McMaster University
Dept. of Mechanical Engineering

ME 4V03 – THERMO-FLUIDS SYSTEMS DESIGN AND ANALYSIS

Fall 2019

OBJECTIVES/RATIONALE: *The objective of the course is to integrate material learnt in prior themo-fluid courses, and to provide students with an introduction to system-oriented design methods. The design, operation and performance of mechanical equipment commonly used in thermo-fluid systems will be reviewed. Methods in system simulation and optimization will be introduced. Prior courses in Thermodynamics, Fluid Mechanics and Heat Transfer are a prerequisite for this course.*

LEARNING OUTCOMES: Upon successful completion of the course the students will be expected to have demonstrated the ability to:

1. Analyze fluid systems and design piping systems and select appropriate pumps.
2. Analyze and select heat exchangers for thermal systems.
3. Perform system analysis and obtain performance characteristics of common thermal systems.
4. Model and perform system simulation of thermal systems.
5. Optimize thermal system performance under different constraints.
6. Integrate exergy analysis into system performance.

INSTRUCTOR:
Dr. C.Y. Ching
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LECTURES:
Tuesday 12:30 – 13:20
Wednesday 12:30 – 13:20
Friday 12:30 – 13:20

TUTORIAL: Wednesday 11:30 – 12:20

OFFICE HOURS: Tuesday and Wednesday 14:30 - 15:30 or anytime I'm in my office.

HOMEWORK

Homework problem-solving is an essential element of this course. Individual work is required on all problems. Over the course of the semester, 10 homework sets are planned. Homework is due by 4:00 p.m. on the date assigned. Late submissions will not be accepted. Solutions to the homework will be posted on the course site on AVENUE.

TESTS AND EXAMINATIONS

There will be two in-class tests and a final examination. The material to be covered in each test and exam will be cumulative.

GRADING SYSTEM
Final grades will be determined by the following weighting of homework, tests and final exam.

Homework	10%
Test I	20%
Test II	20%
Final Exam	50%
Final Grade	***100%***

ACADEMIC INTEGRITY
You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at www.mcmaster.ca/academicintegrity.

Course Outline

1. Review of Piping Systems, Pumps and Compressors

- 1.1 Fundamental Equations, Friction Factors, Head Losses
- 1.2 Valves and Fittings
- 1.3 Types of Pumps and Pump Characteristics
- 1.4 Cavitation and Net Positive Suction Head
- 1.5 Pump-System Operation

2. Heat Exchangers

- 2.1 Review of Heat Transfer
- 2.2 Types of Heat Exchangers
- 2.3 Analysis of Heat Exchangers

3. Power Generation Systems

- 3.1 Review of Thermodynamics
- 3.2 Vapor Power Systems
- 3.3 Gas Power Systems
- 3.4 Other Power Systems

4. Exergy Analysis

- 4.1 Exergy of Systems
- 4.2 Closed and Open System Exergy Balance
- 4.3 Exergetic Efficiency
- 4.4 Thermoeconomics

5. Thermal Systems Design

- 5.1 The Design Process
- 5.2 Life-Cycle Design
- 5.3 Thermal System Design Aspects
- 5.4 Environmental, Safety and Reliability Aspects

6. System Simulation and Optimization

- 6.1 Modeling Thermal Equipment
- 6.2 Description of System Simulation
- 6.3 Methods of Simulation
- 6.4 Simulation of Thermal Systems
- 6.5 Optimization Procedures

7. Design Optimization and System Performance Evaluation

- 7.1 Thermodynamic Optimization
- 7.2 Economic Optimization
- 7.3 Design Evaluation
- 7.4 Performance Evaluation

Suggested Texts

Introduction to Fluid Mechanics, Fox, R.W., McDonald, A.T and Pritchard, P.J.
Fundamentals of Engineering Thermodynamics, M. Moran and H. Shapiro.
Introduction to Heat Transfer, Incropera, F.P., Dewitt, D.P.
Design and Optimization of Thermal Systems, Jaluria, Y.
Thermal Design and Optimization, Bejan, A., Tsatsaronis, G. and Moran, M., J.
Design of Fluid Thermal Systems, Janna, W.S.
Design of Thermal Systems, Stoecker, W.F.

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NOTES ON HOMEWORK SOLUTIONS

Homework policies/procedures

1. Homework is due by 4:00 p.m on the date assigned.
   Late submissions will not be accepted.

2. Solutions to the Homework problems will posted on the course site on AVENUE.

3. Performance on homework assignments comprise 10% of a student's final grade; consequently individual work is required on all homework problems. Students are encouraged to discuss with one another the general principles involved in the homework sets, but solutions to each problem must be attempted individually. Duplicate solutions indicating copying among students will be considered cheating and will be dealt with strictly.

Homework format

1. Use 8-1/2 x 11 paper, and write on one side only.

2. Start each problem on a new page.

3. Clearly label each step of the solution (KNOWN, FIND, SCHEMATIC, ASSUMPTIONS , ANALYSIS etc.)

4. Develop the analysis as far as possible before substituting numerical values.
   If possible, give the answer algebraically before computing the final numerical answer.

5. Clearly indicate your final answer.
   Be sure to include appropriate units.

6. Attach a listing of any computer program(s) used in the solution.

Homework grading

Most problems will be graded on a 10-point scale, with points awarded in the following typical distribution.

Use of proper paper, format;steps clearly labeled	1
Schematic, complete with appropriate control volume	1
Appropriate assumptions	1
Clearly-developed and correct analysis	5
Algebraic solution (if possible)	1
Numerical result (if required), with appropriate units	1

Thermo-Fluids Systems Design and Analysis - Fall 2019

PERIOD	DATE	TOPIC	
1	Tue Sep 03	Introduction to Thermal System Design	
2	Wed Sep 04	Review Piping Systems	
3	Fri Sep 06	Fluid Machinery	
4	Tue Sep 10	Turbomachinery Analysis/Euler Turbomachine Equation	
5	Wed Sep 11	Performance Characteristics	
6	Fri Sep 13	Fluid Systems	
7	Tue Sep 17	Review/Heat Transfer Fundamentals	
8	Wed Sep 18	Double Pipe Heat Exchangers	
9	Fri Sep 20	Shell and Tube Heat Exchangers	
10	Tue Sep 24	Design of Heat Exchangers	
11	Wed Sep 25	Review/Thermodynamic Principles	
12	Fri Sep 27	Vapor Power Systems, Rankine Cycles	
13	Tue Oct 01	Superheat and Reheat /Regenerative Vapor Power Cycles, Binary Cycles	
14	Wed Oct 02	Gas Power Systems, Internal Combustion Engines	
15	Fri Oct 04	Otto and Diesel Cycles/Air-Standard Dual Cycle	
16	Tue Oct 08	**MID TERM TEST I**	
17	Wed Oct 09	Gas Turbines, The Brayton Cycle	
18	Fri Oct 11	Regenerative Gas Turbines	
19	Tue Oct 22	Gas Turbines for Aircraft Propulsion	
20	Wed Oct 23	Vapor-Compression Refrigeration Cycles	
21	Fri Oct 25	Heat Pumps, Gas Refrigeration Systems	
22	Tue Oct 29	Exergy of Systems	
23	Wed Oct 30	Exergy Balance	
24	Fri Nov 01	Exergetic Efficiency	
25	Tue Nov 05	Thermoeconomics	
26	Wed Nov 06	Thermal System Design	
27	Fri Nov 08	Design Considerations/Codes and Standards	
28	Tue Nov 12	Modeling Thermal Equipment	
29	Wed Nov 13	Overview of System Simulation	
30	Fri Nov 15	Methods of System Simulation	
31	Tue Nov 19	**MID TERM TEST II**	
32	Wed Nov 20	System Simulation Programs	
33	Fri Nov 22	System Optimization	
34	Tue Nov 26	Optimization Procedures	
35	Wed Nov 27	Lagrange Multiplier Methods	
36	Fri Nov 29	Review	
37	Tue Dec 03	Review	
38	Wed Dec 04	Review	