LIT
DEPARTMENT OF
INFORMATION TECHNOLOGY

Semester: Semester 1 (Winter 2016/17)

Date/Time: Monday 12th December 2016, 2PM - 4PM

Programme: Bachelor of Science (Honours) in Computing (Games Design and Development)
Bachelor of Science (Honours) in Computing (Software Development)
Bachelor of Science in Computing

Stage: Year 3

Module: ALGORITHMS

COMP 07002

Time Allowed: 2 hours

Instructions: Attempt any four (4) questions

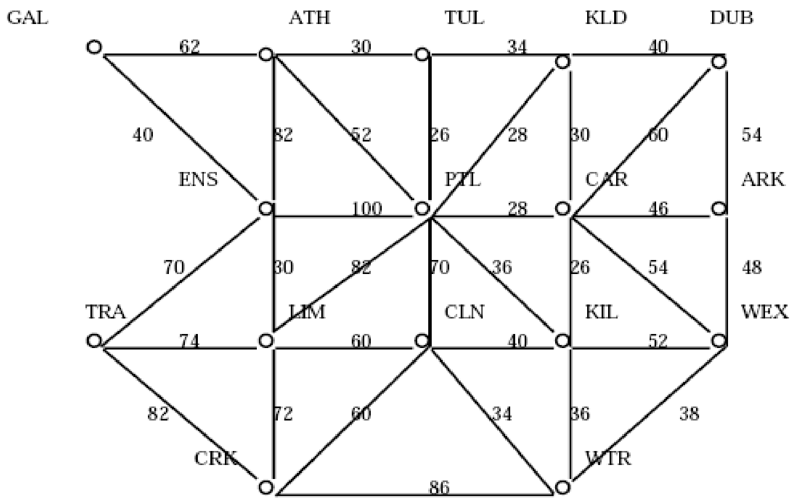
Additional Attachments: None

External Examiners: Derek O'Reilly
Internal Examiners: Janice O'Connell, Eugene Kenny

Question No. 1 **(25 Marks)**

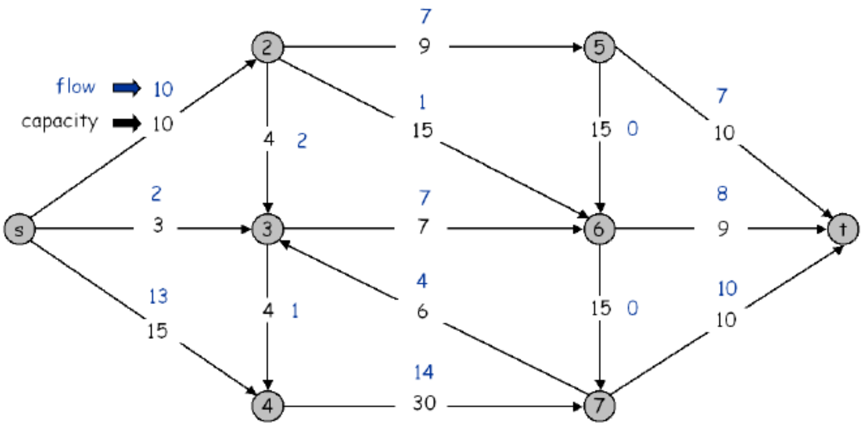
(a) Define adjacency matrices and adjacency lists giving suitable examples illustrating how they can be used to represent directed, undirected, weighted and unweighted graphs. *(10 marks)*

(b) Run *Dijkstra's Algorithm* on the edge-weighted graph below, using GAL as the starting vertex. *(15 marks)*



Question No. 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 Flows 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 No. 3 **(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

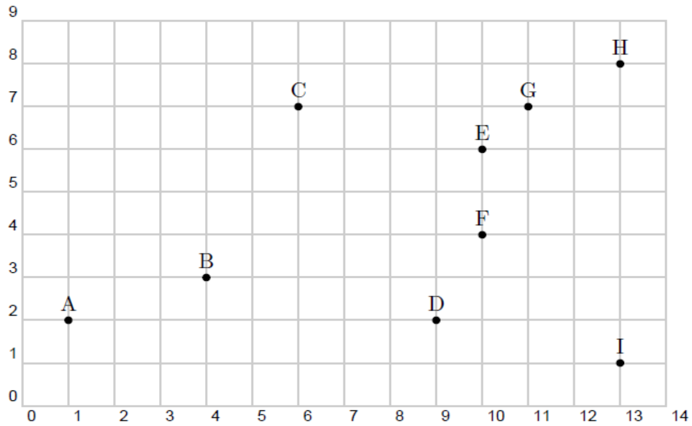
M E N D E R O F R O A D S W I T H T H E A I D O F T H E

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 No. 4 **(25 Marks)**

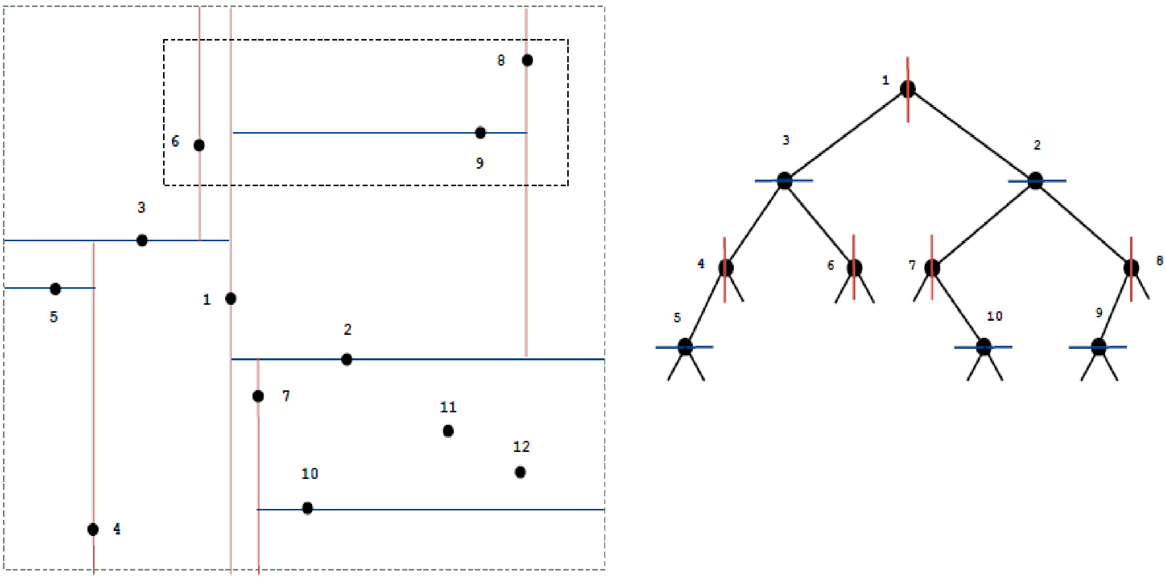
(a) Run the Graham scan algorithm to compute the convex hull of the 9 points below, using I as the base point, and continuing counterclockwise starting at H. *(10 marks)*



(i) List the points in the order that they are considered for insertion into the convex hull.

(ii) Give the points that appear on the trial hull (after each of the 8 remaining points are considered) in the order that they appear.

(b) The figures below illustrate the results of inserting points 1 through 10 into a 2d-tree. *(10 marks)*



(i) List all of the the points in the 2d-tree that are examined (not necessarily just those inside the query rectangle) during the range search for the query rectangle specified above.

(ii) Draw the result of inserting point 11, then point 12 in the two figures above.

Question No. 5 **(25 Marks)**

(a) 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? *(15 marks)*

(b) What is a Reduction? What does it mean to say that one problem reduces to another? *(10 marks)*