Phys 535 **Exercises**

Deadline: Thursday 22 September 2005

Question 1 *Plotting of several functions*

In one plot, combine the graphs of the functions

$$f_n(x) = \frac{x^n e^{-x}}{n!}$$

on the interval $0 \leq x \leq 6$ for $n = 0, 1, 2, 3, 4$

- Label the axes appropriately
- Use different line styles for different values of n
- Produce a PostScript plot of your graph and print it out.

Question 2 *Vector functions with branches*

(a) Implement the sgn function,

$$\operatorname{sgn} x = \begin{cases} -1 & , x < 0 \\ 0 & , x = 0 \\ 1 & , x > 0 \end{cases}$$

for a real, scalar argument x.

(b) 'Vectorize' the function such that, if given an array x, it will return an array of the same dimensions, which each element containing the sign of the corresponding element of x.

Hint: Do *not* use any explicit loop. Use the '`where`' function to vectorize the decision $x \lessgtr 0$.

Question 3 *The Feigenbaum function*

In the interval $x \in [-1, 1]$, the universal Feigenbaum function $g(x)$ can be approximated by

$$g(x) = a_0 + a_2 x^2 + a_4 x^4 + a_6 x^6 + a_8 x^8 + \ldots$$

with

$$\begin{aligned} a_0 &= 1\,, \\ a_2 &= -1.5276329970\,, \\ a_4 &= 0.1048151948\,, \\ a_6 &= 0.0267056705\,, \\ a_8 &= -0.0035274096\,, \\ a_{10} &= 0.00008160097\,, \\ a_{12} &= 0.00002528508\,, \\ a_{14} &= -2.55632 \times 10^{-6}\,. \end{aligned}$$

For $|x| > 1$, the functional relation

$$g(x) = -\alpha\, g[g(x/\alpha)]$$

can be used to map the argument nearer to $x \in [-1, 1]$. Here

$$\alpha = 2.502907875096\ldots$$

is the Feigenbaum *reduction parameter*.

(a) Write a (recursive) IDL function that calculates $g(x)$ for an array argument x [Hint: use one call of the '`where`' function to get indices of the points in the interval $[-1, 1]$ and another one for those not in the interval.

(b) Plot $g(x)$ for $x \in [-30, 30]$ with isotropic axis scaling (i.e. same scale for x and y axis). Use a sufficiently large number of points to make the plot look smooth.

References:

- M. J. Feigenbaum, "Quantitative Universality for a Class of Non-Linear Transformations", *J. Stat. Phys.* **19**, 25–52 (1978).
- `http://mathworld.wolfram.com/FeigenbaumFunction.html`

Question 4 *Quiz*

(a) What are your options to limit the abscissa range of your plot to $[0, 10]$ even if your data's x values are on a different interval? What are the advantages of each approach?

(b) If you want the range to be $[-1.5, 2.5]$, what do you need to set as well?

(c) How can you combine several plots in one window / on one sheet of paper? How do you reset this to get just one plot?

Question 5 *Device-dependent output*

Write a short script that draws a rectangular frame (say, in the form of coordinate axes without data [hint: use '`plot, /NODATA`']) and inside the frame writes 'As square as your screen' if the output is plotted on the screen, or 'Do not print me — save paper!' if the output goes to a PostScript file.

Hint: you can use one of the slots of the structure '`!d`' — find out which one.