



Final Exam Review!



Exam Details:

Before Midterm

- Intro to Java, Object Oriented
 - Class, accessors, abstraction, encapsulation, inheritance, packages, types, SubClass + SuperClass, Interface
 - Arrays, Heaps, Stack
-
- Time Complexity (Big O)
- Iterators
- Linked List
- Stack (LIFO), Queue (FIFO), Deque
- Generics
- ArrayList
- Sorting
 - Bubble, Insertion, Merge, Quick
 - Inplace? Stable?
- Trees
 - Binary Tree (Perfect, Full, Complete, balanced)
 - BST
 - Balancing Trees (Red Black BST)
- Map, Hash Table, Symbol Table
- Exceptions
 - Flow, Stack Trace, Try/Catch, Different Exceptions

After Midterm

- Tree Map
- Set
- Graph
 - Cycles
 - Incident
 - Degree
 - Complete Graph
 - Bipartite
 - BiClique
 - Digraph
 - How they're stored/made
- Graph Algorithms
 - Breadth First Search
 - Depth First Search
- Minimum Spanning Tree (MST)
 - Prim's Algorithm
 - Kruskal's Algorithm



Tree Map

- Benefits of a Tree Map?
- 1 Way of implementing it?



Tree Map

- Benefits of a Tree Map?

Allows for map to be sorted

- 1 Way of implementing it?

Nodes with key, value

Comparator based on key



HashCode

What is a hashcode?

What happens when two objects have the same hashcode?



HashCode

What is a hashcode?

A integer value that is assigned to an object during construction by the Object class

What happens when two objects have the same hashcode?

Collision

What's a Collision?

When two or more key objects in a hash table produce the same hash value, pointing toward the same location. Results in lost data unless collisions are handled, like with Separate Chaining Hash



Sets

What is a Set?

What is the runtime of inserting 100 random integers into a set?

Why is the above runtime apply to Sets but not ArrayList?

Sets



What is a Set?

A Collection of Objects that contains no duplicates

What is the runtime of inserting 100 random integers into a set?

$O(n)$, because in order to ensure that there are no duplicates you have to search through the Set

Why is the above runtime apply to Sets but not ArrayList?

ArrayList has insertions of $O(1)$, unless there needs to be a resize $O(n)$

This is because there can be duplicates



Set Operations - Union

What is the Union of a Set A containing $\{1, 2, 3, 4\}$ and Set B containing $\{2, 3, 4, 5\}$

What is a Disjoint Set?

What is the Union of a disjoint set, where A contains $\{1, 2\}$ and B contains $\{3, 4\}$



Set Operations - Union

What is the Union of a Set A containing $\langle 1, 2, 3, 4 \rangle$ and Set B containing $\langle 2, 3, 4, 5 \rangle$

$\langle 1, 2, 3, 4, 5 \rangle$

What is is a Disjoint Set?

When a two sets do not contain any of the same values, like in the example below

What is the Union of a disjoint set, where A contains $\langle 1, 2 \rangle$ and B contains $\langle 3, 4 \rangle$

$\langle 1, 2, 3, 4 \rangle$



Set Operations - Intersection and Difference

What is the resulting set when finding the Intersection of $\{1,2,3,4\}$ and $\{4,5,6\}$

What is the resulting set when finding the intersection of a disjoint set?

What is the resulting set when finding the difference of $\{1,2,3,4\}$ and $\{1,2\}$



Set Operations - Intersection and Difference

What is the resulting set when finding the Intersection of $\langle 1, 2, 3, 4 \rangle$ and $\langle 4, 5, 6 \rangle$

In A, and B (think AND) $\rightarrow \langle 4 \rangle$

What is the resulting set when finding the intersection of a disjoint set?

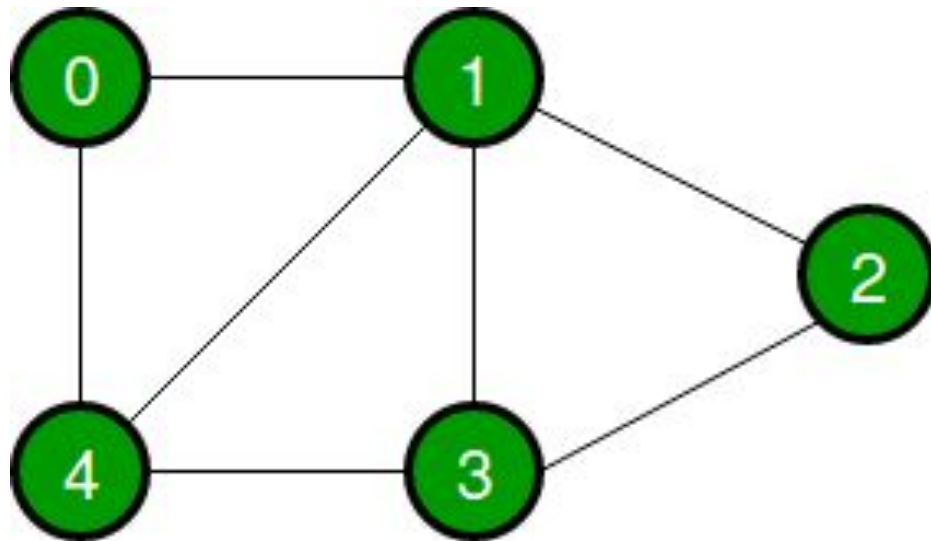
None, because there are no overlapping elements

What is the resulting set when finding the difference of $\langle 1, 2, 3, 4 \rangle$ and $\langle 1, 2 \rangle$

In A, but not B $\rightarrow \langle 3, 4 \rangle$



Graphs





Graph Properties

What is a Cycle in a Graph?

What is an incidence?

What is a degree?



Graph Properties

What is a Cycle in a Graph?

It is when at the edges form a loop

What is an incidence?

Node v is incident to Node w if connected with an edge

What is a degree?

Number of edges incident to a vertex. In a Digraph, In degree is arrows pointing toward the vertex, out degree is arrows originating from the vertex

Types of Graphs



Describe the difference between Directed (Digraph) and Undirected Graphs?

What is a Complete Graph?

What are the total number of edges in a graph with n vertices?

Types of Graphs



Describe the difference between Directed (Digraph) and Undirected Graphs?

Directed graphs consist of one way edges

Undirected graphs consist of 2 way edges (enforced)

What is a Complete Graph?

A Graph with one edge between any pair of vertices

What are the total number of edges in a graph with n vertices?

$$n * (n - 1) / 2$$



What's a DAG?

Are Trees DAGs?

Are Acyclic Graphs Trees?



What's a DAG?

`Directed Acyclic Graph

`(A Digraph with no cycles)

Are Trees DAGs?

`Yes

Are Acyclic Graphs Trees?

Not always

Types of Graphs



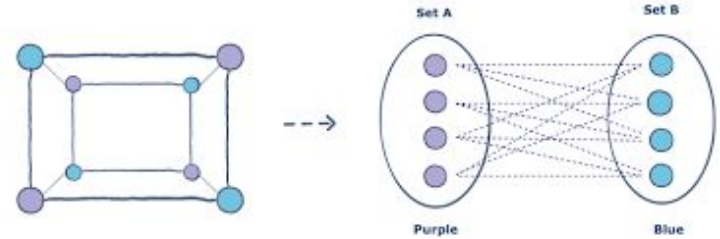
What is a Bipartite Graph?

What is a BiClique Graph?

Types of Graphs

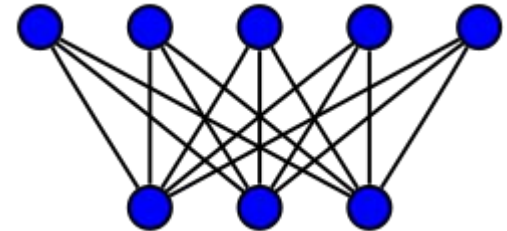
What is a Bipartite Graph?

Set of graph vertices, decomposed into two disjoint sets, meaning they have no element in common, such that no two graph vertices within the same set are adjacent.



What is a BiClique Graph?

Complete Bipartite Graph. Every vertex of the first set is connected to every vertex of the second set





Weighted vs Unweighted Graph

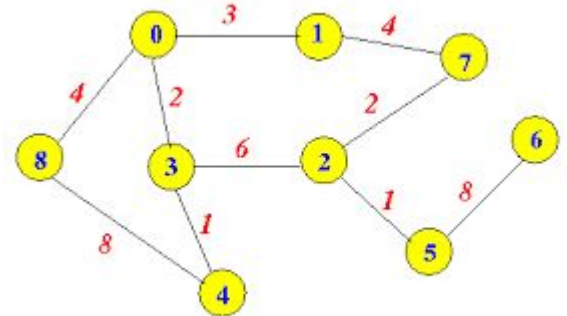
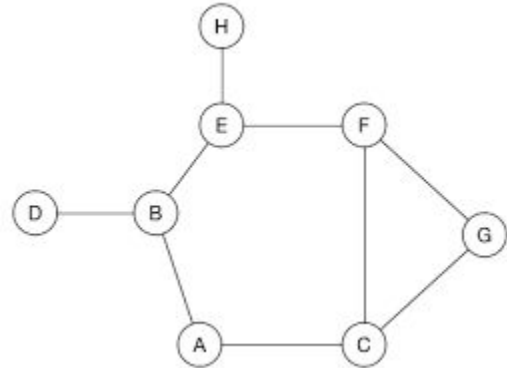
Whats the difference between a weighted and unweighted graph?

Weighted vs Unweighted Graph

Whats the difference between a weighted and unweighted graph?

An unweighted edge's weight is binary, and either exists or does not exist.

A weighted graph has values that indicate a level of precedence attached to each edge





Difference between Connected and UnConnected graph

How many components are there in the disconnected graph?

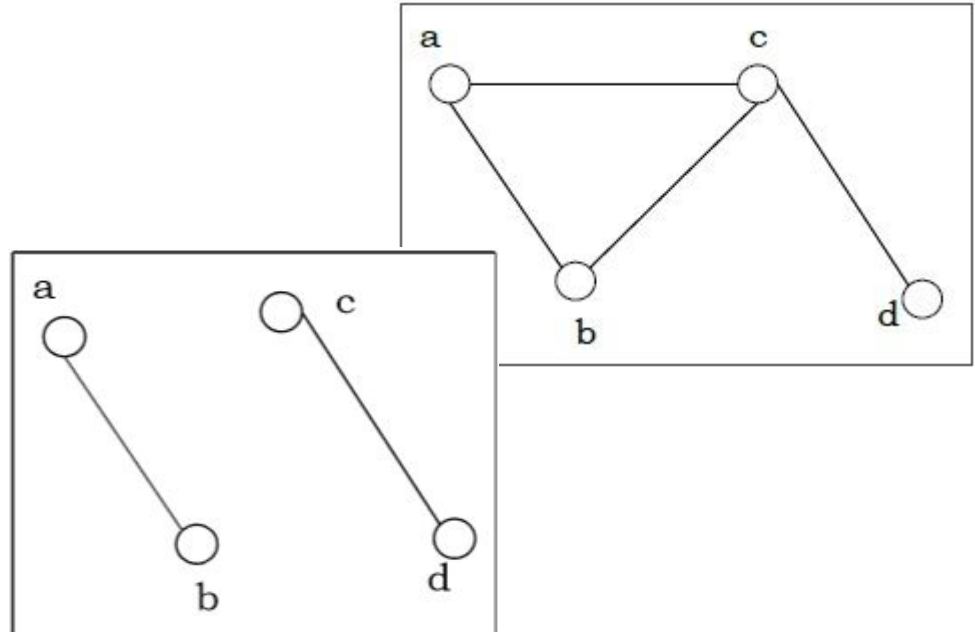
Difference between Connected and UnConnected graph

Connected: any two vertices of the graph are connected by a path

Unconnected: at least two vertices of the graph are not connected by a path

How many components are there in the disconnected graph?

2

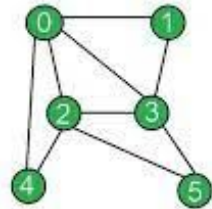




Name 3 ways that Graphs could be Implemented?

Name 3 ways that Graphs could be Implemented?

- List of Nodes, List of Edges between Nodes
- Hash Table of vertex -> set of children
- Adjacency matrix



	0	1	2	3	4	5
0	0	1	1	1	1	0
1	1	0	0	1	0	0
2	1	0	0	1	1	1
3	1	1	1	0	0	1
4	1	0	1	0	0	0
5	0	0	1	1	0	0



Graph Traversals - Breadth First Search

Describe how the BFS Algorithm works in your own words

Time Complexity of BFS

Graph Traversals - Breadth First Search

Describe how the BFS Algorithm works in your own words

- Create a queue initialized with the root
- So long as the queue has values
 - Pop node
 - If that node is the desired node, its over
 - Otherwise, add all the children of the node to the queue



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Time Complexity of BFS

$O(V + E)$ if using Adjacency List, $O(V^2)$ when using Adjacency Matrix



Graph Traversals - Depth First Search

Describe how the DFS Algorithm works in your own words

Time Complexity of DFS

Graph Traversals - Depth First Search

Describe how the DFS Algorithm works in your own words

Recursive function that takes in index of a node and a visited array

- Mark the current node as visited and print the node
- Call the recursive function for each adjacent

Time Complexity of DFS

$O(V+E)$

<https://www.cs.usfca.edu/~galles/visualization/DFS.html>





Graph Traversals - Best First Search

Describe how the Best First Search Algorithm works in your own words

Time Complexity of Best First Search



Graph Traversals - Best First Search

Describe how the Best First Search Algorithm works in your own words

A variation of BFS that uses a priority queue instead of a queue to increase efficiency when working with weighted edges

Time Complexity of Best First Search

$O(n * \log n)$



Applications for the Graph structure



Applications for the Graph structure

- Google Maps
- Computer Networks (Each computer/connected device is a vertex)
- Facebook
- The internet



Is it better to store a path between two nodes in a Set or a List?



Is it better to store a path between two nodes in a Set or a List?

Its better to store the path in a List

Why?

Sets are unordered, meaning when holding the values the order of the path would be jumbled

ArrayLists store its values in order, making it ideal



Minimum Spanning Tree

What is a spanning tree?

Does a minimum spanning tree work with unweighted graphs?

If a MST consists of all vertices, how many edges do you have?



Minimum Spanning Tree

What is a spanning tree?

A graph that contains all of the graph's vertices, reaches all vertices, and is acyclic

Does a minimum spanning tree work with unweighted graphs?

Yes, but any spanning tree will be a minimum spanning tree. With weights, you are able to optimize a shortest path

If a MST consists of all vertices, how many edges do you have?

$V - 1$



MST - Kruskal's

Put Kruskal's algorithm into words



MST - Kruskal's

Put Kruskal's algorithm into words

- Find the edge of shortest weight and highlight it
- For the rest of the edges
 - Find the edge of smallest weight
 - If there is a tie, choose one
 - If that edge would create a cycle, no longer consider that edge
 - Highlight the chosen edge



MST - Prim's Algorithm

Put Prim's into your own words:



MST - Prim's Algorithm

Put Prim's into your own words:

- Select a random starting vertex
- Repeat until the tree meets the properties of a spanning tree
 - Find all the edges that connect the tree to new vertices, find the minimum and add it to the tree



MST - Boruvka's Algorithm

What does the graph need to be able to run Boruvka's?

Put Boruvka's into your own word:



MST - Boruvka's Algorithm

What does the graph need to be able to run Boruvka's?

Connected, Weighted, Undirected Graph

Put Boruvka's into your own word:

- Make each vertex an individual component
- While there are more than one components, do following for each component.
 - Find the closest weight edge that connects this component to any other component.
 - Add this closest edge to MST if not already added



Sample Code

<https://www.cs.umb.edu/~cyrus/cs210/sample-code/>

Look over sample code from class from after/around the midterm

Will definitely be helpful in preparing for the programming portions of the exam