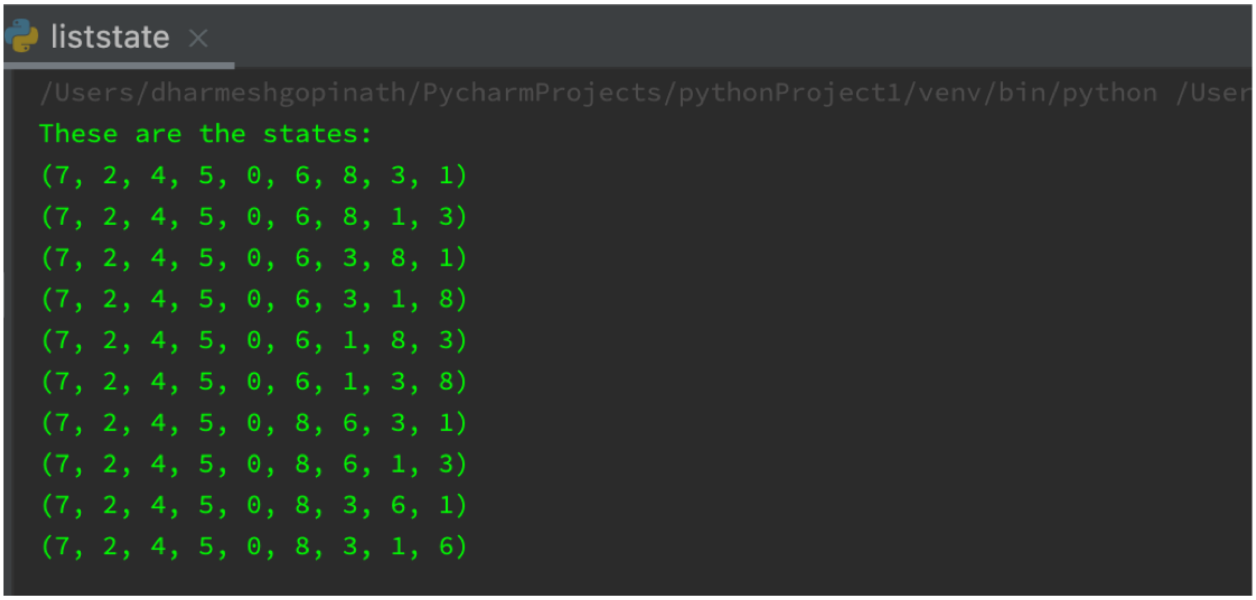
AI Assignment 1

Name: Dharmesh Gopinath

A) [10 pts] Lists all states [No need to submit the output (the list of states) for this part, and just submit the code and the first [or randomly selected] 10 states, since the list will be very long !!!]

Ans:

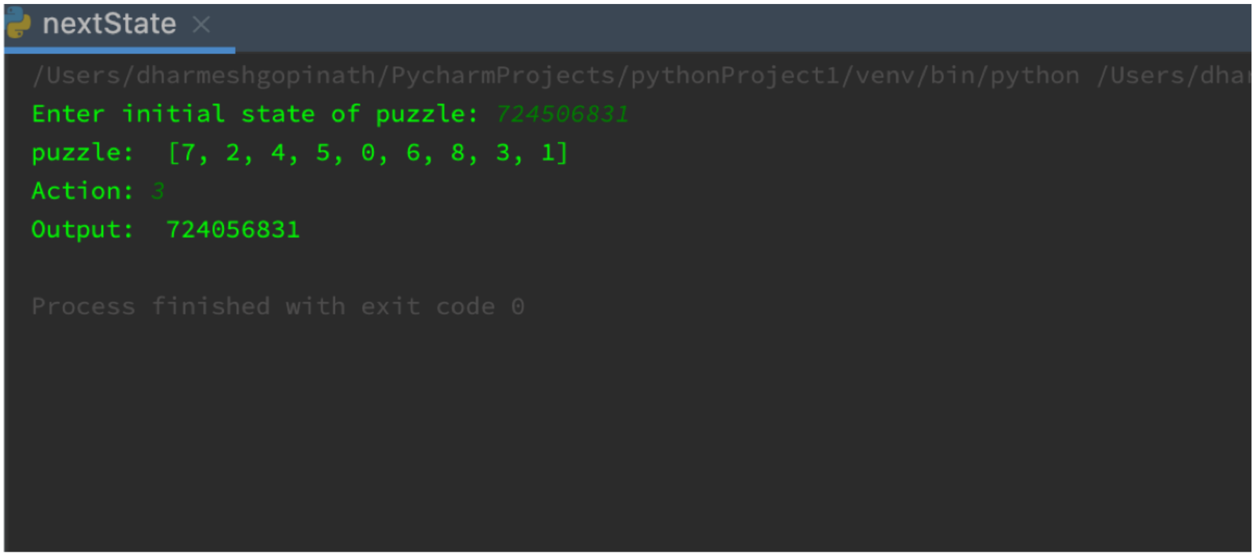


```
/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /User
These are the states:
(7, 2, 4, 5, 0, 6, 8, 3, 1)
(7, 2, 4, 5, 0, 6, 8, 1, 3)
(7, 2, 4, 5, 0, 6, 3, 8, 1)
(7, 2, 4, 5, 0, 6, 3, 1, 8)
(7, 2, 4, 5, 0, 6, 1, 8, 3)
(7, 2, 4, 5, 0, 6, 1, 3, 8)
(7, 2, 4, 5, 0, 8, 6, 3, 1)
(7, 2, 4, 5, 0, 8, 6, 1, 3)
(7, 2, 4, 5, 0, 8, 3, 6, 1)
(7, 2, 4, 5, 0, 8, 3, 1, 6)
```

Caption

B) [10 pts] Gets the current state and the action (moving up:1, down:2, left:3, right:4) as input, and returns the resulting state. Represent the blank spot with “0” and use one of the following naming formats for states
Represent each state with a sequence of numbers from left to right and top to bottom.
Ex. Use 7-2-4-5-0-6-8-3-1 for the state shown above
Represent each state by a 9-digit integer number. Like show the above state by 724506831
Ex: Input (Current state: 724506831, Action: 3) should give output state: 724056831

Ans:



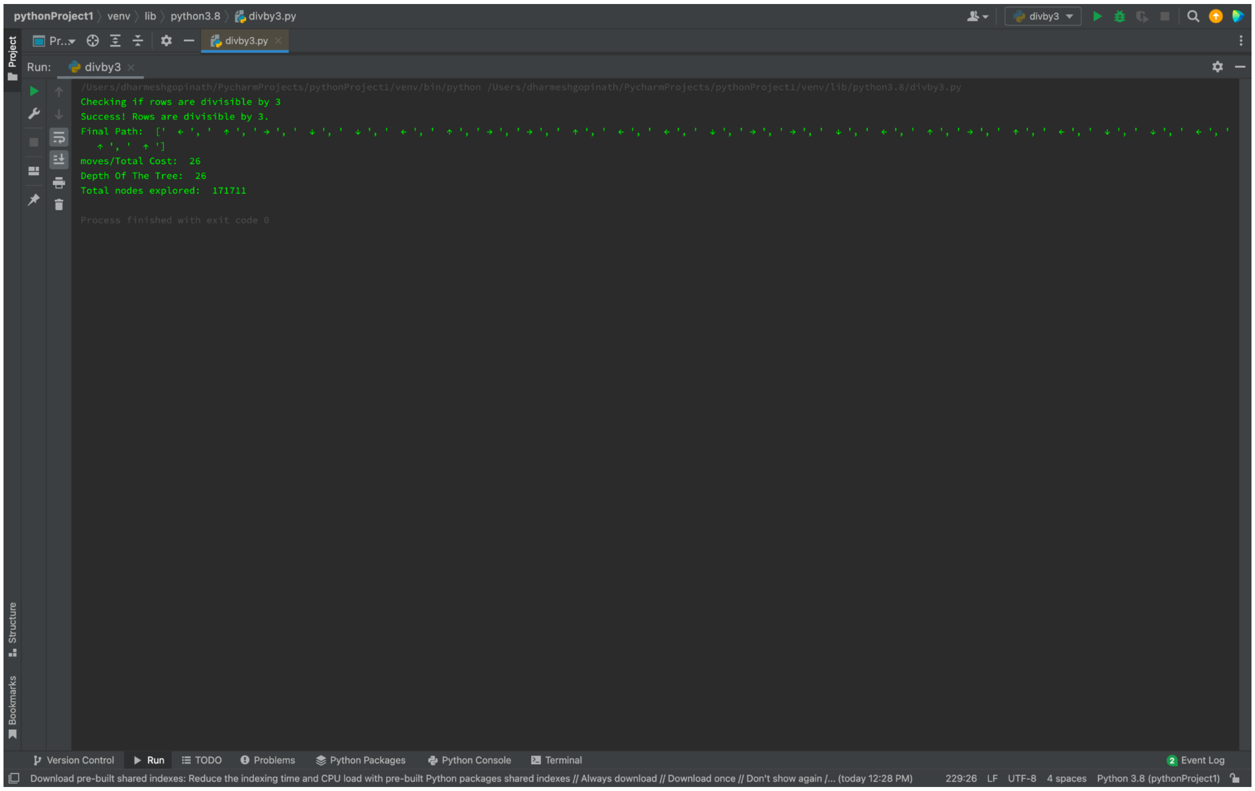
```
/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /Users/dha
Enter initial state of puzzle: 724506831
puzzle:  [7, 2, 4, 5, 0, 6, 8, 3, 1]
Action: 3
Output:  724056831

Process finished with exit code 0
```

Caption

C) [10 pts] Suppose that the goal is to arrange the numbers so that the resulting 3-digit numbers created by each row are divisible by 3. For instance, 7-2-0-5-4-6-8-3-1 is a goal state because 720, 546, and 831 are divisible by 3. Write a program that prompts the user to receive an arbitrary initial state, and then performs random actions to reach the goal state. Show the sequence of actions and the sequence of states.

Ans:



```
/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/divby3.py
Checking if rows are divisible by 3
Success! Rows are divisible by 3.
Final Path:  ['  ← ', '  ↑ ', ' → ', '  ↓ ', '  ↓ ', '  ← ', '  ↑ ', ' → ', ' → ', '  ↑ ', '  ← ', '  ← ', '  ← ', '  ↓ ', ' → ', ' → ', '  ↓ ', '  ← ', '  ↑ ', ' → ', '  ↑ ', '  ← ', '  ↓ ', '  ↓ ', '  ← ', '
   ↑ ', '  ↑ ']
moves/Total Cost:  26
Depth Of The Tree:  26
Total nodes explored:  171711

Process finished with exit code 0
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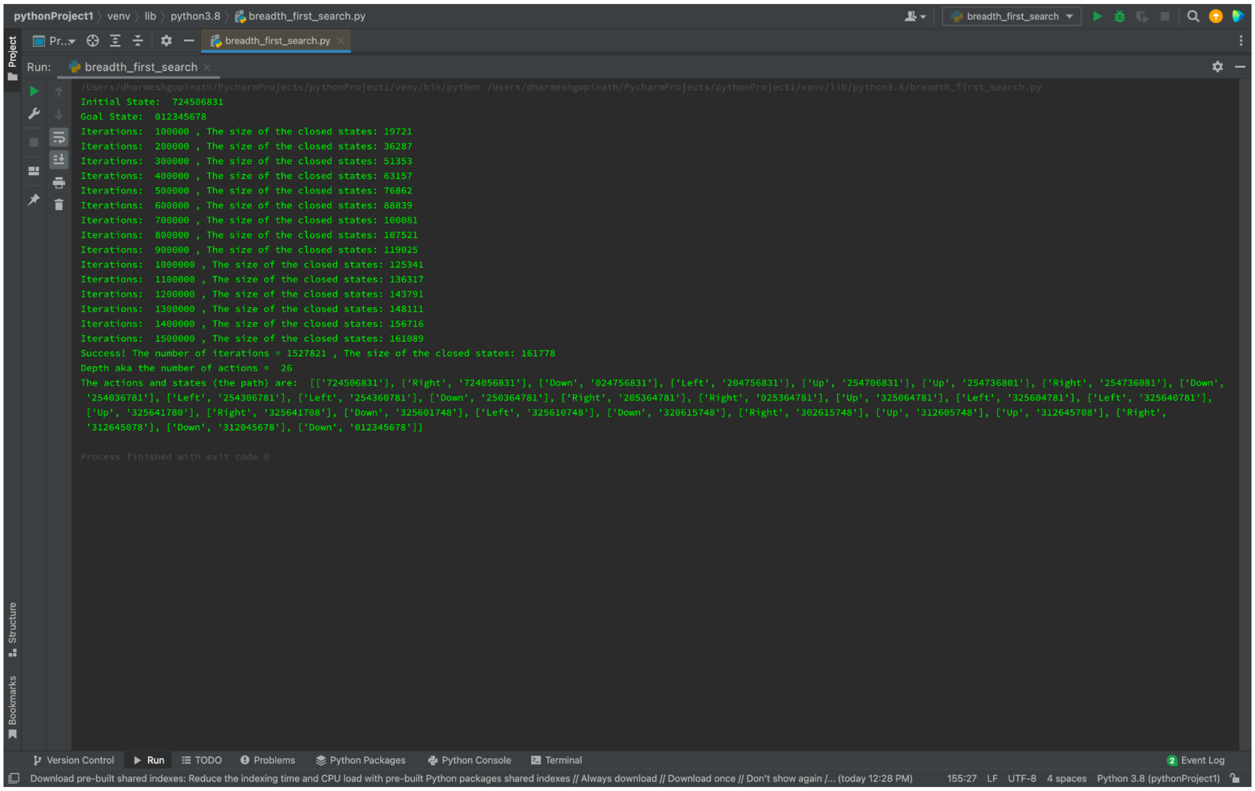
D) [20 pts] Suppose that the goal is arranging the blocks in numerical order as shown below. Develop a Breadth First Search (BFS) algorithm and show the results. Present the sequence of states and moves, starting from the initial state. How many moves (actions) did it take to reach the goal state?

Ans:


pythonProject1 〉 venv 〉 lib 〉 python3.8 〉 breadth_first_search.py
breadth_first_search
Project
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Run:
breadth_first_search
Structure
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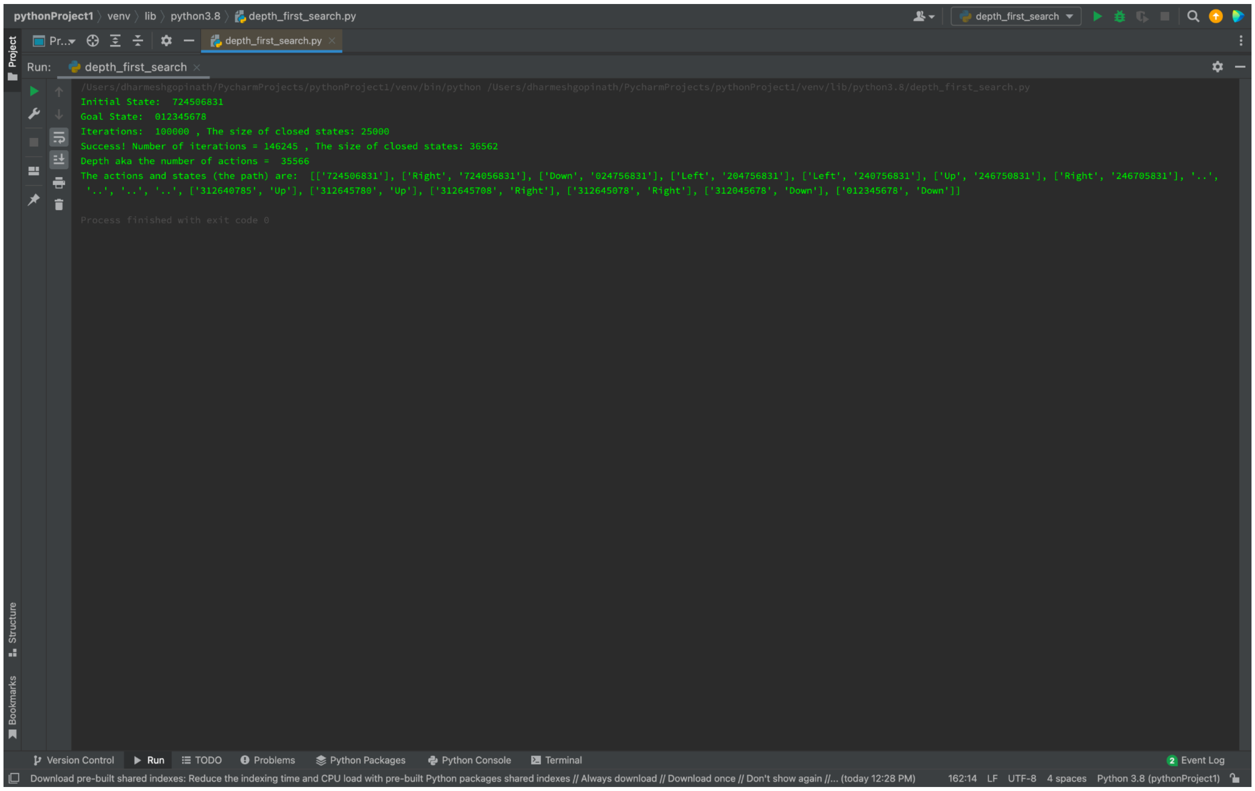
155:27 LF UTF-8 4 spaces Python 3.8 (pythonProject1)

```
/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/breadth_first_search.py
Initial State:  724506831
Goal State:  012345678
Iterations:  100000 , The size of the closed states: 19721
Iterations:  200000 , The size of the closed states: 36287
Iterations:  300000 , The size of the closed states: 51353
Iterations:  400000 , The size of the closed states: 63157
Iterations:  500000 , The size of the closed states: 76862
Iterations:  600000 , The size of the closed states: 88839
Iterations:  700000 , The size of the closed states: 100081
Iterations:  800000 , The size of the closed states: 107521
Iterations:  900000 , The size of the closed states: 119025
Iterations:  1000000 , The size of the closed states: 125341
Iterations:  1100000 , The size of the closed states: 136317
Iterations:  1200000 , The size of the closed states: 143791
Iterations:  1300000 , The size of the closed states: 148111
Iterations:  1400000 , The size of the closed states: 156716
Iterations:  1500000 , The size of the closed states: 161089
Success! The number of iterations = 1527821 , The size of the closed states: 161778
Depth aka the number of actions =  26
The actions and states (the path) are:  [['724506831'], ['Right', '724056831'], ['Down', '024756831'], ['Left', '204756831'], ['Up', '254706831'], ['Up', '254736801'], ['Right', '254736081'], ['Down',
 '254036781'], ['Left', '254306781'], ['Left', '254360781'], ['Down', '250364781'], ['Right', '205364781'], ['Right', '025364781'], ['Up', '325064781'], ['Left', '325604781'], ['Left', '325640781'],
 ['Up', '325641780'], ['Right', '325641708'], ['Down', '325601748'], ['Left', '325610748'], ['Down', '320615748'], ['Right', '302615748'], ['Up', '312605748'], ['Up', '312645708'], ['Right',
 '312645078'], ['Down', '312045678'], ['Down', '012345678']]

Process finished with exit code 0
```

E) [10 pts] Repeat part (D) using a Depth-First Search (DFS). How many moves (actions) did it take to reach the goal state?
Which algorithm found the solution with fewer moves? Explain your observation.

Ans:



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/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/depth_first_search.py
Initial State:  724506831
Goal State:  012345678
Iterations:  100000 , The size of closed states: 25000
Success! Number of iterations = 146245 , The size of closed states: 36562
Depth aka the number of actions =  35566
The actions and states (the path) are:  [['724506831'], ['Right', '724056831'], ['Down', '024756831'], ['Left', '204756831'], ['Left', '240756831'], ['Up', '246750831'], ['Right', '246705831'], '..',
 '..', '..', '..', ['312640785', 'Up'], ['312645780', 'Up'], ['312645708', 'Right'], ['312645078', 'Right'], ['312045678', 'Down'], ['012345678', 'Down']]

Process finished with exit code 0
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pythonProject1 〉 venv 〉 lib 〉 python3.8 〉 depth_first_search.py
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Pr...
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Run: depth_first_search
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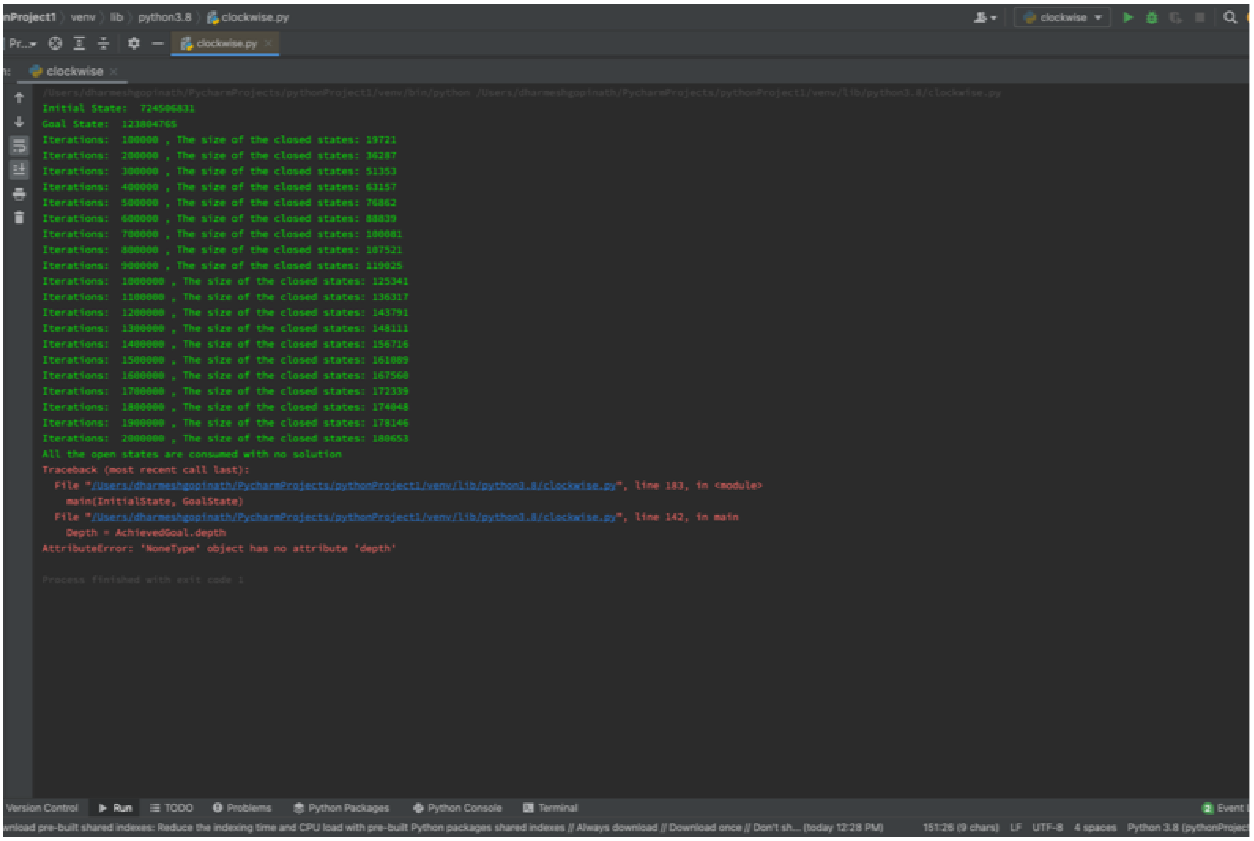
162:14 LF UTF-8 4 spaces Python 3.8 (pythonProject1)

BFS found the path in fewer moves.

F) [10 pts] Repeat Part (D), if the goal is ordering the numbers clockwise around the blank space, with the given initial state, as shown below.

Ans:
The goal state is cannot be achieved through BFS.



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151:26 (9 chars) LF UTF-8 4 spaces Python 3.8 (pythonProject

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/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/clockwise.py
Initial State:  724506831
Goal State:  123804765
Iterations:  100000 , The size of the closed states: 19721
Iterations:  200000 , The size of the closed states: 36287
Iterations:  300000 , The size of the closed states: 51353
Iterations:  400000 , The size of the closed states: 63157
Iterations:  500000 , The size of the closed states: 76862
Iterations:  600000 , The size of the closed states: 88839
Iterations:  700000 , The size of the closed states: 100081
Iterations:  800000 , The size of the closed states: 107521
Iterations:  900000 , The size of the closed states: 119025
Iterations:  1000000 , The size of the closed states: 125341
Iterations:  1100000 , The size of the closed states: 136317
Iterations:  1200000 , The size of the closed states: 143791
Iterations:  1300000 , The size of the closed states: 148111
Iterations:  1400000 , The size of the closed states: 156716
Iterations:  1500000 , The size of the closed states: 161089
Iterations:  1600000 , The size of the closed states: 167560
Iterations:  1700000 , The size of the closed states: 172339
Iterations:  1800000 , The size of the closed states: 174048
Iterations:  1900000 , The size of the closed states: 178146
Iterations:  2000000 , The size of the closed states: 180653
All the open states are consumed with no solution
Traceback (most recent call last):
  File "/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/clockwise.py", line 183, in <module>
    main(InitialState, GoalState)
  File "/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/clockwise.py", line 142, in main
    Depth = AchievedGoal.depth
AttributeError: 'NoneType' object has no attribute 'depth'

Process finished with exit code 1
```

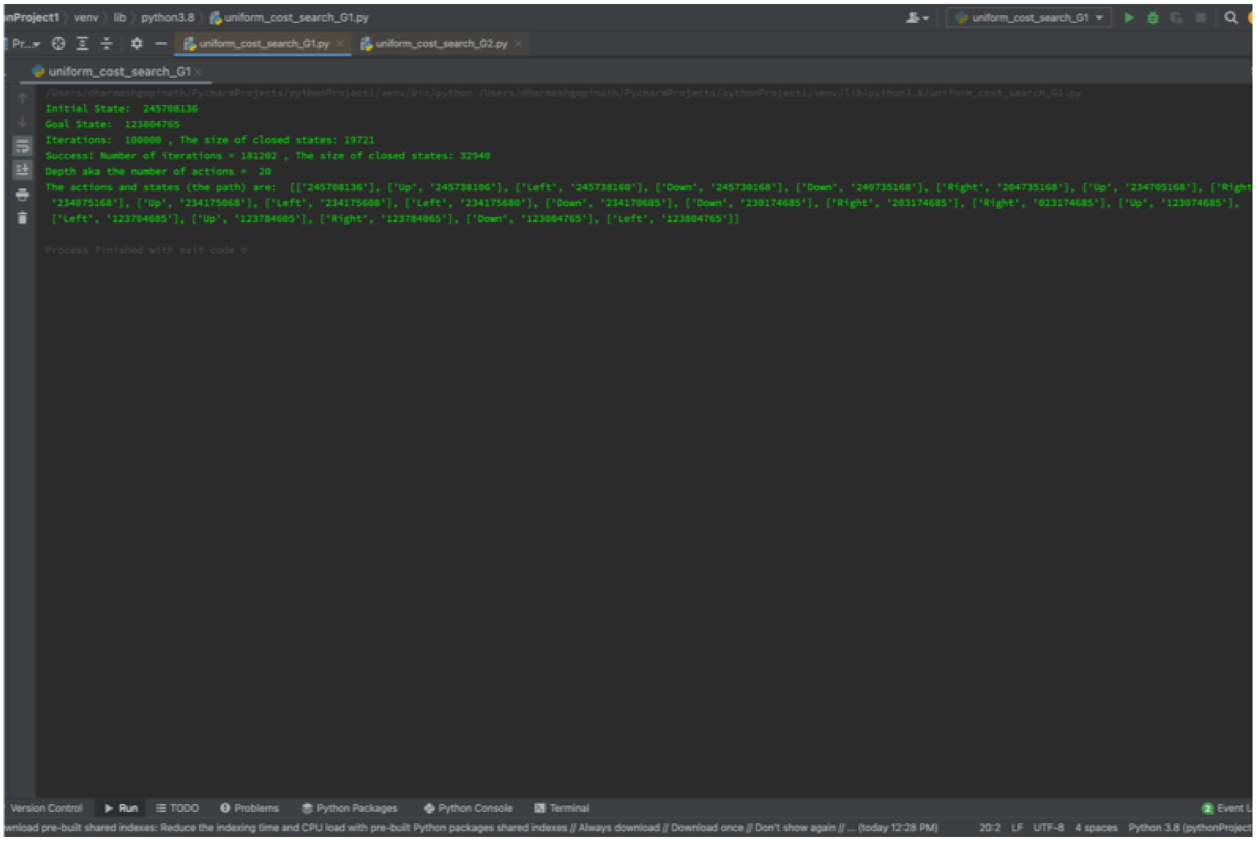
Caption

G) Implement a Uniform Cost Search (UCS), if the goal is achieving the final state in part F from an arbitrary initial state, if we have the following costs for different moves

[15 pts] G1) All moves have a unit cost
[15 pts] G2) Up (Cost=1), Down (Cost=1) Left (Cost=2) Right (Cost=0.5)
Present the sequences of moves and states for each option. How many actions are used to achieve the solution for each option? Explain your observation.

Ans:

G1)


nProject1 〉 venv 〉 lib 〉 python3.8 〉 uniform_cost_search_G1.py
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20:2 LF UTF-8 4 spaces Python 3.8 (pythonProject

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/Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/bin/python /Users/dharmeshgopinath/PycharmProjects/pythonProject1/venv/lib/python3.8/uniform_cost_search_G1.py
Initial State:  245708136
Goal State:  123804765
Iterations:  100000 , The size of closed states: 19721
Success! Number of iterations = 181202 , The size of closed states: 32940
Depth aka the number of actions =  20
The actions and states (the path) are:  [['245708136'], ['Up', '245738106'], ['Left', '245738160'], ['Down', '245730168'], ['Down', '240735168'], ['Right', '204735168'], ['Up', '234705168'], ['Right
 '234075168'], ['Up', '234175068'], ['Left', '234175608'], ['Left', '234175680'], ['Down', '234170685'], ['Down', '230174685'], ['Right', '203174685'], ['Right', '023174685'], ['Up', '123074685'],
 ['Left', '123704685'], ['Up', '123784605'], ['Right', '123784065'], ['Down', '123084765'], ['Left', '123804765']]

Process finished with exit code 0
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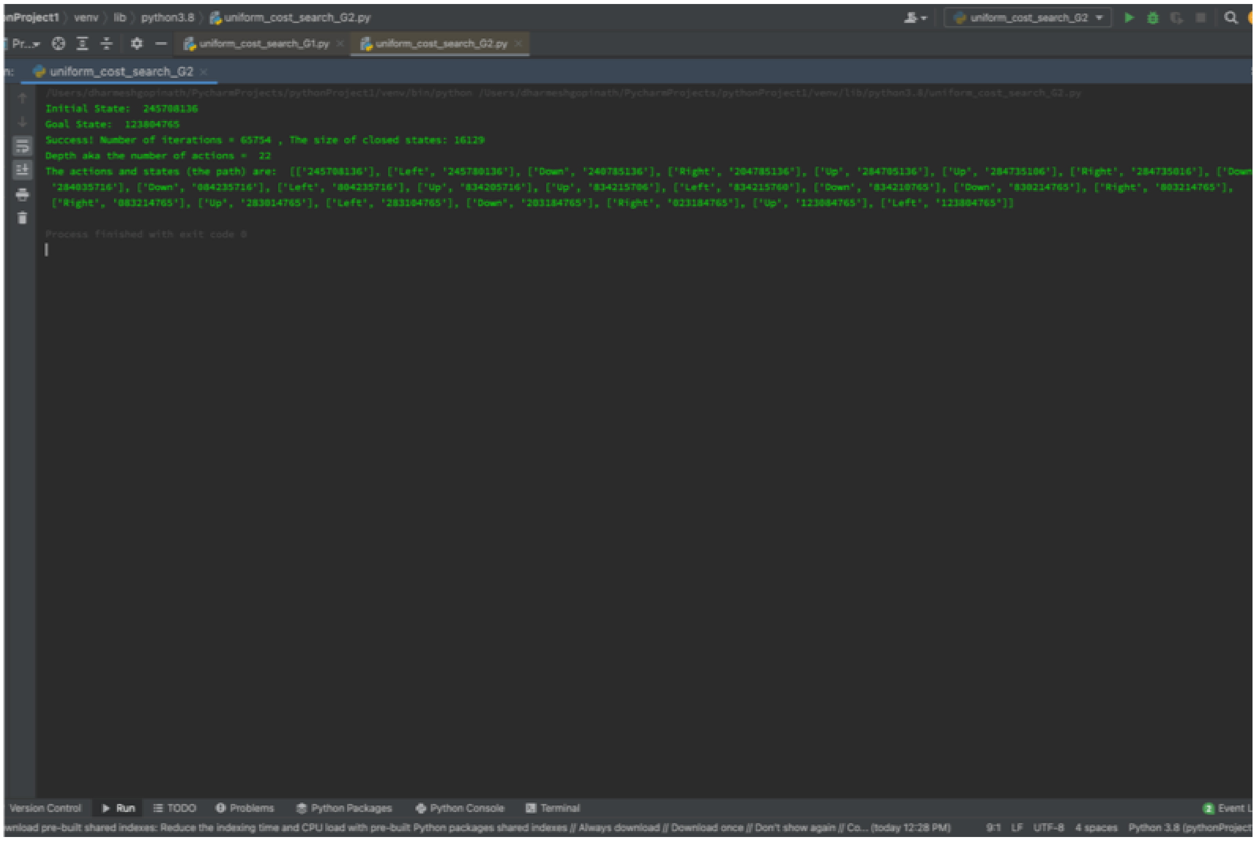
Caption

G2)



nProject1 〉 venv 〉 lib 〉 python3.8 〉 uniform_cost_search_G2.py
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Initial State:  245708136
Goal State:  123804765
Success! Number of iterations = 65754 , The size of closed states: 16129
Depth aka the number of actions =  22
The actions and states (the path) are:  [['245708136'], ['Left', '245780136'], ['Down', '240785136'], ['Right', '204785136'], ['Up', '284705136'], ['Up', '284735106'], ['Right', '284735016'], ['Down
 '284035716'], ['Down', '084235716'], ['Left', '804235716'], ['Up', '834205716'], ['Up', '834215706'], ['Left', '834215760'], ['Down', '834210765'], ['Down', '830214765'], ['Right', '803214765'],
 ['Right', '083214765'], ['Up', '283014765'], ['Left', '283104765'], ['Down', '203184765'], ['Right', '023184765'], ['Up', '123084765'], ['Left', '123804765']]

Process finished with exit code 0
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Caption

Less actions are used in G1 than in G2 to acquire a solution, when a unit cost is used. Of course this outcome is affected by other factors such as given data and task, in addition to the usage of a uniform cost.