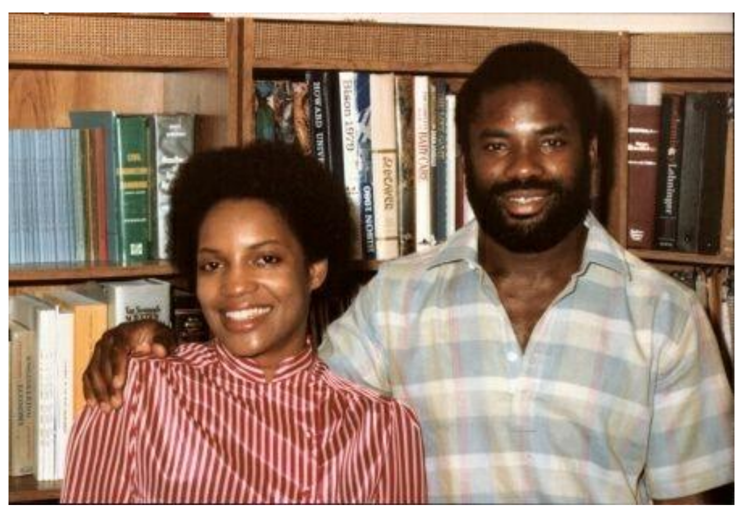
Quest for Internet

In Part C of the first installment of our weekly series at emeagwali.com, we focus on the difference discovery and invention. In 1989, Philip Emeagwali used 65,536 computers to perform a world record 3.1 billion calculations per second. He solved a six-part problem that spanned 41 discoveries and inventions.

The Discoverer is the First Teacher

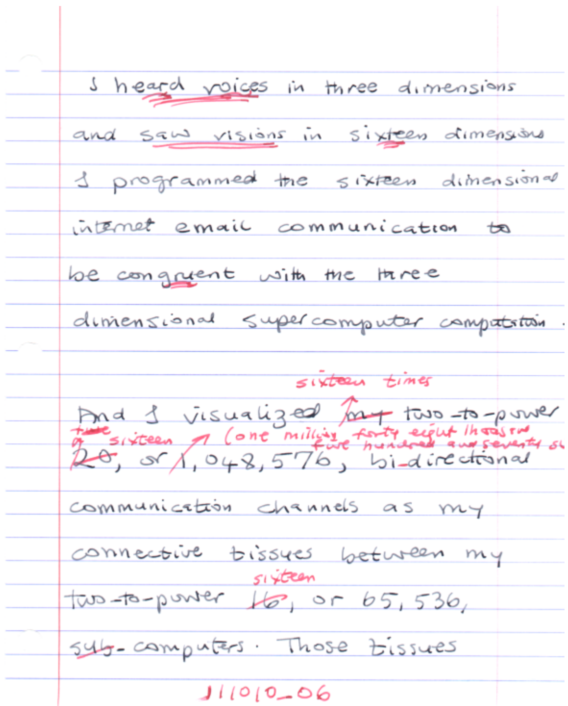
Transcribed and edited from a lecture delivered by Philip Emeagwali. The lecture video is posted at emeagwali.com and youtube.com/emeagwali

Emeagwali stopped pursuing his patent claims because the United States Patent and Trademark Office told him that his 36 algorithms were discoveries, not inventions. He argued that they were inventions, not discoveries, explaining that although the Second Law of Motion encoded within his algorithms was not patentable, his algorithmic techniques that embodied that Second Law within supercomputers should be, because they are the



> To discover means to see something that is previously unseen or unknown.

discrete analogue of the 36 partial derivative inertial terms that he had discovered. In other words, they were functions with input and output.


I heard voices in three dimensions
and saw visions in sixteen dimensions
I programmed the sixteen dimensional
internet email communication to
be congruent with the three
dimensional supercomputer computation.

And I visualized ~~my~~ sixteen times two-to-power
~~twenty~~ sixteen ~~20~~, or 1,048,576 (one million forty eight thousand five hundred and seventy six), bi-directional
communication channels as my
connective tissues between my
two-to-power ~~16~~ sixteen, or 65,536,
sub-computers. Those tissues
J11010_06

Patenting algorithms was a gray area in 1989. You cannot patent a mathematical technique but you can patent a computer technology. The algorithm lies between mathematics and computer. Today, it is possible to patent algorithms; however, because he publicly disclosed his inventions in 1989, the one year filing deadline passed.

Importantly, scientific progress is only measured by discoveries, not patents. To discover means to see something that is previously unseen or unknown. Philip Emeagwali discovered that petroleum reservoir engineers summed only three forces, instead of summing all four forces within their oilfields. The word “invent” means the contrivance of that which did not before exists. He invented 36 algorithms for summing all four forces.

To invent means to originate or create as a product of the inventor’s ingenuity. It does not mean to patent. In supercomputing, it means to correctly formulate and solve one of the “Twenty Grand Challenges” at a world-record speed. Philip Emeagwali simulated the flow of oil, water, and gas—with the forces correctly summed—at the then unheard of speed of 3.1 billion calculations per second. It was a Grand Challenge that was of interest to Mobil Corporation, but completed by one man in 1989.

In summary, Philip Emeagwali received a standing ovation at the International Congress for telling the field’s foremost experts that: Exxon was falsifying its petroleum reservoir equations and that the equations taught in universities are not equating to what’s happening inside a petroleum reservoir. It is an unpatented invention just as the Atomic Bomb and internet are unpatented inventions. If you submit a patent related to the Atomic Bomb, the USPTO will inform you that your invention has been stamped “secret.”

The internet is a planet-sized infrastructure comprising of billions of cables and computers. To patent it require that you build a prototype of the internet, which is impossible because:

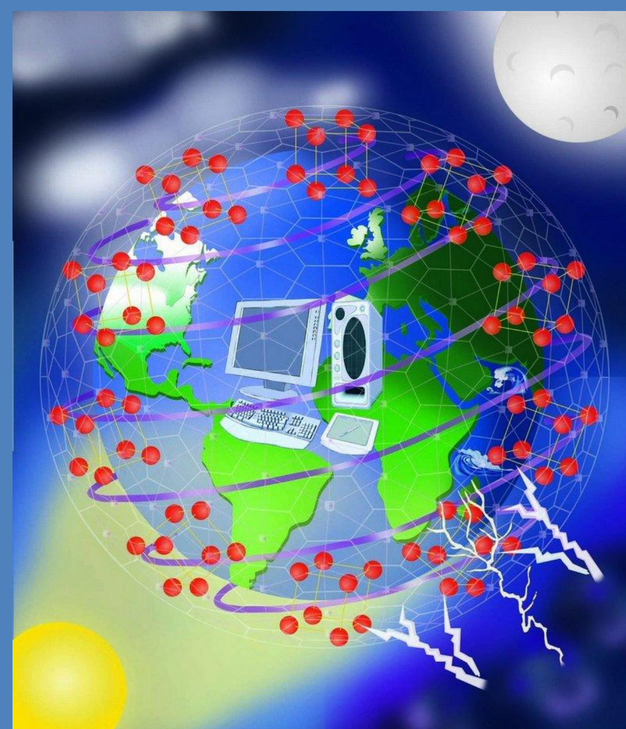
- The Act of Congress of July 4, 1836, section 6, requires an inventor who is desirous to take out a patent for his invention, to furnish a model of his invention, in all cases which admit of representation by model, of a convenient size to exhibit advantageously its several parts.

When reduced to its skeletal bones, the supercomputer Philip Emeagwali programmed was a superinternet outlined by two-to-power sixteen, or 65,536, computers that were interconnected by sixteen times two-to-power sixteen, or 1,048,576 bi-directional communication wires, each akin to a short telegraph wire.

What he discovered and invented was how to push it's frontier by extending the limits of supercomputer computation and superinternet communication. It was newsworthy in 1989.

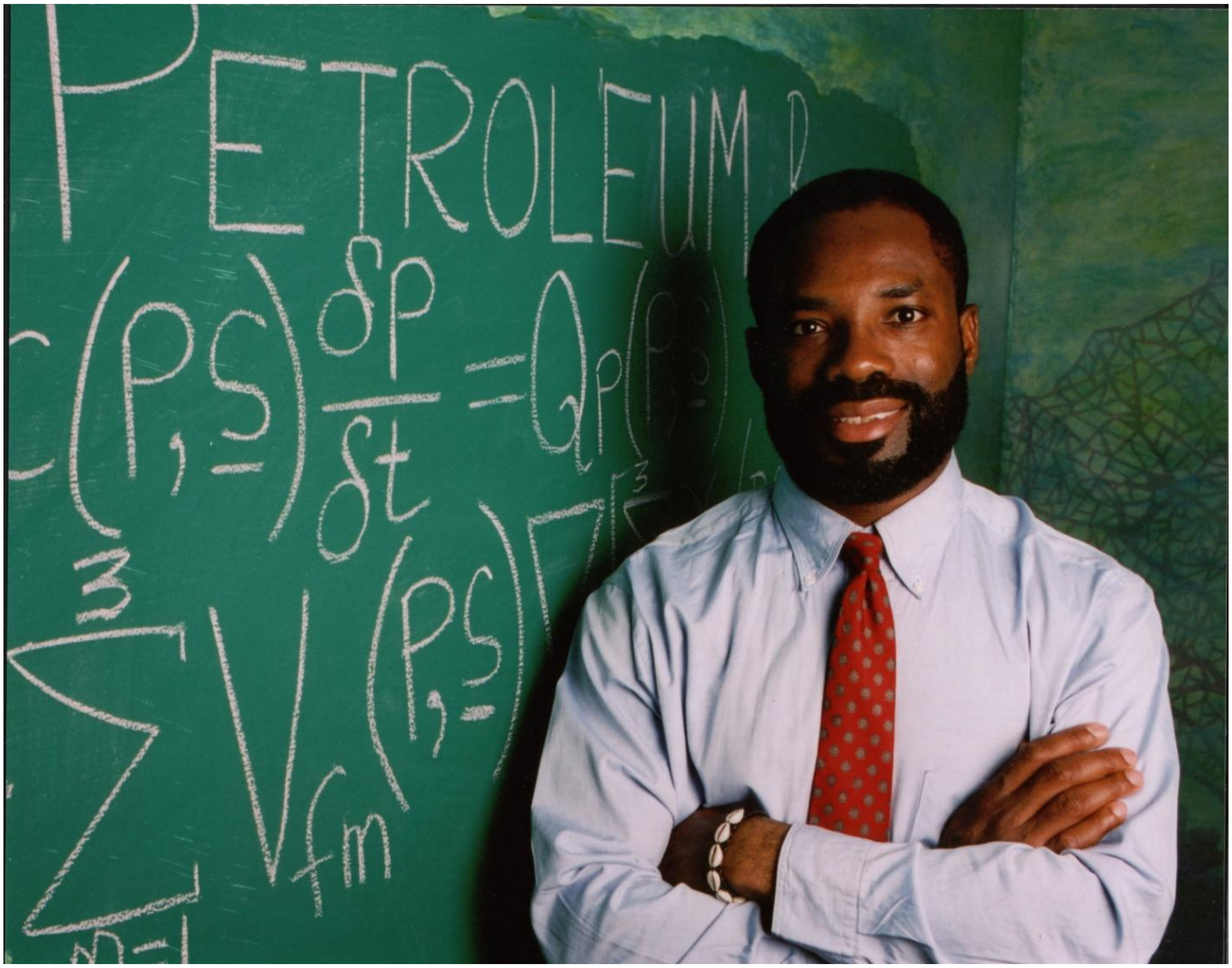
Your dictionary defines the word "invention" without using the word "patent" and groundbreaking inventions, such as the automobile, the airplane, and the Internet, cannot be patented because each has many fathers, mothers, aunts, and uncles.

Groundbreaking inventions, such as the automobile, the airplane, and the Internet, cannot be patented because each has many fathers, mothers, aunts, and uncles.



An artist's rendition of Emeagwali's theorized Internet described in the book "History of the Internet."

Most importantly, the discoverer is the first teacher of his discovery to humanity, present and future.



Philip Emeagwali writes on the board the actual equations used by the oil company Exxon (now Exxon Mobil) to simulate the flow of oil, water, and gas inside its petroleum reservoirs. Emeagwali pointed out that four forces exist inside every petroleum reservoir; he discovered that the Exxon Mobil equation had summed only three forces. Emeagwali correctly summed all four forces, namely: pressure, viscosity, gravity, and inertia.

Scanned from our archives of Philip Emeagwali's Notebooks

STABILITY ANALYSIS

Consider

$$u_t = u_{xx}$$

$$t > 0, \quad 0 < x < 1$$

$$u = 0, \; x = 0, \; t > 0$$

$$u = 0, \; x = 1, \; t > 0$$

$$\left.\begin{aligned} u &= 2x, \; 0 \le x \le 1/2 \\ &= 2(1-x), \; 1/2 \le x \le 1 \end{aligned}\right\} t=0$$

Solution: $u(x,t) = \frac{8}{\pi^2} \sum_{k=1}^{\infty} \left(\sin \frac{k\pi}{2}\right) (\sin k\pi x) \frac{e^{-k^2\pi^2 t}}{k^2}$

We approximate above as

~~$u_{i-1}^n - 2u_i^n +$~~

$$\frac{u_i^{n+1} - u_i^n}{\Delta t} = \frac{u_{i-1}^n - 2u_i^n + u_{i+1}^n}{(\Delta x)^2}$$

Rearranging yields:

$$u_i^{n+1} = \gamma u_{i-1}^n + (1 - 2\gamma) u_i^n + \gamma u_{i+1}^n$$

where $\gamma = \Delta t / (\Delta x)^2$

$$u(x,t) = \frac{8}{\pi^2} \sum_{k=1}^{\infty} \left(\sin \frac{k\pi}{2}\right) (\sin k\pi x) \frac{e^{-k^2\pi^2 t}}{k^2}$$

Expanding preceding approx. yields

$$
\begin{aligned}
u_1^{n+1} &= \qquad\qquad (1-2\gamma)u_1^n + \gamma u_2^n \\
u_2^{n+1} &= \gamma u_1^n + (1-2\gamma)u_2^n + \gamma u_3^n \\
u_3^{n+1} &= \gamma u_2^n + (1-2\gamma)u_3^n + \gamma u_4^n \\
&\ \ \vdots \\
u_{N-1}^{n+1} &= \gamma u_{N-2}^n + (1-2\gamma)u_{N-1}^n
\end{aligned}
$$

Rearranging yields

$$
\begin{bmatrix}
(1-2\gamma) & \gamma & & & \\
\gamma & (1-2\gamma) & \gamma & & \\
 & \cdot & \cdot & \cdot & \\
 & & \cdot & \cdot & \cdot \\
 & & & \gamma & (1-2\gamma)
\end{bmatrix}
\begin{bmatrix}
u_1^n \\ u_2^n \\ \vdots \\ u_{N-1}^n
\end{bmatrix}
=
\begin{bmatrix}
u_1^{n+1} \\ u_2^{n+1} \\ \vdots \\ u_{N-1}^{n+1}
\end{bmatrix}
$$

$$\bar{u}^{n+1} = \bar{\bar{A}}\,\bar{u}^{n}$$
$$= \bar{\bar{A}}\left(\bar{\bar{A}}\,\bar{u}^{n-1}\right)$$
$$= \bar{\bar{A}}\cdot\bar{\bar{A}}\left(\bar{\bar{A}}\,\bar{u}^{n-2}\right)$$
$$= \bar{\bar{A}}\cdot\bar{\bar{A}}\cdot\bar{\bar{A}}\cdot\ldots\cdot\bar{\bar{A}}\,\bar{u}^{0}, \quad (n+1) \text{ times}$$
$$= \bar{\bar{A}}^{n+1}\bar{u}^{0}$$

Suppose

u^{0} = exact I.C.

u_{*}^{0} = erroneous I.C.

Then

$$\bar{e}^{n} = \bar{u}^{n} - \bar{u}_{*}^{n}$$
$$= \bar{\bar{A}}^{n}\bar{u}^{0} - \bar{\bar{A}}^{n}\bar{u}_{*}^{0}$$
$$= \bar{\bar{A}}^{n}\left(\bar{u}^{0} - \bar{u}_{*}^{0}\right)$$
$$= \bar{\bar{A}}^{n}\,\bar{e}^{0}$$

$$\bar{e}^{0} = \sum_{i=1}^{N-1} \alpha_i \bar{V}_i$$

$$\bar{e}^{n} = \sum_{i=1}^{N-1} \alpha_i \bar{\bar{A}}^{n} \bar{v}_i$$
$$= \sum_{i=1}^{N-1} \alpha_i \lambda_i^{n} \bar{V}_i$$

λ = eigenvalue of $\bar{\bar{A}}$

Gerschgorin's Theorem

If $\tilde{\bar{A}}$ is $n \times n$, $\{S_i\}_{i=1}^{n}$ is sum of moduli of elements along col. or rows of $\tilde{\bar{A}}$, where $S_m = \max_i \{S_i\}$

Then

$$\rho(\tilde{\bar{A}}) \leq S_m$$

In other words, spectral radius of $\tilde{\bar{A}} \leq S_m$

From Gerschgorins thm, the error vector $\tilde{e}^n$ is bounded when $\rho(A) \leq 1$

For our approximation, $\tilde{\bar{A}} = \tilde{\bar{I}} + \gamma \tilde{\bar{B}}$ where

$$B = \begin{bmatrix} -2 & 1 & & & \\ 1 & -2 & 1 & & \\ & 1 & -2 & 1 & \\ & & \ddots & \ddots & \ddots \\ & & & 1 & -2 \end{bmatrix}$$

The eigenvalues of $\bar{\bar{B}}$ are

$$-4\sin^2\frac{k\pi}{2N}, \quad k = 1, 2, 3, \ldots, N-1$$

Corresponding eigenvectors are

$$V_K = \left(\sin\frac{K\pi}{N}, \sin\frac{2K\pi}{N}, \ldots, \sin\frac{(N-1)K\pi}{N} \right)$$

$$\hat{\bar{A}} = \hat{\bar{I}} + \gamma\bar{\bar{B}} \equiv f(\bar{\bar{B}}) \Longrightarrow \text{eigenvalues}$$ of $\hat{\bar{A}}$:

$$1 - 4\gamma\sin^2\frac{K\pi}{2N}, \quad K = 1, 2, 3, \ldots, N-1$$

Convergence $\Longrightarrow \rho(\tilde{\bar{A}}) \leq 1$, or

$$-1 < 1 - 4\gamma\sin^2\frac{\pi K}{2N} < 1$$

$$\Longrightarrow \quad \gamma \leq 1/2$$

REF.

Gerschgorin, S.: "Über die Abrenzung der Eigenwerte einer Matrix," Izv. Akad. Nauk SSSR (Ser. Mat. 7, 1931) vol. 16, page 749

Price, H. S., Varga, R. S., and Warren, J. E.: "Application of Oscillation Matrices to Diffusion-Convection Equations," J. Math. & Physics (Sept. 1966) vol. 45, No. 3, p. 301-311

O'Brien, G. G., Hyman, M. A., and Kaplan, S.: "A Study of the Numerical Solution of Partial Differential Equations," J. Math. Phys. (Jan. 1951) vol. 29, No. 70, 223

Richtmyer, R. D. and Morton, K. W.: "Difference Methods for Initial-Value Problems," 2nd ed., New York, 1967

Handwriting of Philip Emeagwali (1983, Library of Congress)

STABILITY ANALYSIS

Assume: slight compressibility, constant viscosity, isotropic and homogeneous flow. The governing equation is

$$\frac{1}{\alpha}\frac{\partial P}{\partial \tau} = \frac{\partial^2 P}{\partial \mathcal{X}^2}, \quad \tau > 0, \quad 0 < \mathcal{X} < L$$

Define

$$t = \alpha \tau / L^2, \quad x = \mathcal{X}/L, \quad u = P/P_i$$

P_i = pressure when $\tau = 0$

Substituting yields

$$u_t = u_{xx} \qquad t > 0, \ 0 < x < 1$$

Consider

Boundary Conditions: $u = 0, \ x = 0, \ t > 0$
$u = 0, \ x = 1, \ t > 0$

Initial Condition:

$$\left.\begin{aligned} u &= 2x, \quad 0 \le x \le 1/2 \\ &= 2(1-x), \quad 1/2 \le x \le 1 \end{aligned}\right\} t = 0$$

The solution $u(x,t)$ is

$$\frac{8}{\pi^2}\sum_{k=1}^{\infty}\left(\sin\frac{k\pi}{2}\right)\left(\sin k\pi x\right)\frac{e^{-k^2\pi^2 t}}{k^2}$$

An approximation is

$$\frac{u_i^{n+1} - u_i^n}{\Delta t} = \frac{u_{i-1}^n - 2u_i^n + u_{i+1}^n}{(\Delta x)^2}$$

Rearranging yields

$$u_i^{n+1} = \gamma u_{i-1}^n + (1 - 2\gamma) u_i^n + \gamma u_{i+1}^n$$

where

$$\gamma = \Delta t / (\Delta x)^2$$

“Stability analysis is the technique that I used to invent my nine differential equations and nine difference algorithms.” Philip Emeagwali

IMPLICIT APPROXIMATION

$$\Delta_t u = \gamma \Delta^2 u^n$$

where

$$\Delta_t u \equiv u_i^{n+1} - u_i^n$$

$$\Delta^2 u \equiv u_{i-1} - 2u_i + u_{i+1}$$

$$\gamma = \Delta t / (\Delta x)^2$$

Rearranging yields

$$-\gamma u_{i-1}^{n+1} + 2(1+\gamma) u_i^{n+1} - \gamma u_{i+1}^{n+1} = \gamma u_{i-1}^{n} + 2(1-\gamma) u_i^{n} + \gamma u_{i+1}^{n}$$

Yielding global equations

$$\tilde{\tilde{A}} \tilde{u} = \tilde{d}$$

$$\tilde{\tilde{A}} = \begin{bmatrix} b_1 & -c_1 & & & & \\ -a_2 & b_2 & -c_2 & & & \\ & -a_3 & b_3 & -c_3 & & \\ & & \cdot & \cdot & \cdot & \\ & & & \cdot & \cdot & \cdot \\ & & & & -a_{N-1} & b_{N-1} \end{bmatrix}$$

$$\tilde{u} = \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ \vdots \\ u_{N-1} \end{bmatrix} \qquad \tilde{d} = \begin{bmatrix} d_1 \\ d_2 \\ \vdots \\ \vdots \\ d_{N-1} \end{bmatrix}$$

$$a_i = c_i = \gamma, \quad b_i = 2(1+\gamma), \quad i = 1, 2, 3, \ldots, N-1$$

Thomas algorithm is most efficient method for solving the above tridiagonal equations

STABILITY OF IMPLICIT APPROXIMATION

$$\begin{bmatrix} 2(1+\gamma) & -\gamma & & & \\ -\gamma & 2(1+\gamma) & -\gamma & & \\ & \cdot & \cdot & \cdot & \\ & & \cdot & \cdot & \cdot \\ & & & -\gamma & 2(1+\gamma) \end{bmatrix} \begin{bmatrix} u_1^{n+1} \\ u_2^{n+1} \\ \vdots \\ u_{N-1}^{n+1} \end{bmatrix} =$$

$$\begin{bmatrix} 2(1-\gamma) & \gamma & & & \\ \gamma & 2(1-\gamma) & \gamma & & \\ & \cdot & \cdot & \cdot & \\ & & \cdot & \cdot & \cdot \\ & & & \gamma & 2(1-\gamma) \end{bmatrix} \begin{bmatrix} u_1^{n} \\ u_2^{n} \\ \vdots \\ u_{N-1}^{n} \end{bmatrix}$$

Reduces to

$$\left(2\tilde{\tilde{I}} - \gamma\tilde{\tilde{B}}\right)\tilde{u}^{n+1} = \left(2\tilde{\tilde{I}} + \gamma\tilde{\tilde{B}}\right)\tilde{u}^{n}$$

where

$\tilde{\tilde{B}}$ is tridiagonal matrix with "-2" on diagonals and "1" at other entries.

$\gamma > 0 \Rightarrow |2\tilde{\tilde{I}} - \gamma\tilde{\tilde{B}}| \neq 0, \Rightarrow (2\tilde{\tilde{I}} - \gamma\tilde{\tilde{B}})$ is nonsingular. $\therefore$ inverse $\exists$

$$u^{n+1} = \left(2\tilde{\tilde{I}} - \gamma\tilde{\tilde{B}}\right)^{-1}\left(2\tilde{\tilde{I}} + \gamma\tilde{\tilde{B}}\right)\tilde{u}^{n}$$

$$u^{n+1} = \tilde{\tilde{A}}\tilde{u}^{n}$$

$$\tilde{\tilde{A}} = \left(2\tilde{\tilde{I}} - \gamma\tilde{\tilde{B}}\right)^{-1}\left(2\tilde{\tilde{I}} + \gamma\tilde{\tilde{B}}\right) = f(\tilde{\tilde{B}})$$

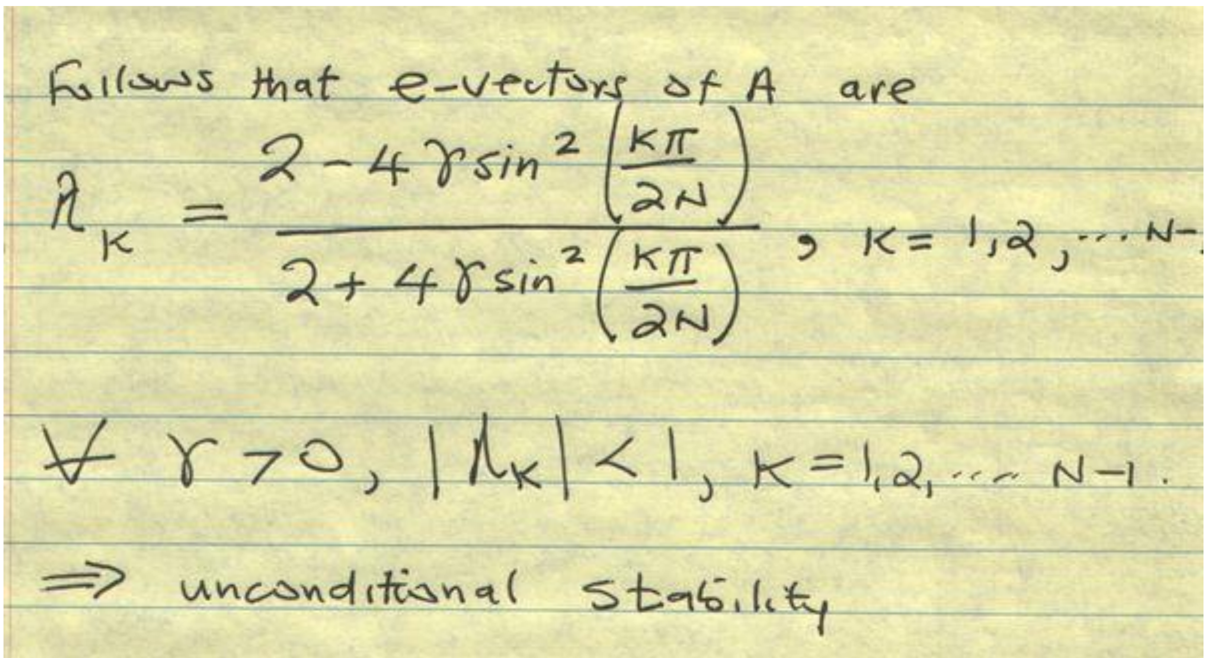
Eigenvalues of $\tilde{\tilde{B}}$:

$$-4\sin^2\frac{K\pi}{2N}, \quad K = 1, 2, \ldots, N-1$$

Eigen vectors of $\tilde{\tilde{B}}$:

$$\tilde{V}_K = \left(\sin\frac{K\pi}{N}, \sin 2\frac{K\pi}{N}, \ldots, \sin\frac{(N-1)K\pi}{N}\right)$$

Emeagwali pointed out that four forces exist inside every petroleum reservoir; he discovered that the Exxon Mobil equation had summed only three forces. Emeagwali correctly summed all four forces, namely: pressure, viscosity, gravity, and inertia.



Follows that e-vectors of A are

$$\lambda_K = \frac{2 - 4\gamma \sin^2\left(\frac{K\pi}{2N}\right)}{2 + 4\gamma \sin^2\left(\frac{K\pi}{2N}\right)}, \quad K = 1, 2, \ldots N-1$$

$$\forall\ \gamma > 0, \ |\lambda_K| < 1, \ K = 1, 2, \ldots N-1.$$

$\Rightarrow$ unconditional stability

Philip Emeagwali's research notes on a typical day at the Library of Congress in Washington, D.C. in 1983. He performed such mathematical analyses almost daily during the 1980s. (Handwriting of Philip Emeagwali)

Date: 10/13/2007, 4:19 pm, GMT +6

Name: Clinton Anokam <208.78.62.81>

Location: Nigeria,kaduna

Number: 215

With your achievement on Earth and of importance to Humanity .What have been your challenges

---

Date: 10/10/2007, 3:28 pm, GMT +6

Name: Philip NG. Ifechukwude <88.202.35.150>

Location: Ibusa, Nigeria

Number: 214

Philip Emegwalim is one of the best thing to happen to Nigeria of this generation.

Date: 10/10/2007, 3:20 am, GMT +6

Name:	Henry Omoregie <196.3.61.4>
Location:	Port Harcourt
Number:	213

OUR DEAR PHILLIP,
IT IS WITH PROUD TAPS ON MY KEYBOARD THAT I MAKE THESE ASSERTIONS: THAT NIGERIA, NAY AFRICA OWES YOU APLENTY FOR YOUR SINGULAR, MILLENIAL ACHIEVEMENTS. YOU DID NOT CARVE A NICHE FOR JUST NIGERIA BUT THE ENTIRE THIRD WORLD. THE ALMIGHTY HAS GIVEN YOU THE TALENT TO ENHANCE THE ENDEAVORS OF MANKIND

Date:	10/9/2007, 12:44 am, GMT +6
Name:	Hon. Kelechi Ansel-Oliaku <91.152.183.208>
Location:	Finland
Number:	212

Dearest Prof. You are in no doubt one of the worlds prominent inventors,innovator,accomplisher and to say the least, a moving scientific encyclopadia. You have however carved a place for yourself in the anals of world history,but remember to whom much is given much is expected, whether you like it or not,you owe it as a duty to the society that gave you life to create more Emeagwalis.My brother,for a person of your calibre to remain in another mans country for more than two centuries is not a credit. Come home and help develop the Igbo land,on that posterity will write your name in gold " Obu aku lue uno,oburu ezigbo aku"

Date:	10/7/2007, 7:50 am, GMT +6
Name:	Baba Ajose <74.7.92.158>
Location:	Los Angeles, California
Number:	211

Philip,
I'm proud of you on your great achievements. However effort needs to be organized privately to share and spread these intellectual knowledge that comes easy to you. There are hundreds perhaps thousands of minds that can and should be molded toward productive activities in Nigeria and on the Continent as a whole. Keep the faith but more importantly, do something.
Regards,
Baba

Date:	10/6/2007, 8:49 pm, GMT +6
Name:	Thayi K. <87.244.157.39>
Location:	Douala, Cameroon
Number:	210

Cher aîné,
Votre cheminement émet de longues ondes

de réflexion à la surface de la conscience. Vos réalisations et votre façon d'être sont plus qu'un exemple pour l'homo africanus disséminé à travers différentes régions du globe terrestre.
Merci d'avoir fait progresser l'humanité par le biais de la science. Merci de redonner espoir ...

Emeagwali, you are more than wonderful and your name is a blessing.
May Chineke, the Gods and our great Ancestors continue to bless you !

Thanks.

Date:	10/4/2007, 4:19 pm, GMT +6
Name:	Sheyin RBG <62.56.224.242>
Location:	Abuja - Nigeria
Number:	209

YOU ARE GREAT!!!!!!!!!!!! From your photo albums, I observed that you have not forgotten your root; You dress like them and identify yourself with them. I also believe that you are sponsoring Africans that will take over from you. Once again be aware that it is only through this effort that the spirit of Prof. Philip Emeagwali will not die. MAY YOUR SPIRIT LIVE FOREVER.

Date:	9/25/2007, 6:14 pm, GMT +6
Name:	Jean <71.242.163.236>
Location:	phila.
Number:	208

once again a very profound

African it is proof Africa

has a Stellar History

Date:	9/22/2007, 5:08 pm, GMT +6
Name:	notonlybridges.blogspot.com <83.165.3.50>
Location:	Spain
Number:	207

The entire story of your life and achievements is inspirational. Your role as a science and technology promoter in developing countries is even more motivating. Regards and good luck.

Date:	9/18/2007, 8:35 pm, GMT +6
Name:	alatta kingsley .o <208.78.59.42>
Location:	abuja
Number:	206

may you keep up inspiring the youth of our generation.nigerian's in particular.God blees you sir,
we will surely get there some day

Date:	9/17/2007, 4:23 pm, GMT +6
Name:	Martin Udogie <80.89.176.36>
Location:	Lagos
Number:	205

Dear Philip Emeagwali,

As a parent, a publisher, and an inspiration speaker, I have followed your progress and have even used one or two of your materials in my presentations.

But I have a short question. We all have your father to thank for his foresight in getting you to solve 100 mathematical questions everyday. As a father yourself, are you applying your father's strategy to your son? Why or why not?

Date:	9/10/2007, 8:33 pm, GMT +6
Name:	uche uzo <172.189.246.43>
Location:	uk
Number:	204

I shudder to think how many brains, destinies, inventions, ideas etc like Emeagwali"s that have been lost because of lack of funds to pursue education. FREE EDUCATION AS A RIGHT AT

ALL LEVELS MUST BE SERIOUSLY CANVASSED. Can you pause and think what the world would have lost if Emeagwali had ended up at alaba because of funds.

Date: 9/8/2007, 1:15 am, GMT +6

Name: Ajibola Oluwaseyi <82.206.131.126>

Location: Lagos state University

Number: 203

i saw this article about a great man & it suddenly occurred to me that civilization actually started for africa and it really sparked a hope in me that africa is destined for GREATNESS

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