Phys 535 **Lab Session**

Exercise 1 *Constructing arrays*

(a) Construct and equidistant array '`equi`' with values $[-5.0, -4.5, -4.0, \ldots, 4.0, 4.5]$

  (a) using an explicit loop (you need to initialize the array first);

  (b) using the '`findgen`' function;

  (c) using the '`linspace`' function.

(b) Construct an array of N equidistant points on the unit circle in the complex plane.

Exercise 2 *Plotting simple functions*

Plot and compare the functions $\sinh\sinh\tanh x$ and $\sin\sin\tan x$ over the interval $[0, 2]$.

Hint: Plot both curves in one graph, distinguishing them by colour or (better unless you have a colour printer) line style.

Label the axes.

Exercise 3 *Multiple plots in one window*

In one window, arrange 12 plots of

$$T_n(x) = \cos(n \arccos x) \tag{1}$$

for $n = 0, 2, \ldots 11$ on the interval $x \in [-1, 1]$. Hint: you need to set the slot '`multi`' of the system variable '`!p`' to get multiple plots in one window.

Bonus questions:

(a) How are the functions $T_n(x)$ called?

(b) How can one plot function values of $T_n(x)$ on the full interval $x \in [-1.1, 1.1]$, i.e. how can we apply Eq. (1) for arguments $|x| > 1$? Show these new plots in a new window, leaving the old one for comparison.

Exercise 4 *Plotting parametric functions*

In IDL, the Bessel function $J_n(x)$ is available as '`beselj(x,n)`'.

(a) Plot the Bessel function $J_1(t)$ over $\sqrt{2/(\pi t)}\,\sin(t + \pi/4)$ for $1 < t < 100$.

(b) Use the same scaling for both axes.

(c) Produce a PostScript plot of your best graph and print it out.

Exercise 5 *Plotting two-dimensional data*

Consider the function

$$f(z) = \frac{1}{(1-x)(1-x^2)(1-x^4)(1-x^8)}$$

of complex argument $z = x + iy$.

(a) Plot $|f(z)| = |f(x,y)|$ as a surface plot for $(x,y) \in [-1.5, 1.5] \times [-1.5, 1.5]$ (make sure the axes don't extend further).

(b) Truncate the data where $|f(z)| > 5$; you can set the values to zero, or retain the phase and set the modulus to 5.

(c) Produce a contour line plot of $|f(x,y)|$, using 30 contour lines

(d) Overplot the unit circle.

(e) Produce a colour-coded plot of $|f(x,y)|$ and overplot the unit circle.

(f) Animate (1-dimensional) plots of $|f(x,y_i)|$, scanning through all values y_i that make up the grid. Make sure the animation is not too fast; indicate the value of y_i in the plot title.

Exercise 6 *Array functions versus explicit loops*

Save the following IDL program to a file '`loop.pro`' and time it using '`time idl loop.pro`' from the shell:

```
N = 10000000
x = linspace(0,10,N)
dx = x[1]-x[0]
f = fltarr(N)
df = fltarr(N)
for i=1L,N-2 do begin $
  f[i] = cos(sinh(x[i])) & $
  df[i] = (f[i+1]-f[i-1])/(2*dx) & $
endfor

exit
```

Now 'vectorize' the loop (i.e. replace it by vector arithmetic statements) and compare execution times.