UNIT OPERATIONS I W/LAB
CHT 2450

Class Hours: 3.0
Credit Hours: 4.0
Laboratory Hours: 3.0
Date Revised: Fall 01

NOTE: This course is not designed for transfer credit.

Catalog Course Description:
A study of fluid statics and dynamics and heat transfer. Topics include manometers, flow measurements, laminar and turbulent flow, viscosity, Reynolds number, pressure drop in pipes, fittings and valves, pumps, net positive suction head (NPSH), and velocity of falling particles. Heat transfer topics include conduction, natural and forced convection and heat exchangers. The laboratory will consist of experiments demonstrating the principles of unit operations. Emphasis will be placed on assembly and proper operation of the equipment. Detailed reports of experiments will be prepared.

Entry Level Standards:
Entering students should have familiarity with mass and energy balances for open systems.

Prerequisites:
CHT 1330

Textbook(s) and Other Reference Materials Basic to the Course:
Reference Materials:

I. Week/Unit/Topic Basis:

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1</td>
<td>Fluid statics; manometers and pressure measurement</td>
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<tr>
<td>2</td>
<td>Mass and energy balances on flowing fluids</td>
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<tr>
<td>3</td>
<td>Laminar, turbulent, sonic and Knudsen flows</td>
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<tr>
<td>4</td>
<td>Dimensionless parameters for fluid flow</td>
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<tr>
<td>5</td>
<td>Calculation of pressure drops for pipeline flow</td>
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<tr>
<td>6</td>
<td>Pressure drops through orifices, fittings, and valves</td>
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</tbody>
</table>
Types of pumps and net positive suction head requirements. Use of catalog library for information on products and suppliers.

Compression, blower and jets; compressible fluids

Types of flowmeters and the theory of operation

Heat transfer by radiation

Heat conduction

Heat conduction

Unsteady state heat transfer

Heat transfer film coefficients

Natural convection

Final Exam

II. Course Objectives*:

A. Measure pressure differential using a manometer containing one or more fluids. I, II, III, V

B. Calculate the pressure drop in a piping system for an incompressible fluid. I, II, III

C. Demonstrate an understanding of the net positive suction head (NPSH) requirement for various types of pumps. I, II, III

D. Calculate flowrate in a pipe using pressure drop across a head meter. I, II, III

E. Calculate terminal velocity for spherical particles falling in a fluid. I, II, III

F. Calculate heat transfer by conduction through a wall made of several different materials. I, II, III

G. Calculate the rate of heat transfer for given heat exchangers in common services. I, II, III

H. Select the appropriate type of heat exchanger for a particular application. I, II

I. Calculate unsteady state heat transfer rate using graphs for common shapes. I, II, III

J. Demonstrate methods of performing tests in a systematic manner by staging equipment and materials needed, checking inventories of parts and materials, assisting in procuring materials and maintaining an industrial style research notebook covering all experimental work. I, II, III, IV

*Roman numerals after course objectives reference goals of the CHT program.

III. Instructional Processes*:

Students will:

1. Attend lectures and discuss concepts. Communication Outcome, Problem Solving and Decision Making Outcome, Information Literacy Outcome, Active Learning Strategy
2. Solve assigned problems out of class and be prepared to discuss the problem solutions. Communication Outcome, Problem Solving and Decision Making Outcome, Numerical Literacy Outcome, Information Literacy Outcome, Active Learning Strategy

3. Participate in laboratory experiments which are direct applications of the concepts studied. Communication Outcome, Problem Solving and Decision Making Outcome, Technological Literacy Outcome, Information Literacy Outcome, Active Learning Strategy, Transitional Strategy

4. Work as part of a group to perform laboratory experiments and collect data. Communication Outcome, Personal Development Outcome, Problem Solving and Decision Making Outcome, Cultural Diversity and Social Adaptation Outcome, Technological Literacy Outcome, Information Literacy Outcome, Active Learning Strategy

5. Maintain a research style lab notebook. Communication Outcome, Information Literacy Outcome, Active Learning Strategy

6. Prepare a formal written report will be prepared comparing the students' experimental results and the results expected from the published correlations. Communication Outcome, Information Literacy Outcome, Active Learning Strategy

7. Make an oral report on a pump type that is not covered in the lecture and will obtain information for the report from the library, manufacturers catalogs and the Internet. Communication Outcome, Technological Literacy Outcome, Information Literacy Outcome, Active Learning Strategy

*Strategies and outcomes listed after instructional processes reference Pellissippi State’s goals for strengthening general education knowledge and skills, connecting coursework to experiences beyond the classroom, and encouraging students to take active and responsible roles in the educational process.

IV. Expectations for Student Performance*:

Upon successful completion of this course, the student should be able to:

1. Calculate pressure as a function of depth and density of a fluid. A

2. Calculate pressure differential in fluids by summing the contribution of each of several immiscible fluids of known density. A

3. Calculate the fluid head equivalent to one atmosphere pressure for various fluids. A

4. Calculate Reynolds number. B

5. Determine the Fanning friction factor by an iterative method using a computer spread sheet and also from a graph of friction factor vs. Reynolds number. B

6. Calculate pressure drop in a pipe using the Fanning equation. B

7. Calculate pressure drop in pipe fittings, contractions and expansions. B

8. Apply the total energy balance equation to determine pressure at various points in a piping system. B

9. Calculate centrifugal pump pressure differential using a pump curve obtained from the catalog library or other source of vendor information. B

10. Demonstrate understanding of the functioning of various types of pumps--including
centrifugal pumps, gear pumps, and piston pumps. Use the catalog library and other sources of vendor information.  

11. Calculate NPSH (net positive suction head) for pumps in various piping arrangements and flow rates. Use the catalog library and other sources of vendor information.  

12. Calculate maximum fluid head attainable for a centrifugal pump based on impeller diameter and RPM. Use the catalog library and other sources of vendor information.  

13. Demonstrate an understanding of the principles used in orifice meters, venturi meters, pitot tubes and rotameters.  

14. Calculate the pressure drop through a frictionless orifice.  

15. Determine orifice coefficient using correlation of coefficient vs. Reynolds number.  

16. Calculate the permanent pressure drop across an orifice.  

17. Explain the advantages and disadvantages of different pressure tap arrangements for orifice meters.  

18. Calculate Reynolds number for falling particles (unhindered).  

19. Calculate terminal velocity of spherical particles from the appropriate equation.  

20. Determine terminal velocity from table of particle characteristics.  

21. Use Fourier's law to calculate heat transfer through a homogeneous body.  

22. Understand the concept of thermal resistance and calculate thermal resistance for flat homogeneous bodies.  

23. Calculate log mean area for cylindrical objects.  

24. Calculate heat transfer for several resistances in series.  

25. Calculate Nusselt's number and Reynolds number to determine heat transfer film coefficients.  


27. Demonstrate an understanding of cocurrent and countercurrent flow in a heat exchange.  

28. Calculate log mean temperature difference for a heat exchanger.  

29. Determine correction factor for log mean temperature for mixed flow heat exchangers using correction factor charts.  

30. Determine overall heat transfer coefficient from experimental data.  

31. Locate typical overall heat transfer coefficient in literature.  

32. Describe methods of construction used to minimize the problem of the difference in thermal expansion of the shell and tubes in shell and tube heat exchangers.  

33. Describe various types of heat exchangers and explain the advantages and disadvantages of
34. Understand the terminology of tubular heat exchangers and the characteristics of tubing. H

35. Describe the two types of pipe tracing (steam and electrical) and explain the advantages and disadvantages of each type. H

36. Calculate dimensionless temperature and dimensionless time for unsteady state heat transfer. I

37. Select curves from literature for simple shapes that best approximate the actual shapes for an unsteady state heat transfer problem. I

38. Calculate unknown quantities from appropriate dimensionless groups and curves in the literature for unsteady state heat transfer. I

39. Plan for each laboratory experiment by reviewing materials needed and comparing needs with the inventory of materials and equipment in the laboratory. J

40. Demonstrate how to assist in the preparation for each laboratory experiment by identifying suppliers of needed equipment and supplies and listing what is needed and where it may be found. J

41. Maintain an industrial style research notebook and record all laboratory work in a manner that will simulate industrial practice. J

*Letters after performance expectations reference the course objectives listed above.

V. Evaluation:

A. Testing Procedures: 30% of grade

The student's progress will be evaluated by 3 exams and an additional comprehensive final exam (30% of grade).

B. Laboratory Expectations: 25% of grade

The laboratory work will comprise 25% of the course grade and the grade will be based on the laboratory notebook.

Week Experiments

1 Fluid statics - manometers and pressure vs. depth and fluid density.
2 Pressure changes in ducts of different diameters. Bernoulli equation.
3-4 Friction loss in air flow through pipes and fittings.
5 Calibration of a rotameter.
6-8 Friction loss in water flow through straight pipes at varying flow rates.
9-10 Pump curve - a centrifugal pump will be operated at varying flow rates so that a pump curve (pressure vs. flow rate) is obtained. The equipment and piping will be set up by students.
11 Types of pumps - centrifugal pumps, gear pumps, vane pumps and piston pumps will be operated and characteristics of various pump types observed.
Determination of thermal conductivity

Shell and Tube Heat Exchangers - Hot water and cold water will be passed through a heat exchanger and the overall heat transfer coefficient will be determined. The equipment and piping will be set up by students.

C. Field Work: 45% of grade

Outside readings and library research will be required in this course. A research report is worth 35% of the grade and will include an oral presentation. Homework assignments are an important part of this course and all homework assignments completed and submitted will be graded "A" and will comprise up to 10% of the course grade (as calculated below).

D. Grading Scale:

The course numerical grade will be calculated using the formula below:

\[ G = 10 \times \frac{H}{HM} + 0.35 \times \frac{T(1) + T(2) + \ldots + T(N)}{N} + 0.3 \times F + 0.25 \times L}{0.9 + 0.1 \frac{H}{HM}} \]

where
- \( G \) = the numerical grade
- \( H \) = the homework grade
- \( HM \) = the maximum homework grade attainable
- \( T(i) \) = the grade on exam number \( i \) (Research papers are included in this category.)
- \( N \) = number of exams and research papers (excluding the final exam)
- \( F \) = the grade on the final exam
- \( L \) = the laboratory grade.

Letter grades will be awarded based on the following schedule:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Range</th>
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<tbody>
<tr>
<td>A</td>
<td>90 – 100</td>
</tr>
<tr>
<td>B+</td>
<td>87 – 89</td>
</tr>
<tr>
<td>B</td>
<td>80 – 86</td>
</tr>
<tr>
<td>C+</td>
<td>77 – 79</td>
</tr>
<tr>
<td>C</td>
<td>70 – 76</td>
</tr>
<tr>
<td>D</td>
<td>60 – 70</td>
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<tr>
<td>F</td>
<td>below 60</td>
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VI. Policies:

A. Attendance Policy:

Pellissippi State Technical Community College expects students to attend all scheduled instructional activities. As a minimum, students in all courses must be present for at least 75 percent of their scheduled class and laboratory meetings in order to receive credit for the course (Pellissippi State Catalog). Individual departments/programs/disciplines, with the approval of the vice president of Academic and Student Affairs, may have requirements that are more stringent.

Chemical/Environmental Engineering Technology Program:

Regular attendance in this course is required. Students who miss the equivalent of 10% of either classroom hours or laboratory may, at the discretion of the instructor, have their course
grade dropped by one letter. Students who arrive late for a class after the roll as been called have the responsibility of seeing the instructor after class the change their status from A (absent) to T (tardy).

B. Academic Dishonesty:

In keeping with college-wide policies, the student is expected to adhere to the general rules and regulations relevant to academic and classroom misconduct as outline in the catalog.