Assignment 2 - 17114003

1)

a) Complexity Classes :

Vertex Cover Problem : NP - Complete as it has a polynomial time approximation algorithm.

DCMST : NP - Hard as there is no approximation algorithm and is difficult to find the optimal result.

b) Let a variable x_i for every node i, representing the condition that the node is a part of the vertex cover. Then for every edge {v,w} we can introduce the clause $x_v V x_w$.
The other condition is $x_1 + x_2 + x_3 + ... + x_n <= k$, upon implementing an additional circuit to compute the bits of the sum with a comparator circuit to enforce the inequality. The CNF of the resulting circuit has only polynomially many clauses.

c) Degree Constrained Spanning Tree is a NP Complete decision problem. This can be shown by a reduction from the Hamiltonian path problem.

2) For this, I have considered components as the main structure. Since,it's a bidirectional graph so a set of cities connected or included in a component can be always traversed from 1 city to another.
Considering a Set of each component for both the flights, if they come out to be the same then ,True. [Code Attached]
Example Test Case : Both the Flights will have the same set of cities connected.

3) A directed graph can be generated from the given conditions. If the graph is acyclic then, there won't be any deadlock. The sequence and deadlock detection can be carried out using Topological sort.
1 -> 2 -> 3 -> 4 -> 5 -> 6
1 -> 3 -> 2 -> 4 -> 5 -> 6
1 -> 3 -> 2 -> 4 -> 6 -> 5
1 -> 2 -> 3 -> 4 -> 6 -> 5

Yes, if Process 3 comes with a resource requirement from Process 6 then there would be a deadlock as Process 6 also comes with a resource requirement from Process 3 and they both will be waiting. [3->6->3]
Topological Sort :

- Search for all the vertices having indegree 0 [There should be atleast one else it's a deadlock]
- Add them into the queue
- For each element in the queue,
  - Print element at Q front
  - Let v_i be the child of Q element polled, reduce its indegree by 1
  - If indegree of v_i is 0 then push it to the queue
- In case the queue is not empty and there are no more vertices with indegree 0 then its a deadlock situation.

4) Code attached in C++
5) Code attached in C++