Best Running Time of MST Algorithms (so far):

<table>
<thead>
<tr>
<th>Kruskal’s MST</th>
<th>Prim’s MST</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O(n + m \log(n))$</td>
<td>$O(n \log(n) + m \log(n))$</td>
</tr>
</tbody>
</table>

...however, we know that, for an MST algorithm, the graph must be at least minimally connected. This means there must be at least one edge on every vertex. The number of edges must be:

$$n - 1 \leq m \leq \frac{n(n-1)}{2}$$

...or in terms of big-O...

$$O(n) \leq O(m) \leq O(n^2)$$

Using the fact they are connected:

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<td>Sparse Graph ($m = n$):</td>
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</tr>
<tr>
<td>Dense Graph ($m = n^2$):</td>
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</tr>
<tr>
<td>All Graphs:</td>
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</tbody>
</table>

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?
**Dijkstra’s Algorithm (Single Source Shortest Path)**

**Dijkstra’s Algorithm Overview:**
- The overall logic is the same as Prim’s Algorithm
- We will modify the code in only two places – both involving the update to the distance metric.
- The result is a directed acyclic graph or DAG

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**Pseudocode for Dijkstra’s SSSP Algorithm**

```
DijkstraSSSP(G, s):
    Input: G, Graph;
          s, vertex in G, starting vertex of algorithm
    Output: T, DAG w/ shortest paths (and distances) to s

    foreach (Vertex v : G):
        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 ________________________ < d[v]:
                d[v] = _________________________
                p[v] = m

    return T
```

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**Dijkstra: What if we have a negative-weight cycle?**

**Dijkstra: What if we have a minimum-weight edge, without having a negative-weight cycle?**

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**Dijkstra makes an assumption:**

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**Dijkstra: What is the running time?**

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**CS 225 – Things To Be Doing:**

1. Final Exam starts on READING DAY!
2. MP7 Part 3 Released TOMORROW; EC due tonight!
3. lab_finale in lab this week!
4. Daily POTDs are ongoing for +1 point /problem