TAM 451, Intermediate Solid Mechanics

Instructor

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Web page of the course

http://www.mechse.uiuc.edu/research/gioia/Courses/tam451.html

Topics

(1) Mathematical Preliminaries.
Summation convention, Cartesian, spherical, and cylindrical coordinates, vectors, tensors, fields, tensor calculus, linear operators, functionals, eigenvalues and eigenvectors of second order symmetric tensors, eigenvalues as extrema of the quadratic form.

(2) Stress, Strain, Energy, and Constitutive Relations.
Cauchy stress tensor, traction, small strain tensor, compatibility. Strain energy, strain energy function, symmetries, elastic modulii.

(3) Elasticity and the Mechanics of Plastic Deformation.
Navier equations, problems with spherical symmetry and problems with cylindrical symmetry (tunnels, cavities, centers of dilatation). Anti-plane shear. Plane stress, plane strain. The Airy stress-function method in polar and Cartesian coordinates. Superposition and Green's functions. Problems without a characteristic lengthscale. Flamant's problem, Cerruti's problem, Hertz's problem. Load-induced versus geometry-induced singularities (unbounded versus bounded energies). Problems with an axis of symmetry. Disclinations, dislocations, Burgers vector, energetics; relation to plastic deformation in crystalline solids.

(4) Fracture Mechanics.
The Williams expansion, crack-tip fields and opening displacements via the Airy stress-function method (modes I, II) and via the Navier equations (mode III), crack-tip-field exponents as eigenvalues, stress intensity factors. Energy principles in fracture mechanics, load control and displacement control. Energy release rate and its relation to the stress intensity factors, specific fracture energy, size effect, stability. The Griffith crack and the Zener-Stroh crack. Anticracks.

(5) Possible Special Topics (if time allows).
Elasticity and variational calculus, nonconvex potentials, two-phase strain fields, frustration, microstructures. Stress waves in solids, P, S, and R waves, waveguides, dispersion relations, geophysical applications. Dislocation-based fracture mechanics, the Bilby-Cotterell-Swindon solution, small- and large-scale yielding, T-stress effects, crack-tip dislocation emission, the elastic enclave model. Deterministic versus statistical size effects in quasibrittle materials. Vlasov beam theory, coupled bending-torsional instabilities. Dynamic forms of instability, nonconservative forces, fluttering (Hopf bifurcation).

Homework

I will regularly assign mandatory homeworks. (In addition, I will sometimes assign optional homework.) I will post PDF files with the homework statements in the web page of the course. You must submit the mandatory homework on the due date. I will correct the homework (not necessarily all problems) and return it to you. Even though the homework will account for a large protion of your grade, the chief purpose of the homework is for you to learn, not for me to evaluate how well you have learned. If you find yourself submitting homework without the conviction that you have properly solved the problems, then you should surmise that you are not doing well. In many ways, having attained this conviction is tantamount to having learned. So, solve the problems and then discuss your approach and results with your colleagues and with me. Then perhaps modify your solutions, make them simpler or more beautiful. Iterate. Finally, submit your solutions.

Grading

I will base the grades on a final, comprehensive exam (30%), a partial exam (20%) and the homework (50%).

Office hours

After each lecture we can dicuss your questions in the classroom (or move to my office if convenient). Please approach me as soon as the lecture ends. All are wellcome to stay and participate in the discussion of any one's questions. Group discussions are a great way to learn, and I'll be able to discuss for as long as need be. We can also meet privately in my office at any other time, by appointment (for which send me an email),

Textbook

There is no textbook for this course. I expect you to take good notes during the lectures.