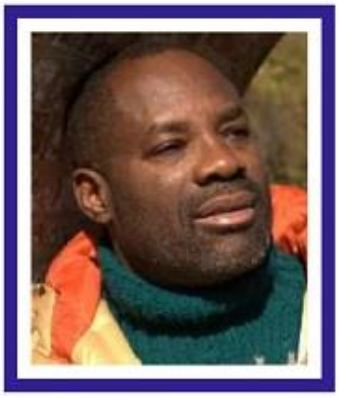

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Quest for Internet

In the third installment of our weekly series at emeagwali.com, we focus on Emeagwali's 1989 discovery in mathematics. He discovered nine partial differential equations that made the news when he solved them on a supercomputer that was connected as a superinternet (a word coined by Emeagwali).

My Supercomputer is a Superinternet

by Philip Emeagwali

Transcribed and edited from a lecture delivered by Philip Emeagwali. The unedited video is posted at emeagwali.com.

Booking Request

Few people understood why I coined the word "superinternet."

What made my ensemble of computers super is its two-to-power sixteen or 65,536 fold increase in the speed of its arithmetical computations. And what made my emsemble of sixteen times two-to-power sixteen or 1,048,576 communication wires that were interconnected as an internet super is its 1,048,576 fold increase in the speed of its email communication.

Like a computer: It computes the fastest. Unlike a computer: It communicates the fastest. So it's not just a supercomputer. It's beyond super. It's a superinternet that made the computer compute 65,536 times faster and its internet communicate 1,048,576 times faster.

The primary discovery and invention that a supercomputer or superinternet scientist can make is to "make fast go faster."

For the superinternet, I am well known, but not known well. It is well known that in 1989, while solving a grand challenge problem, I discovered how to program two-to-power sixteen or 65,536 computers to perform 3.1 billion calculations per second; what is not well known is that those two-to-power sixteen computers were interconnected by sixteen times two-to-power sixteen communication wires as a superinternet , communicating synchronously and computing simultaneously to solve my 24 million algebraic equations.

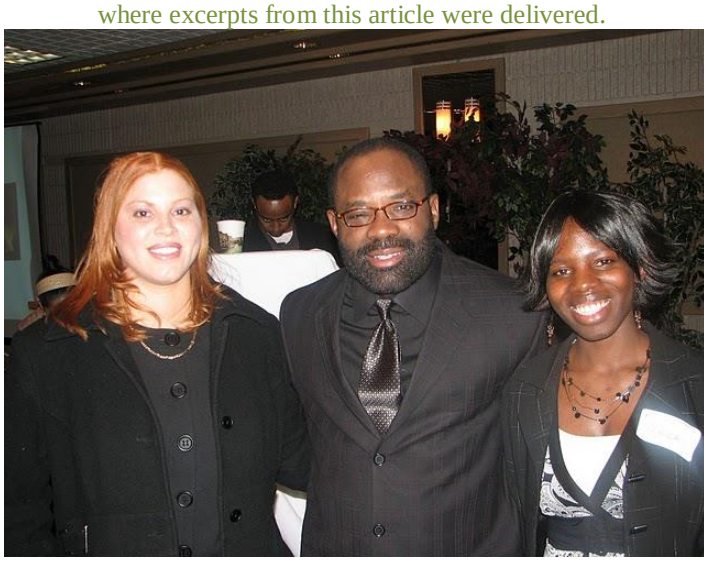
It is not well known that my algebraic equations were reformulated from 18 partial differential and difference equations that I invented. Or that I invented my 18 equations from the iconic formula $F = ma$ which, in turn, were formulated from the 330 year old Second Law of Motion in physics.

It is not well known that I correctly reformulated those partial differential equations to simulate petroleum reservoirs. I did so because Exxon, Mobil and Shell had incorrectly formulated them for reservoir simulators in a manner that defied the Second Law of Motion. Under the Second Law, all simulators should account for the inertial force. Yet, not one did so!

First, I had to discover that the inertial force was missing from the iconic Darcy's formula for a century and half. Discovering that may seem obvious, yet it's not as obvious as the Earth is round. After all, the curved horizon at sea led scientists to theorize that the Earth is round. Similarly, errors in computed solutions led me to theorize that a fourth force was missing. The consequence is profound: ignore the inertial force and you've changed the Second Law of Motion and your simulation will be physics defying.

Second, I had to incorporate these updates into my new partial differential equations, which are akin to the Navier-Stokes equations. These are the only equations that are cross-listed in both the "Seven Millennium Problems" of mathematics and the "20 Grand Challenges" of computing. Because it was challenging, it took me a decade to put the dots together and develop the connections between the Second Law of Motion, Darcy's formula, and the Navier-Stokes equations. I deserve credit for that achievement. The correct formulation was not at all obvious to mathematicians because they barely understood the physics. I certainly couldn't have come up with those 18 correct equations if I didn't deeply understand both the mathematics and the physics. In that sense, I understood mathematical physics better than those that preceded me.

This photo was taken on February 19, 2008 at the University of Idaho's (in Moscow, ID) College of Engineering banquet lecture where excerpts from this article were delivered.



Philip Emeagwali and friends.

Finally, the most difficult part was that I worked alone on solving the problem. In the 1980s, I alone programmed sixteen supercomputers, each powered by two-to-power sixteen computers that communicated along sixteen orthogonal (perpendicular) directions of a superinternet that was metaphorically shaped as a cube in sixteen dimensions. It was big science—in terms of labor and money—completed by one man with zero funding.

Today, no one person can embark on such a project because a supercomputer costs up to 1.32 billion dollars and requires 10,000 programmers. To make a name, you have to be a supercomputer administrator and take the credit for the discoveries of 10,000 scientists.

I did not begin my solution with the supercomputer, as was widely publicized in 1989. I had to understand the governing partial differential equations; understanding those helped me discover that they were not correctly formulated. They were incorrect because they only summed some of the forces. I summed all four forces in the reservoir simulator. Without my doing so, the simulator would compute everything wrong. This is what programmers call GIGO, **G**arbage **I**n, **G**arbage **O**ut.

This means that if you sum three forces in your partial differential equations, don't expect them to simulate as if you summed four. If the sum of the forces encoded into the reservoir simulator *is not equal to* the mass times acceleration, the equality will not magically reappear on any of its 65,536 computers. In simulation, as in life, you cannot plant yams and expect to harvest corns.

The process of discovering partial differential equations and inventing algorithms for solving them was long and complex and not for the faint of heart. How did I invent them? First, I had to arrive at the frontier of knowledge in partial differential equations, before I could move beyond it. I then had to possess the mathematical maturity to understand why the previous equations were not balancing correctly. Finally, I had to have the confidence to attempt to re-derive two century old equations from first principles, namely, the Second Law of Motion.

This achievement of discovering equations and inventing algorithms called not for genius, but for courage—the courage to say: "Your **F** is *not equal to* my **ma**;" the courage to say: "You've unbalanced with three forces the equations that nature balanced with four." Because of my courage to say that the inertial force was missing, I was viewed as the child who pointed out that the Emperor had no clothes. I called upon geophysicists to ensure congruency between the forces in their simulator and reservoir. Both were incongruent to each other because a four-force **F** *was not equal to* **ma** in their simulator but it was equal in their reservoir.

A supercomputer cannot discover that a fourth force was missing. I—its programmer—re-discovered the fourth force and correctly summed all four forces. The following story illustrates how dumb a supercomputer can be. A schoolteacher took her students on a field trip to see a supercomputer. The machine comprised of 65,536 computers interconnected as a superinternet by 1,048,576 communication wires. It occupied the space of a football field and consumed as much electricity as a city of 5,000 people.

"This supercomputer can come up with an answer faster than all of the combined efforts of humanity,"

the teacher explained.

She gave the supercomputer some difficult questions, and within seconds, it spat out the answers. The teacher turned to her students and said:

"You may ask it any question."

A child stepped forward and said,

"Hello, Supercomputer. How are you?"

There was no response!

As this story illustrates, I did more than switch my supercomputer on. I did not make my discoveries by sitting before a supercomputer and chanting the magic words of Ali Baba: "Open Sesame." It took me 15 years to understand the physics, algebra, calculus, algorithm, computation, and communication.

Those who believed that my supercomputer solved the grand challenge problem alone are mistaken. Supercomputers do one thing only. They compute at the fastest speed. If you have an error, the supercomputer will compute it 65,000 times faster.

A supercomputer cannot convert data to information, information to knowledge, and knowledge to wisdom. Only humans can convert data to wisdom. I made discoveries not merely by programming a supercomputer but by taking risks, leaving my safe zones, and jumping into the deep end.

No matter how fast a supercomputer becomes it will still lack the self-awareness necessary to answer the simple question, "How are you?" A machine that can't see itself or react to failures within itself cannot correct incorrect equations. The supercomputer lacks the wisdom possessed by a baby. It can't answer profound questions, such as "Does God Exist?" It is the supercomputer that needs the wizard to make it super, beyond super.

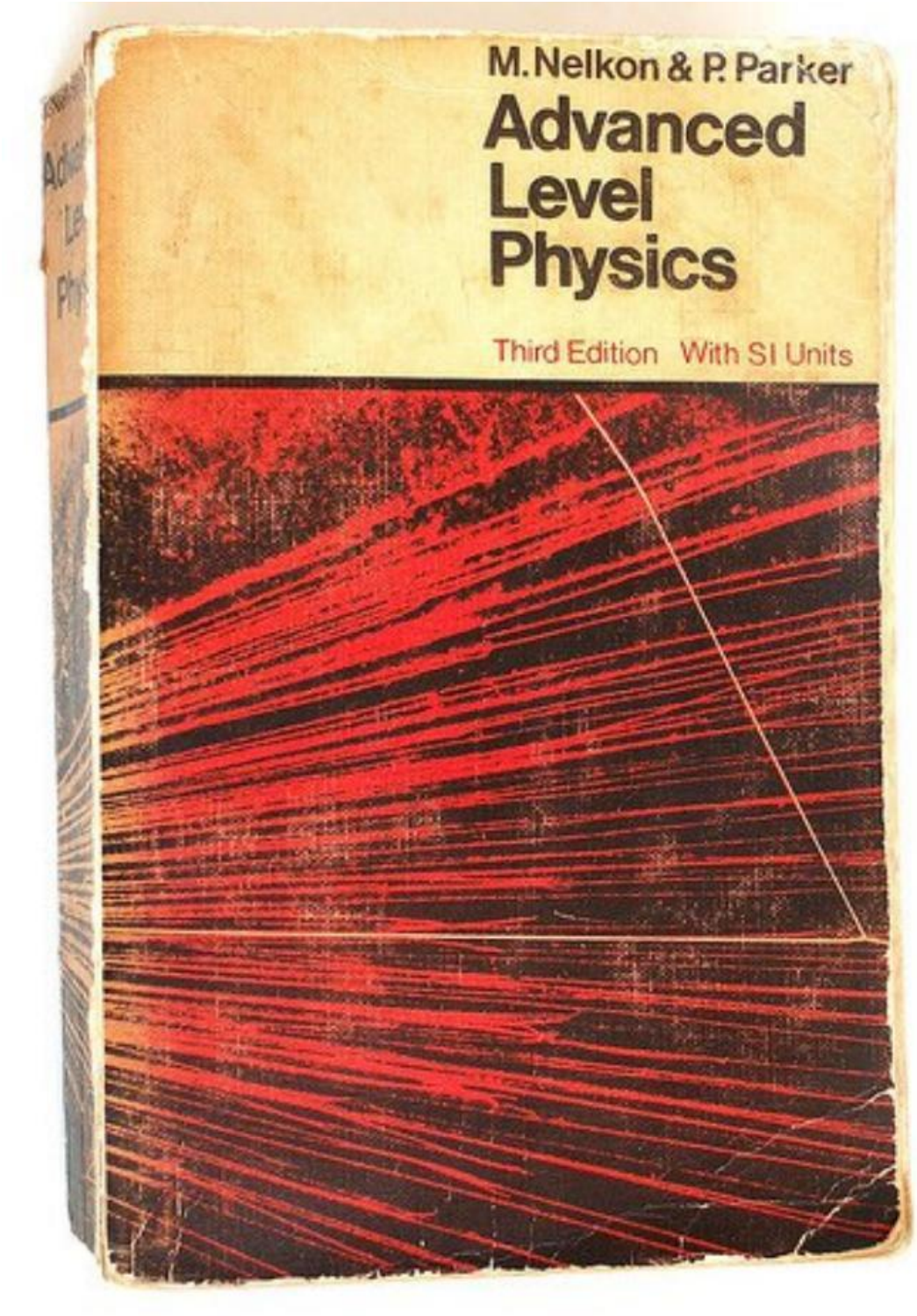
FACTOIDS

Two books that influenced me were

“ An Introduction to the Infinitesimal Calculus” by George William Caunt. I read it in 1970 at age 15 and it gave me my nickname “Calculus.” The equations that I invented are “new calculus.”

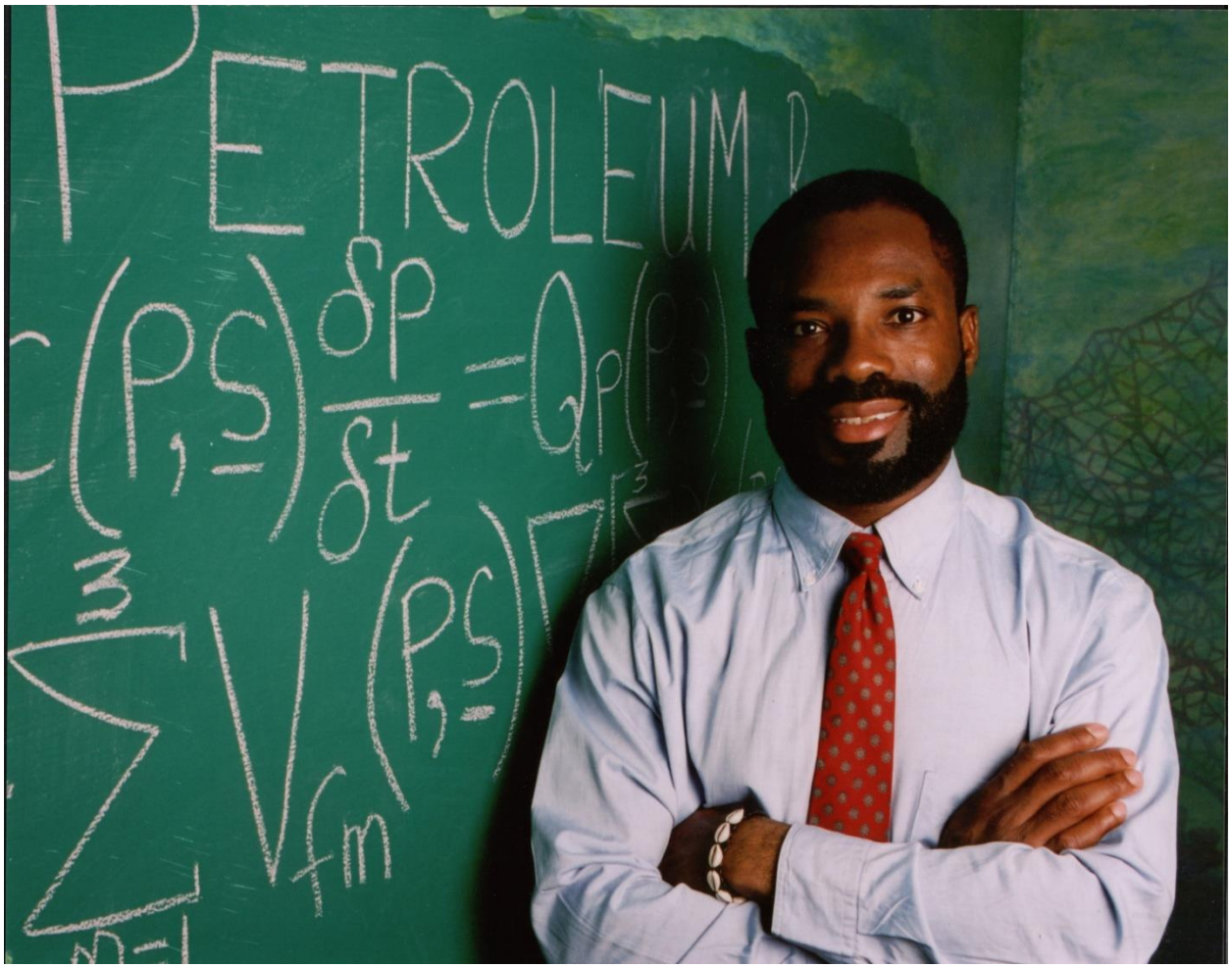
The second book is called “Advanced Level Physics” by Michael Nelkon and Philip Parker. It was first published in 1958. I used the 1970 edition of this book to self-teach myself during after school hours at Sacred Heart Primary School in Ibusa (Nigeria) in 1972.

The mathematics I created (or new calculus) came from the Second Law of Motion described in high school physics textbooks such as the text above.


M. Nelkon & P. Parker
Advanced Level Physics
Third Edition With SI Units

”

This is the publicity photo for a lecture I gave on July 8, 1991 at ICIAM '91, which is the World Cup of Mathematics. I told the field's foremost experts that my new mathematics came from inside a petroleum reservoir. [Philip Emeagwali, 1990]



I write on the board the actual equations used by Exxon (now Exxon Mobil) to simulate the flow of oil, water, and gas inside its reservoirs. I discovered that their equations did not reflect reality and corrected their error. [emeagwali.com]

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Date:	12/28/2006, 6:50 pm, GMT +6
Name:	Pastor Victor Justin <195.166.241.170>

Location:	River State
Number:	132
Prof.Philip You have made Africa Proud	
Date:	12/28/2006, 3:52 pm, GMT +6
Name:	Yomi <155.232.250.51>
Location:	South Africa
Number:	131
Dear Prof, There is no accurate word to describe ur achievement but I will simply say that you have made us proud in Africa. Bravo!	
Date:	12/23/2006, 11:50 am, GMT +6
Name:	balamurugan balusamy <210.212.241.130>
Location:	vellore ,india

Number:	130
	ya ,It was nice site to hang out,got insperation.
Date:	12/22/2006, 9:45 pm, GMT +6
Name:	Ben Chibundu Njoku <158.21.255.8>
Location:	Warri, Nigeria
Number:	129
	Prof, Good to hear of your numeruos achievements. When would think it is right to come home, Nigeria and encourage the upcoming ones that stones on dry land can also produre water. I look up to day you will come and give one those your inspiring lectures.
Date:	12/19/2006, 9:58 pm, GMT +6
Name:	phlip chude <81.199.56.130>

Location: ONITSHA,NIGERIA

Number: 128

SIR,u have done Africa ,Nigeria,Anambra state and my own town Onitsha proud. keep it on and may the good lord strenthen ur life.amen and also am praying to be like you one day. Thanks to you

Date: 12/19/2006, 1:41 pm, GMT +6

Name: Chris Ezeh <85.177.237.93>

Location: Hamburg Germany

Number: 127

Your contributions, aspirations and archievements will always remain as a masterpiece in the annals of the history of mankind. It´s my belief that african can attain their goals only with the right leadership, support and the struggle to reportray our strained image worl-wide.

This is exactly our mission at: EuroAfricaCentral Network: www.euroafricacentral.com
Date: 12/18/2006, 5:45 pm, GMT +6 **Name:** IJEOMA ONONOGBU <82.198.250.74> **Location:** LONDON **Number:** 126
Dear Prof, You are a source of inspiration to the young ones.Having read your articles over the years.I feel particularly proud of you, because you are a true embodiment of success.Continue to shine and God bless.
Date: 12/11/2006, 12:57 pm, GMT +6 **Name:** Nonso Okafor <64.154.26.251> **Location:** Port Harcourt - Nigeria **Number:** 125

You are a proof that Africa is endowned with intellectual giants but the question why is it that is outside Africa that men like you are celebrated and given opportunity to exploit their potentials?

Date: 12/2/2006, 9:12 pm, GMT +6

Name: clement <64.201.33.245>

Location: nigeria,lagos

Number: 124

i need a lot of advice to also develop like u.pls help . kudos2client@yahoo.com is my email address

Date: 12/10/2006, 7:01 pm, GMT +6

Name: BEY Daniel <213.136.114.43>

Location: Côte d'Ivoire - Abidjan

Number: 123

you are a africa's pride.
Je suis très heureux de faire votre connaissance à travers votre site, docteur philip emeagwali.
God bless you
BEY D.

Date: 12/9/2006, 9:23 pm, GMT +6

Name: ikeazor anieto <80.78.18.64>

Location: onitsha

Number: 122

i love u but God loves u most. let make a deal. call me on 234 806 387 1875.thanks.

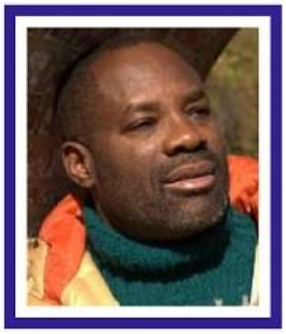
Date: 9/5/2006, 9:25 pm, GMT +6

Name: BINGI MICHAEL <217.113.72.38>

Location: UGANDA,EAST AFRICA

Number: 77

You are wonderful.black people are brain washed, they do not even know about like you who are more than tough.please keep the spirit.you are like Ishango bolongo.the African who encrypted the I shango bone;oldest mathematical script



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This photo was taken in the year I morphed from being a mathematical physicist who creates new mathematics to a superinternet scientist that performed the world's fastest email communications and arithmetical computations. [Philip Emeagwali, 1983]