Lab 2
CS 123 Computation Lab III
Spring 2010
Directions and Problems

Overview
There are two parts to this lab. Part 1.1 asks you to turn the HVAC simulation script you built in Lab 1 into a Maple procedure (function). This will make it easier to invoke multiple times. Part 1.2 asks you to connect the HVAC procedure to some of the graphical user interface widgets which will make the simulation easier to use. Part 2 asks you to solve some college-level math problems with some of Maple's more advanced computational functions.

Pre-lab preparation
1. Reading: chapters 16 and 17. Review older chapters and labs as needed. Parts 1 and 2 of this lab require you to use the HVAC simulation that you built in Lab 1, so you should put your working HVAC simulation script from Lab 1 in a place from which you can conveniently download them to your lab computer when you do the Lab.
2. Practice with the input and output widgets by getting the slider/plot example given in Chapter 16 to work in a fresh Maple worksheet.
3. Create variations of the example problems solved in chapter 17, and use Maple to solve them. For example, change the numbers to generate a variant of a problem, and imitate the example given to see if you can get the solution to the variant. You should be able to use the Maple operations for calculus and optimization to solve them, and you should verify that your answers are correct. While the course staff will be happy to help you with the computational issues that arise when doing these kinds of problems, we can't help too much if you're not prepared for a mathematical workout.
4. As you read chapter 17, note that there is significant math content. This lab requires you to use some of the pre-calculus and calculus that the mathematics course pre-requisites and co-requisites have covered. If you are rusty, you should review the math before the lab.
5. Take the pre-lab quizlet 2 at the CS 122 Maple TA web site. You should do quizlet 2 before lab to be prepared for the first lab.

Problems (80 minutes)

Problem 1.1
Import a copy of your HVAC simulation from your prior work. Save this worksheet as CS123Lab2Prob1.mw.
Convert your script into a Maple procedure named HVACSimulator, in the following way:

Follow the steps laid out in Chapter 15 for converting scripts. The parameters of your procedure should be:

- TotalTime, in minutes
- dt, in minutes
- aFunc, the name of the function controlling airflow.
- fFunc, the name of the function controlling the state of the fan.
- T0, the external temperature, in degrees F.
- Tea, the cooled air temperature, in degrees F.
- If, the amount of air pushed into the room by the fan running on its low setting (in cubic feet per minute)
- hf, the amount of air pushed into the room by the fan running on its high setting

Everything else should be declared to be a local variable.

The results returned by the procedure should be the plot data structure containing the combined plot of the external temperature and the the zone temperature.

We supply a model template as a suggestion for how this function should be laid out, contained in CS123Lab2Starter1-1.mw. If you are using different variables in your simulation, you will have to edit the use of variables in the function as well as filling in the blanks.

We could set up the function so that all the symbols used in the simulation formulae would be procedure parameters, but this would require a lot of typing to use the function. We will presume that the use of the other symbols won’t change very often so they can be fixed within the procedure definition. If we needed to change those, we would have to edit function definition.

Once you have your procedure working, open the file CS123Lab2Prob1-1Tests.mw. Copy and paste each test one at a time into the worksheet. Execute the test and verify that your function is working correctly. You can right-click->Expand Code Edit Region in order to see or modify each test.

After you have gotten your procedure to pass the tests, modify the tests to answer the following questions:

i) Approximately, what is the steady state temperature achieved when the outside temperature is 85, the cool air temperature is 57 and the airflow control airFlow1 is used?
ii) In the regime described in test 3, what is the approximate minimum outdoor temperature that forces the AC to cycle between high and low speeds?

Problem 1.2

Create a copy of the file you were using in Problem 1. Name it CS123Lab2Prob1-2.mw.

Create sliders, text boxes, buttons, and a plot area resembling the figure below. Configure and program them so that pressing the button runs the HVAC1 simulation on the specified fan flows.
Sample GUI interface to HVAC simulation

The user is supposed to set the sliders, then press the Draw Plot button. This will cause the simulation to run and display the results in the plot area.
Problem 2

Anton, Calculus 8th ed. Example 5, p. 314. A closed cylindrical can is to hold 1 liter (1000 cm$^3$) of liquid. How should we choose the height and radius to minimize the amount of material needed to manufacture the can?

Notes on getting the solution

Let $h$ be the height (in cm) of the can
Let $r$ be the radius (in cm) of the can
Let $S(r, h)$ be the function describing the surface area (in cm$^2$) of the can expressed in terms of $r$ and $h$.
Let $V(r, h)$ be the function describing the volume of the can (in cm$^3$) expressed in terms of $r$ and $h$.

As Anton explains, the first step is to use the formulae for surface area and volume to derive a specific equation relating $r$ and $h$ for a 1000 cm$^3$ can. You can look up for formulae for the volume and surface area of a cylinder at web areas such as http://math.about.com/od/formulas/ss/surfaceareavol_3.htm. Don't forget that the surface area includes the the top and the bottom of the can.

Assign the variable $\text{volume}$ the formula for volume of a can. This should be a formula involving $r$ and $h$.

Assign the variable $\text{surface}$ the formula for the surface of a can. This should be a formula involving $r$ and $h$.

Solve $\text{volume}=1000$ for $h$. What you get should be a formula involving only $r$, describing the relationship between $h$ and $r$ for a 1000 cm$^3$ can. Assign the solution to the variable $\text{hexpr}$.

Evaluate $\text{surface}$ for $h=\text{hexpr}$. Assign this result to the variable $\text{objExpr}$, which is short for "objective expression". We don't call it "objFunction" because it isn't a Maple function as defined by the -> notation, just a formula (a.k.a "expression").

Optimization[Minimize]($\text{objExpr}$) will tell you the value of $r$ that minimizes the surface area. Assign the result of invoking Optimization[Minimize] to the variable $\text{minResult}$. Consult Example 12.3.1 to refresh your memory about how to use $\text{minResult}$ so that you can evaluate $\text{hexpr}$ to get the height of the cylinder that minimizes the surface area.

Compare your result to the exact solution you get from minimize and maximize.

Final actions (end of class)

Upload copies all of your work to Blackboard, or email copies to yourself and/or your partners. Be sure to get credit for doing this on the verification sheet before you leave. If you cannot complete the work in the lab period, talk to the instructor before you leave about whether you can
get credit for anything beyond what you finished.