ARIZONA STATE UNIVERSITY

**GENERAL STUDIES COURSE PROPOSAL COVER FORM**

## Course information:

*Copy and paste **current** course information from Class Search/Course Catalog.*

Academic Unit ENGINEERING Department SEBE

Subject CEE Number 181 Title Tech, Social, Sustain System Units: 3

Is this a cross-listed course? (Choose one) yes
If yes, please identify course(s) SOS, FSE181

Is this a shared course? (choose one) If so, list all academic units offering this course Sustainable
Course description:

**Requested designation:** (Choose One) Hist
*Note- a **separate** proposal is required for each designation requested*

**Eligibility:**

Permanent numbered courses must have completed the university's review and approval process.
For the rules governing approval of omnibus courses, contact the General Studies Program Office at (480) 965-0739.

**Area(s) proposed course will serve:**

A single course may be proposed for more than one core or awareness area. A course may satisfy a core area requirement and more than one awareness area requirements concurrently, but may not satisfy requirements in two core areas simultaneously, even if approved for those areas. With departmental consent, an approved General Studies course may be counted toward both the General Studies requirement and the major program of study.

**Checklists for general studies designations:**

Complete and attach the appropriate checklist

- Literacy and Critical Inquiry core courses (L)
- Mathematics core courses (MA)
- Computer/statistics/quantitative applications core courses (CS)
- Humanities, Fine Arts and Design core courses (HU)
- Social and Behavioral Sciences core courses (SB)
- Natural Sciences core courses (SQ/SG)
- Global Awareness courses (G)
- Historical Awareness courses (H)
- Cultural Diversity in the United States courses (C)

## A complete proposal should include:

- ☐ Signed General Studies Program Course Proposal Cover Form
- ☐ Criteria Checklist for the area
- ☐ Course Syllabus
- ☐ Table of Contents from the textbook, and/or lists of course materials

## Contact information:

Name Mike Seven Phone 5-1202

Mail code 5306 E-mail: Mike.Seven@asu.edu

**Department Chair/Director approval:** ***(Required)***

Chair/Director name (Typed): Michael Mamlouk Date: 7/24/13

Chair/Director (Signature): M. S. Mamlouk

**Arizona State University Criteria Checklist for**

# HISTORICAL AWARENESS [H]

## Rationale and Objectives

The lack of historical awareness on the part of contemporary university graduates has led recent studies of higher education to call for the creation and development of historical consciousness in undergraduates now and in the future. From one perspective historical awareness is a valuable aid in the analysis of present-day problems because historical forces and traditions have created modern life and lie just beneath its surface. From a second perspective, the historical past is an indispensable source of national identity and of values which facilitate social harmony and cooperative effort. Along with this observation, it should be noted that historical study can produce intercultural understanding by tracing cultural differences to their origins in the past. A third perspective on the need for historical awareness is summed up in the aphorism that he who fails to learn from the past is doomed to repeat it. Teachers of today's students know well that those students do not usually approach questions of war and peace with any knowledge of historic concord, aggression, or cruelty, including even events so recent as Nazi and Stalinist terror.

The requirement of a course which is historical in method and content presumes that "history" designates a sequence of past events or a narrative whose intent or effect is to represent such a sequence. The requirement also presumes that these are human events and that history includes all that has been felt, thought, imagined, said, and done by human beings. The opportunities for nurturing historical consciousness are nearly unlimited. History is present in the languages, art, music, literatures, philosophy, religion, and the natural sciences, as well as in the social science traditionally called History.

**Proposer: Please complete the following section and attach appropriate documentation.**

| ASU--[H] CRITERIA | | | |
|---|---|---|---|
| **THE HISTORICAL AWARENESS [H] COURSE MUST MEET THE FOLLOWING CRITERIA:** | | | |
| **YES** | **NO** | | **Identify Documentation Submitted** |
| ☒ | ☐ | **1.** History is a major focus of the course. | syllabus |
| ☒ | ☐ | **2.** The course examines and explains human development as a sequence of events. | syllabus |
| ☒ | ☐ | **3.** There is a disciplined systematic examination of human institutions as they change over time. | syllabus |
| ☒ | ☐ | **4.** The course examines the relationship among events, ideas, and artifacts and the broad social, political and economic context. | syllabus - especially weeks 1, 2, 3, 5, 6, 8, 9, 10 |
| | | **THE FOLLOWING ARE NOT ACCEPTABLE:** | |
| | | • **Courses in which there is only chronological organization.** | |
| | | • **Courses which are exclusively the history of a field of study or of a field of artistic or professional endeavor.** | |
| | | • **Courses whose subject areas merely occurred in the past.** | |

| **Course Prefix** | **Number** | **Title** | **Designation** |
|---|---|---|---|
| FSE/CEE/SOS | 181 | Introduction to Sustainable Engineering: Technological, Social, & Sustainable Systems | H (applied for) |

Explain in detail which student activities correspond to the specific designation criteria. Please use the following organizer to explain how the criteria are being met.

| **Criteria (from checksheet)** | **How course meets spirit (contextualize specific examples in next column)** | **Please provide detailed evidence of how course meets criteria (i.e., where in syllabus)** |
|---|---|---|
| 1 - history is major focus | technology and sustainability cannot be understood without historical perspective on how world came to be as it is, and history of technology systems will pave the way for Technologies and Sustainability practices in the future | Syllabus - weeks 1, 2, 4, 5, 8 (and associated homework), 9 (forward looking), ; also note major reading is Grubler, Technology and Global Change |
| 2. human development as sequence of events | without understanding history of how we got to our current high tech, high pop world, impossible to understand either sustainability or technology systems | Syllabus - weeks 1,2,4,5,8,9; also note homeworks for weeks 1, 2, 5, 8,9 |
| 3. systematic examination of human institutions over time | technology understood as social phenomenon is studies over time | syllabus, especially weeks 1,2,3 |

Version 2.1 1/8/2013

Technological, Social, and Sustainable Systems
Brad Allenby
Carolyn Mattick
Sharlissa Moore
Spring 2013
CEE/SOS 181

Lecture: Monday 4:30 – 5:45 PM (20945/27531/21573/26263) BYAC 210.

Discussion (subject to change depending on number of students):
- 10:30 - 11:45 T (23548/27550/23086) ECG G320 (Sharlissa Moore)
- 1:30 - 2:45 T (23550/27552/23088) ECG G320 (Sharlissa Moore)
- 10:30 - 11:45 Th (23549/27551/23087/28169) ECG G320 (Carolyn Mattick)
- 1:30 - 2:45 Th (23551/27553/23089) ECG G320 (Carolyn Mattick)

Professor contact (email preferable): brad.allenby@asu.edu
ERC 409
480-727-8594
Office hours: Email for appointment

Carolyn Mattick: cmattick@asu.edu
ERC 405
Office hours: TBD or email for an appointment

Sharlissa Moore: Sharlissa.Moore@asu.edu
INTDSB 366
Office hours: TBD or email for an appointment

*Course Objectives:* To introduce students to the importance and role of technological, social, cultural, and sustainable systems in the modern world, which is increasingly characterized by integrated human/natural/built complex adaptive systems at local, regional and global scales. Emphasis will be on characteristics and fundamentals of technology systems; complex adaptive systems behavior and evolution; the interrelationship among technological and cultural domains and how cultural products (art, cinema, advertisements and media images, philosophy and religious beliefs) affect technological imagination and technological evolution; and current patterns in technological evolution and the potential cultural, philosophical, and religious challenges that they may create.

At the end of the course, students should be able to:

1. Explain the importance of technology and technological systems;
2. Explain the social and environmental implications of design, construction, operation, and management of technology systems;
3. Identify and explain critical principles of complexity and complex systems;
4. Explain how art, cinema, literature, and other cultural products create the ground from which technological systems emerge, and affect the evolutionary paths of

technological systems; and how they are in turn affected by those technological systems; and,
5. Be able to use these concepts and principles to explore a topic of their choice in a systemic and integrated way in their consultant's report.

In addition to domain-specific goals, this course is also intended to help students:

1. Learn to communicate in short essay form and in small group discussions;
2. Learn the differences between different forms of written communication – short essay, longer research paper, blog, op-ed, and others - write at least one assignment using each form; and learn how each is intended to serve different audiences and purposes;
3. Understand economic, environmental, social, cultural, philosophic and religious issues and impacts associated with technology systems and emerging technologies at a broad cultural and geographic level extending across urban, regional, national and global scales; and
4. Understand the need and develop the capability to participate in lifelong learning.

In terms of ABET criteria, the course will enable students to:

1. Understand professional and ethical issues in the context of engineered and earth systems, and learn to include cultural, ethical, and social perspectives in professional activities;
2. Learn to write, and communicate effectively, in a variety of forms ranging from short essays, to blogs, to a longer research paper;
3. Understand issues and impacts of engineering solutions at a broad cultural and geographic scale extending across urban, regional, national and global scales;
4. Understand the need and develop the capability to participate in lifelong learning; and,
5. Take into consideration contemporary social and cultural perspectives and issues, and environmental impacts, in civil and environmental engineering practices.

*Introduction:* The Industrial Revolution and continuing dramatic and accelerating changes in economic, technological, and cultural systems has fundamentally changed the way people live, relate to each other, express themselves artistically, politically, and culturally, and affect natural and built systems. In fact, many scientists are increasingly referring to our modern period era as the "Anthropocene," which can be roughly translated as the Age of Humans, as the world is increasingly restructured to reflect human economic, cultural, and technological activities. Moreover, the accelerating pace of technological evolution – particularly the coming convergence of nanotechnology, biotechnology, robotics, information and communication technology (ICT), and cognitive sciences – will both reinforce the human domination of the dynamics of natural systems, and pose significant challenges to existing cultural, governance, legal and ethical norms and patterns. Thus, it is not possible to understand the modern world, and to make intelligent choices about the future, without some understanding of technological systems and emerging technologies, the cultural, ethical, political and religious frameworks within which they arise, and the complex systems of which they are a part.

Accordingly, this course will provide students with an introduction to technology and complex systems, and the cultural frameworks within which technology is understood and evolves. Additionally, the implications of technology for sustainability will be explored, a difficult task given that sustainability is itself a cultural construct that must be deconstructed to be understood (lecture 4). It will also introduce students to the implications of understanding the Earth as a terraformed planet, and the technological, economic, religious and cultural patterns that have contributed to its evolution. The potential operational, cultural and ethical implications of future evolutionary pathways will be explored, with emphasis on the challenges they pose and the role of technological systems in both creating, and helping to address, such challenges.

The course will consist of 1.5 hours of lecture, and 1.5 hours of discussion in small groups with the TA's, each week, except where otherwise noted. The course grade will consist of three components: class participation; a homework component that is based on weekly writing assignments; and a consultant's report.

Homework will be a 1.5 line spacing essay of between 375 and 425 words (except where otherwise noted) each week on the topic assigned for that week. It will be due the second class of each week at the beginning of class, where it will be collected by the TA and cross-edited by the students. The consultant's report will be on a topic of the student's choice as approved by the seminar instructor, and will be between 3,750 and 4,250 words, with 1.5 line spacing. The works cited page and headers do not count toward the word count. The reading assignment for each week includes reviewing the slide package for the next week's class prior to class. ***All essays, and the consultant's report, should be submitted via Blackboard, and will be checked to ensure they are not plagiarized.***

*Grading:*

- Class participation: 30%
  - Article presentation in seminar: 5% of the 30%
    - *To be posted 24 hours before the start of the stated class period. 3% will be deducted for late posts.*
  - Contribution to seminar and lecture: 10% of the 30%
    - *e.g. asking and answering questions*
  - Attendance: 15% of the 30%
    - Attendance in all lectures and seminars is required; however, absences will be excused with prior notification of a legitimate conflict (illness, religious observances, etc.)

      Students watching the lecture online must take a quiz on the material in order to get attendance credit.

Essays: 35%
- Each missing paper is minus 5% *from the overall class grade*
- Failure to meet minimum quality standards or a late paper is minus 3% *from the overall class grade*
- Penalty limited to 35% of course grade

Consultant report: 35%, of which
- Grasp and use of course concepts (e.g., complexity, technology systems) and value to the client: 20%
- Accuracy and persuasiveness: 20%
- Organization and structure: 20%
- Proper format: 20%
- Presentation (e.g., no typos, complete sentences): 20%.
- A late paper is minus 3% *from the overall class grade for every week for which it is late*

Grading scale:

| Course % | Grade |
|---|---|
| 100 | A+ |
| 90-99.9 | A |
| 80-89.9 | B |
| 70-79.9 | C |
| 60-69.9 | D |
| Below 60 | E |

| | |
|---|---|
| Consultant report topic due: | Week of February 5 in seminar (submit online) |
| Consultant report outline due: | Week of February 26 in seminar (submit online) |
| Consultant report due: | April 8 at 4:30 pm (submit online) |

*While no formal final exam is scheduled, the instructors reserve the right to administer individual final exams when it is deemed necessary. Students will be notified in advance if such a situation arises.*

****** Due to the holiday schedule, please see your seminar Blackboard site for exact due dates and submission methods! ******

*Academic Integrity*

All students in this class are subject to ASU's Academic Integrity Policy (available at http://provost.asu.edu/academicintegrity) and should acquaint themselves with its content and requirements, including a strict prohibition against plagiarism. All violations will be reported to the Dean's office, who maintains records of all offenses.

***Note: Consultant's reports and essays will be checked for plagiarism (copying language or barely modifying language that is not your own in the consultant's report, without attribution). Plagiarism is considered academic fraud and, if detected, will result in a grade of zero for that assignment, and usually in further academic action by***

***the Engineering School, including failure of the course and a permanent note in your academic record. If you have any questions about what constitutes plagiarism, talk to your seminar instructor or bring it up in class.***

*Self-plagiarism*

Self-plagiarism is the practice of re-using your own text or ideas from previous class papers or publications in work for another course. This is prohibited in CEE 181. While you are welcome to write on the same or related topics as in prior courses, all content in CEE 181 submissions must be unique. You may reference or quote your prior work sparingly, but attribution must be given to the original work.

*Copyright*

All contents of these lectures, including written materials distributed to the class, are under copyright protection. Notes based on these materials may not be sold or commercialized without the express permission of the instructor. [Note: Based on ACD 304-06.]

*Classroom Behavior*

Cell phones must be silenced during class to avoid causing distractions. Laptops and other electronic devices are permitted for the purpose of note-taking and acquiring supplemental information relevant to the class. The use of recording devices are permitted during class but recordings are subject to copyright protection (see Copyright section below). Any violent or threatening conduct by an ASU student in this class will be reported to the ASU Police Department and the Office of the Dean of Students.

This course encourages respectful dialog (including disagreements) and mutual inquiry.

*Disability Accommodations*

Suitable accommodations will be made for students having disabilities and students should notify the instructor as early as possible if they will require same. Such students must be registered with the Disability Resource Center and provide documentation to that effect.

*Offensive Materials*

Some content in this course may be deemed offensive by some students. If you find any material objectionable, you may consult with the instructor or your Program Chair to identify appropriate accommodations.

*Changes to the Syllabus*

Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice.

*Primary Texts and References:*

1. Allenby, *Theory and Practice of Sustainable Engineering*
2. Card, *Ender's Game*
3. *The Matrix* (1st movie in the series)
4. Advertisements as cultural commentary on technology (Dodge Challenger 2010 "Freedom" ad; Apple 1984 anti-IBM ad); will also be shown in class.
5. Beginning of *2001: A Space Odyssey* (transition from artifact to technology through psychological and cultural rather than physical change) (will be shown in class).
6. Videos of robot hummingbird, robot with rat brain, and grid robot systems will be shown in class to illustrate how challenges of technology are not primarily technological, but mainly ethical, cultural, religious, and governance/legal.
7. Videos of very different future technological visions will be shown in order to demonstrate the difference between future scenarios and predictions, and also to illustrate how the line separating life from advertising may become increasingly blurred. Specific videos will include two very different views on augmented reality, and a post-singularity vision of immortality.

*Weekly Schedule (note that the topic of the week's lecture is given for each week; the second session of each week will consist of a small seminar where a) the weekly essays will be collected by the TA and handed out randomly for cross grading, with students commenting on style and substantive content of each essay in a mutually supportive learning environment; b) additional open discussion of issues raised by the weekly lecture; and c) additional instruction in writing, speaking, and learning skills).*

Lecture 1 (January 7): Welcome to the Anthropocene: a discussion of the increasing impact of humans on the world, including information on demographic trends (urbanization, population growth, per capita material, energy, and water consumption); global economic history; role of culture in shaping attitudes towards nature and technology (capitalism and economic growth values; Marxism as scientific materialism); natural cycles (especially C and N), and how they interact in various systems, such as biofuels as response to global climate change. Importance of culture and governance to technology and natural systems, again using biofuels case study: demand is based on consumer relationship with vehicles as "technology of freedom" (cultural and marketing phenomenon), while dysfunctional corn-based ethanol biofuel technology is driven by political considerations (rational politically, irrational environmentally).

Reading: Chapter 1, Allenby; slide package (in this and all subsequent weeks).

Homework (to be handed in at second seminar session): Essay: Why do you think scientists increasingly refer to our modern era as the "Anthropocene"?

Lecture 2 (January 14): Important Themes of the Human Earth: A number of general themes are important for understanding the world as it now exists, and as providing context for engineering and managing technology today. These include the criticality of technology as a contributor to, and shaper of, accelerating economic, environmental, social, and cultural evolution, and how technology is in turn shaped by broader human and social systems; the increasing information density and complexity of the world as many physical domains are re-defined into information structures (e.g., genetics and bioengineering); and the growth of active information functionality within built environments (e.g., the "cognitive city" is a complex of "smart" materials, "smart" buildings, "smart" infrastructure, and "smart" integrated infrastructures). Moreover, natural systems are increasingly integrated with human and built systems, and thus become subject to their dynamics (e.g., reflexivity, intentionality); examples might include genetic engineering and its commoditization through intellectual property law, or carbon cycle and sulfur cycle management. Institutionally, the rapidly evolving technological frontier creates significant social pressures; fundamentalism as a response to modernity becomes increasingly powerful, and professionals and firms are being charged by society with responsibility not just for their actions, but for their technology systems (cf: Monsanto and genetically modified organisms). It thus becomes increasingly possible that technological evolution will become discontinuous in terms of cultural ability to adapt, especially with NBRIC evolution continuing to accelerate. This is especially true as technological evolution functions to redefine what it means to be human, and begins to reframe the human as a design space. Adaptation will be much more difficult as well because foundational values and cultural constructs continue to become contingent over much shorter time frames (swamp/wetlands; jungle/rainforest; wilderness evil to good; natural/supernatural to natural/human). From a cultural and political perspective, the bipolar order imposed by the Cold War has destabilized global power relationships and, rather than being the "end of history" has unleashed even more powerful conflict between, e.g., fundamentalism and modernity in Islam, Christianity, Judaism, environmentalism, Hinduism, and elsewhere, and, some fear, potentially a "clash of civilizations." At the same time, the role of nation-state is changing profoundly, leading to more diffuse power structures, different and more varied forms of community (e.g., online social networks), and a loss of the traditional monopoly of the state on military power (e.g., technologies of mass destruction have been democratized).

Reading: Chapter 2, Allenby.

Homework: Essay: In what major ways does the world we live in now differ from the world 200 years ago?
*Please include at least 1 in-text citation and corresponding reference in this essay.*

January 21: Martin Luther King Day: No lecture.

Lecture 3 (January 28): Complexity, Contingency, and Accelerating Change: There are very important differences between complex and simple systems. Simple systems are generally intuitively understandable, and their dynamics, such as "cause and effect," are relatively easy to understand. The anthropogenic Earth, however, is characterized by complexity, which can be thought of as including four forms of complexity: static complexity (number of components and links among them); dynamic complexity (introduced by features such as lag times and feedback loops that operate as a system moves through time); "wicked" complexity, which comes into play as humans and their institutions get involved; and scale complexity, as humans increasingly operate at the scale of regional and global natural and built systems. These operate together to create radical contingency in the modern world, as it becomes difficult to determine what assumptions and institutions will remain valid over time. An important aspect of this contingency is that it undermines many traditional ethical systems: ethical structures (macroethics) appropriate for complex adaptive systems have not yet been developed.

Reading: Chapter 3, Allenby.

Homework: Consultant report topic statement. Please submit 1 document containing the following:

1. Client
2. Research question
3. Thesis statement or recommendation to client (optional)
4. 2-3 paragraphs describing why this is an important question, how the course themes will be applied/incorporated, and how you will approach the topic and research.
5. Annotated bibliography (APA format) containing at least 3 high-quality sources of information and how they will inform the investigation.

Lecture 4 (February 4): Sustainability. "Sustainability" is a powerful cultural construct that was popularized as "sustainable development" by the Brundtland Commission in 1987, and has two basic themes: an emphasis on environmental quality, and a demand for increased equality in wealth distribution within and among generations. Despite its high popularity, it remains an ambiguous and somewhat contentious concept, and difficult to translate into operational terms that are easily implementable in the design and management of technology or earth systems. This leads to a difficult situation for the problem solver: the sustainability concept is clearly a powerful cultural construct, and cannot be ignored, yet it is at the same time an inchoate social myth that lacks clear operational implications. The sustainability dialog also tends to be naïve, if not somewhat skeptical, of engineering and technology, which leads to significant potential blind spots given the importance of emerging technologies to the shape and dynamics of future social, economic, and environmental systems. It is clear, however, that engineering and technology management today requires a greater focus on the environmental, social, and cultural dimensions of a design or project. Accordingly, much of sustainable engineering is, in fact, learning to translate the mythic language of sustainability into methods and inputs that can inform better engineering and technocratic decisions. Sustainability also offers an interesting case study in the ways that cultural frameworks can guide subsequent technological evolution, with examples that might include energy efficient lighting, hybrid vehicles, renewable energy production, and, at large scale, geoengineering schemes.

Reading: Chapter 4, Allenby.

Homework: You are the head of a design team that has been asked by your marketing department to create a "sustainable cell phone." Write a one page email to your boss explaining how you intend to do that, paying attention to the difference between an email (relatively informal) and a more official work product such as a White Paper, and the difference between an email to your friends, which can be very informal, and to your boss, which should respect rules of grammar, good writing, and appropriate word choice (you can OMG or WTF your friends; you should not use such contractions with your boss, even in an email).

Lecture 5 (February 11): Homo Faber: Human History and Technology. (start class by showing first ten minutes of *2001: A Space Odyssey*. The beginning of *2001* makes a very important point: just as an ape holding a bone is very different from an ape holding a bone *as a weapon*, an artifact is not a "technology" until it is psychologically and culturally integrated with the human in some fashion – it is culture that transmutes mute artifact into technology.). Culture, history, and technology state are co-evolving phenomenon. It is not surprising that periods of human development, such as "Neolithic" or "the Bronze Age," have referred to the dominant technologies of the time, because humans, their institutions, and their societies have always been coupled. Indeed, since the Industrial Revolution economists have used the idea of "long waves" of innovation, characterized by particular technology clusters such as coal and the steam engine, or automobiles, to help understand not just technological evolution, but also economic, social, and cultural evolution as well. This does not imply that technology "determines" other domains of human activity, but that there are coherent patterns of integrated economic, social, cultural, institutional, political and technological systems that, taken together, generate particular Earth system states.

Reading: Chapter 5, Allenby.

Homework: Essay: Why do you think technology clusters have institutional, social and cultural effects, rather than just economic impacts?
*Please include at least 1 in-text citation and corresponding reference in this essay.*

Lecture 6 (February 18): Understanding Technology: Technologies have generic characteristics that tend to be fairly common: for example, they may grow vigorously when young, but they slow as they grow old and eventually even the most fundamental infrastructures are replaced. They must be understood and framed as systems if fundamental change is desired: for example, if plug in hybrids, and solar and wind renewables are to be introduced into a developed economy, the timing will not be determined by how long it takes to build and design them, but rather how long it will take to rebuild the grid to handle greater variability of supply and a large demand spike. More broadly, many cultures have developed technologies, sometimes independently of each other, but few cultures have successfully made technology a core of their success. Part of the reason is that technology is not just widgets, or software, but is also a social and cultural activity, and thus can be inhibited or encouraged by different cultural patterns.

Reading: Allenby, chapter 6.

Homework: Write a 600 word blog on the question, "Why should I need to worry about the electrical power grid if all I want to do is buy a plug-in vehicle because it's good for the environment?" Remember that a good blog should draw the reader in, and can be less formal than a written essay with citations, but the best are still rigorous, analytical, and well written.

Lecture 7 (February 25): Case Studies in Technology Systems: case studies of three major technology systems – automobiles, information and communication technology, and green chemistry – will be presented. Each case clearly indicates the interplay between culture and technology: in the case of automobiles, for example, enhanced engine efficiency tended to be directed towards increasing horsepower and performance, rather than towards preservation of resources, in large part because the performance culture is inseparable from the technology. In the case of telework, a more environmentally and economically efficient practice was difficult to implement because it violated important implicit aspects of capitalist managerial culture (e.g., "people will only work if you are watching them."). In the case of green chemistry, the definition of the technology itself reinforces the increased cultural emphasis on environmental values as opposed to, e.g., purely performance or efficiency values. In each case, it is apparent that each level within a particular technology offers its own unique challenges and opportunities for the sustainable engineer or technology manager: manufacturing a cell phone has different social and environmental issues associated with it than designing and operating a communications network, which in turn raises different issues than the social implications of the services platformed on the physical system. It is also apparent, however, that each technology, as a system, is more complex and integrated than engineers, businesspeople, and policymakers realize. This marks an important area where sustainable engineering offers insights that can improve professional performance significantly.

Reading: Allenby, chapters 9, 10.

Homework: Consultant report outline. Please submit 1 document containing your outline. It should be roughly 1 to 2 pages, 1.5-spaced and contain the following:

1. Client
2. A statement of the main point, theme, or question of your report. Make sure to explicitly state your research question or thesis statement.

3. A list of main topics and sub-topics in the order you want to address them. These may include the evidence in support of (or disputing) your thesis.

Lecture 8 (March 4): The Power of Technology Systems: Start class by showing Dodge Challenger 2010 “Freedom” advert, and Apple “1984” advert. Begin class with discussion as to why those advertisements are so powerful, even if (especially in Challenger case) completely ridiculous; point is making clear the cultural dimensions of any technology, and in particular the association of major technology systems, automobiles and information technology, with psychological sense of freedom. Also note secondary implications: how Apple thinks of its technology by reference to cultural artifacts, in this case the book (and archetypal symbol) “1984” – and successfully got the public to think of it that way as well. Example leads in to discussion of how pervasive the changes that a major technology system can introduce really are, using railroads as good example. To begin with, networks such as railroad require a uniform, precise system of time and a means of communication adequate to the time cycle of the technology; railroad technology called forth “industrial time” and its associated culture, as well as the telegraph. Railroad firms were far bigger than previous commercial firms, and required far more capital; they thus created need for cultural change, in this case co-evolving modern managerial capitalism (modern accounting, planning, and administration systems), as well as modern capital and financial markets. Environmentally, railroads transformed landscapes at all scales: Chicago existed, and structured the Midwest economically and environmentally (e.g., industrial scale farming, with all the cultural and political changes implied by such a shift), because of railroads. Like most major technological systems, railroads fundamentally changed US economic and power structures, restructuring the economy from local/regional business concentrations to trusts and monopolies as railroad infrastructure created the possibility of exploiting scale economies of national markets. Railroads even played a role in helping to shift the fundamental worldview behind American culture from Jeffersonian agrarianism, an Edenic teleology, to a technology-driven New Jerusalem, a cultural schism that replays itself today in the continuing environmentalist challenge to technology.

Reading: Review Allenby, Chapters 5 and 6; first half of *Ender’s Game*.

Homework: Essay: Which, if any, of the changes caused by the railroad could a villager living in the United States in the early 1800s have predicted? Are the important changes technological, or are they economic, political, and cultural?
*Please include at least 1 in-text citation and corresponding reference in this essay.*

March 11: Spring Break: No lecture.

Lecture 9 (March 18): The Five Horsemen: NBRIC. Begin class with video of robot with rat brain central processor, and brain operated prosthetic; and article on birthing a Neanderthal. The first part of the class discussion will focus on what it means for the “human” to become a design space, whether there are any aspects of “being human” that should not be open to design and deliberate change, and the religious and cultural implications of the human as design space (for religion, consider the Great Chain of Being; for literature, consider power of the Frankenstein myth). Examples of "human as design space" that already exist include vaccines (design of immune system, with concomitant longer life, greater resource consumption, etc.), plastic surgery for cosmetic purposes (supports culture of youth, suggests that public will enhance even if risk associated with process). Examples that raise serious ethical, cultural, legal and religious concerns might include drugs for manipulating memory and intelligence, and radical life extension technologies (average life of 150, with good quality of life during entire period). The railroad, a core technological system for a technology cluster, had major impacts even though it was just one technology system. We are currently seeing not one, but five, foundational technology systems in a period of accelerating evolution: nanotechnology, biotechnology, robotics, information and communication technology, and cognitive science. These technologies in some ways are the logical end of the chapter of human history that began with the Greeks 2500 years ago. Nanotechnology extends human will and design to the atomic level. Biotechnology extends it across the biosphere. ICT gives us the ability to create virtual worlds at will, and facilitates a migration of functionality to information rather than physical structures. Robotics and biotechnology merge the biological and technological realms, enabling integration at the level of information systems. Cognitive sciences rationalize cognition, and thus enable ever expanding cognitive networks which increasingly merge human and technology systems. Consider, for example, of the way that Google ™ so dramatically extends human memory, creating a cognitive system that includes not just the human elements, but vast swaths of Net technology, or the way that many militaries are building "augmented cognition" technologies, where technologies intended to scan the battlefield for threats are integrated into each soldier's cognitive systems. Current accelerating rates of technological evolution are not only unprecedented; they have the effect of dramatically extending the spaces within which humans can, intentionally and unintentionally, impact existing systems and design new ones. In doing so, they not only raise the level of complexity of systems that we must strive to understand. Because they also give us rapidly increasing tools to design the human itself, they render contingent much of what we have taken to be fixed.

Reading: Allenby, chapter 8; second half of *Ender's Game*.

Homework: Essay: Compare *Ender's Game* with the war in Iraq, with its heavy reliance on robotic ground, sea, and air platforms. Do you still think *Ender's Game* is science fiction? Why or why not?

Lecture 10 (March 25): The Five Horsemen, Military Operations, and National Security. Emerging technologies have particularly powerful cultural and social implications when they engage with military and security systems. (show video of military robot that could become "lethal autonomous robot" capable of operating in battlefield conditions, and killing people, without human intervention or decision). This is not just because, throughout history, technological evolution and military activity have been linked, although that is certainly true. The existential challenge to society represented by warfare, combined with the immediate advantage that new technology can deliver, tends to accelerate technological innovation and diffusion. The relationships between the resulting technology systems, and consequent social and ethical issues and changes, are quite complex, however, and understanding and managing them to enhance long term military advantage and security, is a critical and underappreciated challenge. This is particularly true when, as now, technological change is both rapid and accelerating, posing the risk of cultural backlashes that could affect both short term mission capabilities and longer term security interests. Moreover, many technologies of sufficient power to be of interest militarily have at least the potential to be deeply destabilizing to existing economic, social, and technological systems. The lethal autonomous robot, for example, could make going to war easier by reducing casualties, and could "automate" war for developed countries, greatly exacerbating cultural tendency to resort to military force rather than more difficult and complex negotiations or multinational activities. Examples might include the possibility that military RFID sensor systems, insect robots and cyborgs are shifted from theatre intelligence to domestic intelligence; that telepathic helmet technology transitions from a small unit communication enhancement to a non-intrusive thought detection device in civil society; or that warrior enhancement technology results in radical life extension for selected civilian populations. Emerging technologies are likely to have similar destabilizing effects within the military as well, potentially affecting not just military operations, but military culture and organization, as well as broader social perspectives on military initiatives generally.

Reading: Allenby, Chapter 11.

Homework: The Army has proposed a technology package that would bioengineer soldiers to be permanently altered to have 200% greater strength, nervous system function, cognitive capability, and skeletal strength. You are the senior Pentagon analyst for emerging technologies. Write a one page memo to the Secretary of Defense outlining the Level I, Level II, and Level III potential implications of this set of technologies. You can use bullet points if you so choose.

Lecture 11 (April 1): The technologist as ethicist: Macroethics. This class will start with three videos: An advert for Google Glass, the darker side of augmented reality, and "Welcome to Life" (or… The Afterlife, Ruined by Lawyers). The first two videos show very different futures involving augmented reality. It is important to realize that neither of these necessarily constitutes a prediction, but rather a scenario that can help inform decisions in the present. Together, all three videos indicate that the line separating marketing from reality may become even more blurry. Is this an ethical future? From the viewpoint of the engineer and the technologist, four important characteristics of the Anthropocene differentiate it from the traditional human systems within which existing ethical structures have developed. The first is that the earth systems characteristics of the Anthropocene are neither "human" nor "natural," but highly integrated composites of both. The second is that, as a result, the dynamics of such Anthropogenic systems include the reflexivity and, thus, unpredictability of human systems. Thirdly, these systems are highly interconnected: managing global climate change is difficult precisely because the climate system is tightly coupled to human economic and technological systems and their future paths, to powerful cultural and ideological systems, and to other )major vehicles by which this complexity, integration, and unpredictability are created. Existing ethical systems and many proposed principles such as the Precautionary Principle (don't implement a technology until you are sure the risks it poses will be less than the existing risks) are inadequate to this level of unpredictability, requiring the sustainable engineer to be much more sophisticated regarding the culture, ethical systems, and contingency of the frameworks within which he or she operates.

Reading: Allenby, chapter 12, watch *The Matrix* (first film in series only)

Homework: Essay: How do you know either reality in *The Matrix* is more "real" than the other (is there a purple pill? A magenta pill? A green one? Why not?)? And if even someone in those realities can't tell which is which, what do you think of the morality of Neo's decision to destroy the Matrix?

Lecture 12 (April 8): Sustainable Engineering Case Studies: Lead in Electronics Solder, Engineering the Everglades, and Running a Mining Megacomplex. Begin by discussing *The Matrix.* What does the movie suggest about Western attitudes towards technology and the image of the human (remember *Frankenstein*). And why are there only two pills? Are there only two realities involved here, or is it a case of "masks all the way down"? How do you know, in fact, you don't live in the Matrix already (the philosophic tradition of Descartes would suggest that you can't show that you don't)? And if so, what are the moral implications of Neo's decision to attack a reality within which most people seem to be happy? With this as background, consider three sustainable engineering case studies: Lead in Electronics Solder, Engineering the Everglades, and Running a Mining Megacomplex. Three case studies demonstrate the complexities of sustainable engineering. Each of these studies demonstrate the need for technologists to appreciate the "wicked complexity" – the social, cultural, and psychological dimensions of the complexity of these systems. A study of lead solder use in electronics, compared to alternatives based on bismuth, indium, and a silver/epoxy mixture, raises questions of how additional mining activity should be evaluated: it is relatively easy to identify environmental issues raised by mining, but understanding the cultural, social, and political implications of mining is far more difficult, and means that a simple answer about whether mining is "good" or "bad" is almost certainly inadequate. The challenge of engineering the Everglades raises complex problems arising from mutually exclusive stakeholder value systems in the context of a highly valued, unpredictable, and complex resource regime – it is, in short, not a simple matter of biology, ecology, or civil engineering, but a far more complicated matter of balancing different worldviews, cultural perspectives (e.g., Native American, environmentalist, developer, agriculturalist, politician), and economic and political interests. The mining example demonstrates the difficulty of managing a major operation in a sensitive social and environmental context, and balancing the needs of society as indicated through the market, and the demands of activists. It again demonstrates that, while technical operations and planning of a major mining operation are very complex, a far higher degree of complexity and ambiguity arises from the social and cultural context within which such operations take place.

Reading: Allenby, chapters 13, 14.

Homework: You are operating a major mine in a developing country that is managed responsibly but is also causing environmental changes in local ecosystems. Write an op-ed (opinion-editorial) piece for your local newspaper defending your operation against environmental activists who demand that you be shut down.

Lecture 13 (April 15): The technologist as problem solver: Industrial Ecology, Life Cycle Assessment, Systems Engineering, and Adaptive Management. Industrial ecology, a relatively new field, is the objective, multidisciplinary study of industrial and economic systems and their linkages with fundamental natural systems. It incorporates, among other things, research involving energy supply and use, new materials, new technologies and technological systems, basic sciences, economics, law, management, and social sciences. Although still in the development stage, it provides the theoretical scientific basis upon which understanding, and reasoned improvement, of current practices can be based. Industrial ecology focuses on long term habitability rather than short term or ad hoc approaches, attempting to understand anthropogenic disruption to fundamental natural systems and cycles rather than just responding to localized perturbations. Typical industrial ecology approaches include mass-flow analysis to understand energy and material flows through economic and environmental systems, and the linkages among them; popular tools based on this approach include life cycle analysis, or LCA. It is important to recognize that industrial ecology and associated practices in general continues to exhibit a strong bias towards the environmental domain, in part reflecting their origin in environmental engineering and science, and in part reflecting the complexity and strong normative dimensions of social issues, which make them much harder for engineers to quantify and evaluate. Systems engineering in many cases is highly technical, but when considered at a project management level it forms a structure within which the sustainable engineer or technologist can create solutions that work in the real world. In general, it requires six steps: determine the actual goals of the system, including clients and stakeholders; establish criteria for ranking alternatives (these may be numerical or qualitative); develop alternative solutions (including technological, functional, and long-term structural alternatives); rank the alternatives, including in the process nonperformance and non-quantitative considerations; iterate on both implementation and system response (learning process); and implement, usually as a continuing process in the case of complex system management. Adaptive management, a similar process developed for design and management of complex resource regimes such as fisheries, forests, and watersheds, provides similar guidance, and should be part of the toolbox of the sustainable engineer.

Reading: Allenby, chapter 7, review chapter 13

Homework: Essay: You are the vice president of engineering at an automotive firm that has promised to design more sustainable products. You have been asked to develop a design process that will aid in this goal. Write a 400-word summary of your proposed process for the company's annual report. You may choose to base your process on either sustainable engineering or industrial ecology best practices. If you include information, tables or figures that are not your own, be sure to include citations and references.

Lecture 14 (April 22): The technologist as leader. Sustainable engineering requires many things of professionals: commitment, respect for values and opinions that differ among themselves, and from the ones we may hold, a willingness to understand and work with social, cultural and environmental contexts. But it also requires that, as knowledgeable citizens in an increasingly technological world, engineers function as leaders within their institutions, communities, and society at large.

Reading: Allenby, chapter 15

Homework: What will you be doing five years from graduation, and what skills will you need to be doing it?

Lecture 15 (April 29): Course summary and discussion.