MONT 104N – Modeling the Environment
Information on Midterm Exam
October 15, 2018

General Information and Groundrules

As announced in class and on the revised course schedule online, the midterm exam for our Montserrat seminar will be given in class on Friday, October 26.

- This will be a full period, individual exam. No sharing of information with others in any form will be permitted during the exam.
- You may use a calculator during the exam, but *no other electronic devices.*
- There will be three or four mathematical problems (each possibly with a few separate parts). These questions will be similar to things you have seen on the problem sets or the group projects from *Chapters 1 - 4* of our text. Some sample exam questions are given later in this document.
- The exam will also include an essay question on a set topic given below. As you will see, part of this consists of three factual questions. You will need to look up some information before coming to the exam to write this part of the essay. Then, the rest of the essay topic asks you to take a stand one way or another about whether this can be justified on ethical grounds. There's no one right or wrong answer for that part; the point there is to get you to think about the issues and try to formulate a position of your own. This section of the exam will take you about 15 minutes or so, so it will be necessary to spend some of your preparation time on deciding what you want to say.

Background for the Essay

Unless you have been following the emerging scientific discipline of *synthetic biology*, you might not be aware that humans today *are already able to create new forms of life almost "from scratch,"* at least on the single-cell level. By this, I mean that we can create life forms by building them up from simpler building blocks (in a way similar to what Victor Frankenstein did in Mary Shelley's novel), not by selective breeding to guide evolution to produce new traits in an existing species, as we have been able to do for thousands of years. For instance, in 2010, a research group headed by Craig Venter (who had earlier spearheaded the Human Genome Project) announced that they had been able create a new species of bacteria by removing the genetic material (DNA) from one bacterial cell and replacing it by alternative DNA *that they had synthesized in their lab from simpler chemical components.* The resulting cells successfully reproduced, hence Venter argued they should be considered as a new, synthetic form of life. In 2016, the same lab announced that they had created another synthetic microbe (that they called Syn 3.0) by a similar process, but using only 473 genes (about 500,000 base pairs of synthesized DNA). One interesting feature of this work is that this seemed to be the *smallest number* of genes that would produce a viable life form of this type. Yet even the scientists who did this work admitted

that they had no idea what about 30% of the genes they had included in Syn 3.0 were actually doing(!).

Essay Prompt

Why is there great interest in creating synthetic bacteria and other single-cell organisms? For what jobs might they be useful? On the other hand, what potential dangers have people suggested in this kind of work? Considering *Frankenstein* as a warning, is this something we should be pursuing with our technology? Are the potential good effects enough to outweigh the possible dangers?

Sample Mathematical Questions

Disclaimer: The actual exam questions will cover the same mathematical topics and will be at approximately the same level of difficulty. However the organization and the content may be completely different.

I. The following table gives estimates of the amounts of carbon (in units of 10^{15} kilograms) contained in the major "reservoirs" of this element on planet Earth:

Reservoir	Carbon Content
Atmosphere	.59
Crust (as fossil fuels)	3.7
Vegetation	2.3
Shallow Ocean	.9
Deep Ocean	37.3

A. What percent of the total carbon present on Earth is contained in each of these reservoirs?

Reservoir	Percent of Total Carbon
Atmosphere	_____
Crust (as fossil fuels)	_____
Vegetation	_____
Shallow Ocean	_____
Deep Ocean	_____

B. Construct and draw a chart (your choice of type) showing how the total carbon breaks down into these categories.

II. Burning coal provides between 9500 and 14000 BTUs of heat energy per pound. Using the information below, answer questions A and B:

- 1 lb $\doteq$ .454 kg
- 1 BTU $\doteq$ .252 Kilocalorie

A. Express the heat energy from burning one pound of coal as a range of values in Kilocalories. Give the endpoints of your range in scientific notation.
B. What is the range of heat energy values provided by burning 1 kilogram of coal, expressed in BTUs?
C. If the 9500 BTU figure comes from bituminous coal and the 14000 BTU comes from anthracite coal, what is the percentage difference in heat energy between anthracite and bituminous?

III. The Honda Civic comes in a standard (gasoline engine) version and a hybrid (gasoline-electric) version. The standard version has a fuel efficiency of about 34 miles per gallon, while the hybrid version gets about 44 miles per gallon. The hybrid version has a "sticker price" (that is, the cost to buy the car new) about $4000 more than the standard. You drive about 10000 miles per year. Assume that gasoline will average $3.00 per gallon over the life of your vehicle.
 A. How many gallons of gasoline would you use to drive the 10000 miles with each version?
 B. What is the difference between your costs for gasoline with the two versions?
 C. If you bought the hybrid version, about how many years would it take for your savings in gasoline costs to make up for the difference in sticker price?

IV. The link next to the one where you downloaded this review sheet shows a spreadsheet scatter plot. Place a check next to the best responses to the questions below.

A. (5) The least squares regression line for this data set would have a slope m about:
$m = -.1$ _____
$m = .3$ _____
$m = 1$ _____

B. (5) Based on the scatter plot, the R^2 statistic is probably:
between .8 and 1 _____
between .4 and .6 _____
between .2 and .4 _____
between .0 and .2 _____