CSCE 221 Cover Page
Programming Assignment #3

First Name　　　　Last Name　　　　UIN

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Type of sources			
People			
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I certify that I have listed all the sources that I used to develop the solutions/codes to the submitted work.

"On my honor as an Aggie, I have neither given nor received any unauthorized help on this academic work."

Electronic signature　　　　Date

Programming Assignment 3 (100 points) – due June 27

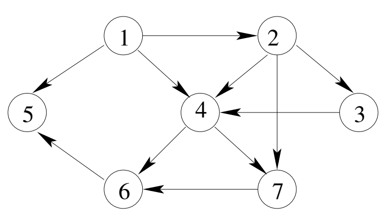
Consider a directed graph without cycles called **a directed acyclic graph** (DAG). In this assignment you are going to find a topological ordering in a DAG. There are many real life problems that can be modeled by such graphs and solved by the topological ordering algorithm. Read the section 9.2, pp. 382-385 in the textbook to learn more about the algorithm.

- The assignment consists of three parts:
  - **Part 1** – implementation of the graph data structure
  - **Part 2** – implementation of the topological ordering for a DAG. Please notice that we take a DAG as an input and the topological ordering for the DAG is returned; or the exception message is displayed: "*There are cycles in the graph*".
  - **Part 3** – preparing a report:
    - ∗ discussing the implementation of the Part 1 and 2 and the running time of the algorithms used to solve the problem.
    - ∗ providing testing cases for correctness
- **Part 1 (40 points)** – demo to your TA in the first lab of June 20 week.

  In this part you should implement a graph data structure which is defined based on an additional type `Vertex`. You can download the supplementary (zipped) file with a code skeleton from the eCampus. The implementation of the `Graph` class should be based on adjacency lists, see the file `graph.h`.

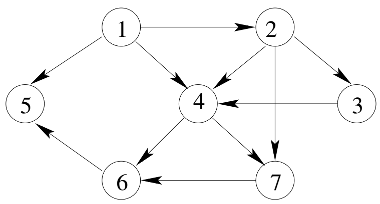
  The graph is populated by reading data from a text file with fixed format, see the example below. At each row, the first number is the label of the start vertex of a directed edge. Other numbers in this row are the end vertices accessed from the start vertex.

  Example. The first row starts with the vertex 1 and provides information about three directed edges to vertices 2, 4 and 5. The number -1 is used as a terminator of a line. In the case when there is no edge for a certain vertex, for example for the vertex 5, the list is empty. This input file is called `input.data` in the supplementary file.




```
1 2 4 5 -1
2 3 4 7 -1
3 4 -1
4 6 7 -1
5 -1
6 5 -1
7 6 -1
```

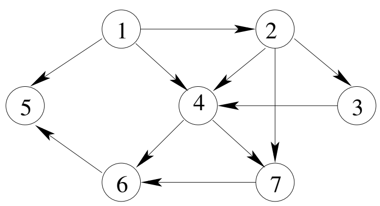
  - The purpose of this part is to read in the data from an input file with a given format, build a graph data structure, and display the graph on the screen in text format.
  - We assume that the graph we are dealing with is sparse and unweighted. Then, adjacency lists will be a natural choice to store the connection between two nodes. The class `Graph` is used to store the graph and implements the necessary operations such as `buildGraph`, and so on. Furthermore, a `Vertex` class can be implemented to store the basic information about a graph node such as a label which in our case is an integer.
  - **We assume that the graph nodes are numbered consecutively starting from 1, and there are no gaps in the node numbering.**
  - `displayGraph()` should print out each vertex and its adjacency list on the screen. For example, consider the graph *G* and its corresponding adjacency linked lists for an input sample graph (`input.data`). Test your program by reading a graph from an input file and use the function `displayGraph()` to display the generated graph in text format on the screen, see the format of the output below.



1 : 2 4 5
2 : 3 4 7
3 : 4
4 : 6 7
5 :
6 : 5
7 : 6

- You can compile your code using this command line:
  `make`
- And you can run your program by executing:
  `./main input.data`

- **Part 2 (40 points)** – due Jun 27 to eCampus.
  - The formal definition of a topological sort:
    Let G be a DAG with n vertices. A **topological ordering** of G is the ordering $v_1, v_2, \ldots, v_n$ of the vertices of G such that for every edge (v_i, v_j) of G, $i < j$.
  - The illustration of the definition of the topological sort ordering gives a sequence of vertices:



`1 2 3 4 7 6 5`

    The topological sort ordering places vertices of the graph along the horizontal line with the following property: if there is an edge from the vertex v_i to the vertex v_j then the vertex v_i precedes v_j in the topological ordering.
  - Topological sort algorithm:
    1. The input is a DAG
    2. Algorithm – see the textbook, Fig. 9.7, p. 385.
       * You can use `topNum` (`top_num`) as in Fig. 9.7, and then traverse the graph to initialize the topological sort ordering vector.
    3. The output of the program should be a vector of vertices (or their labels) set in topological sort order.
       * You need to print the topological sort ordering vector by printing the labels of vertices.

- **Part 3 (20 points) – due April 27**
  - Submit to eCampus: the source code and an electronic version of your report including
    * (15 points) description of your implementation, C++ features used, assumptions on input data.
      · Why does the algorithm use a queue? Can we use a stack instead?
      · Can you explain why the algorithm detects cycles?
      · What is the running time for each function? Use the Big-O notation asymptotic notation and justify your answer.
    * (5 points) test your program for correctness using the four cases below:
      Case 1: Use the example (`input.data`) provided in the description of the problem.
      Case 2: Samantha plans her course schedule. She is interested in the following eight courses: CSCE121, CSCE222, CSCE221, CSCE312, CSCE314, CSCE313, CSCE315, and CSCE411. The course prerequisites are:

course	#	prerequisites	
CSCE121:	1	(none)	
CSCE222:	2	(none)	
CSCE221:	3	CSCE121	CSCE222
CSCE312:	4	CSCE221	
CSCE314:	5	CSCE221	
CSCE313:	6	CSCE221	
CSCE315:	7	CSCE312	CSCE314
CSCE411:	8	CSCE222	CSCE221

Find a sequence of courses that allows Samantha to satisfy all the prerequisites. Assume that she can only take one class at a time. The input file for this case is provided (`input2.data`)

Case 3: Samantha loves foreign languages and wants to plan her course schedule. She is interested in the following nine courses: LA15, LA16, LA22, LA31, LA32, LA126, LA127, LA141, and LA169. The course prerequisite are:

course	#	prerequisites	
LA15:	1	(none)	
LA16:	2	LA15	
LA22:	3	(none)	
LA31:	4	LA15	
LA32:	5	LA16	LA31
LA126:	6	LA22	LA32
LA127:	7	LA16	
LA141:	8	LA22	LA16
LA169:	9	LA32	

Find a sequence of courses that allows Samantha to satisfy all the prerequisites. Assume that she can only take one class at a time.

Case 4. Create a directed graph with cycles and test your program. There is one such a file provided (`input-cycle.data`).