CSC 260, Spring 1999 - Assignment #3

Due in tutorial on April 9. Worth 10% of the course grade.

Note that this assignment is to be done by each student individually. You may discuss it in general terms with other students, but the work you hand in should be your own.

In this assignment, you will use your `circspline` procedure and Maple procedures for numerical integration and for finding the zero of a function to solve a somewhat contrived business decision problem.

The problem: A electrical power company is thinking of installing some number of solar power generating panels, to replace power that is currently generated by burning coal. To satisfy demands by environmentalists, the company would like to replace as much of their current power generation by solar power as possible, as long as it ends up costing them no more money (in total) to generate power than it would if they generated it all by burning coal.

The cost of maintenance, depreciation, and interest on investment for each solar power panel is 16 thousand dollars per year. This cost is the same regardless of whether or not the panel is actually used to generate power.

The amount of power each solar power panel can generate varies over the year (due to the angle of the sun, the weather, etc.). This amount has been measured at four equally-spaced times over the course of a year (end of March, end of June, end of September, and end of December). The amount of power that one solar power panel can generate at these times of the year, in Gigawatt-hours per year, is as follows:

$$0.04,\ 0.06,\ 0.05,\ 0.02$$

The amount that each panel can generate at other times of the year should be obtained by smoothly interpolating from these numbers. This interpolation should be done circularly, since the end of one year is followed by the start of the next year. You should use your `circspline` procedure from the last assignment, or you can read one I wrote into your Maple program with the command

```
> read `/u/radford/circspline.mp`;
```

The cost of generating one Gigawatt-hour of power by burning coal is 800 thousand dollars. This is just the cost of fuel, since the cost of building the coal-fired power plants has already been incurred. By replacing coal generation by solar power generation, the company saves this fuel cost.

The amount of electricity that customers use varies during the course of the year. This amount has also been measured at four equally-spaced times during the year (the same times as for the solar power production data). The consumption, in Gigawatt-hours per year, is as follows at these four times:

$$7.1,\ 3.7,\ 2.3,\ 6.7$$

You should circularly interpolate these numbers to get the consumption at other times of the year.

The power company has a facility for storing solar power for a few days (only), allowing it to be used at night, when it's cloudy, etc. (This and some related aspects of this problem are actually a bit unrealistic.) Solar power can therefore be used to replace coal-generated power up to the capacity of the quantity of solar panels available. If consumption is less than the total capacity for solar generation, the potential to generate the excess power will be wasted.

For this assignment, you should use the `bisection` and `intrect` procedures for finding zeros and for integrating functions that are listed at the end of this assignment. You can read these into your program as follows:

```
> read '/u/radford/bisection.mp';
> read '/u/radford/intrect.mp';
```

Note that the way the `intrect` procedure is called is a bit different from the similar procedure in the lecture notes.

For the computations below, set Digits to 5, and use 100 rectangles in `intrect`.

Question 1: [20 marks] Use the `circspline` procedure to interpolate the data on solar power production and on power use by customers. Save the interpolation functions, in terms of an unknown time variable `t`, in global variables called `solar` and `use`. Hand in plots of these functions for time going from 0 to 1, representing the start of the year to the end of the year.

Question 2: [20 marks] Write a procedure called `saving`, which computes the amount of coal-fired power generation being saved by use of the solar power panels at a given time of the year. The answer will be in units of Gigawatt-hours per year. This procedure should take two parameters, the time of year (from 0 to 1), and the quantity of solar power panels that are available. It will have to use the `solar` and `use` function that you saved in global variables in question 1.

Hand in a plot of the savings over the course of a year when 80 solar panels are installed.

Question 3: [25 marks] Write a procedure called `total_saved`, which computes the total savings in fuel over one year (in dollars) that is obtained by replacing some or all of the coal-generated power by solar-generated power. This procedure will take one parameter, the quantity of solar power panels that are available. This procedure will have to use the `intrect` procedure to do numerical integration.

Compute and hand in the total amount saved when 80 solar panels are installed.

Question 4: [5 marks] Write a procedure called `total_cost`, which computes the total cost over one year for a given quantity of solar panels.

Question 5: [20 marks] Using the `total_saved`, `total_cost`, and `bisection` procedures, find the maximum quantity of solar panels that the company can install without losing any money compared to what the situation would have been if it hadn't installed any solar power panels. Find this quantity to one decimal place of accuracy.

Queston 6: [10 marks] If the company installs the quantity of solar panels you found in question 5, for what portion of the year will these solar panels be fully used?