

Helping Engineers Appreciate the Wider Implications of Technology

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Abstract

For over 30 years, the School of Mechanical Engineering at Purdue University has been offering a course entitled “Technology and Values” to its undergraduates. As we begin transitioning from one instructor to another, it is a good time to describe the unique aspects of this course and reflect on the role it can play in making engineers good citizens in today’s world.

The course deals with the influence of science and technology on personal and societal value systems, as well as with the formulation of practical means by which human values can guide technological development. Special consideration is given to societal problems with a strong technological component. Examples include environmental degradation, energy utilization, underemployment, scientific misinformation, and sustainable development. Interdisciplinary approaches to technological problem solutions are stressed, including remedies provided by the law, economics, and politics.

The class meets once a week for three hours to facilitate discussion on a variety of books. The book list is divided into two parts, a set of five required books that everyone reads, and a list of nine optional books, each of which is assigned to two students, who are asked to summarize the contents of the book from either a pro or con viewpoint to the rest of the class. Supplementary articles covering similar concepts are made available to the whole class during the week that an optional book is assigned. In this way, the total amount of reading per student can be kept manageable while still being able to cover a wide range of materials.

Each week, short writing assignments are also provided, to give students practice in thinking through the concepts and in formulating their analysis of a given ethical dilemma. These assignments include summaries of an assigned short article, responses to questions posed in the major textbook for this course, and analysis of an ethics case. Students must complete a certain number of writing assignments of each type for the semester, but they have the opportunity to write more than this minimum. In this way, they can redo an assignment that gave them trouble earlier on, and they can distribute their work throughout the semester to fit into their schedules.

The course culminates in a 5000-word term paper on a topic of their choice that involves both a technological and a value component. In discussions between the instructor and the student, this topic is refined so that it has sufficient breadth to be interesting, but with enough focus to make the analysis manageable. Overall, students who take this course have come away with a new perspective on their careers and their future goals. By making them aware of issues that accompany the development and use of technology, the course provides them with a toolkit of concepts from philosophy, economics, politics, and sociology that they can use to make informed decisions for a better world.

Key Words

Educating for Sustainable Energy, Innovative Teaching Methods, Other: Engineering Ethics

Helping Engineers Appreciate the Wider Implications of Technology

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1. Introduction

Modern societal issues often have a strong technological component, either as an underlying cause or as a proposed solution. Myriad examples can be found in the news media every day, including issues of global warming, environmental sustainability, and energy sufficiency. It is clear that economic growth, aided by technology, has been partly responsible for depleting our natural resources and polluting our environment. Potential solutions to these problems are being debated by politicians from the local to the national level. Unfortunately, even though an understanding of underlying technologies is a crucial prerequisite to generating good solutions, most politicians called upon to make such decisions are ill-equipped to do so. We need more engineers and scientists who understand pertinent technologies to become involved in the political process and to help influence the direction of future technologies.

A relevant course, “Technology and Values,” taught in the School of Mechanical Engineering at Purdue University, has provided engineers with an awareness of their broader responsibilities to society for over 30 years. The course was originally conceived by Prof. Normand Laurendeau and is now being taught by Prof. Peter Meckl. Since the topics covered in the course are more wide-ranging and philosophical than the typical engineering course and since classes are primarily conducted as discussions among the students and instructor, this course typically requires extra time and experience to teach. For example, Prof. Meckl spent the last few years sitting in on the course, reading different books each time, and helping to guide discussions for each of these books. In this way, he learned from Prof. Laurendeau how to lead discussions and how to cover the main points of each book. Having learned to appreciate both the value of the concepts covered as well as the style in which they are presented to the students, the current instructor, Prof. Meckl, felt it was appropriate to tell others about this course and to encourage them to explore its possibilities at their institution.

This course is unique in that it covers essentially societal and philosophical issues in an engineering context, taught within an engineering program by an engineer, with students receiving engineering credit for completing the course. In addition, students are immersed in various ways of thinking about technology that can only be accomplished by in-depth readings and discussions. Furthermore, rather than sending engineering students to the philosophy department, we believe that it is appropriate for engineering educators to directly demonstrate the

importance of these “soft” skills to engineering students. In this way, we hope that more of our engineering students can become leaders in championing a more holistic view of technology in their future careers.

From a student point-of-view, the objectives of the course are to (1) develop an awareness of technology’s impact on people and society, (2) learn to critically assess complex interdisciplinary issues, (3) develop a tolerant mind, open to changes in values and institutions, (4) develop moral autonomy and moral imagination (wisdom), and (5) develop skills necessary for ethical assessment of potential technological solutions.

Two principal themes characterize the course: the suitability of technological fixes and the search for balance. The first theme addresses such questions as What technological fixes will work? What are the byproducts of a technological fix? and When are social or political fixes better than a technological fix? The second theme strives for effective solutions to technological problems. What is the right balance between technological and political fixes, between costs and benefits, energy and environment, economics and safety, social responsibility and employer loyalty? Where is the balance? Who decides? How do we get there from here? How do we compromise without selling out our most cherished moral principles?

These are important questions. To adequately address them requires an in-depth immersion that includes intense reading, broad discussion, and thoughtful writing. This would be difficult to achieve in a large class using a lecture format. Therefore, the course is designed for a small class of 18 students so as to make in-class discussions effective. As such, it offers a self-selected group of interested students the opportunity to explore these questions and to become catalysts for action. To encourage in-depth discussions, the course meets once a week for three hours (interrupted by only a single 20-minute break for lunch) and uses a round-table format so that students can share their viewpoints. The class instructor employs a devil’s advocate approach to force students to constantly probe their values and biases and to search for salient moral issues embedded in potential technological and political solutions. The topics are structured such that the course proceeds from conceptual to philosophical to religious issues as we get to know each other.

2. Course Material and Policy

The flavor of the current “Technology and Values” offering can be understood by considering the list of readings included in Appendix A. Fourteen books are used in the course – five common readings and nine optional readings. The main textbook for the course is currently *Ethics in Engineering* by M.W. Martin and R. Schinzinger. The remainder of the common readings are read by all the students and discussed in class. These four books are (1) *How Good People Make Tough Choices* by R. Kidder; (2) *Meaning in Technology* by A. Pacey; (3) *The Existential Pleasures of Engineering* by S.C. Florman; and 4) *Zen and the Art of Motorcycle Maintenance* by R.M. Pirsig. In contrast, each of the nine optional readings is presented and debated in class by two students, one student presenting the pro-position and the other the con-position. The remaining students read articles related to the optional readings so that they can participate in class discussions. This process generates various viewpoints from all students, and helps them to search for that irrepressible balanced viewpoint. A summary of each optional book

is handed to the students at the beginning of the course to help them choose which reading they wish to present in class.

The course outline (included in Appendix B) indicates the order implemented for the required and optional readings. The first two classes are used to introduce the material for the course, including basic ethical theories, their application to typical technological issues, and the role of the morally responsible engineer (*How Good People Make Tough Choices*). We next study problems created by technology, focusing especially on economic growth and environmental impact (*Limits to Growth: The 30-Year Update*), the role of technology in economic development (*Small is Beautiful*), the unintended consequences of technology (*Why Things Bite Back*), and the social and philosophical aspects of technology (*Meaning in Technology*). We next consider potential solutions for problems caused by technology through investigation of the relationships between technology and the law (*Science at the Bar*), technology and economics (*The Ecology of Commerce*), technology and politics (*Democracy and Technology*), and technology and social history (*Beyond Engineering*). Midway through these discussions, right before spring break, we consider a positive view of the relationship between engineers and technology by reading Florman's *The Existential Pleasures of Engineering*. A case study illustrates all of these factors for a specific example of technology, in this case genetic, robotic, and information technology (*Radical Evolution*). We finish the course by analyzing the relationships between technology and philosophy (*Zen and the Art of Motorcycle Maintenance*), and technology and religion (*The Religion of Technology*).

The course outline includes readings and assignments designed to enhance each student's understanding of the main books. There are readings and questions to be answered from the main textbook, ethics cases to be analyzed, and relevant articles from the periodical literature. Students who are not responsible for an optional book have the opportunity to read one of the articles, analyze an ethics case, or respond to one of the assignments from *Ethics in Engineering*. The articles and ethics cases are discussed either during or at the end of each class period.

In the early years of this course, students were required to submit a specific number of these various assignments each week. For engineering students who may not be accustomed to doing substantial reading and writing, this proved to be a rather onerous requirement. Therefore, as the course has evolved, these assignments have been adjusted to make it easier for students to meet them. In its current form, students must complete a total of 13 assignments out of a possible 25, giving them an opportunity to better schedule their work around other courses and examinations.

The course policy is also included in Appendix C. When a required reading is due, two questions are submitted for discussion by each student. Most of these questions arise in the classroom, and thus they help the students focus on the important issues. When a student is responsible for an optional book, he/she makes a 15-20 minute presentation that summarizes and analyzes the main thesis of the reading. He/she must also submit a written summary of the book. Students making presentations can then field questions and lead class discussion either during or after their presentation. When a student is not responsible for either a required or an optional reading, he/she has the option of submitting one of each of the following essays: (1) a review of one of the assigned articles; (2) a response to an assigned study question from *Ethics in Engineering*; or (3) an analysis of an assigned ethics case. Article reviews are graded on a twenty-point system,

four each for assignment completion, English usage, organization/clarity, concept identification, and originality. The other essays are graded on a ten-point system, using the same format as described for article reviews.

Altogether, the short essays account for 20% of the student's grade. Another 20% is allotted for presentation and summary of the optional reading. An additional 20% is dedicated to in-class discussions. The remaining 40% of the student's grade is based on a 5000-word essay or research paper, which is submitted near the end of the course. The paper must address a technological issue, focusing especially on its technical, social, and ethical aspects. These papers are discussed during the last class meeting. The paper is evaluated on the use of written language, synthesis, identification of the major concepts, development of ideas, originality, and topic choice. The topics chosen by the better students during the last thirty years are a good barometer of both past events and the evolution of the course material. Typical titles, arranged in chronological order, are as follows:

1. The Thalidomide Crisis: How Did It Happen and Could It Happen Again?
2. Amish Lifestyle: An Ethical Model for Technology?
3. Three Mile Island: The Roles of Machine and Man
4. Acid Rain and Public Policy Decisions
5. Trade Secrets: Efficacy and Abuse
6. The DC-10 Cargo Door: An Inquiry into Responsibility
7. Product Liability: Ethics and Technology in the Law
8. The Recombinant DNA Controversy
9. The Bishop's Letter on the Bomb: A Role for the Church in Technology?
10. The 10,000 Year Experiment: Long-Term Storage of High-Level Nuclear Waste
11. Technology-Forced Value Change: The Videocassette Recorder Case
12. Faith and Violence in the Nuclear Age: Toward an Ethic of Shalom
13. Is Biological Pest Control the Answer?
14. The Consumer Product Safety Commission: Changes in Regulatory Methods
15. Should Modified Life-forms be Patented?
16. Plastic Handguns: Issues and Ethics
17. Technology and Ethics in Animal Experimentation
18. Making Uncertain Decisions: The Greenhouse Effect
19. The Use of Computers for Making Critical Medical Decisions
20. The Effects of Japanese Culture on Its Engineers
21. Hazardous Waste Cleanup: Ethical Alternatives to the Superfund Law
22. Stopping the Proliferation of Nuclear Arms to Third World Countries
23. The Nineteenth Century American Literary Response to Technology
24. Risk Analysis and Informed Consent: The Public's Right to Know
25. Drug-Resistant Microbes: The Loss of Effective Antibiotics
26. When Doctors Disagree with God: The Conflict between Medical and Religious Ethics
27. The Evolution of the Chemical Weapons Convention
28. The Ethics of Cosmetic Pharmacology
29. Virtual Reality: An Ethical Future?
30. Electrical Vehicle Use in Urban Areas: Economics, Environment and Ethics
31. Technology and Symbolism: The Recovery of a Spiritually-Based Ethic

32. An Ethical Analysis of the Strategic Defense Initiative
33. Space Debris: A Tragedy of the Commons?
34. The Myth of Engineering Hubris
35. Just War Theory: Application to Modern Warfare
36. The Evolution of Sustainable Agriculture
37. Renewal of Nuclear Plant Licenses: Ethical and Environmental Issues
38. The UL Approval Process and Consumer Safety
39. Of Locksmiths and Burglars: The Case for a Hacker Ethic
40. Genetically Modified Foods: Are They Worth the Risk?
41. Trigger Locks: Technology, Values and Guns
42. Designing Automobiles for Recyclability
43. Privacy: The Electronic Invasion and Internet Regulation
44. Does Nuclear Power Still Need the Price-Anderson Act?
45. Biotechnology and Food Security in the Global Economy
46. The Psychology and Morality of Online Gaming
47. Failures of Bullet-Proof Vests: A Technical and Ethical Analysis
48. Moral Issues in the Creation of Sentient Machines
49. The Ethics of Electronic Voting
50. The Grandfathering of Coal Power Plants: Particulate Emissions and Ethics
51. Camera Phones: Technological Progress or Societal Nuisance?

Whereas most of the readings in the course deal with large-scale socio-technological issues (macro-ethics), the assigned ethics cases deal with those personal moral issues that may arise in the engineering workplace (micro-ethics). Through these cases, the students learn to satisfactorily resolve moral dilemmas that occur in engineering practice without relying solely on a professional code of ethics. At the beginning of the course, the students learn that moral reasoning can be duty-based, ends-based, care-based, or virtue-based. They also discover that these four approaches to ethics are impotent without considering relevant facts, motives and obligations, and that “Do No Harm” is a much more stringent *prima facie* rule than rules that attempt to prevent evil or promote good. The students learn to defend their viewpoint by using one or a combination of the four basic approaches to normative ethics. They are also taught that certain moral duties are associated with any calling in life, including those affiliated with the engineering profession. As in all professions, special responsibility for moral decisions arises because of the paramount duty to practice for the benefit of the public.

3. Conclusions

The “Technology and Values” course that has been described represents a culmination of over thirty years of continuing evolution. The basic encounter-group format for the course has always worked; evolution has occurred primarily with respect to assignments and appropriate methods of assessing each student’s understanding of the course material. In addition, the selection of books has continuously changed over the years as new technologies have emerged and older books have gone out of print. Interestingly enough, however, many of the books chosen initially have become classics in the field (e.g., Pirsig, Florman) and thus have remained part of the course readings, or have been periodically updated by their authors to include new information (e.g., Meadows, Schumacher).

As far as we can tell, the course described herein is unique in its emphasis on in-depth studies of technology and associated values. Rather than simply focusing on engineering ethics as they apply to individuals (micro-ethics), this course highlights the wider ramifications of technology (macro-ethics), thus challenging students to think beyond merely technical issues to understand the underlying motivations behind technological innovations and the potential uses and abuses of those technologies. The course also makes good use of engineering principles as applied, for example, to energy utilization, the environment, and potential technological fixes so that students can really see the application of their engineering knowledge to practical societal problems.

By allotting a meaningful portion of their grade to classroom discussion, students are rewarded for sharing their views. As a result, the class discussions are usually on-task, energetic, and sometimes even creative. In addition, we get to know the students quite well. The significant result is that by the time the course is over, the students are thinking critically about the important technological issues of the day. Some students even tell us that the course changed their lives, or that the course was the most satisfying learning experience during their undergraduate years at Purdue. Here is a sampling of some student comments about the course:

- I am a better person for having taken ME 492. I am better informed about the world around me, I am more aware of who I am morally and ethically, I am able to question what I read and hear, and (perhaps most importantly) I have been encouraged.
- The classroom environment was very conducive to discussion and sharing of ideas.
- Articles and books were of great value to the course and presented ideas/situations for consideration.
- The final paper assignment helped to review major concepts covered throughout the semester.
- This was the most stimulating and engaging class I have taken at Purdue.

Many of these students have gone on to pursue career paths that have been inspired by taking the course. For example, a previous student completed MIT's program in Technology and Society and today specializes in energy analysis and policy for a major corporation. A more recent student went on to George Washington University for a concentration in Technology and Public Policy, and now works for a major automotive company as a senior specialist in government affairs. Another recent student is currently studying technology and economic development at Carnegie-Mellon University.

Our involvement with this course leads us to the following conclusions. First, a course of this type requires dedication, passion, and commitment. Anyone interested in teaching such a course must be willing to devote a significant portion of time and effort in reading and analyzing the suggested books. The implication is that no one should attempt to develop such a course before having obtained tenure. Second, a course like this requires a commitment by the department to assign a faculty member to an elective course that will only affect 18 students. Despite these challenges, the course is a real pleasure to teach. It provides the opportunity to really get to know a small group of students and to make a significant impact on their lives. Hopefully, those students can also make a lasting impact on their world.

Appendix A

List of Readings

A. Common Readings

1. *Ethics in Engineering*, M.W. Martin and R. Schinzinger, McGraw-Hill (2005).
2. *How Good People Make Tough Choices*, R.M. Kidder, Simon & Schuster (1995).
3. *Meaning in Technology*, A. Pacey, MIT Press (2001).
4. *The Existential Pleasures of Engineering*, S.C. Florman, St. Martin's Press (1994).
5. *Zen and the Art of Motorcycle Maintenance*, R. Pirsig, Harperperennial (2005).

B. Optional Readings

1. *Limits to Growth: The 30-Year Update*, D.H. Meadows, J. Randers and D.L. Meadows, Chelsea Green (2004).
2. *Small is Beautiful*, E.F. Schumacher, Hartley & Marks (1999).
3. *Why Things Bite Back*, E. Tenner, Vintage Books (1997).
4. *Science at the Bar*, S. Jasanoff, Harvard University Press (1995).
5. *The Ecology of Commerce*, P. Hawken, Harper (1993).
6. *Democracy and Technology*, R.E. Sclove, Guilford Press (1995).
7. *Beyond Engineering*, R. Pool, Oxford University Press (1997).
8. *Radical Evolution*, J. Garreau, Doubleday (2005).
9. *The Religion of Technology*, D.F. Noble, Penguin Books (1999).

Appendix B

Course Syllabus

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|----------|----|---|
| January | 10 | <i>Introduction and opening discussion</i> |
| January | 17 | <i>Read How Good People Make Tough Choices. Class discussion</i> Methodology for Ethical Analysis in Engineering (N.M. Laurendeau): pp. 1-4 |
| January | 24 | <i>Presentation and discussion of Limits to Growth: The 30-Year Update</i> MS pp. 1-20, 32-38 (Q 21-3, Q 38-4); Case #1 Can Technology Replace Social Engineering? (A. Weinberg, Bulletin of the Atomic Scientists, Dec., 1965) The Tragedy of the Commons (G. Hardin, <i>Science</i> 162, 1243, 1968) |
| January | 31 | <i>Presentation and discussion of Small is Beautiful</i> MS pp. 39-44, 54-72 (Q 59-3, Q 71-1); Case #2 Shining Examples (C. Flavin and M. O'Meara, <i>World Watch</i> , May-June, 1997) The Rich and the Rest: The Growing Concentration of Wealth (S. Pizzigati, <i>The Futurist</i> , July-Aug., 2005) |
| February | 7 | <i>Presentation and discussion of Why Things Bite Back</i> MS pp. 88-114 (Q 95-3, Q 113-1); Case #3 Does Improved Technology Mean Progress? (L. Marx, <i>Technology Review</i> , Jan., 1987) Risk Analysis and Management (M.G. Morgan, <i>Scientific American</i> , July, 1993) |
| February | 14 | <i>Read Meaning in Technology. Class Discussion</i> |
| February | 21 | <i>Presentation and discussion of Science at the Bar</i> MS pp. 117-143 (Q 124-2, Q 142-2); Case #4 Expert Testimony: The Supreme Court's Rules (M. Berger, <i>Issues in Science and Technology</i> , Summer, 2000) Breeding Sanity into the GM Food Debate (J. Cayford, <i>Issues in Science and Technology</i> , Winter, 2004) |
| February | 28 | <i>Presentation and discussion of The Ecology of Commerce</i> MS pp. 146-162, 172-179 (Q 154-2, Q 179-3); Case #5 Public Money and Human Purpose: The Future of Taxes (D.M. Roodman, <i>World Watch</i> , Sept.-Oct., 1995) Population and Consumption: What We Know, What We Need to Know (R.W. Kates, <i>Environment</i> , April, 2000) |
| March | 6 | <i>Read The Existential Pleasures of Engineering. Class discussion</i> Methodology for Ethical Analysis in Engineering (N.M. Laurendeau): pp. 5-9 |

- March 20 *Presentation and discussion of **Democracy and Technology***
MS pp. 189-194, 203-215 (Q 207-1, Q 215-4); Case #6
Town Meetings on Technology (R. Sclove, Technology Review, July, 1996)
The Technology Assessment Approach to Climate Change (E.A. Parson, Issues
in Science and Technology, Summer, 2002)
- March 27 *Presentation and discussion of **Beyond Engineering***
MS pp. 219-238 (Q 232-7, Q 238-1); Case #7
Do Machines Make History? (R. Heilbroner, Technology and
Culture 8, 335, 1967)
Tomorrow and Tomorrow and Tomorrow (W.W. Wagar, Technology Review,
April, 1993)
- April 3 *Presentation and discussion of **Radical Evolution***
MS pp. 242-270 (Q 252-2, Q 265-5); Case #8
Data Smog (D. Shenk, Technology Review, May-June, 1997)
Exploring the “Singularity” (J.J. Bell, The Futurist, May-June, 2003)
- April 10 *Read **Zen and the Art of Motorcycle Maintenance**. Class discussion*
- April 17 *Presentation and discussion of **The Religion of Technology***
COURSE PAPER IS DUE.
Technological Faith and Christian Doubt (F. Ferré, *Hellfire and Lightning Rods*,
Chapter 4, Orbis Books, 1994)
The Internet as a Metaphor for God? (C. Henderson, Cross Currents,
Spring/Summer, 2000)
- April 24 *Closing discussion*
MS pp. 274-292 (Q 284-2, Q 292-2); Case #9
Protecting Public Anonymity (M.G. Morgan and E. Newton, Issues in Science
and Technology, Fall, 2004)
What is Sustainable Development? (R.W. Kates, T.M. Parris and A.A.
Leiserowitz, Environment, April, 2005)

MS refers to M.W. Martin and R. Schinzinger, *Ethics in Engineering* (2005).

Appendix C

Course Policy

- I. Read all required books and one optional book. If you are not responsible for an optional book, read instead at least one article from the periodical literature, one ethics case, and the assignment from *Ethics in Engineering* (M.W. Martin and R. Schinzinger).
- II. Hand-in homework (due on the day the readings are discussed)

When required reading is due:

submit two typewritten discussion questions (one-page, single-space)

- (b) focus on pertinent issues, potential responses, and follow-up queries.

When optional reading is due:

- (a) two-three page (single-space) typewritten summary of significant facts and concepts in book from either a protagonist or antagonist viewpoint (distribute to class)
 - (b) two discussion questions (extra credit) – use synopsis to guide presentation; use questions to lead discussion.
- (3) When neither of the above is due (13 required/25 possible):
- (a) one-page (single-space) typewritten essay (review, analysis, opinion) for an assigned article (5/10)
 - (b) one-page (single-space) typewritten response to an assigned study question from *Ethics in Engineering* (4/9)
 - (c) one-page (single-space) typewritten analysis of engineering ethics case using a suitable dilemma paradigm, a single ethics theory (*duty-rights, ends-consequences, virtue-wisdom, care-responsibility*), and the ASME code of ethics (Martin and Schinzinger) – each ethics theory may be used only once during the semester (4/9)
 - (d) no more than one of each type of essay is acceptable per class period.

Optional Reading

- (1) Presentation: 15-20 minutes of synopsis plus analysis (penalty for verbosity)
- (2) Debate between representatives of protagonist and antagonist viewpoints
- (3) Question/Answer period (credit for good understanding of material)
- (4) Lead (with moderator) discussion on your book.

IV. Short Essays (180 points)

- (1) Twenty-point grading system for articles; ten-point grading system for ethics cases and study questions
- (2) Four (two) points each for assignment completion, English usage, organization/clarity, concept identification and originality
- (3) Five best essays counted for articles; four best essays counted for ethics cases and study questions.

Discussion Questions (20 points)

Five-point grading system for each set of two discussion questions

- (2) Two points per discussion question with one point each for clarity and perception; a one-point bonus is available for a particularly creative question
- (3) All ten discussion questions counted when determining final grade.

VI. Course Paper (due April 20)

- (1) Length: 5000 words, i.e., 16-20 typewritten pages (double-space); I must OK your topic
- (2) Form: essay, research paper (analysis, comparison, assessment, interpretation)
- (3) **Answer a single well-posed research question using a small number of primary source materials (5) and limited secondary materials (10)**
- (4) Evaluated on use of written language, synthesis and development of ideas, identification of major concepts, originality, and topic choice. Employ an introduction, clearly-defined subsections, and concluding remarks to guide the reader.

VII. Grades

- (1) Paper - 40%
- (2) Short essays and questions - 20%
- (3) Optional book summary, presentation and discussion - 20%
- (4) Class discussion - 20%+

Normand M. Laurendeau (laurende@purdue.edu) was awarded the Ph.D. in Mechanical Engineering from the University of California, Berkeley in 1972. He immediately joined the faculty at Purdue University, rising through the ranks to Professor of Mechanical Engineering in 1982. Dr. Laurendeau initiated development of Technology and Values in 1976. He was appointed the Reilly Professor of Combustion Engineering in 1995, subsequently becoming the Ralph and Bettye Bailey Professor of Combustion in 2000. Professor Laurendeau retired from Purdue University in 2007. He is currently a research associate at Bowdoin College (Brunswick, ME) and a visiting scholar at the Graduate Theological Union (Berkeley, CA). He continues to conduct research at Purdue in the combustion sciences, with particular emphasis on laser-based diagnostics of air pollutants. Dr. Laurendeau has authored or coauthored over 175 publications; his textbook, *Statistical Thermodynamics: Fundamentals and Applications*, was published by Cambridge University Press in 2005. Professor Laurendeau is a Fellow of the Optical Society of America and of the American Society of Mechanical Engineers.

Peter H. Meckl (meckl@purdue.edu) obtained the Ph.D. in Mechanical Engineering from MIT in 1988. He has been an Associate Professor at the School of Mechanical Engineering at Purdue University since 1994. Dr. Meckl's research interests are primarily in diagnostics and control of automotive engines and autonomous machines. He regularly teaches the ethics component for the sophomore mechanical engineering seminar and has been helping to teach Technology and Values since 2000. Dr. Meckl has authored or coauthored over 100 publications in archival journals and peer-reviewed conference proceedings. He is a senior member of the American Society of Mechanical Engineers and the Institute for Electrical and Electronics Engineers, as well as a member of the American Society for Engineering Education.