The new World of Engineering Education: Methods, Content, Sources

Dr. Tom Greene, MIT-CSAIL
Research Affiliate

A short history of Dr. T J. Greene

- Boston College (B.S.'66),
- U.of Toledo (M.S. '70, Ph.D.'73),
- Harvard (Ed.M.'90)
- *UPM 1975-1986*
  - Built a Computer Aided Instruction Lab ('78)
  - Began a Computer Science Department ('80)
  - UN consultant ('88) -- UNIDO
- Visiting Scientist at IBM ('85), at Stanford ('81), at MSC('70)
- *MIT 1987-2007*
  - MIT-Computer Science & Artificial Intelligence Laboratory (CSAIL) (86)
  - Operated an MIT-Harvard-BU Supercomputer DARPA funded collaboration ('90-93)
  - Founding team member of W3C('94-'98)
  - NSF (2000-03), I was a "deliverable" from MIT to NSF.(an IPA), ·
  - Began (2004) Outreach office for CSAIL research.
- March 2007 Research Affiliate with MIT-CSAIL

Introduction

A Fundamental Transformation

- Throughout the world, computing and communications technologies are sparking a new entrepreneurial spirit, the creation of innovative products and services, and increased productivity. There is a shift in focus from learning "information" to learning new "knowledge" .
- A newly emerging "Creative Society" where Success will be based not only on how much we know, but also on our ability to think and act creatively. The importance of a well-educated, creative Engineers is greater than ever before.

New approaches to engineering education are needed.

Big Changes

- Every two or three years, the human knowledge base doubles.
- Every day, 7,000 scientific and technical articles are published.
- Satellites orbiting the globe send enough data to fill 19 million volumes in the US Library of Congress every two weeks. (Hubble alone is 390 Gig per month.)
- US High school graduates have been exposed to more information than grandparents were in a lifetime.
- Only 15 percent of jobs will require college education, but nearly all jobs will require the equivalent knowledge of a college education.
- There will be as much change in the next three decades as there was in the last three centuries. (30 vs. 300)

From : Leadership and Technology, published by the US National School Board Association's

Institute for the Transfer of Technology to Education

The Engineering Education Problem

Much of what people learn in schools today was designed for the era of paper-and-pencil. We need to update curricula for the digital age. Schools must prepare students with the new skills and ideas that are needed for living and working in a digital society. Let's note that the new technologies are changing not only what students should learn, but also what they can learn. There are many ideas and topics that have always been important but were left out of traditional school curricula because of time limits or because they were too difficult to teach and learn with only paper, pencil, books, and blackboard.

In our world now, the knowledge our graduates have at the end of four years must be continuously replaced and updated during their careers.

- Students must now learn and learn-to-learn,
- Teachers must now teach how to self learn.

Generation Gaps? – teachers/learners

"The Generation Gap at Work," project by Jones et al., studied co-existence of four different generations of workers within the U.S. workforce and frequently, within small offices. To find a framework for understanding the gaps across generations and offered tips to manage these sometimes baffling and tense relationships smoothly.They divided the workforce into

- **"Matures," born between 1909 and 1945;---**Matures are the silent generation. They value sacrifice, commitment, and financial and social conservatism. They remember the Depression. They're the 'Establishment.'"
- **"Boomers," born between 1946 and 1964**;---"Boomers value themselves. They're competitive, anti-authority. They grew up with Vietnam, Watergate, Woodstock. They have high expectations. They're diplomatic, loyal and want validation. And they value privacy.
- **"Gen Xers," born between 1965 and 1978**;---"Gen Xers were the first latchkey kids. They're entrepreneurial, pragmatic, straightforward. They grew up with AIDS, MTV, PCs, divorce.
- **"Millenials," born from 1979 onward**.---The Millenials are neo-traditionalists, optimistic and very community-centered. They're technologically adept and busy, busy. They grew up with the O.J. Simpson trial, Columbine and 9/11. They're versatile. They write blogs about their lives," said Jones.

The Generation Gaps that *co-workers may have fundamentally different approaches to work, teamwork, privacy, respect and authority, and even ethics.*

Students and teachers may see the world differently.

- SOURCE=February 2, 2005 issue of MIT Tech Talk (Volume 49, Number 16).

Exponentials- a brief review

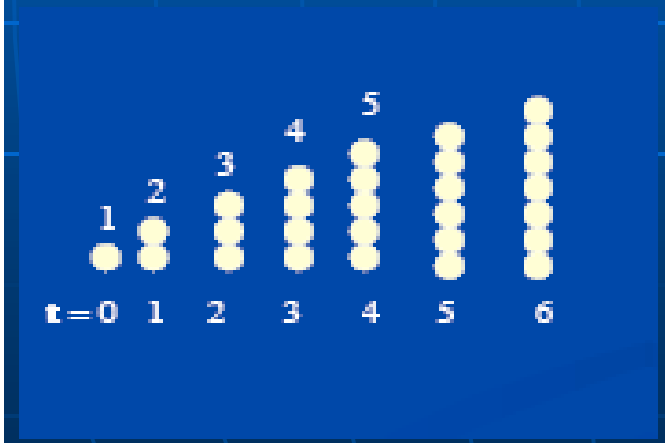
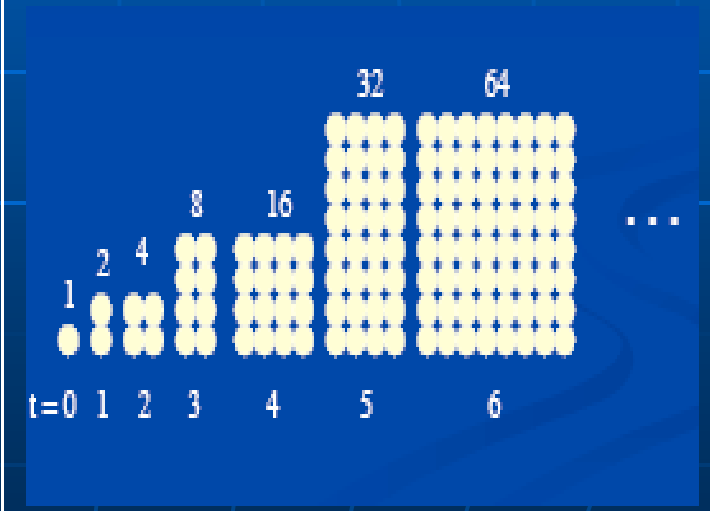
We all know these ideas, but they are important here , so let us review

- Consider Linear change (F = a*x)
  vs. Exponential change (f = a**x)

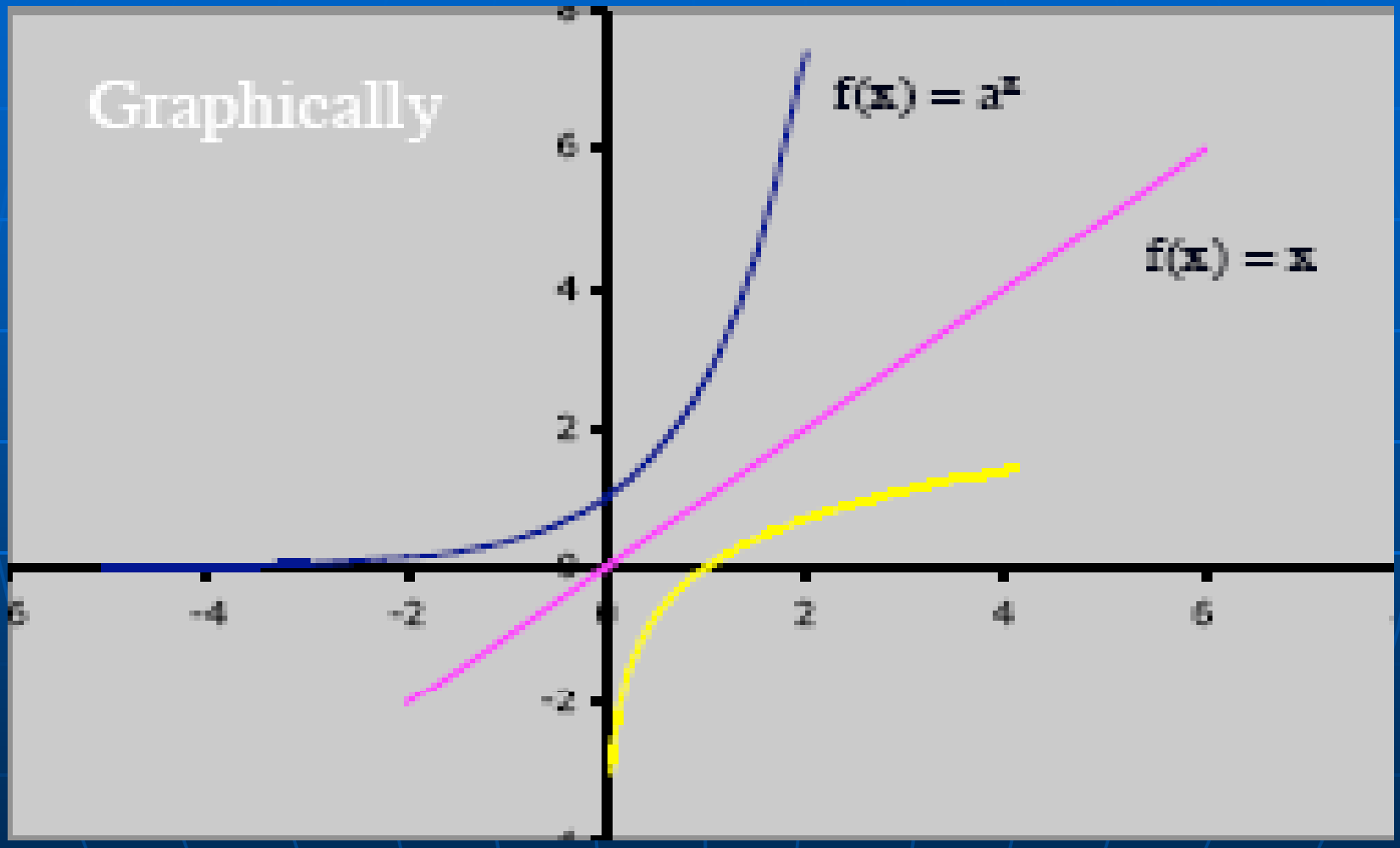
For example if a=2 and x=2 then
(F=2*3 = 6) but (f= 2**3 = 2*2*2 =8)

And if a=4 and x=3 then
(F=4*3 = 12) but (f = 4**3 = 4*4*4 =64)

For bigger numbers the difference is huge!!

For Constant Linear Growth	But for an Exponential Growth (such as Algae : cell division)
Start with 1 object at time zero At time 1 you have 2 At time 2 you have 3 At …3 …4 At …4 …5 At …5 …6 At time 6 you have 7	Start with 1 object at time zero At time 1 you have 2 At time 2 you have 4 At …3 …8 At …4 …16 At …5 …32 At time 6 you have 64
	

Graphically



Exponentials & Doubling time

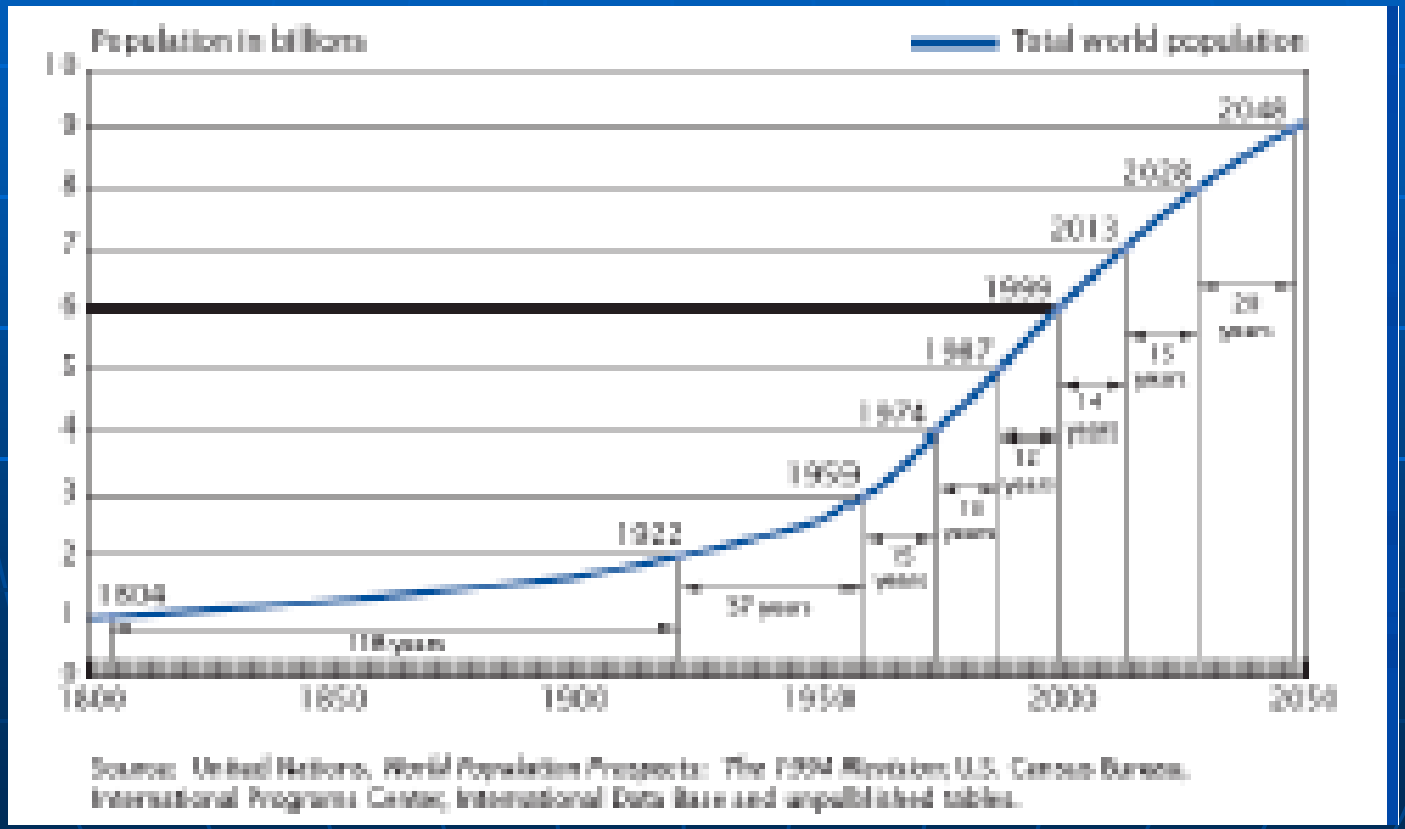
- The **doubling time** is the period of time required for a quantity to double in size or value.
- When the relative growth rate is constant, the quantity undergoes **exponential growth** and has a constant doubling time or period which can be calculated directly from the growth rate.
- This time can be derived by dividing the natural logarithm of 2 by the exponent of growth, or approximated by dividing 70 by the percentage growth rate.
- For example, given a population's growth of 0.9% in the year 2006, dividing 70 by 0.9 gives an approximate doubling time of 78 years so the population will double by 2084.
- Examining the doubling time can give a more intuitive sense of the long-term impact.

Change Engines

- *Computation growth- Moore's Law (Double computer power in 18 months)*
- *Communication growth- Butler's law of photonics (double data from fiber in 9 months)*
- *Knowledge growth (*Every two or three years, the human knowledge base now doubles ,say 2.5 years)
- *Global Population growth (check history--- 91 year doubling rate)*
- Change of this magnitude means we must fundamentally change our way of learning and solving problems.

History of global population

- 35 BCE-Julius Caesar -- 1 Million people
- 2000 CE -- 6 Billion people
- From 3 Billion people in 1909 CE to 6 Billion people in 2000 CE
- Doubling time is 91 years



Learning changes-A New Added role for universities

"A university is a school of knowledge of every kind, consisting of teachers and learners from every quarter." – J. Newman

Traditional functional elements:

1. *Transmit knowledge to next generation,*
2. *Certify technical competence,*
3. *Transmit cultural values*
4. *Create new knowledge*

The new role is

5. *Teach how to learn*

This is a great challenge for both teachers and students and requires new interactions!

Research will drive more changes

- *Brain sciences*
- *Communication technologies*
- *Computation*
- *Information display*
- *Enabling infrastructure and collaborations*

Learning and Brain Sciences

- GWU
- The Institute for Learning and Brain Sciences is an interdisciplinary center

- **Scientific Research Themes**
- Research Themes | Institute Scientists | Core Services | UW Research Seminars
  The University of Washington established the Institute in 2003 to conduct cutting-edge interdisciplinary research on human learning. Scientists working at the Institute, in collaboration with others around the world, are exploring five major research themes.
- Milestones of Learning and Development
- Brain Plasticity and Mechanisms of Developmental Change
- Links Connecting Brain and Behavior
- Nature and Nurture
- Computer Learning vs. Biological Learning
- **Milestones of Learning and Development**
- Institute scientists are exploring the basic principles of human learning and development. Topics include cognitive, linguistic, personality, and social-emotional growth. Researchers focus on identifying crucial behavioral milestones and how they are influenced by the environment and culture.

New resources to help keep up

- *Public video clips*
- *Blogs for learning*
- *Wikis for communities*
- *Open Educational Resources (OER)*
- *Open Course ware (OCW)*

Blogs for e-learning

- http://elearningtech.blogspot.com/

eLearning Trends
eLearning 2.0 Learning Management Systems - LMS
Web 2.0 Enterprise 2.0 Personal Learning Informal Learning
Collaborative Learning Corporate eLearning eLearning Design
Instructional Design Authoring Tools Rapid eLearning Tools eLearning
eLearning Software Blended eLearning eLearning Tools Open Source eLearning eLearning ROI and Metrics

- http://www.articulate.com/rapid-elearning/

Rapid elearning is about getting the right information to people at the right time. It's more than the tools. It's about empowering people with the knowledge that they need to operate at the speed of business.This 7-part series brings you up-to-speed with some basic ideas about rapid elearning and how to get your project off the ground.

So You Want To Be An E-Learning Hero?
5 Ways To Jump Start Your Next E-Learning Project.
What Everyone Ought To Know About Designing An E-Learning Course.
Build A Simple E-Learning Project Plan.
How To Get The Most Out Of Your Subject Matter Expert.
Understanding Multimedia For Rapid E-Learning Design.
I Just Finished My Rapid E-Learning Course. Now, What Do I Do?
What else do you think beginning rapid elearning developers need to know?

Technologies Convergence

The term *convergence* is commonly used in reference to the synergistic combination of voice (and telephony features), data (and productivity applications) and video onto a single network. These previously separate technologies are now able to share resources and interact with each other creating new efficiencies.

Open Educational Resources

- The term "open educational resources" was first adopted at UNESCO's 2002 Forum on the Impact of Open Courseware for Higher Education in Developing Countries funded by the William and Flora Hewlett Foundation.
- Open educational resources are educational materials and resources offered freely and openly for anyone to use and under some licenses to re-mix, improve and redistribute.
- OER Commons is the first comprehensive open learning network where teachers and professors (from pre-K to graduate school) can access their colleagues' course materials, share their own, and collaborate on affecting today's classrooms. It uses Web 2.0 features (tags, ratings, comments, reviews, and social networking) to create an online experience that engages educators in sharing their best teaching and learning practices.
- http://www.oercommons.org

Open Course Ware

- An OpenCourseWare is a free and open digital publication of high quality educational materials, organized as courses. The OpenCourseWare Consortium is a collaboration of more than 100 higher education institutions and associated organizations from around the world creating a broad and deep body of open educational content using a shared model. The mission of the OpenCourseWare Consortium is to advance education and empower people worldwide through opencourseware.

- The Goals
- Extend the reach and impact of opencourseware by encouraging the adoption and adaptation of open educational materials around the world.
- Foster the development of additional opencourseware projects.
- Ensure the long-term sustainability of opencourseware projects by identifying ways to improve effectiveness and reduce costs.

- http://www.ocwconsortium.org/

On-Line Resources you can use

- Online instruction –E-learning1.0
- Video lectures
- Podcast(Utube)
- Public news,govnt,journals,tech news
- OCW

Available Engg Materials

- IEEE Courses
- ACM Courses
- Other Courses

On-line open course ware

This can be a quick approach to get important new material into Engineering Schools.

It is also an opportunity to make a major step forward in the task of Learning to learn.

Open Course Ware is present at KFUPM and MIT. Let us consider the OCW ethics course at MIT an see how it could be of use

Why Engineering Ethics now?

- The increasing concern for the value dimension of engineering is, at least in part, a result of the attention that the media has given to cases such as the Challenger disaster, the Kansas City Hyatt-Regency Hotel walkways collapse, and the Exxon oil spill. As a response to this concern, a new discipline, engineering ethics, is emerging.
- This discipline will doubtless take its place alongside such well-established fields as medical ethics, business ethics, and legal ethics.
- The problem presented by this development is that most engineering professors are not prepared to introduce literature in engineering ethics into their classrooms. They are most comfortable with quantitative concepts and often do not believe they are qualified to lead class discussions on ethics. Many engineering faculty members do not think that they have the time in an already overcrowded syllabus to introduce discussions on professional ethics, or the time in their own schedules to prepare the necessary material.
- To address the need for course material The National academy of engineering of the US has opened the "On-line Ethics Center"
- http://www.onlineethics.diamax.com/

Free Online Course Materials | MIT OpenCourseWare

http://ocw.mit.edu/OcwWeb/web/home/home/index.htm

Gmail – UPDATE ON TRAVEL S... | Free Online Course Materials | ...

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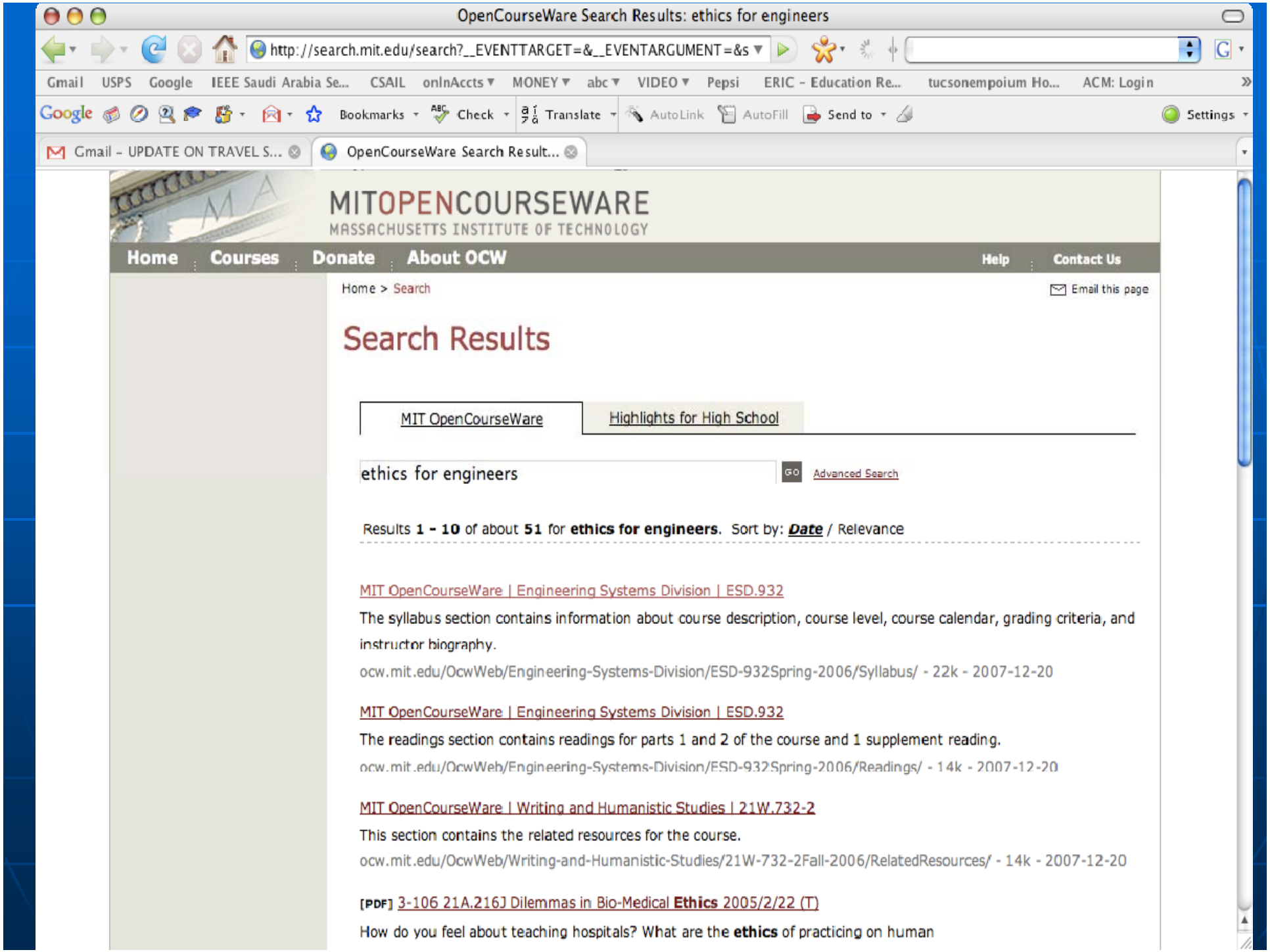
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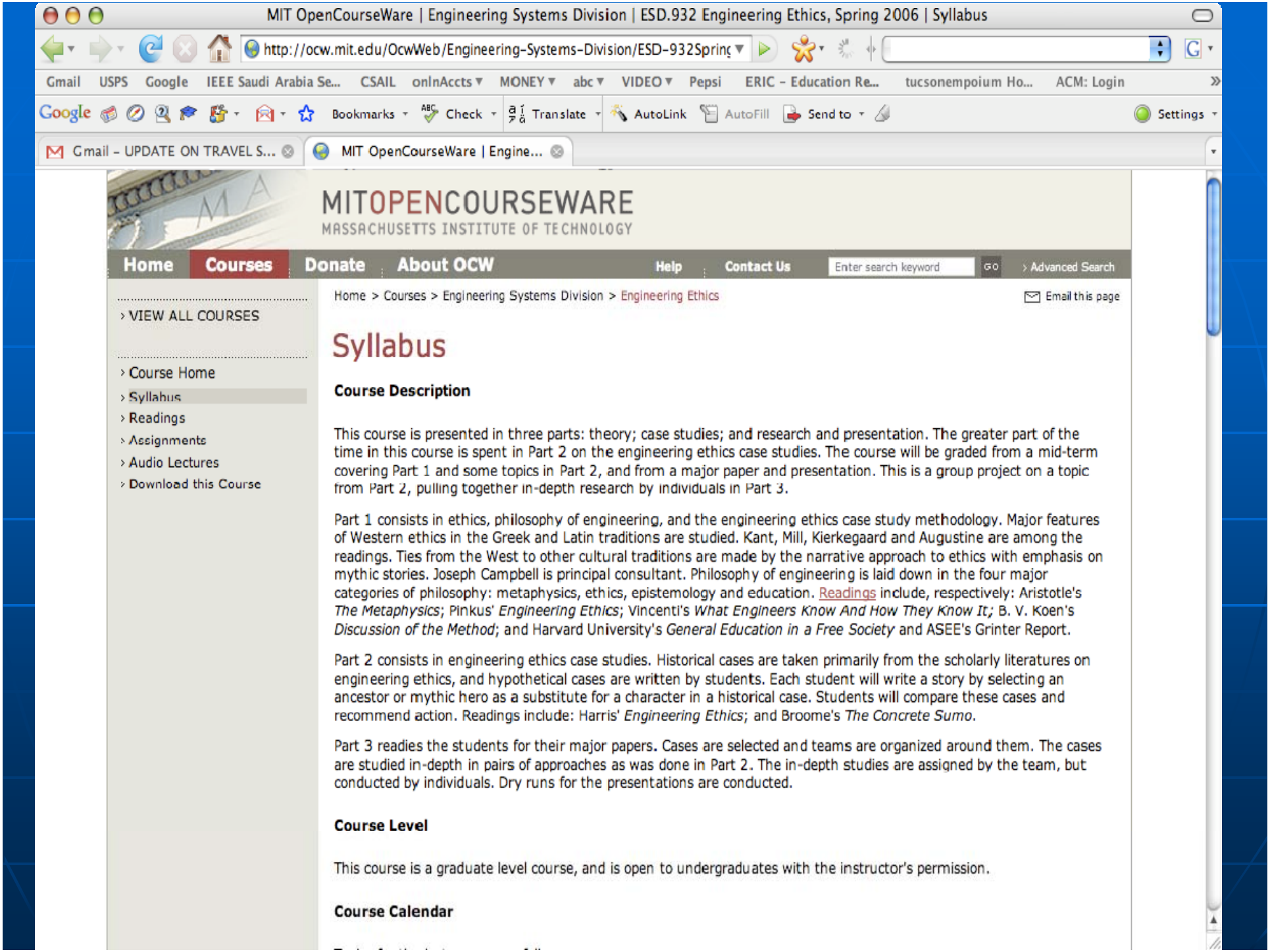
MIT OpenCourseWare | Engineering Systems Division | ESD.932
The syllabus section contains information about course description, course level, course calendar, grading criteria, and instructor biography.
ocw.mit.edu/OcwWeb/Engineering-Systems-Division/ESD-932Spring-2006/Syllabus/ - 22k - 2007-12-20
MIT OpenCourseWare | Engineering Systems Division | ESD.932
The readings section contains readings for parts 1 and 2 of the course and 1 supplement reading.
ocw.mit.edu/OcwWeb/Engineering-Systems-Division/ESD-932Spring-2006/Readings/ - 14k - 2007-12-20
MIT OpenCourseWare | Writing and Humanistic Studies | 21W.732-2
This section contains the related resources for the course.
ocw.mit.edu/OcwWeb/Writing-and-Humanistic-Studies/21W-732-2Fall-2006/RelatedResources/ - 14k - 2007-12-20
[PDF] 3-106 21A.216J Dilemmas in Bio-Medical Ethics 2005/2/22 (T)
How do you feel about teaching hospitals? What are the ethics of practicing on human


MIT OpenCourseWare | Engineering Systems Division | ESD.932 Engineering Ethics, Spring 2006 | Syllabus
http://ocw.mit.edu/OcwWeb/Engineering-Systems-Division/ESD-932Spring
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Syllabus
Course Description
This course is presented in three parts: theory; case studies; and research and presentation. The greater part of the time in this course is spent in Part 2 on the engineering ethics case studies. The course will be graded from a mid-term covering Part 1 and some topics in Part 2, and from a major paper and presentation. This is a group project on a topic from Part 2, pulling together in-depth research by individuals in Part 3.
Part 1 consists in ethics, philosophy of engineering, and the engineering ethics case study methodology. Major features of Western ethics in the Greek and Latin traditions are studied. Kant, Mill, Kierkegaard and Augustine are among the readings. Ties from the West to other cultural traditions are made by the narrative approach to ethics with emphasis on mythic stories. Joseph Campbell is principal consultant. Philosophy of engineering is laid down in the four major categories of philosophy: metaphysics, ethics, epistemology and education. Readings include, respectively: Aristotle's The Metaphysics; Pinkus' Engineering Ethics; Vincenti's What Engineers Know And How They Know It; B. V. Koen's Discussion of the Method; and Harvard University's General Education in a Free Society and ASEE's Grinter Report.
Part 2 consists in engineering ethics case studies. Historical cases are taken primarily from the scholarly literatures on engineering ethics, and hypothetical cases are written by students. Each student will write a story by selecting an ancestor or mythic hero as a substitute for a character in a historical case. Students will compare these cases and recommend action. Readings include: Harris' Engineering Ethics; and Broome's The Concrete Sumo.
Part 3 readies the students for their major papers. Cases are selected and teams are organized around them. The cases are studied in-depth in pairs of approaches as was done in Part 2. The in-depth studies are assigned by the team, but conducted by individuals. Dry runs for the presentations are conducted.
Course Level
This course is a graduate level course, and is open to undergraduates with the instructor's permission.
Course Calendar

Course Calendar

Topics for the lectures are as follows.

Instructors: TB = Dr. Taft Broome

LEC #	TOPICS	INSTRUCTORS
Part 1: Theory		
1	Introduction to the Course: Purpose, Objectives, Scope, Methods, Discussion	TB
2	Introduction to Ethics I	TB
3	Introduction to Ethics II; Initial Discussion of B. F. Goodrich Case	TB
4	Introduction to Philosophy of Engineering I	Prof. Joel Moses
5	Introduction to Philosophy of Engineering II	TB
6	Introduction to Engineering Ethics: Codes of Ethics, Whistle Blowing, Case Study Methodology	TB
7	Case Studies: Finish Challenger Case; Ford Pinto Case	TB
Part 2: Case Studies		
8	Case Studies: Chernobyl, Three Mile Island	TB
9	Case Studies (cont.): News Articles	TB
10	Case Studies: Chernobyl, Three Mile Island (cont.)	TB
11	Case Studies: B. F. Goodrich A7D Air Force Brakes	TB
12	First Principles of Engineering Ethics	TB
	Mid Term	
	Mid Term	
13	Solving Ethical Problems: Discussion of Heroes, Journeys, and Virtue in Mythology	TB
14	Individual, Professional, and Institutional Values	Prof. Sheila Widnall
15	Leadership in Engineering and Industry	TB
16	Competency with Good Character	TB
17	Recap of Semester so Far; Introduction to Codes of Ethics	TB
18	Codes of Ethics (cont.)	TB
19	Safety; Introduction to Narrative Ethics	TB
20	Ethical Terminology	TB
Part 3: Research Projects		
21	Planning for Public Seminar; Terminology (cont.)	TB
22	Public Seminar on Narrative Ethics Purpose: to initiate a systematic approach to the problems of identifying cross-cultural issues in the ethical education of science and engineering students, and extract from these issues lessons that may enhance the research experience in the globalization process	TB with Prof. Segun Gbadegesin, Howard University
23	Human Flourishing	TB
24	Student Presentation	Students
	Final Exam: Final Written Report	

Readings

Students are expected to read the following works associated with Parts 1 and 2 of the course. This page also contains a supplemental reading: a draft preface to Professor Broome's forthcoming book on engineering ethics.

Part 1 Readings

Aristotle. *The Metaphysics*. (Download a version of this from the Internet Classics Archive.)

"The Grinter Report: Summary of the Report on Evaluation of Engineering Education." American Society for Engineering Education (ASEE).

Davis, M., ed. *Engineering Ethics*. Burlington, VT: Ashgate Publishing Co., 2005. ISBN: 0754625249.

Harris, C. E., et al. *Engineering Ethics*. 2nd ed. Belmont, CA: Wadsworth, 1999. ISBN: 0534533973.

Harvard University. *General Education in a Free Society*. Cambridge, MA: Harvard University Press, 1945. ISBN: 0674342518.

Koen, B. V. *Discussion of the Method: Conducting the Engineer's Approach to Problem Solving*. New York, NY: Oxford University Press, 2003. ISBN: 0195155998.

Mitcham, C. *Thinking Through Technology: The Path Between Engineering and Philosophy*. Chicago, IL: University of Chicago Press, 1994. ISBN: 0226531988.

Pinkus, R. L. B., et al. *Engineering Ethics: Balancing Cost, Schedule, and Risk - Lessons Learned from the Space Shuttle*. New York, NY: Cambridge University Press, 1997. ISBN: 0521437504.

Vincenti, W. G. *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History*. Reprint ed. Baltimore, MD: The Johns Hopkins University Press, 1993. ISBN: 0801345882.

Part 2 Readings

Broome, T. H. *The Concrete Sumo*. Cleveland, OH: Online Ethics Center for Engineering and Science, Case Western Reserve University, 1999.

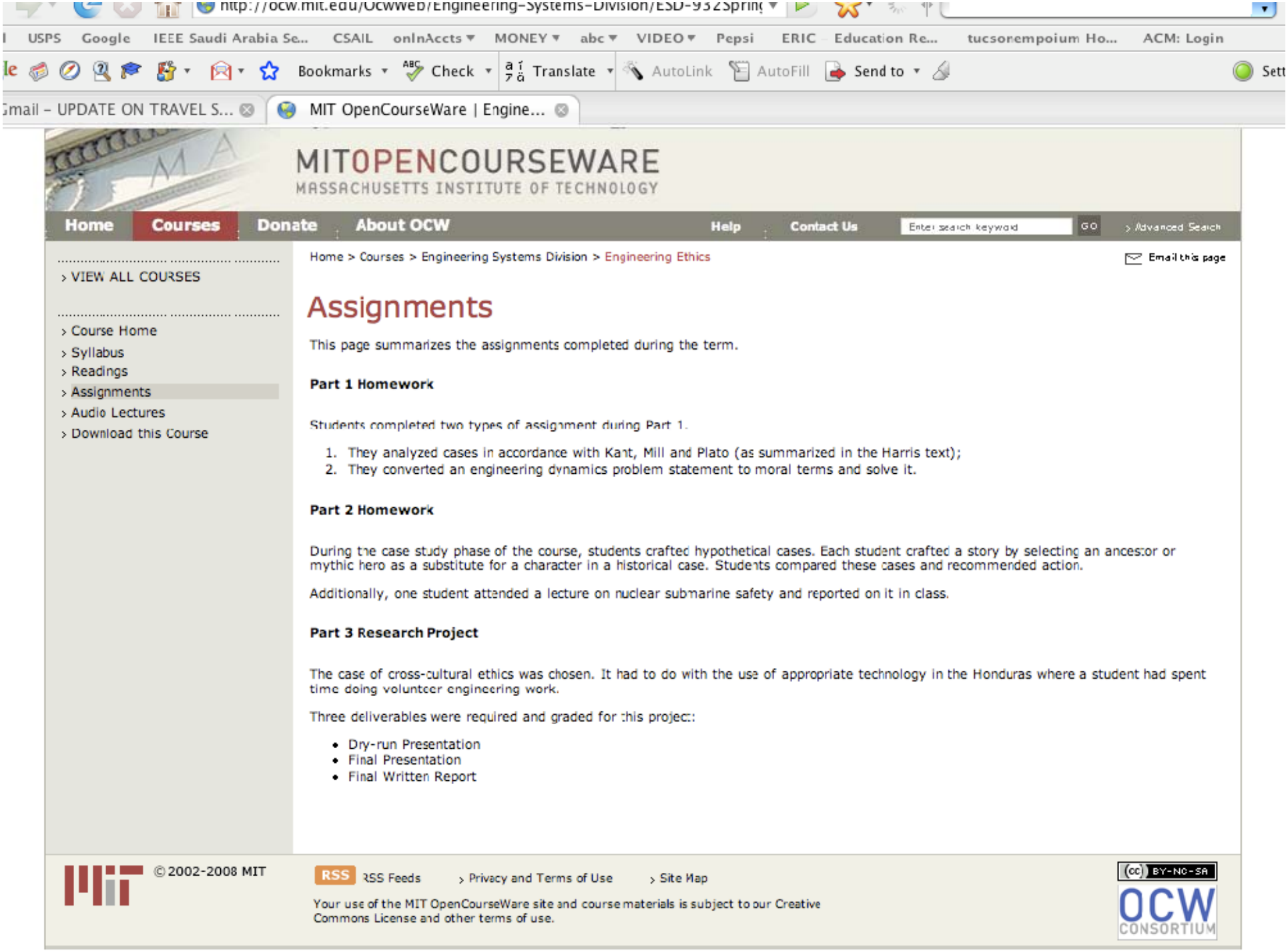
Harris, C. E., et al. *Engineering Ethics*. 2nd ed. Belmont, CA: Wadsworth, 1999. ISBN: 0534533973.

Pinkus, R. L. B., et al. *Engineering Ethics: Balancing Cost, Schedule, and Risk - Lessons Learned from the Space Shuttle*. New York, NY: Cambridge University Press, 1997. ISBN: 0521437504.

Supplementary Reading

Professor Broome is completing a book related to this course. A draft of the preface is presented here as a supplementary reading.

The Nature of Engineering - Author's Preface (PDF)


http://ocw.mit.edu/OcwWeb/Engineering-Systems-Division/ESD-932Spring
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Download this Course
Home > Courses > Engineering Systems Division > Engineering Ethics
Email this page
Assignments
This page summarizes the assignments completed during the term.
Part 1 Homework
Students completed two types of assignment during Part 1.
1. They analyzed cases in accordance with Kant, Mill and Plato (as summarized in the Harris text);
2. They converted an engineering dynamics problem statement to moral terms and solve it.
Part 2 Homework
During the case study phase of the course, students crafted hypothetical cases. Each student crafted a story by selecting an ancestor or mythic hero as a substitute for a character in a historical case. Students compared these cases and recommended action.
Additionally, one student attended a lecture on nuclear submarine safety and reported on it in class.
Part 3 Research Project
The case of cross-cultural ethics was chosen. It had to do with the use of appropriate technology in the Honduras where a student had spent time doing volunteer engineering work.
Three deliverables were required and graded for this project:
• Dry-run Presentation
• Final Presentation
• Final Written Report
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Audio Lectures

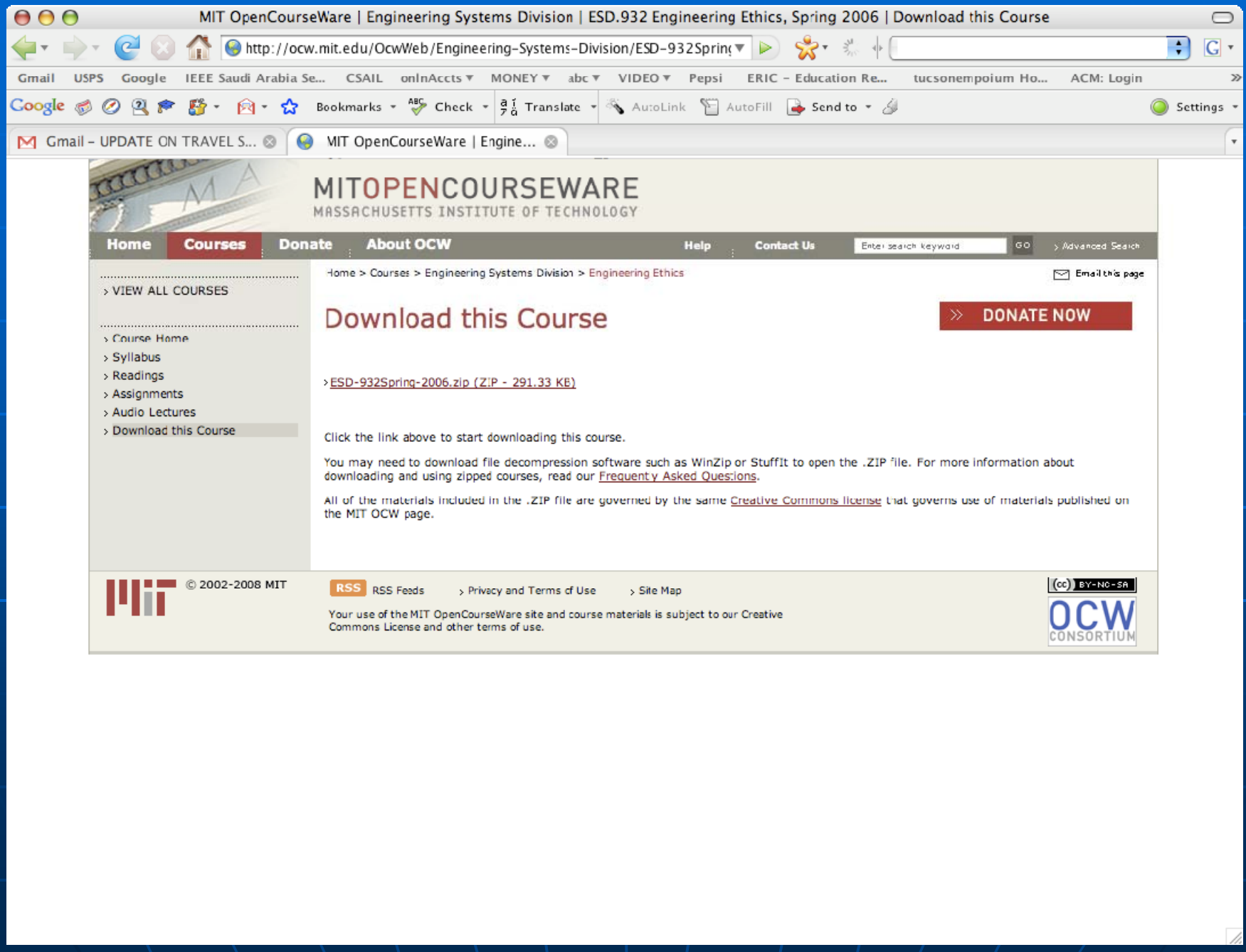
Special software is required to use some of the files in this section: .mp3.

Audio files for guest lectures are presented courtesy of the instructors, and used with permission.

These files are also available for download from iTunes®.

udiolectures

LEC #	TOPICS	INSTRUCTORS	AUDIO LECTURES
Part 1: Theory			
1	Introduction to the Course: Purpose, Objectives, Scope, Methods, Discussion	TB	
2	Introduction to Ethics I	TB	
3	Introduction to Ethics II; Initial Discussion of B. F. Goodrich Case	TB	(MP3 - 14.4MB)
4	Introduction to Philosophy of Engineering I	Prof. Joel Moses	(MP3 - 17.3MB)
5	Introduction to Philosophy of Engineering II	TB	(MP3 - 18.6MB)
6	Introduction to Engineering Ethics: Codes of Ethics, Whistle Blowing, Case Study Methodology	TB	(MP3 - 18.9MB)
7	Case Studies: Finish Challenger Case; Ford Pinto Case	TB	(MP3 - 17.4MB)
Part 2: Case Studies			
8	Case Studies: Chernobyl, Three Mile Island	TB	(MP3 - 17.9MB)
9	Case Studies (cont.): News Articles	TB	(MP3 - 15MB)
10	Case Studies: Chernobyl, Three Mile Island (cont.)	TB	(MP3 - 17.4MB)
11	Case Studies: B. F. Goodrich A7D Air Force Brakes	TB	(MP3 - 12.6MB)
12	First Principles of Engineering Ethics	TB	(MP3 - 22.8MB)
13	Solving Ethical Problems: Discussion of Heroes, Journeys, and Virtue in Mythology	TB	(MP3 - 17.7MB)
14	Individual, Professional, and Institutional Values	Prof. Sheila Widnall	(MP3 - 17.3MB)
15	Leadership in Engineering and Industry	TB	(MP3 - 13.5MB)
16	Competency with Good Character	TB	(MP3 - 16.7MB)
17	Recap of Semester so Far; Introduction to Codes of Ethics	TB	(MP3 - 17.9MB)
18	Codes of Ethics (cont.)	TB	(MP3 - 17.1MB)
19	Safety; Introduction to Narrative Ethics	TB	(MP3 - 16.7MB)
20	Ethical Terminology	TB	(MP3 - 18.1MB)
Part 3: Research Projects			
21	Planning for Public Seminar; Terminology (cont.)	TB	(MP3 - 18.3MB)
22	Public Seminar on Narrative Ethics Purpose: to initiate a systematic approach to the problems of identifying cross-cultural issues in the ethical education of science and engineering students, and extract from these issues lessons that may enhance the research experience in the globalization process	TB and Prof. Segun Gbadegesin, Howard University	(MP3 - 22.7MB)
23	Human Flourishing	TB	(MP3 - 16.1MB)
24	Student Presentation	Students	(MP3 - 13.8MB)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- Get two friends and sign a "contract"
- Plan the schedule of study1
- Plan to test yourselves by writing one question each from each lecture
- Have a graduation ceremony and award each other Certificates of Completion

Conclusion

- *Prepare for more change*
- *As brain sciences and IT drive us*
- *Learn to learn, efficiently, effectively (set goals and then self-test)*

THANK YOU

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