Assignment 9: PacMan!
Analysis Document by Jacob Brown

1. Lindsey Loveland, I will be submitting the source code.

2. They were efficient/reliable with the time we spent together, they knew the assignment specifications, and we both did an equal share of the work.

3. Say we have a theoretical square maze of infinite size which allows for a straight-line distance of N from goal to start as we grow N larger and larger, since a path cannot go diagonal each space that isn't an edge of a maze has 4 neighbors. As N gets very large, 4 neighbors become 16 neighbors as a BST search is start (minus the nodes already visited), 16 neighbors become 64 neighbors as the search continues (minus the nodes already visited). While N becomes larger and larger, runtime is drastically increased since nodes needed to be visited grow drastically.

4.

Straight-line distance does not account for obstacles or if the start and goal are on the same row/column. If you look at maze A. and B (above). you'll see the straight-line distance is the same but the run time complexity would be wildly increase if we relatively increased the size of both mazes since many more nodes would be searched before terminating a BFS.

Whereas the actual solution path length will give a more reliable the run time as shown.

(maze A. and B. above have the same solution path length)

5. **The following are several visualizations of the visited nodes in a BFS,**

('0' in the maze visualization indicates a node visited in the search)

```
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx     xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
x0000000000000000000000000000000000000000000000x   xG0000000000000                                    x
x0000000000000000000000000000000000000000000000x   x000000000000000                                   x
x0000000000000000000000000000000000000000000000x   x0000000000000000                                  x
x0000000000000000000000000000000000000000000000x   x00000000000000000                  x              x
x0000000000000000000000000000000000000000000000x   x000000000000000000                                x
x0000000000000000000000000000000000000000000000x   x0000000000000000000                               x
x0000000000000000000000000000000000000000000000x   x00000000000000000000    x                         x
x00000000000000000000000.......................x   x000000000000000000000                             x
xxxxxxxxxxxxxxxxxxxxxxxxx.xxxxxxxxxxxxxxxxxxxxxx.x   x0000000000000000000000                            x
x.......................x..........x0000000000.x   x00000000000000000000000                           x
x.00000000000000000000000x.0000xxxxx.x0000000000.x  x000000000x00000000000000                          x
x.00000000000000000000000x.0000xG....x0000000000.x  x0000000000000000000000000                         x
x.00000000000000000000000x.xxxxxxxxxx0000000000.x   x00000000000000000000000000                        x
x.00000000000000000000000x.0000000000x0000000000.x  x000000000000000000000000000                       x
x.00000000000000000000000x.0000000000x0000000000.x  x0000000000000000000000000x0000                    x
x.00000000000000000000000x.0000000000x0000000000.x  x00000000000000000000000000000000                  x
xS0000000000000000000000x.......................x   x000000S00000000000000000000000000                 x
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx    xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

A.   B.

```
XXXXXXXXXXXXXX        XXXXXXXXXXXXXXX       XXXXXXXXXXXXXXX        XXXXXXXXXXXXXXX
X00000       X        X000000S000000X       X000000S000000X        X000000S000000X
X000000      X        X00000000000000X      X00000000000000X       X00000000000000X
X0000000     X        X00000000000000X      X00000000000000X       X00000000000000X
X00000000    X        X00000000000000X      X00000000000000X       X00000000000000X
X000000000   X        X00000000000000X      X00000000000000X       X00000000000000X
X0000000000  X        X 00000000000 X       X00000000000000X       X00000000000000X
X00000000000 X        X  000000000  X       X00000000000000X       X00000000000000X
X000000000000 X       X   0000000   X       X0000000000000X        X0000000000000X
X0000000000000X       X    00000    X       X0XXXXXXXXXXX0X         X0XXXXXXXXXXX0X
XS00000000000GX       X     0G0     X       X000000G000000X         X000000G000000X
X00000000000000 X     X             X       X000000 000000X         X000000 000000X
X00000000000000 X     X             X       X00000   00000X         X0X0X0X X0X0X0X
X0000000000000 X      X             X       X0000     0000X         X0000     0000X
X000000000000 X       X             X       X000       000X         X0X0X X X X0X0X
X00000000000 X        X             X       X00         00X         X00         00X
X0000000000  X        X             X       X0           0X         X0X X X X X X0X
X000000000   X        X             X       X             X         X             X
X00000000    X        X             X       X             X         X X X X X X X X
X0000000     X        X             X       X             X         X             X
X00000       X        X             X       X             X         X X X X X X X X
XXXXXXXXXXXXXX        XXXXXXXXXXXXXXX        XXXXXXXXXXXXXXX         XXXXXXXXXXXXXXX
```

D.   E.   F.   G.

The worst case for a maze of Size N is when every node is visited. Worst case behavior for a maze would be O(n) where lowercase 'n' is the number of visit-able nodes in the graph/maze.

If we look at D and E, we see mazes with near average case behavior.

maze A. shows a worst-case behavior and maze B. shows a minimally dense maze with near average case behavior.

A dense maze may not indicate an increase in worst case behavior, since it entirely depends whether the obstacles are neighboring each other and **also** if they directly block the path of start and goal in a meaningful way.

If you look at maze E. you will see that a maze with zero density with better than average complexity.

If you look at maze F. you will see the same maze but in the middle of goal and start, obstacles which directly influence the BFS in a meaningful way and redirect it out to create worse algorithmic complexity.

If you look at maze G. you will see the same maze as maze F. but is more dense overall; with all the density opposite of the path of goal and start. The complexity of maze G. and F. are the same but the density of G.<F. indicating that complexity depends on whether the obstacles are placed in a meaningful way rather than how overall dense the maze is.

6.   8 hours.