# CSYS5020: Interdependent Civil Systems – Assignment 3

## Calculation and Computing Exercise

## Assignment set by: Dr. Mahendra Piraveenan, UoS coordinator

**Due Date: 11th June 2021 Friday at 8.00 PM** **Submission: Electronic**

This assignment should be attempted individually. This assignment constitutes 30% of your final assessment in this subject. Name of the file submitted should be studentnumber-ICS-3.pdf or studentnumber-ICS-3.zip or studentnumber-ICS-3.rar

**The University takes plagiarism or allegations of plagiarism seriously. All students are encouraged to familiarise themselves with the University plagiarism policy before attempting this assignment. Computer scripts and other automated methods may be used to detect similarity of assignment submissions.**

### Q1.

In this question, you will build a simplified transport network based on the data you will find on the Internet.

Select one of the following countries: United States, Britain, France, China, Russia, Italy, India, Canada, Japan, Spain.

From the country that you have selected, select eight cities. These cities will constitute a transport network that you will build. You need not select these eight cities based on their size or any other measure. It is entirely up to you which eight cities you select. However, do select prominent cities so that it makes it easier to find data and build a network.

For this network, select the following:

- Twenty pairs of nodes (out of the possible 56 pairs), for air transport links
- Five pairs of nodes (out of the possible 56 pairs), for direct railway links
- Five pairs of nodes (out of the possible 56 pairs), for direct highway links

For the second and third cases, direct link means links that do not go through any other city in your list. It is OK if these links go through any other city (typically relatively smaller cities), which is not in your list.

It is OK to select the same pair of cities for more than one type of link.

For each of the pair, estimate the number of people who travel between these cities per year in that particular mode of travel. Ignore the direction of travel. Please clearly cite any data sources you use for this purpose. Please note that the requirement is to reach the most educated guess, in the absence of accurate data. Clearly justify your estimate, and state clearly why is it impossible to reach a more accurate estimate for each pair of nodes that you consider. You are required to reach the most accurate estimate possible for the pairs of cities you choose.

Now, build a network in Cytoscape where the eight cities selected are nodes, and the thirty links are the pairs of cities for which you have annual traffic estimates. Make the links weighted, so that the thickness of the links matches the weight of the links. Choose three different colours for air, rail and road links. Mark the nodes with city names.

Submit a Cytoscape session and a high definition snapshot / figure of the final network. The legends also should be marked on the network.

**(Marks = 10 for the final network, 15 for the 30 estimates of traffic, 5 for showing weighted links: 30 for this question in total).**

**Q.2**

Download the following networks.

Sn1.net
Sn2.net
Sn3.net
Sn4.net

Upload them into a Cytoscape session different from the previous one. Visualise each network using any type of force directed layout. (**8 Marks**)

Now, compute the minimum spanning tree for each of these networks. (**16 marks**)

Select the nodes and links which are part of your MST from each network, and make a subnetwork from these in Cytoscape. Clearly show all calculations. (**8 marks**)

**Q.3**

A 'logit' function or Fermi function is a probabilistic model used in many areas of complex systems when we want to calculate probabilities of certain event based on some pay-off or costs on which the said probabilities do not depend linearly.

a) Consider the following variables $x_1 = 1$, $x_2 = 2$, $x_3 = 7$, $y_1 = 4$, $y_2 = 3$, $y_3 = 3$. Assume that $f(x) = e^{-x}$. Calculate $f(x_1) + f(x_2) + f(x_3)$, and $f(y_1) + f(y_2) + f(y_3)$. How do these sums compare with $x_1 + x_2 + x_3$ and $y_1 + y_2 + y_3$? (**4 marks**)

b) Based on this observation, do you think the negative exponential sum favours a more homogeneous distribution (the standard deviation of the distribution is low) or a more heterogeneous distribution (where the standard deviation is high)? (**2 marks**)

c) From Sydney to Melbourne, it is possible to go by Bus (1), Train (2), or Plane (3). Let us assume that the generalised costs for travelling by each mode, including the financial costs as well as time-costs and convenience costs, are as follows: for a full time working professional with a salary above 100k, C1 = 500 units, C2 = 400 units, C3 = 300 Units. For a student who works part time, C1 = 300 units, C2 = 400 units, C3 = 500 Units. For a retired senior citizen, C1 = 600 Units, C2 = 100 Units, C3 = 400 Units. Let us say that they have different levels of sensitivity to the costs of travelling, with sensitivity parameter beta = 10 for working professionals, beta = 5 for students, and beta = 2 for elderly citizens.

   Compute the probabilities of a working professional choosing bus, train and plane respectively, using a logit function. (**8 marks**)

d) Compute the probabilities of a student choosing bus, train and plane respectively, using a logit function. (**8 marks**)

e) Compute the probabilities of an elderly citizen choosing bus, train and plane respectively, using a logit function. (**8 marks**)

f) Now re-compute the nine-probabilities you calculated above, not using a logit function, instead assuming that the probabilities are linearly dependent on the *inverse of* generalised costs. (**6 marks**)

g) Fill the following two tables based on your calculations above.

| Based on logit function | | | |
|---|---|---|---|
| | P(bus) | P(Train) | P(Plane) |
| Working Professional | | | |
| Student | | | |
| Senior Citizen | | | |

| Based on linear relationship with costs | | | |
|---|---|---|---|
| | P(bus) | P(Train) | P(Plane) |
| Working Professional | | | |
| Student | | | |
| Senior Citizen | | | |

Comparing the two tables, what conclusions can you make about the role of logit function in determining these probabilities? (**2 marks**)

**The marks are given out of 100, and your total mark for this assignment will be multiplied by 0.3 to compute your final assignment mark for this assignment out of 30.**

**END OF ASSIGNMENT QUESTIONS**