LIMERICK INSTITUTE OF TECHNOLOGY
OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA
LUIMNIGH

LIMERICK INSTITUTE OF TECHNOLOGY

SPRING EXAMINATIONS 2019/2020

Wednesday 26th February 2020, 2 PM – 5 PM

MODULE: COMP07028 - Statistics, Algorithms & AI

PROGRAMME(S):
LC_KGDVM_KTH Bachelor of Science (Honours) Games Design and Development
LC_KCPTM_JTH Bachelor of Science Computing

YEAR OF STUDY: 3

EXAMINER(S):
Eugene Kenny (Internal)
Mr. Damien Costello (External)

TIME ALLOWED: **3 Hours**

INSTRUCTIONS: **Answer 2 questions from Section A and 2 questions from Section B.**

All questions carry equal marks.

PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO.
The use of programmable or text storing calculators is expressly forbidden.
Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.

Requirements for this paper:
1. Calculators

SECTION A

QUESTION 1 **[25 Marks]**

a) Draw the graph represented by the following adjacency matrix. **[5 marks]**

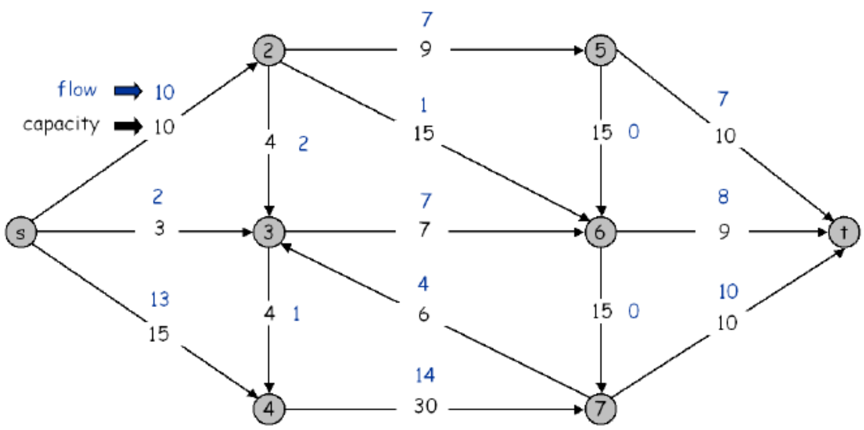
	A	B	C	D	E	F	G	H
A	0	0	2	3	4	0	0	0
B	0	0	3	0	0	6	2	0
C	2	3	0	5	0	4	0	1
D	3	0	5	0	0	0	0	0
E	4	0	0	0	0	0	4	2
F	0	6	4	0	0	0	2	0
G	0	2	0	0	4	2	0	0
H	0	0	1	0	2	0	0	0

b) Outline *Kruskal's* algorithm and show how it can be used to construct a minimum spanning tree using the graph from part (a) above. **[10 marks]**

c) Outline *Dijkstra's* algorithm and show how it can be used to calculate the shortest path from a given source vertex to all other reachable nodes in a graph using the graph from part (a) above and vertex *A* as the source vertex. **[10 marks]**

QUESTION 2 **[25 Marks]**

a) Starting from the following flow (printed above or to the right of the capacities), perform one iteration of the *Ford-Fulkerson* algorithm. Choose a shortest augmenting path, i.e., the path with the fewest number of arcs. **[15 marks]**



(i) Write down the shortest augmenting path.

(ii) Perform the augmentation. What is the value of the resulting flow?

(iii) Is the resulting flow optimal? If so, give a min cut whose capacity is equal to the value of the flow If not, give a shortest augmenting path.

b) Network Flow formulations can be used as the basis for solving many other seemingly unrelated problems. Give two examples and show how they can be reduced to a network flow problem. **[10 marks]**

QUESTION 3 **[25 Marks]**

a) What is a Reduction? What does it mean to say that one problem reduces to another? **[10 Marks]**

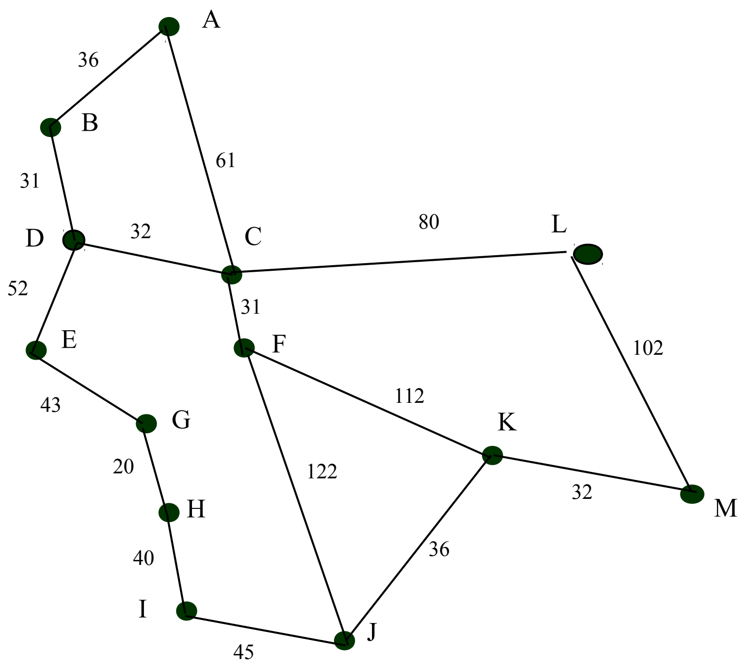
b) What does it mean to say that a problem is in *P* or in *NP*? What does it mean to say that a problem is *NP*-complete? **[10 Marks]**

c) What does in mean for a problem to be *intractable*? What approaches can taken when faced with an intractable problem? **[5 Marks]**

SECTION B

QUESTION 4 **[25 Marks]**

a) Consider the following map: **[20 Marks]**



Using the A* algorithm work out a route from town A to town M. Use the following cost functions:

- *g*(*n*) = The cost of each move as the distance between each town (shown on map)
- *h*(*n*) = The Straight Line Distance between any town and town M. These distances are given in the table below.

i) Provide the search tree for your solution.
ii) Indicate the order in which you expanded the nodes and state the route you would take and the cost of that route.

<u>Straight Line Distance to M</u>

A	223	E	165	H	111	K	32
B	222	F	136	I	100	L	102
C	166	G	122	J	60	M	0
D	192						

b) The straight line distance heuristic used above is known to be an *admissible* heuristic. What does this mean and why is it important? **[5 Marks]**

QUESTION 5 **[25 Marks]**

Consider the following scenario:

There has been a murder! The police are not releasing many details. Suspects are Prof. Purple, General Horseradish, or Reverend Fields. The murder either took place in the study or the hall. The murder weapon was either a heavy candlestick or a revolver. The Reverend is too old and frail to wield the candlestick. We know that the revolver was not taken out of the study. Only the General and the Professor had access to the study.

a) Translate the facts in the above scenario into clauses in conjunctive normal form (CNF). **[15 Marks]**

b) Prove using the resolution refutation process that the Reverend could not have committed the murder. **[10 Marks]**

QUESTION 6 **[25 Marks]**

a) What are the main problems in reasoning about actions and change? **[10 Marks]**

b) What is meant by an operator in the context of STRIPS? **[5 Marks]**

c) For the operators and initial state description given below, explain how a regression planner searches for a plan to satisfy a goal, and give an example of a plan that achieves the goal *On*(*a*, *b*) ∧ *On*(*b, a*) ∧ *OnTable*(*c*) **[10 Marks]**

- blocks are represented by constants: a, b, c, ... etc.
- states are described using the following predicates:

On(*x*, *y*)	block *x* is on block *y*
OnTable(*x*)	block *x* is on the table
Clear(*x*)	there is no block on top of block *x*
Holding(*x*)	the arm is holding block *x*
ArmEmpty	the arm is not holding any block

- initial state: *On*(*c*, *a*) ∧ *OnTable*(*a*) ∧ *OnTable*(*b*) ∧ *ArmEmpty*
- goal state: *On*(*b*, *a*) ∧ *On*(*a*, *c*) ∧ *OnTable*(*c*)
- operators:

[*Holding*(*x*), *Clear*(*y*)] ***STACK***(*x*, *y*) [*On*(*x*, *y*), *ArmEmpty*, ¬*Holding*(*x*), ¬*Clear*(*y*)]

[On(*x*, *y*), *Clear*(*x*), *ArmEmpty*] ***UNSTACK***(*x*, *y*) [*Clear*(*y*), *Holding*(*x*), ¬*On*(*x*, *y*), ¬*ArmEmpty*]

[*OnTable*(*x*), *Clear*(*x*), *ArmEmpty*] ***PICKUP***(*x*) [*Holding*(*x*), ¬*OnTable*(*x*), ¬*ArmEmpty*]

[*Holding*(*x*)] ***PUTDOWN***(*x*) [*OnTable*(*x*), *ArmEmpty*, ¬*Holding*(*x*)]