Appendix A. Lab on the Carbon Footprint of Bicycling

Procedure

In this lab, we will examine the carbon footprint of bicycling. You will systematically study the carbon dioxide (CO_2) emission of this activity as a function of time, rate of cycling, and so on. The data obtained from your study will be compared to the emissions from other forms of transportation, such as cars, airplanes, etc. (see your textbook for more information). Because your experiment will be performed in a closed room, you will first need to record the following information:

Volume of the room = _____(cubic meters)

To gather the rest of the data, please choose a volunteer from each group to participate in the biking experiment. You will need the following information:

Mass of the person _____ (kilograms)

Gender of the person _____

Height of the person _____ (meters)

Note: density of CO_2 = 0.001977 grams/milliliter (g/mL) = 1.97 x 10^{-6} kilograms/milliliter (kg/mL) = 1.97 x 10^{-3} kilograms/liter (kg/L)

Experiment 1

In the first experiment, you will estimate the CO_2 output over time with the person in the room but not bicycling.

TABLE 1
Carbon dioxide output when not biking.

Time (minutes)	Concentration of CO_2 (parts per million; ppm)	Mass of CO_2 in room

Experiment 2

In the second experiment, you will estimate the CO_2 output over time with the person in the room and bicycling at a steady rate (that is, a fixed speed).

TABLE 2
Carbon dioxide output when biking at a steady rate.

Time (minutes)	Concentration of CO_2 (ppm)	Mass of CO_2	Mass of CO_2 added due to biking in room

Biking speed = _____

Experiment 3
In the final experiment, you will estimate the CO_2 output corresponding to bicycling at different speeds. For each speed, you will need to bike for a whole minute before you ramp up to the next speed. Record the CO_2 emitted at the end of the minute.

TABLE 3
Carbon dioxide output as a function of increasing speeds.

Biking speed (miles/hour; mph)	Concentration of CO_2 (ppm)	Mass of CO_2	Mass of CO_2 added due to biking in the room

Analysis

Based on the data you have collected, complete the following:

1. Graph the mass of CO_2 in the room (from Table 2) as a function of time (Graph G1). Does the rate of production of carbon dioxide keep increasing or reach a steady state?

2. Graph the mass of CO_2 in the room (from Table 3) as a function of cycling speed (Graph G2). Do you observe any patterns? Does the mass, height, or gender make any difference?

3. One gallon of gasoline produces about 6.36 kg of CO_2. Use this to estimate how much (in kilograms) of CO_2 is produced by your car (you will need to know how many miles per gallon your car delivers) in a year of driving. Estimate your annual driving mileage; this will give your CO_2 output in kilograms.

Appendix B. Final Exam Questions

Part I: Essay

- Research your preferred alternative energy source and write a paper on the subject.
- After presenting readers with all the facts, you will make pro and con assumptions based on your presented data and conclude with a resolution of support for or against the energy source.

Part II: Calculations

- Based on one of the calculations performed in the lab, we found that a single person breathing normally and sitting in a room that has a volume of 20 cubic meters produced roughly 5 grams of carbon dioxide in 10 minutes. Using this rough estimate, calculate how much CO_2 (in kilograms) will be emitted by a single person over the course of an entire year. Then calculate the same for the entire (current) human population on Earth.
- In the process of doing work, such as biking, we release additional CO_2. Assuming we release 10 grams in 10 minutes, then estimate the mass of CO_2 released by a world in which people bike throughout the year (a bit unrealistic, perhaps). Use the same approach as you did in the previous question.
- It is estimated that only about 45% of the carbon dioxide released from the Earth settles into the atmosphere; the rest is taken up by land and oceans. If the portion of atmosphere where CO_2 can accumulate extends about 100 kilometers beyond the surface of the planet, find the concentration (in parts per million [ppm]) of CO_2 (in kilograms) released into the atmosphere over a year for the entire planet by (i) people doing no work and (ii) people biking all year. (Note that the radius of the Earth is about 6371 kilometers.)