Last Minute Basics and Graph Theory

Presentation slides for developers

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Common data structures

Dictionaries

- Very fast lookups
- Can use tuples (among other things) as keys

```
# with lists
l_grid = []
for r in range(10):
    row = []
    for c in range(10):
        row.append(0)
    grid.append(row)

# with dict
d_grid = {}
for r in range(10):
    for c in range(10):
        grid[(r, c)] = 0
```

```
# say you want to access/add a point outside of the grid
point = l_grid[12][20] # errors, annoying

# with dictionaries
point = d_grid.get((12, 20), None)
if point is None:
    d_grid[(12, 20)] = "Something here"
```

Common data structures (cont)

Sets

- Much faster compared to lists
  - Use if you are storing a lot of data and don’t care about order
- Set functions (union, difference, intersection)

Deque

- when you want a list but are frequently adding removing items from the left/either side

```
from collections import deque

d = deque("B")
d.append("C")
d.appendleft("A")

# deque(["A", "B", "C"])

d.rotate()

# deque(["C", "A", "B"])

d.popleft() # "C"
d.pop() # "B"
```

Useful tips and tricks

- You have access to the python docs during the contest
- Modules such as collections, itertools
- using sys.stdin for faster input

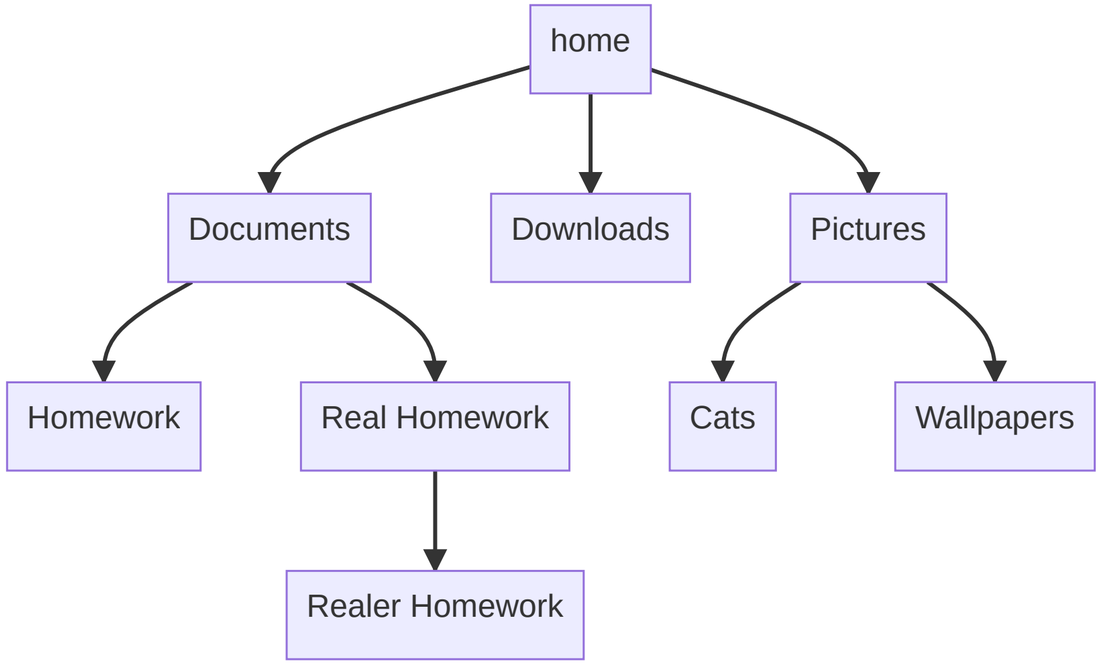
```
import sys
input = sys.stdin.readline

n = int(input()) # 10000
for _ in range(n):
    x = input().strip()
    do_something(x)
```

What is a graph?

Examples of graphs

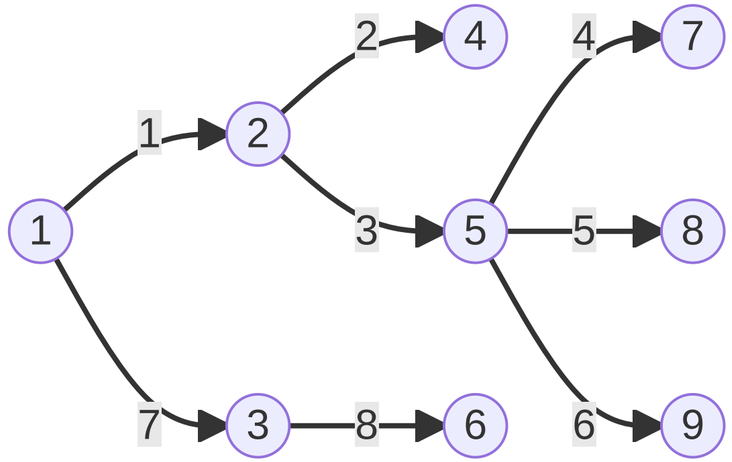
- Social media network
- Cities and roads
- Your folder system



Depth first search

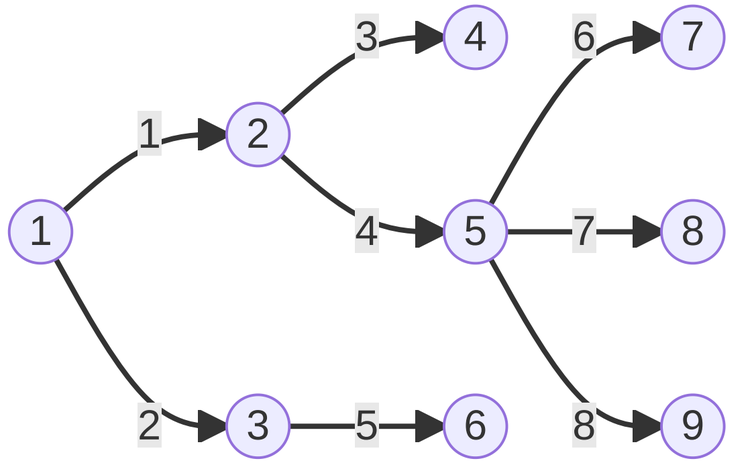
- Traverse the child of each node until we have exhausted all possible nodes
- Can be implemented recursively
- $O(n + m)$ time complexity, where N is the number of nodes, M is number of edges

```
seen = set()
def dfs(node):
    if x in seen:
        return
    seen.add(node)
    # process node
    for child in graph[node]:
        dfs(child)
```



Breadth first search

- Traverse the graph in "layers"
- Often implemented with a queue structure
- $O(n + m)$ time complexity, where N is the number of nodes, M is number of edges




```
visited = set() # prevent searching a node twice
# distance is a dict that maps each node to its
# distance from starting node

distance = {}
# starting node is distance 0 from itself
distance[node] = 0
# use deque for fast insertion/deletion from both ends
queue = deque()
queue.append(node)
visited.add(node)

while queue: # while queue is not empty
    next_node = queue.popleft()
    for child in graph[next_node]:
        if child in visited:
            continue
        visited.add(child)
        distance[child] = distance[next_node] + 1
        queue.append(child)
```

Problem 1

- Basic flood-fill algorithm
- Create a "searched" mapping for all coordinates
- Start a bfs from every non-searched location

```
import sys
from collections import deque
input = sys.stdin.readline

fl = int(input())
n, m = int(input()), int(input())
grid = []
tot_rooms = 0
seen = set()
for i in range(n):
    grid.append(input().strip())


def adj(r, c):
    for row, col in [(r+1, c), (r-1, c),
        (r, c+1), (r, c-1)]:
        if 0<=row<n and 0<=col<m:
            yield (row, col)
```

```
def flood_fill(r, c):
    queue = deque()
    queue.append((r, c))
    seen.add((r, c))
    room_size = 1

    while queue:
        row, col = queue.popleft()
        for coords in adj(row, col):
            if coords in seen or
                grid[coords[0]][coords[1]] == "I":
                continue
            room_size += 1
            seen.add(coords)
            queue.append(coords)
    return room_size
```

Solution (cont)

```
rooms = []
for row in range(n):
    for col in range(m):
        if (row, col) in seen or grid[row][col] == "I":
            continue
        rooms.append(flood_fill(row, col))

rooms.sort(reverse=True)
for room in rooms:
    if room > fl: break
    fl -= room
    tot_rooms += 1

if tot_rooms == 1:
    print(f"{tot_rooms} room, {fl} square metre(s) left over")
else:
    print(f"{tot_rooms} rooms, {fl} square metre(s) left over")
```

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Problem 2

- Run a DFS to search every single possible path
- For each path, we know that every road **not** on the path is a disconnecting road
- run a set union for each path found, take length of final set

```
import sys
import collections
input = sys.stdin.readline

roads = set()
graph = collections.defaultdict(list)

while True:
    r = input().strip()
    if r == "**": break
    roads.add(r)
    graph[r[0]].append(r[1])
    graph[r[1]].append(r[0])
```

```
seen = set()
def dfs(path, node):
    global roads
    for ch in graph[node]:
        if ch == "B":
            npath = path + ch
            trace = set()
            for i in range(len(npath) - 1):
                road = npath[i:i+2]
                trace.add(road)
                trace.add(road[::-1])
            roads &= trace
            continue

        elif ch not in path:
            dfs(path+ch, ch)

dfs("A", "A")
if roads:
    print(*roads, sep="\n")

print(f"There are {len(roads)} disconnecting roads.")
```

Pastebin