September 9, 1993

2.451J and 22.571J

GENERAL THERMODYNAMICS

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Class hours:	Tuesday and Thursday, 11-12:30, Room 4-159
Tutorial period:	Voluntary, Tuesday, 4:30 pm, classroom to be announced 2-190
Homework:	Assigned in class and due one week later; *it must represent individual effort.*
Reference:	Gyftopoulos and Beretta, *Thermodynamics: Foundations and Applications*, Macmillan (1991). Available at the MIT Coop.
Examinations:	There will be two quizzes during the term, and a final examination.
Final grade:	30% homework 30% quizzes 40% final examination

Approximate time allotment:

Topic	Number of Lectures
FOUNDATIONS	8
APPLICATIONS	
Heat engines	1
Simple systems	2
Properties of pure substances	2
Ideal gases	1
Bulk flow	1
Conversion devices	2
Availability functions	1
Energy conversion systems	1
Ideal gas mixtures	2

Outline of 2.451J and 22.571J

FOUNDATIONS

Kinematics and Dynamics
- Systems
- Properties
- States
- Motions

Energy
- Weight process
- First law
- Definition of energy
- Additivity of energy
- Conservation of energy
- Energy balance
- Absolute energy

Stability of equilibrium
- Types of states: unsteady, steady, nonequilibrium, equilibrium, stable equilibrium
- Reversible and irreversible processes
- Second law
- Impossibility of PMM2
- Historical statements of the second law

Adiabatic availability
- Definition of adiabatic availability
- Features of adiabatic availability

Available energy
- Mutual stable equilibrium
- Reservoirs
- Definition of available energy
- Features of available energy

Entropy
- Definition of entropy in terms of energy and available energy
- Features of entropy
- Entropy balance
- Dimensions and units of entropy

Stable equilibrium state principle
- State principle
- Criteria for stable equilibrium states
- The fundamental relation

Temperature

Total potentials

Pressure

Work and heat

Energy versus entropy graphs

APPLICATIONS

Heat engines
- Heat engines
- Heat pumps and refrigeration units

Systems with volume as the only parameter
- Characteristic functions
- Maxwell relations
- Heat and work interactions

Simple systems
- Gibbs, Euler, and Gibbs - Duhem relations
- Gibbs free energy
- Partial properties

Phase rule

Properties of pure substances
- Specific properties
- Specific latent heats
- Two-phase mixtures
- Specific heats
- Equation of state

Ideal gases
- Ideal gas behavior
- The perfect gas model
- Ideal incompressible behavior

Bulk flow
- Bulk flow states
- Bulk flow interactions
- Work, heat, and bulk flow
- The combined rate balance

Conversion devices
- Flow through a pipe
- Diffusers
- Nozzles
- Throttles and valves
- Compressors and pumps
- Turbines
- Heat exchangers

Availability functions or exergy functions

Energy conversion systems

Ideal gas mixtures
- Partial pressures
- Partial properties
- Gibbs-Dalton mixtures
- Ideal gas mixtures
- Entropy of mixing

PI TAU SIGMA
END-OF-TERM QUESTIONNAIRE

SUBJECT NO. 2.451J

A. INSTRUCTOR Prof. Gyftopoulous

What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Good lecturer. Has no regard for students time - problem sets are unnecessarily difficult. Very thorough. Good notes and reviewing of what was covered.

Very good teacher, great ability to transfer his ideas. I appreciate enormously the possibility to ask questions at any time and create stimulating discussions.

Excellent, goes at the right speed. Writes and explains clearly. Wish all Profs. were like that . A real teacher. Prof. Gyftopolous always gives suggestions and guidelines for open research problems in the subject without forgetting to underline the basics.

He has a very good teaching technique. He is always very helpful.

Good lecture skills. Good summary at beginning of class.

Good grasp of material, he sometimes likes to talk too much.

Interesting presentation of material. Starts with the basics and makes logical progression.

Gyftopolis is a wonderful professor. He is clear in his presentation and thorough. He welcomes students to his office to ask questions. I have taken advantage of this and have found him helpful. He answers questions clearly and exactly excellent.

Loves to teach the subject, very available. Has remarkably thorough grasp of subject matter and underlying theory assumptions - rigor is unsurpassed. Don't always stand in front of what you write.

Perfect, he instructs the course material very clearly and quickly reacts to the questions raised in the class.

Excellent, absolutely one of the best teachers ever.

Spends time with students. Needs more examples.

Listen to questions more closely - a few times he would answer a question different than what was asked. Other than that, the lectures were very good and held my attention well.

Is good at handling questions. Interrupts Hochgreb too much.

Prof. Gyftopoulos has an exceptional knowledge of the subject matter and an organized lecture style, although he tries not to be intimidating he is not always successful. One problem is the lectures deviates very little from the book making the class notes of little value. Prof. Gyftopoulos also has the tendency to answer the question he thinks you are asking which is not always the question asked.

Captivating style. Too many quantum tangents taken.

I cannot follow the lecture sometimes. Perhaps this is due to my not-very-good English. The other is due to the dialect of the speaker.

No improvement possible for him.

Excellent lecturer, clear, precise and thorough. He, however, should take more care and control over his course. The problem sets were laden with errors hence wasting students time and causing unnecessary frustration. The rumors are not true, he is a very approachable and caring man. He is very concerned with his students intellectual growth.

A nice instructor. Always ready to answer questions and discuss about difficult points.

An excellent lecturer who manages to keep your attention throughout the class. He does a very good job of making complex material understandable.

Very profound knowledge of the material. Relies too much on the textbook.

Explains material well and clearly. But not very good at listening to students especially when student has different opinion.

Very enthusiastic, need more examples in class, very receptive to questions.

Teaching technique is very good. No improvement suggested. The only suggestion is that the lectures be finished on time.

Digresses too much, repeats too much but obviously understands the material well and once he understands a question he does a good job answering it.

Very enthusiastic, conveys eagerness and insight of the material to class. Not enough examples presented on material.

Don't spend so long answering questions.

Very clear in stating the problems and excellent exposure of the subject. His step-by-step proceeding through the subject was very helpful in understanding difficult problems and capture peculiarities. He shows in a very good way all the complexities of the field and encourages to think independently.

He can help students to understand the concepts if he can organize this course which means that it takes too much time to understand.

He is a good lecturer. Since he has been teaching this subject for a long time, his knowledge and explanation satisfied me.

I feel he spends too much time on tangents instead of focusing on tackling an overview of the material presented in the text. At times, I lose interest. He is well organized and is good at clearing up ambiguities.

SUBJECT NO. 2.451J

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seem irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Thermodynamics is by nature difficult. I felt this course added to the confusion by making things more "precise" and difficult then needed. I understand the first half of the class. The second half was very confusing. Availability (Chapter 24,25) is not explained well at all. Problem sets were too open-ended. For those who haven't had a background in hard-core mechanical engineering it took way too much time to figure it out. Quizzes were "trick questions" that focused on the very latest material covered only - "Why not include some of the basics in the quizzes?" (like heat-engines, maxwell derivations, etc).

The approach is completely new and opens the door to new problems.

Excellent. A way to understand Thermo and really learn. Quizzes and problem sets challenging but not impossible.

It was usually very interesting but sometimes I got confused. problem sets were helpful.

I was a listener. Very theoretical, especially at the beginning of the class, more concrete examples during class would be good.

The subject was challenging, interesting new approach. However, although this class gave more unified vision of thermo, it didn't seem to be as revolutionary as claimed. It would be interesting to have more applications.

Too many quantum mechanics references.

We were not given time to prepare for the exams. In both cases we were tested almost solely on the material that had been presented just the class or two before. We had no time to complete a problem set on this material and get feedback before we were tested on it. Students would get much more out of it if we had a week to absorb the new material before being tested on it. Problem sets - There were lots, but overall they were helpful. Though this is a class for Mech E grad students, some of the class has not had thermo before. Profs. should keep this in mind when presenting material.

Availability definitions are cloudy and seem arbitrary and unclear. (not universal). I feel that I can competently attack a wide variety of Thermo problems now. I would be interested in exploring chemical kinetics/thermo in the class. Problem sets vary greatly in length/difficulty. Good quizzes, relevant material. Excellent book - class descents directly from book, I never used my notes.

The subject is very helpful. It has cleared many problems, I was always confused. The class size is just right, and the problem sets are very good for the understanding of the material learned in class.

Overall, I learned tons, I found it very useful and interesting but I think the exams were inappropriate in that they emphasized what was most recently taught. The first exam was almost exclusively on the problem set just handed in and not returned. We need time to learn, try problems and find our mistakes. Give us time to learn material before we are tested on it.

I liked the subject because it attempts to provide an understanding of Thermodynamics where other classes do not.

Subject material was good, although I wonder if all the time spent on the more abstract (i.e defining entropy, pressure, system etc) was really worth it. Instead, maybe spend more time in lecture on showing ways to solve problems.

Some of the problem sets were a little long. The last parts of the course need to be given more time and emphasis.

The class is very good from the standpoints that it gives the foundation and sources of many results which are commonly taken for granted. I would have liked to have seen a much more applied approach to the material, turbines are more interesting than blocks of metal. The text is very good except that it contains few examples and does not suggest other references. The homeworks were fine but seemed to have little reference to the quizzes.

Content is great. Homework could be improved, too much wasted time in tables for example. The exam emphasis should reflect the problem sets completed not the one handed out the day of the exam. Too slow a pace at first. A quicker run through the early stuff would ease the push at the end.

Good. At first, I did not understand the context very well. As I was learning the course, I improved greatly.

Reduce the first half of the course. We wasted too much time laying down foundations, however important they might have been. Would rather have covered more applied thermo as in the last half. Problem sets and tests were often unclear, imprecise and therefore unfair.

This is a course difficult to understand. However, it is because of the subject itself but not the fault of instructors. I think more delicately designed homework sets are needed. There are too many errors in the problem sets now, which wasted me a lot of time.

The course offers pretty much what was promised, i.e, a totally different approach to thermodynamics. By the end of the course it was clear that only the fundamentals were different, but the applications were the same as other courses. The problem sets took far too long, especially where note algebra and plug-in calculations were required.

I think everything in this class is fine. I really learned alot from this class, especially problem sets are helpful. Comparing with homework, the quizzes are a little disappointing. I think open book, longer time and better problems, quizzes would make this class better.

A challenging subject. However, I like it. Homework is far too heavy and problems are quite ambiguous from time to time. Recitation held only once a week, a time conflict prevents me from attending any one. Should have more recitable time or move to a more flexible time (like evening). 1st quiz is quite fair but the 2nd is totally unfair. It only focuses on the material only 5 hours ago.

I had hoped that we would cover more topics not covered in undergrad. Problem sets were occasionally too abstract. They did not accurately represent the type of questions on the exam. Too much time was spent on availability effectiveness and I still don't understand the proper way to define it.

In general, the subject is very interesting. The course is well organized and conducted. Seems to me, the copies of the official solutions have to be better quality (in technical terms). Sometimes, it was very difficult to read them.

Class was ok, maybe a little too much time spent on the introductory fundamentals. Text was very helpful. Quizzes were on a good level although they didn't always test you on all the relevant material. Homeworks counted for 30% which is too much, 20% is better.

Starts off a little slow.

An excellent subject. Problem sets are nice but somewhat too heavy. Quizzes and problem sets are helpful to fully understand the materials.

It is very interesting and innovative. It is also very slow going especially in the beginning.

Subject captures a scope of very important details in engineering. It is difficult but manageable with hard work. Could learn a lot from challenging problem sets. Certainly, I did not have enough time in quizzes. Text book is very good written.

Class was too abstract in teaching thermodynamics to me who was accustomed to classical thermodynamic, it takes too much time to understand.

It is a good subject. It gave me a clear understanding of Thermodynamics. The class size, number of problems sets are all o.k.

A handout on availability would be useful for me. Problem sets should not be due on the same day we have an exam.

D. **What are your suggestions for improving the lab? Was the number of students in the lab section too high? If your project was assigned to you, would you have preferred a project of your own choosing? Do you feel that you have used your time efficiently in the lab? Did you get out of the lab what you put into it?**

SUBJECT NO. 2.451J

E. On average, how many hours per week did you spend on this course? Include time both in and out of the classroom or laboratory.

20 hours.
19 hours.
18 hours.
15 hours
3 hours - I was a listener.
14 hours.
8 hours.
27 - 28 hours.
13 - 14 hours.
9 hours.
29 hours
10 - 15 hours.
21 hours.
15 - 16 hours.
15 hours.
20 +
15 hours.
15 hours.
25 hours.
15 hours.
25 hours.
12 hours.
12 hours.
18 hours.
25 hours.
5 hours.
10.5 hours.
13 hours.
15 hours.
15 hours.
10 hours.
40 hours.
15 - 20 hours.
11.5 hours.
17 hours.

September 10, 1992

2.451J and 22.571J

GENERAL THERMODYNAMICS

Instructors:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804 Simone Hochgreb, Room 3-342A, Ext. 3-0927
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Class hours:	Tuesday and Thursday, 11-12:30, Room 4-149
Tutorial period:	Voluntary, Tuesday, 4 p.m., Room 2-135
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Ideal gases	1
Bulk flow	1
Conversion devices	2
Availability functions	1
Energy conversion systems	1
Ideal gas mixtures	2
Chemical reactions	3

Outline of 2.451J and 22.571J

FOUNDATIONS

Kinematics and Dynamics
- Systems
- Properties
- States
- Motions

Energy
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- First law
- Definition of energy
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- Definition of adiabatic availability
- Features of adiabatic availability

Available energy
- Mutual stable equilibrium
- Reservoirs
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Entropy
- Definition of entropy in terms of energy and available energy
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- Dimensions and units of entropy

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- State principle
- Criteria for stable equilibrium states
- The fundamental relation

Temperature

Total potentials

Pressure

Work and heat

Energy versus entropy graphs

APPLICATIONS

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Systems with volume as the only parameter
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Phase rule

Properties of pure substances
- Specific properties
- Specific latent heats
- Two-phase mixtures
- Specific heats
- Equation of state

Ideal gases
- Ideal gas behavior
- The perfect gas model
- Ideal incompressible behavior

Bulk flow
- Bulk flow states
- Bulk flow interactions
- Work, heat, and bulk flow
- The combined rate balance

Conversion devices
- Flow through a pipe
- Diffusers
- Nozzles
- Throttles and valves
- Compressors and pumps
- Turbines
- Heat exchangers

Availability functions or exergy functions

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END-OF-TERM EVALUATIONS

COURSE NO.: 2.451
SECTION NO:
INSTRUCTOR(S): Prof. E. Gyftopoulos

A. INSTRUCTOR: What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

"Very intelligent, friendly person. He answers every question in detail. Very good teacher."

"She is sloppy in her board technique - there are too many mistakes."

"Interesting but with terrible accent to understand."

"Vert structured and logical. Sometimes desire for consistency. Gets in the way of a more intuitive exposition. Material is presented in a very good easy. I really think I learned something."

"Positive."

"I think the prof. is great. He is clear, meticulous, and extremely friendly. He gets you excited about the course, and he certainly knows his stuff."

"Very knowledgeable and interesting. His enthusiasm is great."

"Nice professor. Well organized course."

"Prof. Gyftopoulos really knows thermodynamics. He is very organized and systematic. I can't think of any negative attributes. He is the best professor I've ever had. I hope he continues teaching this subject."

"This guy is a total stud (he did write the book). His lectures are very good, though he does tend to go slightly over time. he is always available for questions and is a great help."

"He is the word on this subject, and presents it accordingly well."

"Very nice person, showing consideration for his students."

"Excellent introduction to the basics and the foundation on which the rest of the course was built. Precise definitions eliminated confusion at later points in the course."

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gyftopoulos

"Very good instructor! Understands the material well, explains well. He continually challenged the students to think!"

"One of the great ones!"

"He really knows what he teaches, but needs to do more example problems so we see how to apply the theory."

"Let's face it, this guy will never change, so why try."

"Very good at conveying the basic material. Shows a near-perfect understanding. Does not handle student questions very well, though. Drives the other professor insane. Should strongly consider being conspicuously absent when the other professor is teaching; maybe showing up for tutorials instead."

"Very clear descriptions. His rigid theoretical framework, while elucidating the foundations of thermodynamics, became burdensome when working with real world problems later in the course."

"Very precise, well-organized presentation. Dr. Gyftopoulos is an excellent professor. He should teach the entire course, not just the first half. The class would be better and clearer if he taught the whole thing."

"Very effective instructor. A little soft spoken but full of confidence. Obviously loves the subject. Follows the class's moods and can sense confusion."

"He is a very knowledgeable instructor. My only regret is that he did not teach the entire course."

"Positive: he is most of the time in his office and is willing to answer questions of the material and class. Negative: he did not answer so well the questions about problem set because he thinks if he explains more, he will be going to give you an answer. He should not worry so much about giving an answer but about the student understanding the problem."

"Professor Gyftopoulos is extremely enthusiastic and of course has a very deep understanding of the subject. This enables him to provide very clear and interesting explanations. However, it seems to me that some of his teachings are not universally accepted. This is fine, as long as students are not forced to choose a school of thought. I object to having to reject the conventional school of thought to get [pull, full -?, mates, makes -?] on the first problem of problem set 1."

END-OF-TERM EVALUATIONS

COURSE NO.: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gytopoulos, Prof. S. Hochgreb, & Y. Gur (TA)

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

"I think lots of the reading was extraneous - there is no way that you can learn all of the relations. The homeworks are good, but a bit too long and many of them I can't solve without consultation. The tests should be longer and more comprehensive, with more problems, but less difficult problems - I thought test #2 was unfair, since it only had 2 questions, and thus had a large luck factor."

"The problem sets take far too long to finish, and are tedious in that the time spent on them is usually for raw calculation, not thinking about theory. The second quiz was a fiasco designed to produce a ball curve in the class. It covered perhaps 1/2 of 1 lecture and was primarily an exercise in speed calculation and interpolation from tables. It shows a terrible attitude on the part of the instructors to design quizzes that measure speed, not ability. However, the material is covered relatively well in lecture & the book. Gives a good understanding of basic thermo."

"This class provides a good understanding of the conceptual foundations of thermodynamics but falls short of providing a permanent practical understanding that can be used to solve real problems."

"Problem sets were lengthy but effective. The second quiz contained a poorly worded question that was graded entirely too harshly. We should not be held responsible for the inability of the test - author to express him/herself clearly. The text is excellent, except for the chapters on availability analysis and effectiveness."

"In my opinion the course needs a recitation to keep it from being self-taught. The lectures did little to prepare the students for the problem sets (which accounted for 30% of the final grade). Grading in the course became a contest of who could spend the most time teaching themselves application of difficult concepts or send the most time pestering the TA's (who were wonderfully patient). The entire experience was deflating and negatively impacted the amount I learned. Maybe I'm just a bad student."

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gytopoulos, Prof. S. Hochgreb, & Y. Gur (TA)

"This course is very fast paced, especially in the second half and very time consuming. The homeworks frequently covered material not yet covered or covered very quickly. In general, the course should be very useful."

"I like thermodynamics. What I did not like were the problem sets. They were very long and hard, and we had not example problems on class, so we had to solve them "playing by ear". The exams were also hard and very, very long for the time [allotted]."

"The course is extremely interesting. I particularly like the way in which the fundamentals of thermodynamics are presented. it greatly simplifies the visualization of thermodynamic phenomena. However, this could remain without talking about the controversy and claiming that this new presentation is more true than any other. I do agree that it make modelling much easier to reform."

"Homeworks are quite challenging. The difficulties in quizzes varies too much. Very theoretical. (Read the textbook very carefully.) Good course!"

"I liked the subject. The problem sets were very difficult but excellent in teaching the subject. My only complaint is the 2nd quiz, but there should be some small part which one who has studied hard do without much trouble.

"Homework is too difficult and need much more time than it should be."

"Its a course one probably has to take."

"Very good subject."

"Problem sets are too long, and consequently they should count less towards the final grade. I did not have a bible for 2.451, as most of the grad students here did (I am an undergrad), so I did a lot of learning from the mistakes I made on the problem sets."

"Second quiz was too hard - too limited in scope. Text was good. More in-class examples worked out would be helpful - or worked out in the optional disc section. Too much emphasis on chemical reactions at the end, which seem to be "extra stuff, while too little time and emphasis on learning how to do the various cycles - Carnot - Vankme. Some homework sets were too time consuming."

"I would like the subject to have more thermodynamic fundamental material. In fact, I would like it to be only fundamentals, the applications can be taught in other subjects. But fundamentals are very important because they concern many areas of physics and engineering."

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"We have to take a lot of time to finish some problem sets."

"Problem sets were very instructive, but at times, too demanding."

"It was okay. A little heavy on the fundamentals, but I like the different approach. Problem sets were pretty demanding."

"Beginning part of the course covered the material very well, the last portion seemed rushed and sometimes confusing. Don't put so many interpolation type questions on the quizzes - it just takes too long."

"I was impressed with the [professors] development of the subject. I most liked the fundamentals. I never did understand those as well as an undergrad. I also liked the various applications [indicating - ?] that thermo is indeed a 'general' subject encompassing all of physics. I do not see any changes as required or desirable!"

"The overemphasis on terminology was often confusing. The homework grading was unfair at times. If the problem wasn't done exactly as the solutions, it was marked incorrect even if the answer was okay. I felt that the TA's may have tried to grade too quickly and not make effort to understand the method being used & assumptions made. The wording on the homework problems and tests was confusing. The biggest effort is often trying to figure out what the question is asking. This led to inaccurate grades - the material and concepts may be understood, but the tests were not a good barometer or measure of this understanding. I'd recommend giving more time for the tests. Allow 1 1/2 -2 hours for each instead of 1 hour."

"I liked the course, is a more deep way to see thermo but it probably be better if it is split in two semester and cover more example problems. Also the problem sets were always too long as well as the exams."

"This class [stinks]. Lectures are exact repetition of the book. There are zero example problems done in class. None of the material was motivated by an explanation of where it is being applied. The first third of the semester was used to cover material that should have been compressed into 2 classes."

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END-OF-TERM EVALUATIONS

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D. What are your suggestions for improving the lab? Was the number of students in the lab section too high? If your project was assigned to you, would you have preferred a project of your own choosing? Do you feel that you have used your time efficiency in the lab? Did you get out of the lab what you put into it?

"Recitation was good, a beneficial thing most of the time."

PI TAU SIGMA **FALL 1992**

END-OF-TERM EVALUATIONS

COURSE NO.: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gytopoulos, Prof. S. Hochgreb, & Y. Gur (TA)

E. On average, how many hours per week did you spend on this course? Include time both in and out of the classroom or laboratory.

25, 20, 20, 20, 15, 10-15, 25, 24 and 20 hours per week

16, the homeworks require lots of calculation with little learning.

about 24 + 3

In class 3, out 10-12

Classroom 3, Prep. 9 (Variable dependent on difficulty of problem set)

Lecture 3, Recitation 1, Problem set & home study 8

4.5 in class, 17-20 home study

More than 20

Homework 5, Ready text 3, Quizzes preparation 9, Class 3, Recitation 2

I spent almost 5 hours every day of the week in this class. Almost all my time went for this class, had little time to spend on the others.

About 20 on homework, 3 in class

At least 15-20

An average of 20 hours a week, very extensive homework sets...

Too many, 20 - 30 hours

When I did the homework completely: 20 plus. When I only did some problems: 12+

"Class: 3 hours, Homework 16-20 hours.

Hon 6.21 12.28

September 10, 1991

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2.451J and 22.571J

GENERAL THERMODYNAMICS

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Simple systems	2
Properties of pure substances	2
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Conversion devices	2
Availability functions	1
Energy conversion systems	2
Ideal gas mixtures	2
Diffusion and tranport phenomena	2

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- Systems
- Properties
- States
- Motions

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- Weight process
- First law
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- Conservation of energy
- Energy balance
- Absolute energy

Stability of equilibrium
- Types of states: unsteady, steady, nonequilibrium, equilibrium, stable equilibrium
- Reversible and irreversible processes
- Second law
- Impossibility of PMM2
- Historical statements of the second law

Adiabatic availability
- Definition of adiabatic availability
- Features of adiabatic availability

Available energy
- Mutual stable equilibrium
- Reservoirs
- Definition of available energy
- Features of available energy

Entropy
- Definition of entropy in terms of energy and available energy
- Features of entropy
- Entropy balance
- Dimensions and units of entropy

Stable equilibrium state principle
- State principle
- Criteria for stable equilibrium states
- The fundamental relation

Temperature

Total potentials

Pressure

Work and heat

Energy versus entropy graphs

APPLICATIONS

Heat engines
- Heat engines
- Heat pumps and refrigeration units

Systems with volume as the only parameter
- Characteristic functions
- Maxwell relations
- Heat and work interactions

Simple systems
- Gibbs, Euler, and Gibbs - Duhem relations
- Gibbs free energy
- Partial properties

Phase rule

Properties of pure substances
- Specific properties
- Specific latent heats
- Two-phase mixtures
- Specific heats
- Equation of state

Ideal gases
- Ideal gas behavior
- The perfect gas model
- Ideal incompressible behavior

Bulk flow
- Bulk flow states
- Bulk flow interactions
- Work, heat, and bulk flow
- The combined rate balance

Conversion devices
- Flow through a pipe
- Diffusers
- Nozzles
- Throttles and valves
- Compressors and pumps
- Turbines
- Heat exchangers

Availability functions or exergy functions

Energy conversion systems

Ideal gas mixtures
- Partial pressures
- Partial properties
- Gibbs-Dalton mixtures
- Ideal gas mixtures
- Entropy of mixing

Diffusion
- Diffusion interactions
- Transport phenomena

Fall 1991

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gytopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Professor Gyftopoulos is one of the best instructors that I have encountered in during my sudy at MIT. He has a sincere concern for the student and will always take the time to help you and give an ecouraging word. Prof. Gytopoulos, if you want your research to continue, please don't let Prof.... take over after you retire.

Mostly his lectures are clear and consistent. SOme times, he could spice up theoretical blackboard considerations with real world applications. For instance, I would have been interested if he spent time describing advances in cryogenic techniques, descriptions of real electromechanical hardware and general points of practice in thermodynamics.

Professor Gyftopoulos did a very good job lecturing and always tried to make connections of the abstract concepts to real world example. However, I feel that the homework, especially those assignments early in the course were sort of non-realistic and useless for the most part. (For example, we must have done 10 different problems involving metal blocks interacting in various ways). Why don't we do problems that not only show the use of concepts but also have some practical value. The lectures made the conceptual-practical connections. Why can't the Homework?

Dr. Gyftopoulos is an excellent professor who runs an excellent class. He is the best professor I have had here so far, and I have no suggestions as to how he could improve the class.

Professor Gyftopoulos presents this information in a well-organized and logical manner. His answers to questions and explanations are well-thought out and make good use of physical examples. His recitation sections are instructive and interesting.

Gyftopoulos encourages questions during class and gives careful and thoughtful answers. He reviewed previous lecture material to make transitions easier to follow. Somewhat defensive of his own views of thought at times and aunwilling to help us understand other approaches better. Good narrating during lecture make concepts clearer.

Fantastic professor. His lectures are well organized and easy to understand. He obviously enjoys his field, and he enjoys teaching it to other people. Always willing to answer questions, both during class and afterwards. And he understands a question better than the student does (i.e. Good mind reader). He makes you enjoy thermodynamics.

Positive: very open to student questions and assisting after class. Very positive instructor who excites the learning process. Negative: during the entire course, he never once solved a sample problem to assist students in homework efforts. Allowed recitations to ramble without clear direction. Recommendation: Work problems during formatted recitations.

Excellent way of presenting the topic (as a result thermo caught my fancy in another way). Brilliant.

Excellent, charismatic, exciting, available, knowledgeable, in-depth. The best teacher I have had for a long time. Needs improvement: 1)Needs to carefully listen and clarify questions posed by students. 2)Blackboard techniques. I enjoyed his availability outside of classa great deal.

Prof. Gyftopoulos is a good lecturer. However, his lectures tend to get boring. I think he should try and deal with more practical applications early on rather than talk about "black boxes." Finally, he should try and demonstrate how his thermodynamics is compatible with traditional approaches.

He is a brilliant man and teacher. His brand of thermodynamics and accompanying language requires some getting used to. Also, especially in the beginning of the course, more practical exmaples and less theory might be helpful.

Outstanding; explains very cleary, concisely, has such a thorough understanding of the subject that he can explain many things conceptionally, which are difficult to grasp, otherwise.

Positive attributes: His lecture are very well organized and easy to follow.

Agreat instuctor!

Good teacher. No negative attributes.

I feel that explanation of the material was weak. I hate professors who lectuture to the blackboard not the class.

This guy is great; I don't think he can improve his teaching techniques - he is one of the best in the department already.

His enthusiasm in the lectures is infectious. I thoroughly enjoyed the class.

Clearly com-unicates subject in lectures. Encourages questions from students and is very careful in answering questions.

Very "into" his course material, and therefore knows all aspects of the field. Is humorous, but sometimes his lectures go so fast and so deep into the theory that I often get lost.

He is a very elegant gentleman who is trying his best to find an equation of motion, or shall I say the equation of motion to describe the whole world. Good luck tohim and I wish him the best of everything.

Positive.

Fall 1991

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gyftopoulos and Prof. M. Flik

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Sub. is on for front of thermo.

The material was clear, but the quizzes were too long for the alloted time. A take home test might be in order under certain circumstances.

I felt there was too much emphasis on deriving thermodynamic relations. Many problem sets included lengthly mathematical manipulations of formulas, which revealed little about thermodynamics. The problems sets are long and difficult. 1½ hour exam problems are as difficult as problem set problems, the pace is fast & there is not much time to absorb material later in the course after foundations. The work load is heavy, with term problems, exams, and problems sets on one occasion (f- [?]) due within a few days.

The subject seemed good. However, no attempt was ever made to connect it to the rest of thermodynamics that the rest of the world does. TOO MUCH HOMEWORK, MUCH OF WHICH WAS USELESS.

Course outline and material provide a comprehensive explanation of thermodynamics. Excellent background material for understanding the topic.

The pace of the course was perfect. (I had heard there were problems in the past, but this seemed right for me.) The term problems could have been better designed and more significant. Term problem 2f was a waste of a lot of work and time I think. THe number of problems assigned was appropriate for practice and increasing understanding.

I love the approach of presenting thermo consistency. Too much cycles and energy conversive system. This belongs to undergraduate courses to less real mixture, combustion.

Excellent course in general. The transition from one professor to the other was very difficult. I would recomment that [one professor] teach all lectures in the future and let [the other professor] be a recitation instructor.

I enjoyed thermo very much. However, I did not understand adequately the coverage of Maxwell relations, steam tables, and cycles.

Quizzes were too hard for the class and did not properly gage the ability of thestudents. Homework was very time sonusming and the term projects should be eliminated due to time consumed or emplaced instead of some homework problems.

This is the worst course I have taken at MIT. Please deal with real problems, and cover more interesting topics like gas dynamics, psychrometry, engine cycles (in more detail). And scrap the term problems. Before I took this course I thought I understood thermo. I don't think I do now. The development of fund concepts was good but for too much time was spent on them. Do more math than logic like "impossibility of PMM2."

I'm worried that this course will not be practically integrated in my career as an engineer since its so unlike other thermodynamics and differs fundamentally even from other courses (i.e. heat transer) at MIT. Quiz #2 was absolutely unacceptable. I loved the beautiful way the theory builds upon itself, but maybe they should offer additional, more mentor (?) tutorials on 1) using the tables 2) partial calculus.

Excellent course in every aspect; thoroughly enjoyed and learned a great deal.

It was a course with interesting material. However, the main problem was that the amount of work to do at home was too large. In particular, I feel that the term problems, which were additional to regular homework problem sets, should be deleted. Also quizzes were too long to be accomplished in given time.

The class took too much time, the problem sets were too long. I like the subject and the way it was presented by the professor.

Seemed too advance towards the end. Problem sets consumed a lot of time.

Problem sets were good but much to long. Some of the exam problems were very difficult and did not cover material in either lectures or the text. Too much time was spent discussing the philosophy of thermodynamics.

I thoroughly enjoyed the class. The perspective expounded in the class with regards to the definitions of thermodynamic terms being "non-cycle" has instilled in me a more profound appreciation of thermodynamics. I would highly recommend this course to other students.

The subject was very well covered. All material was useful and relevant. My only complaint was with bad timing of assigning a term problem and homework set to be due near the date of an exam.

A good overview of thermodynamics, but very theoretical. Practical stuff comes much later than you would expect. But the course really gives you a basic "feel" for the material, which can be applied to any problem in thermo.

The subject content is very well chosen and well taught. Please keep it up.

Well organized presentation of material. As Prof. Gyftopoulos is proud to point out, the ideas always progress forward, i.e. no circular arguments. I think that the homework problems should require fewer interpolutions and table lookups, the need to crank through data reduces the time that could be spent thinking about the results.

Fall 1991

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gyftopoulos and Prof. M. Flik

D. What are your suggestions for improving the lab? Was the number of students in the lab section too high? If your project was assigned to you, would you have preferred a project of your own choosing? Do you feel that you have used your time efficiently in the lab? Did you get out of the lab what you put into it?

A lab would be interesting in this class...

[All the other students responded either, "N/A, No lab" or nothing at all.]

Fall 1991

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Prof. E. Gyftopoulos and Prof. M. Flik

E. On average, how many hours per week did you spend on this course. Include time both in and out of the classroom or laboratory.

24 hour/week.

Spent about 6 or so hours a week on this course. Homeworks are tough and long.

11 hours.

About 3 hours.

15 hours/week.

15 hours!

15-20 hours.

20 hours.

20 hours.

Far too many hours - about 40 hours/week.

3 hours in class, 20 hours out of class = ± 23 hours per week.

30 hours - 40 hours/week.

Much too many, 35 hours/week.

Approximately 15-20 hours.

10 hours.

Are of 40-50 hours per week. TOO MUCH HOMEWORK!!!

Approximately 12-18 hours a week.

Approximately 15 hours.

About 15 hours.

80 hours.

September 11, 1990

2.451J and 22.571J

GENERAL THERMODYNAMICS

Instructors: Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804
Markus I. Flik, Room 41-206, Ext. 3-0192

Assistant: Farid Kaymaram, Room 35-108, Ext. 3-4538

Class hours: Tuesday and Thursday, 11-12:30
Tutorial period: Voluntary, to be arranged.

Homework: Assigned in class and due one week later; it must represent individual effort.

Reference: Gyftopoulos and Beretta, Thermodynamics: Foundations and Applications, MacMillan.

Examinations: There will be two quizzes during the term, and a final examination.

Final grade:
30% homework
30% quizzes
40% final examination

Time allotment:

Topic	Number of Lectures
FOUNDATIONS	8
APPLICATIONS	
Heat engines	1
Simple systems	2
Properties of pure substances	2
Ideal gases	1
Bulk flow	1
Conversion devices	2
Availability functions	1
Energy conversion systems	2
Ideal gas mixtures	2
Diffusion and tranport phenomena	2

Outline of 2.451J and 22.571J

FOUNDATIONS

Kinematics and Dynamics
- Systems
- Properties
- States
- Motions

Energy
- Weight process
- First law
- Definition of energy
- Additivity of energy
- Conservation of energy
- Energy balance
- Absolute energy

Stability of equilibrium
- Types of states: unsteady, steady, nonequilibrium, equilibrium, stable equilibrium
- Reversible and irreversible processes
- Second law
- Impossibility of PMM2
- Historical statements of the second law

Adiabatic availability
- Definition of adiabatic availability
- Features of adiabatic availability

Available energy
- Mutual stable equilibrium
- Reservoirs
- Definition of available energy
- Features of available energy

Entropy
- Definition of entropy in terms of energy and available energy
- Features of entropy
- Entropy balance
- Dimensions and units of entropy

Stable equilibrium state principle
- State principle
- Criteria for stable equilibrium states
- The fundamental relation

Temperature

Total potentials

Pressure

Work and heat

Energy versus entropy graphs

APPLICATIONS

Heat engines
- Heat engines
- Heat pumps and refrigeration units

Systems with volume as the only parameter
- Characteristic functions
- Maxwell relations
- Heat and work interactions

Simple systems
- Gibbs, Euler, and Gibbs - Duhem relations
- Gibbs free energy
- Partial properties

Phase rule

Properties of pure substances
- Specific properties
- Specific latent heats
- Two-phase mixtures
- Specific heats
- Equation of state

Ideal gases
- Ideal gas behavior
- The perfect gas model
- Ideal incompressible behavior

Bulk flow
- Bulk flow states
- Bulk flow interactions
- Work, heat, and bulk flow
- The combined rate balance

Conversion devices
- Flow through a pipe
- Diffusers
- Nozzles
- Throttles and valves
- Compressors and pumps
- Turbines
- Heat exchangers

Availability functions or exergy functions

Energy conversion systems

Ideal gas mixtures
- Partial pressures
- Partial properties
- Gibbs-Dalton mixtures
- Ideal gas mixtures
- Entropy of mixing

Diffusion
- Diffusion interactions
- Transport phenomena

Fall 1990

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

His teaching style is novel. He is very good at challenging the students to think independently and to critically judge ideas that they have previously learned. However, he is not always constructive when answering students' questions. Many times he appears to be talking down to the student that has asked the question.

He encourages questions, but sometimes he does this to the point where they go off on a tangent and use up lecture time which may invariably get added to the end of class. Encouraging questions is great, but I think it would be more helpful to everyone if he cut the discussions off sometimes. His lectures are very clear and since he wrote the book, they follow it closely.

I have only positive comments. He has a pleasant friendly attitude. He answers questions well, takes interest in the students' grasp of the material, and remains patient when people are confused. His thoughts are organized excellently, however, he doesn't write everything that he discusses on the board.

Gyftopoulos explains things in great detail and knows his subject intimately. More numerical examples either in lectures or in books would help in solving problems in the book.

I feel very positive. The instructor offers very good explanations in lecture.

I like his style very much because he is very enthusiastic. He gives tremendously enlightening lectures. He obviously cares a great deal about the students. He pays close attention to questions. He answers them well and understands what misconceptions the students have. Once in a while he flames on a topic, but that is okay.

He is the best professor that I have ever had! He loves the subject and he shows it. He conveys this enthusiasm to me and I believe to most of the students. He is a really dedicated educator! Maybe he shouldn't let anyone else lecture.

Most of the time he is okay, though sometimes he is hardly audible when he murmurs through the subject.

He is very enterprising and insightful. Some points are overemphasizeed.

The professor is one of the most inspiring teachers I have ever had the

pleasure of studying under. I wish there would be continuing courses to this subject.

He is arrogant and aloof. Sometimes he is unapproachable and preachy. He is obviously an expert in his field. Perhaps some better preparation and the elimination of the review at the beginning of each class would allow us to get out on time. He typically extended class by 15 or more minutes.

He is enthusiastic, concerned, and articulate.

He explains things clearly. He does tend to get upset when you've misunderstood something, so you save up your questions until you are really sure that you don't understand something. 2.451J wouldn't be the same without him.

The professor demonstrates real depth in understanding the material and has an excellent teaching style. He is experienced and very sharp in getting to the heart of the problem being questioned. I wish that he would have taught the course to the end.

By far, he is the best instructor that I have had at MIT.

He's easy to follow in his lecture and he has a good blackboard style.

He is a very good lecturer. The tests are unreasonably long and they lack focus. The classes are devoted to ideas and the tests are completely number crunching. We need more examples in class.

He is extremely knowledgeable on the subject and is able to answer any question well. He is very good at explaining things. However, I don't find him to be a very dynamic lecturer and since this subject can be quite dry, I lose my attention easily. Also, more examples during lecture would be great.

The professor is very patient. He understands the students' perspective and encourages questions.

The course was organized and the important points were emphasized well. He has completely mastered the subject.

He has a tendency to ramble on a bit and drop his voice so that the finer details of an example or answer to a question are lost to the audience.

Excellent teacher! He understands the students' difficulties well.

The professor definitely know the material, but I think he is <u>too</u> precise. Sometimes I think that he makes easy material seem very difficult. It would be better if he just gave more applicable examples.

He is available for questions after class and treats students with respect.

Bravo! I enjoyed your lectures immensely.

Fall 1990

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Gyftopoulos

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

The subject is very interesting and appears to be a novel way of teaching thermodynamics. It would be helpful if on the homework assignments, a discussion is given on the possible assumptions that can be made. It would be helpful if more examples problems were given in class or tutorial.

The subject is a whole new approach to thermodynamics, which makes it confusing to those with the background that was taught differently. The book was very good, though the homework problems were often difficult. More example problems in the text would be helpful. The quizzes were okay, but a bit long.

The text was excellent. The exams were the perfect length. The problem sets were illustrative of the material. The large course content, however, makes it impossible to cover some areas in appropriate depth.

I couldn't understand very well due to the language problem. The problem sets and quizzes were very difficult for me. I think the class is too large.

The first half of the course covering the fundamentals was extremely clear and coherent. The second half covering the applications needed to be tied together better and more limited in scope. The problem sets were reasonably good, but the exams were too long.

The subject was surprisingly interesting. The only bad thing was the homework. They were very time consuming and I don't really think that they helped me much! Please give more examples in lecture.

The subject seems to try to revolutionize the teaching of thermodynamics. It seems to be a failure, though. All kinds of confusion run around the class. The text was too thick to read.

The subject attempted to put thermodynamics in a new light; it practically succeeded. There was too much material to cover. There was too much to learn in too little time. The homeworks were not designed very well.

The course was a fresh approach to the science of thermodynamics. Many questions that I had had during my undergraduate years were answered. I particularly appreciated all of the time that they spent on us during the tutorial sessions.

The problem sets were not always helpful in learning the material. The homework did not prepare us for the tests. The type of problems were

completely different.

I liked the treatment of entropy and the focus on irreversibility. I also liked the perspective of thinking in terms of availability. I'm not convinced that expressing the first law in terms of a weight process instead of energy buys us clarity or some more intuitive fundamental basis of understanding. Many of the homework problems were unnecessarily vague and ambiguous. The quizzes were too busy. I was time pressured to complete them. I don't believe that this is the best way to test understanding.

The first half of the course is thermodynamic philosophy and the second half is light speed thermodynamics. If we were better prepared for the radical shift around chapter fourteen, it wouldn't leave so many of us in the dust. I feel like I really understand what entropy is. Although my main field is design, I feel that I understand the world a little better. Great class!

I think that this is the way that thermodynamics should be taught. The subject is very cohesive. More time should be devoted to the practical problems and aspects of thermodynamics.

The class was better than I expected. The material was clearer and the problem sets were much easier than previous 2.451J students led me to believe. I feel that this class cleared up a lot of unanswered questions about thermodynamics and I enjoyed the way that the material was presented. The book was very easy to read and I liked the fact that the lectures followed it. I thought that the quizzes and homeworks were very fair and they tested what was covered in class.

Although the problem sets take a lot of time, I do enjoy the course.

The book is very good. Although the problem sets were difficult, I think that they were fair. The problem sets should have been handed back before the tests. The material was all relevant.

We spent almost too much time on the first fourteen chapters. The rest of the semester was a barn burner. The problem sets and the quizzes were fair. Perhaps if the testing period were one hour and forty-five minutes, it would be better. It would be better if the first half hour of recitation could be used for answering questions and then the professors could present their research case studies.

Some of the problem sets are not directly related to the subject and do not help the student understand.

This is a difficult subject and much is unclear. The problem sets were too long and too vague. The tests were too long. Give us three hours to write so that we can think clearly.

This is an excellent class in general. The assignments were too long and there were too many of them considering that people have other classes as well.

The lectures were excellent. The homework was basically pointless. Many of the questions just did not help reinforce the points that we were trying to learn in class. Too bad, because I wish that they were more helpful.

Problem sets relating to the material on the quiz should be handed back before the quiz.

The subject was organized well. They followed the schedule closely. The material covered was very extensive. The grading on the quizzes was not that great because points were taken off for skipping steps.

A lot of material was covered in a brief period. The problem sets and exams were too long. The subjects covered were excellent and relevant. The class size was fine.

The class was fun.

I liked the method of teaching thermodynamics. It was very clear and logical. It seemed that after chapter fourteen, that the course took off and went much faster. Maybe they should even it out a little.

I think that the course had some good points, but it was too theoretical. Afterall, that will help here in the real world. The quizzes and problem sets were way too long. They ended up taking about twenty hours to complete.

Excellent coherent and demanding subject. The recitation strayed from its most useful purpose which was the solution of thermodynamic problems.

The class was great. It was a revelation of thermodynamics. The book is also a breath of fresh thermodynamic air. The problem sets were challenging. The tests were a bit long. It seems that we ran out of time towards the end of the term. Perhaps less time could have been spent on the foundations and more on the chemical reactions.

Fall 1990

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Gyftopoulos

E. On average, how many hours per week did you spend on this course. Include time both in and out of the classroom or laboratory.

3 hours in class. 8 hours preparing for class.

15 hours per week.

30 hours per week.

25 hours per week.

13 hours per week.

10 hours per week.

3 hours in class. 4 hours with homework. 2 hours studying. 9 hours total.

About 12 hours per week.

12 to 15 hours per week.

15 to 20 hours per week.

40 hours per week.

10 to 12 hours per week.

3.5 hours in class. 2.5 hours in tutorial. 12 to 18 hours with the problem sets.

9 hours per week.

3 hours in class. 14 hours with the problem sets. 17 hours total.

3.5 hours in lecture. 10 hours with homework. 13.5 hours total.

3 hours in class. 10 hours studying.

20 hours per week.

3.5 hours in class. 12 to 17 hours outside of class.

5 to 6 hours per week.

15 to 18 hours per week.

18 hours per week.

September 12, 1989

2.451J and 22.571J

GENERAL THERMODYNAMICS

Instructor:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804
Assistant:	Evan T. Hurlburt, Room 31-158, Ext. 3-7933
Class hours:	Tuesday and Thursday, 11-12:30
Tutorial period:	To be arranged.
Homework:	Assigned in class and due one week later; it must represent individual effort.
References:	Classnotes (must be purchased).
Examinations:	There will be two quizzes during the term, and a final examination.
Final grade:	30% homework 30% quizzes 40% final examination

Time allotment:

	Topic	Number of Lectures
1.	Foundations	7
2.	Simple systems	2
3.	Properties of pure substances	2
4.	Ideal gases	1
5.	Bulk flow	1
6.	Conversion devices	2
7.	Availability functions	1
8.	Energy conversion systems	2
9.	Ideal gas mixtures	2
10.	Chemical reactions	2
11.	Chemical equilibrium	2

Outline of 2.451J and 22.571J

FOUNDATIONS

Kinematics and Dynamics
- Systems
- Properties
- States
- Motions

Energy
- Weight process
- First law
- Definition of energy
- Additivity of energy
- Conservation of energy
- Energy balance
- Absolute energy

Stability of equilibrium
- Types of states: unsteady, steady, nonequilibrium, equilibrium, stable equilibrium
- Reversible and irreversible processes
- Second law
- Impossibility of PMM2
- Historical statements of the second law

Adiabatic availability
- Definition of adiabatic availability
- Features of adiabatic availability

Available energy
- Mutual stable equilibrium
- Reservoirs
- Definition of available energy
- Features of available energy

Entropy
- Definition of entropy in terms of energy and available energy
- Features of entropy
- Entropy balance
- Dimensions and units of entropy

Stable equilibrium state principle
- State principle
- Criteria for stable equilibrium states
- The fundamental relation

Temperature

Total potentials

Pressure

Energy conversion systems

Ideal gas mixtures
- Partial pressures
- Partial properties
- Gibbs-Dalton mixtures
- Ideal gas mixtures
- Entropy of mixing

Chemical reactions
- Conservation of atomic nuclei
- Stoichiometry
- The reaction coordinate
- Changes in amounts and composition
- The degree of reaction
- Energy and entropy balances
- Mixture properties at different compositions
- Reactions of formation and standard properties of formation

Chemical equilibrium
- Chemical equilibrium with respect to a single reaction
- Temperature and pressure effects
- Conditions for chemical equilibrium in terms of temperature and pressure

September 13, 1988

2.451J and 22.571J
GENERAL THERMODYNAMICS I

Instructor:	Elias P. Gyftopoulos, Room 24–109, Ext. 3–3804
Assistant:	Jae Bok Song, Room 35–006, Ext.3–0012
Class Hours:	Tuesday and Thursday, 11 – 12:30
Tutorial Period:	To be arranged
Homework:	Assigned in class and due one week later; It must represent individual effort.
References:	Classnotes (must be purchased)
Examinations:	There will be two quizzes during the term and a final examination.
Final Grade:	30% Homework 30% Quizzes 40% Final Examination

	Topics	Number of Lectures
1.	Foundations	7
2.	Simple systems, Phase rule	2
3.	Pure substances	2
4.	Ideal behavior	1
5.	Bulk flow	1
6.	Energy processing	2
7.	Availability functions	1
8.	Energy conversion systems	2
9.	Mixtures	2
10.	Chemical reactions	2
11.	Chemical equilibrium	1
12.	Industrial processes	1

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief introduction
System, properties, states, processes
Weight processes
First law: relation between end states and change in height of a weight

Definition of energy
Additivity of energy
Conservation of energy
Energy balance
Impossibility of PMM1
Absolute energy and relativity

Types of states: unsteady, steady, nonequilbrium, equilibrium, unstable equilibrium, stable equilibrium

Reversible and irreversible processes

Second law: existence of stable equilibrium states, impossibility of PMM2
Adiabatic availability
Reservoirs
Mutual stable equilibrium
Available energy

Entropy: definition in terms of energy and avalable energy
Entropy changes in weight processes
Entropy changes in isolated systems
Principle of nondecrease of entropy
Entropy balance

Stable equilibrium states
State principle
Criteria for stable equilibrium
Fundamental relation

Temperature
Third law
Total potentials
Pressure
Work, nonwork
Heat
Heat engines
Heat pumps and refrigeration units

Graphical representations of basic concepts

SIMPLE SYSTEMS

Stable equilibrium states
Characteristic functions
Maxwell relations
Heat and work interactions
Constant–volume, constant–pressure, constant–temperature, and constant–entropy processes
Subdivision of simple systems
Gibbs, Euler, and Gibbs–Duhem relations

PHASE RULE

PURE SUBSTANCES

Specific properties
Experimental results
Specific latent heats
Two–phase mixtures
Specific heats
Equation of state

IDEAL GASES, LIQUIDS, AND SOLIDS

Specific heats
Perfect gases
Ideal incompressible fluids

EQUATIONS OF STATE

Compressibility factor
van der Waals equation
Other equations of state

BULK FLOW

Bulk flow states
Bulk flow interaction
Work, heat and bulk flow
The combined rate balance

CONVERSION SYSTEMS

Flow through a pipe
Diffusers
Throttles and valves

Compressors and pumps
Heat exchangers
Heat transfer

POWER CYCLES

AVAILABILITY FUNCTIONS

Availability of exergy
Different availabilities
Effectiveness

MIXTURES

Partial properties
Specific properties
Partial Gibbs free energy
Gibbs–Dalton mixtures
Mixtures of ideal gases
Liquid vapor equilibrium
Psychrometry
Fugacity
Activity

CHEMICAL REACTIONS

CHEMICAL EQUILIBRIUM

INDUSTRIAL PROCESSES

September 10, 1987

2.451J and 22.571J
GENERAL THERMODYNAMICS I

Instructors:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804 Gian Paolo Beretta, Room 3-339D, Ext. 3-7921
Assistant:	Pyongwan Park, Room 31-066, Ext. 3-0536
Class Hours:	Tuesday and Thursday, 11-12:30
Tutorial Period:	To be arranged
Homework:	Assigned in class and due one week later; it must represent individual effort.
References:	Classnotes (must be purchased).
Examinations:	There will be two quizzes during the term and a final examination.
Final Grade:	30% Homework 30% Quizzes 40% Final Examination

	Topics	Number of Lectures
1.	Foundations	7
2.	Simple systems, Phase rule	2
3.	Pure substances	2
4.	Ideal behavior	1
5.	Bulk flow	1
6.	Energy processing devices	2
7.	Availability functions	1
8.	Energy conversion systems	2
9.	Mixtures	2
10.	Chemical reactions	2
11.	Chemical equilibrium	1
12.	Industrial processes	1

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief introduction
System, properties, states, processes
Weight processes
First law: relation between end states and change in height of a weight.
- Definition of energy
- Additivity of energy
- Conservation of energy
- Energy balance
- Impossibility of PMM1
- Absolute energy and relativity

Types of states: unsteady, steady, nonequilibrium, equillibrium, unstable equilibrium, stable equilibrium

Reversible and irreversible processes

Second law: existence of stable equilibrium states, impossibility of PMM2
Adiabatic availability
Reservoirs
Mutual stable equilibrium
Available energy

Entropy: definition in terms of energy and available energy
- Entropy changes in weight processes
- Entropy changes in isolated systems
- Principle of nondecrease of entropy
- Entropy balance

Stable equilibrium states
- State principle
- Criteria for stable equilibrium
- Fundamental relation

Temperature
Third law
Total potentials
Pressure
Work, nonwork
Heat
Heat engines
Heat pumps and refrigeration units

Graphical representations of basic concept

SIMPLE SYSTEMS

Stable equilibirum states
Characteristic functions
Maxwell relations
Heat and work interactions
Constant-volume, constant-pressure, constant-temperature, and constant-entropy processes
Subdivision of simple systems
Gibbs, Euler, and Gibbs-Duhem relations

PHASE RULE

PURE SUBSTANCES

Specific properties
Experimental results
Specific latent heats
Two-phase mixtures
Specific heats
Equation of state

IDEAL GASES, LIQUIDS, AND SOLIDS

Specific heats
Perfect gases
Ideal incompressible fluids

EQUATIONS OF STATE

Compressibility factor
van der Waals equation
Other equations of state

BULK FLOW

Bulk flow states
Bulk flow interactions
Work, heat, and bulk flow
The combined rate balance

CONVERSION SYSTEMS

Flow through a pipe
Diffusers
Throttles and valves
Compressors and pumps
Heat exchangers
Heat transfer

POWER CYCLES

AVAILABILITY FUNCTIONS

Availability or exergy
Different availabilities
Effectiveness

MIXTURES

Partial properties
Specific properties
Partial Gibbs free energy
Gibbs-Dalton mixtures
Mixtures of ideal gases
Liquid vapor equilibrium
Psychrometry
Fugacity
Activity

CHEMICAL REACTIONS

CHEMICAL EQUILIBRIUM

INDUSTRIAL PROCESSES

FALL 1987

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Professor Elias P. Gyftopoulos

B. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

He explains things really well.

Lectures directly from the notes, not really offering new insight. Many answers to questions are so round about or extensive that the answer gets lost in the shuffle.

Clear lecturing style, but a bit dry. Good blackboard techniques.

Quite Good. Restrain the length of tangential discussions which often arise.

He is a good instructor. I don't have anything to say more.

Gives out good homework problems which are due! Great underlying, understanding of the material, lectures strictly from notes.

He does have a excellent teaching technique. He can give very good explanations about the content of lecture.

Explains material clearly.

Class notes are good, but lectures correspond to them exactly,usually I don't get any additional insight from going to lecture. However, "stories" are entertaining. It would be helpful for Prof. Gyftopoulos to speak a little more loudly, in general. Good black board technique.

Good presentation, good use of blackboard. Sometimes he goes off on tangents, which take up too much class time. Short ones are good, however.

There is little he could do to improve his enthusiasm is infections, and ability to teach superb. Well organized and a pleasure to listen to.

Excellent lecturer. I liked the presentation of his material. Developed a good foundation for rapid progress though different advanced notions.

He is very good when students ask him questions. He leads the student to the answer and I think this is a good thing to do. Once in a while his enthusiasm wanes.

He knows the subject inside and out, but I wasn't blessed with his insight. Consequently, some of his explanations lost me. At times, he is in his explanations which makes it difficult to take notes. .

Spends alot of time talking & very little explaining. Doesn't answer questions very well. Leaves out a lot & refers you to the class notes. Goes very slowly so he always runs over time.

He knows the subject material well. Somewhat pompous and overbearing though . Seems you too hard if you ask a stupid question.

Has a very good grasp at the subject that allows him to be extremely precise in his explanations and bring to light points that are often missed by students. Good lecture style, reviews previous lectures.

Gives very clear and understandable presentation of material. Very good motivator. Takes a little too much time in answering questions when a short answer would be fine.

Good lecturer. Speaks well, explains well.

A pretty good, very knowledgeable professor with good teaching skills.

He races to get as much material as possible in at the end of the class. He should end at a natural break even if it's 5 minutes early. 5-10 minutes late. Seems friendly & caring about how well the students understand.

Explains very clearly, detailed. Therefore sometimes appears to be slow, but you really understand what's happening.

Always helpful outside of class. Quickly shuts students off with out class questions.

He tends to be slow and labor over points in lecture. Overall he is good.

FALL 1987

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Professor Gian Paolo Beretta, Professor Elias P. Gyftopoulos
Pyongwan Park, T.A.

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

The solutions for the problems sets should be better prepared and checked.

Many concepts in the first half of classnotes are so abstract that I couldn't understand easily.

Good to take as a listener, because you really learn during class.

Homeworks seem to be always in advance of the lectures. That's why I sometimes feel very difficult to do the homework problem, even if I understood the lectures pretty well. Generally speak up, the subjects are interesting.

I like the presentation. I think there are additional assumptions in 1st & 2nd laws that aren't explicitly stated but worth mentioning. Problem sets and especially quizzes, got too far ahead of lecture. Problem sets assume a lot of knowledge from previous thermo courses. I guess that's OK, but I spent alot of time looking for material properties.

Gave clear and understandable definitions to thermo concepts that are abstract. Should possibly give more examples during class and tutorial. Problem sets were applicable and helpful to gaining a full understanding of the material. Thought time spent on introductory concepts well worth it.

Very good presentation of Thermo, in a way that helps give a physical understanding of concepts that were just numbers in my undergrad thermo. Practical applications are presented well in notes but were discussed in lecture. These should be given more time in lecture.

It was unfair to cover material on quizzes and problem sets before it was covered in class. Course notes were quite good in terms of completeness, but rambled too much and were too pedantic in language. Too much material crammed in at end of course.

Text very poor.Class size was OK. Problem sets, we are not given enough information before hand to solve them in most cases. Last quiz concentrated on a small subset of what we were told to study.

Class size is OK. This course started out with a good outline, very nicely prepared class notes, and detailed lectures, but the course quickly became invented. The Homework assignments were on material not yet covered in lecture or assigned in readings. Then the quizzes covered material not yet covered in lecture, readings, homework.. Help in the tutorials would have been nice.

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Professor Gian Paolo Beretta, Professor Elias P. Gyftopoulos
Pyongwan Park, T.A.

I really like this presentation of thermodynamics. It is very structured. The foundations approach first gives me a much better understanding of the subject and the physical questions we are trying to answer with it. The notes need some work in the second part of the subject. They are not as clear, but they are still very good.

innovotive & helpful presentation of basic material. Needs more exposure to devices & prue ideal substance models.

Subject, particularly text, has been under continued development. It's much better this year than last. No particular changes recommended.

Overall, good course, text is satisfactory, class size is okay, and problem sets and quizzes are okay.

All subject matter okay. The second quiz covered material that we hadn't even done a problem set on!

Better than it was.

Good. Problem sets too many. Please give the notes as early as possible.

Problem sets =Great preparation for exams and allows for the thorough understanding of the physics.

The instructions are good, but the subject is so boring. I think it's necessary too. Undergraduate fermodynamics is enough..

I liked the careful coverage of the foundations of the material.

Need more emphasis on problem solving. A bit to theoretical for my tasts.

The recitation period should be scheduled in the course listings and not assigned arbitrarily after the start of classes.

Sometimes the subject seemed to go out of it's way to make concepts seem difficult, that could have been explained more simply, at least initially. Without complete insight into the statements of the text, the tests and problems sets are a struggle. A few examples would go a long way in helping to understand the material. The tests questions were fair,

Alot of material in a short period of time.

Interesting! Initially I thought I would waste my time. Finally it came out Okay. Now I feel comfortable when I refer to eutropy! The material was too much and last lectures were not very helpful. Quizzes , shortage of time but Ok. Problems sets, the bottleneck of the courses large, not well defined, confusing, time consuming etc.

FALL 1987

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451J
SECTION NO:
INSTRUCTOR(S): Professor Gian Paolo Beretta, Professor Elias P. Gyftopoulos
Pyongwan Park, T.A.

E. On average, how many hours per week did you spend on this course.
Include time both in and out of the classroom or laboratory.

20hrs/wk, plus 4hrs/class

15 hrs/wk, but this was without being able to do 25% of the problems assigned. To complete what was expected would have required twice the effort on my part.

25 hrs/wk

10 hrs/wk

10 hrs/wk.

4 hrs/ lecture and recitation, 12 hrs/homework

20 hrs/wk.

Class 4 hrs, Homework 4 hrs, Reading 1-2 hrs.

Class time 3 hrs/wk, Lab time 0 hrs/wk, Prep time 10 hrs.

8 hrs/wk

11-15 hrs/wk.

14 hrs/wk.

I averaged 14 hours per week in this course.

12-15 hrs/wk.

20 hrs/wk.

10-12 hrs.

25 hrs/wk.

10-12 hrs/wk.

10 hrs/wk.

20 hrs/wk.

25 hrs/wk.

15 hrs/wk.

13 hrs/wk.

We spent alot of time in this course, mainly due to the homework.

September 1986

2.451J and 22.571J
GENERAL THERMODYNAMICS I

Instructors:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804 John B. Heywood, Room 3-340, Ext. 3-2243
Assistants:	Woody Chin, Room 7-008, Ext. 3-7080 Christian Schmidt, Room NW13-219, Ext. 3-8970
Class hours: Tutorial period:	Tuesday and Thursday, 11-12:30 To be arranged.
Homework:	Assigned in class and due one week later; it represents individual effort.
References:	Classnotes (must be purchased)
Examinations:	There will be two quizzes during the term and a final examination
Final grade:	30% homework 30% quizzes 40% final examination

Topics	No. of lectures
1. Foundations of thermodynamics	7
2. Simple systems	2
3. One-component systems	2
4. Bulk flow	3
5. Multicomponent systems	2
6. Entropy generation in typical processes	1
7. Chemical reactions	4
8. Industrial processes	2

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief Introduction
Systems, states, properties, processes
Work, adiabatic processes
Nonwork
First Law: relation between work and end-states in adiabatic processes
Definition of energy
Conservation of energy
Impossibility of PMMI
Relativity and conservation of total mass

Classification of states: nonequilibrium, steady, equilibrium, and stable equilibrium states

Second Law: existence of stable equilibrium states
State principle
Reversible and irreversible processes
Impossibility of PMM2
Adiabatic availability
Work by a system and a reservoir

Available energy
Definition of entropy in terms of energy and available energy
Entropy changes in adiabatic processes
Principle of increase of entropy

Stable equilibrium states

State principle
Criteria for stable equilibrium
Mutual stable equilibrium
Conditions for mutual stable equilibrium
Temperature
Entropy constant
Total potentials

Heat

Heat and flow entropy
Inequality of Clausius
Work, heat, and change of entropy
Heat engines
Heat pumps

Graphical representations of basic concepts

SIMPLE SYSTEMS

Stable equilibrium states
Pressure
Characteristic functions
Maxwell relations
Constant pressure and constant volume processes
Enthalpy, Helmholtz free energy, Gibbs free energy
Representation of states on property diagrams
Heat capacities
Phases
Phase rule

SIMPLE ONE-COMPONENT SYSTEMS

Experimental results
Specific heats
Specific latent heats
Mixtures of two phases
Clapeyron relation

SEMIPERFECT AND PERFECT GASES

EQUATIONS OF STATE

Compressibility factor
Van der Waals equation
Other equations of state

MULTICOMPONENT SYSTEMS

Partial properties
Partial Gibbs free energy
Gibbs-Duhem equation
Gibbs-Dalton mixtures
Liquid-vapor equilibrium
Psychrometry

BULK FLOW

Mass balance
Energy balance
Entropy balance
Steady state examples
Combined energy and entropy balance

AVAILABILTY

Availability expressions
Effectiveness
Composition effect
Practical limitations

ENTROPY GENERATION IN TYPICAL PROCESSES

CHEMICAL REACTIONS

Species and composition
Stoichiometry
Reaction coordinate
Degree of reaction
Energy and entropy balances
Differences in values of properties
Reactions of formation and standard properties

CHEMICAL EQUILIBRIUM

Condition for stable equilibrium, chemical equilibrium equation
Equilibrium constant
Effects of temperature and pressure on equilibrium composition
Many chemical reactions
Complete stable equilibrium

INDUSTRIAL APPLICATIONS

Combustion and power
Steel making
Waste heat recovery
Cogeneration of motive power and process heat

FALL 1986

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451
SECTION NO:
INSTRUCTOR(S): Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Nothing to recomment; he is the best teacher I had so far in MIT.

End class on time. Don't feel obligated to fill alotted time.

Dr. Gyftopoulos is an excellent instructor and has handled the course very well.

Excellent board technique; encourages questions; clear presentation style.

He is a very dynamic lecturer. He is well prepared, thorough and clear.

One of the very best i"ve ever come across. I haven't the foggiest notion as to how his technique can be improved.

An excellent instructor. Always concerned about the basic understanding of subject materials. Helped students extensively even outside the class.

He is a fine lecturer and friendly guy. Welcome (even demands) questions and challenges. Discusses more than teaches. No criticism. (Sometimes he mumbles-should speak louder.)

He has the very broad and deep knowledge. And his lecture was excellent.

The prof is an excellent lecturer and very knowledgeable of the subject. He knows how to explain the subject and how to present it in the most informative way. I don't think that there is room for any further improvement in this teaching technique.

Takes a formal approach to topic and encourages questions. Occasionally appears to be short tempered with students asking questions, making them less inclined to ask further questions. Overall a very enjoyable lecturer. Has a nice style and is well informed about impact of theme throughout the world.

Very good lecturer. He motivates the material very well.

He is an excellent instructor.

Explains material clearly and as completely as it deserves. A negative aspect is that, after asking for criticisms, he ignores the criticism he gets.

His teaching technique is super. However, I felt that the focus of some topics were vague, therefore, I had to review after the class.

He makes us fully understand the basic concepts. His pronunciation is sometimes difficult to understand.

I feel that the content of the course as well as the teaching of Prof. Gyftopoulos is excellent. He provides the insight to thermodynamics in such a way that students can absorb it effectively.

He seems to have known all the questions students are going to ask. I like the way he explains the questions.

He gave abundant knowledge on thermodynamics to us. I learned something about physical meanings especially. His writing is simple and clear.

I like the way he asks students to follow a logic problem-solving process instead of to jump at equations which fit the variables. He makes you think, not merely repeat information. Also, I like how he knows a lot of the student's names. For some reason though, he seemed a bit overbearing when I first met him, but this passed as I got to know him.

I have no recommendations for improvement. I find the instructor excellent in all aspects. His knowledge of the subject is unique. His communications skills superb. He is very friendly and accessible. He cares for his students and his course.

He's an excellent instructor and I'm afraid I can offer very little in the way of constructive criticism. Perhaps the long review at the beginning of each lecture could be curtailed.

He was a very good instructor. He used to answer the questions after thinking and in a very good way. He was very well organized. He was always available for meeting the students. I am happy that I am his student.

Prof. Gyftopoulos' lectures are well and logically organized, but I sometimes find them hard to follow because he explains to the class how to get to the next step instead of writing everything down. I miss a lot of what he's saying

This was by far the clearest exposition of thermodynamics I know of. The logical development was at a measured pace, and was put in plain language. The instructor was conscientious and almost always available for help. This instr. is a master of thermo. The only negative thing was that homeworks were sometimes ambiguously stated. That is life, of course, but around here time is short.

Good.

Confident patient. Very helpful outside of class.

I think he was enthusiastic about the subject, which is always nice. He was available to discuss material and frequently quite helpful.

Enjoyed teaching - eager to answer questions - concerned whether the students learn the material - a very good teacher.

Clear explanation of material; excellent attention to detail; enthusiastic; gave relevant examples and problem sets; fair and thorough. Should emphasize the more subtile points.

FALL 1986

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451
SECTION NO:
INSTRUCTOR(S): Professor Elias P. Gyftopoulos, Professor John B. Heywood

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Problem sets long and difficult. Text was relevant. Quizzes too long for the time given.

Material excellent. Problem sets should be substantically shorter.

The course has been very challenging and very exciting. I don't see any was in which it can be improved further.

The text brought a new meaning to the words "bite the yam". No index, rambling, no table of contents... Length of problem sets was somewhere between six hours and return of the living zombie.

More in-class or class note examples would be a tremendous help. The course initially appeared to be floating in a theoretical spare; when practical probles suddenly appeared on the problem sets, I felt unprepared. Otherwise the course is organized quite well and has a very logical flow.

The problem sets were very time consuming. This class is a lot of work! I like the general approach to thermodynamics and the fact that it started from the beginning, i.e. no prior knowledge of thermo.

Some question in the problem sets dealt with material yet to be covered in class and was thus very ambiguous to say the least.

Chapters on chemical reactions and mixtures should be given more time, as they take more time for proper understanding.

Problem sets are tough, time-consuming, but critical to grasping material. Quizzes weren't too tough, but heavily weighted. Most recent material (second quiz was quite unfair I thought). Also, problem sets frequently converned material not yet covered in class - a severe frustration to me.

More advanced parts should be included. The class size is moderate. Problem sets, test, and quizzes are very good and helpful.

The subject is excellent. I took undergrad thermo but I never really understood it as I have after taking this course. The tests were fair and the problem sets (although quite long) are appropriate. The only comment I have is that I would have liked it if the notes contained some examples of the material.

Negative - sometimes the lectures were out of phase with the homeworks and exams. Particularly, the 2nd exam covered material only briefly touched in the homeworks.

Some of the problem sets were too long. Otherwise, the problem sets is very useful to understand the material properly. Maybe try to make smaller problem sets which also address the fundamental concepts.

I am satisfied with this subject. I think chemical reaction is irrelevant to general thermo. Problem set - too complicated procedure of calculation. I request more problems asking the concept.

The course is a much improved and more consistent presentation of thermo than typically presented. The homeworks were often tedious and took excessive time to do. I don't mind the work, but I hate it to be repetitive. The quizzes were fair and gave a good measure of knowledge of material.

The amount of problem sets is huge, but very helpful to understand the subject.

Best subject.

I can't find another reference book for this course. Problem sets are too heavy, especially #10.

The weekly sectional is one of the most valuable part of the course. One thing that could be improved is the text. It needs an index badly! This would help tremendously when studying. Otherwise it is very straightforward.

I find the subject very interesting. I liked the way it was presented as encompassing a great number of our everyday problems, as well as our long term energy problems. I do not think I understood everything, but I believe this is due to the nature and complexity of thermodynamics and the inherent difficulty in understanding its concepts. The class size was perhaps a trifle too large.

Homework should be a mechanism of learning not part of the grade. Answers should be available so you get immediate feedback from homework. Looking at your mistakes a week after you make them is not effective. As an undergraduate, one professor made students hand in a copy of their homework so he could collect them and then go over solutions immediately! I think this is a good idea.

The homeworks were very long and sometimes time consuming. I learned a lot of new ideas in thermodynamics. I think it is better that instead of chemical reactions they focus on engineering application of thermo in industerial apparatuses. Problem sets were very long. The text, quzzes were very good. The grading of problem sets was very bad.

This course was very demanding, got me lost and confused, and wore me out. But it forced me for the first time to really understand thermodynamics -- I think 2.40 encourages the student more to crunch through problems. As I begin to understand thermodynamics I am fascinated by the subject and am glad I took this course, even though the problem sets and reading were long and the quizzes were difficult.

Homeworks were good, practical, but often ambiguously stated. Course was excellent, is to be recommended for all grad students.

His okay.

Text is too general. Needs more examples. We needed more solved problems. The only way I could learn 2.451 was to get old problems with solutions and study them. The notes (text) were only a beginning. Quiz 2 put too much emphasis on mixtures, which we hadn't solved problems for yet.

I think the class was right on. However, an additional, less "philosophical" text with some examples would have been quite useful.

More physical examples should be given of concepts presented. Abstract ideals are more meaningful if examples are discussed.

Quizzes too long and detailed. Otherwise very well done.

I love this subject. Problem sets are vague in definition and meaning of itself, which needs to be improved.

FALL 1986

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE NO: 2.451
SECTION NO:
INSTRUCTOR(S): Professor Elias P. Gyftopoulos, Professor John B. Heywood

E. On average, how many hours per week did you spend on this course. Include time both in and out of the classroom or laboratory.

About 15 hours.

15.

10 hrs.

10-15.

15-20.

14.

In class 3 hrs. Out of class 10 hrs (average).

12-14.

Average 20 hrs/week.

20.

16.

20. (Varying with the problem sets).

30 hours per week.

25 hours.

10 - 20 hours per week.

15 hours.

One problem set takes two nights to finish. 20 hrs/week.

12.

Lectures 3 hours. Homework 15 hours.

18-20.

More than 30 hours.

3 hrs lecture, 1 hr tutorial, 8 hrs preparation. 12 hrs.

About 15 hrs total.

12.

25 hrs/wk.

30.

15 hrs homework; 3 hrs class.

20 hrs/week - 25 hrs/week. Includes 3 hrs class and 1 hr tutorial.

10 hrs.

September 1985

2.451J and 22.571J
GENERAL THERMODYNAMICS I

Instructors:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804 Gian Paolo Beretta, Room 3-339D, Ext. 3-7921
Assistants:	Habib Najm, Room 3-339D, Ext. 3-2411 Theodosios P. Korakianitis, Room 3-473M, Ext. 3-2334 Alexander Sich
Class hours:	Tuesday and Thursday, 11-12:30
Tutorial period:	To be arranged.
Homework:	Assigned in class and due one week later; it represents individual effort.
References:	Classnotes (must be purchased)
Examinations:	There will be two quizzes during the term and a final examination
Final grade:	30% homework 30% quizzes 40% final examination

Topics	No. of lectures
1. Foundations of thermodynamics	7
2. Simple systems	2
3. One-component systems	2
4. Bulk flow	3
5. Multicomponent systems	2
6. Entropy generation in typical processes	1
7. Chemical reactions	4
8. Industrial processes	2

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief Introduction
Systems, states, properties, processes
Work, adiabatic processes
Nonwork
First Law: relation between work and end-states in adiabatic processes
- Definition of energy
- Conservation of energy
- Impossibility of PMMI
- Relativity and conservation of total mass

Classification of states: nonequilibrium, steady, equilibrium, and stable equilibrium states

Second Law: existence of stable equilibrium states
- State principle
- Reversible and irreversible processes
- Impossibility of PMM2
- Adiabatic availability
- Work by a system and a reservoir

Available energy
Definition of entropy in terms of energy and available energy
- Entropy changes in adiabatic processes
- Principle of increase of entropy

Stable equilibrium states

- State principle
- Criteria for stable equilibrium
- Mutual stable equilibrium
- Conditions for mutual stable equilibrium
- Temperature
- Entropy constant
- Total potentials

Heat

- Heat and flow entropy
- Inequality of Clausius
- Work, heat, and change of entropy
- Heat engines
- Heat pumps

Graphical representations of basic concepts

SIMPLE SYSTEMS

Stable equilibrium states
Pressure
Characteristic functions
Maxwell relations
Constant pressure and constant volume processes
Enthalpy, Helmholtz free energy, Gibbs free energy
Representation of states on property diagrams
Heat capacities
Phases
Phase rule

SIMPLE ONE-COMPONENT SYSTEMS

Experimental results
Specific heats
Specific latent heats
Mixtures of two phases
Clapeyron relation

SEMIPERFECT AND PERFECT GASES

EQUATIONS OF STATE

Compressibility factor
Van der Waals equation
Other equations of state

MULTICOMPONENT SYSTEMS

Partial properties
Partial Gibbs free energy
Gibbs-Duhem equation
Gibbs-Dalton mixtures
Liquid-vapor equilibrium
Psychrometry

BULK FLOW

Mass balance
Energy balance
Entropy balance
Steady state examples
Combined energy and entropy balance

AVAILABILTY

Availability expressions
Effectiveness
Composition effect
Practical limitations

ENTROPY GENERATION IN TYPICAL PROCESSES

CHEMICAL REACTIONS

Species and composition
Stoichiometry
Reaction coordinate
Degree of reaction
Energy and entropy balances
Differences in values of properties
Reactions of formation and standard properties

CHEMICAL EQUILIBRIUM

Condition for stable equilibrium, chemical equilibrium equation
Equilibrium constant
Effects of temperature and pressure on equilibrium composition
Many chemical reactions
Complete stable equilibrium

INDUSTRIAL APPLICATIONS

Combustion and power
Steel making
Waste heat recovery
Cogeneration of motive power and process heat

PI TAU SIGMA FALL 1985

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451, Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? REcommend ways in which he/she can improve his/her teaching techniques.

He draws students into discussions very well. Relates material to real world examples. Clear persentation.

His encouragement of questions in class has been carried too far.

End classes on time. Encourages participation but often intimidates students when they ask questions. Overall, lectures are interesting and understandable.

When answering questions he makes sure the one asking understands the answer. He makes good, complete answers that explain the material fully. I like his sense of humor.

Hard to improve.

He has excellent insight into why students get confused over certain topics. He is humorous and makes the classes enjoyable.

Excellent presentation. No need for imorovement.

Excellent instructor.

This was my third thermo class and I have learned something new from every instructor. He seemed to inject a practicality into everything even though it is not stressed in the coursework. I really enjoyed his lectures.

Please stop classes on time. Do not try to make the students change their questions so that he can answer them. Tells good jokes.

Excellent instructor. Best promoter at class discussion I have ever seen.

Very energetic, knows his stuff, and very precise.

I think Prof. Gyftopoulos taught the material very well and was especially good at answering students' questions by redirecting questions to the students to make them think. He also taught the course with some sense of humor which made it more enjoyable. Lectures which differed somewhat from the reading material might be more helpful or interesting sometimes (although repetition helped understanding).

He explains theory quite well, translates theory well to general understanding of practical problems.

He doesn't work practical examples, which makes it difficult to do problem sets.

Excellent instructor.

Overall, a great professor.

Very clear and precise, presents things well on board, sometimes makes minor mistakes on board. Overall, very good.

One of the best instructors I have had at MIT. He's very enthusiastic about the subject and knows the topics extremely well. It is impossible for mortal man to stump him with a question or a situation. He makes you feel like he's your grandfather and cares a lot about you.

Presentation is quite good. I was really impressed.

Sometimes he explains in a very difficult way to understand when he could explain in a more straightforward way. I like his attitude to try to communicate with students.

He is enthusiastic, gives clear explanations and descriptive examples to explain matters at hand.

He explained things very well. Sometimes he knows our questions even before we asked him the full question. He takes pain to make the concept very clear. Any improvement: The notes handed out, perhaps, could be made more readable (he handwrote the notes).

He seems to be one of the best instructors of the institute.

Great as an instructor.

The instructor understands the subject very well. His explanation is very clear and his answers about students' questions are helpful. But at the beginning of the class the material is a little bit difficult to understand. More examples might be helpful.

Very good instructor. Interesting. One fault: Tends to answer questions with questions to force student to think for himself. This Socratic method is nice, but it sometimes takes too much class time.

Experienced, keeps attention.

He explained very difficult points very well from a practical point of view. He was good on the whole.

Unlike some professors, Prof. Gyftopoulos gives a lot of attention and care about the course. The materials and the notes in the class are presented very well. Very useful and enjoyable course.

The explanations were sometimes vague at the first part. Spent so much time in responding to questions which are not common to all students. Conceptual reviews of classical thermodynamics were helpful.

He knows the material very well. He interacts with the class.

His knowledge for this course is nice, but his teaching method is not very effective.

He was spending too much time answering the trivial questions of lazy students, who didn't want to think for themselves.

Very good instruction. If the important points can be stressed and important concepts can be explained more explicitly, the instruction would be perfect.

Good instructor.

Too much irrelevant class discussion.

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451, Professors Gyftopoulos and Beretta

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Terminology is sometimes inconsistent. For example, if heat is defined to relate to the transfer of energy when the thermal gradient approaches zero, then conventional "heat exchangers" should not be called heat exchangers.

Problem sets too long. On both problem sets and quizzes too many proofs. They don't really show whether the student has a good understanding of the subject matter.

Homework was good for learning the material. Good problems. Tests covered the right material and were of the right length. I am glad they did not get too involved with mathematics.

Some homeworks too laborious. Could have learned with less tedious work. Great methodology to thermo.

The course combines theoretical and practical applications in a beneficial way. The tests are bad because they do not allow enough time. Though I do very well on homework problems, I make mistakes on the tests because of the pressure to rush through. The homework problems were long but helpful.

I enjoyed the subject particularly because it was presented in a more conceptual than analytical way compared to most engineering courses. Nothing seemed irrelevant-I wish we had covered more. The only complaint I have is that some of the problem sets took forever to do. The quizzes have been fair and the class notes are excellent.

The course, I thought, was taught well. The lectures were clear and coherent, the homeworks were aligned with the material covered and emphasized critical points, however, they were not always in time with the lectures. We were asked to solve problems before the concepts involved were covered in class, this was very frustrating. This happened occasionally.

A little more give and take in tutorial on how to do problems would lead to better learning. I feel I was stupid to try and fail on homework (34/60) than to copy last year's (60/60).

The material is interesting. The beginning was maybe a little bit slow. The proofs of many theorems went way above

my head (not in the understanding but in the interest). The problem sets are way too long; however, the types of questions are okay.

Great course. A proper textbook with worked examples would have helped greatly. There isn't a good text which talks about this stuff the way it is described in the notes.

This is a very good course. It is very time consuming. Text needs to be edited to make reading easier. Problem sets too long for their weight in credit.

I like the fact that the course emphasizes fundamental definitions and concepts of entropy, stable equilibrium, etc. From my undergraduate thermo courses I was able to work problems, but I now have a much better understanding of the material. The problem sets and quizzes were interesting and helpful.

The amount of work required for the course was way out of line from the 12 units it is rated. I and most people I know had to put in about 30 hours a week just to keep up. Examples in class would help. The explanation of material was usually hard to follow.

I liked the way the course generalized thermodynamic theory. "Mechanical" aspects were covered pretty well (i.e,, turbines, heat exchangers, etc.). Quizzes were okay, as soon as you realized they were based almost solely on problem sets. The problem sets were too long. I think this is because of the lack of examples given in class. There should be a text which would explain methods of attacking problems.

Problem sets are often too long and tedious. They should include problems that are more practical and more to the point. Tutorial was not very helpful. The second part (mixtures, etc.) is done too fast, and I did not absorb the material. First part of course is very good.

No doubt you will hear all about the length of the problem sets from others. Believe me, no matter what I get in the course, I won't regret the hours put into those problem sets. I did poorly on the second exam on the proof. That was somewhat irrelevant at the time. Also, why take the best of two tests? Why not average? Granted, I am an average but consistent performer so my view is biased.

Homework was too demanding. Lectures were way too general an example here or there would improve the theory that they were trying to convey. Exams were nothing like I expected. The first exam required tables without prior exercise of tables. I was very rusty in using tables and I did poorly. The make-up exam saved me (I liked that).

The subject was very good. I liked the conceptual approach to thermo. I think the last half was pretty slow.

The quizzes were okay. The problem sets, however, were sometimes too numerically involved or too long.

This was an excellent course. The only criticism is that the homework sets were generally too long, and not very well stated, leaving many questions vague in meaning.

The assignments are too hard, although they are quite helpful.

Homeworks are sometimes difficult because of prerequisite knowledge in other fields of study. This knowledge should be given more sufficiently when homeworks are given.

The course is tough, the homework is tougher, too much work, very time consuming, sometimes diffiucult to relate homework to course. The quizzes are okay.

The problem sets are very tedious. I can take problems which are conceptually difficult, but very tedious evaluation really made me very "sick."

The only comment is: I think the course could have a book, if the student want to go deeper in the subject he doesn't have references.

Excessive work for the problem sets.

The load on homework problem sets is too heavy, but the problems themselves are interesting and very helpful in understanding the material.

The course spent too much time on rigorous proofs of esoteric points. Time would have been better spent developing more "gut" feeling for basics and in developing techniques for dealing with practical problems. Big gripe-at beginning, the course seemed to propose to deal with non-equilibrium processes, it never did.

The subject is okay. The problem sets are good to have but sometimes it seems that calculation is more important than real understanding. Should be changed.

The materials presented were very useful. I would like to just say that if some materials on non-ideal solutions and surface thermodynamics can be added, the course. would become very comprehensive.

Good, coherent approach. It has been so long since I took classical thermo that the differences didn't bother me. Except in trying to use other textbooks to supplement the class notes. My need was acute in the early part of the subject, and the material absent from (or unclear in) the notes was nowhere else.
Negative: Class notes are mechanically hard to read-being typed in double spacing as they must be. There should be an

index or table of contents or some kind of aid for finding things after you've read things but forgetten where. There should be some source of problem examples. Having to do every problem set from first principles means that there is not time to get insights, and a lot of room for computational errors (e.g., wrong signs, wrong values for constants, wrong interpretation of tables, etc.). I would like to see some dry-run problems with numeric computation, while struggling on the problem sets-without having to hike over to the nuclear energy library, please.

There were useless efforts in assigments to connect units (British/SI). Sometimes assignment involved too complicated computation. The grading was unfair sometimes, regarding series of numerical computation.

Too much emphasis on proofs. Overall a good course.

For M.E. students, there seems no reason that some topics relevant to nuclear should be given.

Everything is okay, the problem sets are very good. I learned the most of contents from them.

The problem sets take too much time to do.

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451, Profs. Gyftopoulos and Beretta

E. On average, how many hours per week did you spend on this course? Include time both in and out of the classroom or laboratory.

24 hours per week.

About 25-30 hours per week. 3 hours for class, 2 hours for recitation.

25 hours per week.

30 hours per week.

3 hours on lecture, 1 hour on recitation, 1 hour on reading, 12 hours on problem sets.

15 hours per week.

Average 3 or 4 hours on reading and 5-6 hours on assignnments.

Don't know. Homework sets too long.

Time in classroom: 4 hours per week. Time out of classroom: 20 hours per week.

12 hours per week.

On an average of 20 hours per week.

A lot. For the homework set, like 10 to 20 hours at least.

Class: 3 hours per week. Home: About 15 hours per week.

20 hours per week.

Around 25 hours per week.

About 18 hours per week.

About 14 hours per week.

Class: 3 hours per week, Tutorial: 1 hour per week. Homework: 15 hours per week. 19 units for a 12 unit class.

Class: 3 hours per week, Recitation: 1 hour, plus an average of 17 hours for homework. 21 hours, total.

About 20-25 hours per week.

10-15 hours per week.

30 hours per week.

About 13 hours per week including lectures.

30 hours per week.

30 hours per week. Seems to have improved over last year's horror stories.

About 20 hours per week.

Too many.

About 20 hours per week.

About 30 hours a week. There was a lenghty problem set due every week.

3 hours in class, one hour in tutorial, 10 hours on homework. Total of 14 hours per week.

32 hours per week.

3 hours in class, one hour in tutorial, 20 hours on homework.

20-25 hours per week.

3 hours in class, one hour in tutorial, 3 hours on reading and reviewing, 16 hours on homework. Total of 23 hours.

September 1984

2.451J and 22.571J
GENERAL THERMODYNAMICS I

Instructors:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804 Gian Paolo Beretta, Room 3-339D, Ext. 3-7921
Assistants:	Theodosios P. Korakianitis, Room 3-339D, Ext. 3-2411 Christopher Vlahoplus, Room , Ext.
Class hours:	Tuesday and Thursday, 11-12:30
Tutorial period:	To be arranged.
Homework:	Assigned in class and due one week later; it represents individual effort.
References:	(1) Class notes (must be purchased) (2) "Engineering Thermodynamics" by Huang, Macmillan Publishing Co.
Examinations:	There will be two quizzes during the term and a final examination
Final grade:	30% homework 30% quizzes 40% final examination

Topics	No. of lectures
1. Foundations of thermodynamics	7
2. Simple systems	2
3. One-component systems	2
4. Bulk flow	3
5. Multicomponent systems	2
6. Entropy generation in typical processes	1
7. Chemical reactions	4
8. Industrial processes	2

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief Introduction
Systems, states, properties, processes
Work, adiabatic processes
Nonwork
First Law: relation between work and end-states in adiabatic processes
Definition of energy
Conservation of energy
Impossibility of PMMI
Relativity and conservation of total mass

Classification of states: nonequilibrium, steady, equilibrium, and stable equilibrium states

Second Law: existence of stable equilibrium states
State principle
Reversible and irreversible processes
Impossibility of PMM2
Adiabatic availability
Work by a system and a reservoir

Available energy
Definition of entropy in terms of energy and available energy
Entropy changes in adiabatic processes
Principle of increase of entropy

Stable equilibrium states

State principle
Criteria for stable equilibrium
Mutual stable equilibrium
Conditions for mutual stable equilibrium
Temperature
Entropy constant
Total potentials

Heat

Heat and flow entropy
Inequality of Clausius
Work, heat, and change of entropy
Heat engines
Heat pumps

Graphical representations of basic concepts

SIMPLE SYSTEMS

Stable equilibrium states
Pressure
Characteristic functions
Maxwell relations
Constant pressure and constant volume processes
Enthalpy, Helmholtz free energy, Gibbs free energy
Representation of states on property diagrams
Heat capacities
Phases
Phase rule

SIMPLE ONE-COMPONENT SYSTEMS

Experimental results
Specific heats
Specific latent heats
Mixtures of two phases
Clapeyron relation

SEMIPERFECT AND PERFECT GASES

EQUATIONS OF STATE

Compressibility factor
Van der Waals equation
Other equations of state

MULTICOMPONENT SYSTEMS

Partial properties
Partial Gibbs free energy
Gibbs-Duhem equation
Gibbs-Dalton mixtures
Liquid-vapor equilibrium
Psychrometry

BULK FLOW

Mass balance
Energy balance
Entropy balance
Steady state examples
Combined energy and entropy balance

AVAILABILTY

Availability expressions
Effectiveness
Composition effect
Practical limitations

ENTROPY GENERATION IN TYPICAL PROCESSES

CHEMICAL REACTIONS

Species and composition
Stoichiometry
Reaction coordinate
Degree of reaction
Energy and entropy balances
Differences in values of properties
Reactions of formation and standard properties

CHEMICAL EQUILIBRIUM

Condition for stable equilibrium, chemical equilibrium equation
Equilibrium constant
Effects of temperature and pressure on equilibrium composition
Many chemical reactions
Complete stable equilibrium

INDUSTRIAL APPLICATIONS

Combustion and power
Steel making
Waste heat recovery
Cogeneration of motive power and process heat

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

Course 2.451J, Professor Elias P. Gyftopoulos FALL 1984

A. INSTRUCTOR..What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Excellent course and lecture in all points. The homework assignments are too long. Apart from that, the course was very well presented, with clear concepts.

Very good, experienced instructor.

Very nice. No comment.

Positive - dynamic speaker, good sense of humor.
Negative - not really in tune with students' needs.

They are both pretty good.

Good presentation of subject.

Course is well organized and well taught.

Very good class - homeworks are too long. A little less time spent on them would be a big help. Homework problems are good. Great lecturer. Class notes are terrible. Could really use some improvements - example problems would be great.

Positive - Explains material very well, starting from basics.
Negative - Sometimes spends too much time answering obscure, unrelated question.

Well organized, presented the material in a very ordered manner and provided numerous examples. I don't feel there is any need for improvement.

He encourages class discussion and questions. He also tries to get at the source of questions, and is very successful at it. The professor tends to be somewhat stubborn sometimes when challenged by students and this may be an area of improvement.

I appreciate his great desire trying to cover a lot of material in the class as much as he can. But problem is that he usually gives too much homework. Usually we spend more than 20 hr/wk for homework. Maybe they don't know that many students are working as an R.A. or T.A. Also maybe they assume that every student might take only 2.451J. I learned a lot from this course. But I lost more time than I learn.

J.G.

Dr. Gyftopoulos is a very interesting lecturer. His concern for the students is great. But he seems to stick too strictly to specific and sometimes ambiguous definitions which are more often confusing than a less formal definition.

Instructor has a fine personality and is the easiest to get along with in class. Had a spell in the beginning where he fought some questions off almost indignantly from confused students but as the course progressed, virtually everything was easily understood. Like the emphasis placed on course.

I feel he does a good job overall, but a lot of time was wasted because he did not always state assumptions clearly.

Positive - quite willing to explain his points
Negative - very biased opinion
Improve - relate material to our background

Positive

He made the subject very interesting. He did a better job at eliciting class participation.

Professor Gyftopoulos is an excellent lecturer. And did his best to present elusive concepts in a clear fashion. His lecturing followed class notes very well.

It might be a little more helpful to include more direct applications.

Very eloquent, extremely good explanations, but tries to defend the existence of theromdynamics among other sciences, although I do not understand why.

Excellent lecturer with very deep understanding of the material and a profound desire to convey the subject matter. Contagious enthusiasm. Unlike most professors, always willing to spare his time for his students.

I doubt that any complaints I make will be considered by this individual, so I will refrain from any comments.

Great lecturing style, very open to answering questions. In fact, he often spent too long answering questions that I feel should have been answered briefly, and continued outside of class if necessary.

Excellent course very well taught.

I appreciate his warm personality which I regard as an outstanding aspect of his excellent teaching. He encourages questions and accepts debates.

Did not provide motivation, early in the term, to learn the very abstract material. Only in the second half of the term was the abstract material applied. Perhaps this sequence is necessary but it makes it very hard to put the necessary effort in at the beginning. The early homeworks were good but class had zero motivation. I called class "thermosemantics" and hated it.

Well, his style is certainly different; overall I guess I liked it. At times it was very frustrating that he seemed to be playing games with us - holding back information that would make things clear until we were obviously thoroughly confused. Asking him questions is dangerous - you don't get the answer, you only find that you didn't understand the question.

Positive points are more emphasis on entropy, availability, chemical reactions. If problems were graded or looked by professor it may had better results. Tutorial classes were not quite organized and more repeated questions were asked.

All the attributes I can think of are positive - excellent motivation of material, easy-going attitude and personality. One of the two best teachers I've ever had.

He made the course slightly enjoyable by using examples, etc.

Positive: He has tremendous enthusiasm and dedication to his field. He really inspires you to understand thermodynamics. Negative: Often his method of answering questions leaves you more confused than when you started. I think this is intentional, not that he wants to confuse you but he wants you to think about it. But still, sometimes a straight answer would be quite helpful.

I know that you are trying to be didactic but you end up "deanswering" questions. We, as students, realize that answers in general have limitations and restrictions - it is much more helpful to say this is the answer in this case but if A or B change your problem changes and as such so does the answer.

Professor Gyftopoulos is very impressive in the braod and meticulous exposition he gives to theromodynamics. I wish however he had taken some time to expose us to some of the other ways of looking at the subject. I think that would be more instructive than showing the subject from one side only!

Availability is not as obscure a subject as Professor Gyftopoulos has left the students thinking. Although his explanations are usually satisfactory, Professor Gyftopoulos needs to go a little farther and bring the subject closer to home, i.e., more intuitive and physically understandable explanations. Avail. effectiveness was never adequately addressed.

Well prepared - answers questions well. Please make better use of the last week of class - I came here to learn how to use thermo not on how to be a politician.

I feel the instructor did a good job of presenting the foundation of thermo. I feel very little time was spent on the application of principles but this is where were were tested. I think devoting 20% of the time to the fine points of application would greatly enhance student learning.

Many concepts not well explained. Professor Gyftopoulos never clarified the material by use of examples. This would have been very helpful.

Friendly enough, but not very good at explanation of his ideas. It takes a long time for his teaching to sink in, mostly because he leaves out parts and fails to emphasize that which is heavily emphasized in tests and quizzes.

Excellent teacher: explains well, good speaker. Sometimes examples are a bit esoteric not everyday understandings and applications.

Positive: 1. He is what I consider to be a pure teacher. Very good at translating complex subjects into simple terms. 2. Friendly, relaxed style stimulated interest, promoted discussion. 3. Very concerned that we learn and understand the subject (this is not always true of M.I.T. professors). 4. He is one of the two best professors I've had since I've been here. 5. Very knowledgable. 6. Always available.
Negative: None

COURSE 2.451J, Prof. Elias P. Gyftopoulos & Prof. G. P. Beretta

FALL 1984

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Problem sets a little too long - this course makes a mockery of its 12 unit listing. On balance, though, an excellent course. I don't think the workload should be reduced - I think the units should increase.

Very nice subject. It was perfect until the beginning of chapters related to mixtures and chemical reactions. The presentation of these materials should be improved. I didn't understand anything about chemical reactions. All I learned was by myself reading such books as Wang and Collen.

Problem sets were extremely time consuming. Closed book quiz and final are not good!

Problem sets were very hard but helped. Some of them got on my nerves for being number crunching exercises (especially some cycle calculations). The theoretical problems were excellent!! Recitation was o.k. Not the best but good enough.

The class notes would be better if more examples are added. Homeworks interesting but too long.

Spend more time on chemical equilibrium and reaction.

I wish we had looked at more applications - possibly discussed some of the more advanced technologies in greater detail.

Problem sets were too long with often hours of neverending interpolations. Some problems were unrelated to lecture. Also, students who worked on the problems sets above, were penalized, because the types of questions that were asked required collaboration between several students.

Quizzes and problem sets were interesting. One of the best courses I've ever taken.

The fact that homework is too much is o.k. But it would be better if most of our efforts are spent to what we really need. For example I think spending too much time to converting S2 unit to British unit.

The amount of problem set was too large. So I spent much time finishing it. I recommend the amount of problem set must decrease.

The subject gives a good thorough background of thermodynamics, but tends to be more elegant than practical. I wish there was a little more emphasis on problem solving.

In many cases the general approach to a problem is left to the student who makes assumptions to get an answer. Since the answer depends in part on the assumptor, an assumptor different than those made by the professor leads to a different answer. These answers are marked completely wrong.

Quizzes were held in that horrible hall Walker.

The problem sets were too long, and to add to the problem the resources to be used were not made clear (i.e. what is allowed), and led to alot of wasted time.

Too abstract, segment on chemical reactions had no lead-up (it came of the blue) separate chemical reactions into a separate course.

Class size was o.k. Problem sets difficult, but very helpful in understanding the subject. Text and quizzes o.k. Course helps to develop a good and different viewpoint of the subject, and clarifies certain concepts.

Thermo will always be "scientific astrology" to me. I was not convinced that entropy is a property. It seemed more a contrived bookkeeping for systems (time only go foreward =, entropy does not decrease).

The class lectures were so different from the homework problems, and I think a better correlation between the two should be approached. A set of example problems reinforcing the class notes would have helped a good deal.

Class size is a bit large. For given credit this class requires too much work. It is an excellent course but some effort should be made to allow for the extraordinary effort required for this class.

The only criticism are the problem sets. They are absurd as a PMM2. As regards subject matter: I learned a lot although I still have a slight reservation whether you wouldn't learn a lot on anything if you spent that much time on it. I think I know Thermo now!

The grading is absurd, particulary the method of giving 2 mid-terms and taking the higher average as the mid-term average. Also - if the instructors and T.A.'s took more time grading I think they would make fewer mistakes. It is NOT necessary to get quizzes back the class period after they are taken. The class notes (the most useful text) desperately need an INDEX.

The problem set is good and instructive. The only defect is that not all the conditions in the problems are given clearly and thus some students who believe they "understand" the problem really get low marks on the homework. I think the conditions should be given instead of leaving for assumptions by students themselves.

Problem sets are too long. Despite about 5 discussions in tutorial on effectiveness, I still don't understand it.

The problem sets are too long. They do not provide all the necessary information. Too much is left up to the student. More examples are necessary in class. The text should have more examples. The section on chemical reactions should be deleted from the agenda.

Excellent course - greatly increased my understanding and appreciation of the subject. I always thought Thermo was boring - now it seems pretty interesting. Homework was, of course, too long, but thank god it counts for 30%

I didn't like having closed book quizzes on tests. I never used my books for this course. The notes could use an index to make finding specific items easier. I din't feel the course would come into much use in practical application.

Overall this was an excellent course, however, I have some major complaints. a) the course load was way too high in fact it was crushing. I spent all week doing thermo and everything else when I had a free moment. This isn't fair. b) the xerox notes although good are very short on worked examples. C) The quizzes were extremely hard and often didn't reflect what was learned in the homework. d) I think they tried to cram too much into one semester. The chemical mixtures although interesting was one too many things. I would like to have spent more time really understanding the subtleties and practical implications of what we had learned earlier. e) don't recommend buying Huang text or Keenan. They are a waste of time.

Notes and problem sets are poorly written and worse yet, poorly proofread. Several equations in the notes and problems sets have been wrong. Notes and texts are incomplete with regard to chemical reactions and chemical equilibrium. It would be very helpful also for there to be an index in the notes and suggested readings for the topics lectured on. There are no examples (problems worked out) in the notes (exception: combustion) or lecture and the tutorial is spent avoiding the questions.

Problem sets took an inordinate amount of time to do. Many problems were just enormous sets of tedious calculations, table look-ups and interpolations. Other problems involved concepts not covered in class. Very little of the lectures involved applications. No example problems were worked. It is extremely inefficient for students to learn how to work problems when the only problems presented to them are ones which they are expected to work independently.

The subject gave me a much deeper knowledge of Thermodynamics than I previously had. It definitely promoted my interest in the subject. However, the lack of a textbook that follows the course was a setback. The notes are very clear but they could use more development examples, and illustrations.

Problem sets - Much too long! I quickly realized that I could not afford to put the time into the problem sets that was really needed. Ergo, I did not get as much out of them as if they had been shorter and afforded more time to put in a full effort. Effort should be given to - reduce interpolations, reduce "trial by error" calculations, and other extraneous calculations.
Grading of Problem Sets - Terrible. Someone needs to speak to the T.A.'s Grading appears arbitrary. Regardless of what is put down it appears that you'll lose at least a point. They need to take a closer look at what the students put down.
General - I would be very interested in taking the second half of the course if the instructors handled it differently. I'm therefore resolved to take it on my Ph.D at UC Berkeley.

Provide suggested readings for each days lecture material in addition to the handouts. I strongly believe that this would have fostered enhanced learning of the subject material. Be specific on the page numbers too. Exams seemed fair but the grading seemed to be somewhat uneven from student to student. Closed book is better. Do it for all of them. Problem sets were o.k. and the realistic examples were useful. T.A.'s very helpful. Tutorial - At least half of each session should have a structured format - example problems should be worked in order to allow the students the opportunity to see the application of new material before the homeworks. Some time should be allowed towards the end of the tutorial for Q/A after doing the examples. I felt that when there was no structured format, that the time was poorly used.

Quizzes were very long for the time given. I feel I would learn much more from the homework if they were more in number and simpler. By this I mean that I could have more opportunity to practice fundamentals, rather than have to sort through one very long problem. With very complicated problems that are few in number, if the one problem is done wrong, little is learned. With many simpler examples, more learning could take place. All of the homework sets had errors or information ommitted. Many were not corrected until after several people-hours were wasted trying to chase something that didn't exist. Problem sets should be proofread or doing before handing out.

One of the worst courses I've taken at M.I.T. because 1) the class notes in lieu of text were terrible - no examples. 2) problem sets were so much work that they obscured the relevant material of the course. Furthermore the problem sets correlated very little with the lecture material and were apparently rather ill-conceived. For example, one problem asked us to explain why a particular phenomenon occured - the correct answer to the problem was that the phenomenon did not occur. 3) I question the fairness of the quizzes. A problem on the 2nd quiz was an unsteady bulkflow problem, something that was never considered in the problem sets and only briefly mentioned in class.

1st part was very frustrating. Homeworks were very poorly done - lots of mistakes and problems not well thought out, as if they had done them a few minutes before class and hadn't tried them themselves. The class notes were poorly written - abominable English and NO SAMPLE PROBLEMS AT ALL! You end up not knowing the first thing about how to solve a problem, and spend MUCH TOO MUCH TIME on the problem set just trying to figure out what's what. The grader, unfortunately, was taking the course with us (!!!) so the grading was often wrong and generally unhelpful. And if you didn't make the tutorials, you didn't find out valuable information like a problem set was wrong, etc. I thought I knew Thermo. Now I'm confused. This course is a poor preparation for the Qualifiers. Very few practical problems. And come on, can we get problem set solutions with answers with fewer than 6 decimal places!? They seem to have a good way of looking at the subject - the Energy-Entrop curve was great, but they conveyed it with all the dexterity of a rock. After hours of studying and pouring over reference books, I can just barely see what they are talking about. And I'm doing well in this course.. The lead level ought to be (3 0 40).

Subject was good. The general apporach was refreshing. The understanding of entropy and availability came across. I think I can apply this to my work of computational fluid dynamics where entropy conservation/generation is critical. Homeworks many times dealt with material not yet covered. This should not be done for graded material. I feel the presentaton of the "frozen" chemical reactions on E-S diagram finally put things in perspective. I had trouble with this from the beginning and presenting these graphs with the stable equilibrium line earlier should be done. The large class was well balanced with 2 instructors. The only problem was it made it a bit intimidating to talk with the instructors and make class contributions.

Critical: 1. Problem sets were too long (I hate interpolating). Though they were <u>extremely</u> helpful. I think the content of the problem sets could be streamlined to maximize learning and thinking time. 2. Discussions in some of the early lectures sometimes dealt with unimportant issues. That is, some of these questions should have been handled on an individual bsis. Positive: This is my 4th thermodynamics courses (I had A's in the previous three). This is the first time that I feel that I truly understand the subject. The way in which such topics as entropy, availability and chemical thermo. is introduced is truly outstanding. I thank you for the course.

September 1983

2.451J and 22.571J

GENERAL THERMODYNAMICS I

Instructors:	Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804 Gian Paolo Beretta, Room 3-339D, Ext. 3-7921
Class Hours:	Tuesday and Thursday, 11-12:30
Homework:	Assigned in class and due one week later.
References:	
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(2)	Class notes (must be purchased).
(3)	"Engineering Thermodynamics" by Huang, Macmillan.
(4)	"Principles of General Thermodynamics" by Hatsopoulos and Keenan, Krieger
Examinations:	There will be one or two quizzes during the term and a final examination.
Final grade:	30% Homework 30% Quizzes 40% Final Examination

	Topics	No. of Lectures
1.	Foundations of thermodynamics	5-6
2.	Simple systems	2
3.	One-component systems	2
4.	Bulk flow	2
5.	Entropy generation in typical processes	1
6.	Energy conversion systems	2
7.	Multicomponent systems	2
8.	Chemical equilibrium	2
9.	Chemical reactions	3
10.	Industrial processes	2

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

The professor has an uncanny knowledge of the subject and in general explains it well. Sometimes, however, he tends to gloss over some details which are particularly difficult or obscure.

+Knows material thoroughly - very impressive and good lecturer - concerned for students. -Should try to do more detailed examples.

He is a very good instructor.

Excellent in teaching, in encouraging questions and discussion and stimulating interest for the course. He has an example for everything, great experience.

Teaching and techniques are excellent. He is beyond my judgment. During the course I came to admire him both as a man and as a Professor.

He is great. Explains difficult material well and carefully. Willing to slow a lecture down if necessary. Possibly he spent too much on theory and not enough on practice.

All positive. Excellent instructor. Best I have had at M.I.T.

Excellent professor, overall. His layout of thermodynamic concepts amazes me.

Best teacher that I have ever met. I would be very pleased to thank him for the course.

Every aspect of his teaching was excellent. Excellent person also. He cares about each student as people.

Very good and also encouraging students very much!

Excellent presentation of material and gives one an actual feel of the material.

Very good teacher.

Excellent teacher. Best I have seen in a while. Excites interest in subject and makes sure that everybody understands. He is able to give physical intuitive meaning to abstract thermodynamical concepts; and actually made me enjoy thermo for the first time after having several terms of the subject.

Excellent.

Sometimes lowers his voice to near inaudibility. No other complaints; I would find it difficult to suggest improvements.

Very good lecturer and openly welcomes anyone when in need of help. But when I asked questions, the answers were too deep. Often I was looking for an answer relating only to the concepts.

Excellent application of theory to real situations, e.g. power plant. Attempted to emphasize concepts with physical situations, e.g. reversibility chalk.

Pos: Challenges students to think about things they have taken for granted as true without thinking about the implications. I like his "dare to be different" attitude.

None. He is an excellent instructor.

Very good teaching technique. Excellent command of the course content.

Good - generated interest because of his own interest in the material. I liked the approach used in presenting the material.

His teaching was very good.

Did an excellent job of presenting potentially mind boggling material in a coherent, down to earth method. A lot like learning thermo from your grandfather.

Interesting lecturer. Good at discussion and explanation. More examples during lecture to enhance understanding.

Pos: Has a well established way of lecture. Neg: Looks a bit solemn. He is good.

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, Prof. Elias P. Gyftopoulos & Prof. Gian Paolo Beretta

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Subject is a good general treatment of thermo, requiring a lot of time and work.

Required too much time.

I like it because it is both fundamental and practical.

Excellent course.

Good subject. Problem sets long. Quizzes okay. Class size large.

Problem sets were good, but perhaps a bit too long. Quizzes are too long. One doesn't have time to finish.

Good course, emphasizes understanding of principles and entropy as a property of matter. Good approach of the main ideas. I would like to have more in irreversible thermo (diffusion).

Well designed course, a bit fast paced.

Homework sets should be more thoroughly checked for errors. Fine course material.

Overall, good. Just would like problem sets a little shorter. And a little more time for quizzes.

Very well organized and well paced subject. Extremely relevant homework sets and quizzes. Despite the size of the class, both professors managed to keep in close touch with the students. The most enjoyable course.

Interesting approach. Too much work on problem sets. Most problems on assignments - applicable. Some a waste of time.

Hard - Reaction Dynamics.

Everything was fine in the course except some T.A.

Problem sets were difficult, but I learned a lot from them. It is a very good subject.

I learned a lot of things during the course. My eyes were opened and I saw aspects of engineering I didn't imagine. Problem sets were far too long and material could be split in 2 courses! I did between 24 and 30 units of work weekly and it wasn't enough. (Never mind the 12 registered units!). Overall, I am glad I took the course but wish it was split in 2 courses.

Some problem sets had a lot of useless busy work. Also some problems were very ambiguous. I could have used more time on tests. Overall scope of course was very well prepared and presented.

I feel an inadequate amount of time was spent on chemical reactions. Not covered as thoroughly in lecture as other subject matter. Problem sets: Since the grades (problem sets) are 30% of the grade, it is not fair to have identical questions to those of previous years. Not all students have access to the previous years class notes and problem sets.

Problem sets took entirely too much time. They did not help to improve understanding of the subject material. In a lot of instances, I was arriving at solutions but had no idea what relevance it had.

Very interesting subject. Suggestions for further improvement: A more appropriate textbook. More illustrative examples in the lectures. Less tedious problem sets.

Problem sets, although difficult, did cover the material and definitely demonstrated the important concepts. However, they sometimes dealt too heavily on theoretical proofs rather than practical applications.

I found the course generally very stimulating. My main problem with course was that it was too fast and there wasn't a good environment in the class for asking questions. I'm not sure if that is due to the professors (I don't think so) or due to the attitude of the students. It is good that there are 2 options for the mid-term exam. I wish there were 2 finals, too. One of my main problems with preparing for exams and doing the homeworks was that there wasn't enough examples in the class notes. For this reason, I think that the Huang text should have been mandatory (If it had been, I would have bought it much earlier in the course and benefitted from it). It also would be good if the discussion section spent more time reviewing homework problems.

This course needs some simple examples to give a complete understanding of basics. References to the book (Read p--- study) should be given. It should be less concerned about psychology of thermodynamics as long as the judgment is made on academic performance - make the course more "practical" concerning examples. No correlations between books and courses. The notes give a better understanding by giving some examples. Add with a note an exercise book or something similar.

September 1982

2.451J and 22.571J

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Instructors: Elias P. Gyftopoulos, Room 24-109, Ext. 3-3804
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10.	Industrial processes	4

FALL 1982

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATION

COURSE 2.451J, Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Positive: The professor has a high capability of teaching. The way he introduces new concepts, practical problems and application does not require a great effort to understand them when he explains them at class. He has a very good control of the students. Negative: None.

Encourages lots of questions and seems very conscientious about the quality of learning that is going on. His occasional (usually pertinent) anecdote helped for relief while in the middle of difficult material. I really can't see him teaching in any other style so cannot offer recommendations for changing his teaching technique-I would hope that he doesn't!

This instructor is excellent. He is a very effective teacher. More solved problems in class or recitation would have been helpful.

He's a good teacher and one of the best I've had here. He does tend to get theoretical about the subject. That's fine but with the weekly problem sets we have no time to think about the loftier aspects of the subject.

More examples. Important concepts or equations should not be asked to be proven as homework,. but should be presented in class.

Quite informative in helping me to understand concepts! More practical detailed examples should be given in the tutorial sessions!!! This was the negative aspect of this course. Excellent presentations on board.

Knows subject very well and able to demonstrate this in his lectures, being able to present the material well and to answer any questions. Spending 30 minutes of each lecture explaining the lecture before seemed to be a waste of time.

Very clear in his explanations and has a profound knowledge on the subject.

Interesting, stimulating, thought-provoking lectures and discussions. Very interested in our understanding of the material as well as appreciating its continued research frontiers and practical implications. Very willing to discuss problems anytime as long as necessary. An intelligent course taught by an intelligent (and humorous) man.

Enthusiastic. Well-organized lecture. Knowledgeable. Too kind to trivial questions (tedious & waste of time).

1) Excellent presentation on the blackboard and of getting ideas across to the students. 2) A bit slow in covering the topics.

Very good teacher; well-organized and explained concepts very well, starting with basic points and working up. I liked the way that class participation was encouraged so much, though he may have embarrassed some students a few times.

Excellent instructor, clear presentations. The only suggestion that I might make is that we work one or two examples in lecture, particularly on multicomponent and chemical sections.

No negative attributes noted. Lectures were well planned and presented. Sometimes classroom answers to students' questions were brief and left a little confusion regarding the full consequences of the answers.

He is a very good lecturer, and is able to keep student attention. He is also very helpful in his office.

Very consistent in presenting material. Always emphasizes fundamental relations when presenting more involved topics.

Lectures were always clear and interesting. Prof. Guftopoulos' understanding of the subject matter was obvious as was his ability to explain it to students. Definitely the best course I have taken here.

Good instructor with no real need for improvement. Enlightens students on the global scale (i.e. politics, economics, knowledge, etc.) of the implications of thermodynamics, in particular entropy.

Very eager to teach and very sincere in the attitude.

Excellent-blackboard technique and lectures. He is very clear and knows exactly what he's talking about and gets it across well. The only improvement that I can think of is to generate a more complete set of course notes.

Now I see why M.I.T.'s graduate Mechanical dept. is #1 in the nation; Prof. Gyftopoulos is very good.

A superb teacher. He is understanding, amiable and, without exception, always availalbe. Undoubtedly the finest professor I have had at M.I.T. or anywhere else!

Very good instruction. Excellent understanding of the physics and of the thermodynamic laws. Well prepared during classes.

Can think of no negative attributes. He is well organized. Excellent speaker. Extremely colorful to listen to.

His presentation of subject was very good.

Very good professor. His class is very interesting and is easy for understanding. I like him.

Excellent in teaching, except if he could give more examples in class.

Excellent all around.

Excellent.

Should be more tolerant of students' questions.

I have nothing negative to say. Very helpful, presented his material clearly and in a well organized, interesting manner.

Excellent speaker. Well organized. Also very entertaining. Going to the lectures was easy. Knows the material completely.

Attempts to draw class into discussion with excellent questions. Students generally reluctant. Stimulating.

Well prepared and excellent presenter of information.

Excellent instructor; the best at M.I.T! Knows subject and knows how to teach it!

Teaches very well.

No negative attributes. Excellent instructor.

Excellent instructor. Should continue to use his present teaching techniques.

Excellent teacher.

He is very persuasive and impressive.

FALL 1982

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATION

COURSE 2.451J, Professor Elias P. Gyftopoulos & Professor Gian Paolo Beretta & T.A.'s

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

The problem sets were extremely long and difficult. No credit was given for late assignments and no extra credit work was available. If you were unable to finish or were confused on the homework, your grade really took a beating. I don't have a good feeling of where I stand grade-wise.

Good subject. Problem sets were much, much too long.

Very long problem sets, but once you do them, you need not study for the tests.

Course is too theoretical. Must include more applications. Problem sets are too lengthy. Course notes distributed must be more explicit, especially on the second law and heat ideas.

Often there was not quite enough detail in notes and texts to complete problem sets which had language very specific to this course. Perhaps some redundancy would help out here. Problem sets should not be emphasized in final grade determination. People merely copy previous year's problems and collaborate during lecture to get high scores without learning the material. This is unfair to those of us who do our own work and make legitimate mistakes. De-emphasize homework grades.

Quite often mistakes were made in the solutions to the problem sets. Please try to find correct solutions before making available to class. Tutorials helpful.

Subject is very interesting and all the parts covered seem to be very important. I would say that the tutorial should be oriented toward problem solution (i.e. solving previous problem with procedure, number, etc.) in order for the students to have a better preparation for doing the homework.

As is typical of M.I.T. courses, more materials were thrown at us than we had time to cover-as a result, some of the potentially interesting lectures were cut off. I would recommend more of an emphasis grade-wise on the homework, since that's where most of our time was spent.

More practical detailed examples should be given in the tutorial sessions!!! This was the negative aspect of this course.

Course presented old ideas and concepts in a very general nature. I have no complaints.

Lack of a good text left a large hole in course. This course was excellent. There were voids in going from theory discussed in class to the applications presented in problem sets. This led to too much time required to complete these problem sets.

Spent too much time dragging our feet at beginning of course and ended up at high speed. As usual, the weekly problem sets were outrageously hard and often the material was never remotely covered in class. 1st quiz was very unfair since it didn't cover material from class and did not properly test our knowledge.

Chemical reactions topic is very badly presented either in class, notes; and the exercises in this part are not representative, considering the small information given. Rest of material was ok. Problem sets are too large. Quizzes are ok! Classes could be divided in smaller periods.

Good basic understanding of the fundamentals of thermodynamics along with practical implications. Long but very relevant homework problems. Perhaps could have spent a bit more time on power cycles.

Would be helpful to work some examples in class. Tutorials were valuable for getting the hints necessary for solving the problems.

No textbook (handout is not sufficient).

1) problem sets very long, instructors seem to forget students have other subjects to cover as well. 2) should solve some problems in class, in order to give some general ideas of techniques. 3) More time for practical applications. 4) on the whole, subject was interesting.

Class size was larger than what I am used to, but it didn't seem to be much of a problem. I thought that too much time was required on problem sets each week-I have a large research committment and was not able to spend as much time as was required doing homework. The problems were generally very good, though, since they were posed as practical questions, rather than academic exercises (usually). In general, there was just too much work required. I'm also not used to taking timed tests in rooms without a clock and I think my test score suffered because of that.

Is a very good subject. Course is well structured. Homework is lengthy and takes a lot of time to do. Quizzes are fair.

Lectures could present a more practical approach to problem solving. Recommended readings or more class notes would be useful-especially since topic is not a universally held discipline. Problem sets were long (their length was not proportioned to usefulness .

In general, a very good subject, but more examples should have been given for chemical reactions. Perhaps, next year, a handout could be distributed with a couple solved examples of typical problems so that familiarity with the notation, tables, etc. is developed.

Definitely the best course I have taken here.

On the whole, subject was most informative, especially lectures on availability. Tutorial sessions, however, were playgrounds for smart asses to engage in useless intellect.

Too much calculations in the homeworks. Quizzes reasonable. Generally, very good course.

There is a definite need for illustrative examples concerning the topics covered during the semester. The actual working out of numerical examples in class and doing the tutorials would have been a tremendous asset in understanding the material. The course was 10 times more difficult than it actually has to be because of this.

We did not cover aluminum and paper making. That could have been very interesting for practical purposes. There must be more explicit examples in class to understand the topics.

Fascinating subject, too much work, should maybe add a few more applications. Quizzes were difficult but fair. Problem sets were too long and too many problem emphasized proofs.

I enjoyed course. I would suggest that reading assignments be assigned rather than left to the individual.

I enjoyed this course but 1) too slow at beginning, too fast at end. 2) problem sets are too long. I felt that they were designed to use up our time rather than to teach us anything.

A good subject. Time schedule not properly followed. Homeworks were hard and time consuming.

Material interesting. Class size was too large subtracting from the teacher-class relationship. Problem sets and quizzes all very long but rewarding.

Course is very good and the problem sets and quizzes are relevant, except there is no textbook assigned, so lack of examples.

Well organized course. Only that too much material was given during the last 2 weeks.

Problem sets were too difficult or not enough explanation was given in the solutions.

Too much time spent on the introductory material so that things of more complexity, i.e. power systems and chemical reactions had to be rushed. Also I would like to see more examples done in class. This would help with the problem sets, which sometimes took way too much time because of inexperience with basic techniques used in problem solving.

An excellent course. Interesting material. Well presented. One criticism: cut down on the numerical work in the homework. Text by Huang was not useful. A better one would be an aid.

As with all M.I.T. courses, all is too much, so I won't say it!

Excellent subject. I enjoyed the way of teaching. Class size was okay. Problem sets, etc. very good.

I especially liked the practical and real-life examples. Problem sets were often long, which is ok, but people's schedules do not always coincide with the schedule of the problem sets - i.e. some allowances in grading should be allowed.

I liked the course.

Too many homeworks, often with wrong data. Finding thermophysical data is very hard when they are not provided with the homework. More exercises on tutorials.

Lots of homework is not a problem but some problems are too lousy and elaborate.

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

JAN 21 1982

COURSE 2.451J, Professor Gian Paolo Beretta

B. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

He has monotone voice.

Great knowledge-should try to be more interesting.

No negative attributes.

Teaches well and very cooperative in helping out students.

Well prepared and excellent presenter of information.

Needs greater self confidence. It'll come with time.

Good speaker. Well organized. A little dry at times.

I have nothing negative to say about him. He was very helpful, presented his material clearly and in a well organized, interesting manner.

Take more time to cover the amount of material that is covered in chemical reaction thermodynamics.

Very good. Always well prepared. Follows the steps of other professor.

He is also good in teaching, except he should be more clear in explanation

Well organized. Excellent speaker. Maybe a bit dry in his presentation.

Fair instruction. Lack of teaching experience.

Like his lectures, very clear, can understand my notes when I get home. Give this man an 'A'.

Very good and helpful.

Excellent blackboard techniques and lectures. Very clear and knows exactly what he's talking about and gets it across well. The only improvement that I can think of is to generate a more complete set of course notes.

More examples in class.

Class is well organized and the way to teach was clear, understandable.

Very good in private consultation; however, somewhat nervous and unclear during lectures.

Very good instructor-explains clearly, neat blackboard organization.

Very consistent in presenting material. Always emphasizes fundamental relations when presenting more involved topics.

Very well prepared to teach the course although he is slow.

No negative attributes noted. Lectures were well planned and presented. Sometimes classroom answers to students' questions were brief and left a little confusion regarding the full consequences of the answers.

Very good.

1) hesitant while giving lecture. 2) knows his subject well, but does not make a good job of getting ideas across.

Enthusiastic. Well organized lecture. Knowledgeable. Too kind to trivial questions (tedious and waste of time).

Seems uncertain of himself while lecturing but he has an excellent mentor and advisor, and I believe he (Prof. Beretta) will gain confidence and become a more fluent lecturer quickly.

Clear and organized lectures and obvious understanding of the material. Also very willing to help as well as guide the student to the answer.

He is very insecure, maybe because of his apparent lack of teaching experience. Does not seem to know deeply the subject, due to his problem of communication.

I am sure he knows material well, but does not present material with a confident appearance and is unable to answer unexpected questions.

Was quite helpful in getting me to understand few puzzling questions in homework. I wish we could spend more time developing the Chemical Reactions portion of the course instead of squeezing it in practically 3-4 lectures! Excellent presentation on board. Please, please, more practical problems during the tutorial sessions!!!!!

Very helpful with problems and available at almost any time for consultation.

This instructor was good. A review of all the material he presented and how to apply it would have been helpful. This instructor seemed to have some difficulty in understanding the difficulty students were having (i.e. didn't understand questions asked of him).

Very concise and presents well organized lectures. Probably needs a bit more experience in teaching in class, but I can't complain about his overall effort. I would recommend that he keep track of his audience a bit more.

Positive: very clear in his lectures; very organized and summarizes very good the subject. Negative: need more practice a professor in order to handle better some students' questions.

September 1981

2.451J and 22.571J

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Outline of 2.451J and 22.571J

FOUNDATIONS

Brief Introduction

Systems, states, properties, processes

Work, adiabatic processes

Nonwork

First Law: relation between work and end-states in adiabatic processes

- Definition of energy
- Conservation of energy
- Impossibility of PMMI
- Relativity and conservation of total mass

Classification of states: nonequilibrium, steady, equilibrium, and stable equilibrium states

Second Law: existence of stable equilibrium states

- State principle
- Reversible and irreversible processes
- Impossibility of PMM2
- Adiabatic availability
- Work by a system and a reservoir

Available work

Definition of entropy in terms of energy and available work

Entropy changes in adiabatic processes

Principle of increase of entropy

Stable equilibrium states

- Criterion for stable equilibrium
- Equation relating properties for stable equilibrium states
- Mutual stable equilibrium
- Temperature
- Entropy constant

Heat

- Heat and flow of entropy
- Inequality of Clausius
- Work, heat, and change of entropy
- Reversible processes in cyclic engines

SIMPLE SYSTEMS

Stable equilibrium states

Representation of states on property diagrams

Reversible, constant pressure processes

Enthalpy

Helmholtz free energy

Gibbs free energy

Maxwell relations

Phases

Phase rule

SIMPLE ONE-COMPONENT SYSTEMS

Processes at constant volume and at constant pressure

Specific heats

Latent heats

Equation of state

Van der Waals equation

Critical point

Fundamental equations

Properties of steam, steam tables

Semiperfect and perfect gases

BULK FLOW

Energy balance

Entropy balance

Mass balance

Combined balances in stady state. Availability.

Availability loss and irreversibility

ENTROPY GENERATION IN TYPICAL PROCESSES

MULTICOMPONENT SYSTEMS

Partial properties

Partial Gibbs free energy

Gibbs-Duhem equation

MIXTURES OF GASES

Partial pressure

Gibbs-Dalton law

Entropy of mixing

CHEMICAL EQUILIBRIUM

CHEMICAL REACTIONS

Stoichiometry

Reaction coordinate

Changes of properties in chemical processes

Standard properties

Steady state chemical reactors

Combustion

Power cycles

Fuel cells

INDUSTRIAL PROCESSES

Aluminum making

Steel making

Paper making

Waste heat recovery

Cogeneration of motive power and process heat.

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Sometimes makes things too simple in an effort to be understood by all. Excellent teacher.

Excellent - one of the best.

Good lecturer. Maybe would be better if he can give more examples in class.

No criticism.

He is an excellent teacher. He take all your attention in class. He always convinces you with his answers.

Yes, he adds to the course. No need for improvement.

Lectures were well organized.

Excellent.

Definitely does a good job. Has a hard balancing job to do.

The guy is the best lecturer I've ever had the pleasure of listening to - very organized, obviously devotes an enormous amount of energy to teaching this course.

The best lecturer I've ever had and am likely to have. Strongest point is he doesn't mind taking his time and encouraged questions.

I liked the professor. Very nice person who would care about the student. This has been a great change from M.I.T. busy professors who can not afford the time to talk to the students.

The instructor was the course. In this subject, it is very important to present the material in a logical, systematic manner and to give insight into the subject, for deep understanding. The professor has done this very well. He knows what he is doing and doesn't need much advice.

Prof. Gyftopoulos answers most questions thoroughly, and encouraged questions in class. One problem was that sometimes simple questions did not get simple answers - the answer was complete and correct, but sometimes too involved, obscuring the information needed.

Excellent familiarity with subject and blackboard techniques. Only problem is a tendency to ramble on about a subject or a story in response to a student's questions since often the student has not properly expressed himself and Prof. Gyftopoulos has really understood the problem. He should spend a bit more time trying to narrow down the question before going off on his lengthy answers and stories.

I have no criticism to him either. He attended even at tutorials. He has strong desire to make us understood totally. He is a perfect professor in M.I.T.

I think he did fine lectures throughout the semester. But I would like to have some more reference material about the subject (what we covered in class).

I thoroughly enjoyed Prof. Gyftopoulos' lectures. Perhaps some of the definitions used could be refined, because they did lead to confusion on occasion.

Best lecturer I have had.

It was a pleasure to listen to Prof. Gyftopoulos' lecture. He welcomed questions which helped a lot. He seemed genuinely interested in having the students really learn the material. No complaints - just praise.

It is good that Gytopoulos teaches recitations, rather than just sending a T.A.

More could be gotten out of the reference books if suggested reading sections were given.

Strong points: He wasted no time on the classical thermo you can get from a book. This course is unique in orientation and we properly focussed on the power of the generality of formulation. Very dogmatic - This is not bad when you must teach techniques in a subject like thermo with many logical inconsistencies.

An excellent instructor. My only complaint is that he should give more examples, etc. rather than just repeating a few ideas over and over.

Excellent instructor - the course is superior and most of the views would never be seen without this instructor.

An excellent instructor. He had an inspiring combination of technical understanding, concern for his students, and good humor. I am grateful for the opportunity to study with him.

No comments, excellent.

Great. Only complaint is that as the professor, he is ultimately responsible for all that happens or fails to happen concerning his class, both in the classroom and on all matters concerning the class. He should have solved the problem of the late problem sets and solutions immediately and totally. He is too nice of a man. His teaching techniques are the best I have ever seen.

Provide shorter answers to in class questions. Draw more class discussion. Dr. Gyftopoulos is very knowledgeable and it is impossible not to learn from him.

The course was basically based on his lectures, and very good.

Did a very good job covering material. I'm still a little vague on some of the more theoretical aspects, but I feel I have an excellent background now for practical problem solving. It would have been nice if he had a text with some applications. The notes were good, but lacking in examples. I used the textbook Thermodynamic Applications by Huang, but found nomenclature varied and sometimes confused me. I was very impressed with Gyftopoulos' bringing practical problems and concepts to light in terms of theory, and also enjoyed his sharing with us some examples of applying the theory of thermo to the 'real world'.

Wouldn't change a thing. His use of humor and relevant stories about experiences in industry held my interest and made it a pleasure to come to class.

Excellent instructor in all respects. He should tell me how to be a better student rather than me telling him how to be a better instructor.

Excellent in his presentation of the material. He shared his enthusiasm of the material with us, and in every class I believe that the students wanted to learn because of this enthusiasm.

Very interesting approach. I appreciate his use of the board - in a logical, assertive manner - that greatly aided in my understanding. Thank you!

Excellent personality. Amusing anecdotes. I believe he spent too much time reviewing the material of the previous lecture before continuing with new material. Perhaps too much concern with certain points of semantics and also a tendency to be easily side tracked. However, his overall enthusiasm added much to my general interest and he seemed very concerend that students should fully understand the material. In addition, he was very available and easily approachable.

Very good and enlightening except perhaps a bit more vigor.

Very well prepared for his lectures (only one time during the term did he have difficulty answering a question and he answered it the same afternoon in recitation). I would like to see his handout notes extended to include the sections of the course that are not now covered.

An outstanding teacher. He senses the understanding level of his students and adapts his instruction to it well. He presents his material clearly and consistently and speaks with authority. Few professors are better at conveying information to students than Prof. Gyftopoulos. His fated flaw is the inability to control or motivate teaching assistants. They (the T.A.'s) robbed the school of money by their culpable negligence to the need of the students. Prof. Gyftopoulos appeared powerless to change this situation.

He should spend a little less time reviewing the last lecture. He, in general, is good, but sometimes gets too involved in what seem to be minor points or definitions. Lecture techniques are good as far as speaking & presenting information is concerned. I would have liked to have seen many more examples worked.

PI TAU SIGMA

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C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

In the beginning, the proof schemes are awkward. The problem sets were graded much too slowly. The T.A.'s were worse than awful.

The quizzes should contain only new and original problems - some students have access to past years' quizzes and exams (and the distributed solutions), and when old problems show up on a quiz, they have an unfair advantage!

Course takes a lot of time and effort. At the beginning, more discussion of examples would be helpful. Problem sets are long, quite hard. Quizzes are quite ok. The problem sets should reflect more of what the quiz problems are.

No criticism: I think this was one of the most worthwhile classes I have taken. In so far as time is concerned, I think that more time should have been devoted to the last part of the course, i.e. chemical reactions and combustion.

Problem sets were extremely long. I had a difficult time understanding the introductory material, which was not covered clearly in the notes. The applications of this material in the problem sets to practical situations were left entirely to the student, without enough explanation (in the class or notes) as to how to apply the methods.

The resumes at the beginning of class are useful but sometimes took almost 1/3 to ½ of the class. You should cut those in time or handing a resume each week or have a resume in one day each one or two weeks. The course is excellent. Is well oriented and taught. Homeworks were excessive. So much work. This should be reduced, or give due time 2 weeks. Course will be and is useful for M.E.'s. Chemical Reactions were not covered as well as rest of the other topics.

Superbly taught, really worthwhile. One major criticism: The work load is really oppresive, so course is not recommended for grad students who expect to accomplish anything during the semester other than learn thermo.

I have considered the course very useful. Well taught. Most of it clear. I do consider that the assignments are too long and although necessary something must be done about it. If one considers that this is not the only course, the time required for the assignments should be appropriate.

The course was well taught, but at times, things were given to us in class that went unexplained for a few lectures. Often, we had to work problem sets with formulas given to us, but without understanding though that was partially beneficial in that it made us question and discuss the material outside of class. The homework assignments got ahead of the lectures too often, especially since the graded homeworks were returned slowly. Very good, thought-provoking course.

Would like more quizzes. Mechanics of homeworks could be greatly improved. More practical examples needed - cycles. Fundamentals are presented well but too many students are in the course as preparations for the M.E. qualifiers. Either deemphasize the perception of this as a qualifier preparer or move the fundamentals (axiomatic approach) to another course.

Excellent all round. A bit slow at beginning. Problem sets were so long that it discouraged further reading or thought. One reason for the problem sets being long was that they often contained errors which made them impossible to solve. Corrections would arrive after a considerable time had been wasted working out.
They were impossible to solve. Very annoying there.

Course was very interesting, informative and the best course I have taken at M.I.T. The course does not need any improvement.

In terms of content, this course was great. In terms of administration, it was probably the worse run course I've taken at M.I.T. due to problem of getting solutions to homework out in time for exams.

No criticism of course. It was, I think, perfect lecture and gave me a much wider view of thermodynamics. Its assignment was a very good test for the further understanding of course.

This is a great course, especially the professor's method of teaching. The concept of availability has made this treatment of thermo the best and most easily understood version I've ever had. Maybe this course needs 3 graders instead of 2. The professors should write the homework solutions.

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Course was a novel and very interesting approach to thermodynamics. Quiz was very reasonable. Homework sets stressed valuable concepts and were thought provoking. Only problem with course was that the vagueness and sometimes seeming negligence in the homework problems was frustrating. I realize that struggling with the vagueness is very valuable in coming to understand some concepts, but a better balance should be reached. All in all, I enjoyed the course very much and learned a lot of things.

I feel this was a very good course and that I got a lot out of it. However, I feel more could be gotten out of it if possibly more examples were worked out during the tutorial.

I have never been enrolled in a course with such slipshod logistics. Problem set solutions are worthless if they are not given out promptly. Graded homework is equally worthless when it was turned in four to six weeks ago. The consistent refusal of both professor and T.A.'s to address this problem was frustrating; many times we got a 'next time' answer and no delivery next time. Subject matter was very good. I learned a wealth of extremely powerful techniques and information. Method of concocting problems was good; I hope there is no change in making the problems thinking problems first and computations later. However, again, this type of problem is forgotten by the time the added help of solutions was found. T.A.'s were both worthless; Somehow, though, with all its faults, the course is still highly recommended; I learned at a faster rate than in most.

I took this course to understand entropy. I now realize I don't even understand energy. Seriously, this is the best class I have taken in my 3 years of grad studies at M.I.T. I say this even though in terms of my grade this is the worst class. Having very little undergraduate classical thermo, but a lot of quantum mechanics, I appreciated the effort to provide a solid base to thermo. (something my undergraduate thermo certainly didn't do). In terms of the course mechanics, the T.A.'s were terrible. Homework was returned so late that it was hard to even remember it when returned for review. Also, homework and class work got badly out of step during the middle of the course.

Course is very good but handling of homework is not good. Solutions are not available soon enough and the problems are poorly graded. Since $\sim$30% of the grade comes from the homeworks, the homework should be competently graded and it has not been during this term. Hopefully, the tests will actually be weighed more heavily than stated.

Very good course. Reduce the material covered and spend some time on free thinking about Thermodynamics, and independent projects.

I enjoyed the course; my understanding of thermodynamics has increased greatly. I appreciate very much the meticulous attention given to the basics of energy and entropy, even at the cost of rushed studies of applications. It was good to have such a re-examination of what I considered to be dusty old thermodynamics. Problem sets were long and difficult, though always instructive. Solutions and graded answers were tardy. Many times I missed points on following problem sets because I could not learn from my previous mistakes. I could have benefitted from some worked out examples. There were few in class, few in notes and few in problem sessions. This especially applies for the study of mixtures and reactions with their many subscripts and also to the concept of availability, which was new and puzzling to me.

Great. Only complaint is that I think it would be a good idea to let the Coop know that the textbook by Huang is <u>not</u> the major text for the course, in retrospect it seems that I bought the wrong book. Too much time was spent in initial part of course dealing with stable equilibrium states and it seemed that much time was lost there. Otherwise course went smoothly. I enjoyed it. Problem sets were entirely too long, often consuming up to 20 hrs. of time to complete (especially set #11, problem 1). Solutions should be passed out immediately and graded sets returned no later than 2 lectures (1week) later. Papers should be distributed before or after class, not during. Quizzes were good, well representative (we'll see about the final).

Too much time required for problem sets: Many times there were mistakes in the problem set statements which, if you were to add up the wasted time of 60 people would result in a waste of ~ 1000 man hours, at least. At $20/hr. that's $20,000 wasted in a course that is stressing efficiency. Otherwise, the course was great, lectures and tutorials were stimulating, exactly what I'm interested in doing working as a career so it was extremely worthwhile.

Definitely the best thermodynamics course I've ever seen. The use of practical applications, including not only engineering considerations, but just as importantly, economic and social aspects of thermodynamics made the course more interesting and very relevant. The only criticism I have concerned the problem sets and T.A.'s. Quite often problems were assigned that were either not possible to solve with information provided or containing serious typo's that only confused the student. Though this requires the student to think more and rely on his/her own judgment, it often resulted in tremendous wastes of time. The T.A.'s seemed extremely unreliable, returning graded homework as much as a month after its due date.

I have learned a lot in the course. The topic is fundamentally fascinating. Often times the problem sets and the lectures seemed unrelated sometimes because they (lectures) were behind schedule and other times because lectures were more abstract than the problems. Also, problem sets took far too long to grade and return. Most of the time I'd forgotten what I did by the time they came back. I would have appreciated a more mechanically oriented approach at some times. i. e. description of how hardware performs certain more abstract processes. I think the 2nd midterm should not have been given as a make-up but should either be mandatory or nonexistent.

Overall, it was an excellent course which I enjoyed very much. I liked the material which was covered as well as the approach taken to cover the material with the possible exception that I felt the first 5-6 lectures went too slowly. Homeworks were lengthy but not unreasonable. I think the grading of both quizzes and homework was a little bit too nit-picky - especially with regard to numerical answers after the equations are properly written out. While in real life we need numerical solutions we also do not need to produce those numbers in one and one-half hours. I claim that everyone in the class is competent enough to punch a calculator and thus the benefit of the doubt should be granted.

I think course needed a relevant handout for the section dealing with Gibbs-Dalton mixtures and partial properties. I had difficulty correlating my notes with Huang's text. It is probably because I missed some important verbal comments in the lectures. There was some difficulty with the timing of problem sets in lst half of course. On several occasions (I wish I could site specific examples) the material in problem sets preceeded material in lecture. If this was done for learning reasons, then ok, but if not, then the sequencing should be corrected. I wish I had received homework solutions and connected homework sets back sooner. On several occasions, I made the same mistake 2 or 3 times. Availability should be defined specifically earlier. The definition was more explicit - on one homework problem ("Here availability is h-T$_o$ S)-: The handout cleared up the problem.

While although the course was very interesting and I have learned a great deal I do have a few criticisms. On the whole, I think that perhaps the emphasis on basic concepts was lacking and that this deficiency was often responsible for the tremendous amounts of time required on each homework assignment. Although I feel I have a mastery of a good deal of the concepts, it has taken a good deal of outside time and effort. Because I have enjoyed this course, my major efforts have been on this subject, often at the expense of other courses and research. Also, I feel the homework was often too demanding in light of the material covered.

My comments will deal with the mechanics of running this class. The problem sets have a large effect on grade that a student received. They were also a valuable tool for learning the material that was presented in lectures. Their length (I had some difficulty completing them on time) and size of class delayed their return. I do not place blame on the grades entirely as has been mentioned by some in class. I believe that it (the delay) is unavoidable. Perhaps this course could be offered in the Spring as well, this would shrink the class. I realize that this option may not be possible.

Thoroughly enjoyed the course. Problem sets took a little too long, but were very realistic and probably contributed a large part to my understanding of the subject. I never could get in touch with a T.A. When I needed, and think they should set office hours.

This course, despite the fact that it is an excellent learning opportunity, showed significant flaws. The instruction value of the problem sets was defeated (not too strong a term!) by the great time lag in grading. Feedback on techniques and concepts was effectively denied the student through this most important vehicle. Not enough can be said about the culpable negligience of teaching assistants and the inability of faculty to regulate them. This laxness permitted bad habits to form, mistakes to be repeated, and learning value to be greatly reduced. Lack of written material to supplement the course is also a flaw. It is obvious such material exists, but is not provided to the student. There should be only 1 quiz - not a "second chance" for those who can't catch up. If a "second chance" is given, it should be averaged into the grade. Several points of course were outstanding as well.

I thought the course covered all material well and that it covered a large amount of material. However, much of what I learned was from doing problem sets and by referring to several texts in order to do problem sets. In other words, I did not feel that I got very much out of lecture or course notes. Too much time in lecture was spent reviewing the last lecture. The lectures also tended to be too theoretical, so that when problem sets were assigned, I felt that I didn't know how to approach the problems. This feeling decreased as semester progressed. Many problem sets were too long - involving trial and error solutions and much data gathering. I often spent over 15 hours per week outside of class.

Lectures were outstanding, both in content and presentation. Topics and problem sets were interesting, current, and relevant. However, I thought that problem sets were too hard. I thought during each problem set that I had to face the whole science of thermodynamics at once. I would rather have problems that clearly defined one concept to be used. Also, in deriving answers to problems, many times I would have to take a stab in the dark at an answer, and never find out if I was right until weeks later, when all was forgotten. I would prefer it if we were allowed to work together on problem sets, and take the responsibility ourselves not to just copy answers from somebody else. In this system, the weight of the homework in grades would be de-emphasized.

This is the best course that I have ever taken. Now I can say that I understand thermodynamics although I did it very bad in the first quiz. My opinion is that thermodynamics is very difficult to teach and very difficult to learn; however this course was excellent. There were only 2 problems: At the beginning of course a lot of definitions were introduced and I felt a little confused. I think the professor must make emphasis that this part of course is necessary and VERY IMPORTANT for the rest of the course. I think the success in the course depends on how well the definitions are understood. There was a little "discontinuity" between given problem sets and the theory explained in class at that time. This happened at the beginning only.

Course is very good one, almost perfect. I liked first part of the course where the basic or fundamental laws and concepts of thermodynamics are explained. Problem sets were too many and we get our corrected solutions very late.

The course was excellent. Although my performance on the homeworks and quizzes may not reflect it, I spent at least 40 hours a week on the course and thought that the time was worth it. My only complaint though is that there was a big lag in the middle of the semester for receiving graded homework. Seeing where a person is going wrong or not understanding a principle is an important item conveyed by the graded homework. The lack of continuity in turning in homework and getting it back made one wonder if he/she was not propagating any mistakes.

I felt that the course spent too much time on certain applications and not enough on funda mental aspects that were brought up but quickly dropped. (What is a non-equilibrium state, relationship of mechanics to thermo). The problem sets were very long - surely ideas could be brought across by shorter problems equally well. The midterm test was fair. The thorough grading of the problem sets was great. It really helps show up deficiencies. The "real life" nature of most of the problems was good.

The course was relevant to many engineering process evaluations, and directly applicable to theoretical or practical problems. Problem sets often stressed more advanced concepts. This is alright except that often some of the more fundamental concepts were not developed completely - this led to frequent problems by several people in the class.

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COURSE 2.451J, T.A.'s

B. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

I never could get in touch with a T.A. when I needed, and think they should set office hours.

I'd like to take this opportunity to voice my utter dissatisfaction with the teaching assistants. Excuses, excuses, excuses. I turned the homework in on time and I think I have the right to get it back within 7 days.

The only criticism I have concerns the T.A.'s. They seemed extremely unreliable, returning graded homework as much as a month after its due date.

In terms of the course mechanics. the T.A.'s were terrible. Homework was returned so late that it was hard to even remember it when returned for review. Also, homework and class work got badly out of step during the middle of the course.

The T.A.'s were both worthless.

T.A.'s were not very good. Careless grading of homework and solutions were not available until it was too late.

It would have been very helpful if the T.A.'s were ever available. Scott did not mention an office and John was rarely in his. The T.A.'s should have established office hours.

The T.A.'s were worse than awful.

Consistent refusal of T.A.'s to address problem of late problem set solutions was frustrating; many times we got a 'next time' answer and no delivery next time.

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C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

In the beginning, the proof schemes are awkward. The problem sets were graded much too slowly. The T.A.'s were worse than awful.

The quizzes should contain only new and original problems - some students have access to past years' quizzes and exams (and the distributed solutions), and when old problems show up on a quiz, they have an unfair advantage!

Course takes a lot of time and effort. At the beginning, more discussion of examples would be helpful. Problem sets are long, quite hard. Quizzes are quite ok. The problem sets should reflect more of what the quiz problems are.

No criticism: I think this was one of the most worthwhile classes I have taken. In so far as time is concerned, I think that more time should have been devoted to the last part of the course, i.e. chemical reactions and combustion.

Problem sets were extremely long. I had a difficult time understanding the introductory material, which was not covered clearly in the notes. The applications of this material in the problem sets to practical situations were left entirely to the student, without enough explanation (in the class or notes) as to how to apply the methods.

The resumes at the beginning of class are useful but sometimes took almost 1/3 to $\frac{1}{2}$ of the class. You should cut those in time or handing a resume each week or have a resume in one day each one or two weeks. The course is excellent. Is well oriented and taught. Homeworks were excessive. So much work. This should be reduced, or give due time 2 weeks. Course will be and is useful for M.E.'s. Chemical Reactions were not covered as well as rest of the other topics.

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Would like more quizzes. Mechanics of homeworks could be greatly improved. More practical examples needed - cycles. Fundamentals are presented well but too many students are in the course as preparations for the M.E. qualifiers. Either deemphasize the perception of this as a qualifier preparer or move the fundamentals (axiomatic approach) to another course.

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Very good course. Reduce the material covered and spend some time on free thinking about Thermodynamics, and independent projects.

I enjoyed the course; my understanding of thermodynamics has increased greatly. I appreciate very much the meticulous attention given to the basics of energy and entropy, even at the cost of rushed studies of applications. It was good to have such a re-examination of what I considered to be dusty old thermodynamics. Problem sets were long and difficult, though always instructive. Solutions and graded answers were tardy. Many times I missed points on following problem sets because I could not learn from my previous mistakes. I could have benefitted from some worked out examples. There were few in class, few in notes and few in problem sessions. This especially applies for the study of mixtures and reactions with their many subscripts and also to the concept of availability, which was new and puzzling to me.

Great. Only complaint is that I think it would be a good idea to let the Coop know that the textbook by Huang is <u>not</u> the major text for the course, in retrospect it seems that I bought the wrong book. Too much time was spent in initial part of course dealing with stable equilibrium states and it seemed that much time was lost there. Otherwise course went smoothly. I enjoyed it. Problem sets were entirely too long, often consuming up to 20 hrs. of time to complete (especially set #11, problem 1). Solutions should be passed out immediately and graded sets returned no later than 2 lectures (1week) later. Papers should be distributed before or after class, not during. Quizzes were good, well representative (we'll see about the final).

Too much time required for problem sets: Many times there were mistakes in the problem set statements which, if you were to add up the wasted time of 60 people would result in a waste of $\sim$ 1000 man hours, at least. At $20/hr. that's $20,000 wasted in a course that is stressing efficiency. Otherwise, the course was great, lectures and tutorials were stimulating, exactly what I'm interested in doing working as a career so it was extremely worthwhile.

Definitely the best thermodynamics course I've ever seen. The use of practical applications, including not only engineering considerations, but just as importantly, economic and social aspects of thermodynamics made the course more interesting and very relevant. The only criticism I have concerned the problem sets and T.A.'s. Quite often problems were assigned that were either not possible to solve with information provided or containing serious typo's that only confused the student. Though this requires the student to think more and rely on his/her own judgment, it often resulted in tremendous wastes of time. The T.A.'s seemed extremely unreliable, returning graded homework as much as a month after its due date.

I have learned a lot in the course. The topic is fundamentally fascinating. Often times the problem sets and the lectures seemed unrelated sometimes because they (lectures) were behind schedule and other times because lectures were more abstract than the problems. Also, problem sets took far too long to grade and return. Most of the time I'd forgotten what I did by the time they came back. I would have appreciated a more mechanically oriented approach at some times. i. e. description of how hardware performs certain more abstract processes. I think the 2nd midterm should not have been given as a make-up but should either be mandatory or nonexistent.

Overall, it was an excellent course which I enjoyed very much. I liked the material which was covered as well as the approach taken to cover the material with the possible exception that I felt the first 5-6 lectures went too slowly. Homeworks were lengthy but not unreasonable. I think the grading of both quizzes and homework was a little bit too nit-picky - especially with regard to numerical answers after the equations are properly written out. While in real life we need numerical solutions we also do not need to produce those numbers in one and one-half hours. I claim that everyone in the class is competent enough to punch a calculator and thus the benefit of the doubt should be granted.

I think course needed a relevant handout for the section dealing with Gibbs-Dalton mixtures and partial properties. I had difficulty correlating my notes with Huang's text. It is probably because I missed some important verbal comments in the lectures. There was some difficulty with the timing of problem sets in 1st half of course. On several occasions (I wish I could site specific examples) the material in problem sets preceeded material in lecture. If this was done for learning reasons, then ok, but if not, then the sequencing should be corrected. I wish I had received homework solutions and connected homework sets back sooner. On several occasions, I made the same mistake 2 or 3 times. Availability should be defined specifically earlier. The definition was more explicit - on one homework problem ("Here availability is $h-T_o S$)-: The handout cleared up the problem.

While although the course was very interesting and I have learned a great deal I do have a few criticisms. On the whole, I think that perhaps the emphasis on basic concepts was lacking and that this deficiency was often responsible for the tremendous amounts of time required on each homework assignment. Although I feel I have a mastery of a good deal of the concepts, it has taken a good deal of outside time and effort. Because I have enjoyed this course, my major efforts have been on this subject, often at the expense of other courses and research. Also, I feel the homework was often too demanding in light of the material covered.

My comments will deal with the mechanics of running this class. The problem sets have a large effect on grade that a student received. They were also a valuable tool for learning the material that was presented in lectures. Their length (I had some difficulty completing them on time) and size of class delayed their return. I do not place blame on the grades entirely as has been mentioned by some in class. I believe that it (the delay) is unavoidable. Perhaps this course could be offered in the Spring as well, this would shrink the class. I realize that this option may not be possible.

Thoroughly enjoyed the course. Problem sets took a little too long, but were very realistic and probably contributed a large part to my understanding of the subject. I never could get in touch with a T.A. When I needed, and think they should set office hours.

This course, despite the fact that it is an excellent learning opportunity, showed significant flaws. The instruction value of the problem sets was defeated (not too strong a term!) by the great time lag in grading. Feedback on techniques and concepts was effectively denied the student through this most important vehicle. Not enough can be said about the culpable negligience of teaching assistants and the inability of faculty to regulate them. This laxness permitted bad habits to form, mistakes to be repeated, and learning value to be greatly reduced. Lack of written material to supplement the course is also a flaw. It is obvious such material exists, but is not provided to the student. There should be only 1 quiz - not a "second chance" for those who can't catch up. If a "second chance" is given, it should be averaged into the grade. Several points of course were outstanding as well.

I thought the course covered all material well and that it covered a large amount of material. However, much of what I learned was from doing problem sets and by referring to several texts in order to do problem sets. In other words, I did not feel that I got very much out of lecture or course notes. Too much time in lecture was spent reviewing the last lecture. The lectures also tended to be too theoretical, so that when problem sets were assigned, I felt that I didn't know how to approach the problems. This feeling decreased as semester progressed. Many problem sets were too long - involving trial and error solutions and much data gathering. I often spent over 15 hours per week outside of class.

Lectures were outstanding, both in content and presentation. Topics and problem sets were interesting, current, and relevant. However, I thought that problem sets were too hard. I thought during each problem set that I had to face the whole science of thermodynamics at once. I would rather have problems that clearly defined one concept to be used. Also, in deriving answers to problems, many times I would have to take a stab in the dark at an answer, and never find out if I was right until weeks later, when all was forgotten. I would prefer it if we were allowed to work together on problem sets, and take the responsibility ourselves not to just copy answers from somebody else. In this system, the weight of the homework in grades would be de-emphasized.

This is the best course that I have ever taken. Now I can say that I understand thermodynamics although I did it very bad in the first quiz. My opinion is that thermodynamics is very difficult to teach and very difficult to learn; however this course was excellent. There were only 2 problems: At the beginning of course a lot of definitions were introduced and I felt a little confused. I think the professor must make emphasis that this part of course is necessary and VERY IMPORTANT for the rest of the course. I think the success in the course depends on how well the definitions are understood. There was a little "discontinuity" between given problem sets and the theory explained in class at that time. This happened at the beginning only.

Course is very good one, almost perfect. I liked first part of the course where the basic or fundamental laws and concepts of thermodynamics are explained. Problem sets were too many and we get our corrected solutions very late.

The course was excellent. Although my performance on the homeworks and quizzes may not reflect it; I spent at least 40 hours a week on the course and thought that the time was worth it. My only complaint though is that there was a big lag in the middle of the semester for receiving graded homework. Seeing where a person is going wrong or not understanding a principle is an important item conveyed by the graded homework. The lack of continuity in turning in homework and getting it back made one wonder if he/she was not propagating any mistakes.

I felt that the course spent too much time on certain applications and not enough on funda mental aspects that were brought up but quickly dropped. (What is a non-equilibrium state, relationship of mechanics to thermo). The problem sets were very long - surely ideas could be brought across by shorter problems equally well. The midterm test was fair. The thorough grading of the problem sets was great. It really helps show up deficiencies. The "real life" nature of most of the problems was good.

The course was relevant to many engineering process evaluations, and directly applicable to theoretical or practical problems. Problem sets often stressed more advanced concepts. This is alright except that often some of the more fundamental concepts were not developed completely - this led to frequent problems by several people in the class.

PI TAU SIGMA

END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, T.A.'s

B. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

I never could get in touch with a T.A. when I needed, and think they should set office hours.

I'd like to take this opportunity to voice my utter dissatisfaction with the teaching assistants. Excuses, excuses, excuses. I turned the homework in on time and I think I have the right to get it back within 7 days.

The only criticism I have concerns the T.A.'s. They seemed extremely unreliable, returning graded homework as much as a month after its due date.

In terms of the course mechanics. the T.A.'s were terrible. Homework was returned so late that it was hard to even remember it when returned for review. Also, homework and class work got badly out of step during the middle of the course.

The T.A.'s were both worthless.

T.A.'s were not very good. Careless grading of homework and solutions were not available until it was too late.

It would have been very helpful if the T.A.'s were ever available. Scott did not mention an office and John was rarely in his. The T.A.'s should have established office hours.

The T.A.'s were worse than awful.

Consistent refusal of T.A.'s to address problem of late problem set solutions was frustrating; many times we got a 'next time' answer and no delivery next time.

September 1980

2.451J and 22.571J

GENERAL THERMODYNAMICS I

Instructors: Elias P. Gyftopoulos, Room 24-109, Extension 3-3804
Maher El-Masri, Room 3-137, Extension 3-3790

Class Hours: Tuesday and Thursday, 11-12:30

Homework: Assigned in class and due one week later.

References:

(1) Article on "Thermodynamics" from Encyclopedia Britannica (to be supplied).

(2) "Thermodynamics" by Keenan, MIT Press.

(3) "Engineering Thermodynamics" by Huang, Macmillan.

Examinations: There will be one or two quizzes during the term and a final examination.

Final grade: 30% Homework
30% Quizzes
40% Final Examination

	Topics	No. of lectures
1.	Foundations of thermodynamics	5-6
2.	Simple systems	2
3.	One-component systems	2
4.	Bulk flow	2
5.	Entropy generation in typical processes	1
6.	Energy conversion systems	2
7.	Multicomponent systems	1
8.	Chemical equilibrium	2
9.	Chemical reactions	3
10.	Industrial processes	4

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief Introduction

Systems, states, properties, processes

Work, adiabatic processes

Nonwork

First Law: relation between work and end-states in adiabatic processes

- Definition of energy
- Conservation of energy
- Impossibility of PMMI
- Relativity and conservation of total mass

Classification of states: nonequilibrium, steady, equilibrium, and stable equilibrium states

Second Law: existence of stable equilibrium states

- State principle
- Reversible and irreversible processes
- Impossibility of PMM2
- Adiabatic availability
- Work by a system and a reservoir

Available work

Definition of entropy in terms of energy and available work

Entropy changes in adiabatic processes

Principle of increase of entropy

Stable equilibrium states

- Criterion for stable equilibrium
- Equation relating properties for stable equilibrium states
- Mutual stable equilibrium
- Temperature
- Entropy constant

Heat

- Heat and flow of entropy
- Inequality of Clausius
- Work, heat, and change of entropy
- Reversible processes in cyclic engines

SIMPLE SYSTEMS

Stable equilibrium states

Representation of states on property diagrams

Reversible, constant pressure processes

Enthalpy

Helmholtz free energy

Gibbs free energy

Maxwell relations

Phases

Phase rule

SIMPLE ONE-COMPONENT SYSTEMS

Processes at constant volume and at constant pressure

Specific heats

Latent heats

Equation of state

Van der Waals equation

Critical point

Fundamental equations

Properties of steam, steam tables

Semiperfect and perfect gases

BULK FLOW

Energy balance

Entropy balance

Mass balance

Combined balances in stady state. Availability.

Availability loss and irreversibility

ENTROPY GENERATION IN TYPICAL PROCESSES

MULTICOMPONENT SYSTEMS

Partial properties

Partial Gibbs free energy

Gibbs-Duhem equation

MIXTURES OF GASES

Partial pressure

Gibbs-Dalton law

Entropy of mixing

CHEMICAL EQUILIBRIUM

CHEMICAL REACTIONS

Stoichiometry

Reaction coordinate

Changes of properties in chemical processes

Standard properties

Steady state chemical reactors

Combustion

Power cycles

Fuel cells

INDUSTRIAL PROCESSES

Aluminum making

Steel making

Paper making

Waste heat recovery

Cogeneration of motive power and process heat.

PI TAU SIGMA
END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attribu of the instructor? Recommend ways in which he/she can improve his/ teaching techniques.

Positive: Generally excellent professor. Clear thinking, articulate, w prepared. Negative: Problem sets are sometimes given well before mate is presented in class. Somewhat limited access for consultation. Quiz are slightly long (just slightly).

It is necessary a text book. We cannot prepare the class.

The knowledge of thermodynamics cannot be denied. Ability to explain even abstract ideas seem to be Professor Gyftopoulos' most positive attribute. More numerical examples would better reinforce material.

Gyftopoulos is indeed very experienced in his field. His knowledge rang from the practical to the philosophical side of thermodynamics. The philosophy he presented is great, but if he expects us to do his massive practical problem sets then he should incorporate examples and more prac points into his lectures.

Very "full" of his subject. Brings it across in a vibrant, exciting way. He has an overshadowing personality that delights and controls the class. However, sometimes made it hard on Prof. El-Masri to compete for control of the class.

He is extremely clear and concise. He does a very good job.

Has an excellent knowledge of the subject and presents it well - examples are good and explanations are effective. Blackboard technique discourage notetaking. He often stands in front of what he has just written and lectures so that only 50% of the class can see the board. This is very important and should be corrected.

Gyftopoulos is about as close to being perfect as I think a professor can be. His desire to teach to others what he knows is overwhelming.

Excellent professor. His teaching technique is exceptional; I would not change it.

He is very good. He doesn't need to improve his way in teaching.

Excellent communication with class. Friendly personality. Ability to explain underlying concepts. Problem sets were very time consuming in the beginning. They should be made shorter.

Positive attributes: 1) extremely thorough understanding of subject. 2) encourages and fully answers student questions during lecture.

He is an excellent instructor.

This professor is an excellent lecturer and is also extremely helpful to individuals.

(cont'd next page)

A very good lecturer & teacher, knows the subject completely and is abl to convey his enthusiasm and examples of practical applications to the students.

This class is like the United Nations; we need interpreters! The accent are just too thick, and they speak too fast. Problems were too long an tedious.
Prof. Gyftopoulos is an excellent lecturer. The only point that he cou possibly improve is in the use of a few more examples in his lectures.

Positive - very concise statement of lecture material. Clear and Consistent technique and nomenclature intersects equations, humor into lecture. Especially helpful as aids student understand students' own question.

He needs no improvement.

I have <u>never</u> had a teacher more (i) concerned about students (ii) solidl prepared (iii) fun to talk to privately or in class.

Excellent instructor, both as far as knowledge of what he's teaching and the way he presents it.

Professor Gyftopoulos has excellent command of course. Knows material and fields any and all questions. Only difficulty in teaching is gettin used to accent. Grades quizzes more harshly than most.

<u>Positive</u>: Adequate notes; well-organized; very enthusiastic teacher.
<u>Negative</u>: Nil.

Good teaching technique. Well organized carefully detailed lectures. Very competent in his field.

Professor Gyftopoulos is ideal.

Very enthusiastic and interested.

Gyftopoulos has a sense of humor.

What about some experiments during the course. Gyftopoulos is an excellent lecturer!

One of the finest professors I have ever had the honor of taking a course under.

Presents material very well. Good teaching techniques.

Excellent professor. Interesting, excellent at explanations.

Explained many of the fuzzy areas of thermo very well. He gave an interesting approach to thermo.

Excellent ability to communicate ideas. Teaching ability doesn't need improvement.

He makes a great effort to explain things clearly and accurately, but sometimes he neglects to write key point or "golden" phrases on the blackboard.

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I feel that the presentation was excellent. The effort he put into explanation was great. He obviously enjoys the material and enjoys explaining it to others. His enthusiasm was contagious.

Communicates his enthusiasm for and grasp of the subject. Outgoing nature and good sense of humor make for engaging lectures.

Good blackboard techniques. Please have more practical examples during the lectures.

He knows thermodynamics really well and communicates magnificently as a teacher.

Very good.

Excellent teacher.

Communicates well with students.

In one word, he is excellent instructor. But one command. He should not spend so much time for question and answer section in class specially for some stupid people.

Explains ideas very well and with good examples. Reviews last lecture at beginning of next lecture - excellent.

Excellent teacher. The best professor I have had at MIT or elsewhere.

PI TAU SIGMA
END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, Professor Elias P. Gyftopoulos and Professor Maher A. El-Ma

PART C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Class size is slightly too large. Course is an excellent global treatment of thermodynamics and should be highly recommended to incoming students who will work in the thermo-fluids area. Everything was quite relevant. Somewhat more material (practical examples of processes, etc.) could have been covered.

This classroom is very uncomfortable! There was no text book. I couldn't find the specific material shown in class in any book. Problem sets very large and somewhat non-real working situations.

The course content was very informative and the problem sets reinforced the lecture material covered. However, more time should be taken in solution of numerical examples, or a tutorial period so chosen so that all students can attend. I think my performance could have been greatly improved if I could have attended the tutorial.

More emphasis on problem solving. The energy conservation applications were good. Get a good text book. Supply students with handouts of references for steam tables, etc., that will be used during course.

The subject was the most satisfying I have had while at MIT. Covered every subject to about the proper depth. The problem sets, however, at times, did tend to be tedious. Please remember that some of us are taking four other subjects at the same time!

Very little criticism of course material. Homework was often tedious, however, i. e. grindwork. That should be avoided.

The coverage of the subject was good. My only suggestion is that more examples be done early in the course to explain the initial foundation.

Text books that are mainly relevant to the materials taught in class are n easily available. I have trouble in finding materials taught in class in other books. The lecture notes given are not so clear and rather hard to learn-it-by-yourself.

Problem sets were too long and too hard. I think more example problems should be discussed(during tutorials). The final grade emphasis on homework is too large(30%). I like the subject because it presented tools to deal with relevant topics such as energy conservation.

Subject is rather fundamental and thorough. I have learned all the basics without any confusion of the definitions and concepts. Class size was large. Homework problems were,sometimes, ridiculously lengthy and not much of teaching value.

No changes necessary - a must course for all MIT students of science!

(cont'd next page)

The problem sets and the test questions tended to be vague at times. Not enough consideration has been given on these problems to a student's lack of familiarity with practice.

The course is quite practical and useful. Problem sets were very good. The lack of a textbook made learning the material more difficult. Had to do a lot of unnecessary running around to look up material because of lack of text.

The only criticism of the course is the length of tests. Exams should not be a race to finish. In order to demonstrate your knowledge of materi ample time should be allowed so that the pressure of finishing in time is not a factor. Some students work well under these conditions, while other as myself, require much more time to think clearly. An example of a cours in which these ideas are practiced is Advanced Fluid Mechanics 2.25.

Problem sets were sometimes too much busy work. This could be helped greatly by providing property tables with the problem sets and also designing problems that require little iteration and interpolation of property values.

The only thing that bothered me about this course was the way quizzes were graded - Problems each consisted of three or four parts and the results of each part were inputs for the next - what was bothering was that numerical mistakes in the first part cut your grade not only in that part but in anything in which you had to use the wrong numerical value.

Enjoyed course overall. Found problem sets to be more difficult than most other courses. Also would prefer more quizzes rather than midterm.

Good notes. Good understanding of energy, concepts of thermodynamics.

The subject was good, but it just seems like there was really too much material. More problems covered in class might have been a good idea.

The class was a bit large. The text (notes) could be improved; it would b nice if there were outside references that also used the "availability" techniques used here. The quizzes were hard but graded fairly. The proble sets were extremely long.

In the beginning of the term, the problem sets were <u>much too long</u>. The workload near the end was more manageable. The books were lacking in thei treatment of work/non-work interactions as well as in their discussions of entropy. Gyftopoulos should write a termo book for his course!

Lack of a text is a hinderance. The section on Chemical Thermodynamics could be dropped with no loss of continuity in course.

Lot of work and quizzes too long. Also may help if more quizzes are given.

Problem sets were incredibly difficult at times as well as time consuming - perhaps the same comprehension of material would result while having simpler homework problems - i. e., eliminate the B.S. and give problems that <u>illustrate</u> and give proficiency in course concepts, not problems that require genius.

Problem sets were a little long. More could have been done to give materi in class which could have applied more directly in solution of problem sets

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Don't depend so much on course 2 material. e.g. - elasticity in Problem Set #3, Since many who take this are not in course 2 and don't have that background.

Some of the problem sets are too tedious. I like them to be difficult and illuminating, but not tedious in number-crunching way. More hour exams.

Excellent course. Tables of properties should be made available early in the course.

The problem sets tended to have too much busy work.

To me it was good enough.

I learned a lot about Thermo. Problem sets were very time consuming.

Very interesting. Good applications to very good theory. Did not understand chemical reactions. Test, lectures & notes very good. Problem sets: Very instructive but sometimes too lengthy calculations that could be avoided.

I liked the way entropy and availability were introduced. Reversibility an availability are thoroughly clarified. The problem sets were really a pain and sometimes irrelevant.

1) Make homework due on the date specified (no exceptions or a stiff penalt that is enforced). 2) Don't give problems that have been given in the past Some people have solutions for these already from past year or make past solution sets available in the library.

September 1979

2.451J and 22.571J

GENERAL THERMODYNAMICS I

Instructors: Elias P. Gyftopoulos, Room 24-109, Extension 3-3804
Michael G. O'Callaghan, Room 3-137, Extension 3-2297

Class Hours: Tuesday and Thursday, 11-12:30

Homework: Assigned in class and due one week later.

References:

(1) Article on "Thermodynamics" from Encyclopedia Britannica (to be supplied).

(2) "Thermodynamics" by Keenan, MIT Press.

(3) "Engineering Thermodynamics" by Huang, Macmillan.

(4) "Principles of General Thermodynamics", by Hatsopoulos and Keenan, John Wiley.

Examinations: There will be one or two quizzes during the term and a final examination.

Final grade: 30% Homework
30% Quizzes
40% Final Examination

Topics	No. of lectures
1. Foundations of thermodynamics	5-6
2. Simple systems	2
3. One-component systems	2
4. Bulk flow	2
5. Entropy generation in typical processes	1
6. Energy conversion systems	2
7. Multicomponent systems	1
8. Chemical equilibrium	2
9. Chemical reactions	3
10. Industrial processes	4

CHEMICAL EQUILIBRIUM

CHEMICAL REACTIONS

- Stoichiometry
- Reaction coordinate
- Changes of properties in chemical processes
- Standard properties
- Steady state chemical reactors
- Combustion
- Power cycles
- Fuel cells

INDUSTRIAL PROCESSES

- Aluminum making
- Steel making
- Paper making
- Waste heat recovery
- Cogeneration of motive power and process heat.

SIMPLE SYSTEMS

Stable equilibrium states

Representation of states on property diagrams

Reversible, constant pressure processes

Enthalpy

Helmholtz free energy

Gibbs free energy

Maxwell relations

Phases

Phase rule

SIMPLE ONE-COMPONENT SYSTEMS

Processes at constant volume and at constant pressure

Specific heats

Latent heats

Equation of state

Van der Waals equation

Critical point

Fundamental equations

Properties of steam, steam tables

Semiperfect and perfect gases

BULK FLOW

Energy balance

Entropy balance

Mass balance

Combined balances in steady state. Availability.

Availability loss and irreversibility

ENTROPY GENERATION IN TYPICAL PROCESSES

MULTICOMPONENT SYSTEMS

Partial properties

Partial Gibbs free energy

Gibbs-Duhem equation

MIXTURES OF GASES

Partial pressure

Gibbs-Dalton law

Entropy of mixing

Outline of 2.451J and 22.571J

FOUNDATIONS

Brief Introduction

Systems, states, properties, processes

Work, adiabatic processes

Nonwork

First Law: relation between work and end-states in adiabatic processes

- Definition of energy
- Conservation of energy
- Impossibility of PMMI
- Relativity and conservation of total mass

Classification of states: nonequilibrium, steady, equilibrium, and stable equilibrium states

Second Law: existence of stable equilbirium states

- State principle
- Reversible and irreversible processes
- Impossibility of PMM2
- Adiabatic availability
- Work by a system and a reservoir

Available work

Definition of entropy in terms of energy and available work

Entropy changes in adiabatic processes

Principle of increase of entropy

Stable equilibrium states

- Criterion for stable equilibrium
- Equation relating properties for stable equilibrium states
- Mutual stable equilibrium
- Temperature
- Entropy constant

Heat

- Heat and flow of entropy
- Inequality of Clausius
- Work, heat, and change of entropy
- Reversible processes in cyclic engines

PI TAU SIGMA
END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

1979

COURSE 2.451J, Professor E. Gyftopoulos

Part A. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

Instructor is very confident and seems to have an excellent understanding of the subject material. My one complaint is the method in which he asks questions of the class, he comes on a little to strong. Although this is a very effective method of training military recruits it isn't particularily effective to learning in an academic institution.

1. Good organization; 2. good blackboard technique; 3. communicates well; 4. knows the subject well; 5. invites too many questions during lectures.

He tends to ridicule (or it seems that way) students as they ask questions and as they fumble for clarifications of their questions. I'm certain this is not deliberate, but the instructor should recognize this and exercise caution.

Too much accent - although good sense of humor. A little too abstract in beginning.

I think Prof. Gyftopoulos is a supergreat teacher: geniunely interested, brilliant, willing always to answer your questions! To improve the course, I can only suggest that he deport the second "prof".

Gyftopoulos approach is too general, too theoretical. Leaves practical applications to problem sets. Examples in class would be very helpful.

Inspiring, pre-eminent!

His class is interesting and funny.

Prof. Gyftopoulos always had time to answer questions. He knows well the subject, and presents it very very well. Prof. Gyftopoulos is wonderful.

The presentation of basic principles was almost marginal-which was bad because it was dramatic but not realistic as were some of the beginning homework problems C H_2, for example, does not exist. The 1st law can be understood by considering particle motion and mechanics. Attending every other lecture was almost possible since over the 1st 30 minutes of class were spent reviewing what was presented in the previous lecture. Especially toward the end of the course (after O'Callaghan's stint) this became boring and much less material was presented in each lecture. Gyftopoulos may encourage questions, but he certainly is excellent at intimidating students who were confused about something Gyftopoulos may have considered obvious or trivial. Gyftopoulos knows the material of this course well and enjoys lecturing which is obvious. He is, so far, the best teacher I have encountered at the 'Tute.

Interesting lecturer, good attitude, fair to students. Emphasizes fundamental understanding. Does not include enough practical applications. (Also, I've heard that much of the theory is not widely accepted). Interrupts O'Callaghan too much! Give the guy a chance.

Very good lecturer; seems to care about subject and students; brings a certain zest to the subject. Really enjoyed the course. Demonstrates the difference between MIT and Podlink State.

Prof. Gyftopoulos has the art of teaching mastered. He is an excellent lecturer and very responsive to the questions of his students. I found him to be the best prof. that I have ever taken for a course. He not only covered the basic material of the course, but he also instilled an interest in the class into furthering their knowledge about thermodynamics and its related areas.

Encourages a lot of discussion.

PI TAU SIGMA
END OF TERM COURSE AND INSTRUCTOR EVALUATIONS

COURSE 2.451J, Professor E. Gyftopoulos and Professor M. O'Callaghan

PART C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

Class size was a little too large, ocassionally questions asked by students were not aware of concern for all and the time used in discussing these areas distracted from coverage of other subject material. PRoblem sets at the end of the course were much longer but the credit was only the same as those at the beginning. Some of these latter problems were also too repetitive , the same problem over and over again.

1. Problem sets too lengthy. 2. Quiz not reasonable = usually requires more time.

Problem assignment too long, did not provide time to reflect on basic principles involved.

Homeworks are weighted too much - you don't have a chance to make mistakes and learn by them without substantial penalty. Tests insufficient time - not in keeping with some of the course material.

The bad part of the subject was chemical reaction, it was very poorly presented. Too few assignments were given in this area, and the O'Callaghan, distribute handouts full of errors. Even the problem he asked in the make up, its solution was not error free.

The homework's were long. It wasn't too great to have a hard a-ssignment before the make-up midterm. The grading on both the midterm and homeworks was important, and it would have been better (for learning more immediate re-inforcement) if the assignments were graded promptly. The TA was helpful but a little arrogant. like Gyftopoulos and imitidating. Some problem statement were very ill defined.

Subject approach is interesting, but I'd say much of the theory is not that relevant for mechanical engineering students. The section on industrial application was OK - it'd be more interesting to do some problems on that part of the course. I'd rather have 2 separate quizzes than 1 + make-up.

I liked the clarity of the concept of entropy, which I'd never understood before.

This course was the most poorly taught course that I have taken at MIT. In many respects, it was taught as if thermodynamics were a religion rather than an engineering discipline. In particular, there was a failure to provide a logical step by step explanation of the subject and the reasons for conclusion reached. On many occassions, especially in the beginning of the course, false arguments were presented. For example, "The first law can not be stated as energy is conserved: money is conserved in a bank and it's not energy". The argument which should have been presented is that we prefer to use this statemtn of the 1st law because it will allow us to define energy as a coll ? of that law without requiring a definition of a thermo-dynamics concept exterior to this argument. The denial of previously

(cont'd comment)
accepted concepts (such as the 1st law example above) also contributed to confu ion because there was no attempt to explain the reasons for denial o redefinition in a clear, logical manner. Furthermore, there was a co sistent failure to determine or announce the assumptions as which the "model" was based. For example, there was even in the lost class, an attempt to define pressure, a continuum concept, for a single particle. Further, there was a general attempt (apparent attempt would be more accurate) to rip up the student. Straightforward questions were answered with questions, further confusing an already confused student. Often when a question was asked, the instructor made fun of the questioner which tended to stop all further attempts at understanding. Furthermore, the problem sets were poorly designed. THe problem statement was often difficult to understand. Important assumptions, restrictions and information were left out. Problem solutions were poor. Often, completely errorenous assumptions were made (e.g. steam under the vapor dove was treated as a perfect gas). When a student made a more accurate assumption than was generally made in the approved solutions, he was marked down for it. The solutions to the problems were handed out so late as to be of little use in learning the subject. They should have been given out immediately following homework submission, which should have been enforced. Problem sets often took in excess of 9 hrs. and included much busy work of no real learning value. I recommend that this course material be presented in a more logical and rigorous manner. Student questions in lecture and tutorial should be answered in a straightforward manner. The so cratic (?) method of teaching should be abandoned. Reasons for abandoning or ignoring conventional practice whould be established clearly. A text for the course which the instructors feel is adequate should be selected or prepared and any variaiton from its contents to the course contents should be noted in class. The problem sets should be written to be easily understandable, if previous years problems/solutions are used, the errors in them should be corrected prior to handing them out. With these corrections, this course could become an excellent and worthwhile course.

Problem set grading very very bad. Very unfair quiz #1, some people allowed excess time which was not allowed in make-up quiz (Consequently make-up quiz was of no help). Quiz problems were too long. Text was non-existent. Overall grading was bad.

September 1978

+77

2.451J and 22.571J

GENERAL THERMODYNAMICS I

Instructors: Elias P. Gyftopoulos, Room 24-109, Extension 3-3804
Ernest G. Cravalho, Room 16-520, Extension 3-1414
R. Kach Rm 7006 Ext. 3-7488.

Class Hours: Tuesday and Thursday, 11-12:30

Homework: Assigned in class and due one week later.

References:

(1) Article on "Thermodynamics" from Encyclopedia Britannica (to be supplied).

(2) "Thermodynamics" by Keenan, MIT Press.

(3) "Engineering Thermodynamics" by Huang, Macmillan.

(4) "Principles of General Thermodynamics", by Hatsopoulos and Keenan, John Wiley.

Examinations: There will be one or two quizzes during the term and a final examination.

Final grade: 30% Homework
30% Quizzes
40% Final Examination

Topics	No. of lecture
1. Foundations of thermodynamics	5-6
2. Simple systems	2
3. One-component systems	2
4. Bulk flow	2
5. Entropy generation in typical processes	1
6. Energy conversion systems	2
7. Multicomponent systems	1
8. Chemical equilibrium	2
9. Chemical reactions-Combustion	2
10. Industrial processes	4

2.451J/22.571J GENERAL THERMODYNAMICS I

September	12	Foundations of Thermodynamics
	14	" "
	19	" "
	21	" "
	26	" "
	28	" "
October	3	Simple Systems
	5	" "
	10	Holiday
	12	One Component Systems
	17	" "
	19	Bulk Flow
	24	" "
	26	Entropy Generation in Typical Processes
	31	Energy Conversion Systems
November	2	" "
	7	Multi-component Systems
	9	Chemical Equilibrium
	14	" "
	16	Chemical Reactions - Combustion
	21	" "
	23	Holiday
	28	Industrial Processes
	30	" "
December	5	" "
	7	" "
	12	Review

Simple systems

- Stable equilibrium states
- Diagrams
- Constant pressure processes
- Maxwell relations
- Phase rule

Simple one-component systems

- Phases
- Processes at constant volume and at constant pressure
- Equation of state
- Van der Waals equation
- Critical point
- Fundamental equations
- Properties of steam-steam tables
- Perfect gases

Bulk flow

- Energy balance
- Entropy balance
- Mass balance

Entropy generation in typical processes

Multicomponent systems

- Partial properties
- Partial Gibbs free energy
- Gibbs-Duhem equation

Mixtures of gases

- Partial pressure
- Gibbs-Dalton law
- Entropy of mixing

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END OF TERM EVALUATIONS Fall 1978

COURSE 2.451J, Professor Elias P. Gyftopoulos

A. INSTRUCTOR. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he/she can improve his/her teaching techniques.

None

Positive attributes. I want to have more example problems in class hour.

Gyftopolous continually interupted Cravalho during his sections.

Very enthusiastic about subject material. Demonstrates a sincere effort in his teaching. More numberical examples would be helpful in class.

Very good, exciting and goes all out to teach.

Good professor but the class is sometimes confusing.

Prof. Gyftopoulos always came to class prepared. His lectures were clear most of the time. Homeworks, however were hard.

Prof. Gyftopoulos is obvious well versed in the subject of T.D. and is quite willing to offer the excellent instruction that MIT students demand. Sometimes in his effort to explain, I was confused by the philosophical approach rather than a straightforeard answer. However, he is creative and certainly offers much insight into the topic - more insight than instructors in previous T.D. courses. I might add, my feel for "availability has been enlared considerably".

Very enjoyable. Promotes the ideal of thinking out problem. I learned much from him but I was afraid I still would have trouble doing a good job on his tests.

Prof. Gyftopoulos is the finest thermo Professor I have ever had. His hot air contains more availability than all of my previous thermo professor put together.

I was very pleased with the way Prof. Gyftopoulos handled the course. Positive attributes - encouraged questions very enthusiastic, many interesting anecdotes concerning the subject matter. I can't suggest any improvements every thing seemed just right.

Too many (original, irrelevant stries). Good approach to subject. I have a better idea of what entropy is now.

Negative: too much emphasis on subjects of personal interest. Positive: very encouraging questions and very elaborate answers. More applications should have been covered.

I appreciate his giving a 15 to 20 minutes review of last lectrue's material before a lecture. This is very helpful in "warming-up" the students before learning new things.

Very good lecturer. Knows material extremely well (sites examples etc). Holds interest of the class with his enthusiasm for the subject.

Positive- stressed ways to relate subject matter to energy questions of current interest.

He knows material very well but tries to present it on a very theoretical level. Do more examples in class using the theory on a concrete problem.

I really enjoyed his pace and the way he can answer questions. Course content is good.

Positive: profound knowledge of subject matter. Evident case for conveying such knowledge. Negative: Tends to spend a lot of time relating stories that, though entertaining, sometimes lack pertinence to the subject.

Good preparation - explains well - makes class interesting - good job.

Prof. Gyftopoulos is a very good lecturer. The material presented was well presented. Sometimes I think he just spent too much time answering questions irrelevant to this subject. Thus slowing down the pace a little bit.

Excellent presentations. Indicated thorough knowledge of material. Enthusiastic Encouraged discussion. Overall - excellent.

Good professor, clearly, suciently, answers all questions. I learned about entropy and also a great deal about availability (a great "plus" in the course) Is willing to admit he is unsure of the answer to a question, then still discusses his feeling of the answer - I admire his honesty.

Positive: knowledgable, confident, takes time to explain, interested in students.

Excellent. Prompting of questions is very good. Sometimes interprets questions incorrectly, however, by jumping to preconceived notion of what he expects to be asked. One of the most enjoyable classroom technique I have encountered.

Instructor showed much patience and fortitude in trying to bring us around to this different approach to thermo. Unfortunately this caused the classes to drage. At times, especially when answering the questions, a 1 minute answer turned into a 10 minute lecture. More examples in class would be helpful, (like a problem calculating availability). It was great to be able to see the instructor almost any time. He always seemed willing to help.

Beautiful teacher (of a beautiful material) Too many people for the T.A. to correct adequately the homeworks.

I felt Prof. Gyftopoulos was concerned about me personally, in the sense that it was important for me to understand the material, and he was willing and available to spend time outside of class explaing questions. Sometimes the lecture speed seemed unbearable slow, other times too fast. This usually related to my previous exposure to the material ((not seen it before - too fast). I think Prof. Gyftopoulos needs to emphasize people asking questions more. If the question refers too far back in material, then see them individually, unless the whole class also misunderstands.

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END OF TERM EVALUATIONS Fall 1978

COURSE 2.451J, Professor Gyftopoulos and Professor Cravalho

. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Was the class size too large? Comment on problem sets, text, quizzes, etc.

First 1/3 of course was confusing.

Best thermo course I ever took.

Subject was as good as any other I've taken at MIT so far.

Need better method of teaching mixtures.

Problem sets were hard and questions were vague. Should give more quizzes covering less material instead of just a midterm and a final.

I feel the class size was a little too large. The size made it difficult to ask questions on particular problems. The instructors also promoted thinking and philosophies but spent little time on problem solving techniques.

The best.

More time should have been spent in class on explaing the availiability business. A text that parallels the course with examples would be helpful.

found the introductory part hard to understand. I would like to have more applications.

I think we didn't have enough exposure to power cycles and other applications of the subject.

No criticism about the subject. The weekly homework assignments presented quite a bit of material which to have your grade based and helped enormously in gaining understanding of the material.

I got very little out of the problem session and would prefer a more structured discussion of the previous week's homework assignment.

Would like one more quiz.

The class size was definetly too large. There was not ext required. If a text was available, closely paralleling the class lectures, it would be a big help. Also, terminology seems to be a problem. For example a student may understand availability in all of 'its' ramifications, however, when faced with a test problem asking for the "availability loss" in a certain process, two or three definitions of this term suggest themselves.

Class size too large - should have more quizzes better with text to follow instead of just notes and handouts. Class material generally good.

Would like to have our homework done in time say one week after we handed in. Would ve to have some assigned reading. Because I have to spend quite some time to look through test to find out what is relevant to current lectures.

A lot of homework - but it was very helpful. I think this much homework is needed for the course. Another quiz would have been better.

Availability should be taught a bit more clearly. Handout solved problems to past homeworks before ___?___ . No books really treat this subject well enough to use as a reference.

Interesting classes and homework. Each problem set solutions should be available 1 week following the due date of the problem set. More communciation between the two instructors needed.

Excellent course overall. Last couple weeks got a little long-winded and slow. Problem sets - I consistently felt I was wasting time trying to figure out the proper interpretation of problems. In real life there are indeed ambiquities, but with problem sets unless the problem states there is ambiquity, the student (me) interprets the question as being definitive. They seemed to be graded that way as well.

I believe more material could have been covered. But the amount of homework should not be increased. I spent about 15-20 hours per problem set and one set took about 25 hours. The problem sets should also be more carefully parpared (exams, too) so all mistakes are eliminated. The make-up exam grading was very unfair to me. On the first test, I was about 15 points above the average. I didn't take the second test so my grade was only 3 points above that average. I dropped from a B to a C because I didn't take the make-up exam!!

Spend much more time in the foundations. It will be much worth for the expansion of this way of thinking (could I say phylosophy without being misinterpreted?) This is the phylosophy of real life! A beautiful course.

I felt some of the problems were too difficult, specifically the metastable stale problem. Also, reactions of solids should have been mentioned at least before we had to work the problem (iron+water in fires) - most particularly because that material is not easily found in our texts, (if at all?)

Dec. 72?

PI TAU SIGMA

MIDTERM COURSE AND INSTRUCTOR EVALUATION

COURSE: 2.451J PROFESSOR: Elias P. Gyftopoulos

Part A. The Course. How do you criticize the course? What parts did you not understand? What parts have seemed irrelevant; what parts should be added? How would you change the approach (i.e. problem sets, problem set solutions, text, quizzes)? Include comments about what parts of the course you have liked the best, and what parts you would like to spend more time on. If the course included a laboratory, comment about the laboratory. Has it been useful or worthwhile?

The course to date has been interesting. Perhaps I would try to include more examples in the material. Problem sets I have found to be difficult so far. It would be better to receive the answers (correct ones) at the same time as my solutions so that I can compare right with wrong. I would like to have a little more on mutual stable equilibrium

This course is very useful to understand deeply the principle of thermodynamic philosophy. But you feel there is also an advanced thermodynamic course necessary for department. I'm thinkg of a course like 2.25 in fluids followed by 2.20.

My overall feeling about the course is positive. Some of the problem sets show signs of very hasty prepararation, and contain errors which could easily be elminated. It would be helpful to get the graded problem sets back sooner, so that we can more easily compare our work to the solutions. The lack of a text at the beginning of the term was something of a nuisance, as it made understanding of the course material quite difficult when classes were missed.

An excellent teacher. He is always well prepared and is very willing to answer question.

If instructor expended more time for the new things it will be much better than work on old concept.

The new approach to thermodynamics, in a more general way opened my mind to new possibilities in this science. I would not change the approach.

The course thus far has been relevant and interesting. There has unfortunately not yet been any quiz or exam. The first is in two weeks, far too much of the semester has already passed. The most interesting aspect has been the approach to the fundamentals of the subject. This has been greatly different from my undergraduate thermodynamics exposure.

I'm glad to have this course. But I think problem session must be added.

Basically it seems to be more of a classical concept rather than the usual thermodynamics courses that I have come across before. Anyway, its nice to learn the subject from other view even though initially it may tend to be easily confused. More time should be given to the homework. Bearing in mind that there are other homeworks as well as reading materials to be done, one week is not sufficient to do a satisfactory job.

Part A (Continued) Course: 2.451J Professor: Elias P. Gyftopoulos

Some of the proofs asked for in the homework have appeared to be somewhat irrelevant. Also a bit of unnecessary emphasis was placed in the beginning on the distinction between stable equilibrium states and other states for a system. Since most thermodynamic relations and thermodynamic applications are for cases of stable equilibrium states, more initial emphasis should be placed on just mentioning the distinctive quality of the stable equilibrium state and then pursuing on deriving the mathematical relations.

The course is quite interesting in its content. I found parts on available work and heat hard to understand. I enjoyed the logical way the course was built up but I find problems in practical applications in the problem sets. It would be better if the homework was returned the week after it was handed in.

Problem sets should be returned sooner than they have been. All parts covered in class seem relevant to the subject. The treatment of states other than stable equilibrium states was very interesting and enlightening. Two midterm exams may be a good idea.

Should have more than 1 quiz in the course, or emphasize the homework more in the final grade.

The text (Encyclopedia) is a good one but we should have been told at the beginning that the Hatsopoulos & Keenan book was mandatory (almost). The assignments (to be turned in) help keep me up to date but they should be passed back sooner. I have like the approach so far but it seems too biased toward the Ph.D. qualifying people. I probably would not change the course.

The only problem is problem sets. In problem sets, some of the problems need formulas or concepts which have not been discussed in the class yet. Since this is a new approach to thermodynamics, there is no text available. The distributed sheets are very good. But the book by Hastopolous & Keenan is terrible. I think the teacher could distribute notes (which are perfect) instead of reference text.

This course is useful in presenting thermo from a different point of view and making me more aware of the fundamental definitions. In criticism too much time has been wasted in question and answers and not enough time spent on the analytical approach to thermo.

The course if fairly difficult. Some of the problem sets seem to parallel the course material rather than coinciding with it. The basics are given during lecture, but application of these basics is left almost entirely to the student. I'm having trouble with the use of steam tables and other material on P.S. 5.

The course overall is good. The presentation is adequately clear and points that aren't particularly clear are explained in class thoroughly. The part, about state equ. and the relevant processes on the G vs. S grups need more clarification.

The course presents the classical thermo material from a different and therefore interesting viewpoint. The presentation of the 1st and 2nd laws is interesting and it involves insight that hadn't been obtained before.

Part A (Contined) Course: 2.451J Professor: Elias P. Gyftopoulos

Like the amount of class discussion, it makes for an interesting class. Too much, however, seems to slow down the lecture and amount of new material. Problem sets are just about right, don't know about tests but don't like the high weighting (50%) of the final.

A good part of the course is the detailed evaluation of fundamental concepts. However much class time is wasted repeating the same information. More problems emphasizing the fundamentals and not simple 'cookbook' problems would be appropriate. Hopefully, yet to come, will be practical applications of the fundamentals.

The course has been primarily review thus far, and could have perhaps moved a little faster if everyone was familiar with the material. The topic of stable equilibrium has been interesting, but contains so much review that it should perhaps be taught as a beginning thermodynamic subject, understanding that part of the course is ahmpered by previous ideas.

The most difficult part of the course was naturally the introduction where fundamental concepts and initial definitions were presented. During these initial lectures, the course seemed more like a study of philosophy than one of thermodynamics. The graphical treatment of some of these basic concepts helped greatly. After establishing firmly the aforementioned concepts, the course has proceeded in a step-by-step manner deriving everything from first principles (more or less) so, therefore, there hasn't been any complaints.

I would have liked to have seen a definite exam schedule established at the beginning of the term. I had hoped to have an exam by now to get some indication of where I stand. Much time was spent in deriving the principles leading to the E vs S graph of allowed state of a system, yet next to no time was spent in showing how instructions with which we are familiar are characterized (or illustrated) on this graph. As soon as possible, some sort of textbook should be made available to this course. On this way, I feel that may questions now answered in class could be taken care of through having the (a) text to back up the lectures. The homework policy seems OK - it's nice to get some credit for effort expended in this area. Sometimes, it is difficulty to extropolate from the material covered in class to some of the homework problems.

Problem sets are very good because you learn the material by doing the problems. Problem solutions are helpful. Lectures lack a good physical insight into the material. Lecturer tends to present material so that it is understandable but the lecturer's technique is not conducive to note taking. Entirely too much weight is placed on the final grade. In theory, it seems fair but if you should be sick that day, you arescrewed royally irrespective of how you had been doing all along in the course. Students should be given better guidance toward mastering course supplementary reading, extra problems, etc. A good text is a must in this course. H & K gives the theory adequately but not applications. This course does not tap a student's actual potential because of its structure.

The course, on the whole, is good. The level is quite high, fortunately. Maybe more should be spent on the concept of non-equilibrium states - a fact on which makes this course different from others in thermo.

I've basically enjoyed the course, I expecially like the rigorous approach of the instructor. Unfortunately, he seems to have deviated from the rigorousness recently. This is not to say that I don't understand the material. It just seems as though the style that I prefer has changed. The big problem I've found is the course has been that the homework assignments have been given before the material has been discussed

Part A (continued) Professor Elias P. Gyftopoulos, Course 2.45lJ

in depth. I suppose that this a graduate course that assumes previous knowledge of the material though. I feel that the text is hardly worth the money. Possibly an alternative could be found.

This is the first time which some concepts in thermodynamics get profound and useful meaning, both practically and theoretically. It is ideal for me, and I don't have any generaly comment about the way it offers, but I guess it would have been much better if it had more units and time per week, to discuss ideas and different aspects of it as much as possible.

This course seems to be taught on many different levels or degrees. The lectures, homework, general textbook and special reading or handout material are not well integrated. Homework is very applied type problems. Lecture is only interested in general principles (few practical example). Textbook is review of undergraduate subject, and special reading and handout are difficult to understand. Please bring the organization of the vary material presentations in closer agreement with each other.

A more rigorous approach to the subject has been used in this course than previous thermo courses I have taken, this approach would be better if this were a "first" thermo course. I would not make any changes, however.

I have liked the course very much although much time was spent on questions. I'm glad that now we spend more time on what is interesting for most of the people and not for one person. I've found very helpful the new approach given in this course to derive the lst and 2nd laws of thermodynamics and their postulates.

Good course. More quizzes would help.

I can find no criticizms of the course. It is well motivated and interesting. The fundamentals were introduced carefully. Perhaps the course proceeded too rapidly to problems of a complicated nature but because it is a graduate course some previous thermodynamics background is assumed and this is therefore not a very serious problem.

The problem sets do not follow the lectures closely enough. They require a lot of outside reading which is not always clear. The lectures are well organized but too much time is wasted by answering questions.

1. Interesting course. 2. On the E-S diagram because of no reference matieral available, we would like to see more hand outs on this particular topic.

I don't think anything seemed irrelevant; the introduction of a new method-theory is describe simple thermo processes and laws was an excellent idea. Presentation was good. Points initially unclear were taken good care by the instructor and made clear. There should be some text, at least for the second half of the course which is taught in the classical way. Some practical applications should be more stressed upon, since this is an engineering course.

This course is somewhat tricky and the instructor doesn't describe the narrow points or he describes some simple discussion too much but some tricky matter very fast.

One of the best I have taken in fours years of M.I.T. Plain fantastic, everything is in the right place and pace.

I have found the course very stimulating. The new approaches informable and understandable. Very good! But the possibility of only one quiz before a final scares me. I feel a strong need for two quizzes.

The final should not be 50% of the total grade but less. Require more problems solved in class. Very interesting point in the concepts of the entropy and availabilities.

Problem set solutions should be handed back at some time as answer sheets. Quite a good course for concepts.

The course so far has been wonderful. I like the approach which emphasizes accuracy and the results have been applied well. I only wish there were a text for the 1st part which went into more depth.

The course presents a new approach to understanding the principles and concepts of thermodynamics. Different from what one is used to but quite interesting.

Good detailed approach.

PI TAU SIGMA

MIDTERM COURSE AND INSTRUCTOR EVALUATION

COURSE: 2.451J PROFESSOR: Elias Gyftopoulos

Part B. The Instructor. What criticisms do you have for the instructor? How would you improve his teaching techniques? Does he add to the course, or could you get it all out of a book? What are his strong points?

So far he has been excellent, again I would like to have more examples. Yes he adds to the course. His strong points are his sense of humor and rapport with the class.

He is a good teacher and if an advanced thermodynamic is supposed to be added he can be a good teacher for that.

I think Prof. Gyftapoulos teaches this course well. His strongest point is that he uses a large portion of class time for questions and discussion. His blackboard technique is good, with the exception that occasionally he is unsure about the sign of certain terms. It is time that this is a "bookkeeping" sort of problem, but many students have some confusion about the sign problems, and their confusion might be lessened instead of increased if he was careful about the matter in his lectures.

Prof. Gyftopoulos is an excellent teacher. He is always well prepared and is very willing to answer questions.

If the instructor expended more time for the new thing it would be much better than working on old concepts.

He is a fairly good lecturer although in the first part he spent too much time answering irrelevant questions, so the course was delayed.

An interesting and informative instructor. The only fault I perceive is a tendency to allow student questioning (students asking questions) to monopolize the limited time available. More such questions should be deferred to office sessions, etc.

The instructor who teaches this course is very good person for giving this course.

Well, as far as the instructor is concerned, his teachings are good. He adds new materials that are not found in the book. His strong points are that you are sure that the material he's giving is useful and in a way that he has of putting things across.

The instructor should try less to teach the course like a philosophy course and concentrate on teaching it like an engineering course in the long run.

I think he should do more problems like in the problem set, on the board. Otherwise he is a good instructor and a nice guy.

The instructor definitely adds to the course. Although much of the course could be taken out of texts the instructor provides enlightening examples and explanations.

Very good book for practical examples. Its incredible they pass those numbers in the back of the book off as "answers". Prof. G. is very effective, extremely competant.

Part B (Continued) Course: 2.451J Professor: Elias Gyftopolous

Has amazing patience with people's questions but occasionally can get "off the beaten track". Adds very much to the course in the way of understanding.

There is one thing I would like to say about him, excellent teacher, no criticism.

No major criticisms. However an unreasonable amount of time is spent answering questions. I'd like to see more practical examples which clarify the basic principles.

At first he spent almost the entire class period responding to questions rather than covering new course material. He has been avoiding that recently, however. One definitely cannot get all the material out of the book.

Very good presentation of the material. Very alert and very exact in his responses to the questions. Also very clearly presents his ideas. His is a definite attraction to the course, you don't need a text. Overall one of the best in the Institute.

Good teacher. Knowledgeable. Good lecturer.

Good. Seems to know the material and is willing to explain what is not understood.

Excellent discussion and answering capabilities - enjoy discussing concepts makes it easy to appreciate concept fundamentals.

The material covered seemed to require perhaps too much time. I thinkg he was very good at responding to questions and seemed to be very interested in the students. He was also very good at using helpful examples.

Good points. 1) Speaks and writes at good speed. 2) Blends theory with graphic illustration in a manner that I haven't found in any textbook. This reinforcement of concepts is one of the reasons I come to class. 3) Great personality and attitude.

Lecturer is interesting and is able to hold students' attention. Why don't you make the questionnair multiple choice or else allow for more time to fill this thing out!

Sometimes more precision is needed. On the whole, the teaching is excellent. Teaching is not irrelevant. To get this out of a book requires far more time and would probably be less clear. Good job!

I already talked to the instructor about this, but the class went way too slow in the beginning because of repeated absurd questions. He has become conscious of this though and things have moved along much better. Otherwise the instructor is excellent.

He is excellent.

He should give more examples of applications to clarify equations and general concepts of course. What he has taught so far I could get out of the textbook and would have difficulty from special handouts. He does make himself available after class which I like.

The course is not all out of a book. Method of presentation is good.

Part B (Continued) Course: 2.451J Professor: Elias Gyftopoulos

He's a fine instructor. He's been especially helpful when somebody is in doubt trying to clarify any point. I only regret that when somebody asks a silly question he laughs at him, in my opinion, in a very impolite way.

Good. Perhaps he entertains too many questions.

I believe he's an excellent teacher. Takes time to answer questions and seems very interested in his students. He is careful and clear. I enjoy his lectures very much.

Spend more time lecturing and less time answering questions.

Good teacher, always available for discussion.

Excellent presentation of the first part of the course. Gave a good insight of simple thermo principles. However he spends more time answering questions than I thought would be required.

He teaches sometimes very good but sometimes not good, and understanding from text of this course is very difficult.

Great guy, his teaching technique is excellent. I have learned many things from him which I couldn't have gotten by just reading the material. His strong point is his devotion and patience he has to explain the course. He doesn't stop until he is sure that you know!

His explanations are very thorough and sound. His encouragement of questions is admirable, but he answers too many irrelevant questions at times. His bits of hoor are a welcome break in the 1 1/2 hour time slot.

Good in general.

Quite painstaking in getting students to understand material.

Now that we don't constantly stop for questions I like the professor's methods and feel that his methods are clearly presented. His ability to answer questions during lecture are helpful.

Excellent but should allow less questions in class.

Good. Dialogue with students good. Sometimes gets into too long arguements with students, beyond the point where the majority of the class is gaining from the exchange.

Prof. Gyftopolous is very willing to take time in and out of the class to answer questions. This is very important to me. In addition, he doesn't make you feel like an idiot when you ask a so-called "dumb" question. This is excellent - this pressure cooker institution is difficult enough without having to be reminded of the level of your ignorance. Sometimes, I wish that Prof. Gyftopoulos would not leave out intermediate steps in the derivation of certain formulas. Example: in the use of higher order Taylor series expressions to show that $\frac{AB}{ds}$ is greater than or equal to $\frac{A}{ds} + \frac{B}{ds}$, I wish that he had just explained this in class as oppossed to assigning it for homework in lieu of a more relevant problem.

2.451J and 22.571J

GENERAL THERMODYNAMICS 1

Instructors: Elias P. Gyftopoulos, Room 24-109, 3-3804
John P. Appleton, Room 3-339, 3-2295
Ernest G. Cravalho, Room 3-282, 3-3282

Class Hours: Tuesday and Thursday, 2:00-3:30 PM

Homework: Assigned in class and due one week later

References:

(1) Article on "Thermodynamics" by J. Keenan, G. Hatsopoulos and E. Gyftopoulos. (to be supplied)

(2) "Classical Thermodynamics" by A. B. Pippard, Cambridge University Press.

(3) "Principles of General Thermodynamics" by G. Hatsopoulos and J. Keenan, John Wiley (1966).

Examinations: There will be one or two quizzes during the term, and a final examination.

Final grade:
20% Homework
30% Quizzes
50% Final Examination

	Topics	No. of lectures
1.	Foundations of classical thermodynamics	5-6
2.	Simple systems	2-3
3.	One-component systems	2-3
4.	Bulk flow	2
5.	Applications to energy conversion systems	2
6.	Applications to industrial processes	6

Outline of First Part of 2.451J and 22.571J

- Brief Introduction
- Systems, states, properties
- Work and nonwork
- First Law
  - Definition of energy
  - Conservation of energy
  - Impossibility PMMI
- Second Law
  - State principle
  - Reversible and irreversible processes
  - Impossibility PMM2
  - Work by a systems and a resevoir
- Entropy
  - Available work
  - Definition of entropy
  - Entropy changes in adibatic processes
  - Principle of increase of entropy
- Stable equilibrium
  - Criterion for stable equilibrium
  - Equation relating properties for stable equilibrium states
  - Mutual stable equilibrium
  - Temperature
  - Entropy constant
- Heat
  - Heat and flow of entropy
  - Inequality of Clausius
  - Work, heat, and change of entropy
  - Reversible cyclic engines

Simple systems

- Stable equilibrium states
- Diagrams
- Constant pressure processes
- Maxwell relations
- Phase rule

Simple one-component systems

- Phases
- Processes at constant volume and at constant pressure
- Equation of state
- Van der Waals equation
- Critical point
- Fundamental equation

1976

PI TAU SIGMA

END OF TERM QUESTIONNAIRE

COURSE 2.451J, Professor Elias Gyftopoulos

A. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he can improve his teaching techniques.

This course should have a good text, the introduced text isn't good and is not completely related to the material. Hand-out are written by hand and it is very difficulty to read them.

Excellent presentation, good use of examples, timely and effective use of written course notes. A small improvement could be made in writing higher on the blackboard. Personal reflections of instructor's were among most interesting points during course.

He is perfect in teaching but there are sometimes problems in communications, i.e., problem sets need to be more explicity (also quizzes) almost consultation with him is a necessary basis to understand what problems really mean.

Lectures delievered with enthusiasm and genuine interest in the learning process of his students. He entertained, at great length, too many questions which should have been deferred to individual sessions out of class. This was bad during the first half of the semester, and improved noticably with time. One problem set was a complete disaster leading to unnecessary confusion and frustration. Two problem sets; ottoming cycle and oxygen separation plant were outstanding.

He is very clear in his concepts. Lost enthusiasm as course went on.

I feel the instructor was basically excellent. The only improvement I can suggest are a lightening of the homework assignments and a better text should be found (or written).

Prof. Gyftopoulos is a very effective, prepared and helpful instructor. He is the best teacher I have had here at MIT.

His teaching is very good. His problem sets are ambiguous and hard to do.

He is genuinely interested in Thermodynamics as well as his students. I find his lectures stimulating and interesting and his enthusiasm for the subject is contagious.

Very good instructor, encourages questions and involves interest. Somewhat long problem sets.

Good.

He is great.

Desires to ensure understanding. Material needed for some problem sets given rather late at times.

No comments.

is teaching techniques are excellent. The only improvement I can suggest is providing notes prior to lectures (when they are given) rather than after the relevant lectures. I also think we went a bit fast after the midterm and relied too much on previous thermo courses, e.g. we never defined what a Rantine cycle is but we sure used them.

His knowledge of the subject was very good, also he had a good relationship with the students. Also he was very helpful out of class.

The best! Excellent!

Great man, enjoys teaching and trys hard to do it in perfection which he does. He nned no improvements. But he should not attend John's lectures!

He is a very good instructor.

Good in any way.

PI TAU SIGMA

END OF TERM QUESTIONNAIRE

COURSE 2.451J, Professor Gyftopoulos and Professor Appleton

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant what parts should be added? Recommend ways to improve the course. Comment on problem sets, text, quizzes, etc.

Relevance of subject material to the engineer in engineering and social areas. Negative: Maybe one week's lectures too much on developing concepts at beginning. More problems dealing with cycles would be useful.

For me it was a perfect subject.

Somehow I lost my enthusiasm.

Problem sets were very lengthy and at times were given in sucession so that one could not be completed before the other was given out. There should also have been more than one exam. The text needs to be improved upon.

I would like to see the theoretical part of the course covered more quickly and have more practical applications.

Didn't understand entropy which is why I took course, still don't.

oo little math in it. Sometimes boring to hear. Problem sets ambigious.

The course provided an alternative perspective of thermo by a rather interesting way. Long problem sets. Text rather good, quiz reasonable.

More quizzes. Homework due each week is good. I would like some correlation between grades (numbers) I have so far received and the letter grade I can expect.

Chemical equations part was pressed quickly. Problem sets should be given after the lectures not before, i.e. not before the material covered.

No comment.

I would like to see a better text and more problems in which we develop the theory rather than just plug in numbers.

I think the subject was more difficult than it should have been because of lack of an adequate text.

I would like at least one more quiz. There just aren't enough evaluations in this course.

Too much emphasize on the grading of the course and the problem sets. Everything okay.

Great course.

1975

2.451J and 22.571J

GENERAL THERMODYNAMICS I

Instructors: Elias P. Gyftopoulos, Room 24-109, 3-3804
Philip Thullen, Room 43-203B, 3-2440

Class Hours: Tuesday and Thursday, 2:00-3:30 PM

Homework: Assigned in class and due one week later

References:

(1) Article on "Thermodynamics" by J. Keenan, G. Hatsopoulos and E. Gyftopoulos. (to be supplied)

(2) "Classical Thermodynamics" by A. B. Pippard Cambridge University Press.

(3) "Heat and Thermodynamics" by M. Zemansky McGraw Hill.

(4) "Principles of General Thermodynamics" by G. Hatsopoulos and J. Keenan, John Wiley (1966).

(5) "Thermodynamics" by J. Keenan, MIT Press

Examinations: There will be one or two quizzes during the term, and a final examination.

Final grade:
20% Homework
30% Quizzes
50% Final examination

	Subject Schedule	Lectures
1.	Foundations of classical thermodynamics	5-6
2.	Simple systems	3-4
3.	One-component systems	4-5
4.	Bulk flow	2
5.	Applications to energy conversion systems	3-4
6.	Applications to industrial processes	2

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  - Impossibility PMM2
  - Work by a system and a resevoir
- Entropy
  - Available work
  - Definition of entropy
  - Entropy changes in adibatic processes
  - Principle of increase of entropy
- Stable equilibrium
  - Criterion for stable equilibrium
  - Equation relating properties for stable equilibrium states
  - Mutual stable equilibrium
  - Temperature
  - Entropy constant
- Heat
  - Heat and flow of entropy
  - Inequality of Clausius
  - Work, heat, and change of entropy
  - Reversible cyclic engines

Simple systems

- Stable equilibrium states
- Diagrams
- Constant pressure processes
- Maxwell relations
- Phase rule

Simple one-component systems

- Phases
- Processes at constant volume and at constant pressure
- Equation of state
- Van der Waals equation
- Critical point
- Fundamental equation

DECEMBER 1975

PI TAU SIGMA

END-OF-TERM COURSE AND INSTRUCTOR EVALUATIONS

Course 2.451J. Professor Elias P. Gyftopoulos.

B. Instructor. What do you feel are the positive and negative attributes of the instructor? Recommend ways in which he can improve his teaching techniques.

He is very enthusiastic and open to questions. However, this sometimes works as a detriment in that too much class time is taken up with questions which are, at best, tangential to the important material.

Tended to be too abstract. Did not seem to know practical applications. Was good in that he generated my interest in thermodynamics.

His accent hampers communication. I feel that some of his homework problems are not representative of some class material. For example, he really likes the quantum stuff. Also feel like he should prepare additional notes for handout rather than relying on the Encyclopedia reference, which was extremely difficult to understand.

Good enthusiasm. Sometimes discussion above my knowledge level.

I found his teaching approach very clear and very easy to follow. Occasionally spends too much time on discussion of trivial points, but not often. He encourages questions, and explains very clearly.

He knows the material very well, but if he can improve the blackboard technique and speak clearly, then he is a very good teacher.

He really looks to know very much about the subject. Probably one problem is the communication to the students what he knows. In my case, I had some difficulty understanding his lectures.

Knows the subject very well and encourages questions. Excellent teache

Dwells too long on fundamentals--will try too hard to say the same thing a dozen ways. Does not challenge a student who has already had undergraduate thermo. But is a good speaker and commands attention. Maybe too nice a guy.

He seems to wander about in his lectures and manages to present very little which is worthwhile.

He knows too much and, furthermore, explains whatever is being asked. However, what he presented in class was something new, which required a lot of time. Unfortunately, he didn't success in his task to make class understand his point.

First half of the course was very boring, probably because he is from course 22.

Well organized and very knowledgeable of the subject. Encourages

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PI TAU SIGMA

END-OF-TERM COURSE AND INSTRUCTOR EVALUATIONS

Course 2.451J, Professor E. P. Gyftopoulos. B (continued).

discussions and questions--which is very good.

Positive: Knows the material thoroughly, emphasis excellent, good diction, delivers very clear, well-formulated lecture.
Negative: Sometimes in emphasis, his voice gets very small and I can't hear, then all of a sudden his voice rises.

Too much emphasis on theoretical ground.

Interesting, but discusses philosophies above the level of the class, thereby generating confusion.

He was very enthusiastic about subject and very eager to help students outside of class. Sometimes he was a bit too theoretical.

Excellent teaching. Aroused my interest.

Great experience. But sometimes difficult to understand.

Professor Gyftopoulos tends to talk about thermodynamics instead of teaching it. Should concentrate more on having a coherent plan of wh he'll cover. Should not allow numerous pointless questions to slow down the pace of the course.

Again, same as before. Good instructor, but we need more class time for discussion to take place.

Positive: His knowledge of fluid mechanics and his effort in helping us as much as possible. Negative: Only the "blackboard technique" but with no influence as a general.

Generates interest in subject. Discusses many interesting applications.

Encourages too many unrelated in-class questions. Pace of lectures too slow. Far too theoretical for too many lectures.

O.K.

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END-OF-TERM COURSE AND INSTRUCTOR EVALUATIONS

Course 2.451J, Professor Philip Thullen, Professor Elias P. Gyftopoulos

C. How do you criticize the subject? What did you like about the subject? What did you not understand? What parts seemed irrelevant, what parts should be added? Recommend ways to improve the course. Comment on problem sets, text, quizzes, etc.

The problem sets did not follow the lectures very well in the beginning. The two instructors used a somewhat different set of definitions which created confusion. The course spent too much time on making very fine distinctions in rather esoteric points while neglecting more important practical matters.

I think that some parts, such as thermodynamics of magnetized media, thermo electricity, irreversible processes, etc., could be taught without detriment of the quality of the course. In my opinion, the pace of the course was slow and the quality of the course very good.

Course should be made more practically oriented. More problems should be given.

It is a bad idea to put this subject together with course 22. Since there are differences which different departments would emphasize. As a result, a lot of discontinuity happened in this subject.

Need better text. Textbook should be more practical.

Only encyclopedia notes for text--very concise--brief explanation which could not be understood readily. Had to do a lot of reading/ reviewing from own personal texts to understand the material.

Found contrast between teaching styles startling. Had a hard time adjusting to Thullen's way of teaching.

The subject is good, but it seems to me it spends too much time in the beginning in defining the definitions; problem sets and quizzes are good.

In general I didn't understand the general approach of the course. As a matter of fact, I was taking course to learn something about thermodynamics, and I didn't. The main difficulty was to correlate the recommended text to what was given and asked in quizzes.

Problem sets very essential part of the course. Good problems and quizzes.

Did not give us credit for having already been exposed to the material before. The course did not extend my knowledge of thermo very much, not as much as a grad course at M.I.T. should.

Overall, the course was O.K. It should move much faster than it did

Course 2.451J, Professors Thullen and Gyftopoulos. C (continued).

and present a lot more real world problems. I did not like the great frequency of the problem sets, the problems were not hard, but I was always doing them.

Criticism--may be too theoretical.

I do not like 2.451J. I feel that I haven't learned much more than what I learned in undergraduate work. Too theoretical.

This course really needs a textbook, even if the text were bad, it would be better than nothing. It's very easy to not begin with a good understanding of the subject and assigned readings in ONE text would be helpful.

The problem sets were good, but I would have preferred more practical applications in both problems and lectures.

Would have liked to go into a little more chemical thermodynamics as well.

Should be taught by just one department. Responsibility for course should be in the hands of one department and one instructor.

The course did not seem to have a clear conception of what was going to be taught, what was going to be assumed as background, and what was not going to be covered. The undergraduate courses are more thorough and better taught. I really feel that the course was slowed unnecessarily by the lack of sufficient preparation and background on the part of the foreign students.

I really blew it up on the second quiz. Why did you take it right after the first one? Quizzes should be given to show an understanding of subject matter--not to waste our time crunching with number

Needs a little more organization and continuity.

It is a good course in general, including recitation classes and films. I would suggest to increase the number of quizzes and exclude the final exam, in order to make the course more efficient.

There should be more example problems discussed in class.

Have the two professors work together to provide more unified treatment. Do something about getting a text.

PI TAU SIGMA

MIDTERM COURSE AND INSTRUCTOR EVALUATION

COURSE: 2.451J PROFESSOR: Elias P. Gyftopoulos

Part A. The Course. How do you criticize the course? What parts did you not understand? What parts have seemed irrelevant; what parts should be added? How would you change the approach (i.e. problem sets, problem set solutions, text, quizzes)? Include comments about what parts of the course you have liked the best, and what parts you would like to spend more time on. If the course included a laboratory, comment about the laboratory. Has it been useful or worthwhile?

The course to date has been interesting. Perhaps I would try to include more examples in the material. Problem sets I have found to be difficult so far. It would be better to receive the answers (correct ones) at the same time as my solutions so that I can compare right with wrong. I would like to have a little more on mutual stable equilibrium

This course is very useful to understand deeply the principle of thermodynamic philosophy. But you feel there is also an advanced thermodynamic course necessary for department. I'm thinkg of a course like 2.25 in fluids followed by 2.20.

✓ My overall feeling about the course is positive. Some of the problem sets show signs of very hasty prepararation, and contain errors which could easily be elminated. It would be helpful to get the graded problem sets back sooner, so that we can more easily compare our work to the solutions. The lack of a text at the beginning of the term was something of a nuisance, as it made understanding of the course material quite difficult when classes were missed.

An excellent teacher. He is always well prepared and is very willing to answer question.

If instructor expended more time for the new things it will be much better than work on old concept.

The new approach to thermodynamics, in a more general way opened my mind to new possibilities in this science. I would not change the approach.

The course thus far has been relevant and interesting. There has unfortunately not yet been any quiz or exam. The first is in two weeks, far too much of the semester has already passed. The most interesting aspect has been the approach to the fundamentals of the subject. This has been greatly different from my undergraduate thermodynamics exposure.

I'm glad to have this course. But I think problem session must be added.

Basically it seems to be more of a classical concept rather than the usual thermodynamics courses that I have come across before. Anyway, its nice to learn the subject from other view even though initially it may tend to be easily confused. More time should be given to the homework. Bearing in mind that there are other homeworks as well as reading materials to be done, one week is not sufficient to do a satisfactory job.

Part A (Continued) Course: 2.451J Professor: Elias P. Gyftopoulos

Some of the proofs asked for in the homework have appeared to be somewhat irrelevant. Also a bit of unnecessary emphasis was placed in the beginning on the distinction between stable equilibrium states and other states for a system. Since most thermodynamic relations and thermodynamic applications are for cases of stable equilibrium states, more initial emphasis should be placed on just mentioning the distinctive quality of the stable equilibrium state and then pursuing on deriving the mathematical relations.

The course is quite interesting in its content. I found parts on available work and heat hard to understand. I enjoyed the logical way the course was built up but I find problems in practical applications in the problem sets. It would be better if the homework was returned the week after it was handed in.

Problem sets should be returned sooner than they have been. All parts covered in class seem relevant to the subject. The treatment of states other than stable equilibrium states was very interesting and enlightening. Two midterm exams may be a good idea.

Should have more than 1 quiz in the course, or emphasize the homework more in the final grade.

The text (Encyclopedia) is a good one but we should have been told at the beginning that the Hatsopoulos & Keenan book was mandatory (almost). The assignments (to be turned in) help keep me up to date but they should be passed back sooner. I have like the approach so far but it seems too biased toward the Ph.D. qualifying people. I probably would not change the course.

The only problem is problem sets. In problem sets, some of the problems need formulas or concepts which have not been discussed in the class yet. Since this is a new approach to thermodynamics, there is no text available. The distributed sheets are very good. But the book by Hastopolous & Keenan is terrible. I think the teacher could distribute notes (which are perfect) instead of reference text.

This course is useful in presenting thermo from a different point of view and making me more aware of the fundamental definitions. In criticism too much time has been wasted in question and answers and not enough time spent on the analytical approach to thermo.

The course if fairly difficult. Some of the problem sets seem to parallel the course material rather than coinciding with it. The basics are given during lecture, but application of these basics is left almost entirely to the student. I'm having trouble with the use of steam tables and other material on P.S. 5.

The course overall is good. The presentation is adequately clear and points that aren't particularly clear are explained in class thoroughly. The part, about state equ. and the relevant processes on the G vs. S grups need more clarification.

The course presents the classical thermo material from a different and therefore interesting viewpoint. The presentation of the 1st and 2nd laws is interesting and it involves insight that hadn't been obtained before.

Part A (Contined) Course: 2.451J Professor: Elias P. Gyftopoulos

Like the amount of class discussion, it makes for an interesting class. Too much, however, seems to slow down the lecture and amount of new material. Problem sets are just about right, don't know about tests but don't like the high weighting (50%) of the final.

A good part of the course is the detailed evaluation of fundamental concepts. However much class time is wasted repeating the same information. More problems emphasizing the fundamentals and not simple 'cookbook' problems would be appropriate. Hopefully, yet to come, will be practical applications of the fundamentals.

The course has been primarily review thus far, and could have perhaps moved a little faster if everyone was familiar with the material. The topic of stable equilibrium has been interesting, but contains so much review that it should perhaps be taught as a beginning thermodynamic subject, understanding that part of the course is ahmpered by previous ideas.

The most difficult part of the course was naturally the introduction where fundamental concepts and initial definitions were presented. During these initial lectures, the course seemed more like a study of philosophy than one of thermodynamics. The graphical treatment of some of these basic concepts helped greatly. After establishing firmly the aforementioned concepts, the course has proceeded in a step-by-step manner deriving everything from first principles (more or less) so, therefore, there hasn't been any complaints.

I would have liked to have seen a definite exam schedule established at the beginning of the term. I had hoped to have an exam by now to get some indication of where I stand. Much time was spent in deriving the principles leading to the E vs S graph of allowed state of a system, yet next to no time was spent in showing how instructions with which we are familiar are characterized (or illustrated) on this graph. As soon as possible, some sort of textbook should be made available to this course. On this way, I feel that may questions now answered in class could be taken care of through having the (a) text to back up the lectures. The homework policy seems OK - it's nice to get some credit for effort expended in this area. Sometimes, it is difficulty to extropolate from the material covered in class to some of the homework problems.

Problem sets are very good because you learn the material by doing the problems. Problem solutions are helpful. Lectures lack a good physical insight into the material. Lecturer tends to present material so that it is understandable but the lecturer's techniqu is not conducive to note taking. Entirely too much weight is placed on the final grade. In theory, it seems fair but if you should be sick that day, you arescrewed royally irrespective of how you had been doing all along in the course. Students should be given better guidance toward mastering course supplementary reading, extra problems, etc. A good text is a must in this course. H & K gives the theory adequately but not applications. This course does not tap a student's actual potential because of its structure.

The course, on the whole, is good. The level is quite high, fortunately. Maybe more should be spent on the concept of non-equilibrium states - a fact on which makes this course different from others in thermo.

I've basically enjoyed the course, I expecially like the rigorous approach of the instructor. Unfortunately, he seems to have deviated from the rigorousness recently. This is not to say that I don't understand the material. It just seems as though the style that I prefer has changed. The big problem I've had is the course has been that the homework assignments have been given before the material has been discussed

Part A (continued) Professor Elias P. Gyftopoulos, Course 2.451J

in depth. I suppose that this a graduate course that assumes previous knowledge of the material though. I feel that the text is hardly worth the money. Possibly an alternative could be found.

This is the first time which some concepts in thermodynamics get profound and useful meaning, both practically and theoretically. It is ideal for me, and I don't have any generaly comment about the way it offers, but I guess it would have been much better if it had more units and time per week, to discuss ideas and different aspects of it as much as possible.

This course seems to be taught on many different levels or degrees. The lectures, homework, general textbook and special reading or handout material are not well integrated. Homework is very applied type problems. Lecture is only interested in general principles (few practical example). Textbook is review of undergraduate subject, and special reading and handout are difficult to understand. Please bring the organization of the vary material presentations in closer agreement with each other.

A more rigorous approach to the subject has been used in this course than previous thermo courses I have taken, this approach would be better if this were a "first" thermo course. I would not make any changes, however.

I have liked the course very much although much time was spent on questions. I'm glad that now we spend more time on what is interesting for most of the people and not for one person. I've found very helpful the new approach given in this course to derive the 1st and 2nd laws of thermodynamics and their postulates.

Good course. More quizzes would help.

I can find no criticizms of the course. It is well motivated and interesting. The fundamentals were introduced carefully. Perhaps the course proceeded too rapidly to problems of a complicated nature but because it is a graduate course some previous thermodynamics background is assumed and this is therefore not a very serious problem.

The problem sets do not follow the lectures closely enough. They require a lot of outside reading which is not always clear. The lectures are well organized but too much time is wasted by answering questions.

1. Interesting course. 2. On the E-S diagram because of no reference matieral available, we would like to see more hand outs on this particular topic.

I don't think anything seemed irrelevant; the introduction of a new method-theory is describe simple thermo processes and laws was an excellent idea. Presentation was good. Points initially unclear were taken good care by the instructor and made clear. There should be some text, at least for the second half of the course which is taught in the classical way. Some practical applications should be more stressed upon, since this is an engineering course.

This course is somewhat tricky and the instructor doesn't describe the narrow points or he describes some simple discussion too much but some tricky matter very fast.

One of the best I have taken in fours years of M.I.T. Plain fantastic, everything is in the right place and pace.

I have found the course very stimulating. The new approaches informable and understandable. Very good! But the possibility of only one quiz before a final scares me. I feel a strong need for two quizzes.

The final should not be 50% of the total grade but less. Require more problems solved in class. Very interesting point in the concepts of the entropy and availabilities.

Problem set solutions should be handed back at some time as answer sheets. Quite a good course for concepts.

The course so far has been wonderful. I like the approach which emphasizes accuracy and the results have been applied well. I only wish there were a text for the 1st part which went into more depth.

The course presents a new approach to understanding the principles and concepts of thermodynamics. Different from what one is used to but quite interesting.

Good detailed approach.

PI TAU SIGMA

MIDTERM COURSE AND INSTRUCTOR EVALUATION

COURSE: 2.451J PROFESSOR: Elias Gyftopoulos

Part B. The Instructor. What criticisms do you have for the instructor? How would you improve his teaching techniques? Does he add to the course, or could you get it all out of a book? What are his strong points?

So far he has been excellent, again I would like to have more examples. Yes he adds to the course. His strong points are his sense of humor and rapport with the class.

He is a good teacher and if an advanced thermodynamic is supposed to be added he can be a good teacher for that.

I think Prof. Gyftapoulos teaches this course well. His strongest point is that he uses a large portion of class time for questions and discussion. His blackboard technique is good, with the exception that occasionally he is unsure about the sign of certain terms. It is time that this is a "bookkeeping" sort of problem, but many students have some confusion about the sign problems, and their confusion might be lessened instead of increased if he was careful about the matter in his lectures.

Prof. Gyftopoulos is an excellent teacher. He is always well prepared and is very willing to answer questions.

If the instructor expended more time for the new thing it would be much better than working on old concepts.

He is a fairly good lecturer although in the first part he spent too much time answering irrelevant questions, so the course was delayed.

An interesting and informative instructor. The only fault I perceive is a tendency to allow student questioning (students asking questions) to monopolize the limited time available. More such questions should be deferred to office sessions, etc.

The instructor who teaches this course is very good person for giving this course.

Well, as far as the instructor is concerned, his teachings are good. He adds new materials that are not found in the book. His strong points are that you are sure that the material he's giving is useful and in a way that he has of putting things across.

The instructor should try less to teach the course like a philosophy course and concentrate on teaching it like an engineering course in the long run.

I think he should do more problems like in the problem set, on the board. Otherwise he is a good instructor and a nice guy.

The instructor definitely adds to the course. Although much of the course could be taken out of texts the instructor provides enlightening examples and explanations.

Very good book for practical examples. Its incredible they pass those numbers in the back of the book off as "answers". Prof. G. is very effective, extremely competant.

Part B (Continued) Course: 2.451J Professor: Elias Gyftopolous

Has amazing patience with people's questions but occasionally can get "off the beaten track". Adds very much to the course in the way of understanding.

There is one thing I would like to say about him, excellent teacher, no criticism.

No major criticisms. However an unreasonable amount of time is spent answering questions. I'd like to see more practical examples which clarify the basic principles.

At first he spent almost the entire class period responding to questions rather than covering new course material. He has been avoiding that recently, however. One definitely cannot get all the material out of the book.

Very good presentation of the material. Very alert and very exact in his responses to the questions. Also very clearly presents his ideas. His is a definite attraction to the course, you don't need a text. Overall one of the best in the Institute.

Good teacher. Knowledgeable. Good lecturer.

Good. Seems to know the material and is willing to explain what is not understood.

Excellent discussion and answering capabilities - enjoy discussing concepts makes it easy to appreciate concept fundamentals.

The material covered seemed to require perhaps too much time. I thinkg he was very good at responding to questions and seemed to be very interested in the students. He was also very good at using helpful examples.

Good points. 1) Speaks and writes at good speed. 2) Blends theory with graphic illustration in a manner that I haven't found in any textbook. This reinforcement of concepts is one of the reasons I come to class. 3) Great personality and attitude.

Lecturer is interesting and is able to hold students' attention. Why don't you make the questionnair multiple choice or else allow for more time to fill this thing out!

Sometimes more precision is needed. On the whole, the teaching is excellent. Teaching is not irrelevant. To get this out of a book requires far more time and would probably be less clear. Good job!

I already talked to the instructor about this, but the class went way too slow in the beginning because of repeated absurd questions. He has become conscious of this though and things have moved along much better. Otherwise the instructor is excellent.

He is excellent.

He should give more examples of applications to clarify equations and general concepts of course. What he has taught so far I could get out of the textbook and would have difficulty from special handouts. He does make himself available after class which I like.

The course is not all out of a book. Method of presentation is good.

Part B (Continued) Course: 2.451J Professor: Elias Gyftopoulos

He's a fine instructor. He's been especially helpful when somebody is in doubt trying to clarify any point. I only regret that when somebody asks a silly question he laughs at him, in my opinion, in a very impolite way.

Good. Perhaps he entertains too many questions.

I believe he's an excellent teacher. Takes time to answer questions and seems very interested in his students. He is careful and clear. I enjoy his lectures very much.

Spend more time lecturing and less time answering questions.

Good teacher, always available for discussion.

Excellent presentation of the first part of the course. Gave a good insight of simple thermo principles. However he spends more time answering questions than I thought would be required.

He teaches sometimes very good but sometimes not good, and understanding from text of this course is very difficult.

Great guy, his teaching technique is excellent. I have learned many things from him which I couldn't have gotten by just reading the material. His strong point is his devotion and patience he has to explain the course. He doesn't stop until he is sure that you know!

His explanations are very thorough and sound. His encouragement of questions is admirable, but he answers too many irrelevant questions at times. His bits of humor are a welcome break in the 1 1/2 hour time slot.

Good in general.

Quite painstaking in getting students to understand material.

Now that we don't constantly stop for questions I like the professor's methods and feel that his methods are clearly presented. His ability to answer questions during lecture are helpful.

Excellent but should allow less questions in class.

Good. Dialogue with students good. Sometimes gets into too long arguements with students, beyond the point where the majority of the class is gaining from the exchange.

Prof. Gyftopolous is very willing to take time in and out of the class to answer questions. This is very important to me. In addition, he doesn't make you feel like an idiot when you ask a so-called "dumb" question. This is excellent - this pressure cooker institution is difficult enough without having to be reminded of the level of your ignorance. Sometimes, I wish that Prof. Gyftopoulos would not leave out intermediate steps in the derivation of certain formulas. Example: in the use of higher order Taylor series expressions to show that d^{AB} is greater than or equal to $d^{A} + d^{B}$, I wish that he had just explained this in class as oppossed to assigning it for homework in lieu of a more relevant problem.