Geometrical Foundations of Continuum Mechanics: An Application to First- and Second-Order Elasticity and Elasto-Plasticity (Lecture Notes in Applied Mathematics and Mechanics)

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This book illustrates the deep roots of the geometrically nonlinear kinematics of generalized continuum mechanics in differential geometry. Besides applications to first-order elasticity and elasto-plasticity an appreciation thereof is particularly illuminating for generalized models of continuum mechanics such as second-order (gradient-type) elasticity and elasto-plasticity.

After a motivation that arises from considering geometrically linear first- and second-order crystal plasticity in Part I several concepts from differential geometry, relevant for what follows, such as connection, parallel transport, torsion, curvature, and metric for holonomic and anholonomic coordinate transformations are reiterated in Part II. Then, in Part III, the kinematics of geometrically nonlinear continuum mechanics are considered. There various concepts of differential geometry, in particular aspects related to compatibility, are generically applied to the kinematics of first- and second-order geometrically nonlinear continuum mechanics. Together with the discussion on the integrability conditions for the distortions and double-distortions, the concepts of dislocation, disclination and point-defect density tensors are introduced. For concreteness, after touching on nonlinear fir

st- and second-order elasticity, a detailed

discussion of the kinematics of (multiplicative) first- and second-order elasto-plasticity is given. The discussion naturally culminates in a comprehensive set of different types

of dislocation, disclination and point-defect density tensors. It is argued, that these can potentially be used to model densities of geometrically necessary defects and the accompanying hardening in crystalline materials. Eventually Part IV summarizes the above findings on integrability whereby distinction is made between the straightforward conditions for the distortion and the double-distortion being integrable and the more involved conditions for the strain (metric) and the double-strain (connection) being integrable.

The book addresses readers with an interest in continuum modelling of solids from engineering and the sciences alike, whereby a sound knowledge of tensor calculus and continuum mechanics is required as a prerequisite.

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