ENV 281F, Fall 2016
Special Topics in the Environment: Is the Internet Green?

Prof. Miriam Diamond	**Prof. Steve Easterbrook**
Dept. of Earth Sciences Office: 22 Russell St. rm 3141 Phone: 416 978-1586 E-mail: miriam.diamond@utoronto.ca Office hours: Wednesday 2-4pm	Dept. of Computer Science 40 St George Street. Phone: 416-978-3610 E-mail: sme@cs.toronto.edu

Course basics are posted on **Blackboard**. We are also using **Piazza** for content delivery and course interaction. Consider these multiple platforms as a "meta" opportunity to think about the key themes in the course.

- **Piazza enrolment: piazza.com/utoronto.ca/fall2016/env281f**
- **Piazza link: https://piazza.com/utoronto.ca/fall2016/env281f/home**

Class Meetings: Tuesday 2-4 pm AB 107; Tutorials Tuesday 4-5pm KP 113 and Thursday 4-5pm SS 1078

Teaching Assistants: Sean Grisdale (Dept. of Geography) and Tim Rodgers (Dept. of Chemical Engineering and Applied Chemistry)

Course theme:

Every year instructors at the University of Toronto are asked if your course is "green" – "where steps have been taken to reduce the use of paper". The implicit "flip side" of that question is that we use computer technology, and likely the Internet, to distribute and gather course materials and assignments. What are the environmental benefits to using computer technology and the Internet rather than paper to exchange information as the question about "greening your course" assumes? We will probe this question and beyond to look at the Internet and information technologies (IT) through the lens of environmental sustainability.

And why should we dedicate a course to examining the environmental sustainability of the Internet? In only a few decades, the Internet has come to permeate virtually all aspects of our lives in addition to education, from how we build and maintain friendships to how we shop, to the way we think and solve problems and retrieve information. Although we are very familiar with and extensively use the Internet, few of us understand the inner workings of the technology. Further, the Internet has many unintended consequences at personal, societal, and environmental levels, whether it is Bitcoin or cloud computing, health apps or minerals in your cell phone. Our task is to think critically about the choices (and lack of choices) that this new technology brings us, and to explore and act on the intended and unintended consequences and responsibilities that come with IT. This course intends to help us make informed choices and be active participants rather than passive consumers of IT.

Course objectives:

This course examines and debates the environmental sustainability of the Internet, including intended and unintended consequences, using lectures, in-class activities, tutorials and real-world examples that foster critical thinking and problem solving. The course will introduce you to disciplinary and interdisciplinary modes of inquiry and engagement.

What you will learn in the course:

- How to probe the breadth, depth and interconnectedness of a system as complex as the Internet; how complex phenomena defy simple explanations, and why it's important to think and solve problems with the help of multiple disciplines.
- Critical thinking and facility with tools for creative and effective problem solving as individuals and in groups.
- Improved scientific literacy and communication skills, through: 1) a deeper understanding of how Internet technologies work; 2) how to assess environmental benefits and costs of the Internet; and 3) how to clearly communicate your ideas using a variety of forms.

Required Texts:

A reading packet of articles is available at Scholar House Productions (shpprint.com) at 100 Harbord Street (just west of Spadina on the south side), 416 977-9641. The cost is $62 including taxes. Plus, we recommend additional readings, videos, and multi-media internet sources weekly.

Course Evaluation:

Assignment 1: Measure the carbon footprint of your IT devices	**Due October 18; 25**	20%
Assignment 2: Unintended consequences of IT: the problem and solutions. Group project.	**Due November 22, 29**	30%
Reading summaries (five over the term)	Throughout the term	10%
Tutorial participation		10%
Final Exam	Final exam period	30%

Coursework Assignments (50% overall): Each assignment is workshopped in tutorials, and then completed outside of class time. You will have the opportunity to improve each assignment through a peer review process.

- Assignment 1 is completed individually. It involves tallying IT devices owned and used by yourself and your family. You will then calculate the embodied carbon emissions contained in those devices.
- Assignment 2 is conducted in groups of 2-4 students. You will explore unintended environmental consequences of <u>one</u> aspect of IT and develop options and a plan for averting or minimizing those consequences. Examples include environmental sustainability of the use of conflict minerals in IT devices, and the social sustainability of mass production of IT devices.

Marking rubrics for each assignment will be available one week before the submission date. Some of the criteria included in the rubrics include depth of critical analysis, coverage of the literature, coherence and comprehensibility, and presentation.

All assignments due in hard copy at the beginning of class on the first due date (Tuesday 2pm). Bring two hard copies of the assignment to class. One we will collect. You will take the second copy of that assignment for peer review in tutorial that week. The following week the final hard copy of the

assignment is due at the beginning of class (Tuesday 2pm). Late assignments should be submitted to the School of the Environment dropbox located at the School of the Environment, by room 1049A in Bancroft Wing of Earth Sciences Building.
All assignments should include the following information:

- Your name
- Title of assignment
- Course title and number
- Instructor's name
- TA's name
- Double or 1.5 line spacing using 12 point type in black ink with 2.5 cm (1 inch) margins
- Include page numbers

Reading summary. You will submit a summary of five required readings of your choice over the duration of the term. Summaries of websites or videos are not eligible. The summary should be 1 page in length or 250-350 words total. Each is worth a maximum of 2% for a total of 10%. A summary for a reading is due before it is discussed in class. Submit in hard copy at the beginning of class. You are responsible for keeping track of the number of reading summaries you submit.
Tutorial participation. Ten tutorials of one hour duration will be held over the course. Please attend and participate! Full attendance and participation will earn you 10%.
Final exam. A two hour final exam worth a maximum of 30% will be held during the exam period at the end of term. The exam will be a combination of short answer and a few long answer questions based on lectures, readings and assignments. You may bring a one page summary of information to the exam.

Class Policies:

Late Penalty for assignments: A lowering of the grade by one increment per day, unless accompanied by a note from a physician, police or registrar, e.g., from B+ to B for 1 day late, B+ to B- for 2 days late including weekends (each day of the weekend is counted). The note must include the dates of absence. Late assignments will not be accepted one week past the due date even if accompanied by a certificate unless you have obtained prior agreement from the instructor.
If you are unable to attend a tutorial, please email your TA and state the reason why. You may be asked to provide documentation such as a note from a physician, police or registrar.
Requests to re-mark your assignment must be submitted in writing to Prof. Diamond and clearly state the reason for your request. Prof. Diamond will respond within a week as to whether your assignment will be remarked. Your assignment will be remarked by your TA.
You can expect a response to a Piazza post within 24 hours on weekdays and 48 hours on weekends. Do not expect responses to questions about assignments within 24 hours of the due date.

Academic Integrity:

Very few have of us have truly original ideas but rather we almost always build on the ideas and information provided by others. We need to re-emphasize that plagiarism — representing someone else's words as your own or submitting work that you have previously submitted for marks in another class or program — is a serious offence. Assignments, reading summaries and exams are reviewed for evidence of these infractions. Penalties for these offences can be severe and can be recorded on your transcript.

- Trust your own ability to think and write and make use of the resources available at U of T that can help you do so (e.g. professors, TAs, writing centres). See the U of T writing website, especially the "How Not To Plagiarize" document at http://www.writing.utoronto.ca/home and the website of the Office of Student Academic Integrity, http://www.artsci.utoronto.ca/osai.

The following is a list of examples (not complete) of what constitutes an academic offence:

- Using someone else's ideas or words without appropriate acknowledgement.
- Copying material word-for-word from a source (including lecture and study group notes) and not placing the words within quotation marks and not citing the author/source.
- Submitting your own work in more than one course without the permission of the instructor.
- Making up sources or facts, including references to sources that you did not use.
- Obtaining or providing unauthorized assistance on any assignment including:
    - Working in groups on assignments that are supposed to be individual work
    - Having someone rewrite or add material to your work while "editing".
    - Lending your work to a classmate who submits it as his/her own without your permission.

On tests and exams:

- Using or possessing any unauthorized aid, including a cell phone
- Looking at someone else's answers
- Letting someone else look at your answers
- Copying material word-for-word from a source (including lecture and study group notes) and not placing the words within quotation marks and not citing the author/source.
- Misrepresenting your identity
- Submitting an altered test for re-grading

Misrepresentation:

- Falsifying or altering any documentation required by the University, including doctor's notes
- Falsifying institutional documents or grades

Participation:

Students are expected to attend every class having prepared their responses to the required readings or videos, etc., and to participate fully in the discussion through both attentive listening and speaking. Research shows that you improve your concentration and recall when you take notes longhand and when you "unplug" from the Internet during class. So, during class please hide your cell phone and minimize your use of computers unless it's necessary.

Accommodation:

The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom or course materials, please contact Accessibility Services as soon as possible: accessibility.services@utoronto.ca or http://studentlife.utoronto.ca/accessibility

Reading/Viewing/Listening hints:

As you read, listen, and/or watch, take notes on the following:

1) **Identify the key terms in the reading**. Think about how the author(s) defines these terms and uses them in the broader argument.
2) **Note key concepts that relate to other readings/lectures** in the course and that help you to understand the main themes in the course and their interrelationships, i.e., build bridges between the readings and lectures.

3) **Note methods used** to investigate the topic or solve the problem. How could you use this method?
4) **Write down any questions** that arise when in lecture and reading (no question is stupid!).
5) **Look up words/concepts** in the reading that you do not understand. Reading with a dictionary at your side is the best way to expand your vocabulary!
6) **Explore the context for the reading.** As you know, the Internet is moving fast! How recently was it published? At what stage in the development of the Internet was it written? What type of publication did it appear in? How does it relate to other readings you have met?

Remember, when writing down a quote, **always put quotation marks around the author's words** and note the page number from which you are quoting. This will provide you with a good basis of quotes for later writing assignments, and will help you to develop responsible practices of note-taking in line with the requirements of academic integrity.

LECTURE SCHEDULE AND READINGS

1) Sept. 13: Why is this course about the Internet and why the question "is it green"?

We will introduce the professors, the course themes, and the students to each other, through a combination of in-class activities and short lectures.

Required Reading:

- Naughton, J. The Internet: Everything You Ever Need to Know, The Observer, Sunday June 20, 2010. http://www.theguardian.com/technology/2010/jun/20/internet-everything-need-to-know

Recommended Sources:

- Can the digital revolution be environmentally sustainable? https://www.theguardian.com/global/blog/2015/nov/13/digital-revolution-environmental-sustainable
- Explore: Internet Society, 2012 Global Internet User Survey Key Findings http://www.internetsociety.org/surveyexplorer/key_findings
- Watch: Manuel Lima on the Power of Networks: https://www.youtube.com/watch?v=nJmGrNdJ5Gwhttps://www.youtube.com/watch?v=nJmGrNdJ5Gw

2) Sept 20: Environmental problem solving, systems thinking and the Internet.

Systems thinking is a method of understanding and thus problem solving for complex systems and processes of change within them. We need to adopt a systems thinking approach to explore the question "is the Internet green" because of the complexity of system (the Internet and society). Life cycle assessment is one tool that takes a systems thinking approach. We delve deeper into systems thinking approaches and explore some properties of systems that cannot be understood by studying parts of a system in isolation (e.g. exponential growth, feedback loops, etc).

Required Reading:

- Meadows, D. 2008. Chapters 1 and 2. *Thinking In Systems: A Primer*. Chelsea Green Publishing. Read until the car sales example ("A systems with delays – Business Inventory")

Recommended Readings:

- TBA

3) Sept 27: A very short history of communication technologies leading to "what is the Internet"? Steve Easterbrook

To know the future we need to look at the past. We very briefly review communication technologies that bring us to the Internet. What is the Internet? What is it made of and how does it work?

Required Readings:

- Blum, A. 2012. The Map. In: *Tubes*: *A Journey to the Center of the Internet.* Harper Collins, Toronto. Chapter 1, p. 11-34.
- Read: How Does the Internet Work? http://computer.howstuffworks.com/internet/basics/internet.htm

Recommended Sources:

- Watch: Videos that demonstrate how internet technology works:
  http://www.youtube.com/watch?v=7_LPdttKXPc
  http://www.youtube.com/watch?v=qv0XCaUkfNk
  http://boingboing.net/2012/06/06/fing-internet-how-does-it.html
  http://www.flixxy.com/how-the-internet-works.htm

4) Oct 4: Is the Internet green? An energy analysis. Miriam Diamond

To answer the question "Is the Internet green?" we examine the energy used in IT. We are interested in energy use because of related releases of greenhouse gases and thus contributions to increasing the rate and severity of climate change. We introduce the environmental analysis tools of mass balance analysis and Life Cycle Assessment.

Required Readings:

- Williams, E. 2011. Environmental effects of information and communications technologies. *Nature* 479: 354-358. DOI: 10:1038/nature10682.
  Clark, D. "Google Discloses Carbon Footprint for the First Time". The Guardian, 8 Sept 2011. http://www.guardian.co.uk/environment/2011/sep/08/google-carbon-footprint

Recommended Sources:

- Teehan, P., Kandikar, M. 2013. Comparing embodied greenhouse gas emissions of modern computing and electronics products. *Environmental Science &Technology* 47: 3997-4003. Focus your reading on the Introduction and Results and Discussion.
- Koomey, J.G., Matthews, H.S., Williams, E. 2013. Smart everything: will intelligent systems reduce resource use? *Annual Review of Environment and Resources* 38: 311-343. Read pages 311-315 (read until "Efficiency of low-energy computing), 328-334.
- The Global Footprint Network. http://www.footprintnetwork.org/en/index.php/GFN/
- Williams, D.R., Tang, Y. 2013. Impact of office productivity cloud computing on energy consumption and greenhouse gas emissions. *Environmental Science & Technology* 47, 4333-4340.
- Boyd, S.B., Horvath, A., Dornfeld, D. 2009. Life-cycle energy demand and global warming potential of computational logic. *Environmental Science & Technology* 43, 7303-7309.
- http://www.lowtechmagazine.com/2009/06/embodied-energy-of-digital-technology.html

5) Oct 11: Beyond the carbon footprint: the Internet's resource use. Miriam Diamond

The IT sector is a major user of industrial energy, and high purity, strategic minerals and critical metals. Our rapacious use of these minerals, their "criticality" and difficulties with recycling them may cause shortages which could curb our ability to produce new IT products. Moreover, some of these strategic

minerals are "blood" commodities or have ethical geo-political implications. How do we combine the exponential growth in IT gadgetry with resource limitations? Who pays the price for resource extraction and who benefits from these resources?

Required Readings:

- Reller, A., Bublies, T., Staudinger, T., Oswald I., Meißner S., Allen, M. 2009. The mobile phone: powerful communicator and potential metal dissipator. *GAIA* 18/2: 127-135.
  Moran, D., McBain, D., Kanemoto, K., Lenzen, M., Geschke, A. 2014. Global supply chains of coltan: a hybrid Life Cycle Assessment study using a social indicator. *Journal of Industrial Ecology* 19(3): 357-365. DOI/10.1111/jiec.12206/ Please read the paper except for the methods section (unless you are very interested in the methods used!).

Recommended Sources:

- The trailer for "Blood in the Mobile", film by director Frank Piasecki Poulsen. http://www.youtube.com/watch?v=wQhlLuBwOtE
- Just Minerals. http://cftn.ca/campaigns/just-minerals
- https://www.facebook.com/mineraljustice
- https://www.amnesty.org/en/latest/news/2016/01/Child-labour-behind-smart-phone-and-electric-car-batteries/

6) Oct 18: Resources in and e-waste out. Miriam Diamond

One of the unintended consequences of using so many IT gadgets and frequently upgrading them is the mountain of e-waste that must be dealt with. How big is the mountain of e-waste? What are the environmental, social and economic consequences of the mass of e-waste being produced and how do those consequences vary depending on where you live?

Required Readings:

- Zhang, K., Schnoor, J.L., Zeng, E.Y. 2012. E-waste recycling: where does it go from here? *Environmental Science & Technology* 46: 10861-10867. DOI: 10.1021/es303166s

Recommended Sources:

- Fitzpatrick, C., Hickey, S., Schischke, K. Maher, P. 2014. Sustainable life cycle engineering of an integrated desktop PC: a small to medium enterprise perspective. *Journal of Cleaner Production* 74: 155-160.
- Robinson, B.H. 2009. E-waste: an assessment of global production and environmental impacts. *Science of the Total Environment* 408: 183-191.
- Williams, E., Kahhat, R., Allenby, B., Kavazanjian, E., Kim, J., Xu, M. 2008. Environmental, social and economic implications of global reuse and recycling of personal computers. *Environmental Science & Technology* 42: 6446-6454.
- Listen: CBC Spark with Nora Young. Episode 212: Get it, Keep it, Fix it http://www.cbc.ca/radio/spark/212-get-it-keep-it-fix-it-1.2847823

7) Oct 25: The Environmental Benefits of the internet

We have discussed the energy and resource implications of the internet. However, the internet offers many opportunities and benefits for environmental sustainability. What are some of those benefits? How can the internet contribute to achieving the United Nations Sustainable Development Goals?

Required Readings:

- Internet Society. 2015. The Internet and Sustainable Development. http://www.internetsociety.org/doc/internet-and-sustainable-development

Recommended Sources:

- United Nations Millennium Development Goals http://www.un.org/millenniumgoals/

8) Nov 1: Individual and social impacts of the internet.

With a third of the global population using the Internet and with Internet usage continuing to rise, what are the consequences to individual health? Do we have agency in controlling health impacts? What are the consequences to societal health? Are the health consequences experienced equitably amongst all users?

Required Readings:

- Coyne, S.M., Padilla-Walker, L.M., Howard, E. 2013. Emerging in a digital world: a decade review of media use, effects, and gratifications in emerging adulthood. *Emerging Adulthood* 1(20): 125-137.

Recommended Sources:

- Sigman, A. 2014. Virtually addicted: why general practice must now confront screen dependency. *British Journal of General Practice*, December, pp. 610-611.

Nov 8: Reading Break

9) Nov 15: Health Benefits of the Internet.

Many different health mobile and wearable devices, such as the Apple Watch, have become both digitalized and connected, thus allowing for collecting and sharing biometric data more easily. We will see how these new health and wellness related apps and social media offer new ways to promote health and solve some of the issues created by other technologies. We will also explore issues related to patient privacy.

Required Readings:

- Lupton, D. 2013. Quantifying the body: monitoring and measuring health in the age of mHealth technologies. *Critical Public Health* 23(4): 393–403.

Recommended Sources:

- Electronic Privacy Information Center: https://epic.org/privacy/medical/ try to identify which are the most concerning issues about electronic data privacy according to the EPIC)
- Ungerleider, Neal. "The Latest Privacy Risk? Looking Up Medical and Drug Information Online". *FastCompany* http://www.fastcompany.com/3042763/privacy-risk-looking-up-medical-health-information-online (Accessed August 19, 2015)
- Sennebogen, Emilie. "What Is Cyberchondria?" *HowStuffWorks* http://science.howstuffworks.com/life/cyberchondria.htm (Accessed August 19, 2015).

10) Nov 22: Why do we embrace the Internet and other new technologies? The idea of progress. Steve Easterbrook

The notion of progress has been a dominant idea in western thinking since the enlightenment. The idea that life for each generation should get steadily better shapes our expectations from technology, and pushes us to value innovation and economic growth. This class will explore ideas about progress and innovation from a number of perspectives, including those of other cultures who do not share a myth of

progress, from the historical perspective (including the myths around inventors as "great men of history"), from an environmental perspective where concerns about sustainability on a finite planet come into direct conflict with the growth imperative, and from an economics perspective, where the opportunity cost of investment in internet innovation must be weighed against other ways of investing our time and effort, such as such as clean energy, transport, food production, and social innovation.

Required Readings:

- Franklin, U. 2004. *The Real World of Technology*. Revised Edition, House of Anansi; Toronto. Revised edition. Chapter 1, p. 1-26.
- Huesemann, M. and Huesemann J. 2011. Technological Optimism and Belief in Progress. In Huesemann, M. and Huesemann J. *Techno-Fix. Why Technology Won't Save Us or the Environment.* New Society Publishers; Gabriola Island, Canada. Chapter 7, p.145-159, 167-172.

Recommended Sources:

- Vergragt, P.J. "*How Technology Could Contribute to a Sustainable World*" Great Transition Institute Working Paper, 2006: http://www.gtinitiative.org/documents/PDFFINALS/8Technology.pdf

11) Nov 29: Are we in the midst of a technological revolution?

Some commentators say that IT is the third technological revolution and that we are now in the midst of it. Evidence for the revolution comes from rapid innovation and change in numerous sectors. As with past technological revolutions, no one knows what the future holds but that there are and will be "winners and losers". This is particularly salient for youth employment. We will explore these themes and tie them in with those introduced over the term.

Required Readings:

- Naughton, J. 2012. Chapter 1. Take the long view. In: *What you really need to know about the Internet*. Quercus; London. p. 9-38.

Recommended Sources:

- Franklin, U. 2004. *The Real World of Technology*. Revised Edition, House of Anansi; Toronto. Revised edition. Chapters 7 & 9, p. 134-156.
- Homer-Dixon, T. 2000. *The Ingenuity Gap*. Toronto: Vintage Canada (Random House); Toronto.
- Episode on Spark "Race against the machine" http://www.cbc.ca/player/Radio/Spark/ID/2247357704/

12) Dec 6: Integration and review.

Good grief. The lectures have finished! What did we learn? What are some of the major questions that have been raised but not answered? What should I know for the exam?