Challenge Problem 8

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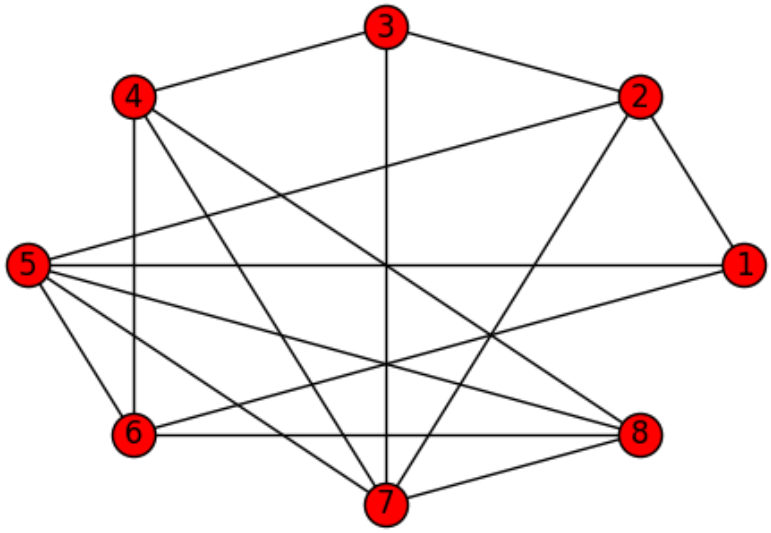
In [2]:
```
import warnings
warnings.filterwarnings('ignore')

import networkx as nx
import matplotlib.pyplot as plt

def calculate_cost(no_of_containers):
    total_cost = 0
    for i in range(no_of_containers - 1):
        total_cost += 85 * i
    total_cost += 125
    return (total_cost)

def container(node_color):
    for node in node_color:
        print ('Chemical ' + str(node) + ' should be stored in container ' + s
tr(node_color[node]))

def check_color(node, neighbor, node_color):

    # If the neighbor is less than the current node, then that edge has alread
y been checked and exits the function
    if (neighbor < node):
        return

    # Compares the two nodes' colors.  If they are the same, then the node rec
ieves a new color
    if (node_color.get(node) == node_color.get(neighbor)):
        node_color[neighbor] += 1

def coloring(graph):

    # Creates a dictionary that tracks the color of each node and assigns an i
nitial color of 0
    node_color = {}
    for node in graph:
        node_color[node] = 1

    # Goes through every edge in the graph and calls method check_colors
    for node in graph:
        for edge in graph[node]:
            check_color(node, edge, node_color)

    # Returns the value with the highest color recorded.
    maximum = max(node_color, key = node_color.get)
    container (node_color)
    return node_color[maximum]
```

```
graph = nx.Graph({1: [2,5,6],
                  2: [1,3,5,7],
                  3: [2,4,7],
                  4: [3,6,7,8],
                  5: [1,2,6,7,8],
                  6: [1,4,5,8],
                  7: [2,3,4,5,8],
                  8: [4,5,6,7]})

nx.draw_circular(graph, with_labels = True)
plt.show()
containers = coloring(graph)
print()
print ('Minimum number of containers: ' + str(containers))
print('Cost of shipment: $' + str(calculate_cost(containers)))
```




```
Chemical 1 should be stored in container 1
Chemical 2 should be stored in container 2
Chemical 3 should be stored in container 1
Chemical 4 should be stored in container 2
Chemical 5 should be stored in container 3
Chemical 6 should be stored in container 4
Chemical 7 should be stored in container 4
Chemical 8 should be stored in container 1

Minimum number of containers: 4
Cost of shipment: $380
```

Description of Graph

The graph is modeled in such a way that each chemical is represented as a node. If a chemical interacts with another, then there is an edge that connects the two.

The graph is written in the form of a dictionary and is drawn in a circular formation by the NetworkX library.

Strategy for Solution

My strategy used to solve this problem was to analyze every edge and make sure that the two nodes in the connection were a different color.

For this graph in particular, my program calculated a proper 4-coloring. In order to prove that the chromatic number for this graph is 4, I will walk through each node to prove one cannot color this graph with only 3 colors.

First, we start at node 5 (n5) and will color it **red**. N5 is connected to n1, n2, n6, n7, n8.

We color **n1 blue** since it is connected to **n5** and cannot be **red**.

```
n5 - red
n1 - blue
```

We color **n2 green** since it is connected to **n5** and **n1**, so it cannot be **red** or **blue**.

```
n5 - red
n1 - blue
n2 - green
```

N6 is connected to **n1** and **n5**, so it cannot be **blue** or **red**, so we are able to color **n6 green**.

```
n5 - red
n1 - blue
n2 - green
n6 - green
```

N7 is connected to **n2** and **n5** so it cannot be **green** or **red**. We color **n7** blue since its the only color left.

```
n5 - red
n1 - blue
n2 - green
n6 - green
n7 - blue
```

N8 is connected to **n5**, **n6**, and **n7**. **N8** cannot be **red**, **green**, or **blue**, which means that there must be a fourth color added. Thus proving that we cannot color this graph with fewer than 4 colors.

Discussion

We are given an assignment to ship chemicals across the country by air express. The shipping costs are $125 for the first container and increases by $85 for every additional container.

To begin, each chemical is initially assigned in container 1. If a chemical interacts with another, they must be stored in different containers. We are to analyze each chemical starting at chemical 1 c_1.

For example, Since c_1 reacts with c_2, c_5, and c_6. C_1 cannot be shipped in the same container with the aforementioned chemicals. So c_2, c_5, and c_6 are moved to container 2. This process will iterate though each chemical to make sure that each chemical is safely labeled.

After this process is complete, we have come to the conclusion that the minimum amount of containers needed for the shipment is 4. To calculate the cost of the shipment, we add $125 and add $85 for every additional shipment.

After this is complete, we come to the conclusion that we need 4 containers and it will cost $380.