

# **TRANSPORTATION PLANNING AND MANAGEMENT**



## **Final Examination A**

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**Muhammad Ishaq Id#15508**

**Submitted to: Engr. Muhammad Majid Naeem**

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**Q1:** Calculate the trips distribution of each zone. Note: (Impedance exponent is 3) (15)

Zone i		Productions	Attractiveness	Interzonal Impedance, j							
S.No	Name			1	2	3	4	5	6	7	8
1	Peshawar	67000	45	45	30	45	37	60	240	45	480
2	Charsadda	63300	37	30	30	25	30	45	220	60	500
3	Mardan	59400	24	45	25	30	15	30	195	85	535
4	Nowshera	56200	28	37	30	15	25	30	180	105	547
5	Swabi	53100	24	60	45	30	30	35	170	115	580
6	Abbottabad	50300	14	240	220	195	180	170	27	280	725
7	Kohat	47800	21	45	60	85	105	115	280	30	440
8	D.I Khan	51500	13	480	500	535	547	580	725	440	25

**Ans:**

Zone, +D8:M2 2 i	Name	Trip Productions, P <sub>i</sub>	Attractiveness , A <sub>i</sub>								
1	peshawar	67000	45								
2	Charsada	63300	37								
3	Mardan	59400	24								
4	Nowshera	56200	28								
5	swabi	53100	24								
6	Abbot abad	50300	14								
7	Kohat	47800	21								
8	DI khan	51500	13								
				for I=Peshawar P1=67000							
Zone i		Interzonal impedance W <sub>ij</sub>									
		Zone j									
		1	2	3	4	5	6	7	8		
1	peshawar	45	30	45	37	60	240	45	480		
2	Charsada	30	30	25	30	45	220	60	500		
3	Mardan	45	25	30	15	30	195	85	535		
4	Nowshera	37	30	15	25	30	180	105	547		
5	swabi	60	45	30	30	35	170	115	580		
6	Abbot abad	240	220	195	180	170	27	280	725		
7	Kohat	45	60	85	105	280	230	30	440		
8	DI khan	480	500	535	547	580	725	440	25		

for I=Peshawar P1=67000							
j		a <sub>j</sub>	F <sub>1j</sub>	K <sub>1j</sub>	a <sub>j</sub> F <sub>1j</sub> K <sub>1j</sub>	P <sub>1j</sub>	Q <sub>1j</sub>
1	peshawar	45	1.1E-05	1	0.0004938	0.1634	10945
2	Charsada	37	4E-05	1	0.0013704	0.4533	28694
3	Mardan	24	1E-05	1	0.0002634	0.0871	5175
4	Nowshera	28	2E-05	1	0.0005528	0.1829	10276
5	swabi	24	5E-06	1	0.0001111	0.0368	1952
6	Abbot abad	14	7E-08	1	0.0000010	0.0003	17
7	Kohat	21	1E-05	1	0.0002305	0.0762	3644
8	DI khan	13	9E-09	1	0.0000001	4E-05	2
<b>Total</b>					0.0030	1	60705

For i =Charsada P <sub>3</sub> = 63300							
j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	3.7E-05	1	0.0016666 7	0.2791	17666
2	Charsada	37	3.7E-05	1	0.0013703 7	0.2295	13630
3	Mardan	24	0.00006 4	1	0.001536	0.2572	14454
4	Nowshera	28	3.7E-05	1	0.0010370 4	0.1736	9221
5	swabi	24	1.1E-05	1	0.0002633 7	0.0441	2218
6	Abbot abad	14	9.39E-08	1	1.3148E-06	0.0002	11
7	Kohat	21	4.63E-06	1	9.7222E-05	0.0163	838
8	DI khan	13	8E-09	1	1.04E-07	2E-05	1
					0.0059720 9		

For i =Mardan P <sub>3</sub> = 59400							
j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	1.1E-05	1	0.0004938 3	0.0381	2261. 3
2	Charsada	37	0.00006 4	1	0.002368	0.1825	10843
3	Mardan	24	3.7E-05	1	0.0008888 9	0.0685	4070. 3
4	Nowshera	28	0.00029 6	1	0.0082963	0.6396	37989
5	swabi	24	3.7E-05	1	0.0008888 9	0.0685	4070. 3
6	Abbot abad	14	1.35E-07	1	1.8881E-06	0.0001	8.645 7
7	Kohat	21	1.63E-06	1	3.4195E-05	0.0026	156.5 8
8	DI khan	13	6.53E-09	1	8.4895E-08	7E-06	0.388 7
					0.0129720 7		

For i =Nowshera, P <sub>4</sub> = 56200							
j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	1.97E-05	1	0.0008884	0.0736	4136
2	Charsada	37	3.7E-05	1	0.0013703 7	0.1135	6379
3	Mardan	24	0.00029 6	1	0.0071111 1	0.5891	33107
4	Nowshera	28	0.00006 4	1	0.001792	0.1485	8342
5	swabi	24	3.7E-05	1	0.0008888	0.0736	4138
6	Abbot abad	14	1.71E-07	1	2.4005E-06	0.0002	11
7	Kohat	21	8.64E-07	1	1.8141E-05	0.0015	84.
8	DI khan	13	6.11E-09	1	7.9429E-08	7E-06	0.369 8

0.0120713

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## For i= Swabi P5=53100

j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	4.63E-06	1	0.0002083 3	0.0671	3564
2	Charsada	37	1.1E-05	1	0.0004060 4	0.1308	6946
3	Mardan	24	3.7E-05	1	0.0008888 9	0.2864	15207
4	Nowshera	28	3.7E-05	1	0.0010370 4	0.3341	17741
5	swabi	24	2.33E-05	1	0.0005597 7	0.1803	9576
6	Abbot abad	14	2.04E-07	1	2.8496E-06	0.0009	48
7	Kohat	21	4.56E-08	1	9.5663E-07	0.0003	16
8	DI khan	13	5.13E-09	1	6.6628E-08	2E-05	2
					0.0031039		

## For i=Abbotabd P6=50300

j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	7.23E-08	1	3.2552E-06	0.0044	223
2	Charsada	37	9.39E-08	1	3.4748E-06	0.0047	239
3	Mardan	24	1.35E-07	1	3.2367E-06	0.0044	222
4	Nowshera	28	1.71E-07	1	4.8011E-06	0.0066	330
5	swabi	24	2.04E-07	1	4.885E-06	0.0067	335
6	Abbot abad	14	5.08E-05	1	0.0007112 7	0.9708	48830
7	Kohat	21	8.22E-08	1	1.726E-06	0.0024	118
8	DI khan	13	2.62E-09	1	3.4114E-08	5E-05	2
					0.0007326 9		

For i= Kohat=47800							
j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	1.1E-05	1	0.0004938 3	0.3243	15502
2	Charsada	37	4.63E-06	1	0.0001713	0.1125	5377
3	Mardan	24	1.63E-06	1	3.908E-05	0.0257	1227
4	Nowshera	28	8.64E-07	1	2.4187E-05	0.0159	759
5	swabi	24	6.58E-07	1	1.578E-05	0.0104	495
6	Abbot abad	14	4.56E-08	1	6.3776E-07	0.0004	20
7	Kohat	21	3.7E-05	1	0.0007777 8	0.5108	24415
8	DI khan	13	1.17E-08	1	1.5261E-07	0.0001	5
					0.0015227 4		

For i=DI Khan P8=51500							
j		a <sub>j</sub>	F <sub>3j</sub>	K <sub>3j</sub>	a <sub>j</sub> F <sub>3j</sub> K <sub>3j</sub>	P <sub>3j</sub>	Q <sub>3j</sub>
1	peshawar	45	9.04E-09	1	4.069E-07	0.0005	25
2	Charsada	37	8E-09	1	2.96E-07	0.0004	18
3	Mardan	24	6.53E-09	1	1.5673E-07	0.0002	10
4	Nowshera	28	6.11E-09	1	1.7108E-07	0.0002	11
5	swabi	24	5.13E-09	1	1.2301E-07	0.0001	8
6	Abbot abad	14	2.62E-09	1	3.6738E-08	4E-05	2
7	Kohat	21	1.17E-08	1	2.4653E-07	0.0003	15
8	DI khan	13	0.00006 4	1	0.000832	0.9983	51411
					0.0008334 4		

Total trip A1	54322
A2	72128
A3	73472
A4	84670
A5	22793
A6	48948
A7	29288
A8	51423

**Q2:** The choice transport modes of a city includes: Autos (A), Light Circular Rail (LCR), Local Buses (LB), Riding Bikes (RB) and Fast Rail (FR). The utility functions of each mode are:

S.No	Mode	Utility functions	C	A	W	R
1	Autos	$3.2 - 0.85C - 0.015A - 0.5W - 0.035R$	300	6	4	25
2	Light Circular Rail	$1.0 - 0.35C - 0.025A - 0.7W - 0.055R$	70	7	10	30
3	Local Buses	$1.7 - 0.15C - 0.075A - 0.9W - 0.075R$	50	10	15	40
4	Riding Bikes	$1.3 - 0.17C - 0.012A - 0.0W - 0.095R$	45	1	0	20
5	Rapid Rail	$1.5 - 0.25C - 0.095A - 0.6W - 0.025R$	90	5	20	15

Where C is the cost in Rupees, A, W & R are access, waiting & riding times in minutes respectively.

- Based on an estimate a population of 30,000 individuals will head for CBD each morning to run there business, how many individuals will choose a particular transport mode & what amount of revenue will be generated? (5)
- If the government subsidizes Light Circular Rail by 30%, Local Buses by 20% and Rapid Rail by 10% what will be the model split and how much revenue will be generated? (5)
- If the government also introduce a subway train in combination with above subsidized rates (As in part-b) having utility function as  $U = 1.2 - 0.22C - 0.015A - 0.65W - 0.020R$  & other attributes as  $C=80, A=4, W=5$  and  $R=10$  and also increase the autos and riding bike cost by 15% and 5% respectively. Will there be any effect on revenue generation? (5)

**ANS: #2:**

**Parts I)** To calculate utility function from hiven data

$$U(\text{Auto}) = 3.2 - .85(300) - .015(60) - .5(4) - .035(25)$$

$$= -254.765$$

$$U(\text{LC}) = 1.0 - .35(70) - .025(7) - .7(10) - .05(30)$$

$$= -32.32$$

$$U(\text{LB}) = 1.7 - .15(50) - .075(10) - .9(15) - .075(40)$$

$$= -23.5$$

$$U(RB)=13-.17(45)-.012(1)-0.0(0)-.093(20)$$

$$=-7.3$$

$$U(RR)=1.5-.25-.95(A)-.6(W)-.025(R)$$

$$=1.5-.25(90)-.95(5)-.6(20)-.025(15)$$

$$=-33.85$$

As we know that

$$P(K)=e^{uk}/\sum e^{ux}$$

$$P(\text{Auto})=e^{-254.765}/e^{-254.76}+e^{-23.5}+e^{-7.3}+e^{-33.85}$$

$$=0.00$$

$$P(\text{LCR})=e^{-32.9}/6.75 \times 10^{-4}$$

$$=0$$

$$P(\text{LB})=e^{-23.5}/6.75 \times 10^{-4}=0$$

$$P(\text{RB})=e^{-7.3}/6.75 \times 10^{-4}=0$$

$$P(\text{R Rail})=e^{-33.85}/6.75 \times 10^{-4}=0$$

**Calculating the number of individuals using facility**

$$Q_{(ij)k} = \text{No of individual} \times P(K)$$

for all mode of transportation Number of individual using different mode is zero so revenue will also be zero

**Ans#2 Part B): When give 30 subsidy**

Autos	C	A	W	R
Light Circular Rail	210	6	4	25
Local Buses	49	7	10	30
Riding Bikes	35	10	15	40
Rapid Rail	63	5	20	15

Utility function for Autos

$$=3.2-.85C-.015A-.5W-.035R$$



Putting the Values

$$=3.2-.85(210)-.015(49)-.5(4)-.035(25)$$

$$=-177.16$$

$$U(L Rail)= 10-.35C-.025A-.7W-.055R$$

$$=1-.35(49)-.025(10)-.7(10)-.055(30)$$

$$=-.25.05$$

$$U Local bus= 1.7-.15C-.075A-.9W-.075R$$

$$=1.7-(.15 \times 35)-.075(10)-.9(15)-.075(40)$$

$$=-20.8$$

$$U riding bikes = 1.3-.17(31.5)-.012(1)-(.0 \times 0)-.095(20)$$

$$=-5.967$$

$$U R rail = 1.5-.25C-1.95A-.6W-.25(03)-.09(50)-.6 \times 20-.025 \times 15$$

$$=-27.1$$

**So as per formula**

$$P(\text{Auto})= e^{-177.16}/e^{-177.16}+e^{-25.05}+e^{-20.8}+e^{-5.967}+e^{-27.1}$$

$$= [0]=1.149 \times 10^{-77}/2.56 \times 10^{-5}$$

$$P(\text{Auto})=0$$

$$P(\text{LCR})=0$$

$$P(\text{P(LB)})=0$$

$$P(\text{BB})=0$$

$$P(\text{RR})=0$$

**and as other values are zero for all modes of transportation**

**Part c: A sub way is introduced and the cost of auto and bike are increases respectively 15 and 5%**

	C	A	W	R
Autos	345	6	4	25
Light Circular Rail	70	7	10	30
Local Buses	50	10	15	40
Riding Bikes	47	1	0	20
Rapid Rail	90	5	20	15
<b>Sub way bus</b>	<b>80,</b>	<b>4,</b>	<b>5</b>	<b>10</b>

$$U = 1.2 - 0.22C - 0.015A - 0.65W - 0.020R$$

So by putting the values to calculate the utility function

U(a)=	-293.825
U(LCR)=	-46.805
U(RT)=	-37.1
U(RB)=	-39.5775
U(RR)=	-62.65
U(Sub bus)	-69.76

P(a) =	0.0
P(LCR) =	21.0
P(RT) =	0.0
P(RB) =	0.0
P(RR) =	0.0
P(Su Busb) =	0.0

<b>Individuals</b>	(Auto) =	0	individuals/day
	(LCR) =	-983	individuals/day
	(RT) =	0	individuals/day
	(RB) =	0	individuals/day
	(RR) =	0	individuals/day
	Sub way bus	0	individuals/day

Revenue		
	(Auto) =	-3.3644E-104
	(LCR) =	-29501142.83
	(RT) =	-8.5935E-11
	(RB) =	-5.77787E-21
	(RR) =	-8.72933E-31
	Sub way bus	-5.28828E-25

Note: The calculation has been also done in excel using standard procedure and formula and we have got the same result there are some attach screen shots

Attributes	C	A	W	R	ak
Automobile	300	60	4	25	3.2
LCR	70	7	10	30	1
LBU's	50	10	15	40	1.7
Riding Bikes	45	1	0	20	1.3
Rapid rail	90	5	20	15	1.5
$U(a) = -255.575$ $U(LCR) = -64.655$ $U(RT) = -49.85$ $U(RB) = -37.665$ $U(RR) = -85.6$					
$P(a) = 0.0$ $P(LCR) = 0.0$ $P(RT) = 0.0$ $P(RB) = 0.0$ $P(RR) = 0.0$					
Qij (Auto) =	0	individuals/day			
Qij (LCR) =	0	individuals/day			
Qij (RT) =	0	individuals/day			

**When 30%subsidu given bu govt**

Attributes	C	A	W	R	ak
Automobile	210	60	4	25	3.2
LCR	49	7	10	30	1
LBU's	35	10	15	40	1.7
Rdidng Bikes	31.5	1	0	20	1.3
Rapid railk	63	5	20	15	1.5
$U(a) = -179.075$ $U(LCR) = -46.805$ $U(RT) = -37.1$ $U(RB) = -26.19$  $U(RR) = -62.65$					
$P(a) = 0.0$ $P(LCR) = 0.0$ $P(RT) = 0.0$ $P(RB) = 0.0$ $P(RR) = 0.0$					

Etc.....

**Note:Abbrevation are used for all modes of tranport**



Stage N	Link		Compute new path impedance			Compare to tree table Stage N-1	Decision
	i	j					
I	A	1	0	4	4	4 < Infinity	Accepted
II	1	2	4	3	7	7 < Infinity	Accepted
	1	4	4	3	7	7 < Infinity	Accepted
	2	1	7	3	10	10 > 4	Rejected
III	2	3	7	4	11	11 < Infinity	Accepted
	2	5	7	4	11	11 < Infinity	Accepted
	3	B	11	3	14	14 < Infinity	Accepted
	3	6	11	12	23	23 > 18	Rejected
	3	2	11	4	15	15 > 7	Rejected
	4	1	7	3	10	10 > 4	Rejected
	4	5	7	5	12	12 > 11	Rejected
	4	7	7	7	14	14 < Infinity	Accepted
	5	2	11	4	15	15 > 7	Rejected
	5	4	11	5	16	16 > 7	Rejected
	5	6	11	7	18	18 < Infinity	Accepted
	5	8	11	8	19	19 < Infinity	Accepted
	6	3	23	12	35	35 > 11	Rejected
	6	5	23	7	30	30 > 11	Rejected
	6	9	23	9	32	32 > 31	Rejected
	7	4	14	7	21	21 > 7	Accepted
	7	8	14	10	24	24 > 19	Rejected
	7	C	14	5	19	19 < Infinity	Accepted
iv	8	5	19	8	27	27 > 11	Rejected
	8	9	19	12	31	31 < Infinity	Accepted
	8	7	19	10	29	29 > 14	Rejected
	9	D	32	4	36	36 < Infinity	Accepted
	9	8	32	12	44	44 > 19	Rejected
	9	6	32	9	41	41 > 18	Rejected

**Minimum Impedance from Zone-A to all other zones and nodes after removal of rejected links**

	Link		Compute new path impedance			Compare to tree table Stage N-1	Decision
	i	j					
I	A	1	0	4	4	4 < Infinity	Accepted
II	1	2	4	3	7	7 < Infinity	Accepted
	1	4	4	3	7	7 < Infinity	Accepted
III	2	3	7	4	11	11 < Infinity	Accepted
	2	5	7	4	11	11 < Infinity	Accepted
	3	B	11	3	14	14 < Infinity	Accepted
	4	7	7	7	14	14 < Infinity	Accepted
	5	6	11	7	18	18 < Infinity	Accepted
	5	8	11	8	19	19 < Infinity	Accepted
	7	4	14	7	21	21 > 7	Accepted
	7	C	14	5	19	19 < Infinity	Accepted
IV	8	9	19	12	31	31 < Infinity	Accepted
	9	D	32	4	36	36 < Infinity	Accepted

**Q4:**The City government wants to start a transit service between three cities A, B &

**C.** The alternatives are having the following attributes.(10)

S.No	Alternative (X)	Initial Cost (million)	Annual Operating Cost (million)	Annual Maintenance (million)	Annual Salvage value (million)	Annual revenue generation (million)	Useful life (Years)	Interest rate, i%
1	CNG Bus	60	16.048	7.99	7.04	25	11	7
2	Bus Rapid Transit	50	19.589	12.116	11	27	12	7
3	Light Rail	66	19.554	16	14	29	12	5
4	Fast Train	95	31.132	19.345	17	45	14	8
5	Metro	70	25	19.535	16	35	18	6

Using Net Present Value which alternative will you recommend and why?

Ans: #4

$$PV = PW (\text{BENEFITS}) - PW (\text{COSTS})$$

$$USPWF = \frac{1 - (1+i)^{-n}}{i}$$

$$SPPWF = \frac{1}{(1+i)^n}$$

All values are calculated for all modes on the base of standard formulas for NPV

**(1) NPV for CNG Bus**

$$\begin{aligned} &= 25 * USPWF (7\%,11) - 60 - (24.038) * USPWF(7\%,11) + 7.04 \\ & \quad (SPPWF)(7\%,11) \\ &= -49.27 \text{ MILL} \end{aligned}$$

**(2) NPV For BUS RAPD TRASIT:**

$$\begin{aligned} &= 27 * USPWF (7\%,12) - 50 - (31.704) * USPWF(7\%,12) + 11 \\ & \quad (SPPWF)(7\%,12) \\ &= - 82.61 \text{ MILL} \end{aligned}$$

**(3) NPV for LIGHT RAIL:**

$$\begin{aligned} &= 29 * USPWF (5\%,12) - 66 - (35.55) * USPWF(5\%,12) + 14 \\ & \quad (SPPWF)(5\%,12) \\ &= - 116.26 \text{ MILL} \end{aligned}$$

**(4) NPV of FAST TRAIN):**

$$\begin{aligned} &= 45 * USPWF (8\%,14) - 95 - (50.47) * USPWF(8\%,14) + 17 \\ & \quad (SPPWF)(8\%,14) \\ &= - 134.31 \text{ MILL} \end{aligned}$$

**(5) NPV of METRO:**



$$= 35 * USPWF(6\%,18) - 70 - (44.53) * USPWF(6\%,18) + 16 \\ (SPPWF)(6\%,18) \\ = - 167.3 \text{ MIL}$$

**Reference Material:**

1. Class Lectures/Presentations/Video demonstrations
2. Engineering Transportation Engineering & Planning by Papacostas
3. Transportation Engineering by C Jotin Khisty & B. Kent Lall
4. Highway Traffic Analysis and Design 2nd Edition By R. J. Salter
5. Transport Planning and traffic engineering Edited by C A O Flaherty
6. Principles of Engineering Economics with Applications By Zahid A. Khan, Arshad N. Siddiquee, Brajesh Kumar, Mustufa H. Abidi