Question 2.1

Office workers within a residential development have a choice of the following work destinations:

Urban Centre A, 150 minutes travel time away, with 7 million m^2 of office space

Urban Centre B, 60 minutes travel time away, with 1 million m^2 of office space

Local shopping area, 12 minutes travel time away with 0.15 million m^2 of office space

The Gravity Model is to be utilized to determine the distribution of trips between the 3 destinations.

The level of attraction to workers is based on the quantity of office space available within each destination

If 10,000 office-worker journeys are generated by inhabitants within the residential development, distribute them between the 3 destinations

(Friction factor = $1.0t^{-2}$).

Solution 2.1

P=10000						
A=1.0	b=-2					
Zone	Aj	t	F	AF	AF/∑AF	T
Urban A	7000000	150	4.44444E-05	311.1111	0.190801	1908
Urban B	1000000	60	0.000277778	277.7778	0.170358	1704
Res	150000	12	0.006944444	1041.667	0.638842	6388
				1630.556	1	10000

Question 2.2

(a)

Travel time for buses between Zone A and Zone B is set at 15 minutes, with the travel time for cars set at 8 minutes.

Use the MNL formula $U_m = a_m - 0.22\ t_{ij}$

Where

$a_{car} = 0.0$

$a_{bus} = -0.9$

Determine modal split for the bus and car

(b)

If the construction of a priority bus corridor between Zone A and Zone B reduces the travel time for buses to 6 minutes, estimate the new modal split.

Solution 2.1

(a)

$U_{car} = 0.0 - (0.2 \times 8) = -1.6$

$U_{bus} = -0.9 - (0.2 \times 15) = -3.9$

Car share = $e^{-1.6} \div (e^{-1.6} + e^{-3.9}) = 0.202 / (0.202 + 0.02) = 0.91$

Bus share = $e^{-3.9} \div (e^{-1.6} + e^{-3.9}) = 0.02 / (0.202 + 0.02) = 0.09$

(b)

$U_{car} = 0.0 - (0.2 \times 8) = -1.6$

$U_{bus} = -0.9 - (0.2 \times 6) = -2.1$

Car share = $e^{-1.6} \div (e^{-1.6} + e^{-2.1}) = 0.202 / (0.202 + 0.122) = 0.62$

Bus share = $e^{-2.1} \div (e^{-1.6} + e^{-2.1}) = 0.122 / (0.202 + 0.122) = 0.38$

Introduction of bus lane increases modal share of bus by a factor of 4.2.

Question 2.3

During the peak morning hour, a bus lane runs a service from a satellite town into the city centre, with an average headway of 2 minutes. Each bus has a capacity of 90 passengers, and each vehicle is on average at 90% capacity. Each bus commuter lives on average 5 minutes walk from their bus stop. Having disembarked, bus commuters walk on average 10 minutes to their place of work.

The bus would take 12 minutes to travel from origin to destination if it did not stop. Picking up passengers, however, adds 6 minutes to the total journey time. The bus fare is 0.5 Euro

For commuters traveling by car, in-car traveling time totals 25 minutes, with available parking on average 5 minutes walk from the workplace. Daily car parking costs Euro 10, Petrol costs per journey averages 2 Euro.

The utility of each mode is estimated using the following formula:

$U_m = a_m - 0.2 \text{ time}_{\text{IN VEHICLE}} - 0.5 \text{ time}_{\text{out of VEHICL E}} - 0.1 \text{ time}_{\text{TRAVEL EXPENSES}}$

Where $a_m = 1$ for car travel and 0 for bus travel

Each car carries 1.4 persons.

Estimate the number of bus and car commuters traveling from the satellite town to the city centre

Solution 2.3

U_{BUS} = 1 – 0.2 (18) – 0.3 (5+1+10) – 0.1 (0.5) = 1 - 3.6 - 4.8 - 0.5 = -7.9

U_{CAR} = 1 – 0.2 (25) – 0.3 (5) – 0.1 (10/2 + 2) = 1 - 5 - 1.5 - 0.7 = - 6.2

Bus share = $e^{-7.9} \div (e^{-4.2} + e^{-7.9})$ = 0.000371 / (0.002 + 0.000371) = 0.16

Car share = $e^{-1.6} \div (e^{-1.6} + e^{-2.1})$ = 0.002 / (0.002 + 0.000371) = 0.84

Bus commuters = 30*90*0.9 = 2430 = 16%

Therefore car number = 2430 $\times$ 84 $\div$ 16 = 12757.5

Assuming 1.4 persons by car

Total number form the town traveling to city centre by car = 12757.5*1.4 = 17861

Question 2.4

Two alternative peak-time routes exist between 2 localities within an urban area:

The time required to take the first route is estimated using the following formula:

T(route 1) = 2.1 + 0.6 x_1

x_1 = volume of traffic flow along route 1 in '000 of vehicles

T(route 2) = 4.1 + 0.3 x_2

x_2 = volume of traffic flow along route 2 in '000 of vehicles.

The total flow between the 2 urban areas is 4000 vehicles per hour during the peak.

Estimate the equilibrium flows during the peak, together with the time of travel along the 2 routes

Solution 2.4

$X_1 + X_2 = 4$

$X_2 = 4 - X_1$

$2.1 + 0.6\ X_1 = 4.1 + 0.3\ X\ (4 - X_1)$

$0.6\ X_1 = 4.1 - 2.1 + 1.2 – 0.3\ X_1$

$0.9\ X_1 = 4.1 - 2.1 + 1.2$

$X_1 = 3.555$

$X_2 = 0.445$

Therefore, at equilibrium, during peak hour, 3555 vehicles use route 1, with 445 vehicles using route 2.

Question 2.5

Two alternative routes connect the city centre to a residential suburb. The performance function for the two routes are as follows

$t_1 = 6 + 3x_1$

$t_2 = 4 + 4.5(x_2)^2$

t_1, t_2 are the mean travel times on routes 1 and 2

x_1, x_2 are the traffic volumes on routes 1 and 2 in 000's of vehicles per hour

The total number of combined vehicles travelling along the two routes towards the city during the peak is 5000 vehicles

Estimate the equilibrium travel times for each route and the volume of cars utilising each

Solution 2.5

$6+3(5-X2)=4+4.5(X2)^2$

$X1+X2=5$

$4.5(X2)^2 + 3X^2 – 17 = 0$

A=4.5
B=3
C=-17

X2=(-3+/-17.74)/9

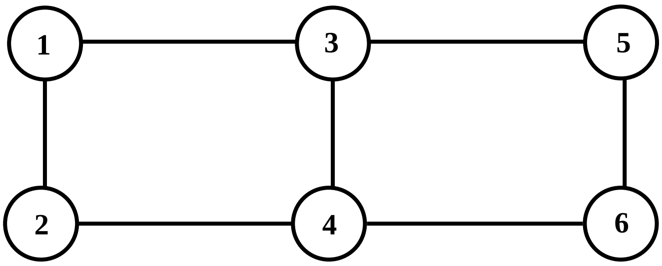
X1=3.361 (3361 cars on route 1)

X2=1.639 (1639 cars on route 2)

Equilibrium time=16.08 minutes

Question 2.6

The following is a diagram for a transport network:



The minimum paths are given below in Table Q2.5.1

Origin zone	Destination zone					
	1	**2**	**3**	**4**	**5**	**6**
1		1-2	1-3	1-2-4	1-3-5	1-3-4-6
2	2-1		2-1	2-4	2-1-3	2-4-6
3	3-1	3-1-2		3-4	3-5	3-4-6
4	4-2-1	4-2	4-3		4-3-5	4-6
5	5-3-1	5-3-1-2	5-3	5-3-4		5-6
6	6-4-3-1	6-4-2	6-4-3	6-4	6-5	

Table Q2.5.1

If zone-to-zone trip interchanges are as given in Table Q2.5.2 below, calculate the flows on each link of the network.

Origin zone	Destination zone					
	1	**2**	**3**	**4**	**5**	**6**
1	-	300	600	300	220	130
2	500	-	250	600	130	290
3	500	350	-	750	540	410
4	100	600	500	-	290	440
5	400	200	750	240	-	420
6	200	550	400	330	330	-

Table Q2.5.2

Solution 2.6

1-2, 2-1=2130
1-3, 3-1=2980
2-4, 4-2=2440
3-4, 4-3=2920
3-5, 5-3=2770
4-6, 6-4=2550
5-6, 6-5=750