UNIFIED ENGINEERING

Massachusetts Institute of Technology

Department of Aeronautics and Astronautics

Fall 2008

Course Facts

1. Introduction

Unified Engineering is the beginning of your education as an engineer focused on aerospace. At MIT, aerospace engineering is taught within the context of the CDIO (Conceive-Design-Implement-Operate) framework. Briefly, that means that we want you to graduate as engineers who can contribute to the development of new products in a modern, team-based environment. So in Unified, you will learn skills that will enable you to become an effective aerospace engineer. Of course, you will learn plenty of disciplinary material as well. As you will see, the structure of Unified reflects the dual goals of teaching disciplinary material and the other skills required of an aerospace engineer.

2. Course Objectives

The basic objective of Unified is to give a solid understanding of the fundamental disciplines of aerospace engineering, as well as their interrelationships and applications. These disciplines are *Materials and Structures (M); Fluid Mechanics (F); Thermodynamics and Propulsion (T);* and *Signals and Systems (S)*. In choosing to teach these subjects in a unified manner, we seek to explain the common intellectual threads in these disciplines, as well as their combined application to solve engineering *Systems Problems (SP)*. Throughout the year we will endeavor to point out the connections among the disciplines.

A second objective of Unified is to guide you to an understanding of the fundamental skills, knowledge and sensitivities that are the traits of a successful engineer. These include the skills necessary to work successfully in a group (including technical and graphical communication) and those of self-education (reading, research, and experimentation). Professional engineers have the knowledge and confidence to make estimates of poorly known parameters, create conceptual models of systems, assess applicability of various models and their resulting solutions to encountered problems, and design new solutions to meet technical challenges. Engineers in positions of leadership are sensitive to the interaction of technical solutions with the economic, political, social and environmental needs, and constraints of society.

The third objective of the faculty and teaching staff is to ensure that you have a positive learning experience. As in most teaching-learning experiences, the effectiveness and efficiency of what we accomplish will depend on the combined efforts of both the faculty and the student. For our part, we will try to make the experience of Unified Engineering stimulating, rewarding, and on occasion, fun.

3. Staff

3.1 Lecturers

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3.2 Graduate Teaching Fellows

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Materials

4. Textbooks

The following textbooks are required, and can be purchased at the MIT Coop or Quantum Books:

Professor	Author	Title	Publisher
Modiano and Win	Oppenheim and Willsky	Signals and Systems (2nd Edition)	Prentice Hall
Lozano	John D. Anderson, Jr.	Fundamentals of Aerodynamics (4th Edition)	McGraw-Hill
Lagace	Ashby and Jones	Engineering Materials 1	Pergamon
Lagace	S.M. Crandall, N.C. Dahl, & Lardner	An Introduction to the Mechanics of Solids (SI version)	McGraw-Hill

Spakovszky	Van Ness	Understanding Thermodynamics	Dover Press
Spakovszky	Van Wylen, Sonntag, Borgnakke	Fundamentals of Thermodynamics	Wiley

The following textbooks are optional, and these are being held on reserve at the library:

1. Introduction to Flight – John Anderson, Jr.
2. Aircraft Performance & Design – John Anderson

5. Assignments

5.1 Homework

Weekly assigned homework consists of a problem set and a systems problem or laboratory write-up.

Problem sets: Problem sets are generally posted to the web site on Friday. They are generally due at 9 am prior to class on Friday of the following week.

A problem set handed out on a Friday generally will cover material taught in lectures between the previous Thursday and the next Tuesday, although this may vary slightly from week to week. As a result, you should be able to do some of the problems on the day the problems are handed out, and all the problems by Wednesday. Each problem set may contain two kinds of questions: "look-ahead" questions and "look-back" questions. The "look-back" questions are the usual kind with which you are familiar, and are based on lectures given in the preceding week. The "look-ahead" questions are based on material that has **not** yet been covered in the lectures. You are expected to perform the relevant reading assignments and answer/solve the "look-ahead" questions **before** the material is covered in class. This will allow the faculty to spend more time in lecture discussing useful and important concepts and targeting difficulties. This approach has been used very successfully in past years in Unified, 16.100 and 16.06. You are expected to work on all problems throughout the week. **Effective time management can be a challenge but is very important in Unified engineering.** We strongly encourage you to manage your time to ensure that your work is done in a timely manner. **Starting early with problem sets and preparing for a quiz is crucial.**

A sample homework solution is provided at the end of this document illustrating the proper way to write up a problem solution to receive full credit.

Late problem sets will not be accepted and will receive zero credit.

System Problems: In weeks where they are presented/addressed, system problems generally will be available on the web on Wednesdays. The problem should be read and understood in preparation for the Systems lecture the next day. The systems problem is then usually due on Thursday of the following week.

Late system problems will not be accepted and will receive zero credit.

5.2 Quizzes

There will be 5 quizzes during the fall term and 1 quiz during the final exam period. The quizzes are two hours and usually closed book. Students are allowed to bring to the quiz any materials specified by the faculty members in charge. The solution to the quiz will be posted after the quiz is graded. We will endeavor to grade and return quizzes within one week.

Be aware that, as a rule, there are no make-up quizzes for unexcused quiz absences. We will give a make-up quiz for excused absences only. There are two situations under which a quiz absence may be excused: **(1) if you have a serious illness or personal emergency that prevents your attendance at the quiz.** You must notify us before the quiz, if possible, and the seriousness of the illness or emergency must be confirmed by Students Support Services. **(2) If you have a valid reason to miss a quiz, you may request to miss the quiz, *a-priori*, and the course staff will determine whether the absence will be excused.** You must make your request at least two weeks in advance of the date you need a decision. The decision to grant such a request is at the discretion of the course staff. Generally, we will grant such requests only for reasons related to MIT educational activities, such as varsity athletic events. Requests due to conflicts from personal activities are unlikely to be granted.

Make-up quizzes may be given before or after the normal quiz date, and may be either written or oral, at the discretion of the instructors.

6. Academic Honesty

The fundamental principle of academic integrity is that you must fairly represent the **source** of the intellectual content of the work you submit for credit. In the context of Unified Engineering, this means that if you consult other sources (such as fellow students, TA's, faculty, literature) in the process of completing homework, system problems, or any other assignment, you must acknowledge the sources in any way that reflects true ownership of the ideas and methods you used.

Doing homework helps to engage with the concepts and material taught in class on a deeper level. To enhance the learning process we strongly suggest that you first try to solve the problems by yourself and then discuss challenges in groups or in office hours if necessary. Discussion among students and in office hours to digest the material and the homework problems or to prepare for laboratories or quizzes is considered useful in the educational process and copies of previous year's problems and quizzes will be made available by the instructors. **COLLABORATION ON HOMEWORK IS ALLOWED UNLESS OTHERWISE DIRECTED AS LONG AS ALL REFERENCES (BOTH LITERATURE AND PEOPLE) USED ARE NAMED CLEARLY AT THE END OF THE ASSIGNMENT.** Word-by-word copies of someone else's solution or parts of a solution handed in for credit will be considered cheating unless there is a reference to the source for any part of the work which was copied verbatim. **FAILURE TO CITE OTHER STUDENT'S CONTRIBUTION TO YOUR HOMEWORK SOLUTION WILL BE CONSIDERED CHEATING.** Official Institute policy regarding academic honesty can be found in the MIT Bulletin Course and Degrees Issue under "Academic Procedures and Institute Regulations."

6.1 Unified Study Group Guidelines

Study groups are considered an educationally beneficial activity. However, at the end of each problem on which you collaborated with other students you must cite the students and the interaction. The purpose of this is to acknowledge their contribution to your work. Some examples follow:

1. You discuss concepts, approaches and methods that could be applied to a homework problem before either of you start your written solution. This process is encouraged. You are ***not*** required to make a written acknowledgment of this type of interaction.
2. After working on a problem independently, you compare answers with another student, which confirms your solution. You ***must acknowledge*** that the other student's solution was used to check your own. ***No credit will be lost due to this comparison*** if the acknowledgment is made.
3. After working on a problem independently, you compare answers with another student, which alerts you to an error in your own work. You ***must state*** at the end of the problem that you corrected your error on the basis of checking answers with the other student. ***No credit will be lost due to this comparison*** if the acknowledgment is made, and ***no direct copying of the correct solution*** is involved.
4. You and another student work through a problem together, exchanging ideas as the solution progresses. Each of you ***must state*** at the end of the problem that you worked jointly. ***No credit will be lost due to this cooperation*** if the acknowledgment is made.
5. You ***copy all or part*** of a solution from a reference such as a textbook or a "bible." ***You must cite*** the reference. ***Partial credit*** will be given, since there is some educational value in reading and understanding the solution. However, this practice is ***strongly discouraged*** and should be used only when you are unable to solve the problem without assistance.
6. You ***copy verbatim*** all or part of a solution from another student. This process ***is not considered academically dishonest*** if the acknowledgement is made. However, you will ***receive no credit*** for verbatim copying from another student as ***you have not made any*** intellectual contribution to the work you are submitting for credit.
7. **VERBATIM COPYING OR USE OF ANY MATERIAL WHICH YOU SUBMIT FOR CREDIT WITHOUT REFERENCE TO THE SOURCE IS CONSIDERED TO BE ACADEMICALLY DISHONEST.**

7. Grades

The rules of the MIT faculty define grades in terms of the degree of the mastery of course material. These definitions are listed in the Bulletin and will be applied in this course using the numerical grade as a guide. The following is the MIT policy on assigning grades to students.

Passing Grades: Undergraduate and graduate students who satisfactorily complete the work of a subject by the end of the term receive one of the following grades:

A—Exceptionally good performance demonstrating a superior understanding of the subject matter, a foundation of extensive knowledge, and a skillful use of concepts and/or materials.

B—Good performance demonstrating capacity to use the appropriate concepts, a good understanding of the subject matter, and an ability to handle the problems and materials encountered in the subject.

C—Adequate performance demonstrating an adequate understanding of the subject matter, an ability to handle relatively simple problems, and adequate preparation for moving on to more advanced work in the field.

D—Minimally acceptable performance demonstrating at least partial familiarity with the subject matter and some capacity to deal with relatively simple problems, but also demonstrating deficiencies serious enough to make it inadvisable to proceed further in the field without additional work.

At the end of the term you will receive two final grades since you are enrolled in two courses. Each student's final grade for each Unified Engineering semester will be based on performance in three areas of assessment:

1) The largest proportion of the grade, 70%, will depend on five two-hour, in-class quizzes and one two hour quiz given during the final exam period. These quizzes may not all count equally; they will be weighted by the number of lectures they cover. All quizzes will be considered in calculating a student's total quiz grade.

2) A further 25% of each student's score will reflect performance on Problem Sets, Lab Reports and Systems Problem assignments. These will be weighted roughly by the expected number of hours required to complete them.

3) The remaining 5% of each student's score depends on their performance in various exercises (many of which will occur in class). These may include answering questions in class, either verbally or using the PRS system, submitting assessment surveys, or completing reading assignments before class. Each individual faculty member will specify the way in which this 5% of the grade is determined for the material they teach. There will be no make-up opportunities granted for missing these activities. These activities are meant to encourage students to keep up to date with the material, rather than cramming at the last minute.

[Note: A student's performance on quizzes is the only true assessment of individual performance (versus that of a study group, for example). Therefore, if an individual's performance on the quizzes is significantly different than on the homework, the average quiz grade may be given proportionally greater weight than described above.]

JOE B: Because different faculty members have different grading systems, a mechanism is needed so that you can convert the numerical grade on a quiz to your overall performance in the class. On each quiz, the professor responsible for the quiz

will determine and announce the numerical score of a mythical student, "Joe B," who always receives a middle B grade. Performance significantly above this score is an A; performance significantly below is a C or worse. Class average is not considered in the grading process and will not be announced, and. Likewise, individual numerical grades will be given on problem sets, systems problems and laboratory write-ups and quizzes. The faculty will announce the Joe B grade, but not the class average. As such, *there should be no competition among students for grades in Unified*. Ideally we would like everyone to learn the material to the standards defined by the MIT faculty for a grade of A.

Re-grade Requests: Re-grades on problem set problems, systems problems, and quizzes will be considered when brought to the grader of the problem within 2 weeks of the solutions to that problem being posted. Each re-grade request should be accompanied by the cover sheet for that type of problem (available on the unified web site). The student should fill out the top portion of the cover sheet and submit it to the grader of the problem. The grader will review the problem and explain any changes that will or will not be made in the grade. Once the new grade is logged the problem will be returned to the student. If the student is still dissatisfied with the outcome of the re-grade request, the student may then approach the professor who issued the problem.

Teaching Methods

The Unified Engineering Team is firmly committed to helping you learn. This commitment takes many forms, including a process of continuous improvement in our teaching effectiveness. During this semester, the faculty will be exploiting teaching methods proven to increase students' learning. These methods include presenting information to the student in the context of a compelling challenge or problem, stressing active versus passive learning in the classroom, enhancing feedback to the student, providing multiple opportunities for hands-on learning, implementing policies to improve class preparation, and providing access/exposure to a wider range of learning media. Through these methods we hope to foster a deeper working knowledge of the technical fundamentals. If we are all (the class and the instructors) successful, it will provide a firm foundation for the rest of your studies in the Department and beyond.

8. Class Exercises

8.1 Exercises at which Student Attendance is Expected

Lectures. The lectures are held MWF 9–11 am in 34-101 and TR 10–11 am in 35-225. They are the primary presentation of the subject material by the faculty.

Systems Problems/Laboratory Lecture. The weekly systems problem and/or laboratory lecture will generally be on Thursday at 10:00 a.m. [in 35-225] It consists of a discussion by the faculty of the systems problem currently being worked on (due the following Thursday), or the laboratory for next week.

Recitations. Each student is expected to attend two one-hour recitations (Tuesday and Thursday) per week. There are two groups that students will be assigned to. Group A

meets from 9am to 10am and Group B from 11am to noon. The recitations will be taught by the faculty and the TAs. The recitations review the concepts as presented in lectures to date, and introduce pertinent examples, to illustrate and exercise these concepts and their applications.

Attendance at lectures and recitations is considered mandatory. Although no formal roll call will be taken, participation during in-class exercises will represent part of your grade.

Quizzes. Quizzes usually will be on Wednesdays at 9 a.m. See Section 5.2 and 7 for details.

Laboratories. The purpose of the Laboratories is to illustrate real phenomena, to contrast them with theoretical models and to teach lab technique. The time available and the level of the students' maturity in Unified are such that it is inappropriate to emphasize laboratory design and construction or detailed lab report writing at this point. Therefore, the lab setup will usually be provided by the Unified staff, and the results will be reported in succinct engineering format.

8.2 Exercises at which Student Attendance is Optional

TF Office Hours. The TFs will be available for consultation Tuesdays 2-5 p.m. and Wednesdays 3-5 p.m. in the Unified TF Office, 33-104. These office hours are primarily for assistance with concepts, interpretation of homework assignments, system problems, and general review. The TFs are often available outside these hours, and additional office hours may be established if demand warrants it.

Faculty Office Hours. Each faculty member will hold weekly office hours at a designated time (TBD) to discuss and to clarify conceptual questions related to the material and homeworks and to help improve your basic understanding. For effective interactions, the students are expected to come prepared to office hours. The meetings will take place in the faculty member's office or in a classroom (TBD). Students can also make appointments with faculty members to obtain additional help if necessary.

We strongly encourage you to attend office hours - the faculty and teaching fellows are devoted to discuss conceptual questions related to the subject material and to give you guidance with the learning process.

8.3 TF Office

The TF Office for Unified Engineering is located in the Department's laboratory facilities in room 33-104. Graded problem sets will be available in the box outside of the TF office. For copies of handouts or other course material, go to the TF office.

8.4 Tutoring

It can happen that from time to time, some students have trouble understanding some of the material, or fall slightly behind in the assigned work. Since Unified has a highly coordinated schedule, falling behind may lead to more problems [can be disastrous]. If you feel yourself falling behind or overwhelmed by the material, communicate the

problem as soon as it arises to the faculty or a graduate TF. The Unified staff will work to set up one-on-one tutoring or whatever form of help is deemed necessary. Problems are dealt with on an individual and confidential basis.

8.5 PRS System

Each student will be distributed a remote transmitter to be used with the Personal Response System (PRS). Each one has its own number, assigned to a particular student. Students are responsible for bringing their transmitter to every lecture, in order to participate in exercises that use PRS. Since class participation will be, in part, gauged by each student's responses, operating other students' transmitters in their place will be considered a violation of MIT's academic honesty policy.

The transmitters cost approximately $50. If a transmitter is lost the student will be responsible for paying for a replacement.

8.6 Sample Homework

To receive full credit:

- Please use separate sheets of paper for each problem
- Write your name on the sheets
- Clearly indicate who you worked with on every question you turn in
- You don't need to type up your solutions but please write legibly
- State your assumptions and display graphs and equations neatly
- Explain your solution clearly and interpret your results
    - Clearly identify intermediate results and their importance
    - Units must be explicitly worked and identified in all work and solutions
- Box your final answer
- Summarize the concepts you have used to solve the problem on the top of the page

The grading weight between numerical results and conceptual results may vary from problem to problem.

The sample below is meant to illustrate the proper way to write up a problem solution; you will see the concepts relevant for this problem in lecture.

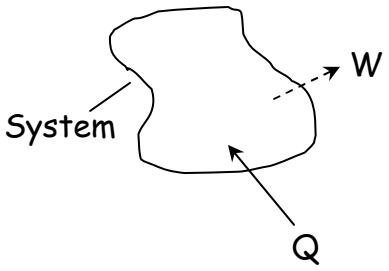
Problem 1

During a reversible process executed by a closed system, the pressure increases from 345 kPa to 1,380 kPa in accordance with pV = C, and the internal energy increases by 22,575 J. The initial volume is V_1 = 85 l. Find the heat transferred.

16.Uni Fall 2008 Problem 1 Tim Target

Concepts used to solve problem:

- 1st law of thermodynamics for a control mass
- Work and heat
- State changes



Known: Initial state p_1 = 345 kPa Final state p_2 = 1,380 kPa

V_1 = 85 l = 0.085 m^3

Find: Heat transfer Q given a known change in internal energy ΔU = 25,575J

Using 1st law of thermodynamics and neglecting potential and kinetic energies yields $\Delta U = Q - W$, where Q is the heat transfer to the system and W is the work done by the system. So the heat transfer becomes

$$Q = \Delta U + W$$

The work done by the system is: $W = \int_1^2 pdV$ (note that work is path dependent)

Knowing that pV = C or p = C/V, the work becomes: $W = C\int_1^2 \frac{dV}{V} = C \ln (V_2 / V_1)$

The constant C can be found from the initial state $p_1V_1 = C$, and the volume ratio can be expressed in terms of the pressure ratio as $V_2 / V_1 = p_1 / p_2$ such that

$$W = p_1V_1 \ln (p_1 / p_2)$$

From 1st law one can thus find the heat transfer $Q = \Delta U + p_1V_1 \ln (p_1 / p_2)$

$$\boxed{Q = -15{,}078 \text{ J}}$$

The negative sign indicates that heat is rejected by the system.