Ventura College Sabbatical Leave Proposal

Michael McCain, Professor
Department of Mathematics
Sabbatical Leaves Taken: None
Date of Hire: January 2005
Proposed Leave Period: Spring 2017 Semester
Abstract: I will be learning from online videos and working through a specific textbook to further my understanding of *Mathematica*, the CDF player and the Wolfram language. The bulk of my project will be creating a large database of fully interactive mathematical figures that can be used across all of our mathematics classes. They will be made accessible to all students and faculty in our district.

The Idea

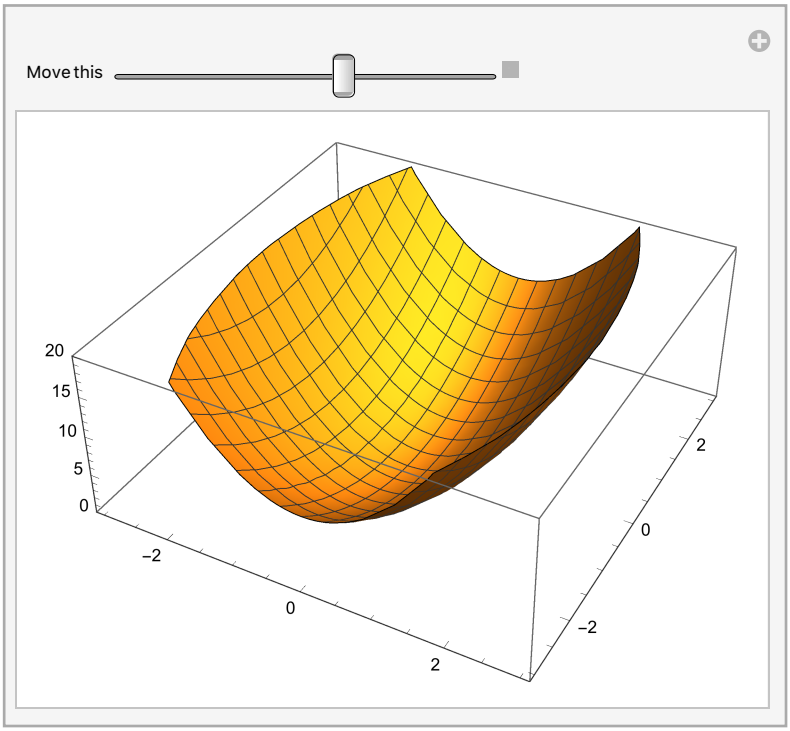
For thousands of years, mathematics has been taught and shared mainly through textual content on a 2-dimensional surface like paper, textbook, chalk and white board. If it's done well, this will include illustrations and diagrams to help in the understanding of textual content. When we read through a document or textbook, or attend a lecture, we immediately gravitate toward visual illustrations in our search for understanding. Even in this document, many of you may have scanned over the illustrations below to look for some immediate understanding to the purpose of this document. Today, there is technology available to teachers that is breaking the barriers on visualization. Drawings, diagrams, pictures and graphs no longer need to be displayed in a static environment. We now have the ability to create content which is rich, dynamic and interactive bringing life to the learning experience.

Textbooks are moving in this direction. Some day our textbooks will be completely digital in nature with content that is dynamically interactive. In fact, the inspiration for my project came from one. It's the only one of its kind and developed with Wolfram technology. I was introduced to it at a technology conference 3 years ago. I have been working towards implementing technology like this in my classroom. In this particular textbook, students interact with animations, diagrams, pictures and graphs in a way that is intuitive and free. The figures dynamically change as the student moves the mouse or move their finger across the screen. Today, we are just seeing the beginning of what this technology can do. I would argue that Wolfram has a strong lead on this type of technology and I'm excited to take part in this by bringing it to Ventura College.

Throughout the years, I have used many different type of technology in the classroom. However, I have always believed there is one area that needs improvement to maximize potential in the classroom. If we can get a handle on this, I believe the ability to share and learn mathematics will change for the better. Whether its hardware or software, the problem with technology today is that instructors have to take valuable time away from teaching our subject to teach how to use the technology. For example, consider the TI graphing calculator. If I sat one down in front of you, I doubt many of you could immediately figure out how to graph a 3 dimensional surface. I doubt I could do it right now with certain calculators. It's not intuitive and it wasn't designed to be. I believe we can do better. My job here is to teach mathematics, inspire my student with its beauty, and prepare them to use it in the future regardless of what technology is available to them.

My project is essentially removing this barrier from the learning process. I will be creating hundreds of interactive figures using software that is specifically designed to remove the technological learning curve for students. The interactive controls that I will implement are intuitive enough that a three year old could understand how to use them. These controls include sliders, checkboxes, pop up menus, setter bars, and locators. In a sense, I am attempting to use technology in a way that enhances learning and while not getting in the way of it. This allows me put my focus on teaching mathematics instead of teaching how to use the technology which isn't necessarily related.

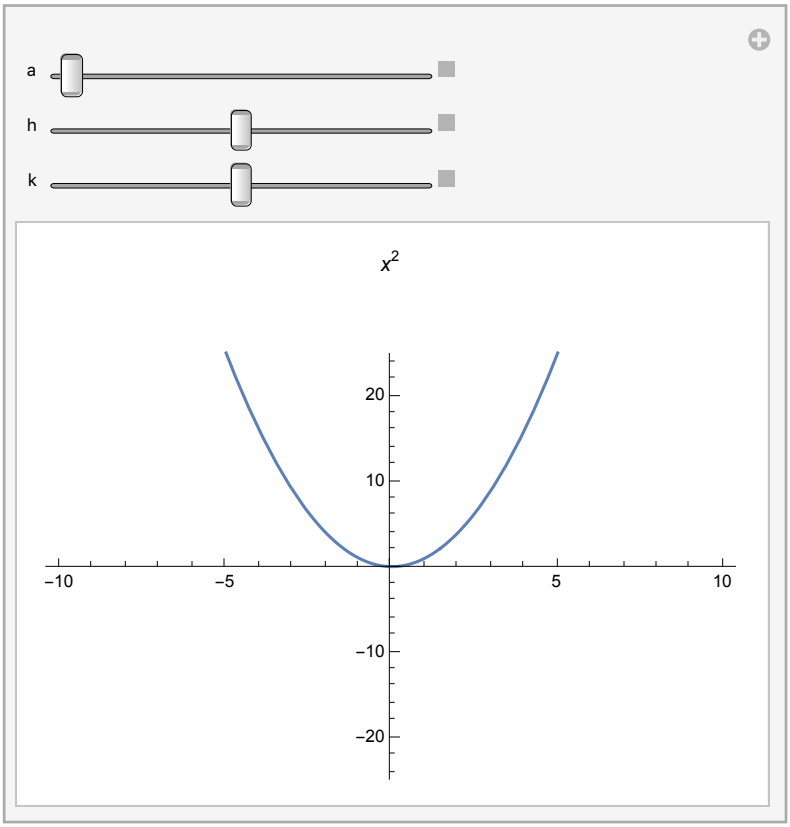
Below is an animation I created in *Mathematica* using the Wolfram language. Try moving the slider. Try rotating the graph. After playing around with it for just a few seconds, the user will develop an intuitive understanding of what the mouse and slider do. As the creator of this figure I can make that slider control anything. This allows my students to see how different parameters affect a graph dynamically. This is much more affective than describing the parameter change in words which is which is what must be done without dynamic software like this.



What you see above is called a CDF (Computable Document Format). It is similar to a PDF (Portable Document Format) which most of us are familiar with. The advantage to PDFs are that we can send them, post and open them on almost every computer. A CDF is even better. It has everything a PDF has in addition to being dynamically interactive. We can share CDFs just like we share PDFs. No need for the user to purchase a program to run them. The program is free and available to anyone with a computer.

Below is another example of a CDF. In Algebra we discuss transformations of the function $y = x^2$ by looking at the function $y = a(x - h)^2 + k$ for various values of a, h and k. I created the CDF below using one line of code in *Mathematica*. The code is usually hidden from student view, but I displayed it below so you can see what's going on behind the scenes. In under a minute, my students can figure out how the variables a, h, and k affect the graph. On top of that, they can do this on their own. Currently, this topic is taught with static images and a written description of the changes. This is not nearly as enjoyable to students, and it takes quite a bit longer to learn this way.

```
Manipulate[Plot[a (x - h)^2 + k, {x, -10, 10}, PlotRange → 25,
  PlotLabel → a (x - h)^2 + k, ImagePadding → {{0, 0}, {0, 40}}],
 {{a, 1, "a"}, 1, 6, 1}, {{h, 0, "h"}, -10, 10, 1}, {{k, 0, "k"}, -10, 10, 1}]
```



My project is composed of 3 parts:

1. I will be creating a large database of interactive CDFs in *Mathematica* with the Wolfram language for all student and faculty use in our district. The CDFs I will create are advanced and much more complicated to create than what you see above. I will be creating CDFs that will span the full range of math classes offered at the community college level. Included in the database will be the code so that instructors and students can change the parameters to make any alterations they wish. This part of my project will take hundreds of hours of work and the bulk of my time.

2. I will also be taking courses through Lynda.com as well Wolfram.com to further my understanding of the Wolfram Language, the CDF player and Mathematica.

3. I will also be working through "Programming with *Mathematica*" by Paul Wellin gaining valuable information to help me create more powerful CDFs.

I am eager to take on this project. This has been a hobby of mine for about 3 years. This is a new technology and I'm excited to learn more and share what I have learned with my students and other faculty.

Tangible Product

When I return from sabbatical leave, I will have created hundreds of CDF interactive animations in *Mathematica* using the Wolfram Language. I will be placing all of these animations in an online database that will be freely accessible to all students and faculty in our district. In addition, through learning to code these animations and working through "Programming in *Mathematica*", I will have gained hundreds of hours of knowledge on the Wolfram Language and how it can be used in the classroom to teach more effectively. I will gladly share my knowledge with any interested students and faculty. I hope that my experience will further the presence of effective technology on campus.

Qualifications

I am well qualified to take on this project. This project requires someone that has a strong understanding of mathematics and programming. It also requires someone that is knowledgeable in technology and its appropriate uses in the classroom. I am well versed in Mathematics and I teach the full range of math classes offered here at VC. I have a background in programming. I have served on the technology committee for a number of years. I stay current on the use of technology inside and outside of the classroom. In addition, I work with *Mathematica* every day and have been for three years. I am consistently creating programs and animation attempting to make learning easier for my students. I am excited to have a full semester to invest in more advanced learning and production. I have no doubts that I will succeed in the goals listed above.

Value to Faculty Member

I am very eager to take on this project. I have been waiting for the right time to chose a sabbatical project that I had serious interest in. I have found one that I am passionate about. I find myself reading textbooks trying to find ways I can teach more effectively using this technology. Since running across this language I have a new love for mathematics. I have been using this technology in the classroom when I can. I have been updating my courses so my students have this tool available to them. There are a limited number of formal classes available to learn this technology so I will be doing most of my learning through online videos and a textbook. However, I am very excited to do this and I am confident this will make me a better instructor.

Value to Students

This semester, I incorporated CDF animations in my Multivariable Calculus class. I used these animations throughout my lectures to help students visualize complex mathematical topics. I have placed all of these animations and more into an online database for my students which they use every day. My students are aware of my proposed sabbatical project. The support for my project is overwhelmingly positive. A number of students have offered their reviews of on the CDFs and how they have specifically impacted them. Below are a few of them.

"When I was introduced to your cdf animations, I was amazed at how much more I was understanding. The cdf animations really do help me understand what we are working with and it especially helps me see how we can apply what we learn in class to real life situations." - **Marco Antonio Bustamante**

"Your class is the first class that has been using CDF animations. All of these math classes have been great but if I could change anything it would be the ability to visualize many of the math problems like what you are doing with these CDF animations. If I had this program when I was in trigonometry and calculus one it would've given me a much better understanding of the subject especially with graphs. Especially since we are working in a three dimen-

sional space in multi-variable calculus it is hard to visualize each graph. These animations also save time in class too and many of the professors may not be able to draw the best graphs in the world so it would benefit them as well.To add this to many more classes would be perfect because it would give each student a better grasp of understanding how each problem would visually look. I believe this is another tool that is currently underutilized at the collegiate level right now and it would be great to see it implemented towards other courses. I am currently looking into working more with the wolfram alpha program because it has helped me so much in your class." - **Tristan Phillips**

"As for the benefit of the CDF animations...I can sum up my "review" of them in one sentence:I wouldn't be able to pass this math course without them! The animations allow me to clearly see the shape and the orientation in space. Seriously, without the animations it would make the class impossible (obviously I could go home and plug it into wolfram alpha, but having it in class when you are first learning the material makes the impact of the CDF animations that much more powerful. Thank you for making that a part of the class, as I could only imagine how many questions there would be during and after class of you hand drew all of the animations on the board! And on top of that, then we couldn't spin them around and manipulate them!" - **Anthony Bonvino**

"I find your animations very helpful. It is nice to see what the math we are working on looks like. In a lot of my math classes, I have wondered why I had to know all the little steps and why cant I just skip them. The animations show me what these little steps are doing and help me understand their importance" - **Michael Bendot**

"The CDF animations allow me to see and understand the applications of the theorems as well as the calculations. The animations encourage an in depth analysis of the problem. They also trigger my interest in the programs used to create the animations." - **Amelia Barajas**

"They are one of the most helpful tools a teacher has ever used in any math I have ever taken. Here's a few reasons why. If a student is a visual learner (like myself), they perfectly show the relationships between algebraic functions, and the graphs they represent. As math becomes more and more theoretical, the visual representation becomes more important. Calculus requires very a theoretical understanding of concept like infinitesimals, and the CDF animations allow the user to show the gradual change that the fundamental concepts such as differentiation and integration actually perform on a function. These animations take simple white board drawings and allow them to show change, such as when the tangent line to a curve is taken from the secant line moving towards one of the 2 points until the space between them is infinitesimally zero. In Calculus 21C, it would be nearly impossible to fully understand and appreciate the 3-D graphs, shapes, fields, volumes if it weren't for the ability to have a movable, interactive 3-D representation. Concepts such as the partial derivatives of 3-D function would be next to impossible to visualize, or the partial derivatives of a 4-D function." - **Drew Hines**

"A big part of mathematics is about graphing. In more advanced math classes we are required to begin to try and visualize how more complex equations will translate into three-dimensional space and while some of those equations aren't particularly difficult there are also some which are very difficult to plot without actually going through and finding individual points to plot. In a lecture setting, this is not really the most ideal or time-efficient way to present very dense concepts and Mr. McCain has utilized the excellent tool of CDF animations to help streamline the teaching of these concepts." - **Anthony Arevalo**

"I think the CDF animations you produce really contribute to helping illustrate mathematical concepts which are often difficult to visualize. Considering most of the stuff we deal with pertains to three dimensions and above—which is pretty darn hard to express on two dimensions—I can say that the interactive animations you make are both cool to look at and definitely provide a more cogent understanding to the processes we learn about. These animation

have made it easier to understand vectors, vector-valued functions, and a plethora of other stuff beyond the second dimension. I believe that had I been exposed to these CDF animations earlier in my mathematical endeavors, it would have made many things much more easier to comprehend." - **Joseph Aceves**

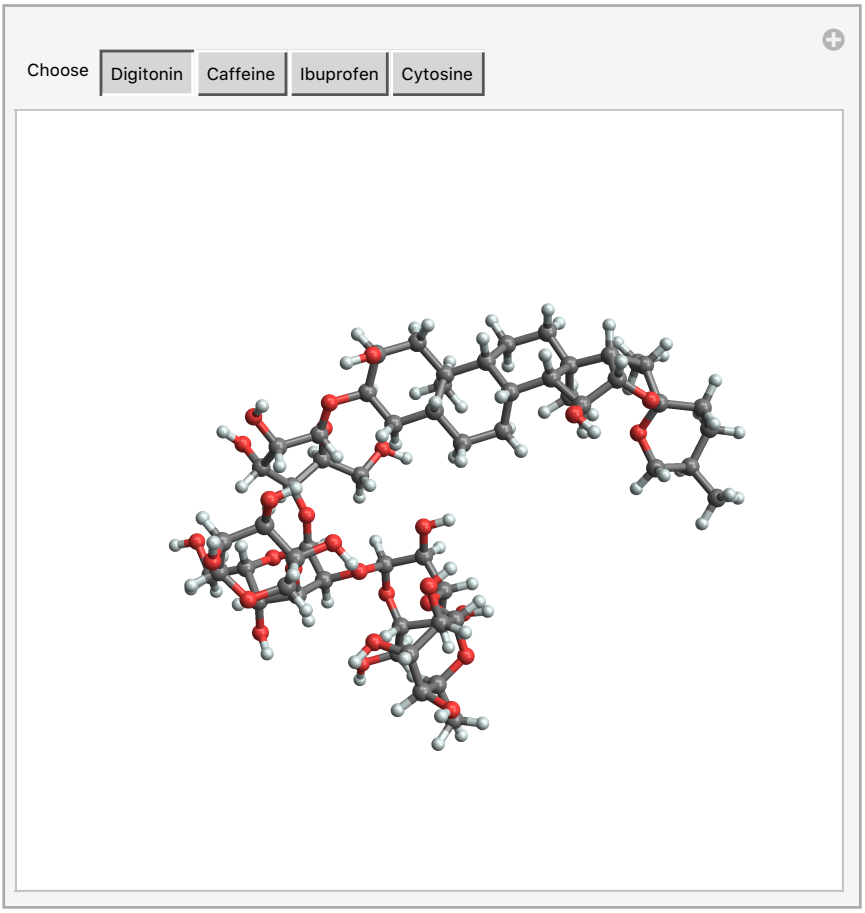
Value to Department

I will be making all of these animations available to our department members. In addition, upon my return, our department will have a member that is knowledgeable in the Wolfram language and is willing to share that knowledge to encourage other teachers in its use. Part of the requirement for some of our classes is to incorporate technology in the classroom. In some classes, we are not doing this at all. Implementing this software can offer that.

Value to the College and District

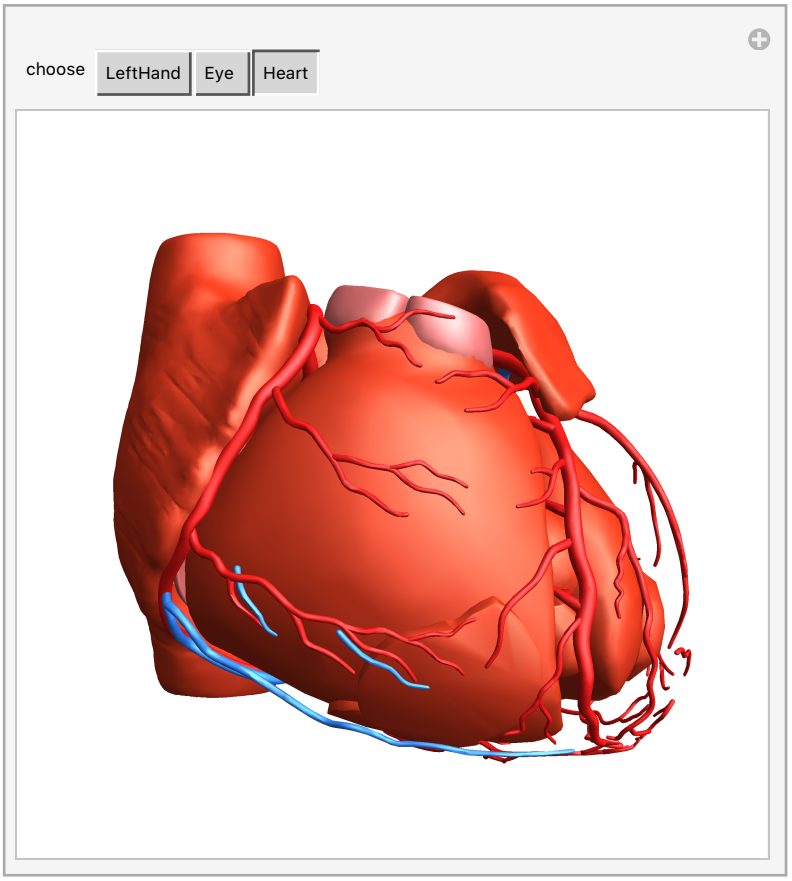
The unifying concept behind Wolfram technology is to take of the data in the world and quantify it making it immediately accessible and computable to everyone. Wolfram has created a huge database of information that anyone can access with *Mathematica* and CDF technology. If you have an Iphone, then you are using the Wolfram database to query things through Siri. For example, you can ask Siri "What is the scientific name of a mountain lion?" or " What is the airspeed velocity of an unladen swallow?" The database, can be used across all disciplines from anthropology to zoology. This project is valuable to the college because I will be opening a door to interactive software that can implemented across all of our disciplines. Below are some CDFs I created for other subjects. These CDFs are pulling data off the Wolfram database in real time. Try clicking the buttons and interacting with them.

In Chemistry,

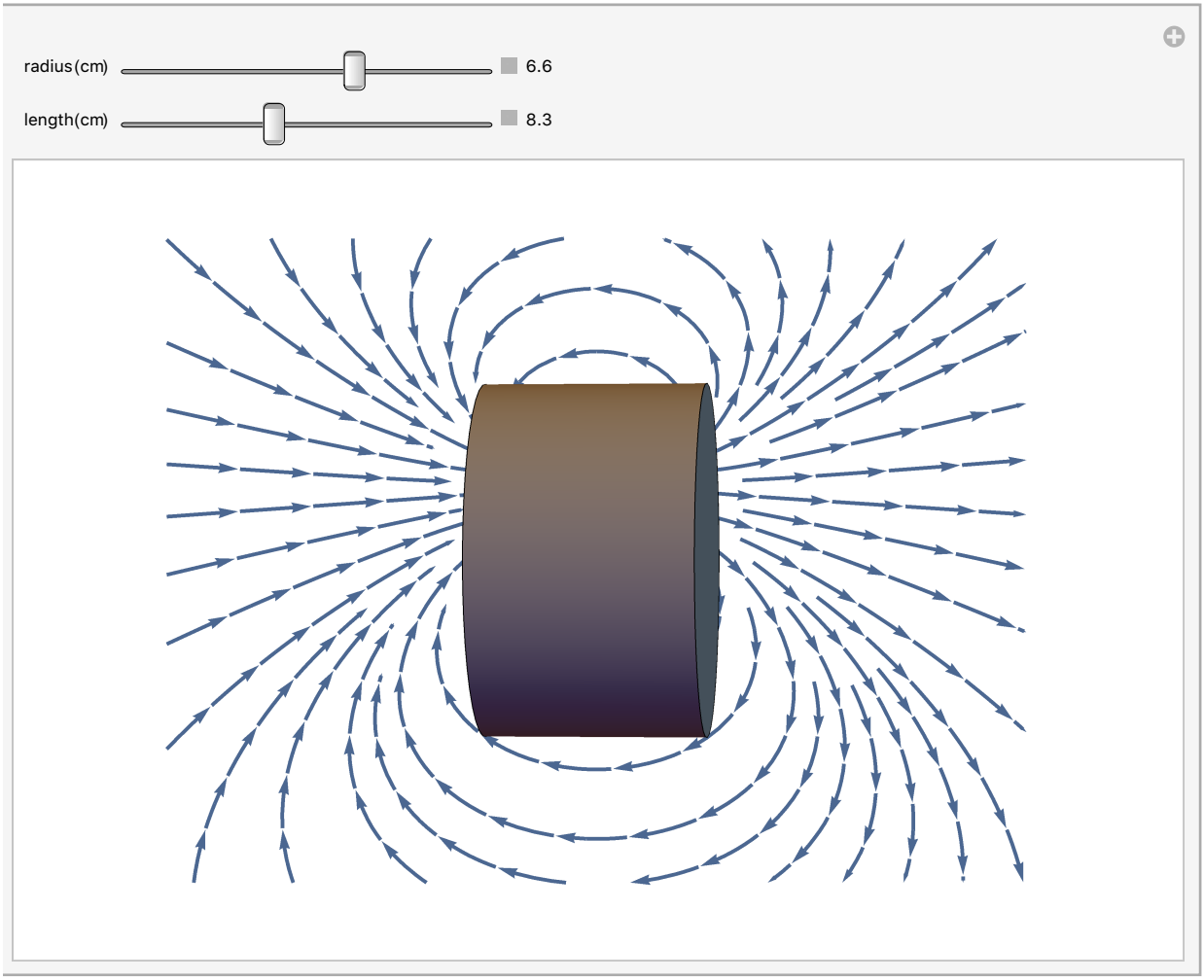


In Anatomy or Biology,

```
Manipulate[AnatomyData[Entity["AnatomicalStructure", a], "Graphics3D"],
 {{a, "Heart", "choose"}, {"LeftHand", "Eye", "Heart"}}]
```

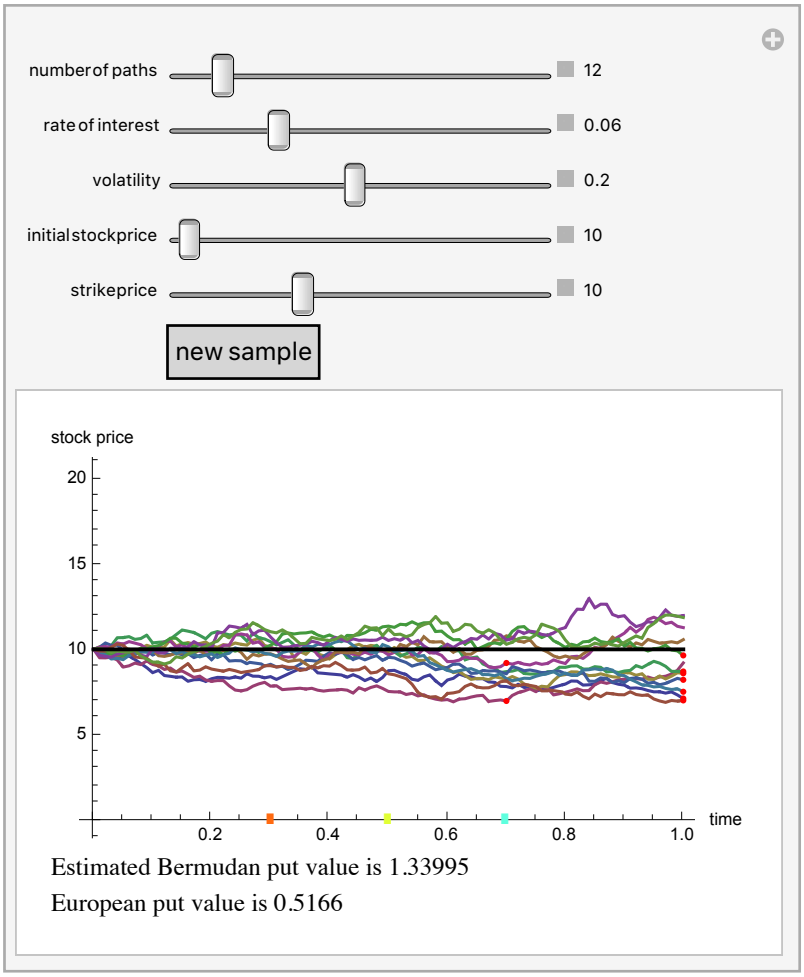


In Physics,



In Engineering,

In Economics,



The applications across all of our disciplines are endless. I have been sharing my animations with other instructors in other departments.

Conclusion

This document was created in *Mathematica*. I look forward to presenting the interactive figures above so that the committee can get a feel for the program. Thank you for considering my sabbatical application.