DEPT. OF EARTH & ENVIRONMENTAL SCIENCES, UNIVERSITY OF ROCHESTER

Physics of Climate

An Introduction to Atmospheric Physics

EES 236/436

Image Credit: NASA Goddard Space Flight Center

Fall 2021

Syllabus

Last Updated: August 31, 2022

Contents

1 Overview

Course Location: LeChase 181
Course Time: Tu/Th 2:00 PM-3:15 PM Eastern

Recitation Location: Meliora 205
Recitation Time: Fr 2:00 PM-3:15 PM Eastern

Instructor: Prof. Lee T. Murray
Personal Pronouns: he/his/him
E-mail: lee.murray@rochester.edu | @leetmurray
Office Location: Hutchison 479
Office Hours: Tu/Th 12:30-1:30 PM, or by e-mail appointment
Office Hours Link: `https://rochester.zoom.us/j/5748824096`

Teaching Assistant: Nic Litza
Personal Pronouns: he/his/him
E-mail: nlitza@ur.rochester.edu
Office Location: Hutchison 206
Office Hours: M/W 4:00-5:00 PM, or by e-mail appointment
Office Hours Link: `https://rochester.zoom.us/j/7654346002`

1.1 Description

A broad and quantitative overview of the basic features of Earth's climate system and the underlying physical processes. Topics include the global energy balance, atmospheric thermodynamics, radiative transfer, cloud microphysics, atmospheric dynamics, general circulation, weather systems, surface processes, ocean circulation, and climate variability and forecasting. Students will understand what drives present-day temperature, precipitation, and wind patterns, as well as major modes of natural climate variability including the El Niño-Southern Oscillation phenomenon and Ice Age cycles, and extreme weather. We will learn how the rise of human civilization has influenced the climate system, and how this legacy and our future actions can influence climate in the coming century.

1.2 Pre-requisites

Required, unless granted permission by instructor:

- PHY 121 (Mechanics) or equivalent

Additionally required for EES 436, unless granted permission by instructor:

- MTH 165 (Linear Algebra with Differential Equations) or equivalent

1.3 Main Learning Goals

The overarching goals of this class are:

1. Graphical literacy: Draw conclusions from atmospheric and other data by creating and interpreting plots and graphs.

2. Investigative thinking: Be able to use logic, data, reasoning, critical thinking, and/or the scientific method to formulate and/or answer a question that is posed about atmospheric systems and climate.
3. Societal and personal relevance: Apply principles from the course to inform everyday choices relating to weather and climate (e.g., weather safety, weather maps, climate change adaptation and mitigation.)
4. Enthusiasm for atmospheric science: Develop an enthusiasm for the skills and perspectives of atmospheric and climate science.
5. Physical processes: Identify and explain the basic physical processes that drive Earth's climate system (e.g., energy distribution, phase changes, stability, winds and currents), and be able to apply logic to predict how processes are impacted as conditions change. These include ability to:
    - Distinguish between weather and climate processes
        - Identify examples of weather and climate
        - Appreciate regional differences in weather and climate and their respective causes
        - Distinguish the temporal and spatial scales associated with weather and climate processes
        - Appreciate the differences in the predictability of the weather versus the predictability of the climate
        - What is and what is not evidence for anthropogenic climate change?
    - Understand the context of our present-day climate in space and time
        - How and why does Earth's climate differ from those of Venus or Mars?
        - In what past climate states has Earth existed? What may have driven these differences?
        - What drives Ice Age advances and retreats?
        - What are the major modes of present-day climate variability and their respective causes?
        - How does anthropogenic climate change compare to natural climate variability?
    - Describe the global distribution of incoming/outgoing/net energy and the influence of the atmosphere on the Earth's temperature. Appreciate how this impacts global temperatures and heat transport in the atmosphere and ocean.
        - Radiation distribution, including longwave and shortwave radiation, and the seasons
        - The greenhouse effect
        - How radiation interacts with and is transformed by Earth's atmospheres via absorption, emission, and scattering
        - Global net radiation budgets
    - Explain how phase changes of water occur, and how they impact weather and climate.
        - What leads to water vapor condensation in the atmosphere?
        - Relative versus absolute measures of humidity
        - Latent and sensible heat
        - Cloud formation and precipitation
    - Understand how the atmosphere is coupled to the ocean, cryosphere, biosphere, and/or solid Earth.
        - The carbon cycle
        - Wind stress and its influence on upwelling, sea ice processes, thermohaline circulation
        - Tropical cyclone and sea surface temperature feedbacks
        - El Niño-Southern Oscillation
        - Land-sea breezes and monsoon circulations

  - Interaction between physical circulations and the distribution of life (e.g. phytoplankton)
- Name and describe the dynamics that drive atmospheric circulation across multiple spatial and temporal scales, and use physical principles to predict how processes will evolve over time.
  - Buoyancy and vertical stability
  - Pressure gradient, Coriolis, centrifugal, and frictional forces
  - Geostrophic and thermal wind balances
  - The planetary boundary layer
  - Trade wind patterns
  - Oceanic wind-driven and thermohaline circulations
  - Air masses and fronts
  - Midlatitude cyclones
  - Tropical cyclones

2 Readings

Note, students do not need to purchase any course materials. All readings may be accessed from their blue links. However, some may require you to be on the campus network or VPN if off campus (see University IT for directions).

2.1 Required

Books

Hartmann, D. L. (2016), *Global physical climatology*, 2 ed., Elsevier, Amsterdam, doi:10.1016/C2009-0-00030-0.

Stull, R. (2017), *Practical Meteorology: An Algebra-based Survey of Atmospheric Science*, 1.02b ed., Univ. of British Columbia, https://www.eoas.ubc.ca/books/Practical_Meteorology/.

Articles and Excerpts

Arrhenius, S. (1896), On the influence of carbonic acid in the air upon the temperature of the ground, *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, *41*(251), 237–276, doi:10.1080/14786449608620846.

Charlson, R. J., J. E. Lovelock, M. O. Andreae, and S. G. Warren (1987), Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate, *Nature*, *326*(6114), 655–661, doi:10.1038/326655a0.

Charney, J. G., A. Arakawa, D. J. Baker, B. Bolin, R. E. Dickinson, R. M. Goody, C. E. Leith, H. M. Stommel, and C. I. Wunsch (1979), *Carbon Dioxide and Climate*, National Academies Press, Washington, D.C., doi:10.17226/12181.

Ferrel, W. (1856), An essay on the winds and the currents of the ocean, *Nashville J. of Medicine and Surgery*, *11*(4), 13, https://en.wikisource.org/wiki/An_essay_on_the_winds_and_the_currents_of_the_ocean.

Fourier, J.-B. J. (1827), Mémoire sur les températures du globe terrestre et des espaces planétaires, *Mémoires de l'Académie Royale des Sciences*, *7*, 569–604, https://geosci.uchicago.edu/~rtp1/papers/Fourier1827Trans.pdf.

Hadley, G. (1735), Concerning the cause of the general trade-winds, *Philosophical Transactions of the Royal Society of London*, *39*(437), 58–62, doi:10.1098/rstl.1735.0014.

Hansen, J., A. Lacis, D. Rind, G. Russell, P. Stone, I. Fung, R. Ruedy, and J. Lerner (1984), Climate sensitivity: Analysis of feedback mechanisms, *Climate Processes and Climate Sensitivity: Geophysical Monograph Series*, pp. 130–163, https://pubs.giss.nasa.gov/docs/1984/1984_Hansen_ha07600n.pdf.

Hansen, J., et al. (2005), Earth's energy imbalance: confirmation and implications., *Science*, *308*(5727), 1431–1435, doi:10.1126/science.1110252.

Hays, J., J. Imbrie, and N. Shackleton (1976), Variations in the earth's orbit: Pacemaker of the ice ages., *Science*, *194*(4270), 1121–1132, doi:10.1126/science.194.4270.1121.

Manabe, S., and R. T. Wetherald (1967), Thermal equilibrium of the atmosphere with a given distribution of relative humidity, *Journal of the Atmospheric Sciences*, *24*(3), 241–259, doi:10.1175/1520-0469(1967)024<0241:teotaw>2.0.co;2.

Mann, M. E., R. S. Bradley, and M. K. Hughes (1999), Northern hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations, *Geophysical Research Letters*, *26*(6), 759–762, doi:10.1029/1999gl900070.

Plass, G. N. (1956), The influence of the 15μ carbon-dioxide band on the atmospheric infra-red cooling rate, *Quarterly Journal of the Royal Meteorological Society*, *82*(353), 310–324, doi:10.1002/qj.49708235307, https://geosci.uchicago.edu/~archer/warming_papers/plass.1956.radiation.pdf.

Price, C. G. (2013), Lightning applications in weather and climate research, *Surveys in Geophysics*, *34*(6), 755–767, doi:10.1007/s10712-012-9218-7.

Sellers, W. D. (1969), A global climatic model based on the energy balance of the earth-atmosphere system, *Journal of Applied Meteorology*, *8*(3), 392–400, doi:10.1175/1520-0450(1969)008<0392:agcmbo>2.0.co;2.

Tyndall, J. (1861), On the absorption and radiation of heat by gases and vapours, and on the physical connexion of radiation, absorption, and conduction, *Philosophical Transactions of the Royal Society of London*, *151*, 1–36, doi:10.1098/rstl.1861.0001.

WMO (2021), State of the Global Climate 2020, *WMO-No. 1264*, https://library.wmo.int/doc_num.php?explnum_id=10618.

2.2 Supplemental

Books

Holton, J. R., and G. J. Hakim (2013), *An Introduction to Dynamic Meteorology*, 5 ed., Elsevier, Amsterdam.

IPCC (2013), *Climate Change 2013: The Physical Science Basis*, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, doi:10.1017/CBO9781107415324.

Marshall, J., and R. A. Plumb (2007), *Atmosphere, Ocean, and Climate Dynamics: An Introductory Text*, 1 ed., Elsevier, Burlington, MA.

Wallace, J. M., and P. V. Hobbs (2006), *Atmospheric Science: An Introductory Survey*, 2 ed., Elsevier, Amsterdam.

3 Schedule

3.1 Lectures

Below is the tentative class schedule, with topics for each class, associated readings, problem set due dates, and exam dates. The schedule is subject to change pending course progress.

Tuesday	Thursday
Aug 24th	26th **1** **Overview** Key Topics 1. Course Description and Expectations 2. Overview of Present-Day Climate Reading • Syllabus • *WMO* (2021) link
31st **2** **History and Evolution of Earth's Climate** Key Topics 1. Early Earth Climate (Hadean to Tertiary) 2. Quaternary Climate (Ice Age Cycles) 3. The Anthropocene Reading • *Hartmann* (2016) §9 ——— 436 Weekly Journal Club • *Mann et al.* (1999)	Sep 2nd **3** **Atmospheric Basics** Key Topics 1. Atmospheric Structure and Composition 2. Pressure, Temperature, Density 3. Equation of State (Ideal Gas Law) 4. Hydrostatic Balance (Barometric Law) Reading • *Stull* (2017) §1 • *Hartmann* (2016) §1.1-1.4

<table>
<tr><th>TUESDAY</th><th>THURSDAY</th></tr>
<tr><td>7th 4
Atmospheric Thermodynamics I
Key Topics
1. First Law of Thermodynamics
2. Adiabatic Lapse Rate
3. Potential Temperature
Reading
• Stull (2017) §3.1-3.4
• Hartmann (2016) §1.6
<hr>436 Weekly Journal Club
• Fourier (1827)</td><td>9th 5
Atmospheric Thermodynamics II
Key Topics
1. Atmospheric Water Vapor
2. Saturation Vapor Pressure
3. Moist Pseudoadiabatic Lapse Rate
Reading
• Stull (2017) §4
• Hartmann (2016) §1.5</td></tr>
<tr><td>14th 6
Atmospheric Thermodynamics III
Key Topics
1. Static Stability
2. Conditional Instability
3. Convection
Reading
• Stull (2017) §5
• Hartmann (2016) §1.6 (revisit)
<hr>436 Weekly Journal Club
• Tyndall (1861)
<hr>PS1 due by 7 PM</td><td>16th 7
Global Energy Balance I
Key Topics
1. The Radiation Spectrum
2. Blackbody Radiation (Planck's Law; Stefan-Boltzmann Law)
3. Effective Temperature
4. Albedo
Reading
• Stull (2017) §2
• Hartmann (2016) §2.1-2.4</td></tr>
<tr><td>21st 8
Global Energy Balance II
Key Topics
1. Greenhouse Effect
2. Global Radiative Flux Energy Balance
3. Top-of-the-Atmosphere Flux Distribution
Reading
• Stull (2017) §21.1
• Hartmann (2016) §2.5-2.9
<hr>436 Weekly Journal Club
• Arrhenius (1896)
<hr>PS2 due by 7 PM</td><td>23rd 9
Global Energy Balance III
Key Topics
1. Top-of-the-Atmosphere Flux Distribution
Reading
• Stull (2017) §21.1
• Hartmann (2016) §2.5-2.9</td></tr>
</table>

Tuesday	Thursday
28th **10** **Atmospheric Radiative Transfer I** Key Topics 1. Selective Absorption and Emission by Atmospheric Gases 2. Scattering of Atmospheric Radiation (Rayleigh; Mie; Optics) Reading • *Stull* (2017) §22.4 • *Hartmann* (2016) §3.1-3.6 --- 436 Weekly Journal Club • *Plass* (1956) --- **PS3 due by 7 PM**	30th **11** **Atmospheric Radiative Transfer II** Key Topics 1. Vertical Radiative Heating and Cooling Rates 2. Radiative Equilibrium 3. Convective-Radiative Equilibrium 4. Clouds and Radiation Reading • *Hartmann* (2016) §3.7-3.13
Oct 5th **12** **Surface Energy Balance I** Key Topics 1. Radiative Heating of the Surface 2. Sensible and Latent Heat Fluxes 3. Turbulence 4. Atmospheric Boundary Layer Reading • *Stull* (2017) §3.6 §18 • *Hartmann* (2016) §4.1-4.5 --- 436 Weekly Journal Club • *Sellers* (1969)	7th **Midterm (In-Class)**
12th **Fall Break**	14th **13** **Surface Energy Balance II** Key Topics 1. Vertical Structure of the Boundary Layer 2. Diel, Spatial and Seasonal Variability in the Boundary Layer Reading • *Stull* (2017) §18 • *Hartmann* (2016) §4.6-4.9

TUESDAY	THURSDAY
19th **14** **Surface Energy Balance III** Key Topics 1. Vertical Structure of the Boundary Layer 2. Diel, Spatial and Seasonal Variability in the Boundary Layer Reading • *Stull* (2017) §18 • *Hartmann* (2016) §4.6-4.9 --- 436 Weekly Journal Club • *Hadley* (1735) • *Ferrel* (1856)	21st **15** **Atmospheric General Circulation I** Key Topics 1. Vorticity and Divergence 2. Apparent Forces (Coriolis, Centrifugal) 3. Real Forces (Gravity, Pressure-Gradient, Friction) Reading • *Stull* (2017) §10
26th **16** **Atmospheric General Circulation II** Key Topics 1. Vorticity and Divergence 2. Apparent Forces (Coriolis, Centrifugal) 3. Real Forces (Gravity, Pressure-Gradient, Friction) Reading • *Stull* (2017) §10 --- 436 Weekly Journal Club • *Manabe and Wetherald* (1967) --- **PS4 due by 7 PM**	28th **17** **Atmospheric General Circulation III** Key Topics 1. Horizontal Force Balances 2. Geostrophy 3. Thermal Wind 4. Barotropic vs. Baroclinic Atmospheres Reading • *Stull* (2017) §11 **EES 436 Term Paper Topics Due**
Nov 2nd **18** **Atmospheric General Circulation IV** Key Topics 1. Hadley, Ferrel and Walker Circulations Reading • *Hartmann* (2016) §6 --- 436 Weekly Journal Club • *Hansen et al.* (2005) --- **PS5 due by 7 PM**	4th **19** **Ocean General Circulation** Key Topics 1. Wind-Driven Circulation 2. Deep Thermohaline Circulation 3. Transport of Energy in the Ocean Reading • *Hartmann* (2016) §7.1-7.8

<table>
<tr><th>TUESDAY</th><th>THURSDAY</th></tr>
<tr><td>9th 20
Weather Systems I
Key Topics
1. Extratropical Cyclones
2. Fronts
Reading
• Stull (2017) §12 §13
<hr>436 Weekly Journal Club
• Hansen et al. (1984)
<hr>PS6 due by 7 PM</td><td>11th 21
Weather Systems II
Key Topics
1. Tropical Cyclones
Reading
• Stull (2017) §16</td></tr>
<tr><td>16th 22
Natural Intraseasonal and Interannual Variability
Key Topics
1. Chaos Theory, Internal Variability and Forecasting
2. Coupled Variability
3. Major Modes of Natural Variability (NAO/AO, SAM, MJO, ENSO, AMOC)
Reading
• Stull (2017) §21.8
• Hartmann (2016) §8
<hr>436 Weekly Journal Club
• Price (2013)
<hr>PS7 due by 7 PM</td><td>18th 23
Natural Climate Forcings
Key Topics
1. Solar Forcing
2. Natural Aerosol Forcing
3. Volcanic Forcing
4. Orbital Forcing (Milankovitch Theory)
Reading
• Stull (2017) §21.2-21.3
• Hartmann (2016) §12
<hr>436 Weekly Journal Club
• Charlson et al. (1987)</td></tr>
<tr><td>23rd 24
Natural Feedbacks
Key Topics
1. Water-Vapor Feedback
2. Planck Feedback
3. Ice-Albedo Feedback
4. Lapse-Rate Feedback
5. Cloud Feedbacks
Reading
• Stull (2017) §21.4-21.9
<hr>436 Weekly Journal Club
• Hays et al. (1976)</td><td>25th
Thanksgiving Break</td></tr>
</table>

<table>
<tr><th>TUESDAY</th><th>THURSDAY</th></tr>
<tr><td>30th 25
Natural Climate Change
Key Topics
1. Solar Forcing
2. Natural Aerosol Forcing
3. Volcanic Forcing
4. Orbital Forcing (Milankovitch Theory)
5. Natural Feedbacks
Reading
• Stull (2017) §21.2-21.9
• Hartmann (2016) §12
<hr>436 Weekly Journal Club
• Charney et al. (1979)
PS8 due by 7 PM</td><td>Dec 2nd 26
Anthropogenic Climate Change I
Key Topics
1. Global Warming Potential
2. Greenhouse Gases (CO_2, CH_4, N_2O, Halocarbons, Ozone)
3. Aerosols
4. Land-Use Change
Reading
• Hartmann (2016) §13.1-13.12</td></tr>
<tr><td>7th 27
Anthropogenic Climate Change II
Key Topics
1. Past, Present, and Future Anthropogenic Forcing
2. Detection and Attribution
3. Future Projections
Reading
• Hartmann (2016) §13.13-13.17
<hr>PS9 due by 7 PM
436 Term Paper Drafts Due by Fri Dec 4 @ 5 PM</td><td>9th
Reading Period</td></tr>
<tr><td>14th
Exam Period</td><td>16th
Exam Period</td></tr>
</table>

3.2 EES 236 Recitation

In addition to lectures, there will be a recitation session held each Friday from 2-3:15 PM, in which the TA will go over example problems similar to the homework and exams, and answer any questions from the class. EES 236 students are required to participate in the recitations. EES 436 students are welcome to attend as well, but not required.

3.3 EES 436 Journal Club

There will be a 1-hr required journal club held each week (time TBD based on graduate student availability), in which a scientific paper or two of relevance to the class will be discussed. Students enrolled in EES 436 will take turns each week in introducing their paper, including relevant background, methods and conclusions. Students enrolled in EES 236 are welcome to join if they are interested.

4 Grading

Students enrolled in EES 236 will have their grade determined as follows:

EES 236	
Problem Sets:	40 %
Midterm:	20 %
Final Exam:	30 %
Quizzes:	10 %
Total:	100 %

A student's final grade will determined as a percentage of total points accumulated, from which letter grades will then be assigned.

Students enrolled in EES 436 will have their grade determined as follows:

EES 436	
Problem Sets:	40 %
Midterm:	20 %
Term Paper:	25 %
Journal Club Participation:	10 %
Quizzes:	5 %
Total:	100 %

4.1 Problem Sets

There will be approximately weekly problem sets assigned on material covered in previous lectures and readings, except during weeks with exams.

The aim of the problem sets is to help you learn the course concepts. Working together with your classmates is thus encouraged, although problem sets should always be solved and written up individually. **If you collaborate, write with whom you worked on your submission**.

Show all work, explaining in sufficient detail how you arrived at the answer. Describe the rationale behind each step using language like "Convert from kg to molecules" or "Apply the hypsometric equation to determine layer thickness." Partial credit for ultimately wrong answers will be assigned based on work shown. **A correct answer with no work shown earns no credit.** A numerical answer without units is incorrect.

Problem sets are due digitally via GradeScope by the date and time indicated (Tuesdays at 7 PM Eastern). After that, 10% is deducted off the possible total score for each day late. No credit is given after one week late.

All problem sets will be scored from 0-100 % of total points. Your lowest problem set score will be dropped; all other problem sets will be weighted equally.

Students enrolled in EES 436 will have additional problems per homework assignment.

4.2 Exams

All exams will be comprised of a multiple-choice section, a short-answer section, and a longer quantitative problem section.

4.2.1 Midterm

There will be one midterm exam that will test qualitative content from Lectures 1-11 and have quantitative problems based on Problem Sets 1-3.

4.2.2 EES 236 Final

There will be one comprehensive final exam for students enrolled in EES 236. The final will contain content from throughout the course, with a greater emphasis on the second half.

4.3 Quizzes

At the end of each lecture, there will be a short quiz on the main concept covered by the reading and/or lecture for that day.

4.4 EES 436 Term Paper

Students enrolled in EES 436 will be required to write a term paper in lieu of a final exam. The paper must be 20 pages, including figures and references, with 10 pt font and 1.5 line spacing. Paper topics will be chosen by the student in consultation with Prof. Murray to reflect their own research and interests, but must be related to atmospheric physics and climate. Students will be required to submit a rough draft for feedback of at least 15 pages length two weeks before the final deadline.

The term paper **must be written following the Style Guide and Reference Format of the American Geophysical Union**, including proper in-line citations consistent with the university Academic Honesty policies.

5 Classroom Policies

5.1 Diversity and Inclusion

This class is an inclusive and welcoming learning environment for all students regardless of background or ability, consistent with University policy, state and federal laws and the instructors' personal beliefs. Students must respect the different experiences, identities, beliefs and values expressed by their peers, and refrain from derogatory comments about other individuals, cultures, groups, or viewpoints.

Please make sure that I am pronouncing your name correctly, and let me know if you have any preferred nicknames and/or pronouns that you would like me to use.

In the event you encounter any barrier(s) to full participation in this course due to the impact of a disability, please contact the Office of Disability Resources. The access coordinators in the Office of Disability Resources can meet with you to discuss the barriers you are experiencing and explain the eligibility process for establishing academic accommodations. You can reach the Office of Disability Resources at: disability@rochester.edu; (585) 276-5075; Taylor Hall; http://www.rochester.edu/college/disability.

5.2 COVID-19

You are expected to adhere to all University policies regarding the COVID-19 pandemic (vaccination, masking, distancing, staying home if you have any symptoms, etc.). Please make sure you stay up to date on these policies, as they continually evolve.

Given the extraordinary circumstances of the COVID-19 pandemic, I acknowledge that students may be subject to a host of pressures and difficulties that will make learning this semester especially difficult. I encourage you to meet with me about any concern or situation that affects your ability to complete your academic work successfully.

5.3 Electronic Devices

Cell phones must be silenced. You may use a laptop or tablet to take notes. Mobile devices and laptops may also be used for prepared active learning activities. However, they should not be used for anything else during class. If a peer tells me your actions on your laptop are distracting during a lecture, you will lose the privilege.

6 Academic Honesty

All assignments and activities associated with this course must be performed in accordance with the University of Rochester's Academic Honesty Policy. A comprehensive description of the University of Rochester's Academic Honesty Policy is available at: http://www.rochester.edu/college/honesty. For this course, all exams and reports need to be completed individually, but I encourage collaboration on the problem sets.

7 Intro Meeting

I would like to learn about your background and goals, both for this course and for the future, to help tailor the semester to those interests. You are encouraged to schedule via e-mail a short 5-minute Zoom meeting early in the semester. The meeting is entirely optional and will not impact your grade.

8 Credit Hour Policy

This course follows the College credit hour policy for four-credit courses, which stipulates that students are expected to complete an "extra period" in addition to the course instructional time of two or three class periods per week. In this course, students enrolled in EES 236 will use this "extra period" for the mandatory recitation, and students in EES 436 through the mandatory journal club. Students may also use this "extra period" for meeting with the instructor and/or TA problem sets, as well as for other enriched independent study, including reading, preparing presentations and working on problem sets and group reports.

9 Feedback

I want you to get the most out of this class. Students are encouraged to offer feedback at any time about the course and my instruction to me in person, through e-mail to lee.murray@rochester.edu, or via an anonymous note placed in my departmental mailbox located in Hutchison Hall 227. At the end of the course, I would greatly appreciate if you fill out the course review.