Laboratory 3 More Programming in MATLAB

This laboratory continues the basics of programming in MATLAB started in laboratory 2. It is designed to give you more practice in MATLAB programming. Mainly, the exercises go beyond those in the previous laboratory in that you are now being asked to devise a solution and then translate this solution into MATLAB code. Topics discussed include M-files, control flow, structures and cell arrays, and more on graphics.

Exercises

Exercise 1

Test your understanding problems: T4.5-3, T4.6-2, T4.7-1 (Intro Matlab 7 ed3); T4.5-1, T4.5-3, T4.6-1 (Intro Matlab 7 ed2); or T4.4-1, T4.4-3, T4.5-1 (Intro Matlab 6).

Easy Plotting

MATLAB has a number of functions for use when data points do not have to be specified exactly. The function `fplot` plots functions defined by a M-file name or function handle. Thus

```
fplot('sin', [0 2*pi])
```

or, equivalently,

```
fplot(@sin, [0 2*pi])
```

plot the sine function over the range shown. MATLAB does the job of working out numbers of data points, etc. The function `title`, `axis`, etc can be used as with `plot`.

The function `ezplot` plots functions defined by string expressions. Using

```
ezplot('sin(x)/x', [-10 10])
```

it plots $\sin(x)/x$ over the range specified. It can also be used to plot an implicit function. For example,

```
ezplot('x^2+(y/3)^2-1', [-2 2 -4 4])
```

plots the ellipse $x^2+(y/3)^2=1$.

Exercise 2

Plot the function $f(x,y)=\sin(x)*\cos(y)$ for $-2\pi \le x \le 2\pi$ and $-2\pi \le y \le 2\pi$.

Exercise 3

Honours were awarded on the basis of a “grand wam”, an average mark over all units of study, weighted according to credit point value and according to the nominal year of each unit of study. The formula is:

$$\text{GWAM} = \sum M_i C_i Y_i \Big/ \sum C_i Y_i$$

Where M is the mark, C the credit point value and Y the year (values of 1, 2, 3 or 4). Honours are awarded as follows: H1 for GWAM ≥75, H2(1) for 75 >GWAM ≥70, H2(2) for 70 >GWAM ≥65. Write a function which will accept a 3-column matrix containing a mark, credit point value and year in each row and will return a value for the GWAM (it could consist of just one line).

Ming obtained the following results :

1st Year		2nd Year		3rd Year		4th Year	
Mark	**CP**	**Mark**	**CP**	**Mark**	**CP**	**Mark**	**CP**
66	6	68	4	76	4	74	12
54	6	77	4	70	4		
		70	4	69	4		

What grade of Honours will he be awarded?

Answer: Second class, division 1.

Exercise 4

Legendre polynomials, $P_n(x),\ n = 0,1,\ldots$ are defined recursively as follows:

$$nP_n(x) = (2n-1)xP_{n-1}(x) - (n-1)P_{n-2}(x) \quad n = 2,3,\ldots \text{ with } P_0(x) = 1,\ P_1(x) = x\,.$$

Write a function that takes an integer n and returns the coefficients of $P_n(x)$ in descending order of powers. Use only one `for` loop.

Use the function `polyval` to evaluate the Legendre polynomial of degree 6 at 0.1.

Answer: $P_6(0.1) = -0.2488$

Exercise 5

The elliptic integral

$$K(k^2) = \int_0^{\frac{\pi}{2}} \frac{dt}{\sqrt{1-k^2\sin^2(t)}}, \quad 0 < k < 1$$

cannot be evaluated in terms of elementary functions. Gauss devised an algorithm to solve this integral which uses a sequence of arithmetic means $\{a_n\}$ and geometric means $\{b_n\}$, where

$$a_0 = 1, \quad b_0 = \sqrt{1-k^2}$$
$$a_n = (a_{n-1} + b_{n-1})/2, \quad b_n = \sqrt{a_{n-1}b_{n-1}}, \quad n = 1, 2, \ldots$$

Both sequences have the same limit g and $K(k^2) = \dfrac{\pi}{2g}$. Also, $a_n > b_n$ for all n.

Write a MATLAB function that computes the elliptic integral $K(k^2)$. Use a `while` loop to generate the sequences and continue looping until $a_n - b_n < eps$, where eps is the relative floating point accuracy value returned by the MATLAB function `eps`.

Write your code so that the function takes either a single number or an array of numbers as k^2-values. Your code should use only one loop, the while loop. Return the answer in the same format (row or column vector) as the input.

What is the value of the elliptic integral for k^2 = 0.4, 0.5, 0.6?

Answer: 1.7775, 1.8541, 1.9496

Exercise 6

Chapter 4, Problem 26 in IM7ed3, 23 in IM7ed2; 16 in IM6

Exercise 7

Chapter 4, Problem 37 in IM7ed3; 31 in IM7ed2; 24 in IM6

Optional problems, Ex 8 is worth looking at

Exercise 8

Chapter 4, Problem 38 in IM7ed3; 32 in IM7ed2; 25 in IM6

Exercise 9

Chapter 4, Problem 28 in IM7ed3; 25 in IM7ed2; 18 in IM6