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## School of Mathematics & Physics EXAMINATION

Semester Two Final Examinations, 2015

### MATH4202 Advanced Topics in Operations Research

*This paper is for St Lucia Campus students.*

Examination Duration: 90 minutes

Reading Time: 10 minutes

**Exam Conditions:**

This is a School Examination

This is an Open Book Examination

During reading time - writing is not permitted at all

This examination paper will be released to the Library

**Materials Permitted In The Exam Venue:**

No restrictions

**Materials To Be Supplied To Students:**

Access to laboratory computers

**Instructions To Students:**

You will need to submit your Python code by Blackboard.

**For Examiner Use Only**

Question Mark

1a	
1b	
1c	
1d	

Total \_\_\_\_\_

## Question 1

We consider the online game “Znumbers”. In this game each number in the grid needs to be moved exactly once. A number must be moved to a square the same distance away as the number itself. Once a number has been moved it is greyed out and cannot be moved again. This is demonstrated in the following series of images:

Figure 1: The initial layout

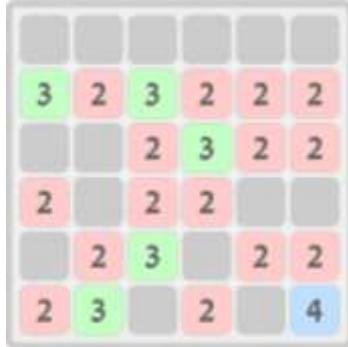


Figure 2: Considering moving the highlighted “2”. Note the ‘X’ squares represent empty squares exactly “2 squares away”.



Figure 3: After moving the “2” to the top left hand corner. It is greyed out and can’t be moved again.



In summary, each number must be moved exactly once to one of its legal destination squares. At most one number can be moved into each square. Numbers can only be moved to squares which are empty – i.e. either started empty, or started occupied and the original number has already been moved.

Part a (5 marks):

Assuming you only move one number per turn, formulate this puzzle as an Integer Program. Write your formulation in the space below.

Part b (8 marks):

Using the data “Data1” from the code stub stub15.py, implement your IP formulation in python – you can use the “if PartB” code block. You may find the function “MoveTo” useful.

The code for Part b and Part d (below) can go in the one file which can be submitted electronically, multiple times if required.

Part c (4 marks):

If you switch the line of code: Data=Data1 to: Data=Data2, you will find your model takes a long time to run. An alternative model could consider moving all numbers at the same time, ensuring all numbers are moved and no two numbers end up in the same square. However, this might allow some solutions that are illegal. Write such a formulation below and explain how the illegal solutions could be handled.

Part d (3 marks):

Implement an IP formulation which can quickly solve the problem using “Data2”. Put your implementation in the “else” section of the “if PartB” test. Switch the line Data=Data1 to Data=Data2 to test this.

**END OF EXAMINATION**