Graph: set of vertices and edges that connect the vertices.
- If the edge pairs are ordered, it is called a directed graph.
- A vertex w is adjacent to vertex v if there is an edge from v to w.
- Edges can have an additional value: a weight.
- A path is a sequence of vertices connected by edges.
- Vertices are also called nodes.

Graph traversal:
- Graph traversal: operation that converts the nodes in a graph into a list
  - may encounter a node more than once
- Depth first traversal
  - Print the data from the first node
  - Go to an unvisited adjacent node of the previous node, print its data
  - Repeat until a node has no unvisited adjacent nodes
  - backtrack to a previously visited node, repeat on an unvisited adjacent node, until you backtrack past root.
  - A stack (or recursion) is useful for backtracking.

Example of a path: 6,4,5,2
Graph traversal

- Breadth first traversal
  - Begin at the root node,
  - Explore all the adjacent nodes.
  - Then for each of those nearest nodes, explore their adjacent nodes,
  - and so on, until it has visited each node.
  - A queue is useful in keeping track of the unprocessed nodes.

DFT: 6 4 5 1 2 3
BFT: 6 4 3 5 2 1
More than one correct DFT and BFT

Recursive Depth First Traversal

- Recursive Depth first traversal, given a node
  - Print the data from the node
  - Mark the node as visited
  - For each unvisited adjacent node of the given node, perform Depth first traversal on that node.
  - What is the base case? when there are no unvisited adjacent nodes

Adjacency matrix:
- a two dimensional matrix, rows and columns are nodes.
- Initialize to 0’s.
- For each edge (v,w) in the graph, set a[v][w] to 1.
  - or set a[v][w] to the weight of the edge from v to w

Adjacency list:
- nodes are stored as objects, and each node stores a list of adjacent nodes.
  - and the weight of the edge to the adjacent node
- uses less space.
Graphs: Representations

An undirected graph and its adjacency matrix representation.

An undirected graph and its adjacency list representation.

Graphs: algorithms

- **Shortest Path**
  - Find the shortest path from one node to another.
  - Paths could be weighted
  - Real world application: Google maps directions

- **Traveling salesman problem:**
  - Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?
  - Basically exponential run time.