 

Professor Thomas J. R. Hughes

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Professor of Aerospace Engineering and Engineering Mechanics
Computational and Applied Mathematics Chair III
The University of Texas at Austin
Institute for Computational Engineering and Sciences

Degrees

Dr. Hughes holds B.E. and M.E. degrees in Mechanical Engineering from Pratt Institute and an M.S. in Mathematics and Ph.D. in Engineering Science from the University of California at Berkeley.

Experience

Dr. Hughes began his career as a mechanical design engineer at Grumman Aerospace, subsequently joining General Dynamics as a research and development engineer. After receiving his Ph.D., he joined the Berkeley faculty, eventually moving to California Institute of Technology and then Stanford University before joining the

University of Texas at Austin. At Stanford, he served as Chairman of the Division of Applied Mechanics, Chairman of the Department of Mechanical Engineering, and Chairman of the Division of Mechanics and Computation, and occupied the Mary and Gordon Crary Chair of Engineering.

Research Interests

Computational mechanics.
Isogeometric analysis: Integration of computer aided design and finite element analysis.
Variational multiscale methods for complex fluid flows and turbulence.
Patient-specific cardiovascular modeling and simulation technologies.
Phase-field methods.

Awards and Honors

Dr. Hughes is a fellow of the American Academy of Mechanics (AAM), the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Civil Engineers (ASCE), the American Society of Mechanical Engineers (ASME), the U.S. Association for Computational Mechanics (USACM), the International Association for Computational Mechanics (IACM), the Society of Industrial and Applied Mathematics (SIAM), and the American Association for the Advancement of Science (AAAS).

He is co-editor of the international journal Computer Methods in Applied Mechanics and Engineering, a founder and past President of USACM and IACM, past Chairman of the Applied Mechanics Division of ASME, and Chairman of the U.S. National Committee on Theoretical and Applied Mechanics (USNC/TAM).

He has been awarded the Walter L. Huber Civil Engineering Research Prize and the von Karman Medal from ASCE, the Melville, Worcester Reed Warner, and Timoshenko Medals from ASME, the Computational Mechanics Award from the Japan Society of Mechanical Engineers, the von Neumann Medal from USACM, the Gauss-Newton Medal from IACM, the Grand Prize from the Japan Society of Computational Engineering and Science (JSCES), and the Humboldt Research Award for Senior Scientists from the Alexander von Humboldt Foundation.

He has received honorary doctorates from the Universite catholique de Louvain, the University of Pavia, the University of Padua, the Norwegian University of Science and Technology (Trondheim), and Northwestern University (Evanston). He held the Cattedra Galileiana (Galileo Galilei Chair), Scuola Normale Superiore, Pisa, in 1999, and the Eshbach Professorship, Northwestern University, in 2000.

Dr. Hughes is a member of the U.S. National Academy of Sciences, the U.S. National Academy of Engineering, the American Academy of Arts and Sciences, the Istituto Lombardo Accademia di Scienze e Lettere (Mathematics Section), the Austrian Academy of Sciences (Section for Mathemematics and the Physical Sciences), and the Academy of Medicine, Engineering and Science of Texas.

The Special Achievement Award for Young Investigators in Applied Mechanics is an award given annually by the Applied Mechanics Division of ASME. In 2008 this award was renamed the Thomas J.R. Hughes Young Investigator Award.
Latest ICES Research Reports

Since April 2004, all preprints authored or co-authored by Dr. Hughes have appeared as ICES Research Reports in downloadable pdf format. Go to http://www.ices.utexas.edu/research/reports/ and search each year by entering "Hughes".

Citations

Dr. Hughes was identified by ISI as among the 15 most highly cited authors in Scientific Computing and the original 100 most highly cited authors in Engineering (all fields). Citation data can be found in ISI Web of Science, Google Scholar, and Publish or Perish under "Hughes TJR". Access to ISI Web of Science is restricted to licensees, but is available through most major research libraries. The web address for Google Scholar is http://scholar.google.com/scholar?q=hughes+tjr&hl=en&lr=&btnG=Search. The Publish or Perish application can be downloaded from Harzing.com http://www.harzing.com/pop.htm. According to Publish or Perish, as of September 1, 2010, Dr. Hughes's total number of citations is 34,408 and his h-index is 80 (but who's counting?).

Recent Archival Journal Publications (since 2005)

"Mixed Discontinuous Galerkin Methods for Darcy Flow," (with F. Brezzi, L. D. Martini and A. Masud), SIAM Journal of Scientific Computing, Vol. 22, No. 1, pp. 119-145, 2005.

"Conservation Properties for the Galerkin and Stabilized Forms of the Advection Diffusion and Incompressible Navier-Stokes Equations," (with G. N. Wells), Computer Methods in Applied Mechanics and Engineering, Vol. 194, pp. 1141-1159, 2005.

"Isogeometric Analysis: CAD, Finite Elements, NURBS, Exact Geometry and Mesh Refinement," (with J.A. Cottrell and Y. Bazilevs), Computer Methods in Applied Mechanics and Engineering, Vol. 194, Nos. 39-41, pp. 4135-4195, 2005.

"A Stabilized Mixed Discontinuous Galerkin Method for Darcy Flow," (with A. Masud and J. Wan), Computer Methods in Applied Mechanics and Engineering, Vol. 195, Nos. 25-28, pp. 3347-3381, 2006.

"A Multiscale Discontinuous Galerkin Method with the Computational Structure of the Continuous Galerkin Method," (with G. Scovazzi, P. Bochev and A. Buffa), Computer Methods in Applied Mechanics and Engineering, Vol. 195, Nos. 19-22, pp. 2761-2787, 2006.

"A Coupled Momentum Method for Modeling Blood Flow in Three-dimensional Deformable Arteries," (with A. Figueroa, I. Vignon-Clementel, K.E. Jansen and C.A. Taylor), Computer Methods in Applied Mechanics and Engineering, Vol. 195, Nos. 41-43, pp. 5685-5706, 2006.

"Isogeometric Analysis of Structural Vibrations," (with Y. Bazilevs, J.A. Cottrell and A. Reali), Computer Methods in Applied Mechanics and Engineering, Vol. 195, Nos. 41-43, pp. 5257-5296, 2006.

"Isogeometric Fluid-structure Interaction Analysis with Applications to Arterial Blood Flow," (with Y. Bazilevs, V.M. Calo and Y. Zhang), Computational Mechanics, Vol. 38, Nos. 4-5, pp. 310-322, September 2006.

“Isogeometic analysis: approximation, stability and error estimates for h-refined meshes,” (with Y. Bazilevs, L. Beirao de Veiga, J.A. Cottrell, and G. Sangalli), Mathematical Models and Methods in Applied Sciences (M3AS), Vol. 16, No. 7, pp. 1031-1090, July 2006.

“Analysis of a Multiscale Discontinuous Galerkin Method for Convection Diffusion Problems,” (with A. Buffa and G. Sangalli), SIAM Journal of Numerical Analysis, Vol. 44, No. 4, pp. 1420-1440, 2006.

“Weak Imposition of Dirichlet Boundary Conditions in Fluid Mechanics,” (with Y. Bazilevs), Journal of Computers and Fluids, Vol. 36, No. 1, pp. 12-26, 2007.

“Variational Multiscale Analysis: the Fine-scale Green's Function, Projection, Optimization, Localization, and Stabilized Methods,” (with G. Sangalli), SIAM Journal of Numerical Analysis, Vol. 45, No. 2, pp. 539-557, 2007.

“Stabilized shock hydrodynamics: I. A Lagragian method,” (with G. Scovazzi, M.A. Christon, and J.N. Shadid), Computer Methods in Applied Mechanics and Engineering, Vol. 196, Nos. 4-6, pp. 923-966, 2007.

“Patient-Specific Vascular NURBS Modeling for Isogeometric Analysis of Blood Flow,” (with Y.Zhang, Y. Bazilevs, S. Goswami, and C.L. Bajaj), Computer Methods in Applied Mechanics and Engineering, Vol. 196, Nos. 29-30, pp. 2943-2959, 2007.

“YZß discontinuity-capturing for advection-dominated processes in arterial drug delivery,” (with Y.Bazilevs, V.M. Calo, T.E. Tezduyar), International Journal for Numerical Methods in Fluids, 54, pp. 593-608, 2007.

Studies of refinement and continuity in isogeometric structural analysis,” (with J.A. Cottrell and A. Reali), Computer Methods in Applied Mechanics and Engineering, Vol. 196, Nos. 41-44, pp. 4160-4183, 2007.

“Weak Dirichlet boundary conditions for wall-bounded turbulent flows,” (with Y. Bazilevs, C. Michler, V.M. Calo), Computer Methods in Applied Mechanics and Engineering, Vol. 196, 4853-4862, 2007.

“Variational multiscale residual-based turbulence modeling for large eddy simulation of incompressible flows,” (with Y. Bazilevs, V.M, Calo, J.A. Cottrell, A. Reali, and G. Scovazzi), Computer Methods in Applied Mechanics and Engineering, Vol. 197, 173-201, 2007.

“The role of continuity in residual-based variational multiscale modeling of turbulence,” (with I. Akkerman, Y. Bazilevs, V.M. Calo, and S. Hulshoff), Computational Mechanics, Vol. 41, 371-378, 2008.

“B-bar and F-bar Projection Methods for Nearly Incompressible Linear and Nonlinear Elasticity and Plasticity using Higher-order NURBS Elements,” (with T. Elguedj, Y. Bazilevs, and V. Calo), Computer Methods in Applied Mechanics and Engineering, Vol. 197, 2732-2762, 2008.

“Isogeometric Analysis of the Cahn-Hilliard phase-field model,” (with H. Gomez, V.M. Calo and Y. Bazilevs), Computer Methods in Applied Mechanics and Engineering, Vol. 197, 4333-4352, 2008.

“NURBS-based Isogeometric Analysis for the Computation of Flows about Rotating Components,” (with Y. Bazilevs), Computational Mechanics, Vol. 43, 143-150, December, 2008.

"A multiphysics model for blood flow and drug transport with application to patient-specific coronary artery flow," (with V.M. Calo, N. Brasher, and Y. Bazilevs), Computational Mechanics, Vol. 43, 161-177, December, 2008.

"Isogeometric fluid-structure interaction: Theory, algorithms and computations," (with Y. Bazilevs, V.M. Calo, and Y. Zhang), Computational Mechanics, Vol. 43, 3-37, December, 2008.

"Duality and Unified Analysis of Discrete Approximations in Structural Dynamics and Wave Propagation: Comparison of p-method Finite Elements with k-method NURBS," (with A. Reali and G. Sangalli), Computer Methods in Applied Mechanics and Engineering, Vol. 197, 4104-4124, 2008.

"N-widths, sup-infs, and optimality ratios for the k-version of the isogeometric finite element method" (with J.A. Evans, Y. Bazilevs, I. Babuska), Computer Methods in Applied Mechanics and Engineering, Vol. 198, 1726-1741, 2009.

"Isogeometric Analysis using T-Splines," (with Y. Bazilevs, V.M. Calo, J.A. Cottrell, J. Evans, S. Lipton, M.A. Scott, and T.W. Sederberg), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 229-263, 2010.

"Patient-specific isogeometric fluid-structure interaction analysis of thoracic aortic blood flow due to implantation of the Jarvik 2000 left ventricular assist device" (with Y. Bazilevs, J.R. Gohean, R.D. Moser, and Y. Zhang), Computer Methods in Applied Mechanics and Engineering, Vol. 198, 3534-3550, 2009.

"Improving stability of multiscale formulations of fluid flow at small time steps" (with M.C. Hsu, Y. Bazilevs, V.M. Calo, T.E. Tezduyar), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 828-840, 2009.

"Isogeometric variational multiscale modeling of wall-bounded turbulent flows with weakly-enforced boundary conditions on unstretched meshes", (Y. Bazilevs, C. Michler, and V.M. Calo), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 780-790, 2010.

"Stabilized methods for compressible flows," (with G. Scovazzi and T.E. Tezduyar), Journal of Scientific Computing, Vol. 43, 343-368, 2010.

"Augmented Lagrangian Method for Constraining the Shape of Velocity Profiles at Outlet Boundaries for Three-Dimensional Finite Element Simulations of Blood Flow," (with H.J. Kim, C.A. Figueroa, K.E. Jansen, and C.A. Taylor), Computer Methods in Applied Mechanics and Engineering, Vol. 198, 3551-3566, 2009.

"Efficient Quadrature for NURBS-based Isogeometric Analysis," (with A. Reali and G. Sangalli), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 301-313, 2010.

"Isogeometric Shell Analysis: The Reissner-Mindlin Shell," (with D.J. Benson, Y. Bazilevs and M.-C. Hsu), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 276-289, 2010.

“Robustness of Isogeometric Structural Discretizations Under Severe Mesh Distortion,” (with S. Lipton, J.A. Evans, Y. Bazilevs, and T. Elguedj), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 357-373, 2010.

“Enforcement of Constraints and Maximum Principles in the Variational Multiscale Method,” (with J.A. Evans and G. Sangalli), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 61-76, 2009.

“An automatic 3D mesh generation method for domains with multiple materials,” (with Y. Zhang and C.L. Bajaj), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 405-415, 2010.

“Isogeometric analysis of the isothermal Navier-Stokes-Korteweg equations,” (with H. Gomez, X. Nogueira and V.M. Calo), Computer Methods in Applied Mechanics and Engineering, Vol. 199, 1828-1840, 2010.

“Isogeometric Collocation Methods,” (with F. Auricchio, L. Beirao da Veiga, A. Reali, and G. Sangalli), Mathematical Models & Methods in Applied Sciences, accepted for publication, 2010.

“A Large Deformation, Rotation-free, Isogeometric Shell,” (with D.J. Benson, Y. Bazilevs and M.-C. Hsu), Computer Methods in Applied Mechanics and Engineering, accepted for publication, 2010.

“A generalized finite element formulation for arbitrary basis functions: From isogeometric analysis to XFEM,” (with D.J. Benson, Y. Bazilevs, E. De Luycker, M.-C. Hsu, M. Scott, and T. Belytschko), International Journal for Numerical Methods in Engineering, accepted for publication, 2010.

“Isogeometric Finite Element Data Structures based on Bezier Extraction of NURBS,” (with M.J. Borden, M.A. Scott and J.A. Evans), International Journal for Numerical Methods in Engineering, accepted for publication, 2010.

“An Isogeometric Approach to Cohesive Zone Modeling,” (with C. Verhoosel, M.A. Scott and R. de Borst), International Journal for Numerical Methods in Engineering, submitted for publication, 2010.

“An Isogeometric Analysis Approach to Gradient Damage Models,” (with C. Verhoosel, M.A. Scott and R. de Borst), International Journal for Numerical Methods in Engineering, submitted for publication, 2010.

“Contact Treatment in Isogeometric Analysis with NURBS,” (with I. Temizer and P. Wriggers), Computer Methods in Applied Mechanics and Engineering, submitted for publication, 2010.

Recent Books (since 2005)

“Isogeometric Analysis: Toward Integration of CAD and FEA" (with J.A. Cottrell and Y. Bazilevs), Wiley, Chichester, U.K., 2009.

2007 ASME Timoshenko Medal Acceptance Speech by Thomas J.R. Hughes

I would like to begin by thanking the members of the Timoshenko Medal Committee, consisting of the five members of the Applied Mechanics Division Executive Committee, Ravi-Chandar, Dan Inman, Zhigang Suo, Tayfun Tezduyar, and Ares Rosakis, the five previous chairs of the Executive Committee, Tom Farris, Wing Kam Liu, Mary Boyce, Pol Spanos, and Stelios Kyriakides, and the five previous Timoshenko Medalists, Ken Johnson, Grisha Barenblatt, Mort Gurtin, Ben Freund, and John Hutchinson. As a former member of the Executive Committee, I completed my ten-year tenure on the Timoshenko Committee the year before last, and now I will have the opportunity to return for another five years. Actually, I am looking forward to it. I enjoyed my time on the Executive and Medal Committees, and the opportunity to work with outstanding mechanicians, such as Carl Herakovich, Stan Berger, Lallit Anand, Alan Needleman, the late Dusan Krajcinovic, and many others. I also want to thank everyone in attendance here tonight.

This award is a great honor. Frankly, I am thrilled to receive it, but I am also humbled by it. The previous recipients represent a who's who of twentieth century engineering science. It is quite an incredible club to join. I promise to do my best to live up to the standard as I continue my scientific work.

Years back, it was customary in a Timoshenko lecture to cite one's contacts with Timoshenko, but that seemed to end around 1992 when Jan Achenbach mentioned in his lecture that he thought he was the first recipient of the Timosheko Medal who had never set eyes on Timoshenko. Since that time it has become customary to cite secondary contacts with Timoshenko. Here are a couple of mine: I was at Stanford for 22 years and for more than half that time I chaired the Applied Mechanics Division, which was later renamed the Division of Mechanics and Computation. This was Timoshenko's group. He chaired it for many years. I believe I am the fifth Timoshenko medalist from that group: The others were Timoshenko himself, the elastician Norman Goodier, the plastician Ras Lee and the applied mathematician Joe Keller. Ras Lee and I overlapped at Stanford for about two years prior to his taking a chair at Rensselaer Polytechnic Institute. Ras had been one of Timoshenko's PhD students and he told me Timoshenko abhorred administrative work. Those of you that know me will realize that there is at least one thing that I have in common with the great man.

Timoshenko created an endowment at Stanford with the instructions that the funds were to be used to support visitors, the teaching of the history of science, and the general advancement of engineering mechanics. The Chairman of Engineering Mechanics (the group's name in Timoshenko's time) was assigned to administer the fund. Presently, the expendable interest is a very significant amount of money. Legend has it that the funds derived from royalties of the famous black books.

Receiving the Timoshenko Medal comes with the responsibility of delivering the Timoshenko lecture. I have enjoyed listening to many Timoshenko lectures in the past and so I thought that it must be a very pleasant and rewarding experience to deliver one. That changes when the moment of truth arrives. I am apparently not the first to have felt a sense of panic when I could not think of what to say. That was evident from reading some of the previous lectures. Often, a member of the Medal Committee will offer helpful advice. It was mentioned in more than one previous lecture that John Hutchinson told the lecturer to "just keep it short." That was helpful, but I needed more help than that. Ravi-Chandar told me to "make it entertaining." Frankly, this did not help. You tell Jerry Seinfeld to make it entertaining, not me. What to do? What would Jerry Seinfeld do? Of course … he would give "the speech about nothing" and it would be the best speech ever. I soon came to realize that it is not easy to speak about nothing, although some of you may think that is what I am actually doing. So I gave up and tried to find inspiration from the past. I downloaded all the presently available Timoshenko lectures from the iMechanica website and read them. In reading them it occurred to me that I was probably the first to have done this. So I contacted Zhigang Suo and asked him if the speeches were available prior to this year and he confirmed that they were not. Very interesting. At the 50th anniversary of the initial award ceremony, I found myself in a unique situation. Ideas began to emerge. For example, I could excerpt the best from the past, “The Timoshenko Lecturers’s Greatest Hits.” There are some nuggets in those lectures, but this would lack originality and this is frowned upon in our business. Another thought occurred to me. It took me quite a long time to read the lectures and the situation will only be worse in the future. So I decided I could help out all future Timoshenko lecturers by discerning the anatomy of a Timoshenko lecture and presenting a concise guide to preparing one. It might become the Cliff Notes of the Timoshenko lectures.

I will begin with some statistics: There are presently 24 Timoshenko lectures poster on the iMechanica website. Some more will probably be found and uploaded but probably not very many. Every one since 1988 is there. The average length of the 24 lectures is approximately 2500 words. The shortest is about 1500 words and the longest about 3500 words. However, the record setters, mentioned in other lectures, are not amongst the ones available. The shortest was a simple “thank you” and the longest consisted of an autobiography that reached the age of 18 at 10:00 pm. The oldest is Maurice Biot’s 1962 lecture. It is quite different than the rest in that it is very philosophical. The style of the lectures seems to have changed quite a bit, assuming Biot’s is representative of that era. It is hard to say. It is the only one of the early lectures available.

The first three topics typically are: thanking everyone; citing some contact with, or inspiration from, Timoshenko; and musing about what to speak about. (If you go back, you will see that I followed this format.) The next topic is where the originality lies, but it seems that there are several themes that have become recurrent at one time or another, possibly because lectures were not readily available previously. One theme that was quite popular until recently was “the glorious 1960’s.” (This one seems destined to fade in popularity in the future for obvious reasons.) Common themes recently have been somewhat pessimistic, reflecting changes that have occurred in academia (e.g., overemphasis on funded research, student evaluations of teaching, etc.) and in mechanics (e.g., funding levels, perception, the name itself, etc.).

With respect to these themes, there is little to add. Everything has been said, and said very well. What I would like to do is to present some thoughts about computational mechanics.

Computational mechanics has been one of the two main growth areas in the field of mechanics for the last 50 years. I will refer to the lectures of Jim Rice and John Hutchinson who described the other. When I started my career, the field of computational mechanics did not exist. Now it is enormous, and it is still growing. I grew up with this field and perhaps I can provide a few insights about its current state.

Obviously, computational mechanics goes hand in hand with new developments in computer technology. So I would like to say a few words about what is happening now in the world of hardware and what it seems to mean for the future.

I think everyone is familiar with Moore’s Law (1965): “the number of transistors on an integrated circuit for minimum component cost doubles every 24 months.” It is not a law but it has been quite an accurate prognostication of what has happened since 1965. Transistor density is roughly proportional to processor performance. Consequently, one strategy for improving performance of a computer program has been simply to wait for the next computer. It is sometimes referred to as the “Beach Strategy.” Go to the beach and when you return, your program runs faster. This has created a generation of lazy programmers. I am here to tell you, the party may be over. Processor performance seems to have saturated about three years ago. What happened? Was it the ultimate encounter with physical limitations imposed by miniaturization that were long anticipated to terminate Moore's Law? No, it happened before those limits were encountered. It turns out that power consumption grows nonlinearly with performance, in the range of quadratic to almost cubic. Processors that consume too much power run too hot and fail because the heat cannot be removed. Heat transfer is the show-stopper, a mechanical engineering problem. However, this does not mean that performance improvements are over. There are other ways, but the most promising entail some form of "parallelism." Parallel architectures will be everywhere, even on the laptop, and the only way to take advantage of them will be through more sophisticated programming. It may be routine in the future for students to take courses in parallelization.

For quite some time parallelism has been the predominate paradigm of supercomputing. The supercomputer of today is very different than the supercomputer of twenty years ago. The Cray 2 at the time was the fastest computer in the world, and not much larger than a refrigerator. (Seymour Cray understood very early on that keeping processors cool was a fundamental problem in supercomputer design.) Today's supercomputers require their own buildings. The computer typically fills one floor and the footprint is the size of a football field, or larger. The other floors house the cooling units. There are tens to hundreds of thousands of processors, with millions on the horizon. The cost, size, and power requirements boggle the mind. One wonders how long this trend can continue, and what are the implications. It would seem that it is destined to reach a limit, but perhaps not. Experimental facilities in particle physics may suggest otherwise.

What will be the future role for computational mechanicians? In the early days, computational mechanicians programmed just about everything, namely, mesh generators, equation solvers, elements, constitutive routines, post-processors, and data managers. Lately, mesh generation, equation solving, visualization, and data management are becoming the province of computer scientists. Theoretical issues are now dealt with by computational mathematicians. However, the more physics-based technologies, and in particular, mechanics, still belong to application scientists and I believe that that will continue to be the case. The skills and knowledge of mechanicians are ideally suited for the creation of fundamentally new theories and models, and corresponding numerical formulations. There are many fruitful application areas, such as, materials, nanotechnology, biology, medicine, multiscale and multiphysics problems, and the integration of disparate areas of engineering, such as design and analysis.

To know a field, you need to know its people. I do not think the mechanics community knows very much about the individuals who have made important contributions to computational mechanics. So, for my last topic, I would like to present vignettes of a few computational mechanicians, in particular, the four who preceded me as Timoshenko medalists. Think of this as a brief finite element analogue of Vasari's Lives of the Artists.

The first computational mechanician to be awarded the Timoshenko medal was John Argyris in 1981. John was a true pioneer and visionary. Perhaps more than anyone, he may be considered the father of the finite element method. His series of articles in the journal Aircraft Engineering formalized the matrix methods of structural analysis and introduced the first finite element. He later wrote a prescient article entitled The Computer Shapes the Theory that anticipated the field of computational mechanics. He was a larger than life figure. In his prime, he led an institute of approximately 125 engineers and scientists in Stuttgart. He had a car and chauffeur on call at all times and he traveled to conferences by private jet with an entourage of assistants. John passed away a few years ago. I worked with him for almost 25 years as an editor of the journal Computer Methods in Applied Mechanics and Engineering, along with J. Tinsley Oden.

Tinsley received the Timoshenko Medal in 1996. He educated himself about finite elements while working in the aircraft industry in the early 1960's. He was instrumental in transforming the finite element method from its intuitive beginnings to a rigorous science based on mechanics and mathematics. His text, Finite Elements of Nonlinear Continua, published in 1972, was a landmark in this process. Of late, his interests have been drawn to nanoimprint lithography, the treatment of cancer, and biology. He is the most articulate spokesman for the field and is a charismatic leader with broad skills spanning research, teaching, administration, and entrepreneurship. Arguably, his greatest achievement is the creation of the Institute for Computational Engineering and Sciences (ICES) at the University of Texas at Austin. I would like to tell you more about ICES but space and time do not permit. The ICES website is a good source of information (http://www.ices.utexas.edu/).

Olek Zienkiewicz, another larger than life figure, received the Timoshenko Medal in 1998. Olek left Northwestern University to chair the Civil Engineering Department at the University of Wales at Swansea in the late 1950's and established it as a center of computational mechanics activity. Olek and his colleagues made many important contributions to the finite element method, including the patch test, the isoparametric concept and isoparametric elements. He published the first finite element text in 1967 and followed it with several expanded editions. His single-minded determination and competitiveness are legendary. (There are some amusing stories.) He traveled the world for years enthusiastically promoting the finite element method. A Swansea riddle went like this: What is the difference between God and Olek? God is everywhere but Olek is everywhere except Swansea. Olek was, and is, a very congenial individual who enjoys people. He is in his mid-eighties and has retired, but still has an avid interest in the field. The sixth edition of his book appeared in 2000, a three-volume set, and rumor has it the seventh may be on the way. I visited Olek and his wife Helen last June in Sitges, a beach resort south of Barcelona, where they spend three months each spring. His enthusiasm and joie de vivre remain unabated.

Ted Belytschko received the Timoshenko Medal in 2001. Ted did his PhD with Phil Hodge and has been a very prominent member of the mechanics community throughout his career. He has also been very active in ASME, and the Applied Mechanics Division in particular, and is probably very well known to many of you. Ted has made fundamental contributions to explicit transient analysis, the most widely used technology in crash dynamics and metal forming, and was the prime mover behind the meshless revolution. Of late, his interests have turned to failure mechanisms, nanotechnology, and quantum-to-continuum coupling. Ted's work is characterized by its creativity. It has had tremendous impact on computational mechanics and engineering analysis. On a personal note, Ted and I have taught industrial short courses together for over 25 years and we are still on speaking terms (we taught one in Austin two weeks ago). Apparently, he is a very easy person to get along with.

Well, I have now slightly exceeded the average length of a Timoshenko lecture. So it is time to stop. I am not sure I satisfied Ravi, but I hope I satisfied John Hutchinson. His lecture was 2802 words. Mine is only 2672.

I will finish by thanking everyone once again. I am very proud to be a member of the community of mechanicians and deeply appreciative of this award.