Courses taught by Hatsopoulos/Gyftopoulos/Beretta at MIT between 1966 and 2024 on

THERMODYNAMICS and QUANTUM THERMODYNAMICS

course programs taken from the official MIT Bulletin Course Catalogues

2.452 Advanced Thermodynamics (A)
Prereq.: 2.451
Year: G (2) - ***Spring 1966*** *- from MIT Bulletin 1965-66 - The General Catalogue Issue*
Year: G (2) - ***Spring 1967*** *- from MIT Bulletin 1966-67 - The General Catalogue Issue*
Year: G (2) - ***Spring 1968*** *- from MIT Bulletin 1967-68 - The General Catalogue Issue*
Year: G (2) - ***Spring 1969*** *- from MIT Bulletin 1968-69 - The General Catalogue Issue*
3-0-9
Systems and ensembles; law of stable equilibrium; systems at positive and negative Kelvin temperatures; equilibrium of heterogeneous systems; solutions and electrolytes; gravity and electromagnetic fields; ionized gases; third law. Thermodynamics of fluctuating systems; canonical and grand-canonical ensembles; Fermi-Dirac and Bose-Einstein statistics. Thermodynamics of irreversible processes; Onsager reciprocal relations; diffusion; electronic phenomena in solids, vacua, and plasmas.
G. N. Hatsopoulos

2.452 Advanced Thermodynamics (A)
Prereq.: 2.451
Year: G (2) - ***Spring 1970*** *- from MIT Bulletin 1969-70 - The General Catalogue Issue*
3-0-9
Principles of quantum statistics; density matrix; coherence supermatrix. General definition of thermodynamic state; probabilistic and deterministic interactions; work; law of stable equilibrium; availability; entropy; principle of increase of entropy. Criterion for stability; general canonical distribution; microcanonical canonical, and rand canonical ensembles. Ideal substances; Fermi- Dirac and Bose-Einstein gases; ideal crystals; the photon gas; adsorbed layers. Theory of non-equilibrium states. Linear irreversible processes; Onsager reciprocal relations; diffusion; electronic phenomena in solids, vacua, and plasmas.
G. N. Hatsopoulos

2.47J Quantum Thermodynamics (A)
(Same subject as 22.58J)
Prereq.: 2.451, 2.461, 8.04
Year: G (2) - ***Spring 1971*** *- from MIT Bulletin 1970-71 - The General Catalogue Issue*
Year: G (2) - ***Spring 1972*** *- from MIT Bulletin 1971-72 - The General Catalogue Issue*
3-0-9
Theory of quantum thermodynamics derived from the general postulates of quantum mechanics and the second law. Definitions of state, changes of state described by unitary transformations in time, equilibrium state, stable state, and reversible processes. Definition and determination of available work and entropy for all systems and all states. Nature of irreversibility and its relation to field theory. Derivation of the general canonical distribution. Applications to bosons and fermions, and to ideal and perfect substances in stable states. Applications to general rate processes and to linear irreversible processes In gaseous, liquid, and solid phases.
G. N. Hatsopoulos, E. P. Gyftopoulos

2.47J Quantum Thermodynamics (A)
(Same subject as 22-58J)
Prereq,: 2.451, 8,04
Year: G (2) - ***Spring 1973*** *- from MIT Bulletin 1972-73 - The General Catalogue Issue*
3-0-9
A physical theory based on the general postulates of quantum mechanics and the first and second laws of classical thermodynamics. Definitions of state, changes of state described by unitary transformations in time, equilibrium state, stable equilibrium state, and reversible processes. Definitions and determinations of available work and entropy for all systems, with one or many degrees of freedom, and all states, stable equilibrium or nonstable. Nature of irreversibility and its relation to field theory. Derivation of the general canonical distribution. Applications to bosons and fermions, and to ideal and perfect substances in stable equilibrium states. Applications to general steady state rate processes and to linear processes in gaseous, liquid, and solid phases.
G. N. Hatsopoulos, E. P. Gyftopoulos

2.47J Quantum Foundations of Mechanics and Thermodynamics (A)
(Same subject as 22.58J)
Prereq.: 2.451, 8.04
Year: G (2) - ***Spring 1974*** *- from MIT Bulletin 1973-74 - The General Catalogue Issue*
Year: G (2) - ***Spring 1975*** *- from MIT Bulletin 1974-75 - The General Catalogue Issue*
3-0-9
Unified quantum approach to mechanics and thermodynamics deduced from three postulates of quantum physics and two postulates of classical thermodynamics. Definitions of state, changes of state described by unitary transformations in time, equilibrium state, stable equilibrium state, and reversible processes. Definitions and determinations of adiabatic availability, available work and entropy for all systems, with one or many degrees of freedom, and all states, stable equilibrium or nonstable. Nature of irreversibility and its relation to field theory. Derivation of the general canonical distribution. Applications to bosons and fermions, and to ideal and perfect substances in stable equilibrium states. Applications to general steady state rate processes and to linear processes in gaseous, liquid, and solid phases.
G. N. Hatsopoulos, E. P. Gyftopoulos

2.452J General Thermodynamics II (A)
(Same subject as 22.572J)
Prereq.: 2.451J or 22.571J
Year: G (2) - ***Spring 1976*** *- from MIT Bulletin 1975-76 - The General Catalogue Issue*
Year: G (2) - ***Spring 1977*** *- from MIT Bulletin 1976-77 - The General Catalogue Issue*
3-0-9
Continuation of application of thermodynamics to analysis of systems and processes, Including chemical reactions and chemical equilibria, combustion, Interfaces between phases, and plasmas. Linear rate processes and phenomenological equations. **Introduction to quantum thermodynamics** by means of a unified presentation of quantum and thermodynamic principles. Relation of second law -to irreducible quantal dispersions. Applications to special problems, including one particle system.
G. N. Hatsopoulos, E. P. Gyftopoulos

2.452J General Thermodynamics II (A)
(Same subject as 22.572J)
Prereq.: 2.451J or 22.571J
Year: G (2) - ***Spring 1978*** *- from MIT Bulletin 1977-78 - The General Catalogue Issue*
Year: G (2) - ***Spring 1979*** *- from MIT Bulletin 1978-79 - The General Catalogue Issue*
3-0-9
Continuation of application of thermodynamic principles to practical problems, followed by a presentation of **quantum statistical foundations of thermodynamics**. First part: thermodynamic analyses of ideal and nonideal solutions, electrolyte, surface phenomena, and gas-solid Interfaces; linear rate processes and phenomenological equations. Second part: Gibbsian and quantum probabilities, and corresponding definitions of states. Derivations of canonical distributions, and Bose-Einstein, Fermi-Dirac, and Boltzmann statistics, and quantum-statistics of semiperfect and perfect gases, including one-particle systems, and Einstein and Debye theories of crystals.
G. N. Hatsopoulos, E. P. Gyftopoulos

2.452J General Thermodynamics II (A)
(Same subject as 22.572J)
Prereq.: 2.451J or 22.571J
Year: G (2) - ***Spring 1980*** *- from MIT Bulletin 1979-80 - The General Catalogue Issue*
Year: G (2) - ***Spring 1981*** *- from MIT Bulletin 1980-81 - The General Catalogue Issue*
Year: G (2) - ***Spring 1982*** *- from MIT Bulletin 1981-82 - The General Catalogue Issue*
3-0-9
Continuation of application of thermodynamic principles to practical problems, followed by a presentation of **quantum statistical foundations of thermodynamics**. First part: thermodynamic analyses of ideal and nonideal solutions, electrolyte, surface phenomena, and gas-solid Interfaces; linear rate processes and phenomenological equations. Second part: Gibbsian and quantum probabilities, and corresponding definitions of states. Derivations of canonical distributions, and Bose-Einstein, Fermi-Dirac, and Boltzmann statistics, and quantum-statistics of semiperfect and perfect gases, including one-particle systems, and Einstein and Debye theories of crystals.
E. P. Gyftopoulos

2.452J General Thermodynamics II (A)
(Same subject as 22.572J)
Prereq.: 2.451J or 22.571J
Year: G (2) - ***Spring 1983*** *- from MIT Bulletin 1982-83 - The General Catalogue Issue*
3-0-9
Continuation of application of thermodynamic principles to practical problems, followed by a presentation of **quantum statistical foundations of thermodynamics**. First part: thermodynamic analyses of ideal and nonideal solutions, electrolyte, surface phenomena, and gas-solid Interfaces; linear rate processes and phenomenological equations. Second part: Gibbsian and quantum probabilities, and corresponding definitions of states. Derivations of canonical distributions, and Bose-Einstein, Fermi-Dirac, and Boltzmann statistics, and quantum-statistics of semiperfect and perfect gases, including one-particle systems, and Einstein and Debye theories of crystals.
E. P. Gyftopoulos, G. P. Beretta

2.452J Quantum Thermodynamics (A)
(Same subject as 22.572J)
Prereq.: permission of instructors
Year: G (2) - ***Spring 1984*** *- from MIT Bulletin 1983-84 - The General Catalogue Issue*
Year: G (2) - ***Spring 1985*** *- from MIT Bulletin 1984-85 - The General Catalogue Issue*
Year: G (2) - ***Spring 1986*** *- from MIT Bulletin 1985-86 - The General Catalogue Issue*
3-0-9
Non-statistical unified quantum theory of mechanics and thermodynamics for all systems, including a single particle. Equation of motion for reversible and irreversible processes. Self-contained review of necessary background. Stability of equilibrium states. Applications to fermions, bosons, black-body radiation, electrons in metals, and crystals. Nonequilibrium states. Applications to rate processes, and relaxation phenomena.
E. P. Gyftopoulos, G. P. Beretta

2.452J Quantum Thermodynamics (A)
(Same subject as 22.572J)
Prereq.: permission of instructors
Year: G (2) - ***Spring 1987*** *- from MIT Bulletin 1986-87 - The General Catalogue Issue*
Year: G (2) - ***Spring 1988*** *- from MIT Bulletin 1987-88 - The General Catalogue Issue*
3-0-9
A comparative introduction to the general foundations of classical and quantum mechanics, statistical mechanics, and thermodynamics, pinpointing structural analogies and conceptual differences. Perspectives and open questions on the significance of entropy and irreversibility. A unified quantum theory of mechanics and thermodynamics, including a novel equation of motion for irreversible processes- Examples and applications. Outline of new research opportunities. Self-contained review of necessary mathematical background.
G. P. Beretta, E. P. Gyftopoulos

2.452J Quantum Thermodynamics (A)
(Same subject as 22.572J)
Prereq.: permission of instructor
Year: G (2) - ***Spring 1989*** *- from MIT Bulletin 1988-89 - The General Catalogue Issue*
3-0-9
A comparative introduction to the general foundations of classical and quantum mechanics, statistical mechanics, and thermodynamics, pinpointing structural analogies and conceptual differences. Perspectives and open questions on the significance of entropy and irreversibility. A unified quantum theory of mechanics and thermodynamics, including a novel equation of motion for irreversible processes- Examples and applications. Outline of new research opportunities. Self-contained review of necessary mathematical background.
E. P. Gyftopoulos

2.980J Quantum Thermodynamics (A)
(Graduate Seminars in Mechanical Engineering)
Prereq.: permission of instructor
Year: G (2) - ***Spring 1990*** *- from MIT Bulletin 1989-90 - The General Catalogue Issue*
Year: G (2) - ***Spring 1991*** *- from MIT Bulletin 1990-91 - The General Catalogue Issue*
Year: G (2) - ***Spring 1992*** *- from MIT Bulletin 1991-92 - The General Catalogue Issue*
Year: G (2) - ***Spring 1993*** *- from MIT Bulletin 1992-93 - The General Catalogue Issue*
Year: G (2) - ***Spring 1994*** *- from MIT Bulletin 1993-94 - The General Catalogue Issue*
Year: G (2) - ***Spring 1995*** *- from MIT Bulletin 1994-95 - The General Catalogue Issue*
Year: G (2) - ***Spring 1996*** *- from MIT Bulletin 1995-96 - The General Catalogue Issue*
3-0-9
A comparative introduction to the general foundations of classical and quantum mechanics, statistical mechanics, and thermodynamics, pinpointing structural analogies and conceptual differences. Perspectives and open questions on the significance of entropy and irreversibility. A unified quantum theory of mechanics and thermodynamics, including a novel equation of motion for irreversible processes- Examples and applications. Outline of new research opportunities. Self-contained review of necessary mathematical background.
E. P. Gyftopoulos

2.997 Quantum Thermodynamics
(Advanced Topics in Mechanical Engineering)
Prereq.: permission of instructor
Year: G (1) - ***Fall 2007***
4-0-8
Explores the foundations of thermodynamics from a quantum theory point of view, by developing a unified theory of mechanics and thermodynamics and a general quantum equation of motion for reversible and irreversible processes from which the second law emerges as a general dynamical theorem. Topics include non-equilibrium and stable equilibrium states of qubits, qudits, and fermion and boson fields; entanglement, entropy, single-particle quantum heat engines, and open conceptual issues in quantum statistical mechanics and quantum theory of open systems. Emphasis on conceptual definitions. logical consistency, and rigorous mathematical-physics approach. The course starts with a very brief review of general thermodynamics principles. Self-contained reviews of the necessary background in classical and quantum mechanics, general thermodynamics principles and linear algebra. Graduate students from all science and engineering courses welcome.
G. P. Beretta (Visiting Professor)

2.43 Advanced Thermodynamics (New)
Graduate (Spring)
Prereq: 2.42 or permission of instructor
Year: G (2) - ***Spring 2024***
4-0-8
Self-contained concise review of general thermodynamics concepts, multicomponent equilibrium properties, chemical equilibrium, electrochemical potentials, and chemical kinetics, as needed to introduce the methods of nonequilibrium thermodynamics and to provide a unified understanding of phase equilibria, transport and nonequilibrium phenomena useful for future energy and climate engineering technologies. Applications include: second-law efficiencies and methods to allocate primary energy consumptions and CO_2 emissions in cogeneration and hybrid power systems, minimum work of separation, maximum work of mixing, osmotic pressure and membrane equilibria, metastable states, spinodal decomposition, Onsager's near-equilibrium reciprocity in thermodiffusive, thermoelectric, and electrokinetic cross effects.
G. P. Beretta (Lecturer)