

## WRITING ABOUT THERMODYNAMICS

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### Abstract

This paper describes an optional writing assignment in thermodynamics initiated several years ago by the first author in two undergraduate engineering courses. Essay topics were not assigned but were chosen by students from one of two general categories: making a connection between thermodynamics and the student's major discipline (e.g., Civil Engineering) or focusing on an environmental issue involving thermodynamics (e.g., energy). Examples of the diverse topics selected for essays are given together with some general observations on the writings. There are benefits to this exercise for both students and teachers and these are briefly discussed.

### Introduction

For decades, the mechanical engineering department at Virginia Tech has offered service courses in engineering thermodynamics to the College. The population for these courses is drawn from junior/senior level students in the departments of aerospace and ocean engineering, mining and minerals engineering, industrial and systems engineering, electrical and computer engineering, engineering science and mechanics, biological systems engineering, and the civil and environmental engineering departments. The courses are ME-3114: Engineering Thermodynamics and ME-3134: Fundamentals of Thermodynamics. The latter is aimed at Aerospace and Ocean Engineering students. Neither course is taught to mechanical engineering students.

It has always been a challenge to engage this group of students with the intent of establishing the relevance of the material. For several years the second author has attempted to address this challenge by meeting with faculty members in each of the departments from which our students come. They have been asked what they feel is the relevance of thermodynamics to the courses which their students subsequently take, and to indicate how we can provide their students with the appropriate background. In some cases it has been possible to establish a direct connection. For example, in mining and minerals engineering where in one course a "heat engine" model of mine ventilation is used and in aerospace and ocean engineering where an application to propulsion devices exists, it is possible to provide a direct and natural connection. But in many cases, the connection is either not immediate or is more related to heat transfer than to thermodynamics. Examples which come to mind include connections with electronic-equipment cooling requirements or machine-tool design. Suffice it to say that in general this faculty-centered

approach has not contributed the kinds of thermodynamic connections we were looking for.

Completely aside from these efforts, six years ago the first author (MJF) introduced an optional essay into the sections which he has taught which not only addresses the issue of relevance, but also accomplishes other objectives which he finds of value. These essays were to either establish a connection between thermodynamics and the student's discipline or address an environmental issue concerning energy. The results were not only interesting, but also led to more students participating in our discussions. Since then, MJF has continued making the writing option available, using it to help the lowest of three test grades. In the past several years, grading in MJF's sections has been as follows: 3 tests at 18% each, homework 8%, quizzes 8%, and the final exam at 30%. This paper briefly describes the assignment, several examples of the topics chosen by students, and some general observations and conclusions.

### **The Optional Essay**

Below is the optional writing assignment in thermodynamics as given to the students. In the fall 2002 semester, most of the 110 students were Aerospace and Ocean Engineering majors at the Junior and Senior levels.

*Write an essay—two to three typewritten pages in length—with a focus on either of two topics, namely:*

- 1. A specific example of how thermodynamics relates to, or could relate to, your field of study, whether it be in Mining, Aerospace, Ocean, Civil, Electrical, Industrial Systems, or Biological Systems Engineering.*
- 2. An environmental issue involving or connected with thermodynamics—energy, heat, work—in some way.*

*To prepare for this and to do a proper job, here are some suggestions:*

- 1. Talk to one or more professors in your department.*
- 2. Go to the library and search for articles in journals, magazines, books, government reports. But don't limit your search to popular or superficial treatments of technical subjects, e.g., as in magazines such as Time or U.S. News and World Report.*
- 3. Don't make the essay too broad, general, and vague. Aim for focus and specificity.*
- 4. Take advantage of help that is available from John Cosgriff, our Engineering Librarian. He can be contacted via e-mail (cosgriff@vt.edu) or by phone at 231-9248.*

5. *Include references in proper format—journal articles, books, reports, and private discussions.*
6. *Please do not rely primarily on the Internet for sources of information. As you know, there is useful information as well as garbage on the net. Be selective.*
7. *Be balanced in your treatment. For example, if you are already convinced that global warming is not a problem or issue then don't just select those articles that support your view.*
8. *Do a good job in organizing and writing the essay in a clear manner. It is something you will want to be able to do well in whatever your future job will be.*

*The essay is optional. I will average the essay grade equally with your lowest test grade. Please see me if you have any questions about the appropriateness of a topic of interest to you.*

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## **Results**

Sixty-seven students out of the class of 110 in the Fall 2002 semester chose to do an essay. Examples of the topics selected by this group, as well as examples from previous classes which included more diverse engineering disciplines, are shown in the attached Appendix.

Each essay was graded independently by MJF and a Ph.D. student assisting in the course. The two grades were then averaged.

The papers were quite interesting. In one case, a student did a thorough report on the Virginia Tech power plant, complete with digital photographs, data (e.g., mass flow rates, pressures, temperatures), and First Law analysis. Some students interested in pursuing biomedical engineering in graduate school chose the human body as a complex thermodynamic system. And many showed a genuine concern for global warming and attempts to alleviate the problem through energy conservation approaches and increases in efficiency. The students who chose the essay, roughly 60% of the Fall 2002 class, seemed excited by making connections between the course and the “real world.” One student—in the top of the class with a test average in the mid-90’s—chose an essay topic because he was interested in doing it, realizing that it would have no effect on his grade.

Other observations, including comments on the essays, were included in an e-mail message sent to students. The message follows.

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*Dear Thermo Students—*

*The essays—all 67—have been graded both by myself and Matthew Rice. I used the average of the two and stapled copies together. The essays will be returned to you in class on Friday.*

*Overall, the topics chosen were appropriate as well as interesting. They included such areas as thermal pollution, carbon dioxide production and global warming, manufacturing, hydrogen-powered vehicles, plasma and ion propulsion systems for space travel, thermal regulation of the human body, the thermodynamics of thermals, fuel cells, hydroelectric power production, marine steam and diesel propulsion, wind power, hybrid engine technology, drilling for oil in Alaska, space shuttle propulsion, the role of oceans in climate, space vehicle heating in re-entry, thermodynamics of metabolism, Scramjet engines, global warming, superconducting motors, nuclear power and the environment, heat transfer in neonates, alternative fuel solutions the Kyoto Protocol, power turbines, ramjet propulsion, snow ski manufacture, bus transportation and diesel fuels, ocean thermal energy conversion, nitrogen oxide emissions, energy-based design methods, gas turbine engines in aircraft, the Cassini Space Probe, fluid mechanics and thermodynamics, and sensor-driven fire models. All interesting topics with connections to thermodynamics in one way or another.*

*The writing ranged from poor to excellent with most essays winding up with a grade in the mid 80's. For those who chose this option, I will average your essay grade equally with your lowest test.*

*There won't be time in class to comment on the essays but I would like to make at least some observations here. They may or may not apply to your essay specifically. Perhaps my comments may help you in the future.*

- 1. There was a general absence of in-text references. Statements are made and the source was not indicated. If you say that “. . . studies have shown that such and such happens,” indicate right there the source by including (7) or [7] after the statement. Group and number the references at the end of your essay or report.*
- 2. Some references were either inadequate or minimal. If you are writing a paper—as many of you will when you go to industry, government, or academia—you will find that web sites and the internet will generally not be accepted as valid references. There is a library on campus and there are journals. To rely chiefly on the internet and magazines like “Popular Mechanics” puts the paper at the high school level.*
- 3. Why not include a simple sketch or diagram to demonstrate a point—whether*

*it is a simplified engine or TS diagram. It can make your message clearer and it breaks up text.*

4. *Some essays were merely a recap of someone else's article with little or no evidence of your own input or critical thinking based on what we have discussed in our course on thermodynamics.*
5. *And some essays obviously reflected a one-sided or biased view. One can look at the references used in an article on global warming or nuclear power and predict what the thrust of the essay will be. Try for a more balanced approach.*
6. *In several cases, the discussion of technical or scientific issues was either superficial or simply incorrect—even from a thermodynamic point of view.*
7. *A failure to recognize obvious energy and pollution costs. For example, consider these statements: "Wind power is free" (Not exactly true since you need a wind turbine or windmill); "Nuclear power is clean energy" (A very big mistake since the problem of disposal and storage of highly dangerous radioactive waste has yet to be solved.); "Hydrogen-powered vehicles offer a pollution-free solution to the energy crisis" (Where exactly does the hydrogen come from? Electrolysis of water using electricity generated in a coal-fired steam plant?)*
8. *A lack of connection with what is going on in the world on energy and environmental issues. For example, if you are going to discuss greenhouse gases and global warming, then of course you should include the Kyoto Protocol and the current Administration stand (opposition) to signing it. It is not enough to simply make vague statements like "the world must pay attention to this problem and reduce carbon dioxide emissions."*

*I recognize that the essays were to be concise and that you may not have had the opportunity for depth. And my comments above are not meant to be critical but hopefully helpful. You will find that writing will be—or should be—an important part of your future, whether you are addressing technical or non-technical audiences. Anything you can do to improve your communication skills will pay off. No doubt about it.*

## **Student Feedback**

The students appeared to appreciate the opportunity to help their lowest test grades even though some were not particularly excited about doing an extra assignment. But when they finished, most admitted that they got something out of it in one way or another. Here are some typical comments:

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- "I had a hard time picking a topic but when I finally decided, I found it more interesting than originally imagined. Learned something new."
- "Not sure I contributed much by my essay but it was good practice for technical writing."
- "Since I'm in ISE and want to go into technical sales, I really wasn't sure about even taking thermo. But I had an interview with the York Corporation and picked a topic on the use of new refrigerants for air conditioning. It seemed to fit in."
- "I had fun in doing the essay. But I don't see why you're so tough on internet sources. I found some good articles, for example, by NASA."
- "Thanks for the chance to help my low test grade. I bombed out on Test 2 even though I studied pretty hard."
- "I'm a Junior in Mining Engineering and picked a topic on ventilation and air quality in mines—an area of interest to me. The essay was actually the first time I used our library seriously. I didn't even know that there was a Library Rep for Engineering."
- "Writing on the Virginia Tech power plant was an education for me. The guys there were very helpful to me and showed me all around. It was a little hard to make connections between thermo diagrams and the various pipes and heaters I saw."

## Conclusions

We believe that the idea of introducing an optional writing essay in two undergraduate courses in engineering thermodynamics has been successful not only for the students but for the faculty as well. Specifically, we believe that the essays (see Appendix for a selected list of essays) show that writing this essay:

1. Provides an opportunity to explore the relevance of thermodynamics in a more personally and professionally meaningful fashion—one that connects with the student's major discipline.
2. Impresses on students the fact that the importance of thermodynamics transcends just this particular course,
3. Broadens the interest and deepens the understanding of the topic,
4. Encourages an awareness of environmental problems connected directly or indirectly with thermodynamics (e.g., energy waste and global warming),
5. Provides feedback to the instructor as to those topics of special interest to the students,

6. Contributes to the goal of making the students technologically persuasive writers,
7. Develops skills in the acquisition, processing, evaluation, and communication of knowledge, and
8. Through the contacts with the faculty in other departments which this assignment encourages, it broadens the Collegiate advocacy base for the course.

### **Appendix—Titles Of Selected Essays**

- *Global Warming and the Relative Thermodynamic Effects*
  - *Public Transportation and the Environment: The Effects of Busses*
  - *Hydrolyzed Water as Propulsion for Deep Space Flight*
  - *Nuclear Waste Disposal: An Environmental Impact*
  - *Thermodynamics and the SCRAMJET Engine*
  
  - *The Energy Equation: Fluid Mechanics Meets Thermodynamics*
  - *Environmental/Energy Issue-Drilling for Oil in Alaska*
  - *Thermodynamics of Metabolism*
  - *Hydroelectricity and Environmental Effects*
  - *Wind Power: A Promising Renewable Energy Source*
  
  - *The Influence of Steam Propulsion on Naval Warfare*
  - *The Vision and Need for Energy-Based Design Methods*
  - *The Hydrogen Fuel Cell Revolution*
  - *The Thermodynamics of Thermals*
  - *NO<sub>x</sub> Emissions Reduction*
  
  - *Heat Transfer in Neonates*
  - *The Role of Oceans in Climate*
  - *Greenhouse Gas Effect*
  - *Nuclear Power and the Environment*
  - *Global Warming*
  
  - *Oil Exploration in the Arctic National Wildlife Refuge: National Necessity or Environmental Time Bomb?*
  - *Mine Disaster Thermodynamics*
  - *Thermodynamics in Mineral Processing Engineering: Froth Flotation*
  - *The Effects of Heat Transfer During the Hydration of Concrete*
  - *Overclocking and Heat Dissipation*
  
  - *Application of Thermodynamics in Mine Ventilation*
  - *Microelectronic Cooling Systems*
  - *Mixing of Air and Methane Gas in a Continuous Mining Face at U.S. Steel's No. 50*
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## *Mine*

- *Role of Thermodynamics in Explosive Selection*
- *The Role of Thermodynamics in the Dewatering of Coal*
  
- *Dissipation of Heat Produced by the Curing of Concrete*
- *Heat and Cold Stress: In Industrial & Systems Engineering – Ergonomics*
- *Thermodynamics and the Sustainability of Food Production*
- *Earth Properties and Earthquakes Liberate Energy*
- *Ways in Which Thermodynamics Could Relate to the Career of Bradley J. Klingemann*
  
- *Application of the First Law of Thermodynamics in Peanut Curing*
- *Wood Drying*
- *Thermal Regulation in the Human Body and the First Law*
- *Thermodynamics in Ocean Engineering*
- *Wind Turbines Powering an Electric Vehicle?*
  
- *The Destructive Effect of Thermal Pollution on Small Bodies of Water*
- *Design Considerations of Aircraft Engine Turbines*
- *The Thermodynamics of Ramjet Propulsion*
- *The Use of Turbines in Marine Engineering*
- *Thermodynamics in Industrial and Systems Engineering*
  
- *Practical Applications of Thermodynamics in Biological Systems Engineering*
- *Thermodynamics in Bioprocessing*
- *The Use of Sea Solar Power as a Potential Energy Source*
- *The Thermodynamics of Natural Ventilation*
- *How Thermodynamics Relates to the Curing of Concrete*
  
- *Energy Use for the Twenty First Century*
- *Adiabatic Compression of Air and its Effect on Miners*
- *Thermodynamics in Mining Ventilation in South Africa*
- *Thermal Pollution and Its Effects on the Environment*
- *Relevance of Thermodynamics in Technical Sales*
  
- *Thermodynamics in Mining and Minerals Engineering*
- *A Search for a Less Polluted Future*

## **Biographies**

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Michael J. Furey is a Professor in the Department of Mechanical Engineering and the Center for Biomedical

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