

# *Introduction to 2<sup>nd</sup> Law of TD*

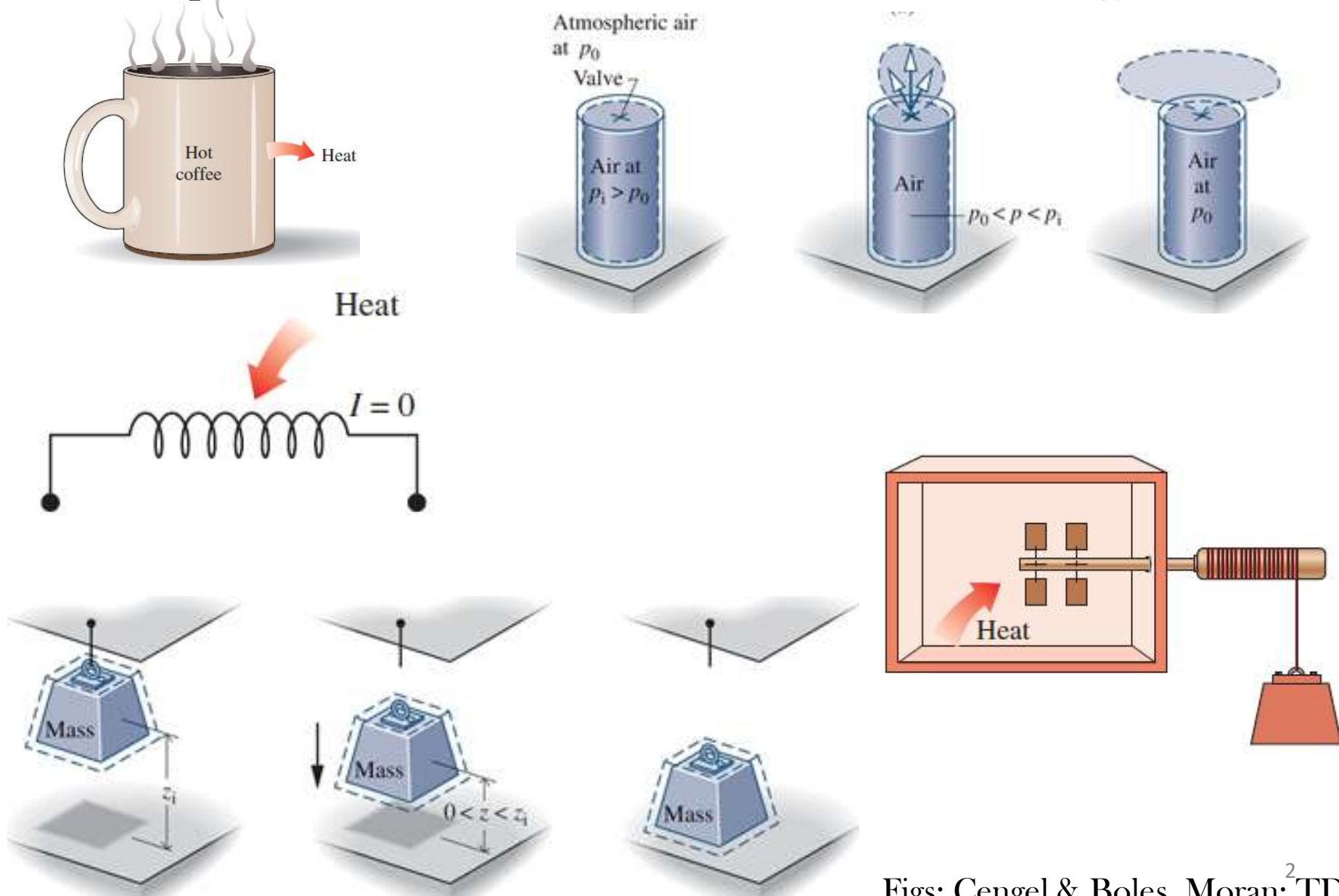
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## Beyond 1<sup>st</sup> law: Why 2<sup>nd</sup> law?

- Can all processes that do not violate conservation of energy occur?



## *Scope of 2<sup>nd</sup> law*

- Direction of processes
- Condition for equilibrium
- Potential to do work while a system tends towards equilibrium
- “Quality” of energy: Work vs. heat
- Performance of work generation and work requirements
- Temperature scales independent of properties of thermometric substances
- Connecting measured and computed properties
- Communication, Economics, Philosophy...!

## *Historical context of 2<sup>nd</sup> law*



James Watt (1736-1819)



Sadi Carnot (1796-1832)



Lazare Carnot (1753-1823)



Emile Clapeyron (1799-1864)

## *Historical events in TD (Borgnakke & Sonntag)*

Year	Person	Event
1660	Robert Boyle	$P = C/V$ at constant $T$ (first gas law attempt)
1687	Isaac Newton	Newton's laws, gravitation, law of motion
1712	Thomas Newcomen and Thomas Savery	First practical steam engine using the piston/cylinder
1714	Gabriel Fahrenheit	First mercury thermometer
1738	Daniel Bernoulli	Forces in hydraulics, Bernoulli's equation (Ch. 7)
1742	Anders Celsius	Proposes Celsius scale
1765	James Watt	Steam engine that includes a separate condenser (Ch. 9)
1787	Jaques A. Charles	Ideal-gas relation between $V$ and $T$
1824	Sadi Carnot	Concept of heat engine, hints at second law
1827	George Ohm	Ohm's law formulated
1839	William Grove	First fuel cell (Ch. 13)
1842	Julius Robert Mayer	Conservation of energy
1843	James P. Joule	Experimentally measured equivalency of work and heat
1848	William Thomson	Lord Kelvin proposes absolute temperature scale based on the work done by Carnot and Charles
1850	Rudolf Clausius and, later, William Rankine	First law of energy conservation; thermodynamics is a new science
1865	Rudolf Clausius	Shows that entropy (Ch. 6) increases in a closed system (second law)
1877	Nikolaus Otto	Develops the Otto cycle engine (Ch. 10)
1878	J. Willard Gibbs	Heterogeneous equilibria, phase rule
1882	Joseph Fourier	Mathematical theory of heat transfer
1882		Electrical generating plant in New York (Ch. 9)
1893	Rudolf Diesel	Develops the compression-ignition engine (Ch. 10)
1896	Henry Ford	First Ford machine (quadricycle) built in Michigan
1927	General Electric Co.	First refrigerator made available to consumers (Ch. 9)

# *What's next?*

- Heat Engines