Data Structures Lab 11 Graphs Name:____________

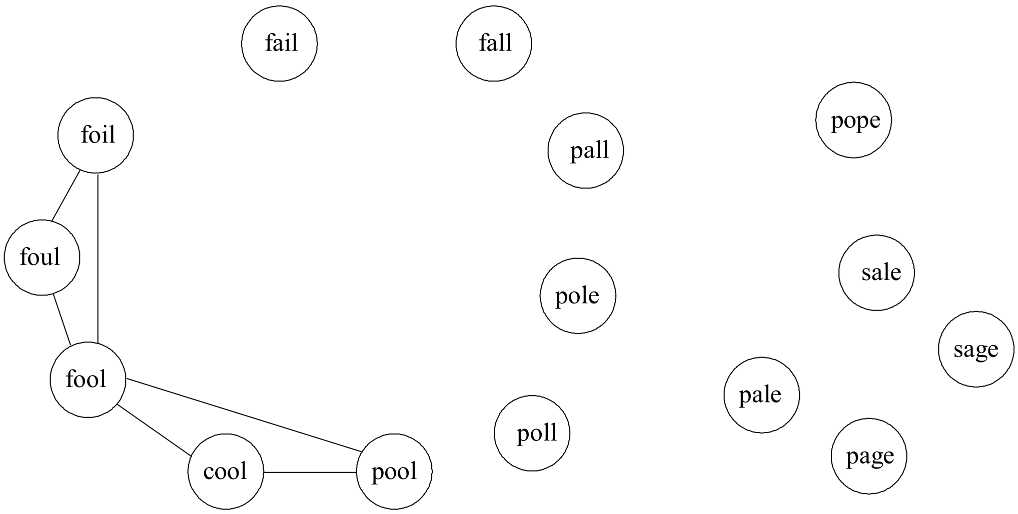
Objectives: To understand how a graph can be represented and traversed.

To start the lab: Download and unzip the lab11.zip file from eLearning.

Part A: In a word-ladder puzzle (discussed in class) transforms one word into another by changing one letter at a time, e.g., transform FOOL into SAGE by FOOL → FOIL → FAIL → FALL → PALL → PALE → SALE → SAGE.

We used a graph algorithm to solve this problem by constructing a graph such that
- words are represented by the vertices, and
- edges connect vertices containing words that differ by only one letter

a) For the words listed below, complete the graph by adding edges as defined above.

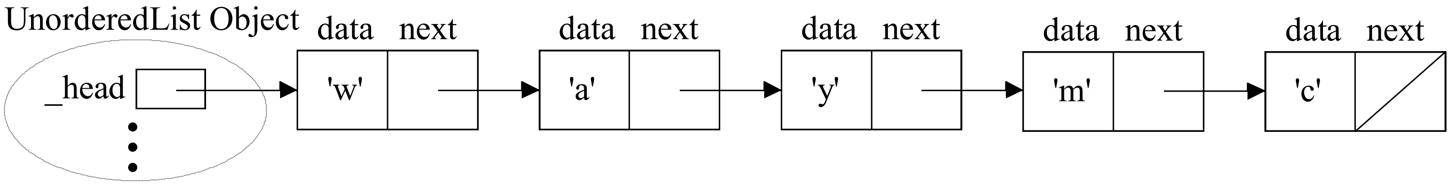


b) To find the shortest transformation from FOOL to SAGE, why did we decide on using a Breadth First Search (BFS) traveral (i.e., where you find all vertices a distance 1 (directly connected) from FOOL, before finding all vertices a distance 2 from FOOL, etc) instead of a Depth-First Search (DFS) traversal?

c) Run the `lab11/word_ladder_BFS.py` program. Examine the "enqueue" and "dequeue" lines of output produced by the `bfs(g,g.getVertex("fool"))` call. Does this output match the expected "enqueues" and "dequeues" performed during a bfs of the above graph starting at "fool"?

d) The `bfs` algorithm sets the value of each vertex's `predecessor` to point to the vertex object that enqueued it. **Add code to the end of the `word_ladder_BFS.py` program** that traverses the "linked list" of `predecessor` references from "sage" to "fool." and prints the corresponding word ladder from "fool" to "sage."

Hint: The code you need to write is similar to the `__str__` code for traversing a singly-linked list:



```
    def __str__(self):
        resultStr = ""
        current = self._head
        while current != None:
            resultStr += " " + str(current.getData())
            current = current.getNext()
        return resultStr
```

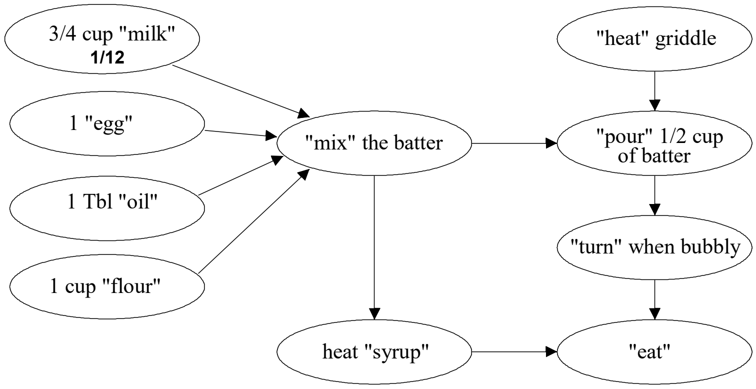
Your code (see partial code at the end of the `word_ladder_BFS.py` program) can:

- walk `currentVert` down the linked list of `Vertex` objects using `getPred` instead of `getNext`
- append to `wordLadderList` the `currentVert`'s word gotten using `getId` instead of string concatenating using `getData`

After your while-loop executes, you can reverse the `wordLadderList` and print the transformation from "fool" to "sage."

Part B: Topological sort

Section 7.5 uses recursion and the run-time stack to implement a DFS traversal. The `DFSGraph` uses a `time` attribute to note when a vertex if first encountered (`discovery` attribute) in the depth-first search and when a vertex in backtracked through (`finish` attribute). Consider the graph for making pancakes where vertices are steps and edges represents the partial order among the steps.



```
from graph import Graph
class DFSGraph(Graph):

  def __init__(self):
     super().__init__()
     self.time = 0

  def dfs(self):
     for aVertex in self:
         aVertex.setColor('white')
         aVertex.setPred(-1)
     for aVertex in self:
         if aVertex.getColor() == 'white':
             self.dfsvisit(aVertex)

  def dfsvisit(self,startVertex):
     startVertex.setColor('gray')
     self.time += 1
     startVertex.setDiscovery(self.time)
     for nextVertex in startVertex.getConnections():
        if nextVertex.getColor() == 'white':
            nextVertex.setPred(startVertex)
            self.dfsvisit(nextVertex)
     startVertex.setColor('black')
     self.time += 1
     startVertex.setFinish(self.time)
```

a) Run the `lab11/make_pancake_DFS.py` program. Write on the above graph the `discovery` and `finish` attributes (e.g., 1 / 12 of "milk") assigned to each vertex by executing the `dfs` method..

b) A *topological sort* algorithm can use the dfs `finish` attributes to determine a proper order to avoid putting the "cart before the horse." For example, we don't want to "pour ½ cup of batter" before we "mix the batter", and we don't want to "mix the batter" until all the ingredients have been added. Outline the steps to perform a topological sort from the `finish` attributes**.**

After you have answers and correct code for all parts of the lab, submit a lab11.zip containing your code on eLearning. If you do not get done today, then submit it by next week's lab period.

Remember to save your lab11!

EXTRA CREDIT:

Add code to the end of the `made_pancake_DFS.py` program to print the topological sort for making pancakes.