar Humidity

One of the biggest mistakes guitar owners/builders make is improper instrument storage and humidification. Humidifying your guitar properly can have drastic effects on the overall tone of the instrument as well as avoiding physical damage. When wood loses moisture, it shrinks, which may cause wood cracking, bad string action, buzzing, protruding fret ends, top sinking, bridge lifting, and other damage. Casual players might not notice until it’s too late as these problems develop slowly. A hard case for your new guitar will protect it from over and under-humidity and other environmental effects.

How a guitar body moves with humidity change.

Ideally your guitars humidity level should be kept at 45–50 percent and at a temperature of 70–75 degrees. These are the levels at which many professional guitar builders keep their showroom and work environment. See how in the figure below the wood in a normal guitar is slightly bowed. Removing or adding humidity changes this to undesirable extremes.



Dry Guitar Symptoms

One of the worst conditions for your new guitar is low humidity. Many areas of the country experience naturally low humidity conditions. In other regions, however, low humidity levels are created due to artificial heating. What many don't realize is that heating a room forces the relative humidity down to a level that poses a threat to all wood instruments, drying them out, bringing potential cracks, wood and paint and finish movement.

When wood is delivered to a guitar maker factory it is immediately conditioned and acclimated to a controlled moisture and temperature level in the factory. As a result, all guitar wood leaves its manufacturing location whether raw or in finished form in the same condition, and all the wood will react more or less the same when exposed to changes in humidity as it travels.

Your classroom might be climate controlled, but the relative humidity may fluctuate unless you make an effort to keep room humidity under control. As we have learned, a good temperature for your guitar is 70 to 75 degrees and a relative humidity of 45-50 percent. This consistency helps the wood stabilize at a specified moisture content ideal for building, storing and playing guitars. As the wood's moisture content changes, so does the size of the wood. Spruce, in particular, shrinks and expands a tremendous amount as it gains and loses moisture and many guitars have thin spruce tops. Even after shipping a guitar to its new destination, significant fluctuations in humidity will cause its wood to shrink or grow if left unmanaged.

A dry guitar can exhibit some of the following symptoms:

1. Low action. Strings are very close to the fret-board.
2. Hump on fretboard where neck joins body.
3. Sunken top across the soundboard between bridge and fingerboard.
4. Back of guitar looks very flat when it is dried out.
5. Sharp fret ends extend beyond the edge of fret-board.

A simple guitar case humidifier or room humidifier will help minimize dry guitar conditions.

Symptoms of a Wet Guitar

It is possible for guitars to become too wet. Usually, a guitar becomes over-humidified when it has been exposed to the elements for an extended time. Keeping your guitar in its case can minimize damage. Wood can expand quite a bit especially if in contact with moisture, causing glue joints to fail, finish to lift, and neck angles to go bad. Distortions in the wood often remain even after repairs, leaving the guitar disfigured.

Symptoms to look for:

1. High action. Strings that are unusually high off the fretboard, making it difficult to play.
2. The guitar sounds dull and lifeless and swollen wood contacting liquids directly.
3. Unusual warp on the back at the end block.

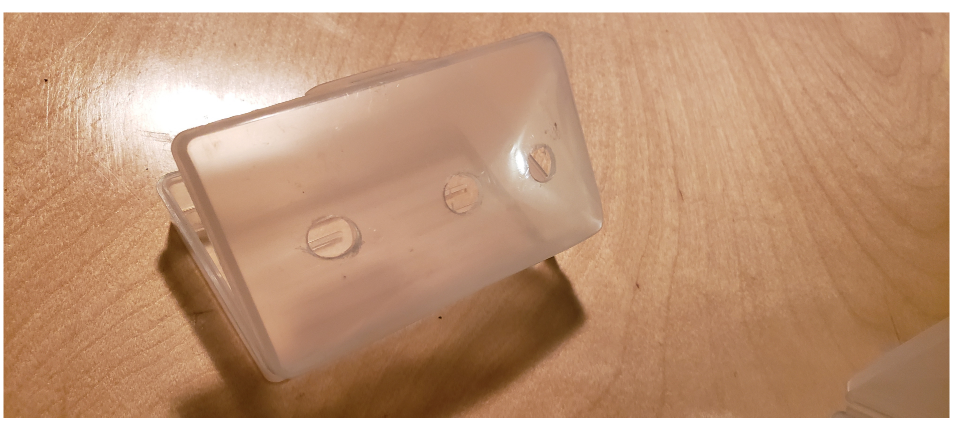
Activity 1: Guitar Humidifier Construction

This MLA will teach you how to make an affordable guitar case humidifier that keeps your guitar fresh and new sounding for years to come. Your new humidifier will also be used to complete activity 2, the lab experiment portion of this MLA.

The guitar humidifier is easy to construct if you use recommended sources from the parts list since most the cutting and fitting of the sponge is pre-done.

1. Obtain a suitable plastic soap box container as shown in the photos below. Other container shapes that fit your guitar case and guitar are possible.

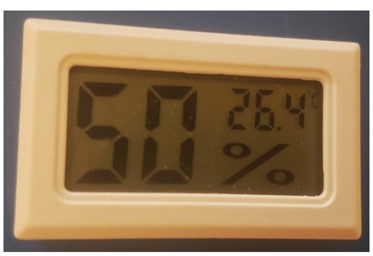
2. Carefully drill three ½" holes into the lid of the container as shown. Be careful drilling the top side plastic it's soft and brittle and can crack. More than three holes or a pattern of holes can be added, but with your case holding a wet sponge, fewer holes is better for releasing about 45-50% humidity to your guitar.



Insert your sponge and add distilled water.

It is recommended you use the magic sponge eraser melamine suggested in the parts list. It holds more water and for a longer time that a traditional sponge. The magic sponge eraser is also cut precisely in the proper size of a soap box making installation very professional and easy. Double Velcro strips should be added to both the bottom of the humidifier box, and the bottom of your guitar case to keep the humidifier in place inside your guitar case. Place it somewhere near the body of the guitar.

2. Using Velcro strips attach your hygrometer inside the guitar case as well close to where your humidifier will be located. Your hygrometer will monitor the humidity level in your guitar case.



How often should I re-wet my humidifier sponge?

This depends on the region in which you live. If you're having trouble getting a reading of 45%-50% humidity, re-wet the humidifier more frequently and possibly add a second humidifier inside the case or use a whole room humidifier to protect multiple guitars and your room.

Quiz and Answer Key

1. Many commercial guitar humidifiers are:

    a. Too expensive

    b. Dry out too quick

    c. Don’t fit your guitar

    d. Both a and b

2. One of the biggest mistakes a guitar owner makes is:

    a. Improper guitar storage

    b. Pay too much for the guitar

    c. Buys the wrong guitar

    d. Fails to humidify the instrument

    e. Both a and d

3. Lack of humidity in guitar wood can cause

    a. Tone change

    b. Physical damage

    c. Lower your action making playing better

    d. Both a and b

4. Loss of moisture in wood causes it to

    a. Stay the same

    b. Expand

    c. Shrink

    d. Turns to rust and lock up

5. Moisture loss in a guitar will result in

   a. Wood cracks

   b. Wood expanding

   c. Frets rusting

   d. Strings breaking

6. The best place to store your guitar is?

   a. On the wall

   b. In its case

   c. In a temperature and humidity controlled room at 75 degrees and 50% humidity.

   d. Both b and c

7. Proper guitar humidity is at what percent?

   a. 35-45

   b. 45-50

   c. 50-65

   d. 20-30

8. Optimal guitar storage temperature is:

   a. 70-75 degrees

   b. 0 degree Celsius

   c. 50-70 degrees

   d. 80-90 degrees

9. Moisture loss also causes what side effects?

   a. Bad string action

   b. Buzzing

   c. Cracking

   d. All of the above

10. Low levels of humidity in a guitar result from?

   a. Artificial heating

   b. Areas of low humidity

   c. Living near the beach

   d. Both a and b

11. As wood is over saturated with humidity the wood

   a. Shrinks

   b. Is at optimum levels

   c. Expands

   d. Saturation in wood is not a problem

12. Wet guitar wood conditions cause

   a. Wood to expand

   b. Glue joints to fail

   c. Lifting finish

   d. All of the above

Activity 2: Laboratory Experiment

Purpose:

This experiment will aid students understanding of how proper humidity of wood plays a key role in guitar manufacturing. If you own a guitar this experiment will show what happens to wood if humidity is neglected.

Objective:

Students will subject samples of poplar wood to humidity levels ranging from 15% (under-humidification) to 45-50% (recommended humidity) to beyond 90% (over-humidification). Weight gain, and wood expansion will be analyzed. This will give us a clear indication of how wood changes as humidity varies and might affect a guitar. **Note:** It is possible to substitute different wood species with varying results.

Lab Limitations:

Moisture Meter Challenges

We attempted to use a commercial moisture meter to measure wood moisture levels of our samples. As the lab evolved, it became clear that the moisture meter chosen from harbor freight, did not have the ability to make moisture content readings well. We had difficulty making readings by simply inserting the meter probes into the wood as the directions suggested. After adding external conductive nails driven to the center of each block, we were able to connect the moisture meter to the nail heads and get some sort of readings but results were inconsistent. The meter chosen did not start measuring until 6% moisture content was reached (meter limitation), which placed our wood samples in the 50% humidity range by then. We also tried using various models of digital multimeters to measure wood resistance but none of the devices used produced satisfactory results. It is left to the user to explore further the use of moisture meters and their value in evaluating wood moisture content.

Drying wood challenge

Attempts were made to dry the wood samples to examine change as moisture was removed. In our given climate area, it proved difficult to reach below 45% moisture initially. We tried using rice, immersing the wood samples in it for weeks. There was no observable change in humidity. We tried air drying the samples with a fan, but that also did not reduce the humidity. We introduced our samples into a large container of rock salt, hoping the salt would draw the moisture out, but after weeks of trying, wood moisture was not reduced. With advice from team members, we decided to try a ceramic heater fan as the drying source. This fan proved to be a success. It was a heater, with a fan inside, that blew away the hot heat generated from the fan allowing the wood to dry to about 15%.

Equipment and Parts:

Quantity	Parts
2	Zip lock bags, 12”
3	Wood Samples: Home Depot Poplar strips cut to length
1	Moisture meter: Harbor Freight Pittsburgh Digital Mini or similar #67143
1	Safety Glasses
1	Cardboard or wooden box built for ceramic heater chamber
3	Guitar Humidification units
3	Hygrometers: Digital, EBAY
1	Digital caliper
1	Digital Scale: Harbor Freight Cen-Tech #60332
1	Heater w/3 spd fan, Duracraft ceramic or similar
-	Scissors, nails, screwdrivers as needed
-	Tape and building supplies to make a dry heat low humidity chamber

Wood Selection/Preparation

Poplar wood strip was selected and cut to size. Poplar is abundant hardwood found at most wood and hardware stores.

Wood sample size: The three sample pieces can be similar but do not need to be exactly the same size since each is measured independently for humidity, and weight gains. Cut 3 pieces of poplar 1.5 (L) x 2 (W) x .75 (H) inches. Measure with a caliper each piece and cut them reasonably close in size. Using smaller sample pieces helps the samples fit inside a 12” zip lock bag (which served as our moisture chamber).

Procedure

Although this lab has 3 parts, after part 1 is complete, users can do parts 2 and 3 in parallel to save time.

Part 1: 50% Humidity (all samples)

In part 1 we stabilize our 3 wood samples at 50% and make initial measurements of weight, length and width. The three 50% measured samples in part 1, will serve as a reference point for weight, length and width for the rest of the lab.

1. Prepare two guitar humidification units with water. Take one zip lock bag and it will act as our initial 50% humidification chamber for all three wood samples.

2. Insert the three wood samples into a 12" zip lock bag along with a hygrometer and guitar humidifier. Here each sample adjusts to 50% humidity to start the experiment. Allow the zip lock bag and the samples to rest for several days while the humidity in the bag normalizes to 50%. The longer the bag stays at 50% before you make measurements, the better for data collection.

3. Keep the hygrometer dry and visible so you can read it during the experiment and away from direct moisture contact. Stabilization of humidity at 50% is relatively easy but add/remove water from the sponge as needed to balance the three samples.

4. After ample time has gone by record initial sample data for each block into table1 Part 1. Using a caliper for length and the digital scale for weight record measurements for each of the three samples.

When done measuring, place one sample back into the 50% sample zip lock bag, marking it and continue to maintain its humidity at 50% for the remainder of the experiment. At the end of the lab we will final measure the 50% sample one more time.

Part 2: 90 % Humidity

1. Take sample 2, mark it as your 90% over-saturated sample and add it to a zip lock bag marking as such on the outside of the bag. Add wet rags or towels, and add water to the humidification device. We want the hygrometer to rise beyond 90%. Do not allow the wet rags, hygrometer or the humidifier to contact the wood directly. Let the humidity in the bag travel to moisturize your sample. It will be easy to get the humidity to 90 % or higher.

2. Allow several days for your sample to absorb humidity. If you have time, longer is better for the stabilization of the wood in its new environment. Once saturated, open the 90% humidity zip lock bag and measure length, width and weight of your samples. Add these measurements to part 2 of table 1.

Part 3: 15% Humidity

Prepare your third sample for the 15% humidity test. Do not use a zip lock bag. It will get too hot to place the sample in a zip lock. The ceramic heater fan used was powerful, but fails to dry the wood sample below 15%. A larger heater fan unit might be capable of drying the wood more.

1. Construct an airflow box around your heater, as shown above, that allows the heater to be enclosed and blow through a small controllable space. Air is diverted to the front of the heater as the pictures show below. You can use tape, glue or nails if the unit is made of wood. We used a tiny cardboard box and duct tape to fit around the heater to hold it, but it does get warm. Your box shape and size will depend on the heater unit chosen. The Duracraft ceramic heater chosen was very small, light and easy to build around

   The box should direct the heat through a small exit in the front of the fan, to heat your sample. When mounted, turn the heater to hottest setting and highest fan speed and allow it to blow through the other open end of the box to check operation. Turn off when done.

2. Mount with duct tape or lay the wood sample in front of the exit side of the box to receive strong hot drying air flow from the heater. We added duct tape inside to build a shelf and lay the wood in front of the fan to receive direct heat.
3. Mount the hygrometer above the cardboard box as shown in the picture, but not directly in line with air flow. Placing the hygrometer directly in line with the heater, we found the hygrometer overheated. As such, we placed the hygrometer above the sample as close as possible to the wood as shown in the photo. We duct taped the hygrometer to the box. Be careful not to cover the hygrometer humidity sensor or it fails to read properly.
4. Turn your heater on and allow 5 days or longer for the sample and hygrometer to stabilize. Humidity will quickly drop to 20% or lower but we want the wood sample to have time to stabilize.
5. After 5 days, record your findings for the 15% sample in table 1 Part 2.

Table 1:	**Part 1: (All samples stay at 50%)** (Starting weight and size L or W of all three lab samples) Theoretical Values of weight, Length, width			**Part 2**: **Sample 1** Maintain 50% **Sample 2** Over-humid 90% **Sample 3** Under-humid 15% Experimental values of Weight, Length, width		
Poplar wood	Weight g	Length in	Width in	Weight g	Length in	Width in
1. 50% Sample	22.1 g	1.503 in	2.006 in	+22.4 g	1.507 in	2.010 in
Percent Change Using Humidification control at 50% (+ denotes an increase in size or weight)				**+1.3 %**	**+0.266 %**	**+0.199 %**
2. 90% Sample	21.7 g	1.507 in	2.008 in	+38.2 g	+1.618 in	+2.017 in
Percent Change Allow Humidification to rise to 90% (+ denotes an increase in size or weight)				**+68.2 %**	**+7.40 %**	**+0.44 %**
3. 15% Sample	20.1 g	1.530 in	2.009 in	-18.2 g	-1.485 in	-2.003 in
Percent Change Allow Humidification to drop 15% or less (- denotes a decrease in size or weight)				**-9.4 %**	**-2.941%**	**-0.298 %**

We predicted that the 50% sample would remain reasonably constant in size and weight throughout the experiment. It was expected that the 90% and 15% samples would experience weight and size changes of larger proportions.

Table 1 shows the data from the experiment. Your numbers will vary but should tend to trend in the same fashion, depending on type of woods used.

Data Analysis:

Science classes often include experiments and problem sets that involve calculating percent change in certain physical parameters of a material or object. The percent change in weight or length of our wood samples would show variation of change with humidity.

Our theoretical value in our calculations of all three samples come from the column of data in Part 1 (All samples stay at 50%) of table 1. Part 2 of the lab data shown in table 1 show the experimental or observed values in two of the three samples as humidity was allowed to change to extremes. We can use the percent change formula to evaluate our lab results for each sample.

Example: Percent change is calculated using theoretical and experimentally observed values in a scientific experiment.

Percent change = [Experimental Value - Theoretical Value] ÷ Theoretical Value × 100

Case 1: Sample 1: 50% Humidity

Weight gain calculations:

Sample 50%: Exact weight: 22.1 g Lab Part 1
Experimental Value: 22.4 g Lab Part 2

Percent change: [(22.4g – 22.1) ÷ 22.1] x 100% = **1.3% change**

What about length and width changes?

Sample 50% length change: **.26%**
Sample 50% width change: **0.199%**

The guitar humidifier minimized changes in weight and size successfully. The data shows a guitar made of this wood and humidified with our humidifier would remain safe from cracks and wood movements over time.

Case 2: Sample 2: 90% Humidity

Sample 90%: Exact weight 22.7 g Lab part 1
Approximate Value: 38.2 g Lab part 2

Percent change: [(38.2 g – 22.7 g) ÷ 22.7] x 100% = **68.2% change**

What about length and width changes?

Sample 90% Length: **7.4%**
Sample 90% Width **.44%**

Our 90% humidified sample weight gain was +68.2%. The wood absorbed a lot of moisture. The wood has absorbed moisture like a sponge and could cause possible cracks, distortions and splits if it were used in a guitar. Length changed by 7.4% and width much less. A change of 7% in wood size over time, could result in cracking and stress fractures in finish. Remember, cracks are often hairline in size. That's all it takes to ruin a great looking guitar.

Case 3: Sample 3: 15% Humidity

Sample 15%:	Exact weight	20.1 g	Lab part 1
	Approximate Value:	18.2 g	Lab part 2

Percent change: [(18.2 g – 20.1 g) ÷ 20.1] x 100% = **9.4% change**

What about length and width changes?

Sample 15% Length: **2.941%**
Sample 15% Width: **0.298%**

Our 15% humidified sample weight drop is 9.4%. The wood has less humidity in it. The wood released its moisture back into the air. Using this wood at 15% humidity levels could cause cracks and splits in your wood. Length changed by 2.941% and width much less. A shrinkage of 2.941% in wood size over time, can definitely result in cracks or splits. Remember, cracks are often hairline in size. That's all it takes to ruin a great looking guitar.

Conclusions:

The numbers are interesting. Wood undergoes change when moisture is maintained, added or removed but by differing amounts. The numbers indicated in table 1 show that length width and weight change at different rates. Imagine if your guitar was made of this wood or a variety of different woods blended together? How will the changing wood react to the glue? How will the wood of differing species react? Will the glue hold, will it crack, will the wood return to its original size if humidity returns? Does the instrument sound right? Have you damaged your instrument? What other parts on a guitar might be damaged? Answers to these questions vary. Are you willing to risk your new guitar costing hundreds and thousands of dollars?

Looking at high moisture numbers, wood added significant water weight at 68%. How does this moisture react with the wood, glue and other parts? What if the guitar is part wood and part resin or other synthetic material used by some makers? How does the wood react to this? How will the synthetic materials react with the wood? Some of the glues used in making your guitar might break down under extreme moisture.

Keeping moisture constant at 50% is the secret and the numbers reflect this.
With the use of the humidification device, an equilibrium in humidity can be reached and maintained with very little change. It is clear that wood will have a greater chance of remaining stable and your guitar safe in its case with a humidifier in place.

Other Investigations:

Re-humidifying over-humidified woods:

Another investigation would be, to take the sample that we over-humidified, and stabilize it at 50%. Does the wood return to its original size? If not how much swelling has occurred? Will the wood return to its former weight after being over humidified? Interesting points of further study are possible. We would love to hear back about your results.

Reviewing Faculty Cohort Members:

- Tom Singer
- Doug Hunt