Continuum Mechanics: Foundations and Applications of Mechanics, Third Edition, Vol. 1; Fluid Mechanics: Foundations and Application of Mechanics, Third Edition, Vol. II. C. S. Jog. Cambridge-IISc Series, Cambridge University Press, 4843/24, 2nd Floor, Ansari Road, Daryaganj, Delhi 110 002. 2015. xxiii + 852 pp. Price: Rs 1495; 2015, xx + 570 pp. Price: Rs 1095.

Teaching and conducting research in continuum mechanics (CM) is a challenging affair in the new millennium owing to a growing reliance on numerical tools supplanting physics and mathematics. Divergence of views and expectations between the teacher and the student has alarming consequences on rating and ranking measures which are intrinsically irrational. Writing CM books offers a non-trivial and unambiguous means for countering the threat of market-driven mediocrity evident globally in contemporary curricula. At this juncture I applaud the efforts at the Indian Institute of Science (IISc) for pursuing and promoting excellence through publishing books penned by its faculty. Reviewing a pair of CM books authored by C. S. Jog is both formidable and rewarding. Taken together, this CM duo exceeding 1450 pages is indeed monumental, and, therefore, demands and deserves a compatibly expansive commentary attempted here.

Astronomical observations inspired Newton, Euler and Einstein in formulating celestial and cosmological models. Einsteinian concept of general covariance spurred the growth of CM transcending mundane terrestrial applications envisaged by Hooke, Euler, Cauchy, Bernoulli, St. Venant and Prandtl. As a forerunner to CM papers and books, the eighth chapter in Bergmann's 1942 book on the general theory of relativity (GTR) with a foreword by Einstein was entirely devoted to the mechanics of continuous matter encrypting the essence of stress–energy–momentum tensor conceived by Maxwell. A section on electromagnetism, Lorentz transformation and relativity adorned Jaunzemis' CM book in 1967. In the GTR centenary year (2015), it is befitting that Jog champions the ideas of Euler and Einstein through a formidable pair of eight-chaptered CM books for solids and fluids separately. Replete with theorems, equations, axioms and proofs, this third edition flaunts a much broader collection of examples, exercises and appendant formulae dwarfing its previous avatars as also all other CM books published till date. See Box 1 for a pictorial presentation of vital statistics and chapter themes.

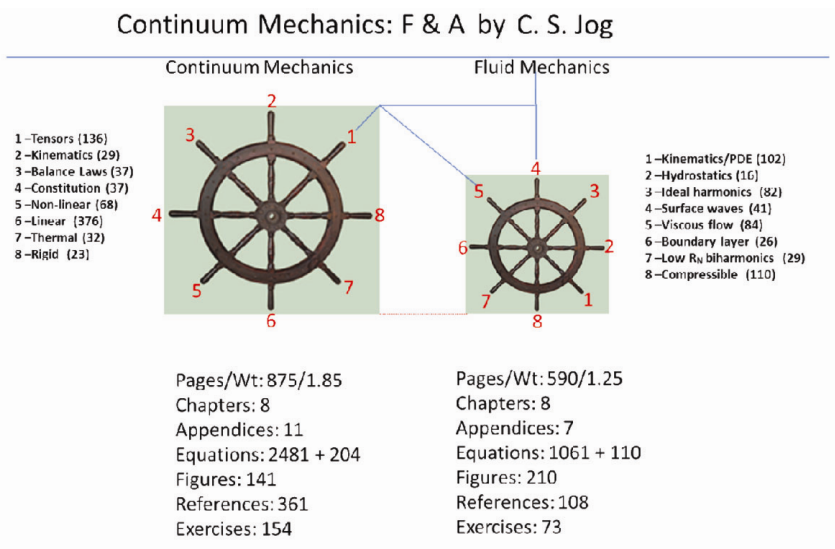
In the first volume, the first two chapters together with the first eight appendices cover the basics of tensors, coordinate systems and kinematics. The next two chapters describing balance laws and constitutive equations set the stage for nonlinear elasticity in chapter 5. Chapter 6 on linearized elasticity running to 300 pages exhibits a rich diversity of problems and solutions that shaped the growth and evolution of the theory of elasticity since the middle of the 19th century. Discussion on papers dating back to Chree (1892), Filon (1902) and Stevenson (1932) gives a glimpse into a passionate era of the subject culminating in the creation of CM – the real jewel in the crown. Nearly 325 papers out of a list of 361 references reveal the emphasis on CM research.

A thermodynamic basis for fracture that began with Griffith and was vastly enriched by Irwin between 1920 and 1950 is now deeply entrenched in CM, as discussed in chapter 7. Fuel cell materials like living cells allowing free flow of heat, ions and mechanical energy demand a thorough thermodynamic appraisal to help us guard against spurious claims and advertisements flooding energy, environment and health-care products. Here one may recall the long history of numerous humorous ideas for inventing perpetual motion machines dating back to Leonardo da Vinci. The last three appendices in the first volume provide useful mathematical results pertaining to matrices, Euclidian spaces and boundary conditions.

The second volume with eight chapters and seven appendices begins with a recapitulation of the governing equations of CM presented in the first volume. Chapters 3 and 4 running to over 200 pages present a panoramic compendium of inviscid ideal and incompressible viscous fluid mechanics problems. Revisiting Greenhill (1879), Jeffery (1915), Filon (1926) and Cochran (1934) besides recreating the magical aura of a bygone era of exact solutions and elegant formulations also serves as a beacon for the way ahead for CM. There is a nice linkage of solids–fluids concepts in the twin volumes. For example, torsion problems in linear elasticity (p. 335, vol. 1) have their analogues in flow inside/outside non-circular tubes (p. 166, vol. 2).

Chapter 2 dealing with hydrostatics, and chapter 4 dealing with gravity and shallow water finite-amplitude waves

Box 1. Pictorial presentation.



belong to inviscid and imcompressible fluid mechanics. Similarly, chapter 8 in the first volume on rigid-body dynamics requires no constitutive assumptions. The basic tenet of CM rests on deformation accompanying motion. Therefore, the concepts of rigid and incompressible continua, however inconceivable or anathematic they may seem to CM, the emergent mathematical concepts of Euler tensor (p. 721, vol. 1), dispersion and group velocity (pp. 209–214, vol. 2) and method of characteristics (p. 223, vol. 2) are useful for appreciating chapters 5–7. Chapter 6 addresses boundary layer solutions and chapter 7 presents low Reynolds number viscous flows which render immense simplicity and solvability of the nonlinear Navier–Stokes equations (p. 36, vol. 2). The resulting biharmonic equation permits elegant results, as illustrated in chapter 7 and appendix E (pp. 500–507, vol. 2). Chapter 8 presents basic acoustics and shock wave theory, which are of great current interest in CM research.

Nearly 85 papers out of a list of 108 references again reveal the preference for highlighting research themes. Overall, only 55 books have been cited in the two volumes out a total of 469 references. There is a need for including more books for the sake of historical as well as pedagogical continuity for teaching and research, and a few are indicated at the end of this review. Appendices A–D (vol. 2, pp. 492–499) list governing equations in cylindrical, spherical, elliptic and bipolar coordinates. Appendix F describes Laplace transforms. The most ambitious appendix of all is Fourier series expansions in appendix G running to 30 pages!

Barring a few like the two books under review, CM books emanating a predominantly theoretical flavour are quickly shunned by practising design engineers. Our daily life resting on rather fragile foundations of economic survival and mass production can hardly support and appreciate the demanding axiomatic CM rigour underpinning nonlinear phenomena. As expressed wistfully and eloquently in the epilogue by Fung: 'On reaching this point in our study, the reader must have a feeling that the panorama of solid mechanics is somewhat unreal. The examples selected and discussed in the book are idealized problems.... The real object has an irregular geometrical shape. Non-homogeneity and anisotropy prevail, nonlinearity reveals itself almost everywhere ... for generations bridges and buildings were designed on the basis of simple truss and beam theory ... airplanes, ocean liners and even space ships, were designed mainly on the basis of the theory of elasticity.'

Albeit such remarks get repeated quite frequently about the theory in general, the rapid rise of computational mechanics has rejuvenated CM for creating challenging and mathematically more rigorous benchmarks, particularly for modelling nonlinear soft matter. On the other hand, big data pools of everything past and new data presently being acquired through experiments and computer simulations have greatly reduced the need for investing on theoretical or experimental models. In a way, this reflects how biology and chemistry evolved primarily for survival of the species followed by the more abstract physics and mathematics for decoding mysterious celestial rhythms.

The triad of energy, environment and healthcare issues is the driver of modern business, research and development. A wide spectrum of healthcare products and services being marketed in the new millennium augurs well for bridging biology and engineering. Though presently bioengineering (BE) products are making the best use of materials and manufacturing processes, the weakest link in the business is mechanics, or more precisely bioengineering mechanics. Modelling soft tissue, bone and tendon entails CM concepts too subtle to be left for empirical or heuristic urges, however successful they might turn out to be in the short run. The two books under review will surely guide the reader to stay clear from conceptual clutter and help clean out the cobwebs of empiricisms and approximations. For example, section 8.5.3 (pp. 451, vol. 2) highlights the power of CM for estimating the shock thickness as 295 nm by exploiting balance laws presented in chapter 3 of the first volume.

The first generation of CM books pioneered by Novozhilov, Murnaghan, Eringen, Rivlin, Green, Zerna and Adkins among others, laid out an ambitious programme encompassing crystals, plasticity, plates and shells besides discussing experimental issues. Later thrust led by Truesdell and his collaborators notably Toupin, Noll, Coleman and Ericksen emphasized a rigorously axiomatic treatment. The staggering quantity of CM literature generated during Truesdell's period continues to command respect and awe even today after 50 years. This period yielded elegant and exact results for isotropic materials undergoing isochoric isothermal deformation. Anisotropy, creep and plasticity data defy analytical interpretation and provide impetus for numerical and computational simulation. Thus CM that began with elegant axiomatic models of finite elasticity albeit limited to simple materials and experiments, is now deeply immersed in finite element routines. Books by Fung and Malvern appeared during the early part of this transition and Ogden's book was published towards the end.

Recent CM books in the new millennium are carrying on with the agenda set by Truesdell enlarging the scope of CM for tackling anisotropy, viscoelasticity, plasticity and fluid flow. It is indeed commendable that the second volume devoted to fluid mechanics succeeds in presenting an entirely new perspective on topics such as acoustics and compressible flows. While vigorously advancing CM frontiers computationally, there is, however, a gnawing feeling that CM books and papers in general appear to avoid acknowledging some really amazing ultra-high resolution experiments for mapping out large strains and deformations in a variety of soft materials and tissues in complex biological environments with the help of ultrasonic waves, markers and transmitters. Today, powerful computational codes are obviating the need for conducting experiments, at least those that are routine, reversible and well-controlled testing conditions. Field trials on new materials and novel applications, however, always demand experimental insight.

In this context, it might be advantageous to combine the axiomatic CM approach with more pragmatic ideas gained from phenomenological models built on statistical mechanics and probability theory. Modern condensed matter science (CMS) exploiting quantum mechanics, probability theory and thermodynamics has enjoyed great success in elucidating the mechanics of soft matter. Axiomatic rhetoric can often be misleading while interpreting engineering properties of matter. As an illustration, bounds on Lame constants discussed in section 5.3 presupposing an isotropic and isothermal state of matter may not hold under

dynamic loading. Another intriguing aside discussed in section 6.2 probes into inconsistencies in the use of linearized plane polar orthotropic elasticity. Despite the overwhelming appeal of linear theory of elasticity for solving practical problems, ironically, however, from a rigorous CM viewpoint, all linear elastic models are fundamentally flawed. Perhaps, the scope of CM can be vastly enriched by including CMS concepts.

For graduate-level teaching, these two books offer a cumulative body of basic CM knowledge distilled for pin-pointing directions for further research. There is a need for providing additional modern references addressing anisotropy, singularities and plasticity observed widely in metals, polymers and biological matter. There is also a general need to describe the nature of experimental reality as highlighted by pioneers like Bingham, Reiner, Murnaghan, Flory, Rivlin, Treolar and, more recently attempted by Ogden. There is nothing absolute or universal about physical laws or mathematical models of matter, and CM is no exception. Small volumes of matter in reality hardly remain continuous, while soft matter and granular media almost always are on the verge of collapse.

Stability and strength of elastic solids have been pursued passionately since Euler, and CM concepts built on energetics and kinematics offer a dizzy array of powerful strategies. Quantum interactions among the constituents and the ambient medium get activated opening up exciting new opportunities for enriching CM with quantum mechanics. Perhaps this new field coined as 'quantinuum mechanics' can help focus attention to unveil the mysteries of soft matter and smart materials. Weiner attempted illuminating statistical mechanics of elasticity, including thermally activated aspects usually deemed outside the scope of classical CM.

In this review, it seems appropriate to take stock of CM in a society increasingly enamoured by enticing software sops and spur. There is a concern that powerful codes may obscure and even trivialize certain deeper unresolved issues of stability, fracture and damage evolution in solids undergoing large deformation. Predicting instabilities and irreversibilities in nonlinear mechanics has opened a Pandora's box of wild speculation. Scientists and sceptics alike are debating on esoteric instability scenarios ranging from the sub-atomic to the eschatological scale encompassing the entire universe (see Wald).

In this context, it is gratifying to note that Jog maintains a steady analytical flow of ideas on elastic and material stability, including numerical results for a St. Venant–Kirchhoff material. He also avers that finite element techniques based on incremental variational formulation become erroneous when instabilities arise. By taking full advantage of *Mathematica*, Jog presents numerous exact results unthinkable a decade ago. A case in point is the oscillating singularity equation (eq. 6. 365), which at first sight looks strangely different, but with some *Mathematica* manipulation, the standard result emerges for the geometry in figure 6.57(a). This will hopefully inspire and empower the present generation of CM researchers to attain mathematical mastery before plunging into the unknown ocean of computation. *Mathematica* can also double as a teaching and learning aid for revisiting other classics like Goldstein.

Mechanics in the new millennium has morphed into a multi-utilitarian ritual for physical, biological and mathematical sciences as well as for business, economics and humanities. Huge private and public funding appears to have somewhat blurred the boundaries demarcating fact and fantasy. Premature claims by science reporters further exaggerated and vulgarized by social media globally have greatly distorted the meaning and structure of mechanics, as lamented and lambasted by Truesdell on several occasions. Cooper in the preface to his book searching for meaning and structure of physics wrote: '...immersed in a chaos, like that planned by Dante,...'. Aggressive science promotion for advertisement, entertainment and aggrandizement has reduced mechanics to a perfunctory act of citing numbers and laws, however irrelevant or obsolete they might be in a specific business context.

Repeated claims on arresting ageing and communicating with aliens since the dawn of history are but a few outrageous examples. Reading these two and other CM books can help one understand and perhaps unveil the recondite nature of skin, tissue and tendon elasticity underpinning life. There is also a need for enlightening the energetics of active fungal, bacterial and other cellular matter invoking CM concepts.

Finally, at this juncture, It is perhaps even more crucial to assess as well as assimilate all the available experimental observations on deforming matter into the CM mainstream, irrespective of whether such matter is animate or inanimate, active or inert, celestial or terrestrial. Experiments and observations have inspired and guided theoretical sciences over millennia and CM too conveyed this spirit of fitting limited theory to unlimited facts rather than fitting carefully selected facts to even more carefully tuned concepts and numerical codes. In the wake of GTR, a pioneering CM book by Murnaghan highlights the excitement of matching Nobel Prize-winning high-pressure data on sodium acquired by Bridgman in 1948. Following an iterative procedure, Murnaghan eventually succeeds in predicting that a 200 kbar pressure will squeeze sodium to 49.7% of its original volume, thus extending Bridgman who had at that time experimentally achieved a maximum pressure of 100 kbar.

It is also amazing here to record the commitment and zeal of CM pioneers like Murnaghan and Truesdell in creating a coherently robust covariant reasoning of CM in the wake of GTR. It is even more remarkable to mention here that Murnaghan had published a book on relativity based on a short course of lectures delivered in the Department of Mathematics at Johns Hopkins, USA in 1920. In this book he writes: '…It is our opinion that it is to the physicist, rather than to the mathematician, that we must look for the conquests of the secrets of nature … the progress in both subjects has been so remarkable that we cannot hope for investigators like Kelvin and Helmholtz who are equally masters of either…'. It is also interesting to record here that both Murnaghan and Truesdell were mentored by the eminent mathematician Bateman and all three of them had worked at Johns Hopkins.

Reflecting on the historic evolution of CM and its future prospects while reviewing these books is like diving into the deep blue ocean in the eloquent spirit of Newton*:* 'I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me'.

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Annual Review of Pathology: Mechanisms of Disease, 2014. Abul K. Abbas, Stephen J. Galli and Peter M. Howley (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, CA94303-0139, USA. Vol. 9. vi + 386 pp. Price: US$ 63. ISBN 978-0-8243-4309-5.

As usual and as expected, this volume of Annual Review of Pathology is marvellous. This volume does not contain what some issues begin with – an interview with an authority on a particular subject, with the history and patterns of his/her research field highlighted in the interview. This is a pity because there are few journals which carry such articles – those from which students would benefit greatly.

Cancer (glioma, ovarian serous carcinoma, melanoma and chronic lymphocytic lymphoma among them) and autoimmune diseases (including IgG4 disease, Sjogren's disease and autoimmune thyroid disease) form a major part of the 17 chapters. Other essays are on atherosclerosis, *Cryptococcus neoformans*, reactive oxygen, etc.

Autoimmune pancreatitis, or to use the more recent term, IgG4-RD (IgG4 related disease) is a truly 21st century disease. Though first documented in the 1960s as an isolated case report, it is only in this century that the disease has come into its own, so to say. Briefly, it usually presents as a chronic pancreatitis; however, it needs to be distinguished from the other more common chronic pancreatitis (usually associated with gall stone disease or alcohol intake) because of some specific morphologic and biochemical associations and therapeutic implications. Histologically, the pancreas shows a dense infiltrate of plasma cells as well as obliterative phlebitis and fibrosis. Specifically, autoimmune pancreatitis is treated by steroids and not by major surgery and is thus a 'medical' rather than a surgical disease.

The discovery in 2001 that patients with this disease have elevated serum levels of IgG4 made diagnosis easier and ultimately also gave it its new name, IgG4-RD. Besides the pancreas, however, a whole range of organs is involved, including the salivary gland, ear, nose and throat, kidneys, lungs, aorta, stomach, retroperitoneum and lymph nodes.

Yet IgG4 is more complex. Unlike other autoimmune diseases which are more common in women and often present in the young, autoimmune pancreatitis is more common in men, especially in the middle aged and old men. Besides, we do not know as yet, whether the raised IgG4 autoantibodies are a direct cause of the disease, or a mere association. Perhaps it is not autoimmune after all. The jury is still out on that and there is much work to be done on this entity – clearly material for a future issue of *Annual Review of Pathology*. I might add here that during the course of my review of this book, I saw a patient with a difficult-to-diagnose case of suspected IgG4-RD and the well-crafted essay helped me make a correct diagnosis – (not IgG4-RD, by the way) – much to the patient's benefit.

Sjogren's syndrome (SS) is a not uncommon autoimmune disease, which, fortunately, is relatively benign. However, SS has, among the autoimmune diseases, the highest incidence of lymphomas; 5–10% of SS patients develop Non-Hodgkin's lymphoma and have a higher mortality rate. Thus, SS is a model for the simultaneous study of autoimmune disease and malignant transformation. SS is histologically characterized by a mononuclear infiltrate in and around the epithelium of the ducts and acini of the exocrine glands. The organs most commonly involved are the salivary glands and the lacrimal glands. Because of the structural and physiologic alterations that take place in these organs, the symptoms of this disease are dry mouth and dry eyes ('keratoconjunctivitis sicca'). Besides these organs, the epithelium of the lungs, kidneys and liver can also be affected, leading to the new term for SS, 'autoimmune epithelitis'.

In SS, T cells predominate among the inflammatory cell populations that affect the organs. The disruption of the Th1/Th2 balance is believed to be a key event in the pathogenesis of SS. However, CD4+ T cells are seen mainly in the milder lesions, whereas the advanced cases of SS contain B lymphocytes. This automatically explains why the lymphoma that most commonly develops in SS is a B-cell lymphoma, specifically, the marginal B-zone lymphoma (a mucosa-associated lymphoid tissue type of lymphoma). Chronic antigenic stimulation of autoreactive B cells as well as t(14;18) translocation and mutations of the tumour suppressor gene *p53* are responsible for lymphomagenesis.

Autoimmune thyroid disease is of two types – Grave's disease and Hashimoto's thyroiditis. Remarkably, though both are characterized by lymphoid infiltrates in the thyroid and the production of thyroid autoantibodies, the clinical manifestations are quite different: Grave's disease presents as thyrotoxicosis, while Hashimoto's presents as hypothyroidism. As one would expect from the above facts, we learn from a Venn diagram that susceptibility genes for the two diseases include some common genes, but also some genes unique to each disease.