COMP 311 DESIGN AND ANALYSIS OF ALGORITHMS –
CAT II

Instructions: Answer All the Questions

a) i) Design the general Knapsack problem algorithm and determine its time complexity using asymptotic Big O.

ii) A mountain climber faces **a Knapsack problem**. There are 7 items to be packed for hiking as shown below .The knapsack is initially empty and can hold a maximum of 24 weights. Show how the climber will maximize the value of the items using a heuristic Greedy by profit,Weight and profit density dynamic algorithm.

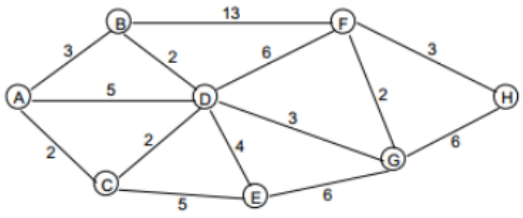
Item *i*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Value *vi*	**3**	**6**	**8**	**1**	**2**	**5**	**7**
Weight *wi*	**7**	**3**	**5**	**1**	**4**	**2**	**6**

iii) Is the algorithm used in a(i) Optimal?, Support your answer.

b) i) Design Dijkstra algorithm and determine its running time complexity

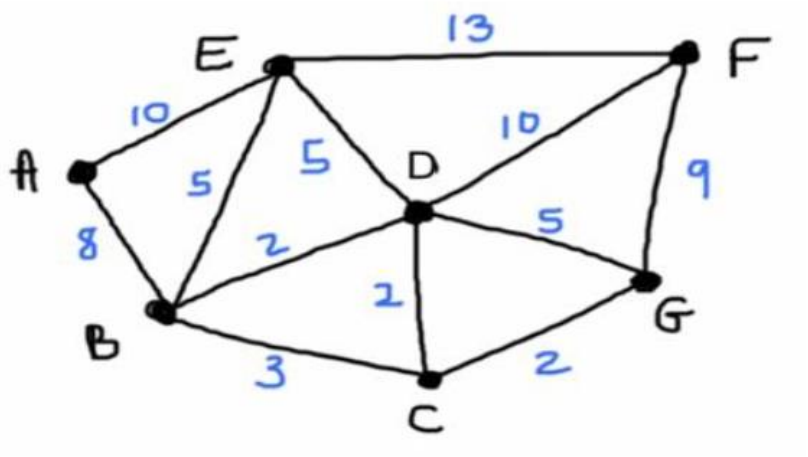
ii) A cable TV company is trying to lay cable to a new neighborhood The homes to be connected are are represented by Node A to Node H.Use Dijkstra algorithm to find the shortest (least weighted) path among the nodes given a starting point of A as shown in the figure below

(show your work in form of a table).



c) Write the fastest-way scheduling dynamic algorithm for automobile factory having two assembly lines

d) **A, B, C, D, E, F, G** are computer terminals with figures on the edge representing the time taken (in seconds) for data to travel from one computer to another. Using Dijkstra algorithm, find the shortest path from terminal A to all the others, clearly displaying the implementation of the algorithm. What is the length in seconds from A to F according to this algorithm?



e) Design the following algorithm and determine their time complexity, what are some of the realword application of this algotithms?

i. OSPF

ii. Topological sorting

iii) Floyd Warshall algorithm

iv) Matrix Chain multiplication problem

f) You are given an exam with questions numbered 1, 2, 3, . . . , n. Each question i is worth Pi points. You must answer the questions in order, but you may choose 2 to skip some questions. The reason you might choose to do this is that even though you can solve any individual question i and obtain the Pi points, some questions are so frustrating that after solving them you will be unable to solve any of the following fi questions. Suppose that you are given the pi and fi values for all the questions as input. Devise the most efficient algorithm you can for choosing set of questions to answer that maximizes your total points, and compute its asymptotic worst case running time as a function of n. **(5Marks)**

g. In computer Science, a **Huffman code** is a particular type of optimal prefix code that is commonly used for lossless data compression. Suppose you a given a six letter alphabet with character and frequency as below,

Character	G	H	I	J	K	L
Frequency	45%	13%	12%	16%	9%	5%

i) Design the Huffman algorithm [4marks]

ii) Use Huffman algorithm to develop a Huffman tree and Huffman codes [4Marks]

iii) Determine its time and space complexity [4Marks]

h) Create a time table schedule algorithm for a school, using some constraints that are generally divided in two categories. **(6Marks)**

Sanity Checks

- A teacher cannot teach two classes at the same time
- A student cannot have two lessons at the same time
- Some teachers must have at least one day off during the week
- All the days of the week should be covered by the time table
- Subject X must have exactly so-and-so hours each week

Preferences

- Each teacher's schedule should be as compact as possible (i.e. the teacher should work all hours for the day in a row with no pauses if possible)
- Teachers that are on leave should be able to express a preference on which day to teach
- Teachers that work part-time should be able to express a preference whether to work in the beginning or the end of the day.
- Class room to use should be dictated by the number students enrolled.

- The algorithm should be smart such that it allocates unit for a lab session especially when the unit involves programming.

i) Consider the four elements $a_1<a_2<a_3$ with $q_0 = 1/8$, $q_1 = 3/16$, $q_2 = 1/16$, $q_3 = 1/16$ and $p_1 = ¼$, p_2 1/8 , $p_3 = 1/16$. Construct the optimal binary search tree for the given set of identifiers

j) Study the following algorithm and then answer the questions that follows

Input: The set of pick-up location s_i and destinations d_i from m passengers P
Output: Number of trips needed

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(1)  Sorted the passenger set P according to s_i
(2)  f[i] = ∅, 1 ≤ i ≤ m
(3)  res = 0
(4)  for i = 1, ..., m − 1 do
(5)     for j = 1, ..., i − 1 do
(6)        Remove the passengers who arrive destinations from f[j];
(7)        if ||f[j]|| == k then
(8)              Continue
(9)        if p_j can share with passengers in f[i] then
(10)          f[j] = f[i] ∪ {p_j};
(11)          f[i] = ∅;
(12)             Continue;
(13)       if f[j] == ∅ then
(14)             f[j] = {p_j}
(15)             res = res + 1
(16) return res
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i. Explain the objective of the algorithm **(3Marks)**

ii. Explain the algorithm design technique used **(3Marks)**

iii. Is the algorithm optimized, explain **(3Marks)**