THE UNIVERSITY OF WESTERN AUSTRALIA

EXAMINATION PAPER CHECKLIST
CITS4403 Computational Modelling

This page is to remain part of your examination file and is to be submitted with your Examination Cover Sheet and content. This page is for information only and will not be printed.

☐ Questions for the examination commence on the page following the Examination Cover Sheet. The examination paper must have page numbers and should state e.g. Page 1 of x.

☐ Ensure type of examination is correct 'permitted materials or no permitted materials'

- **Permitted materials**–Specific materials are permitted. Permitted material selected from the 'Materials Permitted' and 'Other Materials Permitted' area of the online examination request portal will be printed on the Examination Cover Sheet under the headings 'Supplied by the Student'.
- **No permitted materials**-no material is permitted.

☐ All pages, sections and questions are numbered sequentially i.e., pages, Part A, B, C, … etc. Questions 1, 2, 3, … Subsections to question numbering is to be consistent throughout the examination paper i.e. (a), (b), (c), …

☐ General instructions have been entered in the 'Instructions to Students' area of the online exam request portal and are reflected on the Examination Cover Sheet. Instructions have also been clearly communicated to students e.g., Answer Part A in the answer book provided and Part B on the examination paper.

☐ 'END OF EXAMINATION PAPER' is to be stated on the last page of the examination paper. END OF ATTACHMENT' is to be stated on the last page of the attachment where applicable.

☐ The examination paper is of a high-quality readable format, e.g., consistent formatting no blurred text, images are clear and printable.

☐ The document has been saved as a PDF and retains the downloaded unit code. I have also made no adjustment to the template which is A4.

☐ Where relevant the coversheet has been duplicated and an attachment has been included with a separate cover sheet at the end of the examination paper. All attachments will be printed as separate documents. If adding an attachment use a section break on the attachment cover page to restart page numbering.

☐ The level of distinctiveness for main round exams is at least 50% from the exam in the previous teaching period. The level of distinctiveness for Supplementary and Deferred exams is at least 25% from the main round exams.

☐ If this is an anonymous paper, Family Name, Given Name and Signature has been deleted from the cover sheet(s).

The examination paper has been proofread, the above checks completed, and approved for submission.

	NAME OR ELECTRONIC SIGNATURE	DATE
UNIT COORDINATOR (EXAMINER)	Siwen Luo	20/09/2023
CO-EXAMINER (OPTIONAL)	Mark Reynolds	20/09/2023

THE UNIVERSITY OF WESTERN AUSTRALIA

DESK No. | | | |

FAMILY NAME: _____

GIVEN NAMES: _____

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STUDENT NUMBER: | | | | | | | | |

Semester 2, 2023 EXAMINATIONS

School of Physics, Mathematics and Computing

CITS4403

Computational Modelling

Examination Duration: 2 hours

This is an examination WITH NO permitted materials

Provided by the University

1 x 18 Page Answer Booklet

Supplied by the Student

Calculator

No calculators are permitted

Instructions to Students

There are 16 questions. Marks for this paper total 120. Candidate must answer all questions.

All answers are to be written on the Answer Booklet.

1. Define and explain the concept of 2-Dimensional Cellular Automata (2-D CA) in the context of complexity science. Include an example of a 2-D CA that produces complex system. [10 marks]

2. Explain how reaction-diffusion could be responsible for animal patterns. [5 marks]

3. How does one verify the existence of a “percolating cluster” in percolation simulation. Explain the term of phase change and how it is determined in the context of percolation simulation. [10 marks]

4. A wide variety of systems display a common set of behaviours and characteristics when they are at or near a critical point. Illustrate three common behaviours exhibited by critical systems, providing concrete examples for each behaviour. [9 marks]

5. Why do so many natural systems have properties of critical systems? Provide a possible explanation for this phenomenon. [5 marks]

6. In the sand pile model, during each time step, each cell is checked to see whether it exceeds a critical value, K. If the critical value K = 3, when the sand pile model achieves equilibrium, what are the possible values of all the cells. Explain your answer. [5 marks]

7. Explain the purpose of the provided function, especially in what circumstances the following code is used. (The parameter, a, is a Boolean array.) [10 marks]

```
def count_cells(a):
    n, m = a.shape
    end = min(n, m)

    res = []
    for i in range(1, end, 2):
        top = (n-i) // 2
        left = (m-i) // 2
        box = a[top:top+i, left:left+i]
        total = np.sum(box)
        res.append((i, i**2, total))

    return np.transpose(res)
```

8. Outline three elements of agent-based models. [6 marks]

9. What are the two main types of interaction in agent-based modelling? [4 marks]

10. Explain why the segregation we see in Schelling's model is an emergent property. [5 marks]

11. In 1996, Joshua Epstein and Robert Axtell proposed Sugarscape, an agent-based model of an "artificial society" intended to support experiments related to economics and other social sciences. Describe the Sugarscape model in detail, including the agent's attributes, rules, and the original configuration of the Sugarscape grid. [15 marks]

12. Outline five different attributes that would influence the results of the Sugarscape model. [5 marks]

13. A very simple agent-based model of traffic evenly spread out along a road could easily seriously overestimate the flow. Explain how to make a slightly more complicated, and slightly more realistic model of individual car behaviour that can suggest much more realistic and much lower traffic flows. [5 marks]

14. Describe three minimum features that are sufficient to produce evolution. [6 marks]

15. In the simulation of evolution, the following function specifies which agent will die in a time step. *n* is the number of agents and *is_dead* is a Boolean array that contains True for the agents who die during this time step. In this version, every agent has the same probability of dying. Specify which part of this code can be changed to achieve the feature of differential survival in the simulation of evolution. Explain how the differential survival is achieved after updating the code. [5 marks]

```
# class Simulation

    def choose_dead(self, fits):
        n = len(self.agents)
        is_dead = np.random.random(n) < 0.1
        index_dead = np.nonzero(is_dead)[0]
        return index_dead
```

In this code, each agent currently has the same probability of dying, as determined by np.random.random(n) < 0.1, where each agent has a 10% chance of being marked as True (or dead) in the is_dead array. To incorporate differential survival (where agents with higher fitness have a better chance of survival), we can modify the probability of death based on each agent's fitness level.

16. In the late 1970s, Robert Axelrod organised a tournament to compare strategies for playing Prisoner's Dilemma. In Axelrod's tournaments, a simple strategy that did surprisingly well was called "tit for tat", or TFT. Describe this strategy and discuss how the characteristics of this strategy offer a possible answer to the "problem of altruism". [15 marks]

Axelrod's tournaments suggest a possible resolution to the problem of altruism: maybe being nice, but not too nice, is adaptive. But the strategies in the original tournaments were designed by people, not evolution, and the distribution of strategies did not change over the course of the tournaments.

Obviously, the agents in these simulations are simple, and the Prisoner's Dilemma is a highly abstract model of a limited range of social interactions. Nevertheless, the results in this chapter provide some insight into human na- ture. Maybe our inclinations toward cooperation, retaliation, and forgiveness are innate, at least in part. These characteristics are a result of how our brains are wired, which is controlled by our genes, at least in part. And maybe our genes build our brains that way because over the history of human evolution, genes for less altruistic brains were less likely to propagate.

END OF EXAMINATION PAPER