UNAM
UNIVERSITY OF NAMIBIA

FACULTY	AGRICULTURE, ENGINEERING AND NATURAL SCIENCES		
SCHOOL	ENGINEERING AND THE BUILT ENVIRONMENT		
DEPARTMENT	CIVIL AND MINING ENGINEERING		
SUBJECT	TRANSPORT PLANNING AND TRAFFIC ENGINEERING		
SUBJECT CODE	TCVT3792		
DATE	NOVEMBER 2023		
DURATION	3 HOURS	**MARKS**	100

FIRST OPPORTUNITY EXAMINATION

Examiner: **Dr. OR Ambunda**
Internal Moderator: **Dr. PT Johannes**
External Moderator: **Prof. A Taigbenu** (University of the Witwatersrand)

This question paper consists of **9** pages including this front page, and **1** page of formulas, tables and charts.

Instructions

1. **Closed** book examination.
2. Read the questions carefully.
3. The paper contains 9 questions. **Attempt ALL NINE (9) questions** for full marks.
4. Some relevant equations, tables and charts have been provided.
5. Answers should be brief and to-the-point and where necessary be supplemented with neat sketches.
6. Marks for each question are indicated.
7. Assume suitability any missing or 'wrong' data and give proper justification for your assumptions.

QUESTION 1: TRAFFIC FLOW THEORY [11]

1	Vehicles approach a traffic signal at 65 km/h and a time headway of 5 sec/veh. When stopped at the traffic light, the vehicles queue with an average spacing of 6,5 m per vehicle. The traffic light remains red for 125 seconds, and then vehicles depart from the stop line at 40 km/h and a traffic stream density of 30 veh/km. Determine: a) The speed and direction of the shockwave that forms behind the stop line. (3) b) The length of the queue (in km as well as in number of vehicles) when the traffic light changes to green. (2) c) The time it will take for the queue at the traffic signal to disperse (in minutes) (3) d) Determine the position behind the stop line where the queue will disappear. (1) e) Explain why it is important to know the answer to question d) above. (2)

QUESTION 2: TRAFFIC STUDIES [16]

2.1	Define the 85th percentile speed? Indicate how you would determine the value of the 85th percentile speed using a cumulative distribution curve (draw the curve to assist in your explanation). (3)
2.2	Explain the difference between Operational Delay and Fixed Delay. (2)
2.3	Traffic counts were conducted along a road for one hour between 16:00 and 17:00 on certain weekday mornings for one week during March 2021 see Table 1. Hourly, Daily and Monthly Expansion Factors obtained from a continuous count on a similar road are presented in Table 2. a) Calculate AADT for 2021. (9) b) Determine the weekday with the lowest ADT? Give a reason for your answer. (2)

Table 1: Hourly control count volumes (16:00 to 17:00)

Monday	Tuesday	Friday
598 veh/h	528 veh/h	627 veh/h

Table 2: Expansion Factors

HEF (16:00-17:00)	16.2				
DEF	M	T	W	T	F
	5.812	6.327	6.286	6.605	5.554
MEF (April)	1.346				

QUESTION 3: LEVEL OF SERVICE [12]

3.1	Explain the operational conditions of a pedestrian walkway at Level of Service (LOS) B and E. (4)
3.2	Determine the density of vehicles on a freeway that operates at LOS A with the following characteristics: • Freeway is in a rural area (Note: F_N = 0,0 km/h) and the area is mountainous • Two 3,3 m wide lanes per direction • There are no interchanges in the area (very low density of interchanges) • Base free flow speed: 120 km/h • The speed adjustment factor for shoulder lateral clearance is 2.9 km/h • Peak hour volume: 748 veh/h, of which 29% was counted in the peak 15 min • The freeway carries mostly holiday traffic (population factor of 0,9) • 3% trucks and buses, 10% recreational vehicles (RV's) (5)
3.3	List 6 base conditions that must be met in order for the capacity of a freeway to be achieved. (3)

QUESTION 4: TRANSPORT DEMAND [8]

4.1	There are planned to be 132 new medium income houses being constructed just outside Ongwediva. Determine the daily trip generation potential of this new development using Table 3 and Table 4 provided below. (4)

Table 3 Percentage of Households in Each Income Category versus Auto Ownership

	Autos/Household		
Income	*0*	*1*	*2+*
Low	54	42	4
Medium	4	58	38
High	2	30	68

Table 4 Number of Trips per Household per Day

	Autos/Household		
Income	*0*	*1*	*2+*
Low	1	6	7
Medium	2	8	13
High	3	11	15

4.2	Name and describe the steps of the Four Step Method for travel demand forecasting in the correct order. (4)

QUESTION 5: TRANSPORT DEMAND [12]

5	There are three zones with trip attractions and productions as indicated in Table 5 below. Socio-economic factors (K_{ij}) and Friction Factors (F_{ij}) are presented in Table 6 and 7.
5.1	Use one iteration of the Gravity Model to determine the trip distribution of trips produced in Zone 2 to complete the second row of Table 8. (5)
5.2	Calculate the adjusted trip attraction for Zone 1 for the second iteration. (2)
5.3	When will a doubly constrained Gravity Model be reached? (1)
5.4	The Gravity Model and the Fratar Model are both used to estimate trip distribution. Discuss four (4) differences between these methods. (4)

Table 5: Zone Productions and Attractions:

Zone	Productions	Attractions
1	1067	2126
2	1643	984
3	865	465

Table 6: K_{ij}

i/j	1	2	3
1	1.4	0.8	0.7
2	0.6	1.1	0.6
3	0.8	0.9	1.3

Table 7: F_{ij}

i/j	1	2	3
1	0.9	0.6	0.6
2	0.5	0.9	0.5
3	0.7	0.8	0.9

Table 8: OD Matrix after 1 Iteration

i/j	1	2	3
1	854	151	62
2	?	?	?
3	421	251	193

QUESTION 6: PUBLIC TRANSPORT [12]

6.1	a) Explain why is it necessary to balance trip productions and attractions after the trip generation step of the Four Step Method? (1) b) Describe the method for balancing Home Based Work trips. (2)
6.2	Use the Logit Model to determine the market share between three transport modes: bicycle, bus and train. The utility functions for the modes of transport are calculated by Equation 1, with characteristic values presented in Table 9. (5)

$$U_k = a_k - 0.17X_1 - 0.089X_2 \quad \text{(Eq 1)}$$

Note: X_1 in N$ and X_2 in minutes

Table 9: Mode characteristics

MODE	a_k	X_1 (*Cost in N$*)	X_2 (*Time in minutes*)
Bicycle *(F)*	-0,80	N$ 0.00	18 min
Bus *(B)*	-0,40	N$ 10.50	9 min
Train *(R)*	-0,35	N$ 9.00	6 min

6.3	Use the information from Question 6.2. The municipality implements extensive upgrading of the bus networks, and the travel time by bus decreases to 5 minutes, but the cost of bus tickets increases to N$11.20. Determine the new market share of the train mode using the Incremental Logit Method. (3)
6.4	Why does the train mode share change when changes are made to the bus system? (1)

QUESTION 7: TRAFFIC IMPACT STUDIES [6]

7.1	Provide four scenarios when a Traffic Impact Study (TIS) should be conducted. (4)
7.2	Discuss the Traffic Impact Study (TIS) assessment years for a single-phase development that will generate 2250 trips in the peak hour. (2)

QUESTION 8: PUBLIC TRANSPORT AND UNIVERSAL ACCESSIBILITY [9]

8.1	List 5 different groups of stakeholders that will typically be considered or involved in the planning of public transport systems? (5)
8.2	Describe how a ticketing system be used to improve the integration between various modes of public transport? (2)
8.3	Provide four (4) measurements that should be taken during an accessibility audit in a building such as the engineering faculty. (2)

QUESTION 9: TRANSPORT ECONOMICS [14]

9	You have bought a new petrol passenger car. Consider the expenses summarised in Table 10 and answer the following questions.
9.1	Calculate the average fuel consumption considering you drive at an average speed of 45 km/h? (2)
9.2	Calculate the average oil consumption over 100 km at 45 km/h? (2)
9.3	Assume that the fuel and oil consumption calculated above are a good representation of your average fuel and oil consumption over a month. Draw a graph of the monthly cost model for your car as a function of the distance travelled and calculate the fixed and variable costs. (6)
9.4	Determine the total monthly cost of owning and operating your car if you drive 4250 km per month? (2)

Table 10: Vehicle costs

Loan repayment	N$ 2570 / month
Parking	N$ 2480 / year
Vehicle License	N$ 480 / year
Insurance	N$ 550 / month
Maintenance	N$ 8900 / 15 000 km
Fuel price	N$ 16.48 / L
Oil price	N$ 348 / 5L

Vehicle class	Constants			
	K_C	K_D	K_E	K_F
Cars	100,6	1467,6	- 1,7010	0,01524

Vehicle class	Constants	
	R_0	ß
Cars	440	0,0028

9.5	Why are the costs and benefits used to calculate a benefit-cost ratio always translated to Present Value before calculating the ratio? What is a good benefit- cost ratio? (2)

END

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FORMULA PAGE

Traffic Flow Theory / Traffic Studies:

$$q = u.k \qquad k_m = \frac{k_j}{2} \qquad u_m = \frac{u_f}{2} \qquad k = \frac{N}{L}$$

$$h = \frac{3600}{q} \qquad d = \frac{1000}{k} \qquad u_w = \frac{q_2 - q_1}{k_2 - k_1} \qquad \bar{u} = \frac{\sum f_i u_i}{\sum f_i}$$

$$S = \sqrt{\frac{\sum f_i (u_i - \bar{u})^2}{N-1}} \qquad V_w = \frac{(N_e + O_w - P_w).60}{T_e + T_w} \qquad \bar{T}_w = T_w - \frac{60.(O_w - P_w)}{V_w}$$

$$HEF = \frac{24\ hour\ volume}{particular\ hourly\ volume} \qquad DEF = \frac{weekly\ volume}{particular\ daily\ volume} \qquad MEF = \frac{AADT}{ADT\ of\ month}$$

$$D = \sum_{i=1}^{N} (n_i t_i) \qquad S = f.\sum_{i=1}^{N} (t_i) \qquad T = \frac{Vehicles}{Spaces}$$

Freeway LOS:

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID}$$

$$PHF = \frac{Total\ hourly\ volume}{4 \times peak\ 15\ \text{min}\ volume}$$

$$v_p = \frac{V}{(PHF)(N)(f_p)(f_{HV})} \qquad D = \frac{v_p}{S}$$

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

EXHIBIT 23-4. ADJUSTMENTS FOR LANE WIDTH

Lane Width (m)	Reduction in Free-Flow Speed, f_{LW} (km/h)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

EXHIBIT 23-8. PASSENGER-CAR EQUIVALENTS ON EXTENDED FREEWAY SEGMENTS

Factor	Type of Terrain		
	Level	Rolling	Mountainous
E_T (trucks and buses)	1.5	2.5	4.5
E_R (RVs)	1.2	2.0	4.0

Travel Demand Estimation:

$$T_{ij} = P_i \frac{A_j.F_{ij}.K_{ij}}{\sum_j A_j.F_{ij}.K_{ij}} \qquad A_{j,k} = \frac{A_j}{C_{j,(k-1)}} A_{j,(k-1)} \qquad P(A) = \frac{e^{U_A}}{\sum_x e^{U_x}}$$

$$P'_i = \frac{P_i.e^{\Delta U_i}}{\sum_x P_x.e^{\Delta U_x}} \qquad F = P(1+i)^n$$

Transport Economics:

$$PV = \sum_{n=0}^{N} \frac{C_n}{(1+i)^n} \qquad NPV = PVB - PVC$$

$$F = K_C + {}^{K_D}/_{V} + K_E.V + K_F V^2 \qquad S_O = R_O.{}^{\alpha}/_{1000} + \beta.F_S$$