Chapter 6 STEM Math

This Chapter is for Parents of a child who might be interested in some STEM subject like Science or Engineering. It will be a challenging chapter to anyone who doesn't know much STEM Math.

However, I think you can probably understand the main ideas and themes even if you don't understand the math details.

If you have someone you know who is a STEM person you might want to have him or her read this Chapter or, better yet, watch the video of this Chapter.

This is the Chapter which explains why Homeschool Math today can be vastly Superior to Public School Math.

There are two approaches to learning Math, Heuristic and Rigorous

"A **heuristic** technique is any **approach** to problem solving, learning, or discovery that employs a practical **method** not guaranteed to be optimal or perfect, but sufficient for the immediate goals.

A **rigorous** technique is an **approach** which involves proving a meaningful statement is true with a series of **logical deductions** from a well defined set of assumptions, called Axioms, Postulates, or previously proven Lemmas or Theorems.

Modern mathematicians, and some math educators, often try to teach math with a rigorous approach which can be very tedious, boring and DIFFICULT to understand.

Classical mathematicians usually utilized a heuristic approach to learning and teaching mathematics which can be easier and quite enlightening. This is the approach I believe we should take when teaching Math at the High School level.

The wonderful 20th Century teacher, Dr. George Simmons, agrees with this approach as demonstrated in his wonderful book, *PreCalculus Math in a Nutshell*, which is the only textbook I utilize in my Six Tier Program. Any Parent or Teacher should at least read his Preface and the three Introductions to his three Chapters on Geometry, Algebra, and Trigonometry.

https://www.amazon.com/Precalculus-Mathematics-Nutshell-Geometry-Trigonometry/dp/1592441300

It costs only about $15. Wonder why it isn't adopted by our high schools?

BTW, Dr. Simmons wrote what I consider the best Calculus and Differential Equations books before he wrote the PreCalculus book.

And, he wrote the best Topology and Modern Analysis book first, which is how I learned about him when I taught this subject as a professor. This is the math behind theoretical physics subjects like quantum theory. George was a Great Math Teacher.

OK, so what should we be teaching our high school STEM students that will get them optimally prepared for a great University STEM education?

Numbers: Real Numbers, HyperReal Numbers, and Complex Numbers.

We need to teach these number systems heuristically, not rigorously.

Real Numbers correspond to all the points on a Straight Line and are expressed by the decimal number system. Subsets are Natural Numbers, Negative Numbers, Integers, Rational Numbers all of which a STEM student must understand heuristically.

Non-repeating decimal numbers are called Irrational with Algebraic and Transcendental subsets. These are ONLY of interest to Theoretical Mathematicians and just mentioned.

Complex Numbers correspond to all the points in a two dimensional Plane. They are very easy to understand heuristically and involve Trigonometry Functions and Infinite Series. They are vital for many STEM subjects

HyperReal Numbers include the Real Numbers and Infinitesimal Numbers.

Our ancestors approached Numbers Heuristically until the mid-19th Century. Then they began to approach Numbers Rigorously with an Axiomatic Approach. This is a much more difficult approach to numbers and should probably not be taught until a student decides to become a theoretical mathematician.

Indeed, there was a great split between Applied Mathematician and Scientists and Theoretical Mathematicians in the mid 1800's that was not resolved until 1966, ironically the year I earned my Ph.D. Quite an exciting time.

Mathematicians from the best ancient Greek Mathematician, Archimedes, used Infinitesimal numbers reasoning to solve many wonderful math problems such as relating the Area of a Circle to the Ratio of its Circumference and Diameter. Euclid had not done this in his famous Euclid Elements, the first attempt at rigorous math. See Archimedes Tombstone in Tier 2.

The creators of Calculus like Liebniz and Euler in the 1700's utilized infinitesimals and the wonderful creation of Calculus and Differential Equations. Of course, Applied Mathematicans and Scientists and Engineers used them extensively.

BUT, when theoritical mathematicians began to make the Number Systems Rigorous in the mid 1800's, the could not figure out how to include Infinitesimal Numbers. SO, what did they do? They BANNED THEM.

Wow. Applied Mathematicians and Scientists went their own way and continued to use them heuristically. Unfortunately, the theoretical mathematicians wrote our 20th Century calculus books and went a rigorous and difficult way. No more infinitesmals! Horrible setback for Math Ed.

Then in 1966, Abraham Robinson figured out how to make Infinitesmials and HyperReal Numbers Rigorous and they are back in.

Unfortunately, our Calculus books have not caught up yet. Wonder why? Could it be the huge investment in the current Calculus books?

But, of course, I use them extensively when I teach Calculus because they are a very good heuristic way to understand Calculus.

What are the ingredients of STEM Math?

Algebra, Geometry, Analytical Geometery, Trigonometry, Calculus, Differential Equations, all of which depend on. . . .

Functions. Polynomial, Trigonometric, Exponential and their Inverses.

Infinite Series These are like infinite Polynomials.

Tools for analyzing Functions and Solving STEM Problems.

Graphing a Function to get a visual picture of its behavior.

Calculus which are the two Tools for analyzing the behavior of Functions, and understanding their Visual Representations called Graphs and the Area under their Graphs. Differential and Integral Calculus and The Fundamental Theorem of Calculus, the most important Theorem ever, and the reason we are here today!

Differential Equations which is how Functions are discovered and how Physical Models are created..

I realize that most people have difficulty understanding what this all means. For what it's worth, many current High School teachers do to!

But, this is what a Student must learn to master STEM subjects.

Math is the Foundation of all STEM subjects, which essentially are based on Functions which are used to build STEM Models, which then are used to understand STEM topics and subjects.

Any Homeschool Parent with a STEM student must deal with this situation, and now it is possible as you will learn!

THE FUNDAMENTAL PROBLEM with the Standard Math Curriculum

Wonderful Manual Tools were developed to deal with all of the above Math topics by our ancestors who essentially only had Pencil and Paper.

Unfortunately, these Manual Tools are very difficult to learn, master, and use! It's the main reason so many students develop an intense fear and dislike of math. Don't blame them. It was a great struggle for me too.

One has to deal with Numbers and arithmetic calculations. Algorithms were developed for addition, multiplication, division, and square roots of real numbers. And, then algorithms for Complex Numbers.

Logarithms, the inverse of the Exponential Function, became a wonderful tool for performing arithmetic. And the Slide Rule, or Slip Stick, became a wonderful tool used by all Scientists and Engineers for centuries.

Trigonometry Tables were created which were indispensible in solving many math problems.

Then came Calculus in the 1600's which was the foundation of our modern Science and Technology world. Newton's Physics started it.

Calculus is used to analyze Functions.

Manual Tools were developed by Liebniz and Euler and others. Wonderful, but very difficult to learn and master and use.

Then, we had to learn to solve Differential Equations which often led to what are called Special Functions, i.e. Infinite Series.

All of these Manual Tools are very difficult to master.

So, if you wanted to become a STEM professional you had to first learn these Concepts and Tools. Intelligence was necessary, but even more important was a lot of very hard dedicated work to master these things.

Math was TOUGH and was often an insurmountable Barrier to STEM subjects. As you will learn soon, this has all changed.

Integral Calculus flunked many kids out of engineering schools since it was the first really difficult manual tool that had to be mastered. Much more difficult than the tools that led up to it.

Then Miracle #1 happened in 1972.

The first Scientific Calculator, the HP-35 was unleashed on the world.

Now Log and Trig Tables were obsolete. The Slide Rule was obsolete.

Now, a STEM professional could do all arithmetic calculations very quick and easy, AND the Scientific Calculator was an order of magnitude easier to learn and to use to solve math problems.

Needless to say this was a Crisis for Math Educators.

Many of their books and courses were obsolete! Students rejoiced.

Many Teachers were depressed. Much of what they had been earning a very good living teaching for all their lives was now in the dust bin of history. They had to adopt to the new technology and reality.

Many textbooks were obsolete.

But, Calculus and Differential Equations, the workhorses of STEM were not affected very much. Still the old Manual Techniques were all we had. So, for advanced STEM math not much changed.

Until 2009! A massive Educational STEM Math Earthquake more significant than the 1972 Scientific Calculator Miracle #1 happened.

Some background first.

Computers were developed shortly after WWII and really took off in the 1950's. By the 1970's a sophisticated Computer Algebra Program, Macsyma, which could solve Math Problems numerically was developed at MIT.

A teenager in the UK, Stephen Wolfram, used Macsyma to solve physics problems, and soon went to the greatest physics graduate school in the world at Cal Tech, and earned his Ph.D. in physics at age 20 in 1978. He also won the Genius Award.

Wolfram then wanted to develop a more powerful tool, and in 1988 introduced Mathematica to the world. This was an incredible programming language unlike anything before. It was like an incredible Miracle.

Steve Jobs incorporated Mathematica into the Next Computer and this system was used to create the World Wide Web, by Tim Berners-Lee.

Stephen Wolfram introduced an incredible Tool to the world called:

Wolfram Alpha https://www.wolframalpha.com/

Guess what?

Wolfram Alpha will solve any Calculus or Differential Equation Problem immediately including problems that can not be solved with the Classical Manual Techniques. And, much much more!

Wolfram Alpha is more revolutionary for STEM Math than even the Scientfic Calculator.

Now, starting in Middle School we can teach math to students that is virtually impossible to teach with the old, now obsolete, manual tools.

So, the new 21st Century Math Curriculum utilizes this amazing Modern Tool to teach virtually all STEM Math starting in Tier 4 with Algebra and Geometry like Conic Sections.

Then we go on in Tier 5 with Calculus and then Tier 6 with Differential Equations.

A student can now learn all of the STEM math needed for Science and Engineering in a very small fraction of the time and effort needed for the Classical approach.

Unfortunately, ALL high school textbooks are now obsolete. All Calculus and Differential Equations books are obsolete. Why?

They are loaded with all the very difficult Manual Tools which are now obsolete, yet very difficult to learn and master and use.

No modern STEM professional uses them anymore.

Indeed, you don't really need a book to learn Calculus and Differential Equations. Just some Notes, Exercises and Videos and Wolfram Alpha. All delivered with SPIKE Pedagogy.

Unfortunately, the Math Education Cabal doesn't want to give up a multi-billion dollar set of products developed over the last decades.

Can't blame them any more than I could blame the engineering professors who didn't want to abandon Slide Rules and Log and Trig Tables in 1972.

But, that's the world we live in. It's just like Smart Phones replacing Land Lines and many other classical obsolete technologies.

The Standard Math Curriculum is like teaching carpentry with the manual tools of the 1700 and 1800's. Just visit a museum and imagine how difficult it was to use the manual tools. Compare that to modern electrical tools.

Here's an analogy.

The Concept of “a hole in a piece of wood” is easy to learn.

How do you solve the problem of creating a hole in a piece of wood?

Without any tool it is probably impossible.

First, you could create a hole with a nail or spike and hammer. Of course, it was difficult and you could split the wood.

Then, came a wonderful manual tool, the Brace and Bit. This is how I was taught to create a hole when I was a boy in the 1940's. It took a lot of effort to learn it and a lot of practice to master it, which I never really did. And, it took a lot of slow physical effort. And, it was often impossible to drill a hole where I wanted one due to the limitiations of this tool.

Then, came the electric drill. Wow. Much easier to learn and to use. And, much faster and less physical effort. And, you could drill holes in more inaccessible places. Wow! Brace and Bit obsolete.

Then, the electric drill with a batter.y Even easier to use.

OK, analyzing a function with algebraic and manual graphing techniques is like making a hole with a hammer and nail.

Analyzing a function with the Manual Techniques of Calculus is like a Brace and Bit. Hard to learn and difficult to perform. But, much better than a Hammer and Nail.

Analyzing a function with Wolfram Alpha is like a battery powered electric drill. Easy Peasy.

Now, any student can learn STEM math and apply it very quickly and easily. Manual Calculus and Diff Eq techniques are OBSOLETE!

Math is NO LONGER a Barrier to learning a STEM subject.

That is why the Homeschool Math Programs <u>can be vastly</u> Superior to Public School Math.

Eventually Public School Math will catch up,I HOPE.

But, a multi-billion dollar industry will have to transform.

Math teachers will become Coaches.

Math will be delived with SPIKE Pedagogy.

And, the Financial Results will be truly amazing. See later Chapters.

Now, visit https://homeschoolertoday.com/ and look at the Curriculum, and particularly the Tier 4 and 5 Table of contents.

We begin to utilizie Wolfram Alpha in Tier 4 which revolutionizes how Algebra and Analytical Geometry and Trigonometry are learned and used.

Then, in Tier 5 we teach the student Calculus in about one semester.

We do have Tier 6 on Differential Equations available to a student who completes Tier 5.

Better yet, an amazing new Tool was invented in 2016, the SupraComputer.

It is based on the Raspberry Pi, and includes all the Wolfram Tools, plus the training on how to use it. And, it is very easy to use.

Once a student gets to Tier 4, the student will want to acquire a SupraComputer which will make it much easier to learn to use Wolfram Alpha, and also lead the student into the use of the modern powerful Wolfram Language which was introduced to the world in 2016.

So, what to do?

Just get started.

Enroll your student into our program.

The Family Plan is probably the most cost effective way to do it.

Visit: https://homeschoolertoday.com/ and check out the Curriculum and Pricing.

It is Risk Free to try it for a month and actually quite inexpensive to use compared to any other Programs we are aware of today (2019).

Remember, YOU are the Coach, and I am the Teacher.

Together we can give your STEM students a great Math Education that will prepare them to compete with the best educated students in the world.

SPIKE Pedagogy and PROPER Content.