Solid mechanics (Prof. C. Majorana, University of Padova - frontal lessons, 30 h)

Elements of tensor calculus: tensor algebra; operations between tensor: sum / difference, tensor product, tensor composition. General coordinates. Invariants of the trasformation, covariant and contravariant, or mixed systems transformations; composition of indices. Representation of tensors in general coordinates. Tensor algebra in general coordinates. The fundamental tensor; Definition and application of Ricci tensor. Symmetric and skew-symmetric tensor. Isotropic tensor. Tensor fields in Euclidean spaces; derivative in Cartesian and General coordinates, Christoffel symbols; second derivative tensor. Differential operations of the first order: divergence of a vector, divergence of a tensor, rotor of a vector.
Geometry and kinematics of the body: rigid body motion, velocity and acceleration field. Deformation gradient tensor, Green and Finger deformation tensor, with polar decomposition. Deformation tensor in material and spatial framework.
Conservation of mass. Continuity equation. Equilibrium conditions. Energy balance: physical interpretation, local and material form. Second Law of Thermodynamics. Constitutive theory (elastic): theorem Coleman and Noll; The elastic tensor; hyperelasticity. Plasticity and viscoplasticity: classic rate-independent; irreversibility; condition of loading / unloading; plastic flow. 1D model of perfect rate-independent plasticity; plastic model with isotropic hardening; elastoplastic tangent modulus; hardening Kinematics (Effect Bauschinger). 1D model of rate-independent plasticity with isotropic hardening. The elastic-plastic problem of boundary values (BVP): local form of BVP, weak form of the BVP. Rate-independent plasticity: integration algorithms; incremental form; return-mapping algorithms. Plastic dissipation plastic; Model Duvant-generalized Lions. FEM formulation.

Suggested books

Simo, J.C., Hughes, T.J.R., *Computational Inelasticity*. Interdisciplinary Applied Mathematics, Mechanics and Materials, Springer-Verlag, New York (NY), 1998
Malvern, L.E., *Introduction to the mechanics of a continuous medium*. Prentice Hall, Englewood Cliffs (NJ), 1969.
Marsden, J.E., Hughes, T.J.R., *Mathematical Foundations of Elasticity*. Prentice Hall, Englewood Cliffs (NJ), 1983.
Gurtin, M.E., *An Introduction to Continuum Mechanics*. Mathematics in Science and Engineering, Elsevier Science, S. Diego (CA), 2003.
Finzi, B., Pastori, M., *Calcolo tensoriale e applicazioni*. Zanichelli, Bologna, 1961.
Borisenko, A.I., Tarapov, I.E., *Vector and tensor analysis with applications*. Dover Publications, New York (NY), 1980.
Bishop, R.L., Goldberg, S.I., *Tensor analysis on manifolds*. Dover Publications, New York (NY), 1980.
Kay, D.C., *Tensor calculus*. Schaum's Outlines, McGraw-Hill, New York (NY), 1988.
Young, E.C., *Vector and tensor analysis*, Series of Pure and Applied Mathematics, CRC Press, Boca Raton (FL), 1993.
Abraham, R., Marsden, J.E., Ratiu, T., *Manifolds, Tensor Analysis, and Applications*, Applied Mathematical Sciences 75, Springer, 2001.
Bathe, K.J., *Finite Element Procedures*, Prentice Hall, Upper Side River (NJ), 1996.
Hughes, T.J.R., *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Prentice Hall, 1987.
Zienkiewicz, O.C., Taylor, R.L., *The Finite Element Method; Vol. 1: The basis; Vol. 2: Solid Mechanics; Vol. 3: Fluid Dynamics*, Butterworth-Heinemann, Oxford (UK), 2000.