

$$\frac{\alpha(v)}{\alpha(e)}$$
$$\frac{O(v)}{O(e)}$$
 $O(V)$ $O(E)$
$$n!$$
$$E = \frac{V \cdot (V-1)}{2}$$
$$\frac{4 \times 3}{2} = 6$$
 π_1
$$n \times (n-1)!$$
[illegible]

Handwritten notes on graph theory:

- A directed graph with nodes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100. The graph shows a sequence of nodes connected by directed edges, with some nodes having multiple incoming or outgoing edges. A green arrow points to node 1, and a blue arrow points to node 2. A green box highlights the sequence of nodes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.
- A sequence of numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.
- A graph with nodes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100. The graph shows a sequence of nodes connected by directed edges, with some nodes having multiple incoming or outgoing edges. A green arrow points to node 1, and a blue arrow points to node 2. A green box highlights the sequence of nodes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.

2

5 4 3 2 1

[illegible]

part 2 = $\frac{T}{0} \frac{T}{1} \frac{T}{2} \frac{T}{3} \frac{T}{4} \frac{T}{5} \frac{T}{6}$

16 有英文之詞
1)

DFS

- what is Hamiltonian?
- mark
- ~~not~~
- Nb
- unmark

BFS + PQ

- x remove PQ
- x make
- x work
- x add Nbr PQ

$$V \log(V) \rightarrow E \log(V)$$
$$\boxed{O(n)} \\ \vee \log(v)$$


```

while(pq.size() > 0) {
    // remove
    Helper cur = pq.remove();
    // mark
    fvis[cur.node] = true;
    // continue
    vis[cur.node] = true;
    System.out.println("cur.node="+cur.node+" cur.psf="+cur.cur.wid);
    // visit all nodes
    for(HashMap.Entry<Integer, Integer> edge: graph.get(cur.node)) {
        int idE = edge.getKey();
        int wt = edge.getValue();
        if(fvis[idE]) {
            pq.add(new Helper(idE, cur.psf+wt, cur.node+idE));
        }
    }
}

```

$$\begin{array}{c} \sqrt{\log V} \\ \downarrow \\ \in \log V \end{array}$$
$$O(n^2)$$

$$O(\log n)$$



$$E \Rightarrow V(V-1) \rightarrow E_{\text{graph}}(V)$$

$$O(n \log n)$$

$$O(n^2)$$