1: Entropy and Partial Differential Equations by Lawrence C. Evans

Entropy and Partial Diï¬€erential Equations Lawrence C. Evans Department of Mathematics, UC Berkeley InspiringQuotations A good many times Ihave been present at gatherings of people who, by the standards.

Comment Entropy and Partial Differential Equations. Department of Mathematics, UC Berkeley. A good many times I have been Evans Department of Mathematics, UC Berkeley Inspiring Quotations A good many times I have been present at gatherings of people who, by the standards of traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: Snow relates that he occasionally became so provoked at literary colleagues who scorned the restricted reading habits of scientists that he would challenge them to explain the second law of thermodynamics. The response was invariably a cold negative silence. The test was too hard. Even a scientist would be hard-pressed to explain Carnot engines and refrigerators, reversibility and irreversibility, energy dissipation and entropy increase. She did gather that there were two distinct kinds of this entropy. One having to do with heat engines, the other with communication. Entropy and equilibrium A. Thermal systems in equilibrium B. Physical interpretations of the model 1. Positivity of temperature 3. Extensive and intensive parameters 4. Concavity of S 5. Convexity of E 6. Entropy maximization, energy minimization D. Review of Legendre transform 2. Entropy and irreversibility A. A model material 1. Energy and entropy a. Working and heating b. First Law, existence of E c. Existence of S 3. Adding dissipation, Clausius inequality B. Some general theories 1. Existence of S 2. Entropy, temperature and separating hyperplanes a. Conservation laws, Clausiusâ€"Duhem inequality C. Elliptic and parabolic equations A. Entropy and elliptic equations 1. Estimates for equilibrium entropy production a. A capacity estimate b. A pointwise bound 3. Entropy and parabolic equations 1. Evolution of entropy a. Second derivatives in time c. Almost reversible cycles V. Conservation laws and kinetic equations A. Some physical PDE 2 1. Compressible Euler equations a. Equations of state b. Conservation law form 2. A model for dilute gases b. H and entropy B. Single conservation law 1. A hydrodynamical limit C. Systems of conservation laws 1. Compressible Euler equations in one dimension a. Hamiltonâ€"Jacobi and related equations A. Passing to limits VII. Entropy and uncertainty A. A probabilistic model 2. Continuous time Markov chains 3 1. Generators and semigroups 2. Convergence to equilibrium B. Asymptotic evaluation of integrals C. Small noise in dynamical systems 1. An exit problem a. Small noise asymptotics b. Units and constants B. We will begin in Chapters Iâ€"III with a recounting of entropy in physics, with particular emphasis on axiomatic approaches to entropy as i characterizing equilibrium states Chapter I , ii characterizing irreversibility for processes Chapter II , and iii characterizing continuum thermodynamics Chapter III. Later we will discuss probabilistic theories for entropy as iv characterizing uncertainty Chapter VII. I will, especially in Chapters II and III, follow the mathematical derivation of entropy provided by modern rational thermodynamics, thereby avoiding many customary physical arguments. I as well draw connections with Harnack inequalities. As we will cover a lot of material from many sources, let me explicitly write out here some unifying themes: Another ongoing issue will be iv understanding the relationships between entropy and convexity. I am as usual very grateful to F. Yeager for her quick and accurate typing of these notes. Thermal systems in equilibrium We start, following Callen [C] and Wightman [W], by introducing a simple mathematical structure, which we will later interpret as modeling equilibria of thermal systems: We denote by X0 , X1 ,. Owing to 2 ii , we can solve 3 for E as a C 1 function of S, X1 ,. We call the function E the internal energy. We will later interpret 2 , 7 physically as saying the S, E are extensive parameters and we say also that X1 ,. By contrast 8 says T, Pk are intensive parameters.

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2: Entropy and Partial Differential Equations - Download link

This course surveys various uses of "entropy" concepts in the study of partial differential equations, both linear and nonlinear. This is a mathematics course, the main concern is PDE and how various notions involving entropy have influenced our understanding of PDE.

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Thermodynamics is the study of relationships in equilibrium states. Although partial differential equations, in general, apply to more than three variables, in thermodynamic equilibrium states of fixed composition, they are limited to only three. There can be more than three when multicomponent mixtures are studied. For instance, for a fixed mass or number of moles of a given gas in a single state, the relationships may be depicted as in Figure 1. This figure attempts to show a fixed mass of gas and the changes in total pressure when the temperature and the volume of the fixed mass are varied. The gas does not change state. Since changes along the equilibrium surface are governed by equation [1], we can reduce the equation so that only one partial derivative is implicated. If the temperature is fixed, this means that we are constrained to compute along a curve of constant temperature, but it allows us to drop down to a pressure where the ideal gas approximation holds. The changes in the dependent variables are mathematically described in [2]. The integrated forms of equation [2] are found in [3]. Thermodynamics, by convention, fixes the values of the variables in a reference state so that numbers may be compared. The equations of the set [3] are of help in creating these so-called absolute values only if a reference state is agreed to. For instance, common sense tells us that zero pressure could be achieved in a perfect vacuum and that zero mass or molar volume could be achieved if we reduced the dimensions of a container to zero in a perfect vacuum. Obtaining zero absolute temperature requires a stretch of the imagination. It can be visualized as that temperature that is associated with the complete cessation of molecular motion. No one has ever achieved such a low temperature. It is the state at which three phases coexist: It occurs at a fixed temperature and pressure. It is called a point because it can be depicted as the point of confluence of three interface lines on a phase diagram. These are reproducible, time-invariant states to which all substances naturally tend. Equilibrium states are found to have a fixed number of variables necessary to describe them. In the case of a single component, fixed mass or of an fixed mixture of components, the number of variables is only three. A computation or calculation path is a convenient, constrained method of estimating changes between equilibrium states. For instance, in Figure 1, temperature is fixed along the two vertical curves and volume is fixed along the horizontal curve. The final answer will be the difference between h2and h1. Departure functions represent the change at constant temperature between the values of the functions in the ideal gas and the real gas states enthalpy in [4]. Note, also, that there is some confusion in terminology between departure functions and residual functions. To the author, residual functions represent the same idea, but the change is to an hypothetical, ideal state at the same pressure and temperature as the real system. Given the above relationship between standard pressure and volume, we have four choices to define a standard state, i. The last two choices mean the standard state varies with the system pressure and volume. Actually, only one variable can be fixed, the second variable is calculated from the ideal gas relationship at the system temperature. It is yet another example of a term that is thrown around to create the impression of universal comprehension. For gases, the standard state is usually that of a pure gas single component at a reaction temperature or at the temperature of the system and at a pressure such that its fugacity is one atmosphere. It is a corrected pressure. For liquids and solids, the standard state is that of a pure component at a reaction temperature or system temperature and at a pressure of one atmosphere. Most thermochemical data is tabulated at 25 C, leading to the erroneous conclusion that this is the only temperature for the standard state. In [6], v0 must be evaluated at the temperature of the integration, T1 or T2. Note that the standard state for gases is also an ideal gas state. Its purpose is to serve as a starting point for computations. To estimate the values of departure functions we usually use equations-of-state. The convenience functions are derived from the relations given in [5]. The fundamental equation is the first equation given in [5]. See any good thermodynamics textbook for a standard derivation of these equations.

The addition of plus and minus the same integral changes nothing but it facilitates future manipulations it permits elimination of the infinity limit in second pair of integrals in the second line. The last term includes the ratio of the real molar volume to the ideal, standard-state molar volume. Note that the constraint, T, was associated with the path of integration, in other words with dv. Zero superscripts are used in [9] to represent the standard state from which the property is evaluated. Neither the entropy nor the temperature were constrained. This relationship was restricted to a constant temperature path. The third equation is similar, but is restricted to differential changes around the standard state. The fourth equation is an algebraic sum a subtraction of the previous two. The last two equations involve mathematical manipulation and substitution of the last equation of the set [7].

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4: Thermodynamic equations - Wikipedia

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The equilibrium state of a thermodynamic system is described by specifying its "state". The state of a thermodynamic system is specified by a number of extensive quantities , the most familiar of which are volume , internal energy , and the amount of each constituent particle particle numbers. Extensive parameters are properties of the entire system, as contrasted with intensive parameters which can be defined at a single point, such as temperature and pressure. The extensive parameters except entropy are generally conserved in some way as long as the system is "insulated" to changes to that parameter from the outside. The truth of this statement for volume is trivial, for particles one might say that the total particle number of each atomic element is conserved. In the case of energy, the statement of the conservation of energy is known as the first law of thermodynamics. A thermodynamic system is in equilibrium when it is no longer changing in time. This may happen in a very short time, or it may happen with glacial slowness. A thermodynamic system may be composed of many subsystems which may or may not be "insulated" from each other with respect to the various extensive quantities. If we have a thermodynamic system in equilibrium in which we relax some of its constraints, it will move to a new equilibrium state. The thermodynamic parameters may now be thought of as variables and the state may be thought of as a particular point in a space of thermodynamic parameters. The change in the state of the system can be seen as a path in this state space. This change is called a thermodynamic process. Thermodynamic equations are now used to express the relationships between the state parameters at these different equilibrium state. The concept which governs the path that a thermodynamic system traces in state space as it goes from one equilibrium state to another is that of entropy. The entropy is first viewed as an extensive function of all of the extensive thermodynamic parameters. If we have a thermodynamic system in equilibrium, and we release some of the extensive constraints on the system, there are many equilibrium states that it could move to consistent with the conservation of energy, volume, etc. The second law of thermodynamics specifies that the equilibrium state that it moves to is in fact the one with the greatest entropy. Once we know the entropy as a function of the extensive variables of the system, we will be able to predict the final equilibrium state. Callen Some of the most common thermodynamic quantities are: The conjugate variable pairs are the fundamental state variables used to formulate the thermodynamic functions.

5: Entropy and partial differential equations (Book,) [www.enganchecubano.com]

Contents: Entropy and equilibrium; Entropy and irreversibility; Continuum thermodynamics; Elliptic and parabolic equations; Conservation laws and kinetic equations; Hamilton Jacobi and related equations; Entropy and uncertainty; Probability and differential equations.

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Partial differential equations are ubiquitous in almost all applications of mathematics, where they provide a natural mathematical description of many phenomena involving change in physical, chemical, biological and social processes. The concept of entropy originated in thermodynamics and.

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8: Exact differential - Wikipedia

Abstract: The entropy evolution behaviour of a partial differential equation (PDE) in con- servation form, may be readily discerned from the sign of the local source term of Shannon information density.

9: Partial Differential Equations and Thermodynamics 04 04 06 - ISA

Lecture notes for a graduate course "Entropy and Partial Differential Equations". Survey of applications of PDE methods to Monge-Kantorovich mass transfer problems (an earlier version of which appeared in Current Developments in Mathematics,).

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