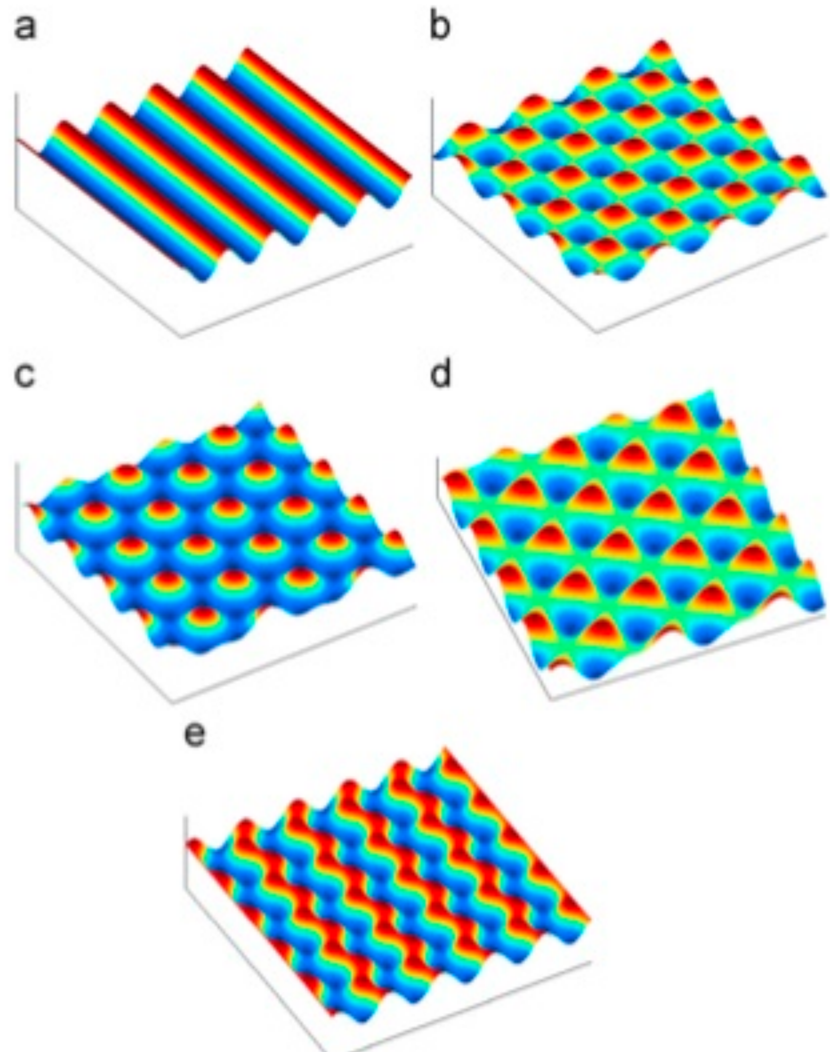
# Professor John Hutchinson




From: S. Cai, D. Breid, A.J. Crosby, Z. Suo, J.W. Hutchinson, "Periodic patterns and energy states of buckled films on compliant substrates", J. Mech. Phys Solids, Vol. 59, pp. 1094-1114, 2011

See:
http://www.seas.harvard.edu/hutchinson/
http://www.seas.harvard.edu/directory/hutchins
http://en.wikipedia.org/wiki/John_W._Hutchinson
http://imechanica.org/node/195
http://imechanica.org/blog/452
http://imechanica.org/node/11330
http://www.lehigh.edu/~inlehi/bio_hutchinson_j.html
http://scholar.google.com/citations?user=-5nvuQIAAAAJ&hl=en
http://www.researchgate.net/researcher/11637931_John_W_Hutchinson

**JOHN W. HUTCHINSON**

Abbott and James Lawrence Professor of Engineering
School of Engineering and Applied Sciences
Harvard University
Cambridge, Massachusetts 02138

**EDUCATION:**

| | | |
|---|---|---|
| B.S. | Lehigh University (Engineering Mechanics) | 1960 |
| Ph.D. | Harvard University (Mechanical Engineering) | 1963 |

**PROFESSIONAL EXPERIENCE:**

| | |
|---|---|
| 1963-64 | Research Fellow, Harvard University |
| 1964-68 | Assistant Professor of Structural Mechanics, Harvard University |
| 1968-69 | Associate Professor of Applied Mechanics, Harvard University |
| 1969- | Gordon McKay Professor of Applied Mechanics, Harvard University |
| 2000- | Abbott and James Lawrence Professor of Engineering, Harvard University |
| 2000-2005 | Associate Dean of Academic Programs, SEAS, Harvard University |
| 2004- | Adjunct Professor, Dept. Mechanical Engineering, Technical University of Denmark |
| 2005- | Distinguished Visiting Professor, Dept. of Materials, UCSB |

**MEMBERSHIPS:**

Member, National Academy of Engineering
Member, National Academy of Sciences
Member, American Academy of Arts and Sciences
Foreign Member, Danish Center for Applied Mathematics and Mechanics
Fellow, American Society of Mechanical Engineers

**AWARDS & HONORS:**

ASTM: Irwin Medal (1982), Swedlow Award (1993); SES: Prager Medal (1991)
ASME: Nadai Award (1991), Thurston Award (2000), Timoshenko Medal (2002)
Honorary Doctoral Degree, The Royal Institute of Technology, Stockholm, Sweden (1985)
Honorary Doctoral Degree, The Technical University of Denmark, Copenhagen, Denmark (1992)
Honorary Doctoral Degree, Northwestern University, Evanston (2002)
Honorary Doctoral Degree, Lehigh University (2004)
Honorary Doctoral Degree, University of Illinois (2005)

**COMMITTEES & SERVICE:**

Defense Sciences Research Council (formerly Materials Research Council) (1978-2002)
Naval Studies Board of the National Research Council (2004-2009)
Armament Panel of the Army Research Laboratories (2009-)
Former Member of Executive Committee and Chair of the Applied Mechanics Division of ASME
Member of the Editorial Board or Associate Editor of over ten Technical Journals

**RESEARCH INTERESTS:**

Hutchinson works on problems in solid mechanics concerned with engineering materials and structures. Buckling and structural stability, elasticity, plasticity, fracture and micro-mechanics are all figure prominently in their research. Examples of ongoing research activities are (1) efforts to extend plasticity theory to small scales, (2) development of a mechanics framework for assessing the durability of thermal barrier coatings for gas turbine engines, (3) the mechanics of ductile fracture and its numerical simulation and (4) the mechanics of thin films, coatings and multilayers.

Most recent paper on shell buckling: Hutchinson, J.W., Knockdown factors for buckling of cylindrical and spherical shells subject to reduced baixial membrane stress. *Int. J. Solids Structures*, **47**, 1443-1448 (2010).

**PUBLICATIONS & FURTHER INFORMATION AVAILABLE ON THE FOLLOWING WEBSITE:**

http://www.seas.harvard.edu/hutchinson

About **Professor John Hutchinson** (article from Harvard School of Engineering and Applied Sciences, www.seas.harvard.edu/news-events/publications/.../john-hutchinson)

## Holding the Center, Bringing the Field of Fractures Together

"Is Professor Hutchinson still there?" ranks as one of the most common questions—apart from "Does Harvard really do engineering?"—that SEAS staff members are likely to hear.

John Hutchinson, Abbott and James Lawrence Professor of Engineering and one of the most distinguished researchers in fracture mechanics, has spent the past four decades at Harvard.

In fact, he earned his PhD and started his career in the same building, Pierce Hall, where he currently works. Such longevity may explain in part why so many students remember and ask for him, but as anyone who has met him knows, his popularity comes down to character.

Hutchinson has an ever-present ease about him that draws in students; a bright-eyed sense of excitement that never wavers, whether it is his first or fortieth commencement; and the ability to see potential solutions to problems where others see only dead ends.

"It is unusual to spend one's entire career at the same institution," he says. "For me this has been great, since Harvard is such a good place to work and teach. I've never felt restless at Harvard, but that can be partly attributed to the fact that I have taken a six-month sabbatical or leave of absence almost every three years—to England twice, California for a year, and to Denmark the rest of the times."

Because of his globetrotting, his influence extends well beyond one campus. In 2002, when he was awarded the Timoshenko Medal, considered the highest honor in applied mechanics, the committee wrote: "An interesting aspect of his personality but also of his impact on mechanics of solids and materials becomes apparent if we look at the names of some of the people with whom he has worked." All the researchers mentioned, with appointments located on the opposite coast and the opposite side of the world, rank as pioneers in engineering and applied mechanics (see sidebar).

Thankfully, Hutchinson is not an academic who looks good only on paper; he excels in the classroom as well. His alma mater, Lehigh University, and the University of Illinois at Urbana Champaign, in bestowing him honorary degrees, both cited his dedication to mentorship.

For the latter, nominator L. Ben Freund wrote: "His abilities as an educator/mentor are most in evidence through his former graduate students who are forging distinguished careers for themselves at Illinois, Brown, Harvard, and many other universities, companies, and laboratories in the U.S. and abroad."

Hutchinson says without hesitation that his students and collaborators, including his one-time acolyte, now Harvard colleague Zhigang Suo, Allen E. and Marilyn M. Puckett Professor of Mechanics and Materials, arrive with "great things" already inside them. "Any faculty advisor knows you cannot take credit for what your students achieve," he says bluntly.

Nevertheless, the evidence, both quantitative (number of coauthored papers) and qualitative (praise from students and colleagues), points to a strong correlation: being taught by or collaborating with Hutchison often leads to a successful outcome.

Faculty should, he contends, provide students with opportunities and startup ideas and then “set them loose.” As evidence, Suo was only one individual in a group of students from China, including Huajian Gao (now at Brown), Young Huang (now at the University of Illinois), and Tianjian Lu (now at Cambridge), who were successfully set loose.

All of them came to Harvard in the 1980s and 1990s to study solid mechanics—and all but one of them worked with Hutchinson. “These individuals, and others among our students, had not only risen to the top of an incrediblycompetitive educational system in China, but they had exceptional training in mathematics and mechanics,” he says. “They were ready to go when they arrived at our doorstep, and we were very lucky to have them as students.”

A teacher thanking his students, which sounds more like a proverb than a practice, showcases why Hutchison stands out. He relishes the chance to work closely with students and postdocs on pieces of a larger puzzle in applied mechanics, which no doubt leaves a lasting impression on them.

He worries that with large-scale, multiple-investigator projects securing the majority of today’s grants and funding, such critical relationships might suffer. He says the “jury is out” on which is the better approach to research, but a funding agency need not look further than Hutchinson’s legacies for what is possible at the small scale or, better, simply stay tuned and wait for what is to come.

Of particular note has been Hutchinson’s collaborations with Tony Evans, a professor of materials and mechanical engineering at the University of California, Santa Barbara, over the past 25 years. “Tony is a materials engineer with an active laboratory, and I am a mechanics theoretician—together we have quite broadresearch interests and we continue to work on lots of interesting technological problems.”

“What counts is what you are doing, not what you have done,” he explains. “Of course, there is satisfaction in realizing that people are using your work—there would be little reason for doing research without that. But it is the act of doing that is the heart of engineering. I saw an interview with Duke Ellington late in his life, when he was asked which of all the songs he had composed he liked the best.

Without hesitation, he replied, ‘The one I am working on now.’ ” Researchers, however, consistently cite a particular paper Hutchinson worked on with Suo, “Mixed-mode cracking in layered materials,” in 1992, as their favorite composition. The article is among the 10 most-cited papers in the field of engineering in the past decade.

“Zhigang was a young faculty member at UCSB when we wrote this article, and he claims he was a bit bored by the task, but I had a pretty good idea it would be a bestseller,” Hutchinson says. “While some have termed this article as one of the ‘bibles’ in our field, in fact most of the papers citing it have been from outside our field, mainly from the electronics industry, where they are famous for getting layered materials to do exceptional things.”

That his work inspired researchers from outside engineering and applied science is yet another confirmation of why his office is likely to remain one of the more popular sites to visit on campus (no rubbing of his toe permitted, however). "Like most of us, I live from day to day.

My plans are to continue working on technical problems in my field that I identify through interactions with colleagues," Hutchinson says.

"As I said, it is the problem that I am working on now that is the most interesting. I have no big aspirations. Any success I may have achieved has been in small increments over long periods of time, and I intend to continue that process for a while longer."

## 2002 ASME Timoshenko Medal Acceptance Speech by John W. Hutchinson

LIFE AS A MECHANICIAN: 1956-

This is a great honor for me; I know that I am undeserving. Nevertheless, I will gladly accept the medal. Several weeks ago, the NPR journalist, Daniel Schor, was elected to the American Academy of Arts and Sciences, and in his acceptance speech he remarked that he had learned how to be gracious about undeserved honors from Henry Kissinger. Shortly after Kissinger received his Nobel Peace Prize, a reception in his honor was held at the State Department. An elderly woman approached Kissinger, grasped his hand, and thanked him from the bottom of her heart for saving the world. Following one of his heavy pauses, Kissinger replied, "you're welcome". In my case, I can thank you because, in addition to recognizing whatever contributions I have made to mechanics, the medal recognizes contributions of the teachers, colleagues and students with whom I have had the pleasure to interact over many years. In fact, I have always felt that the Timoshenko Medal is above all else a celebration of mechanics as a wonderful field. We have the great luxury to work in a field where basic math and science mix side by side with engineering applications. In any given day it is not unusual for our thoughts to range from the highly theoretical to very practical. I'd like to use my twenty minutes before you tonight to give a few randomly selected, personal reminiscences about some of the subjects on which I have worked with asides on a few the people in our field that I have had the pleasure to know. Speaking of this, I must mention that, although I cannot claim to have known Timoshenko, I did have the pleasure of meeting him briefly very early in my career. I'm not sure how much longer our Timoshenko Medalists will be able to make this claim. I will also say that I pick up one of his books on the average about once a month.

For me professionally, mechanics has been structures, fracture and materials. If you think back to 1956 when I started college, you will recall that computers were just beginning to be used to solve structural problems, fracture was just beginning to develop as an engineering science, and the mechanicians working on materials could be counted on the fingers of one hand. How things have changed! Those of us here over fifty or so have all been at the center of this revolution, most of the time without realizing that a revolution was underway. I will not be putting special emphasis on the role of computers in mechanics, even though this is like ignoring a bull in the china shop. The computer has transformed not only our field, but most fields of engineering and science. We can be proud that it is our colleagues in mechanics who led the way in developing the some of the most powerful numerical methods for engineering problems. In recent years the Timoshenko Medal has gone to some of the pioneers of the finite element method. I've been a user of computers, but not a developer of numerical methods, per se, so I am happy to leave it to future colleagues to tell us more about the ongoing developments on the computational side.

When pressed to state what I regard as the most remarkable single contribution of an individual in solid mechanics in my lifetime, I am inclined to say that it was Warner Koiter's Ph.D. thesis, "On the stability of elastic equilibrium", published in Amsterdam in 1945. The thesis developed the theory of elastic buckling and post-buckling behavior, the effect of initial geometric imperfections on buckling, and applied this theory to columns, plates and shells. But that was not all, most of Koiter's subsequent seminal contributions to shells, both linear and nonlinear, had their beginnings in his thesis, and many aspects were already well developed there. I take pride in the fact that Bernie Budiansky and I were among the first to discover Koiter's thesis, and that was not until 1963. Incidentally, the thesis work was carried out during the war in occupied Holland. Koiter later told me he did much of the work in a closet by the light of a candle—he may have been exaggerating. The thesis was published in Dutch. Budiansky and I relied on our astrophysics colleague, Max Krook, who knew Afrikaans and, therefore, a little Dutch to provide us translations of critical sections. Some years later, after Koiter's approach was widely appreciated, I naively asked Koiter why he had never published his work on stability. He looked at me down his long nose and informed me it had been published! In Dutch, as his thesis! Shell buckling was one of the hot areas in the 60's, motivated by rockets and other aerospace structures. The perplexing aspect everyone was trying to come to terms with at the time was the notorious discrepancy between the collapse load of actual shells and what was predicted theoretically for buckling of a perfect shell. Thin cylindrical shells under axial compression were observed to collapsed at loads as small as 20% of the theoretical prediction in contrast to columns and plate structures which showed good agreement between experiment and theory for the perfect structures. The key to understanding the discrepancy was the highly nonlinear post-buckling behavior and the extreme sensitivity to imperfections, which were related and clarified by Koiter's thesis. Skeptics at the time thought that the basic theory for the perfect shell was intrinsically flawed, but it wasn't. In fact, in the late 60's, Rod Tennyson at the University of Toronto succeeded in making shells so nearly perfect that they buckled within 95% of the prediction for the perfect shell. All that is now history. Buckling problems of all kinds arise continually in many areas of technology. Sometimes I wonder where the expertise on buckling will reside when all of us aging bucklers cross the bar. ABAQUS can solve buckling problems, but it can't pose or understand them. I'm afraid it would not take long to count the number of courses on buckling now taught in this country. On that somewhat pessimistic note, I'll move on to fracture.

I was born a few years after Griffith wrote his landmark paper on the fracture of glass, but all the other developments of fracture mechanics occurred during my lifetime and most of them occurred during my lifetime as a mechanician. It is worth extolling fracture mechanics since to me it represents mechanics at its best: mathematical theory and problem solving (analytical and numerical), strong experimental underpinning, test method development, and, last but not least, engineering applications and materials characterization. All these are mixed together in an essential and rich manner. Fracture mechanics is going strong after fifty years of development. Fracture problems also arise every day in many areas of technology, and fundamental connections to microscopic and atomistic failure processes will continue to challenge some of us for many years to come. The chief limitation of fracture mechanics is simultaneously its great strength—namely, the details of the failure process are all swept under the rug as a critical parameter to be measured by experiment. Thus, crack mechanics provides a framework for carrying out macroscopic measurement and application of behavior that is controlled at much smaller scales, even at the atomic scale in some instances. Tests are designed to measure material toughness, or crack growth rate, and then this data could be applied to predict the integrity of a structure. I think I am correct in saying that after fifty years of measuring toughness and fatigue crack growth rates experimentally, there is probably not a single instance where a critical application has made use of toughness that has been predicted theoretically. You have to give the earlier developers a great deal of credit for understanding this from the start—I'll single out George Irwin and Paul Paris as two of many of our colleagues who had the great insight to set this in motion. Paris's early contribution was not the Paris Law (Paris, himself, is always the first to say it is no law at all). Along with Irwin, his contribution was the recognition that a truly esoteric quantity from elasticity theory, the stress intensity factor, could be used to develop a framework to measure crack growth and predict structural integrity.

Two motivations drove the development of nonlinear fracture mechanics. One was the quest to characterize behavior nearer the tip where the fracture process occurs. But equally important was the more practical problem of the huge specimens required for measuring fracture toughness based on linear fracture mechanics of the tough, ductile steels used in the nuclear reactor industry. In the late 60's and early 70's, engineers at Westinghouse were using specimens the size of a large file cabinet and weighing several tons to determine the toughness of pressure vessel steels. For every set of conditions, several specimens must be tested. Even for the most important applications, this was untenable. Thus, Jim Begley and John Landis at Westinghouse had plenty of motivation to see if they could make use of Jim Rice's J-integral theory when extensive plasticity occurs, in analog to the way the stress intensity factor is employed when the deformation is elastic. It worked, not immediately, of course, but after the usual hard work. Now the fracture toughness of very tough steels can be measured using small specimens, thanks to a healthy mix of theory and experimentation. It has to be emphasized that this approach is still phenomenological—just like the linear approach it makes no pretense at incorporating a description of the microscopic fracture process. A computational approach to crack growth in ductile alloys based on the mechanics of the fracture process began to emerge in the early 70's, motivated by problems in the nuclear power industry. Just when progress started to be made, the Nuclear Regulatory Commission and EPRI, who were supporting most of this work, stopped the funding. It took almost a whole decade before groups working independently in France, Germany, the UK and America moved ahead on this more fundamental approach. While much remains to be done on the nucleation and propagation of cracks in tough, ductile alloys, the approach appears to be the first computational method based on microscopic fracture processes that is ready as an engineering tool. I would be remiss if I did not emphasize that this approach still requires experimental calibration. As I said in the beginning of my remarks on fracture mechanics, toughness is measured not predicted, and I suspect this will just as true ten years from now.

Fracture mechanics remains a remarkably vital subject, and I've only scratched the surface of the history. Nevertheless, it is time to expand into my last period, materials, which is an even larger subject and which I will treat even more cursorily. The mechanics of materials has been around a long time, but back in the early 1960's mechanicians working on fundamental aspects of material behavior were few and far between. Certainly, Frank McClintock deserves special mention as one of the earliest of the modern generation. As an undergraduate applying to graduate school, I recall being told by C.C. Lin, an eminent fluid mechanician at MIT, that materials (not plastics, incidentally!) were the future for a young man. Indeed, by the mid¬1970's, structures had definitely lost out to materials as far as attracting the attention of many of us. Looking back, one can see that the emerging interest in materials had an enormously energizing effect on solid mechanics. So much so, that I remember friends in fluids wistfully envying our great source of problems. There is an enormously rich set of physical phenomena at many length scales associated with materials, and mechanics seems to be uniquely suited to organizing the interplay among the multitude of influential factors. Incidentally, color is not necessarily one of the influential factors, as this story will relate. I had worked on the transformation toughening of a ceramic, zirconia, for over a year and was giving a talk on the subject, when someone in the audience had the audacity to ask me for the color of zirconia. I hadn't a clue, of course. For about the last twenty years, I've had the great fortune to work closely with Tony Evans on many different materials engineering problems. Evans knows that too much information will confuse any mechanician, and he has always been very selective about the facts he feeds me. Needless to say, the color of zirconia was not one of them.

The subject of materials is too big for an after dinner talk, apart from some light hearted remarks. I'll repeat the advise that Rod Clifton gave to young mechanicians when he was up here a couple of years ago-- young man or young woman, its biological materials.

I've already remarked on the wonderful mix of theory, experiment and application comprising mechanics: a veritable melting pot of engineering, mathematics and physics. Lying at the crossroads of such intellectually diverse fields can create tensions. When I was a young fellow, there was a decided tension between colleagues who viewed mechanics as rightfully belonging to the field of mathematics and those who saw mechanics as part of engineering science. One of the first technical meetings I attended was the US National Congress of Theoretical and Applied Mechanics at the University of Minnesota. For the opening general lecture, Clifford Truesdell gave a lecture with a distinctly mathematical tilt on nonlinear continuum mechanics. George Carrier, a colleague of mine in fluid mechanics from Harvard, gave his general lecture on oceanography the following day. To the great amusement of his audience, he spent the first few minutes of his lecture mimicking Truesdell by giving an overly formal mathematical definition of an ocean. Without slighting the contributions of our former colleagues on either side of the fence on this issue, I think nearly all of us here will agree on how this tension has played out. Leaving aside who foots the bills for our research, mechanics is rightfully part of engineering and science. The fact that mechanics abounds with so many wonderful mathematical problems is a seductive added bonus.

Colleagues of my generation owe much gratitude to the Russians for stimulating the flow of research funds and university expansion in engineering and science. I was a sophomore in college when Sputnik went up, and it is only a slight exaggeration to say that I surfed the wave that Sputnik generated for many years afterward. The high flying years in the 1960's in engineering and science funding contributed to unrealistic expectations in later years, which haven't completely faded away. I'm going to resist the temptation to speak on the erosion of funding for mechanics in the current environment, which provides grist for many a Timoshenko after dinner talk. The idea of funding for research in mechanics, as if it were a basic science or mathematics, is a product of the two trends of the 60's that I just mentioned. That is, mechanics as mathematics rather than engineering science, and the overly flush period in the 60's when funding could be had for almost any reasonable research project in the physical sciences. My younger colleagues here may regret not experiencing the largess of those earlier years, but at least you are spared from forming habits that are hard to shed. On the positive side, we in mechanics work on a vast array of subjects within engineering and science, and we draw our support form an equally broad range of sources, even if we have to scramble to do it. As a community, our interests are much more diverse than in the "good old days", which of course presents both benefits and difficulties to the field of mechanics per se.

In closing I want to pay special tribute to the extraordinary colleagues with whom I have had the great fortune to share this profession, colleagues at Harvard and at many Universities in the US and abroad. Among these colleagues have been many exceptional graduate students. Indeed, some have been so exceptional that they needed almost no help from me at all, and I hardly remember them setting foot in my office. As I said at the start, the Timoshenko Medal is the recognition that means the most to me. From here on out, I'm happy and no further recognition is necessary. I'll be working purely for the pleasure of mechanics itself. Some of you probably saw the interview with Duke Ellington in the Ken Burns series on American Jazz, held near the end of Ellington's career when he was in his eighties. Ellington was asked, which of all the songs he had composed did he like the best. "The one I am working on at the moment", Ellington replied. And so it is in mechanics!