PRIFYSGOL CYMRU; UNIVERSITY OF WALES

DEGREE EXAMINATIONS JANUARY 2003

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

Students are permitted to use the calculators provided by the University

Scientific Modelling and Simulation
CS 329

*Answer **2** questions from **3**.*

Question 1.

1(a) Through brief examples, describe the four basic aspects of functionality of *Mathematica* as a language for computational science. Hence, or otherwise discuss the strengths and weaknesses of *Mathematica*, as a software package for scientific computation, quoting the major steps involved in computational science.

[10 marks]

(b) To illustrate the use and syntax of *Mathematica* 'pure functions', applied to lists, consider the following commands. Interpret each command in turn through their evaluation:

```
(#1^3 + #2^4 &)[x, y]
Map[(#^2 &), [2, 3, 5, 7, 11]]
Select[%, (# > 30 &)]
```

[6 marks]

(c) Using pure functions, *NestList* recursion and the default *Random* command, define your own function to construct a random walk in the form of a list. Start at the origin and visit a thousand points, each between –0.5 and +0.5. Via *Select*, apply a threshold cut-off to extract positive values only. Provide the relevant commands to plot this walk in the form of continuous line plots. What would be the implications if *NestList* were replaced with the *Nest* command?

[9 mark]

Question 2.

(a) Using the Koch fractal and the Cantor set, describe and illustrate what is meant by a fractal image.

[3 marks]

Define the box fractal dimension and state its dependencies. Establish the box dimension for the Koch fractal and the Cantor set.

[6 marks]

(b) Discuss Iterated Function Systems with specific reference to the "Chaos Game" and the generation of the Sierpinski triangle, describing the functions involved and their attractor.

[6 marks]

Via *Mathematica* coding, utilising *Nest* and *NestList* commands with bias of choice, implement both deterministic and non-deterministic algorithms to generate the Sierpinski triangle attractor. Illustrate in both instances and from the same start point, the implementation of these two algorithms over the first six points of the generated sequence. What conclusions can be drawn from this exercise?

[10 marks]

Question 3.

(a) As an example of an application area with its implementation via *Mathematica*, write brief notes on the topic of Fast Fourier Transforms. {Hint: one may cover issues, such as, convolutions, windowing techniques, sampling frequencies}

[12 marks]

(b) What is meant by a digital signature of a public-key encryption system, such as that following the Rivest, Shamir, Adleman algorithm (RSA)? Define a trapdoor function and provide an explanation of why the RSA algorithm transmits the message correctly.

[7 marks]

You are given an exponent 11 and two prime numbers, 31 and 47. By defining a modular inverse exponent and using *Mathematica* coding, show how you would encode and decode messages for transmission and receipt.

[6 marks]