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Classical Continuum Thermomechanics and its Invariant Structure

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ABSTRACT. In classical continuum thermomechanics, it is natural to introduce an ordered collection of nine fields defined for each particle *X* of the body *B*, for all time t. This collection consists of the motion of *B*, the mass density as mass/present-volume, the absolute temperature, the internal energy/mass, the entropy/mass, the traction vector as force/present-area on an oriented surface whose unit normal is n, the body force/mass, the scalar contact heating/present-area on an oriented surface whose unit normal is n and the radiant heating/mass. This collection is said to define a *thermodynamic process* if it satisfies the balance of energy and the Clausius-Duhem inequality for every material part *P* contained in *B* and for all time t. The set of all thermodynamic processes is given additional structure by requiring it to satisfy two invariance axioms. The elements of classical continuum thermomechanics and these axioms, together with their many fundamental implications, are discussed in these lectures.

Continuum thermomechanics adopts the Clausius-Duhem inequality as the primitive statement of the second law of thermodynamics. Thus, these lectures will include a discussion of the implications of this inequality from the viewpoint of classical thermodynamics. Specifically, the situation of a deformable heat conducting body which is immersed in an environment (or reservoir) of uniform temperature (not necessarily constant in time) and otherwise subject to loading and heating will be examined. Interest will be directed toward the relationship between the Clausius-Duhem inequality and the well-known classical statements of the second law of thermodynamics due to CARNOT, CLAUSIUS, KELVIN and PLANCK. Efficiency and reversibility of global thermodynamic processes will be discussed as well as Carnot processes and cycles. Two elementary identities for the efficiency of a thermodynamic process will be given and a main efficiency estimate, which is sharp for reversible, Carnot processes, will be shown. A connection to the classical verbal statements of the second law will be made.

CONTENT. 1. The Body and its Configurations, **2.** The Fields and Thermodynamic Processes, **3.** Classical Implications of the Second Law, **4.** The Axiom of Translation Invariance and its Consequences, **5.** A Theorem Concerning Thermodynamic Processes, **6.** The Second Axiom of Euclidean Invariance.

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