CS341 Final F2008

1. [Not on final]

A) Bad.

B) T(n) = 2T(n/2) + O(n)

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mergeKArrays(A)
    if (A has 1 element)
        return A
    lower = lower half of A
    upper = upper half of A
    res1 = mergeKArrays(lower)
    res2 = mergeKArrays(upper)
    return merge(res1, res2)
```

2. We first prove that the problem is in NP. Given a truth-value assignment, it takes polynomial-time to check whether the Boolean formula evaluates to true.

We prove that this problem is a reduction of 3-SAT. Given an instance of 3-SAT with n variables, m clauses, and Boolean formula S, we construct an instance of our problem as follows. The Boolean formula F is the same as S. We set k = n.

If there is a solution to this instance of 3-SAT, then there is a satisfying truth-value assignment that satisfies F. There are at most k variables set to true, since k=n and there are at most n variables. Then we have a solution to our instance of Cheapest 3-SAT. If there is a solution to our instance of Cheapest 3-SAT, we have found a satisfying truth-assignment for the 3-SAT formula, so there is a solution to the instance of 3-SAT.

It takes polynomial-time to construct our Cheapest 3-SAT instance, since F = S and k = n. Since 3-SAT is NP-complete, Cheapest 3-SAT must also be NP-complete.

3. A) 

B) Run the Floyd-Warshall algorithm on G. The shortest path from a vertex v to itself is the shortest cycle in the graph. Floyd Warshall takes O(n^3) time.

4. A) 2+5 = 7, 1+3+3 = 7

B) We first prove that this problem is in NP. Given two sets S1 and S2, it takes polynomial-time to take the sums of both sets and check whether they are equal. Hence we have a polynomial-time verification algorithm for this problem.

We prove that this problem is a reduction of subset sum. Given an instance of subset sum with positive integers a_1…a_n and target value K, we construct an instance of our problem as follows.

Our set of numbers for Balance is S = a_1…a_n. Let S be the sum of a_1…a_n. We add S-2K to the set of numbers.

If there is a solution to this instance of subset sum, there is a set of numbers in a_1…a_n that sum to K. If we add element (S-2K) to this subset, it's sum is now (S-K). Our remaining numbers in Balance must then sum to (S-K). Hence we have found a solution for this instance of our problem.

If there is a solution to this instance of our problem, we have partitioned our set of numbers into two sets of equal sum. The sum of all numbers is S + S - 2K = 2S - 2K, so each subset must have sum S-K. One of these subsets must contain the element S-2K. Then its remaining elements must sum to K, and we have found a subset of a_1…a_n that sums to K.

It takes linear time to construct the instance of our problem from subset sum. Hence our problem is a polynomial-time reduction of subset sum. Since subset sum is NP-complete, our problem is also NP-complete.

C) Our algorithm works as follows. We first take the sum of all the numbers, let's call it S. If S is odd, we terminate. Now we want to find a subset of the numbers that sums to S/2. Now we can just use the subset sum algorithm to solve the problem. Our recurrence is

subsum[i, L] = (subsum[i+1, L - a_i] OR subsum[i+1, L]), where subsum[i, L] is whether there is a subset in {1…i} with sum L.

There are S*(S/2) subproblems (S choices for i and S/2 choices for L). Each subproblem can be solved by looking up 2 values. Hence the time complexity is O(S^2).

5. [Not covered]

6. A) Only if e is sufficiently small.

B) False [Not covered]

C) False. We can just iterate all triples of vertices.

D) Well we haven't found one yet

E) True [Not covered]

7. We construct our subproblem as follows. P(j, k) = true if the substring of s from index j to k is a palindrome. Every P(j, j) = true. For all j < k, our recurrence is

P(j, k) = (s[j] == s[k]) AND ((k-j <= 2) OR P(j+1, k-1))

Then our result is the largest k-j for all P(j, k) = true. In other words, P(j, k) is true if the characters at j and k are the same and the substring between characters j and k is a palindrome.

There are O(n^2) subproblems, since j, k are both in the range [1, n]. Each subproblem takes O(1) time to compute, so we have that the runtime is O(n^2).