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

Regular Examination

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This question paper consists of 10 pages including this front page.

Instructions

a) This is a **CLOSED BOOK** exam. No information sources may be consulted.
b) This question paper consists of **EIGHT** compulsory questions.
c) Answer ALL questions and show your work
d) Marks for each question are indicated
e) ALL resources (Tables, Monograms and Equations) are provided from Page 9 of this question paper.
f) Where information is not given, make reasonable assumptions and give justification.
g) Pocket calculators may be used. No programmable calculators are allowed.

QUESTION 1: TRAFFIC FLOW THEORY [15]

1.1	Describe the difference between a backward forming shockwave and a backward recovery shockwave. Draw a time-space diagram that depicts both of these shockwaves. (6)
1.2	The capacity measured on a particular road is 2200 veh/h. Traffic flow then reaches LOS F and the vehicles come to a standstill at an average spacing of 8 m per vehicle. A linear relationship between speed and density is known to exist on this road and Greenshield's Model is applicable. Determine: a) The free-flow speed, optimum speed, jam density and optimum density. (4) b) The mathematical relationship between speed and density (u-k). (1) c) Draw the three fundamental diagrams of traffic flow theory. Indicate all important values on the graphs. (4)

QUESTION 2: TRAFFIC STUDIES [14]

2.1	Describe the monthly and daily variation of traffic along a typical road in an urban area. Draw a graph depicting each variation pattern. (4)
2.2	A speed study observed the speeds of 50 vehicles. Appropriate speed bins were selected as 55-60 km/h, 60-65 km/h, etc. to 85-90 km/h. The frequency distribution curve is presented in Figure 1 below. Determine: a) The modal speed (1) b) The pace (1) c) Draw a cumulative distribution diagram and estimate the median speed and the 80th percentile speed. (4)

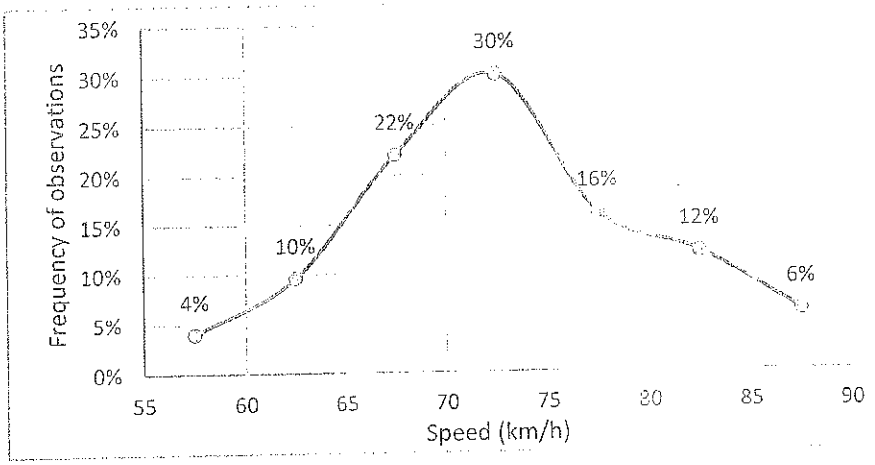

Figure 1: Frequency Distribution

2.3	A test vehicle is driving on a dual carriageway road. It takes the driver 3.53 minutes to travel eastwards between two intersections that are 4.25 km apart. 315 vehicles drive westwards on the opposite side of the road, 6 vehicles overtake the test vehicle, which itself passes 15 vehicles. The driver then does a U-turn and travels back to the first intersection in 4.98 minutes. 145 vehicles are counted travelling eastwards, 4 vehicles overtake the test vehicle, and the test vehicle passes 19 vehicles. Determine the traffic volume, average travel time and density of the westbound traffic stream. (4)

QUESTION 3: LEVEL OF SERVICE [10]

3	Determine the density of vehicles on a freeway with the following characteristics: Freeway is in a rural area and the area is mountainous Two 3,3 m wide lanes per direction There is an interchange every 2.5 km. - Base free flow speed: 100 km/h - Shoulder lateral clearance is 0.9 m - Peak hour volume: 2148 veh/h, of which 29% was counted in the peak 15 min - The freeway carries mostly holiday traffic (f_p = 0.85) - 3% trucks and buses, 12% recreational vehicles (RV's) (10)

QUESTION 4: TRANSPORT DEMAND [15]

4.1	The Gravity Model and the Fratar Model are both used to estimate trip distribution. Discuss four (5) differences between these methods. (5)
4.2	There are two zones, each generating trip attractions and productions as indicated in Table 1 below. Socio-economic factors within zones are equal to 1.1, and 0.8 between zones. Assume a travel time (R_{ij}) of 3 minutes within zones, and 7 minutes between two zones. Friction Factor F_{ij} can be calculated with the equation: $F_{ij} = R_{ij}^{-1.4}$. a) Use the Gravity Model to distribute trips between the two zones. Do one iteration of the Gravity Model. (6) b) Calculate the adjusted trip attractions for the second iteration. (4)

Table 1: Trip Productions and Attractions

Zone	Trip Productions	Trip Attractions
1	1 023	2 124
2	1 643	763

QUESTION 5: TRANSPORT DEMAND [15]

5.1	A 30% increase in the route distance of a public transport system resulted in a 17% increase in passenger demand. a) Calculate the log arc elasticity. (1) b) Explain why the number of passengers increase with an increase in length of the routes? (1) c) 58 000 daily trips are made when the routes were 1680 km in length. Calculate how many kilometres of route were added if the number of passengers is now 67 000? (2)
5.2	The road network indicated in Figure 2 shows an area with 12 distinct zones. The numbers in brackets represent the free flow travel time in minutes on the link in both directions. a) Determine the minimum time paths from zone 3 to all other zones and draw the minimum path tree (skim tree). (6) b) Calculate the number of trips on each link if trip distribution between zone 3 and the destination zones given according to Table 2. Indicate the trips on each link on your minimum path tree. (3) c) Determine the travel time on link 2-7 if the capacity of that link is 900 veh/h per direction. (2)

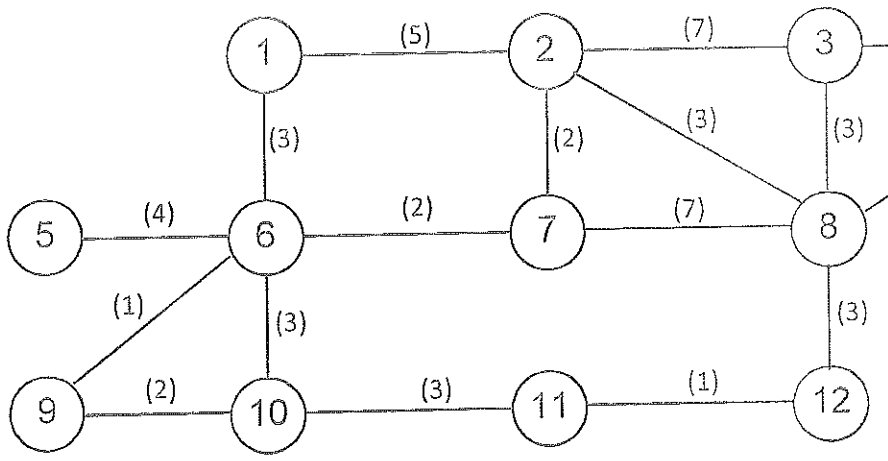

Figure 2: Road network

Table 2:

J	Trips
1	250
2	115
5	520
9	175
12	90

QUESTION 6: PUBLIC TRANSPORT [10]

6.1	Discuss three factors that can assist to encourage public transport modal integration. (6)
6.2	The decline of an urban area because of inadequate transport opportunities has been referred to as a "vicious cycle" that starts with increasing use of private vehicles and therefore more congestion. a) Discuss how this cycle affects public transport usage. (2) b) Explain how this cycle be broken? (2)

QUESTION 7: TRANSPORT ECONOMICS [6]

7	Develop a formula for the Net Present Value of a project with the following cost components: (6) ◦ Construction cost – C ◦ Maintenance costs – M ◦ Salvage value – S ◦ Road User Costs – R ◦ Improvement in travel time costs – T Reduction in accident costs – A

QUESTION 8: TRANSPORT ECONOMICS [15]

8	You have bought a new petrol passenger car. Consider the expenses summarised in Table 3 and answer the following questions.
8.1	What is the average fuel consumption considering you drive at an average speed of 45 km/h? (2)
8.2	What is the average oil consumption over 100 km at 45 km/h? (2)
8.3	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)
8.4	What is the total monthly cost of owning and operating your car if you drive 4250 km per month? (2)

Table 3: 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

8.5	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? (3)

Traffic Flow Theory / Traffic Studies:

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

$$h = \frac{3600}{q} \qquad d = \frac{1000}{k} \qquad u_w = \frac{q_2 - q_1}{k_2 - k_1}$$

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

$$D = \sum_{i=1}^{N}(n_i t_i) \qquad S = f.\sum_{i=1}^{N}(t_i) \qquad F = P(1+i)^n$$

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

LOS for freeways:

$$PHF = \frac{V_{hour}}{4 \times V_{peak\ 15\ min}} \qquad D = \frac{v_p}{S}$$

$$v_p = \frac{V}{(PHF)(N)(f_p)(f_{HV})} \qquad f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

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

EXHIBIT 23-3. SPEED-FLOW CURVES AND LOS FOR BASIC FREEWAY SEGMENTS

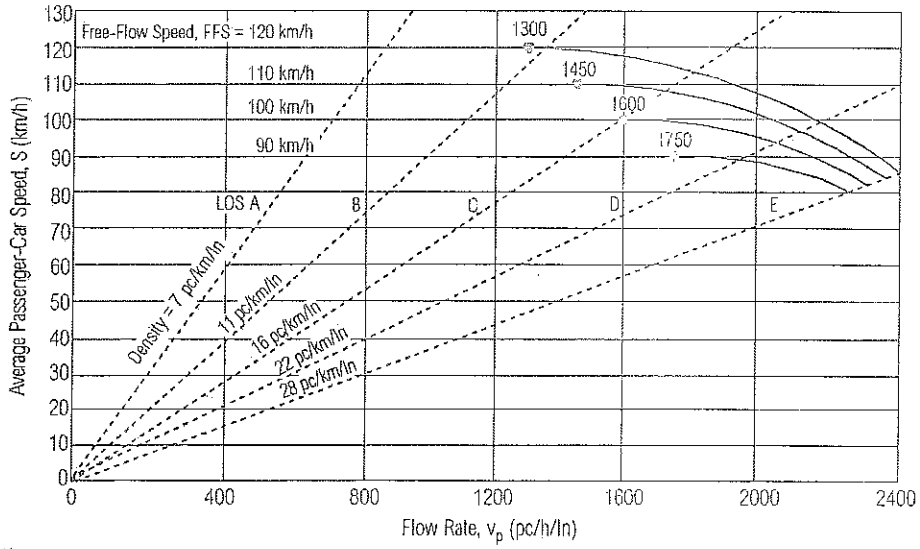

EXHIBIT 23-8. PASSENGER-CAR EQUIVALENTS ON EXTENDED FREEWAY SEGMENTS

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

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

Travel Demand Estimation:

NO	LAND USE	CODE	UNIT	RECOMMENDED TRIP GENERATION RATES		
				PERIOD	RATE	SPLIT
11.2	GENERAL OFFICES: Suburban	710	100 m²	am/pm	2,3	85:15
				daily	11,0	50:50
			employee	am/pm	0,6	85:15
				daily	2,8	50:50
15	RESTAURANT High turnover sit-down	832	100 m² occupied seat	pm generator/ midday	15,6 0,6	70:30 70:30

$$T_{ij} = P_i \frac{A_j.F_{ij}.K_{ij}}{\sum_j A_j.F_{ij}.K_{ij}} \qquad A_{j,k} = \frac{A_j}{C_{j,(k-1)}} A_{j,(k-1)} \qquad T_{ij} = (t_i G_i) \frac{t_{ij} G_j}{\sum_x t_{ix} G_x} \qquad G_i = \frac{T_i}{t_i}$$

$$P(A) = \frac{e^{U_A}}{\sum_x e^{U_x}} \qquad P'_i = \frac{P_i.e^{\Delta U_i}}{\sum_x P_{x.} e^{\Delta U_x}} \qquad t = t_0 \left[1 + 0{,}15\left({}^{V}/_{C}\right)^4\right]$$

$$e_M = \frac{\Delta D/D_{avg}}{\Delta X/X_{avg}} \qquad e_L = \frac{logD_0 - logD_n}{logX_0 - logX_n} \qquad F = P(1+i)^n$$

Transport Economics:

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

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