Assignment 2 (Due November 14 2023)

Submit clear and well explained answers. You can submit one answer per group. You can use the internet (but not pay wall sites like Chegg) to look for answers, but the final answer must be in your own words. You can also use code you found online for the experiments. Please cite all resources used for answers as well as codes.

1. **Knapsack Problem** (50)
   Consider a collection of K items out of which n items cannot be subdivided (0-1 knapsack) and m items can be divided into fractions (fractional knapsack), $K = n + m$. For each item, we are given the weight in pounds and the total cost. Given a maximum weight limit V, design an algorithm that selects the set of elements that will give the maximum value. Note that the problem is a combination of 0-1 and fractional knapsack problem.

Id	Weight (in Pounds)	Cost (in Dollars)	Type
1	3	50	W
2	2	25	W
3	4	60	W
4	1	15	W
5	3	40	W
6	2	30	W
7	3	50	F
8	2	30	F
9	4	50	F
10	1	10	F

   (a) Submit a well commented code for your algorithm. Include the code to generate inputs and a read me on how to run the algorithm on the inputs. We will run the algorithms to check. (10)

   (b) Show how the algorithm works, step by step, for the given example in Table 1. The maximum weight, V, is 10 pounds. W (whole) indicates for the items that cannot be subdivided and F(fractional) stands for items whose fractional value can be taken (10)

   (c) Prove the correctness of your algorithm (10)

   (d) Compute the complexity of your algorithm (10)

   (e) Let the weight of all the items be W and the cost of all the items be C. Let n=m=$K/2$. Let the limit of the weight be $V = (K/2) * W$. Prove that in this case, taking any subset of half the items will provide the maximum value (10)

2. **Measuring Signal Strength** (25)
Consider that you are testing how far a cell phone tower can send its signal. To do so, you have marked testing spots of increasing distance going away from the tower. The first testing spot is at distance of 1 unit, the second is at distance of 2 unit, and so on. A test is when you stand at a designated spot and try to see if you can receive the signal.

[HINT: This a well know computer science problem, and you may find a solution online. However, the online problem will not be the same "story" as given here. If you can find an analogous problem you can use the answer as long as you cite the source].

The conditions for the test are as follows;

- If the signal can be received at the spot at distance n, it can also be received at all spots at distance ¡ n
- If the signal cannot be received at the spot at distance n, it also cannot be received at all spots at distance ¿ n
- For every call you have to pay $1.
- When you cannot receive a signal then you have to call the headquarters to let them know using a special phone that uses a different wireless connection. However, since you have low battery on the special phone you can only make R calls at most from the special phone. These calls are free—do not cost anything.

Given these conditions, what is the cheapest way that you can test the furthest spot upto where the signal is received given that you have K test spots. The answer is a function of K and R. Explain your answer and how you obtained the formula.

If you solve for K=2 then you get **12 points** If you solve for general K then you get **25 points**

3. **Halloween Candy** (25)
There are N children standing in a row to receive candy. Each child has a number associated with him/her. The eggs should be distributed such that (i) every child gets at least one candy and (ii) if a child has higher ratings than his/her neighbors he/she will get more candies than them. Design an O(N) algorithm to find the minimum number of candies to be distributed, given the ratings of the children as input.

If your algorithm works but has higher complexity then you will get half the points, i.e. 12 points

Example: Ratings [4, 9,3,1]; Candy distribution:[1,3,2,1]; Total=7