THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Student Number |__|__|__|__|__|__|__|__|

Family Name _____

First Name _____

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School of Mathematics & Physics

EXAMINATION

Semester One Final Examinations, 2020

MATH7232 Operations Research and Mathematical Planning

This paper is for St Lucia Campus students.

Examination Duration: 120 minutes (+ additional 30 mins encompassing reading time, and time to scan and upload solutions). You must commence your exam at the time listed in your personalised timetable. The exam will remain open **only** for the duration shown.

Materials Permitted While Completing the Exam:

You may access any material during the exam including material on paper, in your electronic files or online. However, you may not communicate with other people during the exam.

Instructions to Students:

There are **50** marks available on this exam from **2** questions.

You can write your answers on blank paper or write electronically on a suitable device. Scan or photograph your work, if necessary, and upload your written answers to Blackboard as a **single** PDF file, along with your separate Python files for each question.

Who to Contact: Since students may not all undertake the online exam at the same time, or in the same time zone, and that some questions may be randomised, responding to student queries and/or relaying corrections to exam content during the exam will not be feasible. Course coordinators will not be able to respond to academic queries during the exam.

If you have any concerns or queries about a particular question, or need to make any assumptions to answer the question, state these at the start of your solution to that question. You may also include queries you may have made with respect to a particular question, should you have been able to 'raise your hand' in an examination room.

If you experience any technical difficulties during the exam, contact the Library AskUs service via the Live Chat or Phone for advice (open 7:00am – 10:00pm AEST every day during the final exam period). You should ask the library staff for an email documenting the advice provided so you can provide this to the course coordinator.

Certification (must be signed before submission):

I certify that my submitted answers are entirely my own work and that I have neither given nor received any unauthorised assistance on this assessment item.

Signed:_____Date:_____

Question 1

30 marks total

Part A

10 marks

The Acme Widget Company (AWC) supplies widgets. AWC needs to move widgets from its warehouses to its customers. They know the demand per year for widgets at each customer and the widget throughput capacity per year at each warehouse. They also know the transportation cost per widget from each warehouse to each customer.

a) Formulate a linear programming model that will work out the optimal movement of widgets to satisfy all demand each year. Clearly define all sets, data, variables, objective function and constraints.

b) Using the data provided in the stub, code your solution in Python. What is the optimal objective value and solution?

c) Use Gurobi's sensitivity analysis features to determine the reduction in cost per unit increase in capacity at warehouse A.

Part B

16 marks

AWC currently imports widgets but wants to move to a closed loop supply chain where they will rebuild widgets at the end of their useful life. To do this, they must determine where to locate rebuilding facilities.

There are several options for where to locate the rebuilding facilities. In addition to the data in Part A, AWC knows the following for each candidate rebuilding facility:

- The cost of constructing the facility
- The annual capacity for rebuilding widgets
- The transport cost per widget to each warehouse and from each customer
- The rebuilding cost per widget

AWC wish to minimise their total cost of facility construction, widget rebuilding and transportation over a 10-year horizon.

Formulate a mixed integer programming model to assist them. Clearly define all sets, data, variables, objective function and constraints.

Part C

4 marks

Upon further reflection, AWC have decided that each customer will return widgets to exactly one rebuilding facility. Modify your formulation to reflect this. You need only specify additional variables and constraints.

Question 2

20 marks total

A game involves two dice, one red and one blue. When you roll the **red** die, you get 1 point if an even number comes up, but lose 1 point if it is an odd number. When you roll the **blue** die, you get 4 points if either 5 or 6 come up, but lose 2 points for the other four outcomes.

To play the game, you make a total of 50 dice rolls. For each roll, you can choose either the red die or the blue die. In order to win the game, you must finish with a positive total score. For example, you would win with a total score of 1 or 100, but lose with a total score of 0 or -20.

Part A

8 marks

We wish to find a strategy that maximises our probability of winning the game.

Provide a dynamic programming formulation to solve this problem. You should use Bellman's equation and identify the stages, states, actions and the value function.

Part B

12 marks

a) Implement your formulation in Python to find the optimal probability of winning the game.

b) Assuming you start with 0 points, which die should you roll first?

c) Suppose you start the game with m points. What values of m would change which die you rolled first?

END OF EXAMINATION