Important

There are general homework guidelines you must always follow. If you fail to follow any of the following guidelines you risk receiving a **0** for the entire assignment.

1. All submitted code must compile under **JDK 8**. This includes unused code, so don't submit extra files that don't compile. Any compile errors will result in a 0.
2. Do not include any package declarations in your classes.
3. Do not change any existing class headers, constructors, or method signatures.
4. Do not add additional public methods.
5. Do not use anything that would trivialize the assignment. (e.g. don't import/use `java.util.LinkedList` for a Linked List assignment. Ask if you are unsure.)
6. Always be very conscious of efficiency. Even if your method is to be $O(n)$, traversing the structure multiple times is considered non-efficient unless that is absolutely required (and that case is extremely rare).
7. You must submit your source code, the `.java` files, not the compiled `.class` files.
8. After you submit your files redownload them and run them to make sure they are what you intended to submit. You are responsible if you submit the wrong files.

Graph Algorithms

For this assignment, you will be coding 4 different graph algorithms.

The first two algorithms are breadth-first search and depth-first search. These algorithms are search algorithms that start at the given vertex and traverse the entire graph in a particular order (the order in which the vertices are visited depend on whether you are doing breadth-first search or depth-first search, the edges that are in the graph, and the order the adjacent vertices are listed). The order in which the vertices are visited is then returned.

The next algorithm is Dijkstra's algorithm. This algorithm finds the shortest path from one vertex to all of the other vertices in the graph. You may assume that none of the edges will have a negative weight.

The last algorithm is Kruskal's minimum spanning tree algorithm. This algorithm finds the minimum spanning tree of the graph and returns the edges that make up that minimum spanning tree.

For all algorithms, you may assume that you are allowed to go from a vertex to itself, and that the distance of that is 0. In addition, the graph with be either directed or undirected; it will not be a mix of the two.

A word of advice: look over and understand the framework before starting the homework. Understanding how the graphs are represented and how the relevant data structures work will be instrumental to this homework.

A note on JUnits

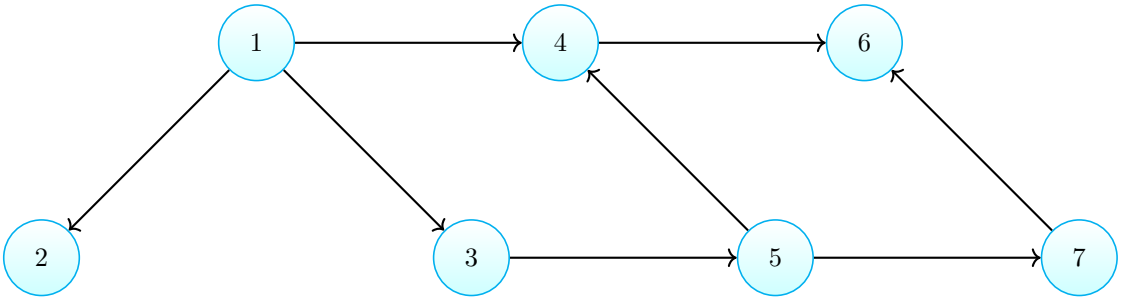
We have provided a **very basic** set of tests for your code, in `GraphAlgorithmsStudentTests.java`. These tests do not guarantee the correctness of your code (by any measure), nor does it guarantee you any grade. You may additionally post your own set of tests for others to use on the Georgia Tech GitHub

as a gist. Do **NOT** post your tests on the public GitHub. There will be a link to the Georgia Tech GitHub as well as a list of JUnits other students have posted on the class Piazza.

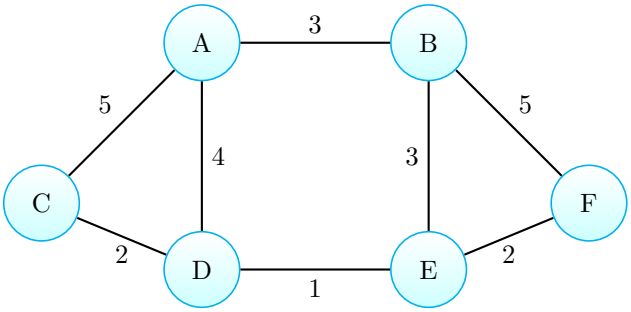
If you need help on running JUnits, there is a guide, available on T-Square under Resources, to help you run JUnits on the command line or in IntelliJ.

Visualizations of Graphs

The directed graph used in the student tests is:



The undirected graph used in the student tests is:



Style and Formatting

It is important that your code is not only functional but is also written clearly and with good style. We will be checking your code against a style checker that we are providing. It is located in T-Square, under Resources, along with instructions on how to use it. We will take off a point for every style error that occurs. If you feel like what you wrote is in accordance with good style but still sets off the style checker please email Carey MacDonald (careyjmac@gatech.edu) with the subject header of "CheckStyle XML".

Javadocs

Javadoc any helper methods you create in a style similar to the existing Javadocs. Like the existing Javadocs, the Javadocs for your helper method(s) must describe well what the method does, what each parameter means (if any), and what the returned value is (if any). If a method is overridden or implemented from a superclass or an interface, you may use `@Override` instead of writing Javadocs.

Exceptions

When throwing exceptions, you must include a message by passing in a String as a parameter. **The message must be useful and tell the user what went wrong**. "Error", "BAD THING HAPPENED", and "fail" are not good messages. The name of the exception itself is not a good message.

For example:

```
throw new PDFReadException("Did not read PDF, will lose points.");

throw new IllegalArgumentException("Cannot insert null data into data structure.");
```

Generics

If available, use the generic type of the class; do **not** use the raw type of the class. For example, use `new LinkedList<Integer>()` instead of `new LinkedList()`. Using the raw type of the class will result in a penalty.

Forbidden Statements

You may not use these in your code at any time in CS 1332.

- `break` may only be used in switch-case statements
- `continue`
- `package`
- `System.arraycopy()`
- `clone()`
- `assert()`
- `Arrays` class
- `Array` class
- `Objects` class
- `Stack` class
- `Collections` class
- `Collection.toArray()`
- Reflection APIs
- Inner, nested, or anonymous classes

Debug print statements are fine, but nothing should be printed when we run them. We expect clean runs - printing to the console when we're grading will result in a penalty. If you use these, we will take off points.

Provided

The following file(s) have been provided to you. There are several, but you will edit only one of them.

1. `GraphAlgorithms.java`

   This is the class in which you will implement the different graph algorithms. Feel free to add private static helper methods but **do not add any new public methods, new classes, instance variables, or static variables**.

2. `GraphAlgorithmsStudentTests.java`

   This is the test class that contains a set of tests covering the basic operations on the `GraphAlgorithms` class. It is not intended to be exhaustive and does not guarantee any type of grade. **Write your own tests to ensure you cover all edge cases.**

3. `Graph.java`

   This class represents a graph. **Do not modify this file.**

4. `Vertex.java`

   This class represents a vertex in the graph. It contains the data in this vertex. **Do not modify this file.**

5. `Edge.java`

   This class represents an edge in the graph. It contains the vertices connected to this edge, its weight, and whether or not it is directed. **Do not modify this file.**

6. `VertexDistancePair.java`

   This class holds together a vertex and a distance. It is meant to be used with Dijkstra's algorithm. **Do not modify this file.**

7. `DisjointSet.java`

   This class implements the disjoint-set data structure. It is meant to be used with Kruskal's algorithm. **Do not modify this file.**

Deliverables

You must submit **all** of the following file(s). Please make sure the filename matches the filename(s) below, and that *only* the following file(s) are present. T-Square does **not** delete files from old uploads; you must do this manually. Failure to do so may result in a penalty.

After submitting, be sure you receive the confirmation email from T-Square, and then download your uploaded files to a new folder, copy over the interfaces, recompile, and run. It is your responsibility to re-test your submission and discover editing oddities, upload issues, etc.

1. `GraphAlgorithms.java`