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**SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY**

**SAULT STE. MARIE, ONTARIO**

# COURSE OUTLINE

**COURSE TITLE:** HEAT TRANSFER IN UNIT PROCESSES

**CODE NO.:** PPE 250-4 **SEMESTER:** IV

**PROGRAM:** PULP AND PAPER ENGINEERING TECHNOLOGY

**AUTHOR:** JACK BETHUNE

**DATE:** MAY 1994 **PREVIOUS OUTLINE DATED:** NEW

**APPROVED:**

DEAN DATE

HEAT TRANSFER IN UNIT PROCESSES — PPE 250-4

**COURSE NAME** — **COURSE NUMBER**

**TOTAL CREDIT HOURS: 64** HRS

**PREREQUISITE(S)**: NONE

## I. PHILOSOPHY/GOALS:

The effective use and conservation of energy is one of the routes to cost effectiveness in any process operation. Knowledge of the underlying theories of heat transfer and their application will allow technologists to play a more useful roll in process operation, modification and evaluation. This course deals with the underlying theories and applications of heat transfer that relate to unit processes involved in pulp and paper manufacture. Examples of topics to be covered include a review of the physics of heat, temperature, and basic laws plus the theory and application of theory of combustion, heat exchangers, and evaporators.

## II. STUDENT PERFORMANCE OBJECTIVES:

Upon successful completion of this course the student will:

1. Be able to define heat and thermal energy in terms of molecular activity.

2. Be able to define and use the following terms: Ice Point, Boiling Point, Steam Point and Triple Point.

3. Be able to define and use common units of heat energy such as the calorie and British Thermal Unit.

4. Be able to calculate heat capacity and specific heat of materials.

5. Be able to apply the concept of thermal expansion by performing calculations and solving problems.

6. Be able to define and similarly apply concepts related to phase changes, heat of fusion, heat of vaporization, vapour pressure, humidity and P-V-T diagrams.

7. Be able to identify and use the components of material and energy balances to solve problems.

8. Be able to apply the theories represented in the Ideal Gas Law, Boyle's Law, Charles' Law and Gay-Lussac's Law to practical problems.

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**II. STUDENT PERFORMANCE OBJECTIVES:** (continued)

9. Be able to differentiate between characteristics of Ideal and Van der Waal's gasses and also be able to correctly apply these theories.

10. Be able to state the laws of thermodynamics.

11. Be able to define entropy and enthalpy and be able to use these concepts in the solution of practical problems.

12. Be able to describe the difference between complete and incomplete combustion.

13. Be able to calculate air/fuel ratios for various combustion situations.

14. Be able to apply the principles of chemical stoichiometry to calculations of air/fuel ratios as required.

15. Be able to calculate Boiler Efficiency values for various industrial combustion situations.

16. Be able to trace the flow of boiler feedwater through a typical furnace generating superheated steam for electrical generation.

17. Be able to describe differences in heat flow measurements due to conduction, connection and radiation.

18. Be able to compute heat flow rates for a variety of different scenarios.

19. Be able to describe and differentiate between various types of equipment commonly used in heat transfer processes.

20. Be able to state the relative advantages and disadvantages of heat transfer equipment types.

21. Be able to describe the most important properties of evaporating liquids.

22. Be able to describe and differentiate between types of evaporating equipment.

23. Be able to define and use the common measures of evaporator performance: capacity, economy and steam consumption.

24. Be able to describe and evaluate differences between single and multiple - effect evaporator systems.

25. Be able to describe the use and function of reboilers and vapour recompression systems.

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| **III. TOPICS TO BE COVERED:** | **Approximate Time Frames** |
|---|---|
| 1. Heat and Temperature | 3 weeks |
| 2. Some Basic Laws | 3 weeks |
| 3. Combustion | 3 weeks |
| 4. Flow of Heat | 4 weeks |
| 5. Evaporation | 3 weeks |

| **IV. LEARNING ACTIVITIES** | **REQUIRED RESOURCES** |
|---|---|
| 1: Heat and Temperature<br>1.0 Introduction<br>1.1 Heat and Thermal Energy<br>1.2 Temperature Scales<br>1.3 Units of Heat Energy<br>1.4 Heat Capacity and Specific Heat<br>1.5 Basic Calorimetry<br>1.6 Thermal Expansion<br>1.7 Phases and Phase Change<br>1.8 Heat of Combustion | Course Manual for PPE 250<br>Unit 1, pages 1 - 29 |
| 2: Some Basic Laws and Other Tools<br>2.0 Introduction<br>2.1 Material Balances<br>2.2 Types of Balances<br>2.3 Ideal Gases<br>2.4 Kinetic Theory<br>2.5 Real Gases | Course Manual for PPE 250<br>Unit 2, pages 30 - 53 |
| **TEST 1** | **PAGES 1 - 53** |
| 2.6 Law of Motion<br>2.7 Energy Balances<br>2.8 Thermodynamics<br>2.9 Entropy<br>2.10 Basic Cyclic Processes<br>2.11 Total Energy Equation | Course Manual for PPE 250<br>Unit 2, pages 54 - 74 |

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| **IV. LEARNING ACTIVITIES** (continued) | **REQUIRED RESOURCES** |
|---|---|
| 3: Combustion<br>3.0 Introduction<br>3.1 Theory of Combustion<br>3.2 Burner Types<br>3.3 Boiler Efficiency<br>3.4 Types and Designs of Furnaces | Course Manual for PPE 250 Unit 3, pages 79 - 86 |
| 4: Flow of Heat<br>4.0 Introduction<br>4.1 Conduction<br>4.2 Conduction and Convection<br>4.3 Heat Transfer Coefficients<br>4.4 Extended Surfaces<br>4.5 Convection | Course Manual for PPE 250 Unit 4, pages 87 - 103 |
| **TEST 2** | **PAGES 54 - 103** |
| 4.6 Heat Transfer from Condensing Vapours<br>4 Heat Exchanger Equipment<br>4 8 Radiation | Course Manual for PPE 250 Unit 4, pages 104 - 113 |
| 5: Evaporation<br>5.0 Introduction<br>5.1 Evaporator Operations<br>5.2 Types of Evaporators<br>5.3 Evaporator Performance and Capacities<br>5.4 Single Effect Calculations<br>5.5 Multiple Effect Evaporation<br>5.6 Multiple Effect Calculations<br>5.7 Reboilers<br>5.8 Vapour Recompression | Course Manual for PPE 250 Unit 5, pages 117 - 137 |
| **TEST 3** | **PAGES 104 - 137** |

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## V. EVALUATION METHODS:

A final grade will be derived from the results of three tests and four assignments as calculated below.

| | |
|---|---|
| Test 1 | 25% |
| Test 2 | 25% |
| Test 3 | 25% |
| Assignments | 25% |

Letter grades will be assigned as follows:

A+ = 90 - 100%
A = 80 - 89%
B = 70 - 79%
C = 60 - 69%
R = Less than 60%

Students having a final standing of "R" and who have a course average of at least 55%, and who have attended 85% or more of the lecture hours, may be permitted to write a full course supplementary exam for a maximum C grade.

## VI. REQUIRED STUDENT RESOURCES:

Bethune, J. and Sugden, A. Heat Transfer in Unit Processes, Course Manual for PPE 250, (Available in College Bookstore)

## VII. ADDITIONAL RESOURCE MATERIALS AVAILABLE IN THE COLLEGE LIBRARY BOOK SECTION:

The course manual lists sixteen reference texts in the bibliography section. Most of these are available in the college library.

## VIII. SPECIAL NOTES:

Students with special needs (e.g. physical limitations, visual impairments, hearing impairments, learning disabilities) are encouraged to discuss required accommodations confidentially with the instructor.

Your instructor reserves the right to modify the course as he/she deems necessary to meet the needs of students.

Sault College

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