TEXAS A&M UNIVERSITY – CORPUS CHRISTI
MEEN-4360: THERMAL SYSTEM DESIGN
SPRING 2014

I. COURSE INFORMATION

COURSE PREREQUISITE: MEEN 3345 or Consent of Instructor
Meeting Times & Place: Lecture MW 2:00-3:15 p.m., EN-214

II. PROFESSOR INFORMATION
Instructor: Andrew Conkey PhD
Office: EN 219 Phone: 825-2559
Email: andrew.conkey@tamucc.edu
Office Hours: TBD, by appointment too

III. TEXTBOOK

Required

Recommended (Books that you used for Thermodynamics, Heat transfer, and Fluids)


Instructor’s Notes (Will be posted on BlackBoard)

IV. COURSE DESCRIPTION

Apply principles of thermodynamics, fluid mechanics and heat transfer in design of thermal systems. Topics include

(i) Exergy analysis
(ii) Power and refrigeration systems
(iii) Mixtures
(iv) Psychrometrics and HVAC
(v) Reaction thermodynamics
(vi) Heat exchanger calculation
(vii) Case study: chosen from power generation, HVAC, petrochemical and process industries, avionics or propulsion systems thermal managements, etc. Service learning is encouraged.
V. STUDENT OUTCOMES

1. Students will demonstrate the ability to apply first law and second law analyses to thermal systems at the component level.
2. Students will demonstrate the ability to perform psychrometrics and HVAC calculation.
3. Students will demonstrate the ability to perform combustion calculation.
4. Students will demonstrate the ability to perform heat exchanger calculation.
5. Students will apply knowledge gained to a case study subject to multiple constrains, including economic evaluation and life-cycle assessment.

VI. ASSESSMENT AND GRADE ASSIGNMENT

The methods of evaluation and the criteria for grade assignments are:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>10%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>10%</td>
</tr>
<tr>
<td>Exam 1</td>
<td>20%</td>
</tr>
<tr>
<td>Exam 2</td>
<td>20%</td>
</tr>
<tr>
<td>Proposal &amp; Presentation</td>
<td>15% (5% - Proposal, 10% - Oral Presentation)</td>
</tr>
<tr>
<td>Written Reports</td>
<td>25% (3x2% - 3 Progress Reports, 19% - Final Report)</td>
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</tbody>
</table>

Grading Scale: A = 100-80; B = 70-79; C = 60-69; D = 50-59; F = below 50

VII. CLASS POLICIES

Attendance: Attendance will not be taken every lecture. All students are expected to attend all classes and arrive on time. Professional behavior is expected; no phone calls or texting messages in class. Homework assignments will be posted on MEEN-4360 BlackBoard page. Late homework will only be accepted for an acceptable cause, for example, death in family, car accident, hospitalized, doctor appointments, etc. Late homework must be made up within one week of the absence. Homework will be accepted if it is delivered to me by 5:00 p.m. on the due date. Late assignments will not be accepted. See page 5 for format.

Quizzes will be concept based as well as short work out or problem set up. Administered at the beginning of the Monday lecture and cover material (lecture, example problems, and homework) from the previous week.

Writing Assignments and Oral Presentations: Students will write one team proposal, three team progress reports, and one 10-page team report on Case Study. The students will give an oral report (team) of the Case Study.

Design Component: Students have problems (homework, quiz, and/or exam) involving the design of thermal and fluid systems. Students will apply the knowledge gained to a team design project that includes engineering analysis, economic evaluation and life cycle assessments.

Do NOT write your SSN or the student ID on the homework submitted. Pages are to be numbered and stapled at the upper-left corner.
### VIII. Tentative COURSE SCHEDULE

<table>
<thead>
<tr>
<th>Lecture #</th>
<th>Topic</th>
<th>Assignment Due</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Organization &amp; Introduction (review of thermo)</td>
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<tr>
<td>2</td>
<td>Exergy analysis</td>
<td></td>
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<tr>
<td>3</td>
<td>Exergy analysis</td>
<td>Homework #1, quiz</td>
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<tr>
<td>4</td>
<td>Exergy analysis</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Exergy analysis</td>
<td>Homework #2, quiz</td>
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<tr>
<td>6</td>
<td>Rankine power cycle</td>
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<tr>
<td>7</td>
<td>Rankine cycle &amp; gas turbine power cycle</td>
<td>Homework #3, quiz</td>
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<tr>
<td>8</td>
<td>Gas turbine power cycle</td>
<td></td>
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<tr>
<td>9</td>
<td>Case study &amp; gas turbine power cycle</td>
<td>Case Study Proposal, quiz</td>
</tr>
<tr>
<td>10</td>
<td>Gas turbine propulsion &amp; Otto cycle</td>
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<tr>
<td>11</td>
<td>Diesel cycle &amp; compression refrigeration cycle</td>
<td>Homework #5, quiz</td>
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<tr>
<td>12</td>
<td>Compression refrigeration cycle</td>
<td></td>
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<tr>
<td>13</td>
<td>Review</td>
<td>Homework #6, quiz</td>
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<tr>
<td>14</td>
<td><strong>Exam I</strong></td>
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<tr>
<td>15</td>
<td>Gas mixtures &amp; psychrometrics</td>
<td>Homework #7</td>
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<tr>
<td>16</td>
<td>HVAC</td>
<td>Quiz</td>
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<tr>
<td>17</td>
<td>HVAC</td>
<td>Homework #8</td>
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<tr>
<td>18</td>
<td>Evaporative cooling, cooling tower</td>
<td>Quiz</td>
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<tr>
<td>19</td>
<td>Chemical reactions</td>
<td>Homework #9</td>
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<tr>
<td>20</td>
<td>Combustion thermodynamics</td>
<td>Quiz</td>
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<tr>
<td>21</td>
<td>Chemical equilibrium, Gibbs function</td>
<td>Homework #10</td>
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<tr>
<td>22</td>
<td>Review</td>
<td>Quiz</td>
</tr>
<tr>
<td>23</td>
<td><strong>Exam II</strong></td>
<td></td>
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<tr>
<td>24</td>
<td>Heat exchanger</td>
<td>Progress Report #1</td>
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<tr>
<td>25</td>
<td>Heat exchanger</td>
<td>Quiz</td>
</tr>
<tr>
<td>26</td>
<td>Case study</td>
<td>Progress Report #2</td>
</tr>
<tr>
<td>27</td>
<td>Case study</td>
<td>Quiz</td>
</tr>
<tr>
<td>28</td>
<td>Case study</td>
<td>Progress Report #3</td>
</tr>
</tbody>
</table>

May 14, 1:45 to 4:15 – Class Presentation of Case Study & Final Team Report
IX. INSTRUCTIONAL METHOD
Lectures, group discussions, home assignments, spreadsheet based calculations, textbook software for computer-aided solutions. The student is expected to have read the chapter before coming to the class.

X. E-mail:
Must enter MEEN-4360 in the email’s subject field, then follow with topic (HW, Quiz, Missed Class, Project, etc.)

XI. FOOD AND DRINKS AND OTHER
No eating in laboratory/computer areas. No dipping in class.

XII. SUPPORT SERVICES FOR STUDENTS WITH DISABILITY
Texas A&M University-Corpus Christi complies with the Americans with Disabilities Act in making reasonable accommodations for qualified students with disabilities. If you suspect that you may have a disability (physical impairment, learning disability, psychiatric disability, etc.), please contact the Services for Students with Disabilities Office, located in Driftwood 101 (DW-101), at 825-5816. If you need disability accommodations in this class, please see me as soon as possible.

ACADEMIC HONESTY
The engineering and engineering technology professions are based on truth, honesty, integrity, and professionalism. Scholastic dishonesty will not be tolerated. See the University Catalog sections on Academic Integrity and Academic Honesty. Cell phones and electronic communication devices are NOT permitted in the exam.

XIII. GRADE APPEALS
A student who believes that he or she has not been held to appropriate academic standards as outlined in the class syllabus, equitable evaluation procedures, or appropriate grading, may appeal the final grade given in the course. The burden of proof is on the student to demonstrate the appropriateness of the appeal. A student with a complaint about a grade is encouraged to first discuss the matter with the instructor. For complete details on the process, including the responsibilities of the parties involved in the process and the number of days allowed for completing the steps in the process, consult Texas A&M University-Corpus Christi University Procedure 13.02.99.C2.01 Student Grade Appeal Procedures (http://www.tamucc.edu/provost/university_rules/index.html), and the College of Science and Engineering Grade Appeals webpage (http://sci.tamucc.edu/students/GradeAppeal.html). For assistance and/or guidance in the grade appeal process, students may contact the chair or director of the appropriate department or school or the College of Science and Engineering Dean’s Office.
Homework Guidelines:

Taking the time to include information when working out a problem will help strengthen your knowledge of working out problems. Briefly jotting down a few notes is not a good practice in terms of long term recollection, nor for preparation for the exams. Documenting where you get information, why a particular step is required, and how you are progressing in a problem is an excellent professional skill to develop. In addition, the detailed workout will be necessary for the course project.

The following is required for all submitted work:

- Prepare formal solutions on 8-1/2” x 11” 'engineering problem' paper, or white letter paper.
- Work submitted on paper torn out of a spiral notebook will not be accepted.
- Each homework assignment must have a cover page containing pertinent details, such as: name, course & section, HW assignment number (or equivalent), and due date.
- All pages should be stapled together.
- All work should be presented on one side of the paper only.
- If a problem takes more than half a page, then begin each new problem on a new sheet. If there is more than one problem per sheet, then each problem must be separated by a double line.
- Problems must be organized in the same order as assigned, unless specified otherwise.
- Your name, course, section number, and due date must appear at the top of each page.
- The current page number as well as the total number of pages in the assignment must appear in the upper right corner of each page.
- The format for each problem solution should generally consist of:

  **Problem Info:** Summarize the problems statement and include all information that is known about the problem. A bullet list is acceptable. Include sketches or diagrams as appropriate. Original diagram of problem statement should be included too.

  **Required/Task/Objective:** State what has been asked to be determined in complete sentences. Bullet lists work well here too.

  **Figures:** Almost every problem in this course will require detailed diagrams to support your solution! Draw all figures clearly and neatly, use a straight-edge if needed. Show an appropriate and consistent set of units, number each figure, and when appropriate, refer to a figure by its number in the solution. Draw figures such that they are of reasonable size, i.e. no smaller than a 2.5” x 2.5” in area. Also, it is ok and encouraged to draw a figure more than once if needed. Figures are a good place to help define variables and their relation to the problem. Many problems require a reference system too.

  **Solution:** Present your solution in a logical and methodical manner. What are the key equations/relationships that are to be used? What are the assumptions to the problem? Clearly indicate answers by including the variable designation, the numerical value (with units!), and by 'boxing' the answer. Also include any summarizing comments, observations, or conclusions in sentence form as may be appropriate. Graphs or plots that are required for problems must have properly labeled axis, titles, and legends (if more than one plot on graph).

See an example on the following page
A piston-cylinder device initially contains 0.07 m$^3$ of nitrogen gas at 130 kPa and 120°C. The nitrogen is now expanded polytropically to a state of 100 kPa and 100°C.

Determine the boundary work done during this process.

**PARAMETERS:**

\[ V_1 = 0.07 \, m^3 \]

\[ P_1 = 130 \, kPa = 130 \times 10^3 \, kPa \]

\[ T_1 = 120°C = 393 \, K \]

**MATERIAL:** Nitrogen gas

**PROCESS:** Polytropic Expansion

**FINAL STATE:**

\[ P_2 = 100 \, kPa = 10^5 \, kPa \]

\[ T_2 = 100 \, °C = 373 \, K \]

\[ V_2 = ? \]

**TASK:** Calculate \( W_0 \).

**GOVERNING EQUATIONS**

Assumptions: Nitrogen gas behaves as an ideal gas

**Boundary Work for Polytropic Process:**

\[ W_0 = \frac{P_2 V_2 - P_1 V_1}{1 - n} \tag{6} \]

For ideal gases, polytropic relation is:

\[ pV^n = \text{constant} \tag{6} \]

Also,

\[ pV = mRT \Rightarrow \frac{pV}{T} = mR \tag{6} \]

**Finding \( V_2 \) and \( n \)**

From (6)

\[ \frac{pV}{T} = \frac{P_2 V_2}{T_2} \Rightarrow V_2 = \left( \frac{P_2}{P_1} \right) \left( \frac{T_1}{T_2} \right) V_1 \]

\[ V_2 = \left( \frac{130 \times 10^3}{100 \times 10^3} \right) \left( \frac{393}{373} \right) (0.07) \Rightarrow V_2 = 0.08637 \, m^3 \]

From (6)

\[ P_1 V_1^n = P_2 V_2^n \]

\[ \left( \frac{V_2}{V_1} \right)^n = \left( \frac{P_2}{P_1} \right) \Rightarrow n \ln \left( \frac{V_2}{V_1} \right) = \ln \left( \frac{P_2}{P_1} \right) \]

\[ n = \frac{\ln \left( \frac{P_2}{P_1} \right)}{\ln \left( \frac{V_2}{V_1} \right)} \Rightarrow n = 1.248 \]

\[ W_0 = \frac{130 \times 10^3 \times 0.08637}{1 - 1.248} \Rightarrow W_0 = 1867 \, J \]

or \( W_0 = 1.87 \times 10^3 \)