LIMERICK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA LUIMNIGH

LIMERICK INSTITUTE OF TECHNOLOGY

SPRING EXAMINATIONS 2018/2019

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.

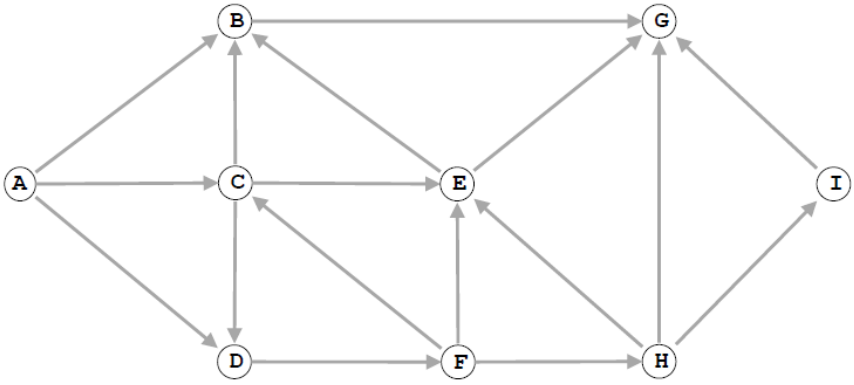
Requirements for this paper:
1. Calculators

SECTION A

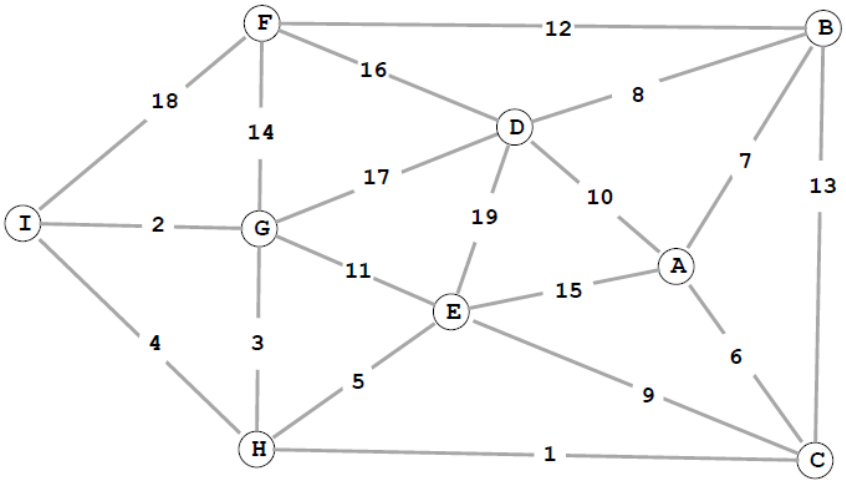
QUESTION 1 **[25 Marks]**

a) Define adjacency matrices and adjacency lists giving suitable examples illustrating how they can be used to represent directed, undirected, weighted and unweighted graphs. **[10 Marks]**

b) Run *depth-first search* on the digraph below, starting at vertex A. Assume the adjacency lists are in sorted order: for example, when exploring vertex F, consider the edge F → C before F → E or F → H. **[5 Marks]**



c) Consider the following weighted graph with 9 vertices and 19 edges. Note that the edge weights are distinct integers between 1 and 19. **[10 Marks]**



(i) Complete the sequence of edges in the MST in the order that *Kruskal's algorithm* includes them.

(ii) Suppose that the edge D-I of weight *w* is added to the graph. For which values of *w* is the edge D-I in a MST?

(iii) Complete the sequence of edges in the MST in the order that *Prim's algorithm* includes them. Start Prim's algorithm from vertex A.

QUESTION 2 **[25 Marks]**

a) Convert the regular expression (a (b * | c) *) into an equivalent NFA (nondeterministic finite state automaton). **[10 Marks]**

b) Suppose that you run the Boyer-Moore algorithm to search for the pattern **[10 Marks]**

I D O F T H E

in the text

M E N D E R O F R O A D S W I T H T H E A I D O F T H E

Trace the running of the algorithm, circling the characters in the pattern that get compared with the text.

c) If *M* is the length of the pattern string to be matched and *N* is the length of the text string, what is the running time for the Brute-force substring matching algorithm for typical inputs (in English texts say) and in the worst case. Give an outline proof for both cases. **[5 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]**

For the 8-puzzle problem, given this initial starting state:

2	8	7
3	1	4
5	6	

a) Show the search tree that results from using *breadth-first-search* (down to level 2) and *depth-first-search* (down to level 3) from the initial starting state above. Assume level zero is the root of the tree. **[15 marks]**

b) Describe the terms *complete* and *optimal* with regards to evaluating search strategies? **[10 marks]**

Are either depth-first-search or breadth-first-search complete or optimal? Justify your answer.

QUESTION 5 **[25 Marks]**

Consider the following scenario:

d has been murdered. *a*, *b*, and *c* are suspects (i.e., at most one of *a*, *b*, and *c* are guilty). *b* claims that he did not know the victim *d* (i.e., if *b* did know *d*, then *b* is lying). *a* and *c* claim that *b* did know *d* (i.e., if *b* did not know *d*, then *a* and *c* are lying). Anyone who lies is guilty.

a) Express the key facts and relationships using *first order predicate calculus*. **[5 marks]**

b) Convert the expressions above into clauses in conjunctive normal form (CNF). **[10 marks]**

c) Prove using the resolution refutation process that *b* committed the murder (is guilty). **[10 marks]**

QUESTION 6 **[25 Marks]**

a) What are the main problems in reasoning about actions and change? **[5 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 $On(b, a) \wedge On(c, b) \wedge OnTable(a)$ **[15 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: $On(c, a) \wedge OnTable(a) \wedge OnTable(b) \wedge ArmEmpty$
- goal state: $On(b, a) \wedge On(a, c) \wedge OnTable(c)$
- 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*)]