UNIVERSITY OF JOHANNESBURG

PROGRAM	:	Baccalaureus Ingeneriae (BIng) *CIVIL ENGINEERING SCIENCE*
SUBJECT	:	**TRANSPORTATION ENGINEERING 3B URBAN DEVELOPMENT STUDIES 3B21/**
CODE	:	**VVICIB 3/VVI3B21 /UDS 3B21**
DATE	:	SUPPLEMENTARY EXAM – JANUARY 2020
DURATION	:	THREE HOURS (3 HOURS)
WEIGHT	:	50:50
TOTAL MARKS	:	**100 MARKS**

EXAMINER	:	DR HA QUAINOO
MODERATOR	:	PROF. F OKONTA
NUMBER OF PAGES	:	PAGES 7

INSTRUCTIONS	:	PLEASE ANSWER ALL THE QUESTIONS.
REQUIREMENTS	:	NONE

UNIVERSITY OF JOHANNESBURG
DEPARTMENT OF CIVIL ENGINEERING SCIENCE
TRANSPORTATION ENGINEERING 3B / URBAN DEVELOPMENT STUDIES
UDSB21

SUPPLEMENTARY EXAMINATION – JANUARY 2020

Answer All Questions | **Time Allowance: 3 Hours**

Question 1

A study of travel demand for Province Z divided into 12 zones produced the data in Table 1, relating Trips generated in the urban centres to Employment and Car Ownership.

Table 1: Trip Generated, Employment levels and *zonal* Car ownership

Zone	Employment ('00) X_1	Car Ownership ('000) X_2	Trips generated ('000) Y
1	57	8	64
2	59	10	71
3	49	6	53
4	62	11	67
5	51	8	55
6	50	7	58
7	55	10	77
8	48	9	57
9	52	10	56
10	42	6	51
11	61	12	76
12	57	9	68

(a) Develop a multiple regression (Trip Generation) model for the above data.
(b) If the level of employment and car ownership were to be constant at 4,500 and 5000 respectively, what would be the expected number of trips generated in a zone?
(c) Calculate the Standard Error of the regression trip generation model in (a) and interpret its significance in relation to the answer in (b) above.
(d) Estimate the Coefficient of Determination, and briefly discuss the significance of your answer.

[25 marks]

[Hint: important formulae:

$$\Sigma Y = na + b_1\Sigma X_1 + b_2\Sigma X_2$$

$$\Sigma X_1 Y = a\Sigma X_1 + b_1\Sigma X_1^2 + b_2\Sigma X_1 X_2$$

$$\Sigma X_2 Y = a\Sigma X_2 + b_1\Sigma X_1 X_2 + b_2\Sigma X_2^2$$

Se = Square root of $\{\Sigma (Y - \hat{Y})^2 / (n-k-1)\}$

Where Se = Standard error
Y = Sample values of the dependent variable
Y = Corresponding estimated values from the regression
n = number of zones
k = number of independent variables

$$R^2 = 1 - \frac{\Sigma (Y - \hat{Y})^2 / (n-k-1)}{\Sigma (Y - \bar{Y})^2 / (n-1)}$$

QUESTION 2

(a) A proposed 50 kilometre urban road upgrading project presented two design alternatives. The first design costs R 35 million per kilometre (which includes drainage structures and a toll-gate). The annual maintenance would cost R 50 000 per kilometre over the first 20 years and then R 60 000 per kilometre over the remaining 10 years. In addition, there is an anticipated road accident cost of

R3 000 000 per annum over the entire 50 kilometres stretch of road. It is envisaged that the Average Daily Traffic at the toll-gate would be 3000 vehicles per day at a toll-charge of R62 per vehicle. The design life of this alternative is 30 years.

The alternative design for the 50 kilometre road would cost R 40 million per kilometre. However, the annual road maintenance is R45 000 per kilometre for the first 27 years and then R52 000 per kilometre over the remaining 8 years. The expected annual road accident cost is R2 200 000 over the entire road length. The ADT and toll-gate charge remain the same.

Using **Net Present Value** analysis at an interest rate of 11% per annum, determine which of the two design alternatives is a better option.

(Hint: $F = P(1+i)^n$; $P = A[(1+i)^n - 1] / [i * (1+i)^n]$) **[16 marks]**

(b) Determine the proportion of person-trips by each of two modes of transportation (private auto and mass transit) given the data below:

Utility functions: $U_k = A_k - 0.05T_a - 0.04T_w - 0.03T_r - 0.014C$

Parameter	**Private auto**	**Mass Transit**
T_a = access time (min.)	5	10
T_w = waiting time (min.)	0	15
T_r = riding time (min.)	25	40
C = out-of-pocket cost /km (cents)	150	100
A_k = calibration constant	-0.01	-0.07

The Multimodal Logit model is given as

$$P_i = e^{U(i)} / \sum_{r=1}^{n} e^{U(r)}$$

Where: U(i) = utility of mode i

U(r) = utility of mode r

n = number of modes available

[9 marks]

Question 3

A transport study undertaken for three zones 1, 2 and 3 yielded estimated future work trip productions and attractions presented in Table 3.1 Compute the expected inter-zonal trips (two iterations only). State the adjustment values for the 3rd iteration. Tables 3.1, 3.2 and 3.3 show the number of trip productions and attractions in each zone together with their associated travel times and Friction factors.
Assume $K_{ij} = 1$.

Table 3.1: Inter-zonal trips

Zone	**1**	**2**	**3**	**Total**
Trip Productions	150	350	200	700
Trip Attractions	285	100	315	700

Table 3.2: Zonal journey times in minutes

Zone	**1**	**2**	**3**
1	6	4	2
2	2	8	3
3	1	3	5

Table 3.3: Travel times and associated Friction Factors

Time (min)	1	2	3	4	5	6	7	8
Friction Factor	82	52	50	41	39	26	20	13

[Hint: use this variant of the Gravity model equation:

$$T^{m}_{i-j} = \left[\frac{P_i * (A_j F_{ij}^{m} * K_{ij})}{\sum_{j=1}^{n} (A_j F_{ij}^{m} * K_{ij})} \right]_p$$

Adjustment factor: $A_{jk} = \dfrac{A_j \; * \; A_{j\,(k-1)}}{C_{j\,(k-1)}}$

where each symbol has its usual meaning

[25 marks]

Question 4

In planning the daily dispatch of municipal buses from four depots, 1, 2, 3 and 4 to trading centres 1, 2, 3, and 4 (as shown in Figure 4.1), Municipality M wishes to minimise its daily operational costs. You have been approached to analyse and select routes that would help minimise transportation costs. Daily expenditure per bus, C_{ij}, for transporting commuters from the depots to designated trading centres are as follows:

C_{11} = R440	C_{21} = R370	C_{31} = R530	C_{41} = R540
C_{12} = R260	C_{22} = R355	C_{32} = R425	C_{42} = R450
C_{13} = R253	C_{23} = R316	C_{33} = R400	C_{43} = R500
C_{14} = R340	C_{24} = R545	C_{34} = R380	C_{44} = R490

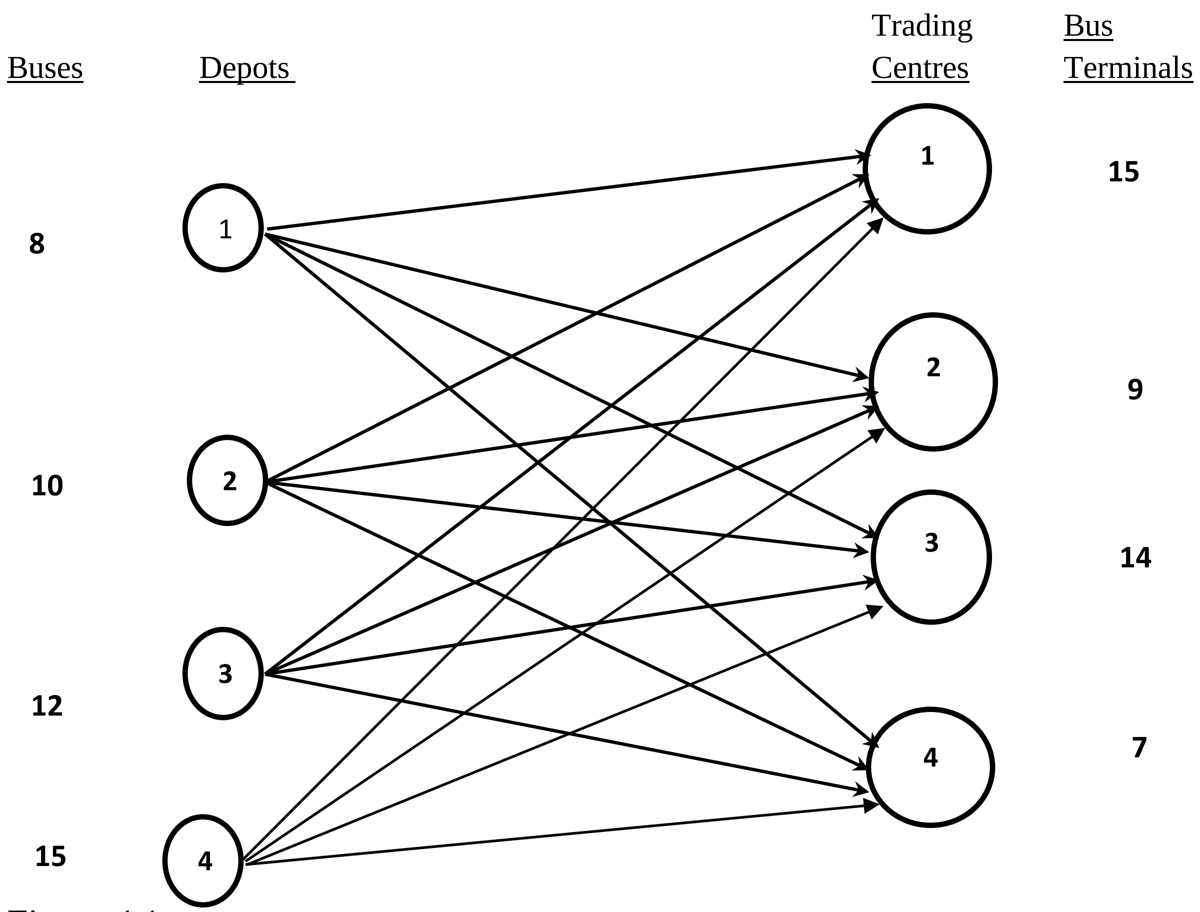

Figure 4.1

If X_{ij} is the number of buses travelling from Depot i to Trading Centre j at a unit cost of C_{ij},

(i) Formulate the transportation problem as a linear programming model

(ii) Use (a) the North-West Corner method and (b) The least Cost method to determine the initial basic feasible solution of the transportation problem; comment on the significance of the two solutions

(iii) Hence find the optimum solution using the Stepping Stone Method based on the initial basic feasible solution obtained from the North-West Corner method.

[25 marks]