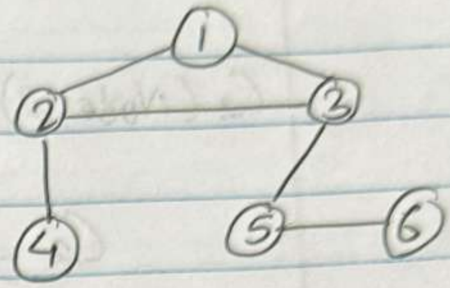
Nodes (V) : {1, 2, 3, 4, 5, 6}
Edges (E) : {(1,2), (1,3), (2,3), (2,4), (3,5), (5,6)}

① Order (N) : Total nodes = 6
Size (M) : Total edges = 6



② Degree Distribution P(k) :

$k_1 \Rightarrow \{2, 3\} = 2$
$k_2 \Rightarrow \{1, 3, 4\} = 3$
$k_3 \Rightarrow \{1, 2, 5\} = 3$
$k_4 \Rightarrow \{2\} = 1$
$k_5 \Rightarrow \{3, 6\} = 2$
$k_6 \Rightarrow \{5\} = 1$

Average degree $\langle k \rangle = \frac{1}{N} \sum_{i=1}^{N} k_i$

$$= \frac{2+3+3+1+2+1}{6} = \frac{12}{6} = 2$$

③ Local Clustering Coefficient (C_i)

$$C_i = \frac{2E_i}{k_i(k_i-1)}$$

C_1 (Node 1) : $E_1 = 1 \quad \{2, 3\}$

$k_1 = 2$

$$C_1 = \frac{2 \times 1}{2(2-1)} = 1$$

C_2 (Node 2) : $E_2 = 1 \quad \{1, 3, 4\} \Rightarrow \{1, 3\}$ exist

$k_2 = 3$

$$C_2 = \frac{2 \times 1}{3(3-1)} = \frac{1}{3}$$

C_3 (Node 3) : $E_3 = 1 \quad \{1, 2, 5\} \Rightarrow \{1, 2\}$ exist

$k_3 = 3$

$$C_3 = \frac{2 \times 1}{3(3-1)} = \frac{1}{3}$$

C_5 (Node 5) : $E_5 = 0 \quad \{3, 6\}$ no connection

$k_5 = 2$

$$C_5 = \frac{2 \times 0}{2(2-1)} = 0$$

④ Network Average Clustering Coefficient $(\langle C \rangle) = \frac{1}{N} \sum_{i=1}^{N} C_i$

$$\langle C \rangle = \{C_1, C_2, C_3\} = \frac{1 + 1/3 + 1/3}{3}$$

$$= \frac{5}{9} \approx 0.556$$

③

⑤ Density (ρ) $= \dfrac{M}{N(N-1)/2} = \dfrac{6}{6(6-1)/2}$

$= \dfrac{2}{5}$ or 0.4

homework-1

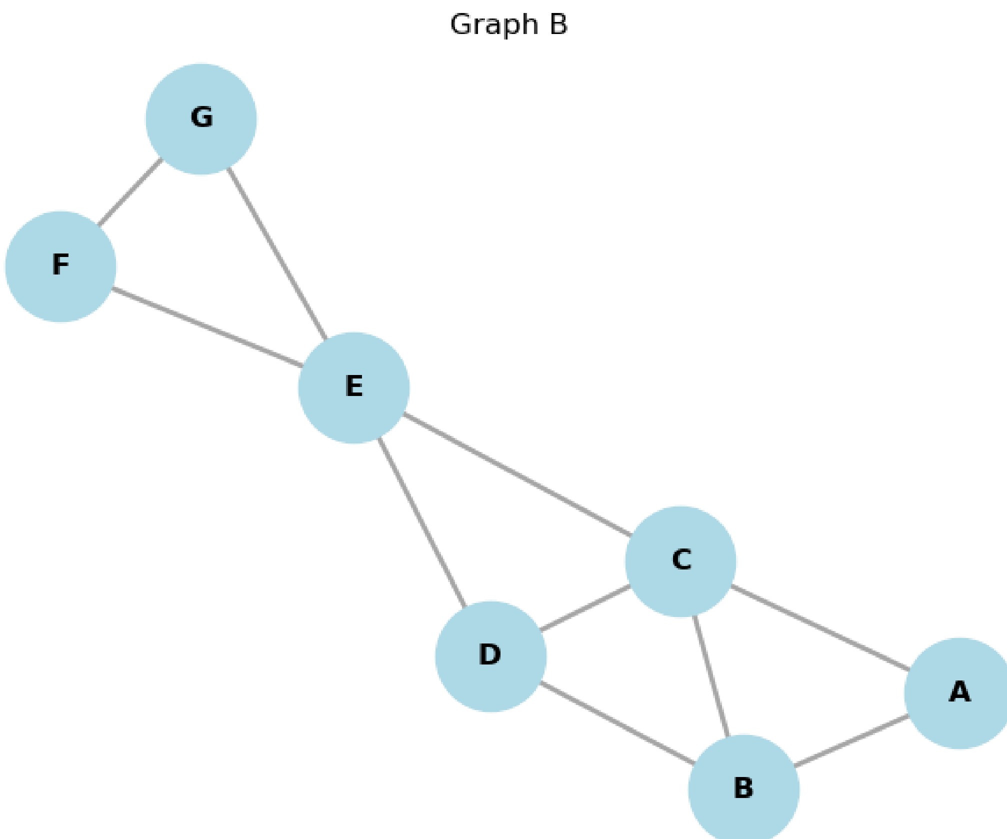
October 22, 2025

[1]:
```
!pip install networkx igraph -q
```

[2]:
```
import networkx as nx
import matplotlib.pyplot as plt
import numpy as np
```

[3]:
```
edge_list = [
    ('A', 'B'), ('A', 'C'),
    ('B', 'C'), ('B', 'D'),
    ('C', 'D'), ('C', 'E'),
    ('D', 'E'),
    ('E', 'F'), ('E', 'G'),
    ('F', 'G')
]
G = nx.Graph()
G.add_edges_from(edge_list)

plt.figure(figsize=(8, 6))
pos = nx.spring_layout(G, k=0.5, iterations=50)
nx.draw_networkx_nodes(G, pos, node_color='lightblue', node_size=2000)
nx.draw_networkx_edges(G, pos, width=2, alpha=0.7, edge_color='gray')
nx.draw_networkx_labels(G, pos, font_size=12, font_weight='bold')
plt.axis('off')
plt.title('Graph B')
plt.show()
```



[4]:
```
order_N = G.number_of_nodes()
size_M = G.number_of_edges()
density = nx.density(G)
avg_degree = np.mean([d for n, d in G.degree()])
avg_path_length = nx.average_shortest_path_length(G)
avg_clustering = nx.average_clustering(G)

print(f"Order (N): {order_N}")
print(f"Size (M): {size_M}")
print(f"Density (p): {density:.4f}")
print(f"Average Degree <k>: {avg_degree:.2f}")
print(f"Average Path Length <d>: {avg_path_length:.2f}")
print(f"Average Clustering Coefficient <C>: {avg_clustering:.4f}")
```

```
Order (N): 7
Size (M): 10
Density (p): 0.4762
Average Degree <k>: 2.86
Average Path Length <d>: 1.71
Average Clustering Coefficient <C>: 0.7381
```

[5]:
```
print("Degree (k) Distribution:")
degrees = dict(G.degree())
for node, deg in sorted(degrees.items()):
    print(f"Node {node}: {deg}")
```

```
Degree (k) Distribution:
Node A: 2
Node B: 3
Node C: 4
Node D: 3
Node E: 4
Node F: 2
Node G: 2
```

[6]:
```
print('Local Clustering Coefficient Distribution:')
clustering = nx.clustering(G)
for node, coeff in sorted(clustering.items()):
    print(f"Node {node}: {coeff:.4f}")
```

```
Local Clustering Coefficient Distribution:
Node A: 1.0000
Node B: 0.6667
Node C: 0.5000
Node D: 0.6667
Node E: 0.3333
Node F: 1.0000
Node G: 1.0000
```

How does the density reflect the overall connectivity?

A density of ≈ 0.476 is moderately high. It indicates that the network is well-connected, with almost half of all possible connections being present. It is far from being a sparse network.

Does the Average Path Length suggest this is a "small world"?

Yes. An average path length of ≈ 1.71 is extremely short. It means that, on average, any node can reach any other node in the network in less than two "hops." This high degree of closeness is a defining characteristic of a small-world network.

How does the Average Clustering Coefficient indicate the level of local community formation?

An average clustering coefficient of ≈ 0.738 is extremely high. This value (which measures the "cliquishness" of neighborhoods) shows a very strong tendency for nodes to form tight-knit local communities. The high values for C_A, C_F, and C_G (all 1.0) confirm that their immediate neighborhoods are perfect triangles. This high clustering, combined with the low path length, is the classic signature of a small-world network.

[ ]:
```
```