CITY UNIVERSITY OF HONG KONG

Course Code & Title: **EE6605**

Complex Networks: Modeling, Dynamics and Control

Session: Semester A 2020/21

This is an **open-book** Test on Thursday October 22

Answer **all** questions

*** Student Name: _____**

*** Student ID: _____**

You have **60 minutes (8:00-9:00pm)**, plus 10 minutes to save your answers as pdf file and upload the pdf file to Canvas. Deadline for receiving your answer pdf file is **9:10pm**

Answering this exam paper implies your acknowledgment of the **Pledge** for following the **Rules**

"I pledge that the answers in this examination are my own and that I will not seek or obtain an unfair advanta

I will not plagiarize (copy without citation) from any source;
I will not communicate or attempt to communicate with any other person during the examination; neither will
I will use only approved devices (e.g., calculators) and/or approved device models.
I understand that any act of academic dishonesty can lead to disciplinary action."

Question 1 [60 Marks] (Basic Concepts and Network Modelling)

Q-1.1 [10 Marks]

For the network shown in Figure Q1.1, compute (1.1a) and (1.1b):

(1.1a) [5 Marks]

(a1) [2 marks] Node-betweenness of Node C (no need to normalize)

Answer: $B(C)$ = _____

(a2) [3 marks] Edge-betweenness of Edge B-C (no need to normalize)

Answer: $B(B\text{-}C)$ = _____

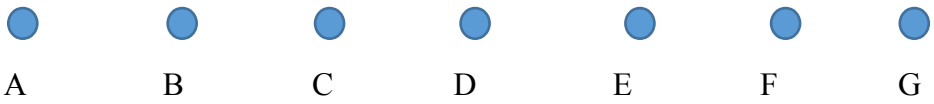

Figure Q1.1

(1.1b) [5 Marks]

(b1) [2 marks] Average distance of Node A to all other nodes

Answer: L = _____

(b2) [3 marks] Degree correlation of P(1,1), and of P(1,2).

Answer: P(1,1) = _____ P(1,2) = _____

Q-1.2 [10 Marks]

(1.2a) [5 Marks] Consider the following network model:

- Step 1 (Initialization) Start with an undirected large-sized fully-connected network.
- Step 2 (Process) Pick up an edge: if removing it does not disconnect the whole network, then remove it; but if removing it will disconnect the network, then do nothing. Continue to pick up another edge from the resultant network and repeat the above possible edge-removal operation.
- Step 3 (End) After every possible edge has been operated once, and once only, stop.

(a1) [2 marks] What kind of network will you obtain?

Answer:

(a2) [3 marks] If the initial large-sized fully-connected network is directed, what is your

conclusion?

Answer:

(1.2b) [5 Marks] Consider Figure Q1.2, where Node 2 sends 2 emails to all its neighbours (i.e., Nodes 1, 3, 4), with the following events:

Node 1 accepts the first email but rejects the second.
Node 3 rejects the first email but accepts the second.
Node 4 accepts both emails.

Calculate the weight w_{24}

Answer: w_{24} = _____

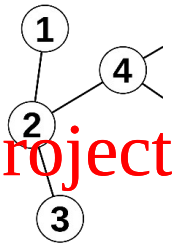

Figure Q1.2

Q-1.3 [10 Marks]

Consider the graph shown in Figure Q1.3. Find:

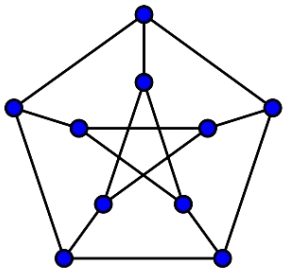

Figure Q1.3

(1.3a) [2 marks] the coreness of the network

Answer: coreness = _____

(1.3b) [2 marks] the clustering coefficient of any inner node

Answer: C(in) = _____

(1.3c) [2 marks] the clustering coefficient of any outer node

Answer: C(out) = _____

(1.3d) [2 marks] the length of girth of any inner node

Answer: g(in) = _____

(1.3e) [2 marks] the length of girth of any outer node

Answer: g(out) = _____

Q-1.4 [10 Marks]

Are the two graphs in Figure Q1.4 isomorphic? Show your reasoning.

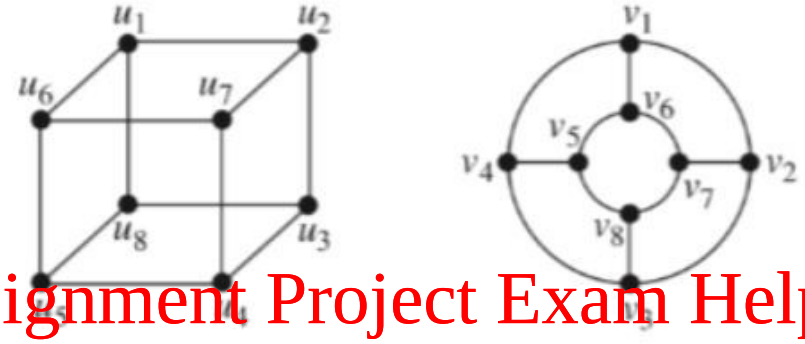

Figure Q1.4

Answer: Yes: u1 - v1, u2 - v?, u3 - v?, u4 - v?, u5 - v?, u6 - v?, u7 - v?, u8 -v?

Or: **No**: Because _____

Q-1.5 [10 Marks]

Given a network with $N = 1{,}000$ nodes.

(1.5a) [5 marks] If the network is undirected, with average degree $\langle k \rangle = 10$. How many edges does this network have?

Answer: _____

(1.5b) [5 marks] If the network is directed, with average out-degree $\langle k \rangle_{out} = 10$. How many directed edges does this network have?

Answer: _____

Q-1.6 [10 Marks] Consider the 6 graphs shown in Figure Q1.6.

Answer each question (type your answers like: A), C), F), ..., etc.)

(1.6a) [2 marks] Eulerian graph(s): **Answer:** _____

(1.6b) [2 marks] Semi-Eulerian graph(s): **Answer:** _____

(1.6c) [2 marks] Hamiltonian graph(s): **Answer:** _____

(1.6d) [2 marks] Semi-Hamiltonian graph(s): **Answer:** _____

(1.6e) [2 marks] Neither Eulerian nor Hamiltonian graph(s): **Answer:** _____

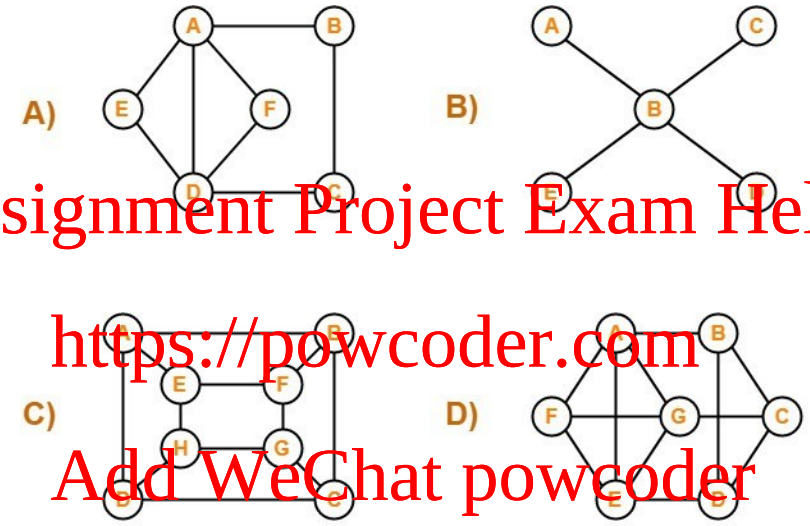

Figure Q1.6

Question 2 [40 Marks] (Applications)

Q2.1 [20 Marks] Consider the traffic network shown in Figure Q2.1. (For this question, **no need** to draw pictures, and n**o need** to show calculation steps.)

(2.1a) [15 marks] Show a spanning tree with the shortest total path length (type your answer like: connecting edges 1--3, 3--6, ...)

Answer: Connecting edges _____ and the total path length L = ___

(2.1b) [5 marks] Based on the above answer, find a path from Node 1 to Node 8 with the shortest total path length (type your answer like: The path is 1-->3-->6--> ... -->8)

Answer: The path is _____ and the total path length L = ___

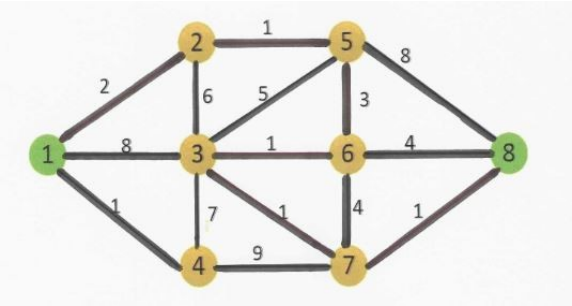

Figure Q2.1

Q2.2 [20 Marks] Solve the Chinese Postman Problem shown in Figure Q2.2 (type your answer like: Add edges 1-4, 4-3, 2-4, ..., etc.). **Show numerical comparison** of all possible choices. (For this question, no need to compute the total basic time **T**, which is not useful.)

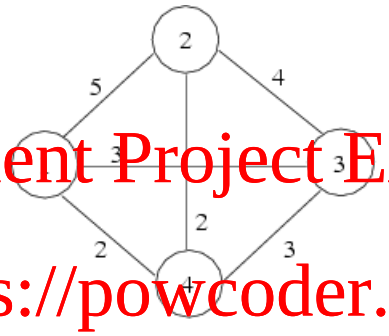

Figure Q2.2

Answer:

----- End -----