An interview with
JOHN BUTCHER

Conducted by Philip Davis
On
20 August, 2003,
at the
Department of Applied Mathematics, Brown University

Interview conducted by the Society for Industrial and Applied Mathematics, as part of grant # DE-FG02-01ER25547 awarded by the US Department of Energy.

Transcript and original tapes donated to the Computer History Museum by the Society for Industrial and Applied Mathematics

ABSTRACT

John Butcher discusses his schooling in New Zealand, first exposure to computers in Australia, and his contributions to numerical analysis. After suffering poor (and sometimes violent) math teachers in high school and failing to receive admittance to Cambridge for graduate school, Butcher accepted a research studentship at the University of Sydney, which was completing a copy of the ILLIAC computer, and received his Ph.D. in physics. While completing his dissertation on cosmic ray physics, he was one of the first people to run a program on a computer in Australia using a paper-tape (pre-punch-card) system, and he initially took up numerical analysis as a hobby. Butcher argues that, just as classical diatonic music still dominates music, established mathematical tools continue to be more popular than newly developed methods for most problems. He eschews theory for its own sake, pursuing instead problems with applicability or inherent interest, although he believes that matching theoretical tools to real-world phenomena is a job best left to scientists. The tools Butcher developed to represent computationally significant quantities are nearly identical to those of Hopf algebras commonly used by physicists today. He notes that although some great thinkers can break the rules successfully, too many scientists think they are “masters.” Given the rapid and unexpected evolution of computing and numerical analysis since World War II, Butcher dares not speculate about its future.

DAVIS: This is an interview with Professor John Butcher of the University of Auckland in New Zealand. The interview is taped in the Department of Applied Mathematics on August 20, 2003, on the occasion of a conference supported by the Air Force Office of Scientific Research – supported in part by them – on ODEs [Ordinary Differential Equations] and PDEs [Partial Differential Equations], at which Professor Butcher gave one of the principal talks. The interviewer is Phil Davis of the Department of Applied Mathematics at Brown.
Let's do just a little bit of background. You are a New Zealander by birth?

BUTCHER: Yes, I'm a New Zealander by birth.

DAVIS: How old were you when you first realized that you had an interest in mathematics and an unusual talent in mathematics?

BUTCHER: Well, I first realized interest as a very small child, but, as for talent, I'm not so sure about that.

DAVIS: Well that's a piece of modesty –

BUTCHER: I didn't really…in an objective sense I have to admit I seemed to have talent, but I didn't really know it at first.

DAVIS: Well, I suppose so, but you probably at an early age liked the material?

BUTCHER: Oh yes, oh yes –

DAVIS: Would this be in the elementary school already?

BUTCHER: I think I was successful in that sense.

DAVIS: Did it depend in any way on intelligent teachers?

BUTCHER: No, no, not in the least. Certainly not.

DAVIS: Or members of the family or something like that?

BUTCHER: No, I was the only member of my family at that time to have a tertiary education. As for the teachers, they were terrible, actually.

DAVIS: Really? They didn't know any math?

BUTCHER: Well, that's certainly true, as a matter of fact. It was just after the war that I was in high school, and there were no…I went to school in country towns mainly. Even when I went to a city school the quality of teacher was terrible. So can I give you an example of –

DAVIS: Yes, please.

BUTCHER: – of how geometry was taught at my high school. This is 100 percent true. If Dickens had written this, *Nicholas Nickleby* would not be published; it would be too extreme. The geometry class starts with the teacher coming into the room and saying to us all, "Write out the theorem." It's based upon the theorem, you see. People would…everyone would write it out on paper verbatim. He collects them all. And we're doing some trivial task, just to keep us at our books. He looks through thirty or forty of these boys' attempts to prove the theorem by Pythagoras, or whatever it is. And he looks through them all and puts them in two piles, and gets his cane out and canes half the class.

DAVIS: Canes half the class?

BUTCHER: Yeah, they just have to bend over and get their behind hit twice. That was essentially the end of the class. Then he gave a number of the next theorem to learn for the next geometry class. Now I don't think that's good teaching; not even in 1949 that wasn't good teaching, let alone today.

DAVIS: Is it legal still?

BUTCHER: Not now.

DAVIS: Caning isn't legal.

BUTCHER: It's illegal now, but it wasn't then.

DAVIS: Well, I remember a definition of geometry that comes from years and years ago in my part of the world: geometry is a subject where you draw a line down the page and on the one side you put something and on the other side you put the reason. What was important, you see, was that you drew the line. If you didn't draw the line –

BUTCHER: That line was not part of our protocol, but remembering the theorem (as in a Euclid-type book) was crucial, unless you wanted to go away painful.

DAVIS: Where were you an undergraduate?

BUTCHER: Auckland – well, it's what's now the University of Auckland. In those days, it was a single university system, like the California system, a university with several colleges.

DAVIS: And you read maths there?

BUTCHER: Oh yes.

DAVIS: And this is where you got a higher degree also.

BUTCHER: No, no it isn't, there was no opportunity for that there.

DAVIS: Where did you get a higher degree?

BUTCHER: Well…my situation was a bit unusual, I think. I'd already set my heart on going to Cambridge University after I'd finished at Auckland, and it didn't come about. The only way it could have come about was for me to get a scholarship to go there, and I was not successful in that. So I had a brief stint as a school teacher for a while, which I wasn't very good at –

DAVIS: I take it you didn't cane the students –

BUTCHER: Well, it was the custom at the school to cane people. I tried to avoid doing it. There was an advertisement in the paper for someone to take on the role of what was called a research studentship, in Australia, at the University of Sydney. They had a new gadget there called a computer that they were just building. It was a copy of the ILIAC computer from the University of Illinois. There were no computers in New Zealand at that stage in 1956 and I didn't know what it meant, to be honest. I asked people who might have known, who didn't know, and they made up answers which were wrong. Nevertheless, I applied for this position and was successful in getting it, and I moved to Australia for several years –

DAVIS: This was at the University of Sydney?

BUTCHER: Yes, the University of Sydney.

DAVIS: And not the University of New South Wales?

BUTCHER: It did not exist then. Well, it came into existence when I was there as a matter of fact.

DAVIS: Was [Thomas M.] Cherry on the –

BUTCHER: Cherry was, he was a big shot in Australian mathematics –

DAVIS: Yes I know –

BUTCHER: He was president of the Australian Mathematical Society. At that stage, I never got to know him personally, until he retired, as a matter of fact. I met him many years later in Seattle. I think he lived in Seattle after he retired, and we were on good terms for a while, but when I was just a young man I didn't dare speak to such a great person as that.

DAVIS: I met Cherry once. He came to an International Congress of Mathematicians in 1950 that was held in Cambridge, Massachusetts. Cherry was there and I was introduced to him. I was in the same position as you were; actually, I had my degree already at that time. Were there any other notable teachers at the University of Sydney? Was this in maths?

BUTCHER: Not it was not, it was in physics –

DAVIS: You were in physics?

BUTCHER: In those days in New Zealand, you did master's degrees just by examination. I'd done master's degree in Auckland as well as my bachelor's degree, and that made me formally qualified to do a Ph.D. in Australia. With that, there were no courses, just simply research, and I learned some aspects of this part physics I was working on, cosmic ray physics –

DAVIS: Well you had a supervisor –

BUTCHER: My supervisor was a person who was famous in Australia. His name was Harry Messel, a former wartime Canadian paratrooper and a student of Erwin Schrodinger. He was quite a well-known person in nuclear physics. But the man who knew about numerical and other things was a man called Bennett, John Bennett. He was, in some sense, associated with some of the pioneering work in computing. He became the first professor of computer science in Australia.

DAVIS: That's a name that I vaguely remember. So your thesis –

BUTCHER: Was supervised by Bennett and Messel, actually, but it was in cosmic ray physics, computation aspects. They had this computer that came into action early on when I was there. I was one of the first people to run a program in Australia.

DAVIS: This was still with punch cards?

BUTCHER: Not punch cards; we used paper tape. You typed programs on through teletype, or some equipment like that –

DAVIS: Programming more or less in machine language –

BUTCHER: Oh yes, certainly, everything in machine language. Assemblers were in the future. There was a clever, clever piece of code, which occupied twenty-five words of memory, which enabled you to write statements with decimal addresses. So two base-sixteen characters represented the command and the address in the computer ran from zero to one thousand and twenty-three – but you could write that in decimal if you wanted to because it converted automatically.

DAVIS: You weren't programming in fixed point?

BUTCHER: Yes, fixed point. There was some software for doing floating point, but it had a very slow interpreter. So we did our code almost completely in fixed point.

DAVIS: My first programming experiences, on one of the very first machines called the SEAC, and the programming was called a four-address system. Take something from Cell A, combine it with Cell B, operate on it, put it in Cell C, and then go to Cell D for your next instruction.

BUTCHER: Was this a disc machine?

DAVIS: I don't know the interior of the thing, but I don't think so.

BUTCHER: This machine I used was a one-address system, you did the statements in sequence, then you jump somewhere else.

DAVIS: Was that work on your thesis your first serious meeting with computation?

BUTCHER: With [machine] computation, yes. It was not my first publication. I had a paper in statistics, which I wrote as an undergraduate. It must have been the summer I was working in what was the called the Applied Mathematics Laboratory in New Zealand. It was mainly statistical work. And I had a paper in a journal called *Biometrika*, when I was quite young.

DAVIS: Statistics in biological –

BUTCHER: Yes, biological applications. My only other publications were in physics journals, in *Physical Review* and *Il Nuovo Cimento* and *Nuclear Physics*.

DAVIS: I take it that gradually you moved away from physics.

BUTCHER: Well, I took up numerical analysis as a hobby, really. I didn't actually enjoy the physics, to be really honest; that wasn't really what I was meant to be doing.

DAVIS: In those years, were there courses in numerical analysis?

BUTCHER: No, I've never taken a course in numerical analysis in my life.

DAVIS: But you've given them.

BUTCHER: Oh, yes, certainly.

DAVIS: So, in the mid-1950s it was a rare place that had a course in numerical analysis?

BUTCHER: Well, this man Bennett that I mentioned, he had studied numerical analysis – had been a research assistant – in England as part of the…there's a group of people there at the Mathematics Laboratory.

DAVIS: In Oxford?

BUTCHER: Cambridge. Who I think were pioneering, in some sense – Maurice V. Wilkes, would be one of the people, for example.[1] He's a pioneer in numerical methods, making machines; the design side and computational. I think Bennett was part of that group of people.

DAVIS: So after a few years you were firmly in numerical analysis?

BUTCHER: Yes, that's right. It really came to me, to my working on my own for several years until my first paper appeared.

DAVIS: One of the things that strikes me is that the numerical analysts seem to be divided into two classes. The first class are those that concentrate very heavily on theoretic material, and the other class are those who concentrate on algorithmic material, and then of course there are people who are in between in all proportions. I suppose, to some extent, one has to be in both, know both of these things. But there are definitely people that are in algorithmics and rather less…where do you place yourself on this?

BUTCHER: Well, algorithmics has a variety of meanings –

DAVIS: What I mean is writing –

BUTCHER: Writing codes –

DAVIS: Writing good codes.

BUTCHER: Yes, I don't really do that very much. I have attempted to participate in that work from time to time, but it's not my particular talent, I don't think.

DAVIS: When I was interviewing Lawrence Shampine the other day, you've met him –

BUTCHER: Yes, of course, I know him quite well.

DAVIS: He says he's definitely in algorithmics.

BUTCHER: I know that – I would say that, yes. I think some of his early work was on the more theoretical side, but it's undoubtedly on the algorithmic side now, as you've defined it.

DAVIS: One of the things that I used say to my students when I was teaching numerical analysis is that I thought that, in a certain sense, the best numerical analysis was not in textbooks but it was built into code. I don't know if you'd go along with that or not.

BUTCHER: Well, I think there's some good numerical analysis built into code and there's good numerical analysis built into the documentation of code. [Davis laughs.] It's like saying that good music is not in harmony textbooks but it's in the symphonies of

[1] The University of Cambridge Mathematical Laboratory was later renamed the Computing Laboratory.

Beethoven. But for the ordinary person, they can't read the score and get as much out of it as they can by listening to a performance, that's what I meant by documentation, as compared with the code itself.

DAVIS: Then of course comes along Schoenberg and Stravinsky and they say forget the harmony –

BUTCHER: But people don't forget the harmony –

BUTCHER: Musicologists at various times have said that classical music is finished; there isn't any more need for diatonic harmony and so on. They're wrong. The fads of the Schoenberg type come along and they go – and they can influence music, of course – but music derived essentially along the path that traditional classical music has followed, that it the sort of main path, and is today, in spite of Schoenberg and possibly even Stravinsky.

DAVIS: To you, classical music is not dead; it's alive and well?

BUTCHER: I don't simply mean classical music per se, I mean the type of attitude to music that we regard as classical music. That is to say, based on classical harmony, but developed and modernized, in some sense. The same thing for computational mathematics. I think that some people would get the idea that this is the way things should be done now. Old ideas of doing linear algebra are out of date because this new algorithm solves these problems better. Here's a new way of doing certain differential equations, here's a new way of doing that… They have a following of some sort, just like Schoenberg had a following. But the mainstream, I think, is still flowing, with modifications. People learn from enthusiastic new ideas but they don't necessarily get overwhelmed by them.

DAVIS: Have you ever introspected as to how your ideas that you consider as original ideas emerged?

BUTCHER: Well, it's hard to know what an original idea really is because…

DAVIS: Some sort of an advance.

BUTCHER: The things that I believe that I've contributed to are based on what I've felt has been a need to understand how to do certain things better, how to analyze things in a more precise way and more practical way. I think I'm motivated by what I think good outcomes are, not by theory for its own sake.

DAVIS: So there's an interplay between the theory and the computational experience?

BUTCHER: Partly computational experience, but also my view of what interesting computational experience might be.

DAVIS: Computational experience can suggest something?

BUTCHER: Of course it can, of course it can. But I don't think I've really made many steps forward along those lines I think the –

DAVIS: Perhaps an algorithmic person –

BUTCHER: Some of the great advances in computation can be put down to observations that practitioners have made. The famous work of Charles F. Curtiss and Joseph O. Hirschfelder – the people who are supposed to have invented the idea of stiffness for differential equations. They might not have been the only people to do that, but they discovered difficulties in certain engineering calculations and they identified the nature of the difficulties. And that opened up avenues to explore in purely mathematical analysis. But I don't think I've ever done that. I don't think I've ever proposed anything – realized anything computationally – that opens up new paths.

DAVIS: One of the impressions that I have from listening to some of the talks at this conference is how ambiguous (if that's the right word) the results you get are after you have written code along a certain path, algorithm, or something. You want to know to what extent is this giving you the answers, the theoretical answers. This is combined with another question of how close are the mathematical models to what is really going on in the universe in the first place. So you have this two-way ambiguity.

BUTCHER: There's so much there. This is a basic idea in the philosophy of science isn't it, really: we think we know some scientific phenomenon to the extent that we can more-or-less know when it's going to occur and not going to occur. Moving from there into mathematics, mathematicians try to make a model of this phenomenon that lives on its own, in some sense, that people can study this model independently of the science –

DAVIS: Yes, this is really a question of philosophy and the methodology of the thing –

BUTCHER: But we can even go further than that. Once you have a mathematical model, an applied mathematical model, there might be no obvious computational counterpart to it. There's not the interface between applied mathematics in the traditional sense and computational mathematics. There's another link. To try to produce numbers from a program that is supposed to describe a mathematical model, I think that's all you can do. You can't talk about the real world because that other interface is someone else's job to look after.

DAVIS: So the way you see your work is not to go back to the real world phenomenon and see how that checks out with the answers that you're getting –

BUTCHER: I think that a possibly a good research team would contain aspects of the modeling and some experimentation, as well as the computational side. They're all equally important: they're all important and they're all vitally important.

DAVIS: I've noticed that you've had the opportunity to go all over the world at various times and for various lengths of time, do you think that there is, as you go from country to country, a particular flavor that characterizes the mathematics in Country A versus Country B? Or do you think that it's so unified –

BUTCHER: Mathematics is unified of course, but there are styles of the way mathematics is understood and taught and developed that vary from country to country.

DAVIS: You've noticed this –

BUTCHER: Oh yeah, well, I think so –

DAVIS: Have you taught in other countries?

BUTCHER: No…well…not taught in a very serious sense. I've just given seminars, series of seminars, and so on.

DAVIS: Have you collaborated with people from Europe?

BUTCHER: Well, the main person I tend to work with now is from Europe but he lives in the USA, he's from Poland, [Zdzislaw] Jackiewicz. He and I have had a long-standing collaboration. He's at this conference now.

DAVIS: Yes. I think that the interest in training of the mathematicians in Slavic countries – in Poland, Russia, and so – is rather different –

BUTCHER: I think it is, it is, from the Anglo-Saxon countries, English-speaking countries, for example.

DAVIS: Yes, rather different, I think they are rather less abstract.

BUTCHER: The abstract would be in France, and to some extent Germany.

DAVIS: The United States was quite abstract in pure math.

BUTCHER: Pure maths. But there's now a definite strength in applied mathematics, which is not always abstract. I think there's a range of attitudes within applied mathematics, a range of styles.

DAVIS: Are there any countries that you've been in where you can characterize, for the purposes of this interview, how they differ?

BUTCHER: Well, I can see particular characterizations coming out, but they're all related to individual people who have contributed in those counties.

DAVIS: Not to the general math culture?

BUTCHER: I wouldn't know about that very much. I know that the enormous strength in Scandinavian countries in numerical analysis probably comes from the heritage of

[Germund] Dahlquist, and other people, and so on. I think that the present generation of Swedish numerical analysts, the great people in this area, have all got some connection to Dahlquist, I think.

DAVIS: I wonder where Dahlquist got it from?

BUTCHER: I don't know.

DAVIS: I have to ask [Bertil] Gustafsson, perhaps he knows.

BUTCHER: Gustafsson would possibly…he might know that, actually. He would know that.

DAVIS: I think Dahlquist is still around. I should go over and interview him.

BUTCHER: Well, it would be wonderful. You should do that, if you can do that, but go in the summer –

DAVIS: Go in the summer, not in the winter? He's where in Stockholm?

BUTCHER: Stockholm. Stockholm can be a little bitter in the winter.

DAVIS: Well, they've had a terrible summer in Europe, I mean I've been reading in the papers about France and Germany, even the UK.

BUTCHER: Well, I don't think the summers in Stockholm reach the great heights.

DAVIS: Right. As you look back over the things that you've done over the years, what would you think are your main contributions to numerical analysis? Your favorite things, put it that way.

BUTCHER: Well, some of the things that I feel I've made other people aware of would be the use of graph structures to represent computationally significant quantities, the modern name for it is Hopf algebras. But I was –

DAVIS: Hopf algebra?

BUTCHER: Hopf algebras, I think. Hopf.

DAVIS: Can you say just a little bit about this?

BUTCHER: I know nothing about Hopf algebras, but I've been told that they've been discovered quite recently as tools to study…in Feynman diagrams there's a basic difficulty of division tools and things, I don't know if you know that, but physicists have trouble, as I understand it. In the early days of this aspect of nuclear physics, I think, the Feynman approach to evaluating cross-sections for nuclear reactions or whatever it is, hinged upon a methodology that wasn't mathematically sound. I think that they had to do sort of a tricky way out of it, what is called renormalization. These are things I don't really understand, but these are the words they use, which is some way of forcing –

DAVIS: Forcing convergence?

BUTCHER: Forcing convergence, something like that. Maybe in things that I know, that you and I both know more about, like divergent series, something like that, we have to do something to make sure things diverge in a way you can control and look at the difference of things, maybe. Some mathematicians have recently discovered that – a famous mathematician called Connes, who is a Fields Medalist, actually, Alain Connes, and a German mathematician called [Dirk] Kreimer – they invented an algebraic system for studying these things; apparently they're called Hopf algebras. Someone else since then discovered that the tools they are using are the same as the tools I invented in numerical analysis thirty years ago. So this is a coincidence, in some sense, so that I have an undeserved, minor sort of fame.

DAVIS: Well, you must feel good about that.

BUTCHER: I do, really. When I first did this it was very hard to get it accepted or published or anything. People have said today: "Why wasn't this published in a place that mathematicians would be more aware of it?" It wasn't my fault. I tried to get it published, and I did, of course, but after difficulty.

DAVIS: Would this be parallel to the invention of distributions to explain the Dirac function, which was illegal, you know, at one point?

BUTCHER: I understand. I don't know how theoretical physicists do their job, exactly. They have different rules of encounter than mathematicians do.

DAVIS: They certainly do, different standards.

BUTCHER: There's sort of arcane game we play in New Zealand, England, and other places, called cricket, which you've probably heard of, you probably even know roughly how it's played.

DAVIS: I know there's a bat.

BUTCHER: There's a bat and a ball, and so on, but what I'm talking about is a certain personality. There's a famous cricketer named [Donald] Bradman, he's the most famous Australian, as a matter of fact –

DAVIS: This was years ago isn't it?

BUTCHER: Years ago. He died about ten years ago, or so. At one of my high schools, the teacher was supposed to be teaching science, but he preferred to talk about sport because this was something that would keep the attention of the boys a bit better, probably even girls' a bit better. He was talking about the way that in cricket you must keep the bat straight up and down, and keep your left elbow forward, and the various dsciplined ways of hitting, and you must never do a shot like, like a baseball shot, I suppose, across the...you should not do that in cricket because…and it was explained in some sense. One of the boys put up his hand and said, “But sir, Bradman plays that shot.” The teacher said, “Yes, but Bradman was a master.” Now there are some people who think they are masters and they think they can take short cuts.

DAVIS: The masters can get away with it.

BUTCHER: Yes, that’s right. Look, there are ways of driving a car which are dangerous but Stirling Moss could do it and get away with it, to some extent. And there are scientists who, in some sense, are masters: they have some sort of insight that goes beyond mathematics.

DAVIS: Well, yes, going back two hundred years, [Leonhard] Euler was a master. He was able to squeeze stuff out that was thought illegal.

BUTCHER: Yeah, I think so. And, of course, [Oliver] Heaviside and people like that, they were masters, and [Richard] Feynman, I’m sure was a master. I mean great scientists. I’ve worked with scientists, who are not great, necessarily, (less great, at least) and some of them do things which are silly, you know, absurd things. They use formulas in a situation where they weren’t meant to be used, just because they want any formula that will do. That doesn’t necessarily lead to success, but great scientists can often do things because they’re masters and they know something which is not in the textbooks of mathematics. Not yet, maybe never will be. You can’t tell the difference between a master and a non-master except by their successes. Sometimes they’re right; master gamblers, you know, sometimes they’re lucky. But I think it’s more than that. I think there are some scientists who really think deeply about scientific matters beyond what mathematicians are able to describe precisely. The tools are not there yet like, as you mentioned, distribution theory. Why did I mention that, now?

DAVIS: Well, we came to the…what was it, the Hopf algebras?

BUTCHER: Hopf algebras, that’s right. But my use of what apparently was Hopf algebras was purely for an application in numerical analysis. This application is partly intuitive but actually, it is also quite practical.

DAVIS: Changing the subject just a bit, there are now a number of packages – like *Mathematica*, and so on – for doing formal algebra on the computer. Do you find them useful in your work?

BUTCHER: Of course, they’re tools. They’re useful tools, and I use tools when I can, just like I use pocket calculator when I have to. But they’re nothing else but tools.

DAVIS: But you do find them useful?

BUTCHER: Yes, yes. They don't replace thinking. They just replace trivial manipulations.

DAVIS: I notice a number of formulas in various talks that seem to have been derived by one of these packages. In the old days you would never go up to up to, I don't know, an order of four –

BUTCHER: Oh, I see.

DAVIS: – the accompanying algebra is just too formidable.

BUTCHER: Well, there are some people who like doing long, complicated manipulations; they just seem to enjoy it.

DAVIS: This is part of their psychology?

BUTCHER: Oh, I think so. There's a Slovak mathematician, who's now dead, who studied the Runge-Kutta methods. He was the first person to find a sixth-order method, matter of fact.

DAVIS: Work it out?

BUTCHER: Yes, but he didn't…I never met him but I corresponded with him a little bit, and he tried to calculate the formulas for the successive derivatives of a differential equation solution, and at the same time the explanations for what the Taylor expansions of the Runge-Kutta calculation, and compare them as a means of finding the conditions for order six. It was all done by hand computations, and some of the formulas are two or three pages long.

DAVIS: Do you know whether this stuff has been built into code?

BUTCHER: His sixth-order methods I don't think are used because they're not as efficient as other sixth-order methods. He assumed there to be eight stages of calculation but there are only seven needed, for example.

DAVIS: What is the trade off, in your experience, between teaching and research in the university?

BUTCHER: I think they live off each other to some extent. Of course, teaching at various levels – I mean, teaching a research student is different from teaching undergraduates – but the whole bundle of teaching activities, I think they are things that one gains with experience. The formal sort of teaching in which you can be judged by the quality of your demeanor when you're speaking and the timbres of your voice and the accuracy of your writing on the blackboard and the avoidance of trivial mistakes and finishing on time and so on, I never acquired those skills, and I never will. But I've built on the strengths that I think I have.

DAVIS: I notice that you list yourself as an honorary research professor. Does this mean that you don't do any teaching?

BUTCHER: No, it means I've retired. It really means I don't get paid very much.

DAVIS: Oh, you've retired. You're like myself.

BUTCHER: Yes, I think so –

DAVIS: One of the club.

BUTCHER: One of the club. But I do have a part time position at a lower absolute pay rate than a professor.

DAVIS: Well, my situation is that the University gives me this office and gives me the computer and hasn't kicked me out yet. This has been very good for me.

BUTCHER: This is what they should do and they won't do quite the same for me because there's…well, I had an office, a wonderful office like this at one time, not to much bother about windows but plenty of bookshelves and room, but I've had to downsize and I'm now in quite a small room and I have to give books away. I've gone through several different rounds of giving things away to libraries, and other places, and to individuals.

DAVIS: But it's very good; you're very active in research.

BUTCHER: Well, I think a person should be active in research, if that's what they've got a talent for.

DAVIS: I think it keeps you young.

BUTCHER: It keeps you young, I think it's true, matter of fact, but not just for one's personal well being. I couldn't say I've got any wisdom, but I've got more than I used to have, you understand what I mean? I think people who have had a lifetime of experience are a resource that one doesn't throw away lightly. There are stupid, crazy people who never learn much, but have strong opinions, you know; it's not as important that they simply be given a permanent role in a university. But I think if someone really has contributed to research and one has learnt some way of teaching that suits many students, they should be valued. As you are, and I hope I am.

DAVIS: Suppose a young person came to you and said, "I think I'd like to do a higher degree in numerical analysis," what math background should such a person have? Or what general background?

BUTCHER: Well, people have come to me with those very words, paraphrased of course, and I don't talk too much about the details of their background because, really, in our university there would never be anybody with exactly an ideal background. But there are people who I think are suitable for doing it, in terms of their intellect and their commitment to mathematics and, of course, obviously, a good technical training but not necessarily in specific areas.

DAVIS: In other words you wouldn't want to say you must come in with linear algebra and you must come in with complex variables, you must come in with abstract algebra, whatever?

BUTCHER: I've never had the luxury of being able to impose such requirements. Nevertheless, some of my students have been successful. I measure success in terms of them becoming part of the scientific community in their own right, and producing good ideas, partly with me and partly independently of me.

DAVIS: Anticipating future developments in numerical analysis, I know this is difficult, but do you see any stone walls against which one can't get through?

BUTCHER: You mean intrinsically?

DAVIS: Intrinsically. If there's a mathematical model, and we have some equations and so on, and everything is feasible, numerically speaking –

BUTCHER: I'm not sure that I have ever been involved with such stone walls. I know some walls, but they're not so much stone, they're vertical walls. For example, there are various barriers, complexity barriers, things in ordinary differential equations that you cannot do because there are theorems saying you cannot correctly do some of these things, but the right question to ask is not how to get through the wall, but to get around the wall.

DAVIS: In certain areas of these models there are no existence theorems known.

BUTCHER: Oh, you're talking about the –

DAVIS: That's another aspect –

BUTCHER: Oh, I see. I wasn't think of that –

DAVIS: That's another aspect, but one goes ahead anyway –

[End of Tape 1 Side A] [Start of Tape 1 Side B]

BUTCHER: Well, when the tape ended I was saying it's known that there cannot be a fifth-order, five-stage Runge-Kutta method. That's a known fact, and one can say therefore one should not even explore such a question. But another way of looking at it is to say, "let us invent a new type of numerical method which is very much like the Runge-Kutta method, has the same properties of it in many ways, the same performance, the same cost, as much as possible like it, but is not the Runge-Kutta, and achieves the same sort of performance that this nonexistent method would have had had it existed." Does that make sense? This is a kind of a – not a wall which you go through, it's a wall you go around. Then you've got the other side of it: you have something which is – it might not be what would be futile to look for, but it's something which is just as good, and in some sense possibly more interesting. Does that make sense?

DAVIS: What you're saying certainly makes sense. What I had in mind was something a little more abstract, almost in the sense of Gödel's theorem.

BUTCHER: Okay, I see, I understand. The completeness of mathematics or something like that.

DAVIS: Yes, something like that. You cannot do this computation. Now of course this is a very negative thing, and the assumption of all the numerical analysts is that simply given a mathematical model and you can get the computational solution which is true to the model. Otherwise we're out of business.

BUTCHER: I can't think of anything that really is close to this Gödel-type result. There is predicting the future, in the sense of following the evolution of a physical model, to some extent, that's of limited value. You really can't do it very far into the future, because the result is too sensitive of initial conditions and so on – masses of planets, and, I don't know, gravitational constants, all these things, they are things that are more perturbational and are bound to have a big effect in the end –

DAVIS: This is the butterfly effect?

BUTCHER: Butterfly effect, that sort of question. So what does that mean to us? It means we really can't do things that are unreasonable. We can nevertheless predict the future, a little bit in the future; we can work out where the planets are going to be in the next fifty thousand years, but not the next million years, maybe. And we can predict the weather tomorrow, to some extent, but we can't predict it in six months.

DAVIS: Even next week, I think, is a bit conjectural.

BUTCHER: Well, I put those bounds well apart, because it's not what I know about. But I think…well, I think we do computation for practical reasons, we solve problems that are reasonable to solve.

DAVIS: Well, ultimately that's what buying our bread and butter. We're not doing it **ultimately** for just the aesthetics of the situation. Well, when I look back over the years and think that my first computational experience, of a real sort, was: I just had my undergraduate degree, this was during the war, World War II, and I was stationed at Langley Field in what is now NASA, but in those days they hadn't invented space, it was all aeronautics, and we were computing with slide rules and some electric machines for multiplying and dividing, and also planimeters –

BUTCHER: What's a planimeter?

DAVIS: You don't know what a planimeter is?

BUTCHER: No, I don't.

DAVIS: A planimeter is a device which will, if you draw on a graph and trace the curve, it will give you the area under the curve –

BUTCHER: Analog –

DAVIS: Yeah, analog device –

BUTCHER: A lot like a differential analyzer.

DAVIS: Yeah, well, this is truly mechanical –

BUTCHER: Yes, yes –

DAVIS: That's interesting. And a better and more costly one, would give you two things: it would give you the area and it would also give you the first root, and these things are… My observation in those days was this is all silly, you could do this just by a formula, you know, something like that. When I think of problems that I had to deal with, it had to do with stability of airplanes, and how difficult it was, how difficult it was to get eigenvalues. I mean, it took, you know, several days to get the eigevalues of a three-by-three matrix, and so on. It takes a microsecond now –

BUTCHER: I think I could do that quicker than three days, a three-by-three matrix. Five by five, I couldn't –

DAVIS: Working with slide rules and so on…Anyway, the question – this is purely trying to be prophetic here – whether the next fifty years in numerical analysis is going to see the same sort of –

BUTCHER: Make computers look obsolete.

DAVIS: Yeah, make computers look obsolete; maybe we'll have quantum computers or something.

BUTCHER: Well, I don't understand quantum computers. I know people believe in them to some extent – in some sense believe in them – but I don't know anything about them. There are certainly advances in computers all the time: computers two years ago are obsolete and they're quaint. As for the computers in the days when you first used them, and even when I first used them, they seem strange now; they're historical –

DAVIS: They put them in museums.

BUTCHER: They put them in museums.

DAVIS: Well, I think that winds up our interview and I would like to thank you very much for the opportunity to talk these things over with you.

BUTCHER: Well, thank you for the opportunity.