Sabbatical Project
Fall 2020 – Spring 2021

Mathematics Through Sound and Music

Jesse Nason

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Sabbatical Leave Proposal
Jesse Nason

Please respond to the following questions on a separate sheet(s) of paper. The Sabbatical Leave Committee will use this document to evaluate and prioritize all proposals submitted. Please be as complete as possible, keeping in mind the criteria established for evaluation.

1. Briefly state the purpose of your sabbatical leave.
This application for sabbatical leave is to request time to create a series of videos and worksheets which demonstrate mathematical concepts through sound and music. These materials are intended for use in the classroom of any mathematics course taught at LBCC. The idea for this project is inspired by demonstrations I have given for the last 4 years at the annual LBCC Science Night. During Science Night, I demonstrated the concepts of a function, integral and derivative through synthesized sound. The Science Night demos have always been a hit with students regardless of their math background. I would like to develop this into something greater - video examples with accompanying worksheets available for any math instructor at LBCC to use in their classes, with a range of topics that covers every math class we offer.

2. Give all pertinent details of your proposed plan. This should include all activities, projects, research, itinerary, study, employment, expected outcomes, relationships with current coursework, etc. connected with your proposed leave.

I will need the time to do the following: create 40 videos and worksheets; ensure that the videos meet ADA compliance for closed captioned material; organize them so that any instructor could know where they are appropriate to use in any of our classes; test the materials through the help of my colleagues; final review/revision of materials after testing.

I aim for each video to be at most 5 minutes. The goal is for these videos to be presented in class as a video example, with a follow-up activity in worksheet form. The instructor can show the video, have a few minutes of class discussion, and then have the class work in groups on the worksheet. That entire activity should take up no more than 30 minutes of class time and will be used to supplement the material that the instructor is already teaching and replace any example they would have planned.

I have been a musician for over 25 years, recording more than 10 albums and performing on national tours. I have also filmed and edited 4 music videos. For the sound and music component of the videos, I can draw from my vast amount of experience in sound design and music theory. I also have the recording equipment needed to professionally record my voice and instruments used for the videos. For the video component, I am already proficient in and will be using Adobe Premiere for video editing. The filming and editing will encompass less than 50% of the work I will be doing for this sabbatical project. This allows for the majority of my time to be spent developing the mathematical applications, the worksheet prompts and questions, and

organizing the material to help instructors align the examples with particular topic sections in our math classes.

Since my videos are intended for class use, they will need to be closed captioned. I have read through my options at https://lbcc.instructure.com/courses/26987 and I am in contact with Jerome Thomas from the Instructional Media Production Services department at LBCC if I need any additional help.

Once all of the video and worksheet packets are created, I will organize them for use in particular classes. This will be in the form of a spreadsheet that will associate each topic with a math class LBCC currently offers. I have taught all of these classes except one, and I also oversee textbooks for our department. I know what is covered in all of our courses, so this organization will not be difficult. An example of what the spreadsheet will look like is:

Topic	**Class**	**Video link**	**Worksheet link**
Functions	Math 130, 40, 45, 50	youtube.com	dropbox.com

I will be hosting the videos on a You-Tube page I will set up, and I will host the worksheets on dropbox. I will send the spreadsheet out to all LBCC math instructors, and they can download the materials from dropbox themselves and link to the video in class.

Once a few video/worksheet packets are completed, I will be sending them to my colleagues in the math department. Some of them have already given me ideas for topics, so I will start with those colleagues to help me. Their feedback will help me finalize those early videos and help me ensure the rest meet our standards.

3. Provide a timeline indicating how the activities in your plan will be completed within the time frame of the proposed leave.

September 2020:
First two weeks: I will organize all topics that I have decided upon and begin material/script preparation for the videos. I will also prepare the format that all the worksheets will follow.
Second two weeks: I will film and edit **2** videos, choosing from the topics that I have demonstrated the last 4 years at Science Night. This is so I can get used to the process of filming and editing. Once the videos are complete I will write the necessary prompts and worksheets.

October 2020:
I will film and edit **5** videos and write the necessary prompts and worksheets. Two of the topics will also be from my Science Night list.

November 2020:
Send the videos from September and October to my colleagues for testing. I will also film and edit **6** videos and write the necessary prompts and worksheets.

December 2020:
Receive feedback from colleagues and implement any edits or changes that they advise. I will also film and edit **5** videos and write the necessary prompts and worksheets.

February 2021:
I will film and edit **6** videos and write the necessary prompts and worksheets.

March 2021:
I will film and edit **6** videos and write the necessary prompts and worksheets.

April 2021:
I will film and edit **5** videos and write the necessary prompts and worksheets.

May 2021:
I will film and edit **5** videos and write the necessary prompts and worksheets.

June 2021:
I will prepare the materials to present when I return

4. Describe how the proposed leave will contribute to your professional development, including how it relates to your current assignment.

Early on in my career as a community college math instructor, I decided that I wanted to teach every class. After 10 years (5 of which at LBCC), I have taught all of the classes we offer except for one (Mathematics for Elementary Teaching). However, much of the content from that class is covered in two others I have taught. Because of this experience, I am very aware of the common problems that almost all of our students have. The usual suspects are fractions and algebraic terms, but a more common thread is connecting abstract concepts to examples that most people are familiar with.

Sound and music are in our everyday lives. Developing these videos and worksheets to demonstrate mathematical concepts through sound and music has been an idea of mine for a few years and it is something that I am very passionate about because being a mathematician and a musician make up my entire being. This project would shine new light on the material that I have already developed over the last 10 years, and it would force me to take a different and creative approach to old problems. I would be able to use the materials in any class I teach in the future, and I can use the experience as a foundation upon which to create more. I am inspired by the mathematical and musical approach to these videos, and I believe that would inspire students to also see things in a new way.

5. Describe how the proposed leave will benefit the college and students.
I have already asked for input from members of my department, and their responses were overwhelmingly enthusiastic! From them, I received 15 distinct topics that are part of the list I have below in part 6. Each math class that is taught at LBCC will have multiple video lessons that can be used during the course of a semester. This will bring a new perspective to the instructors and students that use these materials, and hopefully inspire them to dive deeper into the material they are studying.

Typical examples in mathematics are geared toward the sciences. However, there is a lot of science and math in sound and music that is rarely explored. Furthermore, sound and music are wound up in art and entertainment, which is also a rarely explored topic in science and mathematics. Since most students may not have a major in the STEM fields, my goal is to have these video examples help all students find something interesting about math that doesn't just have to do with scientific application.

6. List and describe the specific, tangible products you will bring to the college within 90 days after you return to your assignment.

After considering the feedback from my colleagues and finishing all of the video and worksheet packets, I will organize them for use in particular classes. The information will be organized in a spreadsheet that will be made available to all LBCC math instructors through the Canvas page for the Math Department. I will host the videos on a You-Tube page that I will set up, and I will host the worksheets in a Dropbox folder online and also have them available on the Math Department Canvas page. An instructor will be able to look at the spreadsheet on Canvas, find the appropriate You-Tube and Dropbox links, and easily integrate the examples into their regularly planned work.

Upon returning from sabbatical, I will provide the link to the You-Tube page which will host the 40 videos and a link to the Dropbox folder. I will also have a binder of the 40 in-class worksheets that accompany the video examples. The videos and worksheets will cover the following topics:

Fractions, Division, Multiplication (5 topics)

- Fraction multiplication - subdividing the measure
- Least common denominator (least common multiple)
- Division related to a Fraction
- Powers of 2
- Prefixes - "semi", "deci", etc

Applicable courses:
Math 120, 130, 140, 28, 825

Sequences and Series (3 topics)

- Harmonic Series
- Fourier Series
- Recursive Series

Applicable courses: Math 45, 70, 84

Functions and Graphs (12 topics)

- What is a function
- Function of two variables
- Phase (horizontal) shift
- Vertical shift
- Transformations
- Function composition
- Exponential Function
- Logarithmic Function
- Piecewise Function
- Periodic Functions
- Piecewise Functions (Dirac Delta)
- Mathematics of a Compressor

Applicable courses: Math 130, 21A/B, 40, 45, 47, 50, 60, 80, 84, Stat1

Trigonometry (7 topics)

- Circles
- Sine and Cosine graphs
- Amplitude Modulation
- Frequency Modulation
- Trigonometric Identities and Sound Beating
- Harmonic Motion
- Oscillators - frequency and period

Applicable courses: Math 120, 40, 50, 60

Calculus (3 topics)

- Derivative
- Integral
- Tangent Line (linear function)

Applicable courses: Math 60, 70, 80

Miscellaneous Topics (10 topics)

- Sound through hearing canal (cycloid curves) - Math 40, 70
- Analog to digital conversion - Math 60, 70
- Additive Synthesis (Harmonics, Timbre, Organ Stops) - Math 70
- Symmetry in Music - Math 120
- 12-tone music

Miscellaneous Topics continued

- Golden Ratio
- Logarithmic Tuning
- Modular Arithmetic
- Sample and Hold (random numbers)
- Fractals

References:

Benson, David J - Music, A Mathematical Offering
Wright, David - Mathematics and Music
Fauvel, Flood, Wilson - Music and Mathematics
Math 372 - Mathematics and Music - Cal State Monterey Bay

7. Describe how you will share the outcomes of your proposed leave with other interested parties upon your return.

When I first started at LBCC, I was sent videos from Ladera Barbee (now one of the Math Department's co-department heads). She was working on her sabbatical project of flipping her classroom. That experience helped me think of this project and that it would be a worthwhile one. I will be sharing my videos with my department during the process of the sabbatical so that they can help me with quality control. Upon my return, I will demonstrate one of them to our department during one of our weekly "Math Department Lunch Hours" and then share with all of them the You-Tube and Dropbox links for their use.

8. If applicable, please disclose any additional sources of employment earnings during the proposed leave.

Not applicable

	9/6/19
Signature of Applicant	Date Originally Submitted

BRIEF SUMMARY OF SABBATICAL PROJECT

The goal of my sabbatical project is to demonstrate a variety of mathematical concepts through sound and music. I specifically focus on mathematical concepts that are taught at the community college level, from arithmetic and algebra to calculus and differential equations. These concepts are demonstrated through examples involving music theory, electronic instruments, synthesized sound, music technology and recorded musical history.

The inspiration for this project came from my own history of being a musician as well as a mathematician, and also from the demonstrations my colleague Pablo Bert and I have given at the annual LBCC Science Night. These demonstrations give great examples of mathematical concepts that are different from the usual examples from physics, business, and biology. I believe through the videos and questions I've created students can gain an appreciation of math through the lens of sound and music.

DETAILED RESULTS OF SABBATICAL PROJECT

The result of this Sabbatical Project is the demonstration of a variety of mathematical topics, specifically ones seen at the Community College level, through a different lens than typically seen. Most demonstrations of mathematical topics are through the lens of physics, biology, chemistry, or economics. My goal with this project was to have examples that could be relevant to anyone with an appreciation of music or even musicians themselves. Since most people listen to music for entertainment, this exposes a wider variety of people to mathematical concepts.

Furthermore, the results of my project, specifically the short videos, lecture notes and discussion questions, can be used by all instructors at Long Beach City College. I have designed them to be examples that take up about 15-20 minutes of class time, and every class we teach can find a use for at least one of the 40 that I have made. I have already started using them in my Math 60 and Math 70H classes, and other colleagues in the mathematics department are using at least 4 of them in a new ethnomathematics class pilot.

The videos average 6-7 minutes in length, hosted on YouTube with appropriate closed captioning, and are accompanied by a PDF of the spoken material (about 3-5 pages each), followed up by discussion questions with instructor notes on answers. Even without a knowledge of music theory or instruments, any instructor can follow the example and lead the discussion questions.

DESCRIPTION OF PROFESSIONAL BENEFIT FROM THE SABBATICAL PROJECT

I have benefitted immensely from being granted the time to complete this sabbatical project. I have had a long career in both mathematics and music, and it has always been a pleasure to demonstrate the connection between the two at the annual LBCC Science Night. But I had never had the time to really go deep into the connection between the two until this project. I have been able to combine two passions in my life and gain a much more rounded understanding of the mathematics in sound and music. This has expanded the set of mathematical applications that I can discuss in my classes, and this will enhance all math classes that I teach at LBCC in ways that I hadn't been able to before.

Additionally, in making these videos I have improved my skills for recording, editing and publishing videos on mathematics. My expertise in this was limited but was also found to be very important in the transition to online instruction the semester before my sabbatical. And now, after this sabbatical, I am well prepared to make future videos for classes I may teach under a hybrid or online model. One of my takeaways from the Covid pandemic was that my teaching methods should always be reconsidered and that it is good to try new things to get information across. While I prefer discussing mathematics with my students in person, I can also see the usefulness of delivering instruction through short videos and then following that up with in person or video conferencing discussions.

Finally, the library of videos and discussion questions that I have completed now give me more examples to use in class to explain concepts. There were a couple of topics in my original sabbatical proposal list that I found worked best in one video, and so I was able to include a few more topics that I hadn't considered before (like Polar Graphs and Parametric Equations). I have started to use these already in my Fall 2021 classes, and the discussions with my students are inspiring further thought into more topics I can use as examples. I see these videos as just the tip of a continuing exploration of mathematics in sound and music, and this will benefit my understanding of mathematics and in turn benefit the students who take my classes.

DESCRIPTION OF STUDENTS' BENEFIT FROM THE SABBATICAL PROJECT

In most mathematics classes at the community college level, the applications that are used for the "why am I learning this" questions are usually from physics, economics, biology, chemistry, etc. There are great reasons for these, since modern technology, medicine, and business have benefited greatly from modern mathematics. However, topics from the arts are rarely used as examples of mathematics, and I think there are a wealth of examples to be explored and shared with students. There is historical basis for this, as the Quadrivium from classical antiquity consists of the subjects Arithmetic, Geometry, Astronomy and Music. One of my goals with this project was to give students a new way to consider how mathematics is a part of the everyday music and sound that we enjoy, and therefore give them new examples of why we learn mathematics.

Furthermore, I think it is beneficial for students to see that what we teach in each subject doesn't live in a vacuum. The development of music theory and mathematical theory run parallel throughout history, and this is an example of how the subjects we learn at the community college level are connected. We need what we learn in a calculus class to help us learn about velocity and acceleration in a physics class. But we can also see the need of radical functions from algebra in the development of the modern equal tempered tuning system used by the music department. The more students are exposed to these connections, the more engaged they will be in our classes, and this will benefit their learning and also their outlook on the world we send them out into.

DESCRIPTION OF COLLEGE'S BENEFIT FROM THE SABBATICAL PROJECT

Most importantly, the college has benefited with interesting and engaging content that can be used in all math classes offered at the campus. I have shared these with my colleagues, and already a few are using them in development of new class material. The students who are exposed to these new examples will come away with a more well-rounded understanding of mathematics, and start to see math behind many other things in everyday life.

The college also benefits from my growth as a mathematician and educator. I have a renewed inspiration in the subject that I can use to inspire our students. I have also developed and enhanced my skills in creating content of a mathematical nature and delivering that to our students.

TANGIBLE PRODUCTS

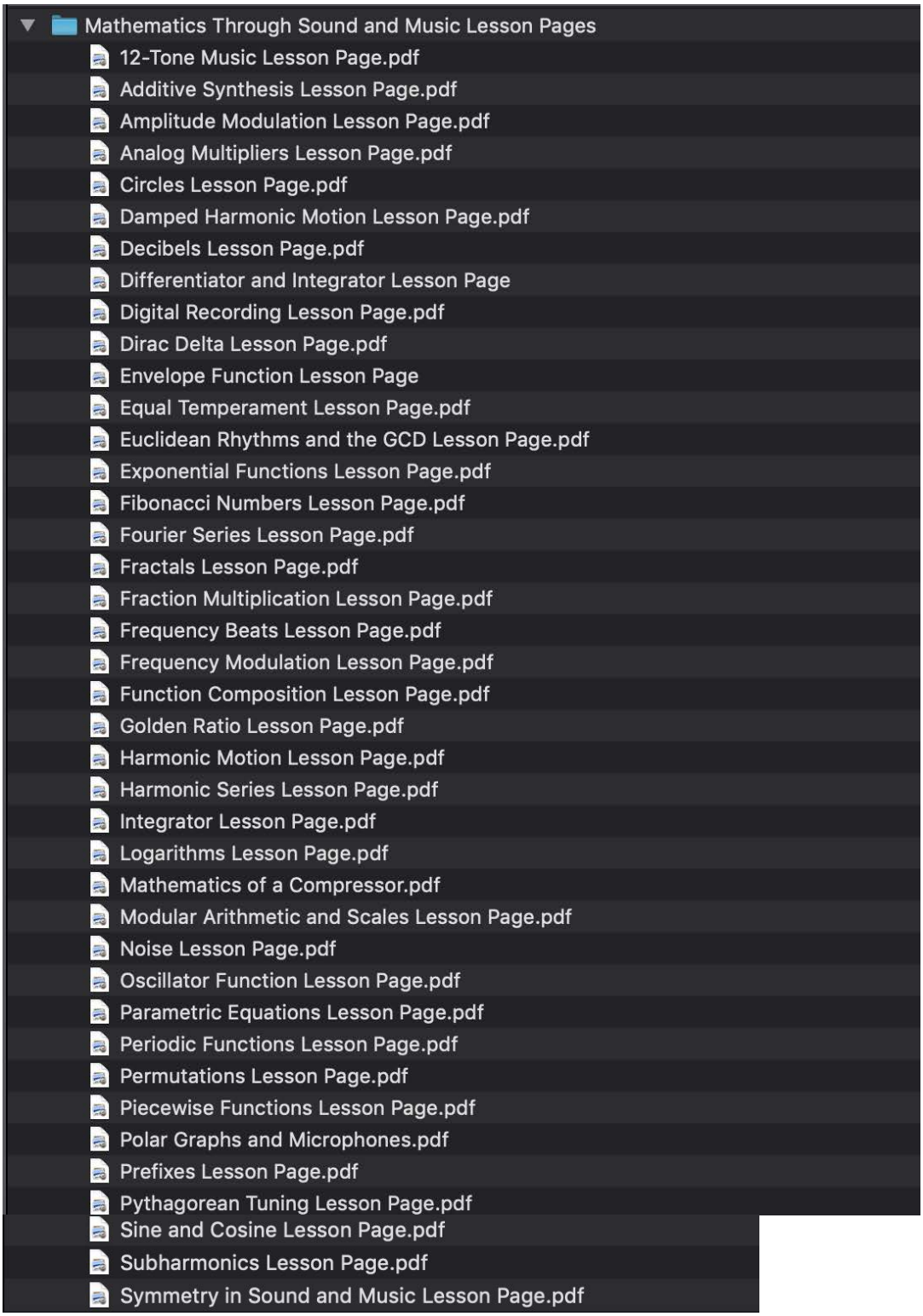
I. Digital Files on Flash Drive

- 40 PDFs of Lesson Pages, which contain notes related to videos, discussion questions and instructor notes/answers to discussion questions.

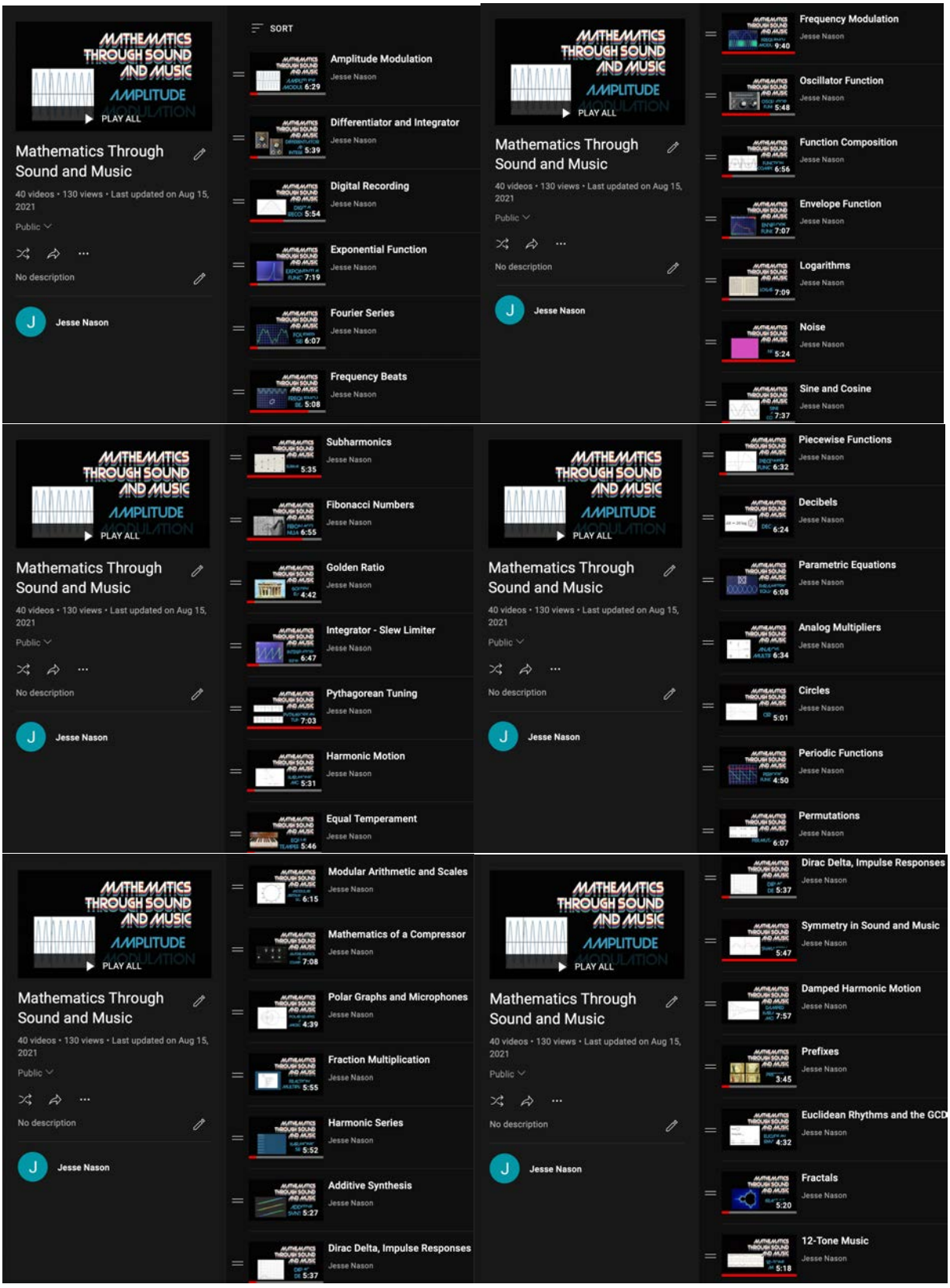
II. Tangible Items Provided in Binder

- Screen Shot of all items on Flash Drive
- Screen Shot of video playlist on YouTube
- Links to all Lesson Pages on Dropbox, links to all Videos on YouTube, and recommended LBCC math classes for use
- Video Summary with Titles and Time Length

SCREEN SHOT OF TANGIBLE PRODUCTS ON FLASH DRIVE



SCREEN SHOT OF VIDEO PLAYLIST ON YOUTUBE



LINKS TO LESSON PAGES ON DROPBOX and VIDEOS ON YOUTUBE
Including suggested LBCC math classes for use

Mathematics Through Sound and Music Lesson Pages folder on Dropbox
https://www.dropbox.com/sh/oqc5k1zd4u01kgn/AACFFMVJxp_J5gSY-_FCrNkCa?dl=0

Mathematics Through Sound and Music YouTube Playlist
https://youtube.com/playlist?list=PLXiWNYyzCiriqyRMldNrP7A4ZAs2o3HVr

12-Tone Music (Math 21 A/B, 28, 29, 130, 140, 45, Stat 1)
https://www.dropbox.com/s/hrfxn3sw734o7r0/12-Tone%20Music%20Lesson%20Page.pdf?dl=0

https://youtu.be/GLFPkLJwqi0

Additive Synthesis (Math 28, 29, 130, 140, 45)
https://www.dropbox.com/s/5mtksabbkjbpuio/Additive%20Synthesis%20Lesson%20Page.pdf?dl=0

https://youtu.be/iflKCEPre1A

Amplitude Modulation (Math 40, 45, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/6i5f8rl4qqwmb4h/Amplitude%20Modulation%20Lesson%20Page.pdf?dl=0

https://youtu.be/D-t_7reo5es

Analog Multipliers (Math 40, 45, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/47k83o22v2hhrpa/Analog%20Multipliers%20Lesson%20Page.pdf?dl=0

https://youtu.be/WebirhVI5pY

Circles (Math 40, 45, 50, 60, 70, 80, 84, 120)
https://www.dropbox.com/s/4ot5cvp0490sakb/Circles%20Lesson%20Page.pdf?dl=0

https://youtu.be/ToaGxNC1iJA

Damped Harmonic Motion (Math 84)
https://www.dropbox.com/s/nogdm3upnmq9rio/Damped%20Harmonic%20Motion%20Lesson%20Page.pdf?dl=0

https://youtu.be/Ss1qkq7pMv0

Decibels (Math 21 130, 140, 45, 50)
https://www.dropbox.com/s/q65m4nkzu2lrx6f/Decibels%20Lesson%20Page.pdf?dl=0

https://youtu.be/g2POf_kLUfg

Differentiator and Integrator (Math 60, 70, 80, 84)
https://www.dropbox.com/s/btkf1z0fe9nbvy0/Differentiator%20and%20Integrator%20Lesson%20Page.pdf?dl=0

https://youtu.be/cdSUvkazjSI

Digital Recording (Math 21 A/B, 45, 50, 60, 70, 130, 140, Stat 1)
https://www.dropbox.com/s/dundkrfqxjkgo0e/Digital%20Recording%20Lesson%20Page.pdf?dl=0

https://youtu.be/qWhotoNrRms

Dirac Delta, Impulse Responses and Convolution Reverbs (Math 84)
https://www.dropbox.com/s/8s55bo9kou9htkh/Dirac%20Delta%20Lesson%20Page.pdf?dl=0

https://youtu.be/Vw15pUcMKsI

Envelope Function (Math 21 A/B, 40, 45, 47, 50, 60, 80, 84, 130, Stat 1)
https://www.dropbox.com/s/sdngw40qr9lmc73/Envelope%20Function%20Lesson%20Page.pdf?dl=0

https://youtu.be/_ExCQJdssbI

Equal Temperament (Math 28, 29, 45, 130, 140, 825)
https://www.dropbox.com/s/v3o5jkkf87ufoiy/Equal%20Temperament%20Lesson%20Page.pdf?dl=0

https://youtu.be/pLfnvm8X5Ik

Euclidean Rhythms and the GCD (Math 28, 29, 120, 130, 140, 825)
https://www.dropbox.com/s/t8u0o2rnrku2gmw/Euclidean%20Rhythms%20and%20the%20GCD%20Lesson%20Page.pdf?dl=0

https://youtu.be/WzxOBpUphbI

Exponential Functions (Math 21 A/B, 40, 45, 47, 50, 60, 80, 84, 130, Stat 1)
https://www.dropbox.com/s/ff5hzqhzddhmhiw/Exponential%20Functions%20Lesson%20Page.pdf?dl=0

https://youtu.be/AgU77EtQkrg

Fibonacci Numbers (Math 45, 50, 70, 130, 140)
https://www.dropbox.com/s/xh34if3h5bz4ewu/Fibonacci%20Numbers%20Lesson%20Page.pdf?dl=0

https://youtu.be/3uxCE4ilfTw

Fourier Series (Math 70, 84)
https://www.dropbox.com/s/pi650oyzjc0fqhq/Fourier%20Series%20Lesson%20Page.pdf?dl=0

https://youtu.be/rFQbwsrBCi0

Fractals (Math 45, 70, 84)
https://www.dropbox.com/s/3vf4fvk3w77z3vt/Fractals%20Lesson%20Page.pdf?dl=0

https://youtu.be/s7VM7zeeOFc

Fraction Multiplication (Math 28, 29, 120, 130, 140, 825)
https://www.dropbox.com/s/odxbamxw0l4s7oz/Fraction%20Multiplication%20Lesson%20Page.pdf?dl=0

https://youtu.be/2SJL6WILQ00

Frequency Beats (Math 40, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/yxqa4i40io3ws8r/Frequency%20Beats%20Lesson%20Page.pdf?dl=0

https://youtu.be/7L8G__8Cl30

Frequency Modulation (Math 40, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/myuiw9st90axqtx/Frequency%20Modulation%20Lesson%20Page.pdf?dl=0

https://youtu.be/QVKbHx0I1bc

Function Composition (Math 45, 50, 60, 130, 140)
https://www.dropbox.com/s/90dgsqoned975dp/Function%20Composition%20Lesson%20Page.pdf?dl=0

https://youtu.be/k5fIF5aClfs

Golden Ratio (Math 45, 50, 70, 130, 140)
https://www.dropbox.com/s/uihx8kg136u1v47/Golden%20Ratio%20Lesson%20Page.pdf?dl=0

https://youtu.be/MtwiRD-0YaE

Harmonic Motion (Math 40, 45, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/hxb0ahzp3v02xp3/Harmonic%20Motion%20Lesson%20Page.pdf?dl=0

https://youtu.be/ha_PjqRCzYg

Harmonic Series (Math 40, 50, 70, 84)
https://www.dropbox.com/s/24c4ekoov6pf4cp/Harmonic%20Series%20Lesson%20Page.pdf?dl=0

https://youtu.be/z00LmG-z0YY

Integrator – Slew Limiter (Math 60, 70, 80, 84)
https://www.dropbox.com/s/ao6ant3fr497r1i/Integrator%20Lesson%20Page.pdf?dl=0

https://youtu.be/r154ULwa2tY

Logarithms (Math 21 A/B, 45, 47, 50, 60, 80, 84, 130, 140, Stat 1)
https://www.dropbox.com/s/0gu9pjgujxsi3uy/Logarithms%20Lesson%20Page.pdf?dl=0

https://youtu.be/8w5YrFYqLc0

Mathematics of a Compressor (Math 40, 45, 47, 50, 60, 80, 84, 130, 140)
https://www.dropbox.com/s/v0cosv0ekeas325/Mathematics%20of%20a%20Compressor.pdf?dl=0

https://youtu.be/4-B_tSri18Y

Modular Arithmetic and Scales (Math 28, 29, 45, 50, 60, 80, 84, 130, 140)
https://www.dropbox.com/s/jg7spzctswfwfbm/Modular%20Arithmetic%20and%20Scales%20Lesson%20Page.pdf?dl=0

https://youtu.be/5Cy1NDP_re4

Noise (Math 21 A/B, 45, 50, Stat 1)
https://www.dropbox.com/s/afgow6nipad4h2z/Noise%20Lesson%20Page.pdf?dl=0

https://youtu.be/IDh5SNHxGio

Oscillator Function (Math 40, 45, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/qy52hmfeevda3m4/Oscillator%20Function%20Lesson%20Page.pdf?dl=0

https://youtu.be/qe8Dhty4LOQ

Parametric Equations (40, 45, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/2u3jn33jhuyzb74/Parametric%20Equations%20Lesson%20Page.pdf?dl=0

https://youtu.be/E8dhiu1EKqI

Periodic Functions (Math 40, 45, 47, 50, 60, 80, 84, 130, 140)
https://www.dropbox.com/s/paih5s8u5vmgfkb/Periodic%20Functions%20Lesson%20Page.pdf?dl=0

https://youtu.be/b9v720cGcnM

Permutations (Math 130, 140, 45, 84, Stat 1)
https://www.dropbox.com/s/l4gibt6ewlf1dd9/Permutations%20Lesson%20Page.pdf?dl=0

https://youtu.be/gQRurlcJWEI

Piecewise Functions (Math 40, 45, 47, 50, 60, 80, 84, 130, 140)
https://www.dropbox.com/s/kn7r1zw8cyf3lk6/Piecewise%20Functions%20Lesson%20Page.pdf?dl=0

https://youtu.be/kBq96RXfgq0

Polar Graphs and Microphones (Math 40, 50, 70, 80)
https://www.dropbox.com/s/875zdqzfw126gqy/Polar%20Graphs%20and%20Microphones.pdf?dl=0

https://youtu.be/F2OJ2xmQv8U

Prefixes (Math 28, 29, 45, 50, 120, 130, 140, 825)
https://www.dropbox.com/s/ly074s3xuggz4bq/Prefixes%20Lesson%20Page.pdf?dl=0

https://youtu.be/HoTtdT3I3sU

Pythagorean Tuning (Math 28, 29, 45, 50, 120, 130, 140, 825)
https://www.dropbox.com/s/5v0prhk121wclq0/Pythagorean%20Tuning%20Lesson%20Page.pdf?dl=0

https://youtu.be/jFHa3is2ibw

Sine and Cosine (Math 40, 45, 50, 60, 70, 80, 84)
https://www.dropbox.com/s/5coohh8jzymz0ld/Sine%20and%20Cosine%20Lesson%20Page.pdf?dl=0

https://youtu.be/bPgO86RZfBA

Subharmonics (Math 28, 29, 120, 130, 140, 825)
https://www.dropbox.com/s/dsrfxkvb33otmqh/Subharmonics%20Lesson%20Page.pdf?dl=0

https://youtu.be/ex7otW2VfvY

Symmetry in Sound and Music (Math 40, 45, 50, 60, 70, 120, 130, 140)
https://www.dropbox.com/s/0nmuqhefq9z0auq/Symmetry%20in%20Sound%20and%20Music%20Lesson%20Page.pdf?dl=0

https://youtu.be/6PJO7DmDlTk

VIDEO TITLES AND TIME LENGTH

12-Tone Music	5:18
Additive Synthesis	5:27
Amplitude Modulation	6:29
Analog Multipliers	6:34
Circles	5:01
Damped Harmonic Motion	7:57
Decibels	6:24
Differentiator and Integrator	5:39
Digital Recording	5:54
Dirac Delta, Impulse Responses, Convolution Reverbs	5:37
Envelope Function	7:07
Euclidean Rhythms and the GCD	4:32
Exponential Functions	7:19
Fibonacci Numbers	6:55
Fourier Series	6:07
Fractals	5:20
Fraction Multiplication	5:55
Frequency Beats	5:08
Frequency Modulation	9:40
Function Composition	6:56
Golden Ratio	4:42
Harmonic Motion	5:31
Harmonic Series	5:52
Integrator – Slew Limiter	6:47
Logarithms	7:09
Mathematics of a Compressor	7:08
Modular Arithmetic and Scales	6:15
Noise	5:24
Oscillator Function	5:48
Parametric Equations	6:08
Periodic Functions	4:50
Permutations	6:07
Piecewise Functions	6:32
Polar Graphs and Microphones	4:39
Prefixes	3:45
Pythagorean Tuning	7:03
Sine and Cosine	7:37
Subharmonics	5:35
Symmetry in Sound and Music	5:47

REFERENCES

Here is a list of books and websites that I referenced in my research for these videos

Books:

Music: A Mathematical Offering
Written by David J. Benson
https://homepages.abdn.ac.uk/d.j.benson/pages/html/music.pdf

Music and Mathematics From Pythagoras to Fractals
Edited by John Fauvel, Raymond Flood, and Robin Wilson

The Theory of Sound Vol One and Two
Written by J.W.S. Rayleigh

Websites:

https://www.soundonsound.com/synthesizers/synth-secrets
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