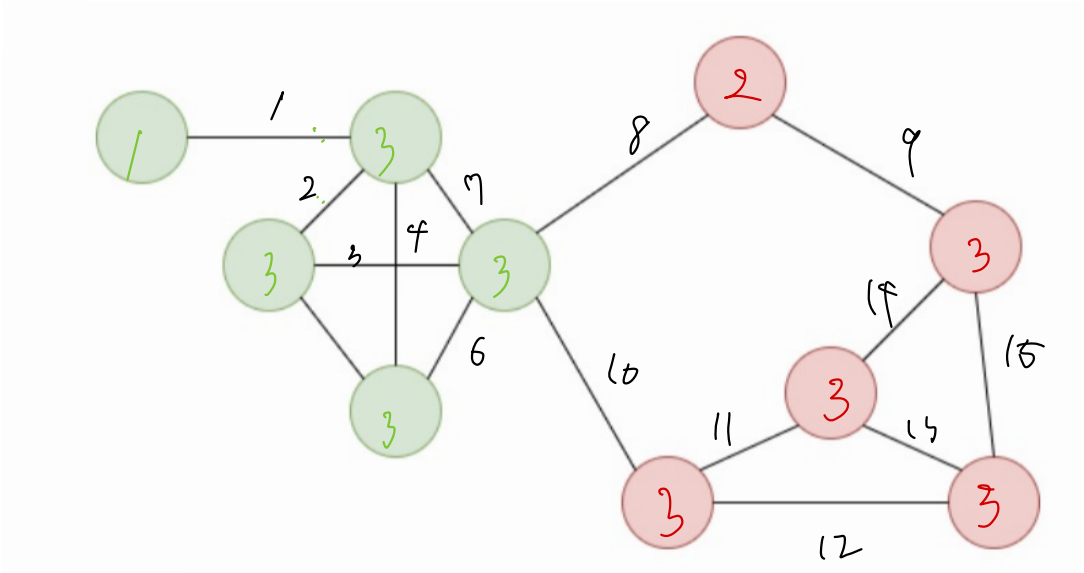
1. In the python file.

2 Determine the modularity of the network below.



$$Q = \sum_{c=1}^{n} \left[\frac{L_c}{m} - \gamma \left(\frac{k_c}{2m} \right)^2 \right]$$

where the sum iterates over all communities c

m = # of edges (15)

L_c = # of in the community links for community c 7, 8

k_c = Sum of degrees of the nodes in community c 13, 14

γ = resolution # assume $\gamma = 1$

$$\Rightarrow Q = \left(\frac{7}{15} - \left(\frac{13}{30} \right)^2 \right) + \left(\frac{8}{15} - \left(\frac{14}{30} \right)^2 \right)$$

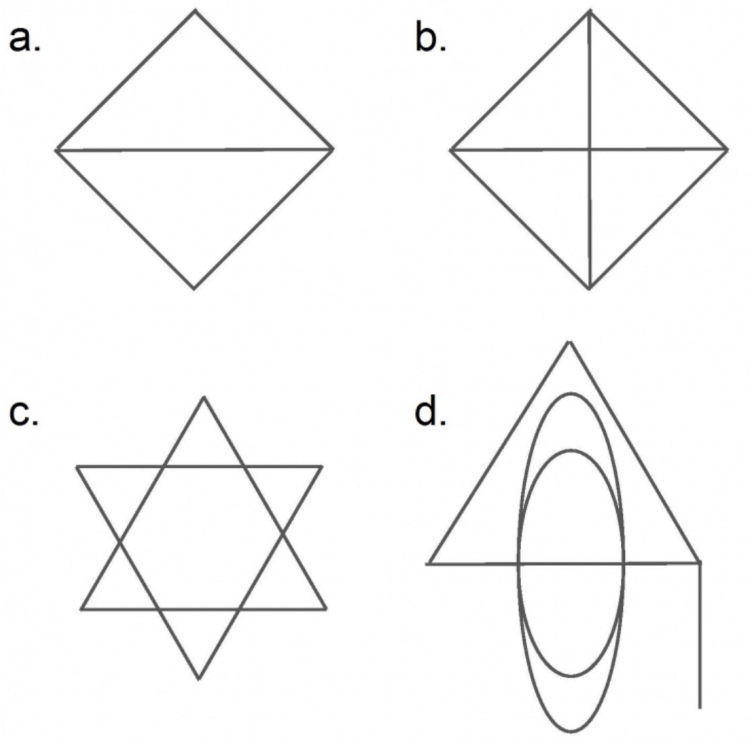
$$= 0.2789 + 0.3156$$

$$= 0.59444$$

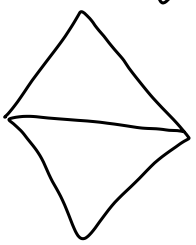
3. (c)

```
The group 0 is  {8, 14, 15, 18, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33}
The group 1 is  {1, 2, 3, 7, 9, 12, 13, 17, 21}
The group 2 is  {0, 4, 5, 6, 10, 11, 16, 19}
```

4. (5 pts) (The Königsberg Problem from section 2.12 of Network Science) Which of the icons in image 2.19 can be drawn without raising your pencil from the paper, and without drawing any line more than once? Why?



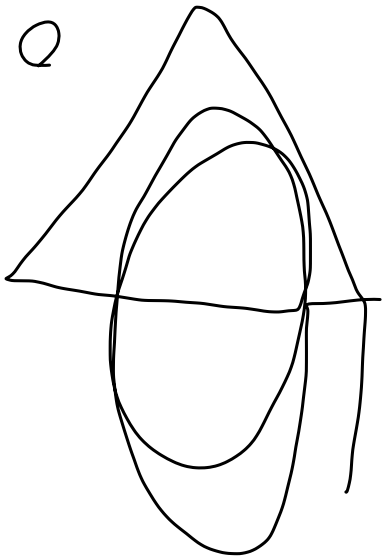
a ✓



b ×

c ×

d ○



Since every node has to have even number of edges except for the start and finish point so that it can allow to enter and leave.

5. (5 pts) What is the probability that a random node has degree 95 in $G_{1000,0.1}$?

According to the test cases, the probability is 3.7%. (the mean of results in 100 attempts)

6.

```
"""
Since the number of node is 1000,
Subcritical regime is p<0.001
Critical point is p = 0.001
Superctical point is p>0.001
Connected regime is p>ln(1000)/1000 {0.00690}

If the probabilty is less than 1/N which is 0.0001, they are mostly separetd but it exceeds the critical point
the components are rapidly connecetd and become one giant component.
"""
```

7. (four regimes.png)

Harmonic_centrality.png

8.

Mean degree distribution is 2.00180147 : m=1

9.

It seems like that the scale free network is always connected...

four_regime_scale_free.png.

10.

```
"""
The network is specified by G(n,m).
The network starts with m connected states.
Nodes with m links are added to the network one by one.
m new links each connect to an existing node with a probability proportional to the degree of the existing node.
Therefore, the node with the highest degree is more likely to have links. This is called preferential selection.
Nodes are added repeatedly until the number of nodes reaches n.
The resulting network is a scale-free network.
"""
```