PRIFYSGOL CYMRU; UNIVERSITY OF WALES

DEGREE EXAMINATIONS JANUARY 2002

SWANSEA

Computer Science

CS 329 Scientific Modelling and Simulation

Attempt 2 questions out of 3

Time allowed: 2 hours

Students are permitted to use the dictionaries provided by the University through the invigilators

Scientific Modelling and Simulation
CS 329

*(Attempt **2** questions out of **3**)*

Question 1.

(a) Scientific modelling and simulation often demands graphical visualisation in two and three dimensions. Using plot functions, write a Mathematica function to plot simultaneously the functions: "x" and "n^x" between the range 0 to 5 for x and any integer n.

If your function were instigated with n=1, plot the associated result.

[5 marks]

(b) Compose a command to plot the function: sin(x) and a second function of your choice between the range: -6*□□x□6*□.

Indicate the options available on the plot command to customise the output.

[6 marks]

(c) Discuss, through reasoned argument, whether surface plots are preferable to contour plots, with respect to efficiency and accuracy in representation.

[6 marks]

(d) The parametric equations for the Moebius band in three dimensions are:

$$r(t,v) = a+b\ v\ \cos(t/2)$$
$$x(t,v) = r(t,v)\ \cos(t)$$
$$y(t,v) = r(t,v)\ \sin(t)$$
$$z(t,v) = b\ v\ \sin(t/2)$$

where Cartesian spatial position (x,y,z) is a function of two variables, t and v, with constant factors a=1.0 and b=0.5. Use this specification to compose the corresponding Mathematica code to plot the Moebius band in 3D.

{Hint: You may include calls to external packages.}

[8 marks]

Question 2.

(a) Under general scientific modelling and computation, comment upon numerical computation in particular, and provide some examples of typical application areas for computation.

Describe the status of and state the major steps involved in computational science.

[6 marks]

(b) Fitting data is a common procedure in scientific modelling. In this regard, what is the difference between interpolation and linear-regression?

Through coding and drawing of results, demonstrate how interpolation works for user-defined values, with appropriate Mathematica functions, for the following data set, heightdata. This list-of-lists data represents rainfall over a thirty-day period in a specific geographical zone; day 0, fall of 10.5 cm, day 30, fall of 7.6 cm:

heightdata = {{0, 10.5},{5, 7.4},{10, 6.5},{20, 8.0},{25, 8.4},{30, 7.6}}

You may define your own function, *height*, which calls standard Mathematica functions. Describe the format of your output and indicate how to obtain height readings at day 10 and day 15.

What interpolation order does Mathematica use by default? How would one adjust this to say linear order?

Show, in Mathematica code, how one would plot a combined graph of the interpolating function and the points, using the Epilog Mathematica option and the pure function Map. Comment upon the parameters used.

[11 marks]

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Question 2. cont'd

(c) In contrast, through plotting and coding, demonstrate how linear-regression works, using appropriate Mathematica fit functions, constant, x and x^2, for the data set:

dataset = { {1,4}, {2,3}, {4,3}, {7,6}, {10,11} }

Provide an alternative coding option to Epilog, to plot a combined graph of the fitting function and the points.

Under what circumstances would linear-regression prove inadequate? What options would then be available in Mathematica?

[8 marks]

Question 3.

(a) What are the common attributes of a 'Fractal'?

Starting from an arbitrary point in the plane P_0, describe in steps, the constructive process to generate the Sierpinski triangle, based upon three vertex points (0,0), (1,0) and (0.5, Sqrt[3.]/2):

[6 marks]

(b) In Mathematica code, provide a non-deterministic algorithm to generated the Sierpinski triangle. Comment upon how non-determinism is invoked and the use of recursive Mathematica commands. Draw ten typical initial steps of your algorithm and comment upon the outcome.

By way of contrast, show how you would adjust your algorithm to generate a Sierpinski triangle via a deterministic route and call your procedure.

Do both non-deterministic and deterministic algorithms provide the same final result? Provide reasons for your answer.

[12 marks]

(c) What is meant by 'Fractal dimension', and provide the formula for this in the case of the Box-dimension.

Show your workings and calculate the box-dimension for the Sierpinski triangle fractal.

[7 marks]