#39: MSTs: Kruskal + Prim's Algorithm

Kruskal's Algorithm

Pseudocode for Kruskal's MST Algorithm

```
1   KruskalMST(G):
2     DisjointSets forest
3     foreach (Vertex v : G.vertices()):
4       forest.makeSet(v)
5
6     PriorityQueue Q    // min edge weight
7     Q.buildFromGraph(G.edges())
8
9     Graph T = (V, {})
10
11    while |T.edges()| < n-1:
12      Vertex (u, v) = Q.removeMin()
13      if forest.find(u) != forest.find(v):
14         T.addEdge(u, v)
15         forest.union( forest.find(u),
16                       forest.find(v) )
17
18    return T
19
```

Kruskal's Running Time Analysis

We have multiple choices on which underlying data structure to use to build the Priority Queue used in Kruskal's Algorithm:

Priority Queue Implementations:	Heap	Sorted Array
Building :7		
Each removeMin :12		

Based on our algorithm choice:

Priority Queue Implementation:	Total Running Time
Heap	
Sorted Array	

Reflections

Why would we prefer a Heap?

Why would be prefer a Sorted Array?

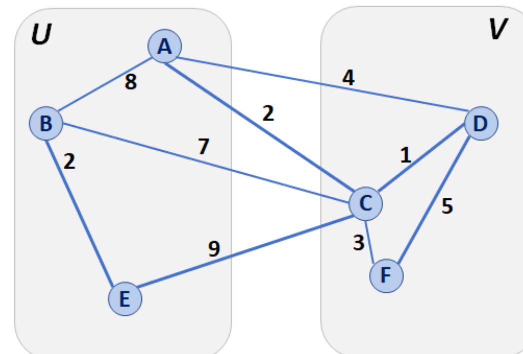
Partition Property

Consider an arbitrary partition of the vertices on **G** into two subsets **U** and **V**.

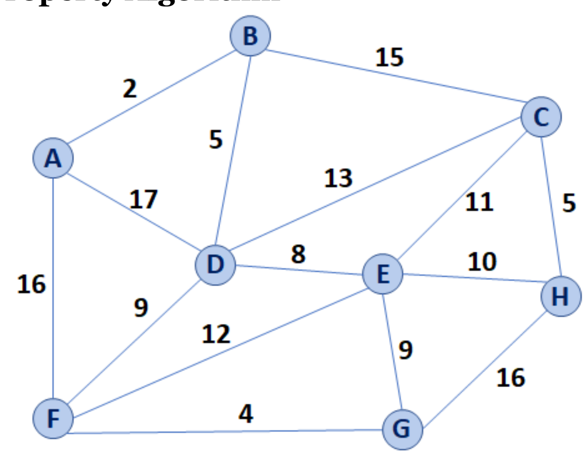
Let **e** be an edge of minimum weight across the partition.

Then **e** is part of some minimum spanning tree.

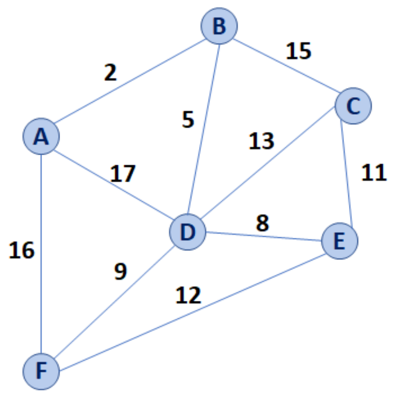
Proof in CS 374!



Partition Property Algorithm



Prim's Minimum Spanning Tree Algorithm



Pseudocode for Prim's MST Algorithm

```
PrimMST(G, s):
  Input: G, Graph;
         s, vertex in G, starting vertex of algorithm
  Output: T, a minimum spanning tree (MST) of G

  foreach (Vertex v : G.vertices()):
    d[v] = +inf
    p[v] = NULL
  d[s] = 0

  PriorityQueue Q   // min distance, defined by d[v]
  Q.buildHeap(G.vertices())
  Graph T           // "labeled set"

  repeat n times:
    Vertex m = Q.removeMin()
    T.add(m)
    foreach (Vertex v : neighbors of m not in T):
      if cost(v, m) < d[v]:
        d[v] = cost(v, m)
        p[v] = m

  return T
```

	Adj. Matrix	Adj. List
Heap		
Unsorted Array		

Running Time of MST Algorithms

Kruskal's Algorithm:

Prim's Algorithm:

Q: What must be true about the connectivity of a graph when running an MST algorithm?

…what does this imply about the relationship between **n** and **m**?

Kruskal's MST	Prim's MST

Q: Suppose we built a new heap that optimized the decrease-key operation, where decreasing the value of a key in a heap updates the heap in amortized constant time, or O(1)*. How does that change Prim's Algorithm runtime?

Final big-O Running Times of classical MST algorithms:

Kruskal's MST	Prim's MST