

**University of New Brunswick**  
**Department of Chemical Engineering**

**UN 0702 POWER PLANT THERMODYNAMICS**

**LECTURE NOTES**

**MODULE 1**

**STEAM POWER CYCLES**

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**PREPARED BY**

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# **THERMODYNAMICS**

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# **POWER PLANT THERMODYNAMICS**

## **MODULE 1**

### **STEAM POWER CYCLES**

- 1. STEADY FLOW PROCESSES**
- 2. STEAM TABLES AND CHARTS**
- 3. THERMODYNAMIC THEORY**
- 4. COMPLEX RANKINE CYCLES**
- 5. STEAM POWER CYCLES**
- 6. STEAM CYCLE THEORY**
- 7. PLANT EFFICIENCIES**
- 8. AVAILABLE ENERGY**
- 9. HEAT EXCHANGERS**

# THERMODYNAMICS

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## Preface

**T**hermodynamics is a very powerful engineering tool, yet it is often a conceptually difficult subject for engineering students. The nineteenth century German physicist Arnold Sommerfeld (1868–1951) seemed to voice the feelings of many when he made the following comments about thermodynamics<sup>1</sup>:

Thermodynamics is a funny subject. The first time you go through the subject, you don't understand it at all. The second time you go through it, you think you understand it, except for one or two points. The third time you go through it, you know you don't understand it, but by that time you are so used to the subject, it doesn't bother you anymore.

# **LAWS OF THERMODYNAMICS**

## **ZEROTH LAW (nature of heat)**

**Two objects that are in thermal equilibrium with a third object will be in thermal equilibrium with each other.**

## **FIRST LAW (conservation of energy)**

**Energy can neither be created nor destroyed, but only converted from one form to another.**

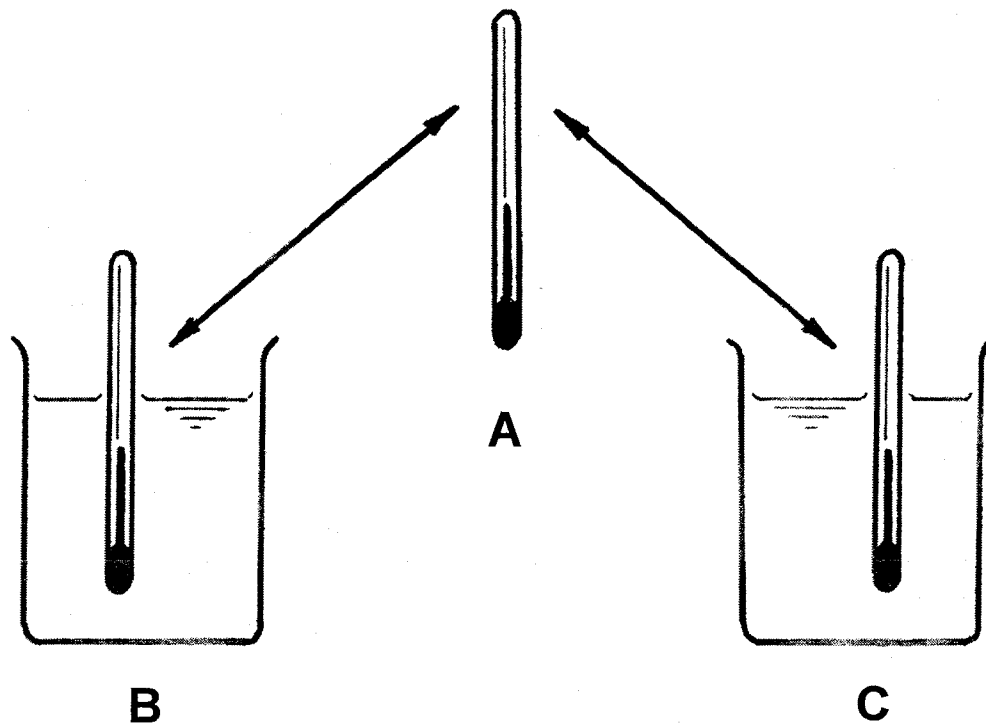
## **SECOND LAW (conversion of heat to work)**

**No heat engine can generate work without net rejection of heat to a low-temperature reservoir.**

# ZEROth LAW OF THERMODYNAMICS

(NATURE OF HEAT)

Two objects that are in thermal equilibrium with a third object will be in thermal equilibrium with each other.



"However in general you certainly cannot expect that a relation applying between A and B and between A and C will inevitably apply between B and C. Two boys who like the same girl will not necessarily like each other. Water is miscible with alcohol and so is gasoline. But gasoline and water won't mix. Thus, the Zeroth Law is a statement about the nature of the world not derivable from a more primitive or elementary proposition. It is a genuine Law that provides the basis for much of our subsequent discourse."

(John B. Fenn)

# FIRST LAW OF THERMODYNAMICS

## (CONSERVATION OF ENERGY)

Energy can neither be created nor destroyed  
but only converted from one form to another.

Therefore

$$dE = \delta Q - \delta W$$

where

$dE$  = small change in  $E$

$\delta Q$  = small amount of  $Q$

$\delta W$  = small amount of  $W$

For a system absorbing heat and doing work

$$dE = \delta Q - \delta W$$

# **SECOND LAW OF THERMODYNAMICS**

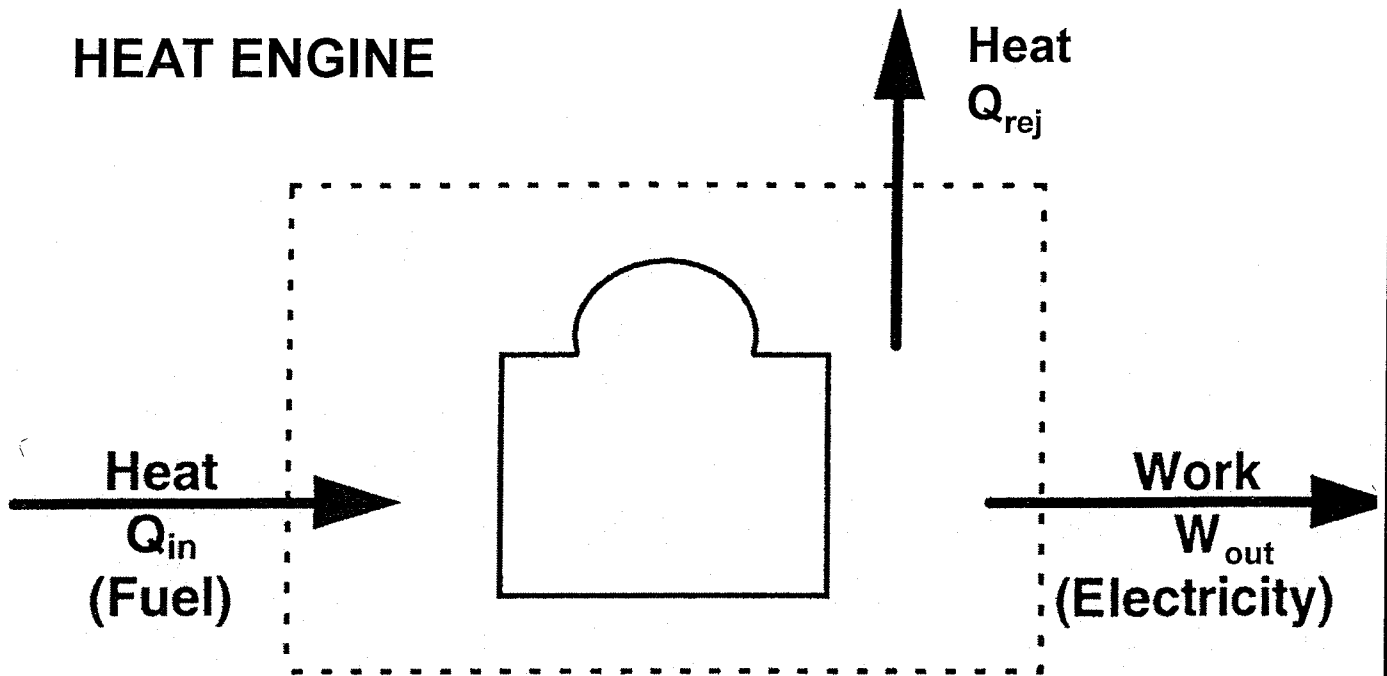
**(CONVERSION OF HEAT TO WORK)**

**No heat engine can generate work without net rejection of heat to a low-temperature reservoir.**

**If the cold reservoir could be at absolute zero (no molecular motion and hence no internal energy) then the efficiency of the carnot cycle would be 100% and all the heat would be converted into work.**

**The second law thus defines a portion of heat which is *unavailable* for conversion into work under ambient conditions.**

# HEAT ENGINE EFFICIENCY



## EFFICIENCY

$$\eta = \frac{\text{work output}}{\text{heat input}}$$

$$Q_{in} - Q_{rej} = W \quad (\text{First Law})$$

$$\eta = \frac{Q_{in} - Q_{rej}}{Q_{in}}$$

$$\eta = 1 - \frac{Q_{rej}}{Q_{in}}$$