Transportation

- Congestion = ازدحام مروري
- Transportation planning = التخطيط مروريا
- MOE → Measures of effectiveness.
- Prelimenary feasability = دراسات جدوى اولية
- Q_0 → zero ابدا
  يعني الطريق اللي هو فاضي يعني ما
- UTP → Urban transportation planning.
- Cul-de-Sac = Dead end = Termination.
- Metropolical Area = Urbanized Area > 5000

* OD-Survey = Origin-Distination survey:-

1. Coding and Zoning:-

* Zoning:- dividing study Area (SA) into number of small areas, depending on the following:-

1- Adminstrative Census tracts.
2- Exsisting road ways that devids these tracts into two or more subareas.
3- Existing rail way
4- Land Uses.
5- Natural or historical Features.

* Followed *

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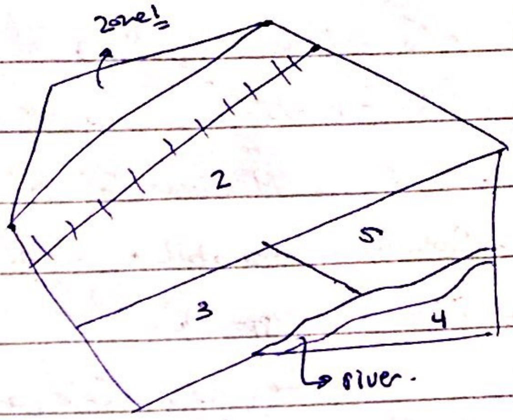
- we can also Zoning depending on:-
  1. Age
  2. Employment.
  3. Population Per Zone ≥ 1000
  4. Salary
  5. Areas



- Travel time = actual travel time on Links during peack hours.
- Capacity = Max. num. of vehichles a Link can hold per hour.

* Demand Modeling:-
- Aggrigate sequential Modeling techiniques.

→ 4-Step demand Modeling:-

1. ~~Step~~ Trip generation → Trip Production
   → Trip attraction.

2. Trip distribution:
   → defining No. of trips produced from a zone one attracted to another zone.
   - We use Mathmatical Models to identify:-
     1- Gravity Model
     2- Growth Factor
     3- Avg growth Factor.

* Followed:-

3- Modal Split:-

→ splitting the No. of trips distributed according to the Modes of transportation.

4- Network Assignment [Route Choice]:-

→ dist. the No. of the trip / Mode on the Links connecting pairs of TAZ's.

* Trip purposes:-

1- Home-Based work (HBW)
2- Home-Based Other (HBO)
3- Non-home Based (NHB).

* Example:- Determine the number of daily trips that are produced from the Following zones using cross classification Method:-

HH = 60

Annual income	Low (L)			Meduim (M)			High (H)		
	$60 * \frac{9}{100} = A$			$60 * \frac{40}{100} = B$			$60 * \frac{51}{100} = C$		
Autos owned	0	1	+2	0	1	+2	0	1	+2
	A*54%	A*42%	A*4%	B*4%	B*58%	B*38%	C*2%	C*30%	C*68%
Avg. No. of trips / HH	1	6	7	2	8	13	3	11	15
	3	[illegible]	[illegible]	2	[illegible]	[illegible]	2	101	313
Σ Avg No. of Daily trips / trip purpose	19			233			416		
	HBW = 17%	NHB = 52%	HBO = 32%	HBW	NHB	HBO	HBW	NHB	HBO
	4	10	5	40	122	75	71	[illegible]	133

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* Activity Units:- → • square Area.

• Number of Employees.

* Trip rate of Attraction = $\frac{\text{Number of trips attracted according to purpose}}{\text{Activity units}}$ = Area of Attraction or No. of employees

retail Non-retail other retail

* In trip rate attractions:-

Trip rate could be used instead of cross classification.

* In case No. of prod. ≠ No. of Attractions.

Calibrate

HBW OR HBO NHB

* Calibrate = $\frac{\Sigma \text{Production}}{\Sigma \text{Attraction}}$ * Att Per Zone.

* Both Prod. & Att. can be considered unrealible

* Multiply att. * $\frac{\Sigma \text{Prod.}}{\Sigma \text{attr.}}$ = $\text{Att}_{\text{calibrated}}$

* Use the Calibrated attractions for both Prod. & Att.

* at the end of trip generation, Make sure that for SA

ΣProd. = ΣAttr.

* Followed *

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B- Trip Distribution :-

1- Gravity Model :-

* O-D Matrix = Origin- Distination Matrix

D(j) \ O(i)	1	2	3	Aj
1	T_{11}	T_{21}	T_{31}	P_1
2	T_{12}	T_{22}	T_{32}	P_2
3	T_{13}	T_{23}	T_{33}	P_3
Ai	A_1	A_2	A_3	

* Try To Minimize the Diagonal Trip From Zoning

* $\Sigma A_{calc.} \Rightarrow$ This No. can differ From $\Sigma A_{given} \longrightarrow$ Calibrate.

* impedence → عائق , عقبة

* Friction coeff → ↑ → ↑ attractions. → It's a function of impedence.

* $T_{ij} = \dfrac{P_i * A_j * FF_{ij} * k_{ij}}{\Sigma A_j * FF_{ij} * k_{ij}}$

→ Number of Daily Trips.

* 12 إني بفضل ال Zone بكبر الحجم نفس الحاجة .

* Followed *

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* Example in slides:- [12.4]:-

O_i / D_j	1	2	3	
1				
2				
3				
A_i				

$$T_{11} = \frac{P_1 * A_1 * F_{11} * k_{11}}{(A_1 * F_{11} * k_{11}) + (A_2 * F_{21} * k_{21}) + (A_3 * F_{31} * k_{31})}$$

$$= \frac{140 * 300 * 39 * k_{11}}{(300 * 39 * k_{11}) + (270 * 52 * k_{21}) + (180 * 50 * k_{31})} = 47$$

etc.

→ if the difference between $A_{calc.}$ & A_{given} → ≤5% (Tolerance Limit); then stop itterations.

• Tolleance Limit = $\frac{A_{calc.} - A_{given}}{A_{given}} * 100\%$

→ $A_{jk} = A_j * \frac{A_{j(k-1)}}{C_{j(k-1)}}$

↳ k = Num. of itterations

* To Calibrate Attractions For the second itteration:-

Zone 1 → $A_{12} = A_{1\,(2-1)} * \frac{A_{given}}{C_{1(2-1)}} = \frac{300 * 300}{379} = 237$

↓ computed A

- Followed *

ZAEB

* Zone 2 :

$$A_{22} = \frac{270}{210} * 270 = 347$$

* Zone 3 :

$$A_{32} = \frac{180}{161} * 180 = 201$$

* For second itteration:-

$$T_{11} = \frac{237 * F_{11} * k \cdots}{(237 * k * f_{11}) \cdots} = 34$$

* Assuming that a 3RD iteration is needed

$\downarrow$ A_{jk} — $\downarrow$ $k=3$

Zone 1 : $A_{13} = \frac{300}{303} * 237 = 234.6$

Zone 2 : $A_{23} = \frac{270}{268} * 347 = 349.58$

Zone 3 : $A_{33} = \frac{180}{179} * 201 = 202.12.$

* Followed*

* Trips attracted to zone 1 :

$$T_{11} = \frac{140 * 234.6 * 39}{(234.6*39)+(349.58*52)+(202.12*50)} = 34.22$$

$T_{21} = 151.676$

$T_{31} = 114.43$

$C_{13} = 300.516$

accessable ← bus stops إذا عندي *

* Modal Split:-

↳ UTF → القانون موجود في الدوسية.

* Example:-

$$UTF = \frac{1}{1000} * 1.8 * 15,000 = 27.0$$

نسبة مستخدمي النقل العام.

→ Transit Mode split = 45%

→ 45% * 10,000 = ---- ← عدد الرحلات التي تستخدم النقل العام.

* Followed *

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3- Trip Interchange Models:-

↳ التوزيع طارئين

استقرارا

• QRS Method :-

↳ MS_a → Proportion of trips Made by autos.

MS_t → Proportion of trips Made by transit

$$* \; MS_a = \frac{I_{ijt}^{b}}{I_{ijt}^{b} + I_{ija}^{b}}$$, where: I = impedence = In-veihcle travel + 2.5 * Excess time + 3 * cost / (Annual Income / HH)

Excess time → waiting, walki, Parking

Annual Income → buisness min annual.

→ Cost → transit → Fare

↳ Auto → Fuel, Maintinance, license —

→ buisness min annual = 360 - 104 - 10 = 250 days.

104 → weekends, 10 → bank

↳ In min = 250 * 8 * 60 = 120000 min/year.

→ b → Given, It's a component that depends on the trip purpose → HBO, HBW, NHB.

* Followed*

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* Example 12.9:-

$$I_{SDa} = \left(\frac{10}{30}\right) * 60 + 2.5 * 5 + 3 * \left[\frac{.15 * 10 + .75}{\frac{24000}{120000}}\right] = 66.25$$

$$I_{SDt} = \left(\frac{8}{20}\right) * 60 + 2.5 * 8 + 3 * \left[\frac{.1 * 8}{\frac{24000}{120000}}\right] = 56 \text{ Eq. min.}$$

* $MSa = \frac{56^2}{56^2 + 66.25^2} = 41.6\%$

* Utility Function:

linear regression expressing. the utility of using a mode of transportation

$U_A = \text{Constant} + \beta_1 * X_1 + \beta_2 * X_2 + \cdots \beta_n X_n.$

→ U_A = Utility of using autos (dependant varials)

$\beta_1 \rightarrow \beta_n$ = coeff of corolation.

$X_1 \rightarrow X_n$ = are independent variables (such socio-economic and trip maker characharistic)

* Followed

- Logit:

using Utility Functions for the modes of transportation.

$$U_m = f\,(\text{socio-economic, trip, etc...})$$

$\hookrightarrow t$

$\hookrightarrow a$

$$P_{(t)} = \frac{e^{U_t} \rightarrow \text{given}}{e^{U_t} + e^{U_a}}.$$

4- Root Choice [4 steps Traffic assignment]:- → • Do not take volume during the day into consideration.

1. Diversion curve:-

↳ * اذا كان عندي اكثر من مسارين

بيربط نفس ال O , D

• Do not take the Cost paid using a specific route into consideration.

2. All or nothing:-

• regardless the link of the trips, we choose the links with shorter travel time, and volume (trips/day).

* Followed

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* اذا كان عندي اكثر من مسارين ↵

بربطه فيه ال O, D

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* Followed*

From	To	Path	travel time (min)
1	1	–	–
	2	1-2	8
	3	1-2, 2-3	11
	4	1-5, 5-4	11
	5	1-5	5
2	1	2-1	8
	2	–	–
	3		
	4		
	5		

* The rest of the solotion is in the slides*

* Skim tree :-

Network for each node of origin with Links destinshed to each node of distination after assigning vol. / Link

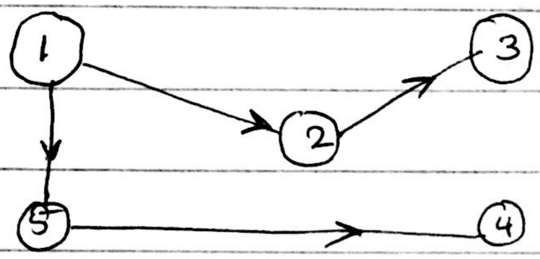
- Delete un-used Links.

* Followed*

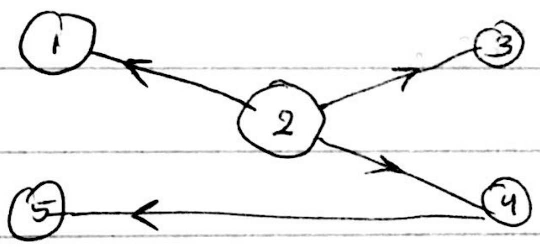
* Example in slides:-

- Skim tree:

- Node 1:



- Node 2:



- Summary:-

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• Summary :-

- 4-step generation:-

1. Trip Generation → Production : Cross-classification
→ Attraction: Trip - Rate

2. Trip Distribution → Gravity Model.

3. Model Split → - Trip end.
- Trip interchange : QRS method.
- Logit Model.

4- Traffic Assignment → Diversion curves. (
(Route choice) → All or nothing.

* Example of Trip generation Typical Method:-

→ Three Trip purposes defined for this neighborhood.

$$T_{shopping} = \overset{b_0}{.12} + \overset{b_1}{.09}\,(\overset{Z_1}{HH}) + \overset{b_2}{.011}\left(\frac{\overset{Z_2}{\text{Annual income}}}{1000}\right) - \overset{b_3 * Z_3}{.15}\left(\frac{\text{Employment}}{100}\right)$$

T_{social}/

* Expected values of trips = Avg value.
* Propability = percentage

* Trip Generation
  - → Production
    - → Cross-classification.
    - → linear regression
    - → poission.
  - → Attraction
    - → trip rate
    - → linear regression.
    - → poission.

* Poisson = $P(T_i = \text{integer}) = \dfrac{e^{-\lambda}\,\lambda^{T_i}}{T_i!}$

λ = expected no. of trips = e^{BZ}.

* Followed

2- Trip distribution:- [Fratar Method]

current

j / i	1	2	3	A_j
1	t_{11}	$t_{21}=428$	t_{31}	t_1
2	$t_{12}=428$	t_{22}	t_{32}	t_2
3	t_{13}	t_{23}	t_{33}	t_3
P_i	t_1	t_2	t_3	

- Estimate no. of trips for 10 years, where G_i's are as follows.

$$T_{12} = t_1 * G_1 * \frac{t_{12} * G_2}{t_{11}G_1 + t_{12}G_2 + \dots}$$

ij

$$T_{21} = t_2 G_2 * \frac{t_{21}G_1}{\dots}$$

$$\bar{T}_{12} = \frac{T_{12} + T_{21}}{2}$$

→ In Example:

$$T_{AB} = 600 \times 1.2 * \frac{400 * 1.1}{(400*1.1)+(100*1.4)+(100*1.3)} = 446$$

$$T_{BA} = 700 * 1.1 * \frac{400*1.2}{(400*1.2)+(300*1.3)+\cancel{(100*1.3)}} = 411$$

$$\bar{T}_{AB} = \frac{446+411}{2} = 428$$

* followed*

- Example page 97:

	initially capacity	during reconstruction capacity
route 1: $t_1 = 2 + 3\frac{x_1}{c_1}$	2500	2500
route 2: $t_2 = 4 + 2\frac{x_2}{c_2}$	4000	2000

Assuming UE applied:

Check if both routes are used:

$t_1(3.5) = 2 + 3 * \frac{3.5}{2.5} = 6.2$ VS $t_2 = 4 + 2*0 = 4$ min. → 1>2 → ok

$t_2(0) = 2+0 = 2$ min Vs $t_2 = 4 + 2\frac{(3.5)}{4} = 5.75$ min → ok

- both routes can used, we can use UE ✓

* Befor reconstruction:

$t_1 = t_2$

$2 + \frac{3}{2.5}x_1 = 4 + \frac{2}{4}x_2$ → 1

and from conservation of flow, $x_1 + x_2 = 3.5$ → 2

- substitution of 2 in 1

$x_1 = 2.206$ → Traffic Flow on route 1 2206 vehicle,

$x_2 = 1.249$ → " " " " 2 = 1249 vehicle

* $T_1 = T_2 = 4.647$ min.

* Followed *

route	initially capacity	during recon. capacity	total Flow before	total Flow after	TTT before	TTT after
1	2500	2500	3500	?	is equal	
2	4000	2000	35000		(fixed)	

→ Before:-

TTT = total travel time in all used routes (veh.min or veh.hr).

$TTT = x_1 t_1 + x_2 t_2$

$= (4.647 * 3500) = 16264.5$ veh-min.

→ After reconstruction :

Now: $t_1 = 2 + 1.2 x_1$; $t_2 = 4 + \frac{2}{2} x_2 = 4 + x_2$

TTT before = TTT during const.

$t_1(q) = t_2(q) = 16264.5$ veh.min

$(4 + x_2) q = 16264.5$ (Thousands)

$q = \frac{16.2645}{4 + x_2} \rightarrow$ 3

20)

* Followed*

from $t_1 = t_2$ & $t_1 = q - x_2$ → $q = x_1 + x_2$ (during const.)

$2 + 1.2x_1 = 4 + x_2$

$2 + 1.2(q - x_2) = 4 + x_2$

$q = 1.67 + 1.83x_2$ → (4)

. Using eqn's (3) and (4) we get

$$1.67 + 1.83x_2 = \frac{16.2645}{4 + x_2}$$

$$1.83x_2^2 + 8.99x_2 - 9.5845 = 0$$

→ Find the roots

→ $x_1 = 2.418$ (2418 veh/hr)

$x_2 = .901$ (901 veh/hr)

$q = 3.319$, reduction = 3500 − 3319.

* Followed *

* Example 2 page 98 :

Two routes with fixed $q = 6000 \frac{veh}{hr}$. , we need to compute total travel time.

	before (capacity)	After
$t_1 = 4 + 5 \frac{x_1}{c_1}$	4400	4400
$t_2 = 3 + 7 \frac{x_2}{c_2}$	5200	8200

* Check:-

$t_1(6) = 4 + 5 * \frac{6}{4.4} = 10.82$ min $>$ $t_2(0) = 3 + 7(0) = 3$ min.

$t_1(0) = 4 + 0 = 4$ min $\quad$ $t_2(6) = 3 + 7 * \frac{6.5}{5.2} = 11.08$ min

$\underbrace{\qquad\qquad\qquad\qquad}_{\text{both are used}}$

Befor:-

- Since UE: $6 = x_1 + x_2 \rightarrow (1)$

$t_1 = t_2$

$4 + \frac{5}{4.4} x_1 = 3 + \frac{7}{5.2} x_2 \rightarrow (2)$

* Followed

• Substitute for $x_2 = 6 - x_1$ in eq 2, we get :-

$x_1 = 2.85$, $x_2 = 3.15$, $t_1 = t_2 =$

$TTT_{before} = \frac{x_1 * t_1 + x_2 t_2}{60}$

$$= \frac{\overset{veh/hr}{2850}\left(4 + \frac{5}{4.4} * 2.85\right) + \overset{veh/hr}{3150}\left(3 + \frac{7}{5.2} * 3.15\right)}{60}$$

min, min

$TTT = 723.88$ veh-hr.

* Since We have (q) fixed at $6000 \frac{veh}{hr}$

• Check

$t_1(6) = 4 + 5 * \frac{6}{4.4} = 10.82 > t_2(0) = 3 + 7(0) = 3min$

$t_2(0) = 4min < t_2(6) = 3 + 7 * \frac{6}{2.2} = 22.09 min$

$t_1 = t_2$ $6 = x_1 + x_2$.

$4 + \frac{5}{4.4} x_1 = 3 + \frac{7}{2.2} x_2$

substitute for $x_2 = 6 - x_1$

$x_1 = 4.19$ $x_2 = 1.81$ $t_1 = t_2$

$TTT_{after} = 875.97$.

* Example 3 :

* Two routes connect (O-D) where Flow is 15000 $\frac{veh}{hr}$.

PF's = route 1 : $t_1 = 4 + 3x_1$, t's are in min

route 2 : $t_2 = b + 6x_2$ and x's in thousands of $\frac{veh}{hr.}$

. If UE Flow on route 1 is 9780 $\frac{veh}{hr}$, determine the free Flow travel time on route 2 and find Equ. time?

* افترضنا أن $t_1 = t_2$ لأنو طالب (VE)

* Sol:-

$q = 15$, $x_1 = 9.78$

$t_1 = 4 + 3(9.78) = 33.34$ min

$t_2 = t_1$

$t_1 = t_2$, $x_2 = 15 - 9.78$

$b + 6x_2 = 4 + 3x_1$ $= 5.22$

$b = 2.02$ min ← Free - Flow travel time on route 2

* Example 4

* Three route connect an (O-D) with following PF's

$t_1 = 8 + 0.5 X_1$
$t_2 = 1 + 2 X_2$
$t_3 = 3 + 0.75 X_3$

} t's in mins
• X's in thousands of veh/hr.

* if the peak-hr traffic demand = 3000 veh/hr → determine UE traffic flow? $\begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix}$??

$q = 3$ (given)

• Check

$t_1(3) = 9.5$
$t_2(0) = 1$
$t_3(0) = 3$

$t_1(0) = 8$ min
$t_2(3) = 7$ min
$t_3(0) = 3$
↓
route 1 will never be used

$t_3(3) = 5.25$
$t_1(0) = 8$ min → will not be used.
$t_2(0) = 1$ min

* UE applies only for routes 2 & 3

$t_2 = t_3$ → $q = X_2 + X_3$ (1)

$1 + 2X_2 = 3 + .075 X_3$ → (2)

$X_2 = 1.545$ (1545 veh/hr)
$X_3 = 1.455$ (1455 veh/hr).

* Example 5*

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* Three routes connect (O-D) with the following:-

$t_1 = 2 + .5 x_1$	if the peack-hr demand ; a) 10,000 veh/hr
$t_2 = 1 + x_2$	determine UE Traffic flow? b) 5000
$t_3 = 4 + .2 x_3$	

• Check:-

$q = 10$ (given)

$t_1(10) = 7$	$t_1(0) = 2$	$t_1(0) = 2$
$t_2(0) = 1$	$t_2(10) = 11$	$t_2(0) = 1$
$t_3(0) = 4$	$t_3(0) = 4$	$t_3(10) = 6$ min

all three routes are Used

$x_1 + x_2 + x_3 = 10$ —— 1

$t_1 = t_2 = t_3$ → 2

$x_2 = 10 - x_1 - x_3$

$t_1 = t_2$

$2 + .5 x_1 = 1 + x_2 \longrightarrow x_2 = 1 + .5 x_1$

* Also, $t_1 = t_3$

$2 + 0.5 x_1 = 4 + 0.2 x_3$

$x_3 = 2.5 x_1 - 10$

following

- Using eq 1 and sobstituting for x_2 and x_3 with x_1 :

$$10 = x_1 + (1 + .5x_1) + (2.5x_1 - 10)$$

$\downarrow$

$x_1 = 4.75 \left(4750 \frac{veh}{hr} \right)$ $\left[\begin{array}{l} x_2 = 3375 \frac{veh}{hr} \\ x_3 = 1875 \frac{veh}{hr} \end{array} \right]$