An interview with
EUGENE ISAACSON:

Conducted by Philip Davis
On
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at the Courant Institute in New York

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ABSTRACT:
Eugene Isaacson spent his entire educational life in New York City: he attended public schools in Brooklyn (where had an outstanding high school math teacher, Edna Kramer), did his undergraduate studies at City College and his graduate work at NYU. In 1949 he completed his doctoral dissertation on the motion of water waves over a sloped beach, which grew out of the interest of J. J. Stoker, Kurt Friedrichs, Fritz John, and Hans Lewy in wave motions and was supported by the Office of Naval Research. His first computing experience came on one of the early UNIVAC I machines purchased by the Atomic Energy Commission (AEC); he preceded John Wheeler (and later Edward Teller) as the project chief for this machine. During World War II Isaacson worked on the Mathematical Tables Project and joined the Courant Institute in 1944, where he spent the rest of his career. Despite an initial interest in point-set topology, Isaacson became interested in and did his most productive work in applied mathematics. He led a team to help the Harvard computing laboratory discover the computational needs for scientific work while it was developing (along with IBM) the Mark 1 computer. Isaacson is perhaps best known to many for the textbook he coauthored with Herb Keller, *Analysis of Numerical Methods*, and for his time as editor of *Mathematics of Computation* and the *SIAM Journal of Numerical Analysis*. He has collaborated with a variety of scholars including Gideon Zwas, Eli Turkel, Zipora Alterman, David Houghton, and Akira Kasahara.

DAVIS
This is an interview with Professor Eugene Isaacson held on September 10, 2003, in his office at the Courant Institute in Washington Square, New York. The interviewer is DAVIS. I would like to start with just a little bit of background information. I don't really know too much about your early career. Are you a native of New York?

ISAACSON
Yes, I was born in Brooklyn.

DAVIS
Born in Brooklyn. New York schools all the way through?

ISAACSON
Yes. City College. And then NYU for a Masters, and then for a Ph.D.

DAVIS
I see. So you went to grammar school and high school in Brooklyn?

ISAACSON
Public School 56, and 150. And then Lew Wallace Junior High School. Those are in Brownsville.

DAVIS
Do you have any recollection of your first awareness of being good at math? How old were when you felt that you were good in math, particularly good?

ISAACSON
I knew that I could solve certain problems that were numerical-math-type problems when I was on the order of eleven or twelve years old. The first mathematics teacher I had was in junior high. I had no problems, until one day I missed the explanation of how you solve two simultaneous linear equations and two unknowns. I came, perplexed, to talk to my uncle who lived next door to us, in an apartment house in Brooklyn. He had graduated from high school years ago, but he remembered how to do the solution. And so from that point on I had no further cause to bother him about mathematics.

DAVIS
So you were a mathematician essentially from the age of ten.

ISAACSON
On that order of magnitude, yes.

DAVIS
How old were you when you realized that you wanted to become a professional, when the opportunities to become a professional arose?

ISAACSON
The opportunity never sank in quite realistically until I started to go to college. I thought that I would be a high school teacher, perhaps, and in mathematics. I had a very good math teacher in high school, Edna Kramer.

DAVIS
Oh, Edna Kramer, she wrote some popular, average-man-on-the-street books, didn't she?

ISAACSON
I haven't looked at any of her books.[1] But she tried to help [Richard] Courant in the writing of *What Is Mathematics*, which he did with Herb Robbins. But Courant rejected all of her efforts. I understood that she had prepared lots of pages of material for possible inclusion in the book, but apparently Courant – or Courant and Robbins – didn't care for that. I met her again at a seminar at NYU when I was a graduate student here. I was quite surprised to see her at that time. She conducted a test at the end of my high school studies in which she tried to decide who should get the math prize. And I was lucky – I outlasted the other contenders.

DAVIS
Did you major in math as an undergraduate?

ISAACSON
Yes.

DAVIS
Let me just go back, momentarily, to a bit of gossip with respect to the Courant and Robbins book. I understand that Robbins was quite touchy about this, the collaboration.

ISAACSON
I wasn't aware of any conflicts that they had until years later when I was told about it. But I didn't see any conflict; I thought that they got along very well. Robbins came to NYU during my Masters degree period and I believe that he left before I came back. I got my Masters degree in 1941 and I returned to Courant in January of 1944.

DAVIS
Were you in the [military] service?

ISAACSON
No, no. I was 4F. And I worked in my father's small decorating store even though I was colorblind, red-green colorblind.

DAVIS
Your Ph.D. thesis was already in applied math?

[1] Kramer is the author of several mathematics books, including *The Nature and Growth of Modern Mathematics* and *The Main Stream of Mathematics*.

ISAACSON
Yes. It had to do with water waves – waves over a sloping beach. [James Johnson] Stoker, [Kurt] Friedrichs, Fritz John, and Hans Lewy were interested at that time in understanding how wave motions could be studied mathematically. Actually, Stoker wrote a book on water waves.[2] In one of the sections, you'll see that by taking aerial photographs of waves caused by a ship that was traveling at presumably escape speed – trying to escape surveillance or tracking and making circular turns – you could deduce what the speed of the ship was from the aerial photograph. So that turned out to be important. Another thing that you learned from the waves approaching the beach was what the slope of the beach was under the water, in case you wanted to land troops there.

DAVIS
So this was information, mathematical theory in the service of defense and offense, wouldn't you say?

ISAACSON
Yes. It was supported by the Office of Naval Research.

DAVIS
I see. Under whom did you do your thesis?

ISAACSON
I did the thesis under Friedrichs, technically, but the problem that he suggested I work on didn't get me anyplace. The problems that were being solved by the people whose names I mentioned before, in particular Hans Lewy, appealed to me more as something that I could do. So I extended a work of Lewy, who had solved a problem of the motion of waves on a sloping beach when the angle was a rational multiple of pi, beach slope, and I did it for all slopes. In the process, I confirmed Lewy's conjecture that by proving that there was such a solution and that it is was continuous, you would then have another proof of the Gauss Quadratic Reciprocity rule. [laughter] Lewy was the one who spotted that –

DAVIS
What a connection.

ISAACSON
Yes.

DAVIS
What year did you get your Ph.D.?

ISAACSON
I got the Ph.D. in 1949.

[2] J. J. Stoker, *Water Waves: The Mathematical Theory with Applications*, 1957, Interscience Publishers, New York.

DAVIS
Just putting in my own experience with Ph.D.s, I also had that experience. I started off with one professor and it didn't work out, and I switched to another professor and it worked out perfectly, and so on. So this is not an unusual situation, I would guess.

ISAACSON
No. Friedrichs actually tested me on the validity of what I had produced. I produced a formula and showed him how I'd done it. Actually, at one point I had found the formula that involved the absolute value of an analytic function, and I said, "How can you from that find the representation" –

DAVIS
Of the function, of the whole function –

ISAACSON
Right. He said just take the logarithm –

DAVIS
And you got the imaginary part –

ISAACSON
That gave me the idea for completing the solution.

DAVIS
Did your thesis involve computation?

ISAACSON
No, there were no computations.

DAVIS
So it was quite theoretical.

ISAACSON
Yes.

DAVIS
Now you were a graduate student at NYU in the period when there were a number of great mathematicians, applied and so on: Courant and Friedrichs and Lewy and Stoker and Fritz John and so on –

ISAACSON
Fritz John came a little later.

DAVIS
With whom did you interact most, let's say, as a graduate student?

ISAACSON
My closest connection was with Stoker, because Friedrichs was a very well organized person and I never had any trouble getting to see him, but you had to make an appointment. Whereas with Stoker, I was able to catch him as I spotted him in the hall or passing his room. We had adjoining offices at one time. So that was why I had more contact with Stoker, who was the guy who kept everyone interested in the water waves while he was interested in water waves.

DAVIS
How about your interaction with Courant?

ISAACSON
At one point in 1949-1950 area –

DAVIS
This was postdoctoral?

ISAACSON
Yes, postdoctoral.

DAVIS
Mina [Dr. Mina Rees] was at City College wasn't she?

ISAACSON
No, at that time she was in the Office of Naval Research. She was in charge of the mathematics branch.

DAVIS
She gave out the grants and so on –

ISAACSON
Right. But she took a sabbatical, a six-month sabbatical, and came to the Courant Institute. Courant thought that I should speak with her, and perhaps we could work on some problem having to do with hyperbolic PDEs [partial differential equations], the initial value problem for linear hyperbolic PDEs. By that time, I had experience with numerical methods, and I had an idea of how to possibly pursue that problem. By writing the equations in characteristic form, you could then derive finite difference formulas that permitted you to use a technique to show that the errors were bounded in a certain way as you proceeded in solving the equation in time steps and as you decreased the mesh widths you could prove convergence of the solution.

DAVIS
There was a famous paper by Courant, Lewy, and Friedrichs in the late –

ISAACSON
In 1928.

DAVIS
Nineteen twenty-eight, was it? It was very influential and had to do with the ratio of space-steps to time-steps and so on. I think it's now called the Courant number –

ISAACSON
Oh yes. The ratio of the time-step to the space-step –

DAVIS
The ratio time-step to the space-step, yes. So it was in your postdoctoral days that you got interested in computation and numerical methods. What computer were you working with in those days?

ISAACSON
Well, we started in 1952 with the first computer put out by Remington Rand at that time. They had just bought the company that made the first large-scale commercial computer (whose name I don't recall at the moment), and we got model four in the production line. We had just gotten the contract to operate it as a northeastern computing facility of the Atomic Energy Commission.[3] At one time John Wheeler –

DAVIS
Physicist from Princeton?

ISAACSON
John Wheeler, the physicist from Princeton, guided the priorities of problem sets that could be put on the machine at NYU. He did it for maybe six months to a year, and then Edward Teller took over –

DAVIS
The famous atomic physicist at Los Alamos who died a couple of days ago.

ISAACSON
For the first five months I was the acting chief for that project. I hired all of our former – not all, but many of our former – graduate students and our current graduate students back as programmers. First of all to learn what programming was –

DAVIS
It was quite different in those days.

ISAACSON
Yes. So Herb Keller was one of those people –

DAVIS

[3] Remington Rand bought the Eckert-Mauchly Computer Corp. in 1950. It delivered the first UNIVAC I computer in 1951. The Atomic Energy commission purchased the fourth and fifth UNIVAC computers.

Coming back to this great array of stars, Courant, Friedrichs, and so on. New York University, in an ironic, tragic way, was a beneficiary of Hitler. Can you say something about that?

ISAACSON
Yes. Well, Courant, Lewy, Friedrichs, and Fritz John were from Germany and were forced out by the Nazi occupation there. Courant came in the 1940s – I'm sorry, he actually came in the late 1930s – and I attended some of his lectures while I was an undergraduate at City College. I was a senior at City College –

DAVIS
You came down to NYU?

GENE ISSACSON
A friend of mine had gone to NYU and found that Courant was there. He told me about it, so I dropped in on some of his lectures on complex variable theory. That was in 1938-1939. I graduated in 1939 from City [College], and then for the following two years, until 1941, I attended NYU full-time. From 1941 to the end of 1943, I worked in my father's business, and I got an opportunity to get back into some mathematical endeavor by joining what was left of the Mathematical Tables Project.

DAVIS
Were Milton Abramowitz and Arnold Lowan [involved]?

GENE ISSACSON
Abramowitz had already left. Lowan was the director of a small group, on the order of twenty-some-odd people. Gertrude Blanch was the head operator of that facility. And there was Abraham Hillman.

DAVIS
This group ultimately moved to the Bureau of Standards in Washington, where I was employed, and they were already in place and I knew these people –

GENE ISSACSON
I think that we were employed through the Bureau of Standards even at that time.

DAVIS
They did this very influential set of tables that were used all throughout World War II. I have the impression, perhaps you can confirm it, that, prior to World War II, or America's entry into World War II in 1941, there were relatively few opportunities for a young person to go into mathematics as a profession and to get a job after graduating, but World War II changed all that dramatically. Can you say anything about that?

GENE ISSACSON
I know that there were possibilities to get fellowships to study mathematics on the graduate level, but they were not easy to come by and it never occurred to me to apply for

them. It was only after I was working at the residue of the mathematical tables project that I again contacted NYU and Charlie DePrima, who was a graduate student or a postdoc at that time,(who) told me that there were probably positions available. So I contacted Courant during December of 1943. After speaking to me on two, possibly three, visits – where I was sort of dangling, I didn't know what was going on – he said that I should come to work, and so I started January 1, 1944.

DAVIS
You've been at NYU since 1944?

ISAACSON
Yes, I was on a leave of absence once for a year at City College.

DAVIS
Was there a relationship between your Ph.D. work and your subsequent interest in applied maths or computation?

GENE ISSSACSON
I think I was always interested in applied mathematics and computing. The experience at the math tables project reinforced that interest in me. As you know, in those days we had these mechanical devices that were called "computing machines" and –

DAVIS
A "computer" was frequently a woman (working on these mechanical devices).

GENE ISSACSON
Right. At any rate, they had Marchant, Monroe, and Friden mechanical computing devices.[4]

DAVIS
That lasted all the way until 1953, as a matter of fact, when the first generation of digital computers came in. So, actually, you went from your interest in waves, and so on, and this spread out in some way. Would you say that your interest in computation became more intense as time went on?

GENE ISSACSON
I think so; there is no question about it. My masters thesis at NYU arose from some honors work I had done at City College in point-set topology. I had studied [Waclaw] Sierpinski's book and was interested in the structures that he described there.[5] I had a math professor at City College, Shelby Robinson, who had an interest in topology. I asked him a question and he spoke to Leo Zippin, who at that time was a topologist at Queens College –

[4]See: www.hpmuseum.org/prehp.htm
[5] Waclaw Sierpinski, *Introduction to General Topology*, 1934, translated by C. Cecilia Krieger, University of Toronto Press, Toronto.

DAVIS
Right, Zippin. Zippin was a topologist who had a finger in the solution in one the Hilbert problems, I think.[6]

GENE ISSACSON
I'm not sure of that aspect, and I've forgotten completely what the mathematics was that I was doing then. At any rate, it was the experience of the concrete handling of numbers to find solutions to problems that struck me as being quite interesting. That's how my interest changed from the abstract mathematics of point-set topology to applied mathematics. It occurred over a period of years at NYU. I became interested in water waves, and later on in meteorology, applications of mathematics in meteorological problems.

DAVIS
What are some of the areas of applied and computational mathematics that you've been involved in over the years? You've just named a few, but could you just expand on that a bit?

ISAACSON
An interesting experience occurred when the Harvard computing laboratory, which had just built the mechanical computer Mark 1 with IBM's support, was interested in finding out what features of computing are important for scientific computation. They asked us to try to solve some problem on their computer. If we formulated the problem and explained what method should be used, they would provide the personnel who knew how to program that Mark I, and would operate it and, presumably, would determine what fraction of time is devoted to memory transfers and multiplication, divisions, and so on, and decide how to try to design the next computer to make is more efficient.

DAVIS
This was early work, you might say, in complexity theory. Did you intersect Grace Hopper at all in that experience at Harvard?

GENE ISSACSON
I don't think I so.

DAVIS
That wasAiken, Howard Aiken?

ISAACSON
Yes, Howard Aiken, A-I-K-E-N.

DAVIS
Right. You didn't know Grace at that time?

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[6] Zippin's book with Deane Montgomery, *Topological Transformation Groups*, did help to provide a solution to the fifth of Hilbert's twenty-three problems, concerning Lie's concept of a continuous group of transformations without the assumption of the differentiability of the functions defining the group.

GENE ISSACSON
I may have met her, but I never really spoke with her at any great length that I can recall.

DAVIS
At a later point in your career, you wrote a very influential book on numerical methods. Can you say a few words about how that arose?

ISAACSON
I had given a course for introduction to mathematics, or something like that, and over the years the mimeographed notes were written up by one of our students (I think the name was [Lester] Rubenfeld). One of the sales people who was looking for manuscripts for a competitor of Wiley, I forget the name at the moment, suggested that I write a book about it. Some years after that, Herb and I decided that we would really do it. He also had notes. His were more numerical than mine were.

DAVIS
Which Herb are we talking about?

ISAACSON
Herb Keller.

DAVIS
Herb Keller. There are a lot of Herbs in our business. There's Herb Greenberg, wasn't he here?

ISAACSON
Yes.

DAVIS
Herb Greenberg, and Herb who wrote the book with Courant, the statistician. One has to keep these Herbs apart. [laughter]

ISAACSON
Anyway, we finally put out the book, many years after we started on it.[7] When Wiley decided that it wasn't worthwhile hanging on to it – that it required some revision for them to continue it – they did not offer to us the option to take it over into a paperback, which they were just doing with some other books that they had discontinued. Herb and I thought we ought to really get it out to the public in an inexpensive format and Herb was in favor of getting Dover to publish it. I was reluctant to cut off the relationship with Wiley, but the editor at that time must have had many other things on her mind because she didn't respond in a reasonable timeframe and so we decided to go with Dover.

DAVIS

[7] EuISAACSON and Herb Bishop Keller, *Analysis of Numerical Methods*, 1966, Wiley, New York.

I know that we're on tape now. I think I know who you mean, the editor at Wiley, do you remember her name?

ISAACSON
No.

DAVIS
Anyway, let her remain anonymous. But I'll tell you that Mrs. Anonymous gave me some problems also with one of the books that I did with Wiley. End of that; that's a piece of gossip. Anyway, this book that you did on numerical methods must have been of great satisfaction to you.

ISAACSON
Yes, we were very happy with it. And it was so in demand that the offer from Wiley seemed so – [tape glitch]

DAVIS
We're okay now, so let's proceed with our interview. If you have the time I would like to continue a bit, is that okay?

ISAACSON
Sure.

DAVIS
Very good. We were talking about the textbook – it's essentially a textbook, isn't it? – that you wrote. It must have been used in many places as a textbook in numerical analysis; it was very influential. But coming back to your research work, I know this is going to be a tricky question, and maybe a little embarrassing, but what do you consider your main contribution in the research line and in computation?

ISAACSON
I don't think that I've had the good fortune to be able to invent new things and stimulating ideas in that regard. I've worked on the fringes of the research in numerical methods and in certain problems that struck me from time to time. I've been mostly an editor over the years and –

DAVIS
Of a technical journal?

ISAACSON
Yes. I edited *Mathematics of Computation* for nine years, and I did at least six, I think, for the *SIAM Journal of Numerical Analysis*. That work was probably one of my main contributions. The solution of the hyperbolic system that I told you about earlier, with Courant and Mina Rees, may have had something to do with the upwind differencing method that people tried out for fluid dynamics problems. I studied a problem for Stoker's sixtieth birthday edition of the Courant journal, *Communications on Pure and*

Applied Mathematics, in which I analyzed how a balloon that was rotationally symmetric about some axis would behave as you blew it up. It was a balloon of a rubber-like material that was supposed to be incompressible, and I proved that with that limitation, the limiting state would be a sphere, which is a perfectly natural idea and can be rather easily demonstrated.

DAVIS
So this was a theoretical result.

ISAACSON
Yes.

DAVIS
Do you ever meet or have any interaction with Professor [John Lighton] Synge? Was he ever a guest at the Courant Institute?

ISAACSON
He probably was, but I don't recall. With Stoker, I worked on the problem of water flowing down a river and a river system, and we published a paper that appeared in an engineering journal, an IEEE publication. At that time it was a great help to the engineers who were concerned with constructing dams, how to operate them, and what could be done mathematically to predict the behavior of floods and rivers and connecting river systems. Years later, I was invited to attend a meeting at North Carolina State University having to do with this subject. I didn't realize that the engineers were really working on these methods and using what I thought were now old-fashioned techniques.

DAVIS
Did you ever have this experience with respect to numerical methods: that you had a problem and you set up a numerical strategy and went on the computer, and it didn't prove out? It turned out not to be a good strategy. Because such an experience is also valuable, and it says stay away from this kind of thing. Has this ever happened to you?

ISAACSON
Yes. It's more frequent than success is –

DAVIS
Yes, but that's the point of what is called numerical experimentation. You have collaborated with a number of people over the years. Is collaboration an easy thing with you or difficult? Can you say some word about it?

ISAACSON
I've been very lucky. I worked at one time with Gideon Zwas, the late Gideon Zwas, who was a very easy person to work with.

DAVIS
I don't know that name, how is it spelled?

ISAACSON
Z-W-A-S. He was at Tel Aviv University. And I collaborated with Eli Turkel, also from Israel now.

DAVIS
Any relation to the famous Studs Turkel?

ISAACSON
No, not as far as I know. [Laughter] I also collaborated with Zipora Alterman on some river-flow-type problems. I collaborated with David Houghton and Akira Kasahara.

DAVIS
Not Cathleen [Morawetz]? Did you work with Cathleen?

ISAACSON
I don't think that I ever published anything with her, but I certainly had contact with her. She was instrumental in getting the book, the Courant-Friedrichs book on shock waves and fluid flows. She sort of kept them on track. And at one point I did some calculations on water waves that may appear in that book, and if it doesn't then it appears in other work that Stoker wrote.

DAVIS
For the sake of the transcription of the tape we've been talking about Professor Cathleen Morawetz, Cathleen Synge Morawetz. S-Y-N-G-E.

ISAACSON
Is that the person you asked me about before? He came to NYU at one time –

DAVIS
Yes. That's her father.

ISAACSON
I also had the experience of meeting him at the International Conference in Stockholm. We went on a cruise, as did many of the participants, and there I had a chance to speak to him more closely.

DAVIS
Of course, he was a great authority on mechanics. I shared an office with him briefly at the National Bureau of Standards in Washington, for maybe a couple of months. I was a young kid and he was the great authority and professor and so on. He told me lots of stories about his uncle, the playwright.[8] Have you…let me put it this way, one is doing research in mathematics and one sometimes has a goal in mind and sometimes one doesn't have a goal in mind, and one wants to work freely somehow and let ideas come

[8] John Milllington Synge.

how they may. Have you ever introspected about how, in your experience, new ideas occur to you?

ISAACSON
The most intensive period of research that I did was on my doctoral thesis and there I really concentrated to the exclusion of anything else for at least three or four months. I never had that experience again.

DAVIS
Really! Was it a sense of discovery or grinding out something or what was the feeling of this intense engagement?

ISAACSON
Well, after Friedrichs said, "If you have the absolute value, just take the logarithm and then you have the analytic function, because that's the real part of the analytic function."

DAVIS
The imaginary part –

ISAACSON
That just blew it away. I now had the solution; I knew everything that I needed to write down the solution.

DAVIS
So it was an experience in which you discovered the correct tool, as it were.

ISAACSON
Right. And it was so trivial, you know. It's not any great thing to –

DAVIS
But still, triviality is often the clue to a good idea. How, in your career, did the balance between teaching and research work out?

ISAACSON
I enjoy teaching, but I don't think that I'm a very good teacher. I'm much better on one-to-one interaction, talking to people about mathematical problems. The reason I say that it is that I've seen the comments of students in general classes. I generally got better remarks from students in more advanced courses.

DAVIS
Here you taught across the board, all kinds of courses in your day?

ISAACSON
Yes. Usually we taught one undergraduate and one graduate course. For the last few years of my teaching I taught this least advanced course that would qualify for the math

requirements for the degree. Although I tried hard to find interesting things to talk about, they were interesting to me more so than to the students, generally speaking.

DAVIS
So would you say that you found more pleasure in the advanced courses than in the elementary courses?

ISAACSON
Yes.

DAVIS
And the things that were of more interest to you, then, assumes they were in advanced courses?

ISAACSON
Yes.

DAVIS
So would you say that the impact of the teaching experience on the research experience was rather minimal?

ISAACSON
That's right. There was very little –

DAVIS
That's interesting because some people say the other way around you know.

ISAACSON
Well, if you're teaching things at the forefront of knowledge, then of course that would be the ideal situation. But I never found myself in that position. The closest I came to it was when I was teaching the numerical methods course, but by that time the luminaries like Peter Lax, Heinz Kreiss, and Gil Strang had already put their mark on the subject.

DAVIS
Well, I have about exhausted the topics that I wanted to bring up with you. I wondered whether you have anything else that you would like to tape?

ISAACSON
No, I think that I've given you a smattering of an idea of my background and my joys. I have two sons who are mathematicians, my wife was a math major, and my mother was very good at arithmetic.