MAE 301 Course Syllabus Fall 2008

1.1. Instructor's name, office address, telephone number, e-mail address, regularly scheduled class meeting times, and office hours for out-of-class consultation.

Sec: 001
Location: DN 327 for Lectures Riddick 315 for Tests
Days: MW
Time: 3:00-4:15 PM

Instructor: M. A. Boles
Office: BR 3184
E-Mail Address: boles@ncsu.edu
Office Telephone: 919-515-5234
Office Hours: 12:00-1:20 PM MW

1.2. Course prerequisites or restrictive statements.

Prerequisites: MA 242, PY 208 or PY 202

1.3. Designation of course as a General Education Requirement (GER). N/A

1.4. Student learning outcomes for the course.

Course Motivation: This course is an introduction to the concept of energy. It provides the basic tools necessary for the analysis of any engineering system in which energy transfer or energy transformations occur; thus, thermodynamics is an important part of the training of almost all engineering disciplines.

Course Objectives: The students will be asked to demonstrate their knowledge of the material covered in MAE 301 through their mastery of the following course objectives. Through the study of MAE 301 the student will be able to:

1. Determine properties of real substances, such as steam and refrigerant 134-a, and ideal gases from either tabular data or equations of state.

- Use absolute, gage, and vacuum pressures correctly.
- Calculate gage and vacuum pressures using the manometer equation.
- Use absolute and Celsius temperatures correctly.
- Determine property data using the steam and R-134a tables.
- Sketch P-v, T-v, and P-T plots for steam, R-134a, and ideal gases.
- Locate data states on P-v, T-v, and P-T plots for steam, R-134a, and ideal gases.
- Determine the condition of a data state as a compressed, saturated, or superheated state and determine the thermodynamic properties at that state by using property tables.
- Demonstrate the use of quality in finding properties of two-phase substances.
- Apply the concept of the generalized compressibility factor to demonstrate when the ideal gas equation may be used to determine the state of a gas.
- Apply the ideal gas equation to solve problems involving pressure, temperature, and volume of ideal gases.
- Determine changes in internal energy and enthalpy for ideal gases.
- Determine mass flow rate from its definition and relation to volume flow rate.

2. Analyze processes involving ideal gases and real substances as working fluids in both closed systems and open systems or control volumes to determine process diagrams, apply the first law of thermodynamics to perform energy balances, and determine heat and work transfers.
  - Determine the pressure-volume relation for processes and plot the processes on P-v and diagrams.
  - Calculate the boundary work for a variety of processes for closed systems.
  - Apply the first law to closed systems containing ideal gases, steam, or R-134a to determine heat transfer, work, or property changes during processes.
  - Apply the first law to steady-flow open systems containing ideal gases, steam, and refrigerant-134a to determine heat transfer, work, and property changes during processes.
3. Analyze systems and control volumes through the application of the second law.
  - Determine the efficiency of heat engines and compare with the Carnot heat engine efficiency.
  - Determine the coefficient of performance of refrigerators and heat pumps and compare with refrigerators and heat pumps operating on the reversed Carnot cycle.
  - Determine entropy changes for both ideal gases and real substances.
  - Determine the properties of a working fluid at the end of an isentropic process.
  - Plot processes on both P-v and T-s diagrams.
  - Apply both the first and second laws to determine heat transfer, work, and property changes during processes occurring in both closed and open systems.
4. Analyze the basic Otto and Rankine cycles

1.5. All required Textbook(s), title(s), date(s), price(s), Calculators, price(s)

Y. A. Çengel and M. A. Boles, Thermodynamics: an Engineering Approach (Packet including Property Table Booklet), 6th Ed, The McGraw Hill Companies, New York, 2008. $143.75 (new), $107.85 (used)

Only models of calculators approved by the instructor are permitted to be used in the classroom during tests and the final exam. *No other models of calculators or variations of the models listed below are permitted during tests and the final exam.* The following are the only calculators that will be permitted in the classroom during tests and the final exam and are the only ones allowed on the Fundamentals of Engineering Exam. Prices for these calculators range from $9.95 to $20.00.

Hewlett Packard – HP 33S
Casio – FX 115MS or FX 115MSPlus
Texas Instruments – TI 30X IIS
Texas Instruments – TI 36X SOLAR

1.6. Course organization and scope. List of topics and approximate time allocated to each major topic.

Topics covered: (number of classes): Based on 3 classes per week for 14 week semesters, classes meet 3 days per week for 50 minute lectures (or 2 days per week for 75 minute lectures):

1. Basic Concepts (2)
2. Energy transfer by heat, work, and mass (3)
3. Properties of pure substances (5)
4. The first law of thermodynamics (10)
5. The second law of thermodynamics (6)
6. Entropy and 1^{st} & 2^{nd} law applications (10)
7. Introduction to power cycles (2)
8. Review and tests (4)

1.7. Projected schedule of reading assignments.

<u>Course Outline</u>:

	Date	Topic	Readings
Aug.	20	Introduction, Definitions, Units, Systems	1.1-1.3
		Properties, State, Processes, Cycles	1.4-1.7
		State postulate, Temperature	1.8-1.9
		Pressure, Problem-Solving,	1.10-1.13
	25	Energy, Heat Transfer, Work	2.1-2.4
	27	The First Law of Thermodynamics	2.5
		Energy Conversion Efficiencies	2.6
Sep.	1	***Holiday***	
	3	Pure Substance, Phase-Change	3.1-3.3
	8	Property Diagrams	3.4
		Thermodynamic Property Tables	3.5
	10	The Ideal-Gas Equation of State	3.6
		Compressibility Factor, Other Equations of State	3.7-3.8
	15	Moving Boundary Work, Energy Balance for Closed Systems, Specific Heats	4.1-4.2
	17	**Test 1 for Chapters 1-3**	
	22	Internal Energy, Enthalpy, Specific Heats for Ideal Gases	4.4
	24	Internal Energy, Enthalpy, Specific Heats of Solids and Liquids	4.5
	29	Mass Balance for Control Volumes	5.1
Oct.	1	Flow Work and the Energy of a Flowing Fluid	5.2
		Energy Balance for Steady-Flow Systems	5.3

	Date	Topic	Readings
Oct.	6	Some Steady-Flow Engineering Devices	5.4
		Nozzles, Diffusers	5.4
	8	No Class	
	13	Turbines, Compressors	5.4
		Throttling valves, Mixing chambers	5.4
	15	Heat exchangers, Pipe and Duct Flow	5.4
		Unsteady-flow process	5.5
	20	Introduction to the Second law, Thermal Reservoirs	6.1-6.2
		Heat engines	6.3
		Refrigerators, Heat Pumps, Perpetual-Motion Machines	6.4-6.
	22	**Test 2 for Chapters 4 and 5**	
	27	Reversible & Irreversible Processes, Carnot cycle	6.6-6.7
		Carnot Principles, The Thermodynamic Temperature Scale	6.8-6.9
	29	Carnot Heat Engine, Carnot Refrigerator and Heat Pump	6.10-6.11
		Entropy, The Increase of Entropy Principle	7.1-7.2
Nov.	3	Entropy Change of Pure Substance, Isentropic Processes	7.3-7.4
	5	Property Diagrams Involving Entropy, What Is Entropy	7.5-6.6
		T ds Relations, Entropy Change of Liquids and Solids	7.7-7.8
	10	Entropy change of Ideal Gases	7.9
	12	Reversible Steady-Flow Work, Compressor work	7.10-7.11
		Isentropic Efficiencies of Steady-Flow Devices	7.12
	17	Entropy Balance	7.13
	19	Exergy and second law analysis	8.1-8.4
		Review, Exergy transfer, exergy balances	8.5-8.8
	24	**Test 3 for Chapters 6 and 7**	
	26	***Holiday***	
	1	Vapor power cycles - Rankine	10.2
		Gas power cycles - Otto	9.5
	3	Review	
Dec.	15	**Sec 001 Final Exam 1:00-4:00 PM**	

1.8. Projected schedule of any homework due dates, quizzes and tests.

All homework will be assigned on Wednesday of the current week of class and will be due on Wednesday of the next week. All homework papers are to be stapled in the upper left-hand corner and placed on the instructor's desk before the start of class. Tests and final exam are scheduled according to the projected schedule of reading assignments given above in Section 1.7. Unless given further notice, the exam time for this section is that listed in the Semester Examination Schedule published by the Department of Registration and Records.

1.9. Course grades are determined as follows:

The grading components are 10% homework, 20% Test 1, 20% Test 2, 20% Test 3, and 30% Final Exam. No incompletes are accepted for this course without verifiable, written doctor's note indicating more than one week's incapacitation.

The final grade will be based on the final average and determined as follows:
90 and above A
80 and < 90 B
70 and < 80 C
60 and < 70 D
Below 60 F
Plus/minus grades will be used for those border line cases where there is excellent attendance, excellent homework grades, and improvement in test and exam grades.

1.10. Instructor's policies on incomplete grades and late assignments.

Incompletes are accepted only for medical reasons. Makeup work, if any, must be arranged within two weeks of due date at the option of the instructor, prior to two weeks before the end of classes.

1.11. Instructor's policies on attendance:

Students are expected to attend all classes, and attendance may be recorded from time to time and may be used to determine grades for border line cases. **NCSU policy on attendance, including what constitutes an 'Excused Absence,' is at this link (www.ncsu.edu/policies/academic_affairs/courses_undergrad/REG02.20.3.php).**

Work that is late due to an excused absence will either be 'excused' from your grade, or it may be turned in late. It is the students' responsibility to contact the instructor to discuss the most appropriate action.

In the event that a test is scheduled for a day in which the University is closed due to inclement weather, that test will be held at the next regularly scheduled class when the University is officially open.

1.12. Instructor's Academic Integrity statement, which consists of:

1.12.1. The faculty acknowledges the existence of the University policy on academic integrity found in the Code of Student Conduct Policy (POL11.35.1) and expects students to adhere to it.

1.12.2. the utilization implication of the Honor Pledge[1]; and,

An Honor Pledge is expected to be signed and dated on each test, final exam, and any additional special assignments. The Honor pledge will be as follows: "I have neither given nor received unauthorized aid on this test, exam or special assignment. I have not discussed the contents of this test or exam prior to taking it."

1.12.3. the expectations of faculty concerning honesty in the completion of test and assignments.

It is the expectation of faculty that students neither give nor receive unauthorized aid on any test, exam, or special assignment. The faculty recognizes the value of discussions by students regarding weekly homework assignments in student groups, with teaching assistants, and the faculty. However, homework assignments submitted for grading must be the product of the student submitting the work. Possession of copies of a solution manual by students is prohibited. In fact the solution manual for this course specifically states at the bottom of each original page that if you are a student using the solution manual, you are using it without permission.

1.13. Statement for students with disabilities:

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities at **http://www2.ncsu.edu/ncsu/provost/info/hat/current/appendix/appen_k.html**.

1.14. Statement on laboratory safety:

There are no laboratory assignments for this course; therefore, no special safety training or equipment is needed.

1.15. Statement on extra expenses:

There are no charges or fees beyond the purchase of your calculator and textbook packet which should include the textbook and property table booklet.

1.16. Statement on transportation:

No transportation is required for this course.

1.17. Statement on personal communication devices:

All personal communication devices must be turned off upon entering the classroom.

1.18 Helpful Relations

Helpful Relations

General Relations: $h = u + pv, \quad g = h - Ts, \quad du = Tds - Pdv, \quad dh = Tds + vdP$

$$C_v = \left(\frac{\partial u}{\partial T}\right)_v = \left(\frac{du}{dT}\right)_{IG}, \quad C_P = \left(\frac{\partial h}{\partial T}\right)_P = \left(\frac{dh}{dT}\right)_{IG}, \quad \eta_c = \frac{w_{c,s}}{w_{c,a}}, \quad \eta_t = \frac{w_{t,a}}{w_{t,s}}, \quad \varepsilon_{regen} = \frac{\Delta h_{comp\,gas,act}}{\Delta h_{comp\,gas,\max}}$$

Closed System First Law: $Q_{net} - W_{net} = \Delta U$

Conservation of Mass for Steady-Flow: $\sum_{inlets} \dot{m}_i = \sum_{exits} \dot{m}_e \qquad \dot{m} = \rho A \vec{V} = \frac{A\vec{V}}{v}$

First Law for Steady-Flow: $\dot{Q}_{net} + \sum_{inlets} \dot{m}_i \left(h + \frac{\vec{V}^2}{2} + gz\right)_i = \dot{W}_{net} + \sum_{exits} \dot{m}_e \left(h + \frac{\vec{V}^2}{2} + gz\right)_e$

Boundary Work: $W_b = \int_1^2 PdV$ **Steady-flow Work:** $w_{sf} = \frac{\dot{W}_{rev,sf}}{\dot{m}} = -\int_1^2 vdP$

Ideal Gas Relations: $PV = mRT, \quad \frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1}, \quad C_P = \frac{k}{k-1}R, \quad C_v = \frac{R}{k-1}, \quad k = \frac{C_P}{C_v}$

$$\Delta S = m\left[\int_{T_1}^{T_2} \frac{C_P(T)dT}{T} - R\ln\left(\frac{P_2}{P_1}\right)\right] \qquad \Delta S = m\left[\int_{T_1}^{T_2} \frac{C_v(T)dT}{T} + R\ln\left(\frac{v_2}{v_1}\right)\right]$$

Polytropic Process Relations:

general: $P_2V_2^{\,n} = P_1V_1^{\,n}, \qquad W_b = \frac{P_2V_2 - P_1V_1}{1-n}, \quad n \neq 1 \qquad and \qquad W_b = PV\ln\left(\frac{V_2}{V_1}\right), \quad n = 1$

ideal gas: $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}, \quad W_b = \frac{mR(T_2 - T_1)}{1-n}, \quad n \neq 1 \qquad and \qquad W_b = mRT\ln\left(\frac{V_2}{V_1}\right), \quad n = 1$

For ideal gases undergoing an isentropic process with constant specific heats, n = k = C_P/C_v.