National University of Computer & Emerging Sciences, Karachi
Department of Computer Science
Fall-2022
CS2009: Design and Analysis of Algorithms
Assignment 5
Due Date: 9th December 2022

20% penalty for 1 day late
40% penalty for 2 days late
Submission is not allowed afterward

Max Marks: 80 Points

Question # 1 — 35 Points

Watch the video lecture on [P, NP, NP-hard, and NP-complete problems](). And write the answer to the following question in your own words.

(a) What is meant by P and NP Problems? Explain P = NP.
(b) Why it is important to find approximate solutions for NP-Complete Problems.
(c) What is the difference between NP-Hard and weakly NP-hard class problems?
(d) What is the 3-SAT problem?
(e) What is meant by NP-complete problems? How can we prove a problem is NP-complete. Explain with an example.
(f) What is Reduction?
(g) A problem that is solvable in time complexity of $T(n) = 3 * n^n$ and space complexity of $S(n) = n^2$ and it can be validated in $T(n) = 2^n$ time. Is it an NP-Complete or NP-Hard? Explain

Question #2 — 10 Points

Consider the following APPROX-VERTEX-COVER algorithm. Proof that this algorithm is a 2-approximation method for VERTEX-COVER.

```
APPROX-VERTEX-COVER(G)
    C = ∅;
    E'=G.E;
    while(E' ≠ ∅ ){
        Randomly choose a edge (u,v) in E', put u and v into C;
        Remove all the edges that covered by u or v from E'
    }
    Return C;
```

Question #3 **15 Points**

An Instance (X, F) of the set-covering problem consists of a finite set X and a family F of the subset of X, such that every element of X belongs to at least one subset of F:

$$X = \bigcup_{S \in F} S$$

We say that a subset $S \in F$ covers all elements in X. Our goal is to find a minimum size subset $C \subseteq F$ whose members cover all of X.

$$X = \bigcup_{S \in C} S$$

Algorithm 1: GREEDY-SET-COVER (X, F)

$U \leftarrow X$
$C \leftarrow \emptyset$
While $U \neq 0$
  do select an $S \in F$ that maximizes $|S \cap U|$
    $U \leftarrow U - S$
    $C \leftarrow C \cup \{S\}$
return C

Consider each of the following words as a set of letters: {arid, dash, drain, heard, lost, nose, shun, slate, snare, thread}. Show which set cover GREEDY-SET-COVER produces when we break ties in favor of the word that appears first in the dictionary.

Question #4 **20 Points**

Consider the following points in 2D
(6,2), (9,5), (-2,2), (-3,4), (-8,8), (-10,4), (-10,3), (-8, -6), (-4, -4), (6,4), (6,-6), (-6,-10), (8,0)
Find the smallest convex set containing all the points using Package Wrap (Jarvis March) and Graham Scan (Show all iterations).

****Best of luck****