## MESABI RANGE COMMUNITY & TECHNICAL COLLEGE – VIRGINIA/EVELETH

# Course Outline

**Course Title:** Thermodynamics
**Semester Course Prefix and Number:** ENGR 2450
**Old Quarter Course Prefix and Number:**

**Submitted By:** M. Threapleton
**Approval Date:** April 2002
**Revision Date:** April 2002

**Number of Credits:** 3
**Semester(s) Offered:**
**Negotiated Class Size:**

**Number of Lecture Credits:** 3
**Number of Lab Credits:**
**Number of Lab Hours:**
**Number of Studio/Demonstration/Internship Credits:**

---

**Course Purpose Code:**

______ **0 –** Developmental Courses
______ **1 –** Non-transferable, General Education
______ **2 –** Technical course related to career programs
______ **3 –** College course which has the primary goal of applying certain concepts (e.g. vocal ensemble)
__X__ **4 -** Other college course not considered a part of general education (MNTC) e.g. computer science, health, physical education
______ **5 –** Course which is intended to fulfill the Minnesota Transfer Curriculum (MNTC) requirements.
______ **9 –** Continuing Education/Customized Training specialized credit course (not occurring in 0-5)

**Catalog Description:**
This course covers basic thermal energy relationships, processes, and cycles. First and Second Law of Thermodynamics, entropy, and availability. This course is intended for engineering majors and includes open-ended design.

**Prerequisites and/or recommended entry skills/knowledge:**
Course Prerequisite(s): PHYS 1571 Engineering Physics I
Reading Prerequisite: None
Composition Prerequisite: None
Mathematics Prerequisite: None

**Career Programs and Transfer Majors Accessing this Course:**
Engineering transfer students in aerospace, chemical, civil, and mechanical engineering.

**Minnesota Transfer Curriculum Goal(s) partially met by this course if applicable:** Notes: No more than two goals may be met by any one course. (Curriculum Committee review and the Chief Academic Officer's approval are required).

0. __X__ None
1. _____ Communications
2. _____ Critical Thinking
3. _____ Natural Sciences
4. _____ Mathematical/Logical Reasoning
5. _____ History and the Social and Behavioral Sciences
6. _____ The Humanities and Fine Arts
7. _____ Human Diversity
8. _____ Global Perspectives
9. _____ Ethical and Civic Responsibility
10. _____ People and the Environment

**Learning outcomes, including any relevant competencies listed in the Minnesota Transfer Curriculum:**

The student will:

1. identify, define, and apply substance properties including symbols, units, and physical sense.
2. utilize conservation of mass in analysis problems.
3. use the general energy equation to derive equations for several open and closed transient and steady state systems.
4. utilize the Second Law of Thermodynamics for in-depth thermodynamics system analysis.
5. explain the operation of all covered gas and vapor cycles.
6. use general equations for thermodynamics.
7. explain avaliability.
8. complete an extensive capstone design project in a team environment and submit a professional report.

**Student assessment methods:**

The final grade is determined by grades earned on homework problems, periodic examinations, a comprehensive design project, and a comprehensive final examination.

**Use of instructional technology** (includes software, interactive video and other instructional technologies):

The students will use Microsoft Office computer software, Graphical Analysis computer software, and computer projection equipment.

**Outline of the major course content:**

I. Concepts of thermodynamics
   A. Definitions
      1. Systems: closed, open, and isolated
      2. Property, equilibrium, state, and process
      3. Point and path functions and cycles
   B. Units and dimensions
   C. Pressure
   D. Temperature
   E. Heat
   F. Work

II. Properties of substances
   A. Definitions
      1. Extensive and intensive properties
      2. Physical and thermodynamic properties
      3. Homogeneous substances and phases
   B. The state postulate
   C. The total energy
      1. Kinetic energy
      2. Potential energy
      3. Internal energy
      4. Enthalpy
   D. Equlibrium diagrams
   E. Properties of pure substances
      1. The superheated-vapor region
      2. The compressed- or subcooled-liquid region
      3. The liquid vapor saturation region
   F. Specific heats
   G. Ideal gases
      1. Ideal gases with linearly varying specific heats
      2. Ideal gases with constant specific heats
      3. Polytropic processes for ideal gases

H. incompressible substances
I. Approximation of properties for compressed-liquid states

III. Conservation of mass
  A. General conservation of mass equation
  B. Conservation of mass for closed systems
  C. Conservation of mass for open systems
    1. Uniform flow
    2. Steady state
    3. Transient analysis

IV. Conservation of energy
  A. General conservation of energy equation
  B. Problem organization for analysis of thermodynamic systems
  C. Conservation of energy for closed systems
  D. Conservation of energy for open systems
    1. Uniform flow
    2. Steady state
    3. Transient analysis
  E. Introduction to simple thermodynamic cycles

V. Entropy and the Second Law of Thermodynamics
  A. Reversible and irreversible processes
  B. Thermal-energy reserviors
  C. The Clausius Statement and the Second Law of Thermodynamics: heat engines
  D. Carnot's Principle and the thermodynamic temperature scale
  E. The Clausius inequality and entropy
  F. The T ds equations
  G. The entropy change for ideal gases
    1. Arbitrary processes for ideal gases
    2. Isentropic processes for ideal gases
  H. The entropy change for incompressible substances
  I. The entropy change for pure substances
  J. The increase-in-entropy principle
  K. The Carnot Cycle

VI. Second-law analysis of thermodynamic systems
  A. A general expression for the total rate of entropy change
  B. Reversible work and irreversibility
  C. Maximum work and availability
  D. Second-law analysis of closed systems
  E. Second-law analysis of open systems
    1. Steady state
    2. Transient systems

VII. Gas cycles
  A. Basic considerations
  B. Ideal and actual cycles
  C. Air-standard assumptions
  D. Gas Carnot Cycle
  E. Stirling and Ericsson Cycles
  F. Ideal Otto Cycle
  G. Ideal Diesel Cycle
  H. Ideal Brayton Cycle
  I. Ideal Brayton Cycle with regeneration
  J. Ideal jet-propulsion cycles
  K. Ideal Brayton Cycle with intercooling and reheating
  L. Ideal refrigeration cycle
  M. Actual gas cycle

VIII. Vapor cycles
    A. Ideal Rankine Cycle
    B. Ideal Rankine Cycle modified with reheat
    C. Ideal Rankine Cycle modified with regeneration
    D. Ideal vapor-compression refrigeration cycle
    E. Actual vapor cycles
IX. Thermodynamic relationships
    A. Mathematical preliminaries
    B. The Gibbs Equations and the Maxwell Relations
    C. General equations for du, dh, and ds
        1. Internal energy
        2. Enthalpy
        3. Entropy

**Additional special information** (special fees, directives on hazardous materials, etc.)
A scientific calculator with exponential and logarithmic capabilities is required for this course. Engineer's paper will be required for all homework assignments.

**Transfer Information:** (Please list colleges/majors that accept this course in transfer.)
University of Minnesota; University of Minnesota-Duluth; Minnesota State University, Mankato; St. Cloud State University; Michigan Technological University; North Dakota State University; University of North Dakota all accept for engineering majors.

**Approvals:**

| Body | Representative Signatures | Date |
|---|---|---|
| Curriculum Committee | Kim Giermann | |
| Faculty Association | Georgia Suoja | |
| Meet and Confer | Jill Peterson | |
| Chief Academic Officer | Jill Peterson | |

Distribution: Original – Administrative Office, Library, Learning Center, Records, Student Services, Curriculum Committee Chair