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Information Processing and the Second Law of Thermodynamics: An Inclusive Hamiltonian Approach.

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We obtain generalizations of the Kelvin-Planck, Clausius, and Carnot statements of the second law of thermodynamics for situations involving information processing. To this end, we consider an information reservoir (representing, e.g., a memory device) alongside the heat and work reservoirs that appear in traditional thermodynamic analyses. We derive our results within an inclusive framework in which all participating elements – the system or device of interest, together with the heat, work, and information reservoirs – are modeled explicitly by a time-independent, classical Hamiltonian. We place particular emphasis on the limits and assumptions under which cyclic motion of the device of interest emerges from its interactions with work, heat, and information reservoirs. Finally, our findings are illustrated with a simple, analytically solvable example – a quantum Maxwell demon.