Perception & Reaction time :

$$\boxed{D = V * t_r * 1.47} \rightarrow \left(2.5 \text{ sec or } 35\% \uparrow \text{ in complex Condition}\right)$$

D → ft ; V → mph ; 1.47 → $\frac{5280 \text{ ft (mile)}}{3600 \text{ sec (hr)}}$

Stoping Sight Distance (SSD) :

SSD = PIEV dist. + Breaking dist.

$$= \boxed{V * t_r + \frac{u_i^2 - u_f^2}{2g\left(\frac{a}{g} \pm G\right)}}$$

$g = 32.2 \text{ ft/sec}^2$, 9.81 m/sec^2

G %

u :

$a = 11.2 \, (\text{ft/s}^2)$

$$\boxed{SSD = \frac{u_i^2 - u_f^2}{30\left(\frac{a}{g} \pm G\right)}} + 1.47 \, u \, t_r$$

SSD ⇒ ft

u ⇒ mph

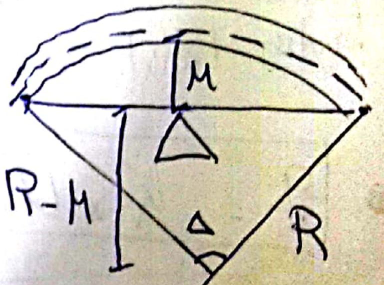
$\frac{a}{g} = 0.35$

****** when there is a obstruction :

$$\boxed{\Delta = \frac{180 \, SSD}{\pi R}}$$

$$\boxed{M = R\left[1 - \cos\left(\frac{90 \, SSD}{\pi R}\right)\right]}$$

$$\boxed{SSD = \frac{\pi R}{90}\left[\cos^{-1}\left(\frac{R - M}{R}\right)\right]}$$



الوحدات كانت بال km/h

** سؤال سنوات فاينال :

الفكره حساب SSD_{min} من القانون وحساب SSD_{act} من ال R , Δ

ومقارنه $SSD_{min} < SSD_{act.}$ → safe

و اقتراح حلول اذا لم تكون امنه .

Traffic flow :

1. Flow rate "q" : $\boxed{q = \frac{n * 3600}{T(sec)}}$ (Veh/h)

(equivalent hourly rate)

2. Density "K" : $\boxed{K = \frac{n * 5280}{L(ft)}}$ (Veh/mi)

3. Speed "U" : $\boxed{U = \frac{distance}{Time}}$ (mph), (kph), (ft/sec)

1. Time mean speed "$\bar{U}_t$" : $\boxed{\bar{U}_t = \frac{1}{n}\sum_{i=1}^{n} U_i}$ بحل عليها اذا ذكرت صراحة بالسؤال

2. Space mean Speed "$\bar{U}_s$" : $\boxed{\bar{U}_s = \frac{n}{\sum_{i=1}^{n}(1/U_i)} = \frac{nL}{\sum_{i=1}^{n} t_i}}$
   - Avg. running speed
   - Avg. travel speed

- $\boxed{q = K * \bar{U}_s}$, $\boxed{q = \frac{1}{\bar{h}_a}}$, $\boxed{K = \frac{1}{\bar{d}_a}}$, $\boxed{U_s = \frac{\bar{d}_a}{\bar{h}_a}}$

ha : time headway (sec).

da : space headway (ft).

Green shields :

// $U_o = \frac{dq}{dU_s}$

⇐ للاشتقاق :-

اضرب Us ← اشتق

اضرب Us ← عوض $U_s = \frac{q}{k}$

١ — اشتق $\frac{dq}{dk}$ → K_o

$$q_{max} = U_o * K_o = \frac{U_f}{2} * \frac{K_j}{2} \quad \text{if} \quad \boxed{\bar{U}_s = U_f - U_f\frac{k}{k_j}}$$

Greenberg :

2. $q_{max} = Ce^{\ln K_j - 1}$, $\boxed{\bar{U}_s = C\ln\frac{k_j}{k}}$, $U_o = C$, $K_o = e^{\ln K_j - 1}$

اشتقاق :-

اضرب بـ k

واشتق $\frac{dq}{dk}$

Critical Gap :

, Greenshields → acceptable avg. min. time gap → the gap accepted by 50% of Drivers

2 Raff :

no. of shorter accpt. − gap acceptance − no. of rejected gaps Longer

$$\underbrace{\text{no. of shorter accpt.}}\ = \ \underbrace{\text{no. of rejected gaps Longer}}$$

$$\boxed{t_c = t_1 + \frac{\Delta t(r-m)}{n-p+r-m}}$$

احفظ وادرس الاشتقاق .

$t_1, \Delta t \rightarrow$ عن طريق الجدول الفترة ذات اقل خرق

$r, m \rightarrow t_1$ عند acep. / reject. قيم الـ (m above acep., r above reject.)

$n, p \rightarrow t_2$ عند n p

Stochastic Approach to Gap & Gap acceptance problems :

* assume distribution of mainstream arrivals "Poisson"

⇒ Probability of X arrivals in any interval time t sec :

$$\boxed{P(x) = \frac{\mu^x e^{-\mu}}{x!}} \quad (\text{for } X = 1, 2, 3 \dots)$$

μ : avg. number of vehicles arriving in time t .

λ : arrivals rate معدل وصول السيارات

V : total number of veh. arriving in T sec

- $\boxed{\lambda = \frac{V}{T}}$ معطى $\qquad \boxed{\mu = \lambda t}$ ← الوقت المطلوب

$$\boxed{P(x) = \frac{(\lambda t)^x e^{-(\lambda t)}}{x!}}$$

- probability of zero cars arriving "$t \geq t_c$" "$X = 0$" :

(prob. of gab occuring) احتمالية وجود فراغ

$$\boxed{P(0) = P(t \geq t_c) = e^{-\lambda t}}$$

$t \geq 0$ ⇒ "Continious Function"

$$\boxed{P(t < t_c) = 1 - e^{-\lambda t}}$$

$t \geq 0$

t_c , from Raff .

احتمالية عدم وجود gap .

■ Using Poisson to determinate <u>expected number of accepta</u> gaps will occure at unsign. interc. or ramp (merge are at T period : main streams flow + Volume are known.

→ assume $\boxed{T = hour}$, the $\boxed{V = \frac{Veh}{h}}$, since (V-1) gaps occure between V successive vehicles.

ال freq. = احتمالية * عدد (حجم)

① expected no. of gaps grater than or equal to t :

$$\boxed{frequence\ (\overset{gaps}{h} \geq t) = (V-1) * e^{-\lambda t}}$$

of existense of Gaps (accepted)

② expected no. of gaps less than t :

$$\boxed{frequence = (h < t) = (V-1)(1 - e^{-\lambda t})}$$

of no existense of Gaps (Rejection)

طريقة حساب tc :

- نفس خطوات السلايدات

①

t	accepted Gap (less than t)		rejected Gap (greater than t)	
	0	→ 2	116	→ 13
	2	→ 10	103	→ 37
	12		66	

- جدول الفترات (الفرق) :

②

t	② change in accepted	③ change in # of rejected	difference Between 2 & 3
(–)			8
$(t_1 - t_2)$			5
(–)			10

~~اقل فترة لها~~
الفترة التي لها اقل فرق (difference) تكون تحتوي على ال tc

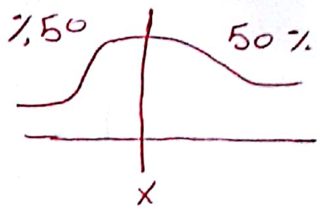
③ $(t_1 - t_2)$

t_1 → m & r

t_2 → n & p

$$\boxed{t_c = t_1 + \frac{\Delta t\,(r-m)}{n-p+r-m}}$$

Spot Speed Studies :



1] Average Speed :

$$\boxed{\bar{u} = \frac{\sum f_i u_i}{\sum f_i}} \qquad \boxed{\bar{u} = \frac{\sum u_i}{N}}$$

f_i : no. of observations in each speed group

u_i : mid value of the ith speed group

N : no. of observed value

2] ~~Bese~~ Standard Deviation of Speeds :

- measure of the spread of the individual speeds.

$$\boxed{S = \sqrt{\frac{\sum(u_i-\bar{u})^2}{N-1}}} \qquad \boxed{S = \sqrt{\frac{\sum f_i(u_i-\bar{u})^2}{N-1}}}$$

indiviual

u_i : mid value of speed calsses ;

f_i : frequency of speed classes ;

3] Min. sample size :

- Speed distribution → normal distribution over a given section of highway.

● normal dist.

$$\boxed{f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(X-\mu)^2/2\sigma^2}}$$

for $-\infty < X < \infty$

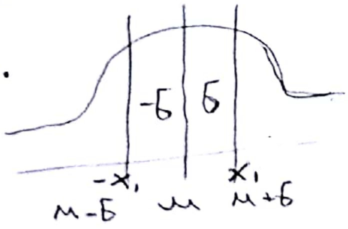
μ = true mean of popul.

σ = true standard Devia.

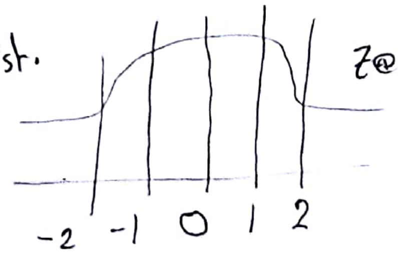
σ^2 = true Variance

$$\boxed{Z = \frac{X-\mu}{\sigma}}$$

normal dist.



Z dist.

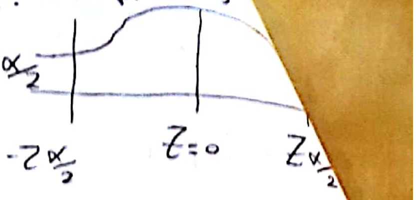


$Z@x_1 = \frac{\mu+\sigma-\mu}{\sigma} = 1$

- min. Sample Value :

$$\boxed{n = \left[\frac{Z_{\alpha/2} \times \sigma}{d}\right]^2}$$

Z : no. of stand. deviat. crossponding to required confidence level = 1.96 for 95% CL



σ : standard deviation (mi/h)

d : Limit of acceptable error in the avg. speed estimate (mi/h)

accurate with a spicified confidence & margin of error.

hourly expansion factors : HEF

→ expand Counts $ of duration <24 hour → 24 hr Volume

→ by multiplying :

→ the Compute mean of these product

$$\boxed{\text{24 hour volumes} = \text{HEF} * \text{Volumes of} \underset{\text{(hourly) لكل ساعة}}{<\text{24 hr duration}}}$$

$$\boxed{\text{HEF} = \frac{\text{total Volume for 24-hr period}}{\text{Volume for particular hour}}}$$

→ same geo. & traffic chara. , permenant or control Counts معطى من

→ لأي ساعة معينة

the

[2] Daily expansion factors : DEF

→ determine weekly volumes from 24-hr Volumes

→ 24-hour volumes → week volumes

$$\boxed{\text{Week Volume} = \text{DFF} * \text{Volume of 24-hr}}$$

$$\boxed{\text{DEF} = \frac{\text{avg. total Volume of week}}{\text{avg. Volume of particular day}}}$$

→ معطى

→ لأي يوم معين

[3] Monthly expansion factors : (MEF) :

$$\boxed{\text{AADT} = \text{ADT for given month} * \text{MEF}}$$

$$\boxed{\text{MEF} = \frac{\text{AADT}}{\text{ADT for particular month}}}$$

→ معطى

$$\text{AADT} = \frac{\text{Total yearly} \forall}{12}$$

(ADF)

$$\text{Avg. daily factor} = \frac{\forall \text{ of total day in month}}{30 \text{ or } 31}$$

$$\text{AADT} = \frac{\sum \text{Total Volume in every month}}{365}$$

→ سؤال سنوات سطرين ب 6 علامات):

■ Steps : حل المثال

① تحويل الساعات ل 24-hr Volume باستخدام ال HEF و من ثم حساب ال mean لها عن طريق :

$$\boxed{\text{Avg. daily Volume} = \frac{\Sigma \text{Volume}}{\text{عدد ساعات (ايام)}}}$$

ليوم واحد

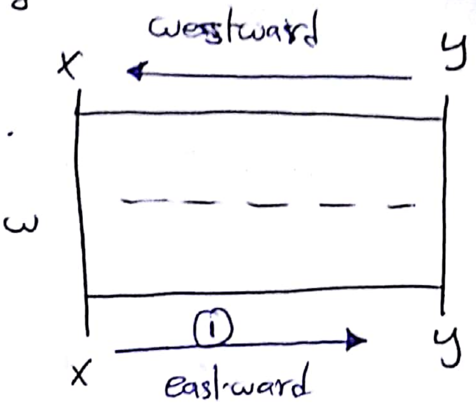
② تحويل اليوم الى اسبوعي باستخدام DEF (لليوم المطلوبة) ضرب و من ثم حساب ADT عن طريق :-

$$\boxed{ADT = \frac{\text{Avg. daily volume from ①} * DEF}{7}}$$

③ حساب ال AADT عن طريق ال MEF الخاص بال شهر المطلوب.

$$\boxed{AADT = ADT \times MEF}$$

Moving-Vehicle Technique :



e : time to travel from X-X to y-y (min).

Tω : time to travel from y-y to x-x (min)

Ne : no. of Veh. traveling west in opposite lane while test car traveling east.

Oω : no. of Veh. overtake test car while traviling west (y-x)

Pω : no. of Veh. that test car passes with traveling west (y-X)

Vω : the Volume in westward direction :

$$\boxed{V_\omega = \frac{(N_e + (O_\omega - P_\omega))60}{T_e + T_\omega}}$$

عدد مركبات
زمن

Oω = Zero if our speed is Avg. speed of street

avg. travel time in westward direction :

$$\boxed{\frac{\bar{T}_\omega}{60} = \frac{T_\omega}{60} - \frac{O_\omega - P_\omega}{V_\omega}}$$

$$\boxed{\bar{T}_\omega = T_\omega - \frac{60(O_\omega - P_\omega)}{V_\omega}}$$

$$V_e = \frac{(N_\omega + (O_e - P_e))60}{T_e + T_\omega}$$

$$\bar{T}_e = T_e - 60\left(\frac{O_e - P_e}{V_e}\right)$$

microscopic :

$$\boxed{\ddot{X}_{n+1}(t+T) = a\,\frac{\dot{X}^{m}_{n+1}(b+T)}{[X_n(t) - X_{n+1}(t)]^{L}}\,[\dot{X}_n(t) - \dot{X}_{n+1}(t)]}$$

at m=0 , L=1 => green berg

① تكامل $\dot{x}_{n+1}(t+T) = a\ln(x_n(t) - X_{n+1}(t))$

② استقرار u = سرعات ثابتة ⇐ steady state

③ استقرار $X_n - X_{n+1} = \frac{1}{k}$

④ استقرار boundary condition

$k_{max} = k_j \Rightarrow \boxed{u=0}$

HW 1: Due date 26-10-2017

Q1: a driver takes 3.2 seconds to react to a complex situation while travelling at a speed of 55 mph. how far does the vehicle travel before the driver initiates a physical response to the situation?

Q2: A car hits a tree at an estimated speed 35 mph on a 3 downgrade. If the skid marks of 100 ft are observed on dry pavement $\left(\frac{a}{g}\right) = 0.45$, followed by 250 ft $\left(\frac{a}{g}\right) = 0.20$ on a grass stabilized shoulder, determine the initial speed of the vehicle just before the pavement skid begun.

Q3: Assume you are observing traffic in a single lane of a highway at a specific location. You measure the average headway and average spacing of passing vehicles as 3.2 seconds and 165 ft, respectively. Calculate the flow, average speed, and density of the traffic stream in this lane.

Q4: Assume you are an observer standing at a point along a three-lane roadway. All vehicles in lane 1 are traveling at 30 mi/h, all vehicles in lane 2 are traveling at 45 mi/h, and all vehicles in lane 3 are traveling at 60 mi/h. There is also a constant spacing of 0.5 mile between vehicles. If you collect spot speed data for all vehicles as they cross your observation point, for 30 minutes, what will be the time-mean speed and space mean speed for this traffic stream?

Q5: On a specific westbound section of highway, studies show that the speed-density relationship is $u = u_f\left[1 - \left(\frac{k}{k_j}\right)^{3.5}\right]$ It is known that the capacity is 4200 veh/h and the jam density is 210 veh/mi. What is the space-mean speed of the traffic at capacity, and what is the free-flow speed?

Q6: At a specified point on a highway, vehicles are known to arrive according to a Poisson process. Vehicles are counted in 20-second intervals, and vehicle counts are taken in 120 of these time intervals. It is noted that no cars arrive in 18 of these 120 intervals. Approximate the number of these 120 intervals in which exactly three cars arrive.

Q7: An observer has determined that the time headways between successive vehicles on a section of highway are exponentially distributed and that 65% of the headways between vehicles are 9 seconds or greater. If the observer decides to count traffic in 30-second time intervals, estimate the probability of the observer counting exactly four vehicles in an interval

Q1 : $D = V_i * t_r = 3.2 * 55 * 1.47 = \boxed{258.72 \text{ ft}}$

Q2 : Calculate $U_{2i} = U_{1F} \Rightarrow$

$$D_{b_2} = \frac{U_{2i}^2 - U_{2F}^2}{30(\frac{a}{g} \pm G)} \Rightarrow 250 = \frac{U_{2i}^2 - 35^2}{30(0.2 - 0.03)} \Rightarrow \boxed{U_{2i} = 50 \text{ mph}}$$

$$D_{b_1} = \frac{U_{1i}^2 - U_{1F}^2}{30(0.45 - 0.03} \Rightarrow 100 = \frac{U_{2i}^2 - 50^2}{30(0.45 - 0.03)} \Rightarrow \boxed{U_{1i} = 61.32 \text{ mph}}$$

Q3 : $h_a = 3.2$ sec

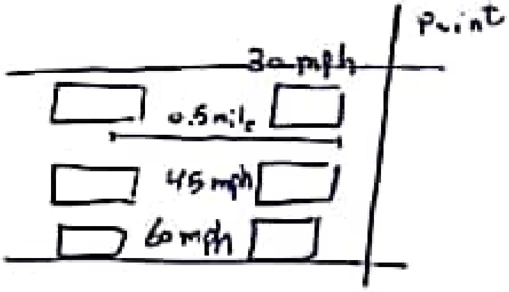
$d_a = 165$ ft

$$\text{flow} = \frac{1}{h_a} = \frac{1}{3.2} = \boxed{0.3125 \text{ Veh/sec}} \xrightarrow{*3600} \boxed{1125 \text{ Veh/h}}$$

$$\text{density} = \frac{1}{d_a} = \frac{1}{165} = \boxed{6.06 \times 10^{-3} \text{ veh/ft}} \xrightarrow{*5280} 31.99 \sim \boxed{32 \text{ Veh/mile}}$$

$$\text{avg. speed} = \frac{d_a}{h_a} = \frac{165}{3.2} = \boxed{51.563 \text{ ft/sec}}$$

Q4 :



$K = \frac{1}{d_a} = \frac{1}{0.5} = \boxed{2 \text{ Veh/mile}}$
Per all Lanes

Lane 1 : $\bar{U}_s = 30 \text{ mph} \Rightarrow q = 30 * 2 = 60 \text{ Veh/h}$

$\rightarrow$ no. of Vehc. $= \frac{(30 \text{ min} * 60) * 60}{3600} = \boxed{30 \text{ Veh}}$

Lane 2 : $n = \boxed{45 \text{ Veh}}$

Lane 3 : $n = \boxed{60 \text{ Veh}}$ for <u>30 mint</u>

يتبع →

① $\overline{u_t} = \frac{1}{n}\sum u_i = \frac{1}{135}(30^2 + 45^2 + 60^2) = \boxed{48.33 \text{ mph}}$

② $u_s = \frac{n}{\sum \frac{1}{u_i}} = \frac{135}{\left(\frac{1}{30} * 30 + \frac{1}{45} * 45 + \frac{1}{60} * 60\right)} = \frac{135}{3} = \boxed{45 \text{ mph}}$

Q5 :

$\boxed{1}$ $\overline{u_s} = u_f - \frac{u_f}{k_j^{3.5}} k^{3.5}$, $k = \frac{q}{u_s}$

$\boxed{2}$ $\left(\overline{u_s} = u_f - \frac{u_f}{k_j^{3.5}} * \frac{q^{3.5}}{u_s^{3.5}}\right) * u_s^{3.5} \Rightarrow \boxed{u_s^{4.5} = u_f u_s^{3.5} - \frac{u_f}{k_j^{3.5}} q^{3.5}}$

اشتقاق $\frac{dq}{du_s}$:

$\boxed{3}$

$4.5\, u_s^{3.5} = 3.5\, u_f\, u_s^{2.5} - \frac{u_f}{k_j^{3.5}} * 3.5\, q^{2.5} \frac{dq}{du_s}$

$\Rightarrow \frac{u_f}{k_j^{3.5}} * 3.5\, q^{2.5} \frac{dq}{du_s} = 3.5\, u_f\, u_s^{2.5} - 4.5\, u_s^{3.5}$

$\Rightarrow \frac{dq}{du_s} = \frac{(3.5\, u_f\, u_s^{2.5} - 4.5\, u_s^{3.5}) * k_j^{3.5}}{u_f * 3.5 * q^{2.5}} = ⓪$

$\Rightarrow 3.5\, u_f\, u_s^{2.5} - 4.5\, u_s^{3.5} = 0 \Rightarrow 3.5\, u_f\, u_s^{2.5} = 4.5\, u_s^{3.5}$

$\Rightarrow \boxed{\overline{u_0} = \frac{3.5}{4.5} u_f}$ — ①

$\boxed{4}$ $u_s^{4.5} = u_f u_s^{3.5} - \frac{u_f}{k_j^{3.5}} q^{3.5}$, $u_s = \frac{q}{k}$

$\Rightarrow \left(\frac{q^{4.5}}{k^{4.5}} = u_f \frac{q^{3.5}}{k^{3.5}} - \frac{u_f}{k_j^{3.5}} q^{3.5}\right) \Big/ q^{3.5} \Rightarrow \left(\frac{q}{k^{4.5}} = \frac{u_f}{k^{3.5}} - \frac{u_f}{k_j^{3.5}}\right) * k^{4.5}$

$$\Rightarrow q = u_f * k - \frac{u_f}{k_j^{3.5}} * k^{4.5} \Longrightarrow \frac{dq}{dk}$$ اشتق

$\boxed{5}$ $$\frac{dq}{dk} = u_f - \frac{u_f}{k_j^{3.5}} * (4.5\, k^{3.5}) = 0$$

$$\Rightarrow \overset{1}{\cancel{u_f}} = \frac{\overset{1}{\cancel{u_f}}}{k_j^{3.5}} * 4.5\, k^{3.5} \Longrightarrow \boxed{K_o = \left(\frac{k_j^{3.5}}{4.5}\right)^{\frac{1}{3.5}}}$$

~~[illegible]~~ $q = k_o * u_o$

$$4200 = \left(\frac{210^{3.5}}{4.5}\right)^{\frac{1}{3.5}} * \frac{3.5}{4.5} u_f \Rightarrow \boxed{u_f = 39.52 \text{ mph}}$$

$$\boxed{u_o = 30.74 \text{ mph}}$$

Q6 :

no cars arrive $\Rightarrow p(0) = \frac{18}{120} * 100 = \boxed{15\%}$

$p(0) = e^{-\mu} \Longrightarrow 0.15 = e^{-\mu} \Longrightarrow \boxed{\mu = 1.897}$ $\Rightarrow$ @t = $\underline{\underline{20 \text{ sec}}}$

$$\boxed{P(x) = \frac{\mu^x e^{-\mu}}{x!}} \Rightarrow P(3) = \frac{(1.897)^3 e^{-1.897}}{3!} = \boxed{0.1707}$$

no. $= 120 * 0.1707 = 20.48 \simeq \boxed{21}$

Q7 : $\boxed{p(h \geq t_c) = e^{-\lambda t}}$, assume $t_c = 9$ sec

$$p(h \geq 9) = 0.65 = e^{-\lambda * 9} \Longrightarrow \boxed{\lambda = 0.0479}$$

$$\boxed{P(x) = \frac{(\lambda t)^x e^{-\lambda t}}{x!}} \text{ @}t = 30 \text{ Sec} \Longrightarrow P(4) = \frac{(0.0479*30)^4 * e^{-0.0479*3}}{4!}$$

$$= \boxed{0.0422}$$

The Hierarchy of intersection Control :

1 Level I : Passive control - Basic rule of the road.

Rule 1 : Both vehicles have at Least one safe SSD to the Collision Point.

- ⊛ Vehicle A at minor street is Located one safe SSD from CP :

$$\boxed{d_A = 1.47\, S_A t + \frac{S_A^2}{30(0.348 \pm 0.01G)}}$$

- ⊛ Vehicle B at major street, $d_{b(act)}$ (⇒ Location of B on major street when its ~~becomes~~ first becomes Visiable for A)

$$\boxed{d_{B(act)} = \frac{a\, d_A}{d_A - b}}$$

- ⊛ vehicle B have one safe SSD :

$$\boxed{d_{B(min.)} = 1.47\, S_B t + \frac{S_B^2}{30(0.348 \pm 0.01G)}}$$

- $d_{B(act)} \geq d_{B(min)}$, the adequate SSD for basic rule of road has been provided (no control), othewcwise rule 1 Violated go to Rule 2 LvL 1 :

Rule 2 : Veh. A must travel 18 ft past CP in same time that Veh B travel to a Point 12 ft befor CP :

$$\boxed{d_{b(min)} = (d_A + 18)\frac{S_B}{S_A} + 12}$$

* استخدمها للمقارنة مع $d_{B(act)}$
same Rule 1

- Rule 1 ~~or~~ and Rule 2 must be provided to use LvL 1 (no control) else go to Level 2 :

2 Level II : Yield or Stop Control

- using ~~[illegible]~~ stop or yield ~~at~~ a sign at an intersection if <u>one</u> or more of the following Cond. exist :

1- Level I was Violated "no right of way rule can provide".

2- A street entering ~~a~~ a designated through highway طريق مهم وهناك مدخل له يجب التشيك عليه

3- An unsignalized intersection within a signalized area. تقاطع غير محكوم بلى شيء حوله تقاطعات محكومه باشارات.

■ Stop at minor approach "Two-way Stop" :

one or more of : "if ~~not~~ safe use yield , not safe check all-way"

[1] Vehicular traffic Volumes on through(<u>major</u>) street or highway > $\boxed{6000 \text{ Veh/day}}$

[2] restricted View exists that requ. road users on [minor] street to stop inorder to adequately observe confl. traffic on [major] street.

[3] Crash records indicate that are <u>susceptible</u> Corrections Crashes by installation of Stop sign : حوادث قابلة للتصحيح

* 3 or more crashes in 12-month period.
* 5 or more crashes in 2-year period.

i.e : Right-angle Collisions involving minor street users failing to yield the R-of-way to traffic on ~~mgor~~ magor street.

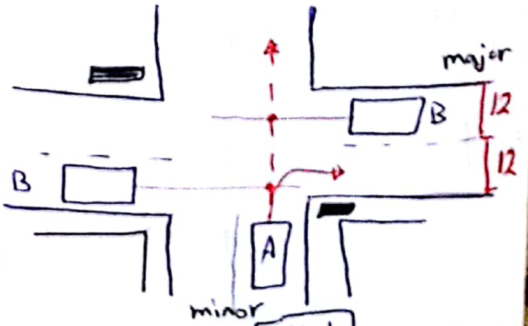
■ <u>Stop control</u> :

right turn + through movem. with no LT ⇒ $\boxed{t_g = 7.5 \text{ sec}}$

$\boxed{d_{A\text{-stop}} = 18 + d_{cl}}$ (dist. from curb to center of closet Lane)

$\boxed{d_{B\,min} = 1.47 * S_{maj} * t_g}$

$\boxed{d_{B\,act} = \dfrac{a\,d_A}{d_A - b}}$



ملحوظة

■ 1:1 unsafe ركب على الجهتين

1:1 safe بشيك على الكل

Yield Sign :

1] at entrance of roundabout " shall not be used to control the circulatory road way " لانه الاولويه دائما للي داخل الدوار او الي بيدور يطلع منه

2] A- Level 1 → violated & stop sign not need " safe ".

B- at second crossroad of a divided highway, where the median width at interse. is 30ft or grater → yield of stop sign at ~~R~~ entrance to the first road way & yield sign at entrance to the second road way.

C- on channelized turn lane that is seperated from adjec. travel lane by island, ~~[illegible]~~ even adj. lane conrol by signal or stop.

D - at intersection where special problem exist and حكم المهندس بيبين ان المشاكل يمكن حلها عن طريق yied

E - Control is need because acceleration lane length and/or sight distance is not sufficent for merging traffic at entering roadway for merge-type → غير كافيه ليصبح نفسها الموجودة

Multiway-way stop control :
all

1] where Traffic control signals are justified
لحد ما يركبو الاشاره بركب ال all-way

2] five or more repoted crashe in a 12- month period can be correction by allway stop , ex: RT & LT collisions and Right angle collisions .

3] Minimum volume :

ex أي 8 ساعات (ليس شرط تتابعها)

A]- Volucular Vol. entering the intersection from major street approaches (Total of both approaches) at least 300 veh/h for ~~each~~ any 8 hours of an avg. day (mon, Tue, Wed ...)

and 8

$\boxed{B}$ Combined of Vehicular, Pedistrain, Bicycle Volume entering the intersection from minor street approaches (total of both app) avg. at Least 200 Unit/h for the same 8 hours and avg. deddy to minor-street vehc. traffic at least 30 s/Veh during the highest hour (major Volume highway)

$\boxed{C}$ if 85 Percentile approach speed of the major highway > 40 mph, min. Vehichrar Volume are 70%.

$\Longrightarrow$ $0.7 \times 300 =$

$0.7 \times 200 =$

$\boxed{B}$ في حال 80% من الشروط الثلاثة فوق انطبقوا حتى لو كانت السرعة > 40

يعتبر انه فيه all stop خصوصاً لما يكون no signal criterion is satisfied

// Traffic Signals warrants :

[1] warrant 1 : Eight-Hour Vehicular Volume :

* **one** of the following conditions exist for each of any 8 hours of an avg. day :

[A] (Veh/h) ~~of~~ in min 100% Columns of Cond. A Table 4C-1 exist on major street & on higher-volume minor-street :

(Veh/h) ≥ min.

((total of both appr.)) (one direction only)

or

(Veh/h) of 100% Columns of Cond. B, Table 4C-1 . . . .

⇐ بقوم باختيار اعلى 8 ساعات فيها حجوم مرورية على ال major و بقارن الشرطين فوق لكل ساعة منهم .

[B] if the posted or statutory speed Limit or the 85-~~th~~-Percentile Speed on the major street > (70 km/h or 40 mph) Or the intersection Lies within the built-up area of an isolated Community having population of < 10,000 ⟹

⇒ (Veh/h) in 70% Columns of Cond. A & B in table 4C-1 may be used in place of 100% .

or ل

⇐ مباشره في معلومه من هاي المعلومتين بعمل Check على 70 % .

(*) **both** of the following condition exist for each of any 8 hr of an avg. day :

في حال ال 100 % لم تنطبق لكل من A,B وما في معلومات بعمل Check ↵ عن سرعة وسكان

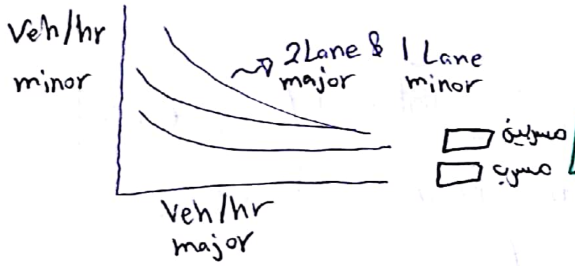
[1] (Veh/h) in 80% Columns of Cond. A in Table 4C-1 exist on major street & higher-Vol. minor street

AND

[2] (Veh/h) in 80% columns of Cond. B in Table 4C-1 exist . . .

[2] warrant 2 : Four-Hour Vehicular Volume :

* each of any 4 hours of an avg. day, the plotted point representing (Veh/h) on major street (total (Σ) of both approaches) and crossponding (Veh/h) on the higher-Volume minor-street approach (one direction only) all ~~above~~ fall above (*) the curve in figure 4C-1 :



① → min. Volume on minor for use curve — if not → W_2 not met

وايضا اذا النقطه اسفل ال Curve . ②

(*) if Speed > 70 km/hr or 40 mph
Pop. < 10,000
⟹ use figure 4C-2 مباشره .

** يتم اختيار ال 4ساعات حسب أكبر ٤ ساعات فيهم Σ major Value = highest

وفي حال كان ال متساويه = Σ لأكثر من ساعه ← بختار الساعه الي الها أكبر higher-Volume minor street

[3] warrant 3 : Peak Hour : (*)

Shall be applied only :

1- unusual cases, such as : a- office complexes
b- manufacturing plants
c- industrial complexes

2- high-occupancy vehicle facilities that attract or discharge large no. of vhecicles over short time .

⟹ ES find that the criteria either of the following two categories are met :

riterion A : if all 3 cond. exist for the Peak hour Same 1hr (any ~~Consec~~ four Consec. 15-min period) & an avg day :

1. Total stopped time delay experienced by traffic on الاعلى حجم one minor approach (one direction only) controlled by Stop sign :
   one Lane ≥ 4 Veh-hr
   two Lane ≥ 5 Veh-hr   AND

2. (Veh/hr) one the same minor-street appr. (one dirc. only)
   one Lane ≥ 100 Veh/hr
   two Lane ≥ 150 Veh/hr   AND

3. Total entering Volume serviced during the hours :
   three appro. intersection ≥ 650 Veh/hr
   4 or more appro. interse. ≥ 800 Veh/hr   Or

Criterion B : plotted point representing the (Veh/hr) on major street (total of both appr.) and ~~cross~~ Corresponding (Veh/hr) on the higher-vol. minor approac. (one dire. only) for 1 hour (any four....... 15-min) of an avg. day falls above the curve in figure 4C-3 .

(*) if the :
   Speed > 70 km/h or 40 mph
   Pop. < 10,000

⟹ use 4C-4 in place of 4C-3

🟩 we pick the peak hour based on the highest Total major

(*) لو في حال لم تنطبق ← بعمل تشييك على ال peak اللي تليها
minor 5

5

[4] Warrant 4 : Pedestrian Volume :

** at intersection or midblock crossing if the BOth of th following Criteria met :

[A] pedestrain volume crossing the major street (both of app.) at intersection or midblock Location :

Σ مجموع

- ⊛ Σ ≥ 100 for each of any 4 hrs] at avg. day
- or ⊛ Σ ≥ 190 ~~during~~ during any 1 hours

AND ~

[B] Gap/hr ≤ 60 ⊛ in the traffic stream of adq. Length to allow Pedes. to cross during the Period when the Pedis. Volume is satisfied "A condition met".

(For only one of major appr.)

hr	E	W
1	54✓	60
	61	59✓

▪ IF noone of warrants was met except of warrant 4

→ Signal traffic $\xrightarrow{\text{should be}}$ pedistrain ~~activated~~ actuated

- divided major street having a mediam with sufficient width 30ft for pedistrain to wait → required applied separately to each direction of Vehcular traffic.

** حجم المشاة لكل اتجاه يطبق عليه نفس الشروط ومكن احتاج اشاره باتجاه واحد فقط

- Shall not be applied at Location where distance to the nearest traffic signal control along major street < 90 m (300 ft), unless → proposed TCS will not restrict progressive movement of traffic.

** اذا كان التقاطع بعيد عن تقاطع محكوم باشارة بمسافة 90 متر ← ما بطبق
بطبق ال warrant لانه الناس بقدرو يمشوا ال ٩٠ متر ولانه راح
أخر السير على الطريق.

5 warrant 5 : School Crossing :

** need when frequency & adequacy of gap in Vehicular traffic stream as related to ① number & size of groups of school children .

** shchool crossing across major street show the :

① number of adeq. gaps during the period when the children are using the crossing < number of min. in same period.

AND

② min. of 20 students during the highest crossing hour .

- At Least 20 students / Highest hr + no. of Gap < no. of min. (50 gap within 60 min) .

- before a decision to install TCS Consideration خد بعين الاعتبار تنفيذ : implemention of other remedial measures :

① warning signs , ② flashers , ③ school speed Zone , ~~④~~ ④ school crossing guards , ⑤ a grade - spearated crossing

في حال ذكر بالسؤال

→ many or one of remedial measures used but faild to provid safe crossing for school children . check on w5 بدل ←

- Same of condition in w4 about 90 m distance traffic . control signal -

→ if only w5 is met → use pedistrain — actuated signal

6 Coordinated signal System :

need for TCS if One of following Criteria is met :

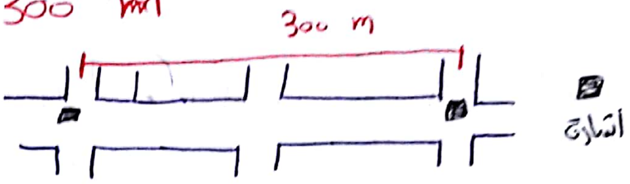
A ~~other~~ on a one - way street or astreet has a traffic predominantly في غالب الوقت in one direction , adjacent TCS are so far apart that they not Provide the necessary degree & vehicular platooning

** تقاطعات محكومة بإشارة ضوئية بينهم تقاطع غير محكوم بركب عليه اشارة عشان الانسيابية .

OR

B two-way street, adjecent TCS donot provide . . . .
. . . . platooning, and Proposed & adjacent TCS will
Collectively provide a progressive operation.

- Should not be applied where the resultant spacing of traffic control signals < 300 m



7 warrant 7: Crash experience:

need if ALL of the following Criteria are met:

A Adeq. trial of alternative with satisfactory observance and enforcement has faild to reduce the crash frequency

AND:

B 5 or more reported Crashes have occured within a 12-month Period. متوقع ان يتم حلهم بوضع اشارة

Crash involving:

Personal injury - property damage - head-on - Side swipe

- rear-end crash not Crashed to be correction by TCS.

* Crash outcome:

Personal injury (slight / sever), fataLity, property damage.

AND:

C Check for: 80% Column of CW1-A
or 80% Column of CW1-B
or at Least pedistrain Volume 80% × 100 Ped./hr/4hr
or 80% × 190 Ped./hr/1-hr

or $V > 40$ mph
or $P < 10,000$
use 56% column in Table 4C-1 in Place of 80% for A or B.

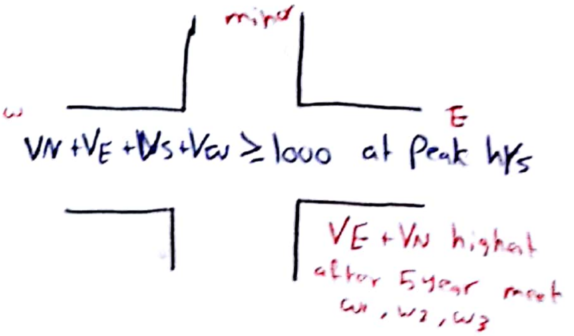
Warrant 8: Roadway network: "two arterial"

TCS is need if the common intersection of two or more major routes meet one or both of following Criteria:

A the intersection has a total existing, or immediately projected entering Volume at Least $\boxed{1000 \text{ Veh/hr}}$ during $\boxed{\text{the peak hour}}$ of typical weekday AND 5-year projected Volume that meet ~~of of~~ one of W1, 2, 3 during an avg. weekday.

OR

B at Least 1000 Veh/hr for each of any 5 hrs of non-normal business day (satur. - sunday)



$V_N + V_E + V_S + V_W \geq 1000$ at Peak hrs

VE + VN highat after 5 year meet W1, W2, W3

مكرره

● W3 → Criterion A:

Total-hour Delay: > 30 s/Veh.

use peak hour (1130 - 125)

$$125 \frac{\text{Veh}}{\text{hr}} * \frac{30}{3600} = 1.04 < 4$$

Definitions :

1. Cycle "C" ⟶ time for one complete sequence (60-120 s).
2. phase : part of cycle give to stream traffic having Simultaneous ROW.
3. Change & Clearance : $\boxed{Y_i = (\text{yellow} + \text{All red})}$ time use to Clear the intersection after green.
4. Yellow interval : 3-5 sec (<3 → use 3; >5 → use 5 and add extra → all red — ضيف الزايد لل)
5. Green time : G_i = time within agive phase during greed is show.
6. Lost time : time during which the intersection is not effectively use (start up delay + Clearance Lost time) → الناس اليوما بستغلو الضو الاصفر وال AR
7. efficitive green time : time during agiven phase is effect. available for moving Vehicle : $\boxed{g_i = G_i + Y_i - L_i}$
8. Green ratio : $\boxed{\frac{g_i}{C}}$ → if it equal 1 → no. intersection exist
9. Saturation flow rate "S_i" : max. flow rate that can be accomodated by a Lane group, assume that the Lane group has green time during full hours : (ال cycle معطاه ال green كامل)
10. Geometric Conditions : ⊛ no. & width of Lanes, grades, allocation of lane for diff. uses " designation of Parking Lane.
11. Approch : Consist of Lane or group of Lanes through veh. enter the interse.
12. Lane group : individual Lane or multiple Lanes which are grouped based on the allowed movements within each Lane & the sequencing of allowed movement by traffic signal.

■ LT- protected :

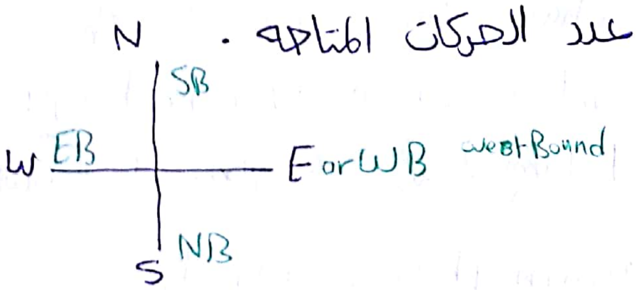
**Cross product of LT volume & ~~&~~ opposing TH&RT Volume (HCM)

- LT * (TH + RT) > 50,000 during Peak hr → one opposing Lane
  (opposing)
- > 90,000 during Peak hr → 2 opposing Lane
- > 110,000 → 3 opposing Lane
  or more

→ need protected-LT

● اذا كان احد الـ approach يحتاج protected LT نضع ايضا للمقابل له .

■ تحديد عدد الـ Lane group لكل طريق بشوف عدد الحركات المتاحه .



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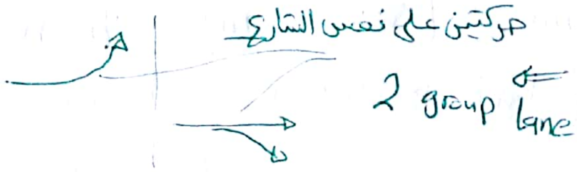


▨ Establish Analysis Lane Groups :

* each Approach treated separately & subdivided into grouping of traffic movement for analysis purposes.

● $\boxed{\text{min. no. of groups} = \text{no. of Lane} - 1}$ if no. of Lane > 1

$\boxed{\text{max. no. of groups} = \text{no. of Lane}}$ افضل اشي

1 Flow Rate :

(or analysis Period)

$$\boxed{V_p = \frac{V}{PHF}}$$

Vp: flow rate during Peak 15-min Period (Veh/h)

V: hourly Volume (Veh/h)

PHF : Peak-hour factor

→ for intersection, each approach, each movement

** $PHF = \frac{\text{hourly Volume}}{\text{max. rate of flow}} = \boxed{\frac{V}{4 * V_{m15}}}$

** بشوف اعلى ساعه (Peak) وبحسب الحجوم كل 15دقيقه منها

دقيقه	no. of Veh.	4 * no. of Veh (Rate of flow)
15		Take max
30		اكبر ربع ساعه
45		
60		
	ΣV	4 * V_{m15}

/ Saturation flow rate : flow (Veh/hr) that can be accommodated by Lane group assuming green phase were displayed 100 %. of time $\left(\frac{g_i}{c} = 1\right)$. أكبر عدد سيارات ممكن تمر اذا اعتبرت انه يعني كل ال cycle اخضر .

$$\boxed{S = S_o \, N \, f_w \, f_{HV} \, f_g \, f_p \, f_{bb} \, f_a \, f_{LU} \, f_{LT} \, f_{RT} \, f_{Lpb} \, f_{Rpb}}$$

number of Lane in Lane group

appro. grade

heavy veh.

exist. of parking lane and acti.

area type

LT, RT in Lane group

ped. LT

ped – bic RT

Lane width

blocking effict of bus

Lane utilization

expressed as total for all Lanes ~~[illegible]~~ in group Lane.

base satu. flow rate per lane (PC/h/Ln) = 1900 اذا لم يعطي

Saturation Headway :

$$h_s = \frac{\sum_{j=n}^{l} h_j}{(l+1-n)} = \boxed{\frac{(h_7+h_8+h_9+h_{10}+h_{11}+h_{12})}{(12+1-7)}}$$

وقت اللازم لوصول
البعد عن نقطة معينة

h_s : satu. headway → hour, → one Lane, → Pass. Car

l : Last queued Veh. position

h_j : headway of jth queued Veh

n : position of veh. where sat. flow start

للتحويل

$$** \quad \boxed{S = \frac{3600}{h}}$$

S : satu. flow rate Veh/h

h : sat. headway in S/veh

- Max. S = 1900 (PC/hr/Lane) is possible at (Signalized intersection)

  → h ≃ 1.9 sec

- S↓ → Lane allow LT & RT → Car reduce speed to turn

  Lane Permettied LT ~~→ [illegible]~~ " " → to wait gap

3 Lost time :

⊛ time which is not efficitively serving any movement of traffic

- Start-up Lost time : (red → green)

  ⊛ Portion of green time not utilized , $\boxed{l_1 \simeq 2 \, \text{sec}}$

- Clearance Lost time : (greed → yellow)

  Portion time during yellow & All red not utilizated by traffic

⊛ Start-up & Clearance Lost time For Phase :

$$\boxed{t_L = l_1 + l_2}$$

l_1 → Start-up

l_2 → Clearance

t_L: total lost time for a movement during a cycle in sec (per phase).

- Lost time Fixed, regardless of cycle Length.

** short cycle → Lost time comprise Larger % of Cycle → Larger total t_L

Large cycle → more phase → similar proportion of Lost time

4 Effective green and Red times :

i = per phase

$$\boxed{g_i = G + Y + AR - t_L}$$

g_i: effic. green (sec) for traffic movement

G → displayed green time for traffic movement

Y → yellow

AR → all-red

t_L → Total time Lost during a cycle

⊛ effictive red : time during which a traffic movement is not effectively utilizing the intersection :

$$\boxed{r_i = R_i + t_L}$$

R_i → displayed red time for a traffic movement

** وقت الاشاره وهي حمرا + الوقت المستغل من المركبات الاخرى على شكل احمر (يعني واقفين) وهو مسموح الهم يتحركو مثل الضو الاصفر وال AR .

- assuming the cycle Length and g_i ~~are~~ have been already determined :

$$\boxed{r_i = C - g_i}$$

5 Capacity :

~~at~~ allways $S \geq C$ → intersection ~~&~~ approaches dont receive a constant green ~~&~~ indication.

no intersection

$$\boxed{C = S * g/c}$$

S : satu. flow rade

g/c : ratio of g_i/c

** الكل (group lane)

C : Capacity = max. hourly volume that can pass through intersection from a Lane ~~of~~ group of Lanes under (prevailing road way, traffic control Cond.)

(Veh/h)

سائد

] Critical Lane groups and total Cycle Lost time :

phase لكل

* Critical Lane groups : Lane group with the highest ratio of Vehicles arrival flow rate to vehicle satu. flow rate. (V/S) :

$$\boxed{Y_c = \sum_{i=1}^{n} \left(\frac{V}{S}\right)_{ci\,max}}$$

Y_c : Σ of flow ration for critical Lg

V/S : flow ration for critical Lg

n : no. & CLg.

$$\boxed{\uparrow Y_c \leftarrow \text{ازدحام اكبر} \leftarrow \downarrow LOS}$$

* Total Lost time for Cycle :

$$\boxed{L = \sum_{i=1}^{n} (t_L)_{ci}}$$

$(t_L)_{ci}$: total ~~time~~ lost time for critical group in sec.

n : no. & critical group.

7 Cycle Length :

** min. Cycle length is the sum & the individual phase lengths (rounded to nearst 5 sec).

$$\boxed{C_{min} = \frac{L \times X_c}{X_c - \sum_{i=1}^{n} \left(\frac{V}{S}\right)_{ci}}}$$

L : total lost time in sec

X_c = critical V/C ration for intersection

$(V/S)_{ci}$ = flow ratio for critical lane gr.

N : no. & critical Lane groups

$$60 \leqslant C \leqslant 120$$

اذا اقل من 60 ← برفعها لـ 60

اذا اكبر من 120 ← تقلل عدد الـ phases

For design :

X_c is assumed :

$X_c = 1 \longrightarrow Y_c \geq 0.9$

$X_c = 0.9 \longrightarrow Y_c < 0.9$

** webster's opt. cycle Length : seek to minimize Vehicle delay.

$$\boxed{C_{opt} = \frac{1.5 \times L + 5}{1 - \sum_{i=1}^{n} \left(\frac{V}{S}\right)_{ci}}}$$

$X_c = \frac{V}{C}$

* في حال ثبات ر

$C_{opt} > C_{min}$

دائما

8 Allocate green time to each phase :

* V/C ratio are equalized for critical lane groups to distribute green time

$$\boxed{g_i = \left(\frac{V}{S}\right)_{ci} \times \left(\frac{C}{X_i}\right)}$$

→ for each phases

بعد تقريب الـ cycle لاقرب 5 اعد حساب الـ X_c وعوضها هنا

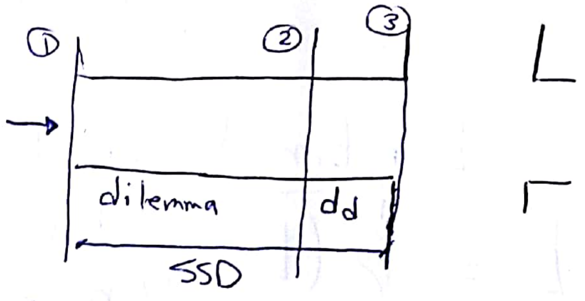
Check : $C = g_1 + g_2 + g_3 + L \rightarrow = C$ ok

$\boxed{9}$ Change and Clearance intervaL :

* dilemma Zone : Created if safe stop before intersection cannot be accomplished and continuing through the intersection at constant speed will result in vehicle entering the intersection during a red indication.

Vehicle :

- before SSD → stop safty befor intersection
- after SSD before dd : wrong decision
  ① stop after stop Line
  ② enter intersection during red inde.
- Located at dd → can enter intersection befor AR'.
  closer



ITE Formula :

$$\boxed{Y = t_r + \frac{V}{2a+2gG}}$$

Y : yellow time (rounded to nearest 0.5 Sec) مقربه لاعلى

tr : Percep.-react. time = $\boxed{1 \text{ sec}}$

V : speed of apprea. traffic — انتبه التحويل اضرب ١.٤٧

a : deceleration rate for vehicle (10 ft/sec², 3.05 m/sec²)

g : acceleration ratio due to gravity (32.2 ft/sec, (9.807 m/sec²)

G : percent grade divided by 100

$$\boxed{AR = \frac{W+L}{V}}$$

AL : All-red time (rounded to nearest 0.5)

W : width of cross street in ft (m) → الشارع الي بتقاطع معاه

L : Length of the Vehicle, usually 20 ft, (6m)

V : speed of approaching traffic (m/sec)(ft/sec) ← تحويل

$\boxed{10}$ Check Pedestrain crossing time :

اعمل Check في حال وجود مشاة.

* Compare between green time for Pedistrain ~~and~~ crossing with apportioned green time for the phase. (Gp with G) or (gp with g) : $\boxed{G_i = g_i + L_t}$ → one phase

- min. Pedistrain green time :

$$G_p = 3.2 + \frac{L}{S_p} + (0.27 N_{ped}),\ W_E \leq 10\text{ ft}(3.05\text{ m})$$

$$G_p = 3.2 + \frac{L}{S_p} + \left(2.7 \frac{N_{ped}}{W_E}\right),\ W_E > 10\text{ ft}$$

3.2 : Ped. start-up time

L : cross walk Length in ft (m) عرض

Sp : walking speed for Ped. → 4 ft/sec (1.2 m/sec)

Nped : no. of Ped. crossing during intervaL

WE : effictive Cross walk ~~Length~~ widthin : عرض اللون الابيض للمشاه

adj. if not ok :

$\boxed{g_{II} = G_p - t_L}$, $\left(\frac{g_{II}}{g_{III}}\right)_{befor} = \left(\frac{g_{II}}{g_{III}}\right)_{after}$ / $\left(\frac{g_{I}}{g_{II}}\right)_{b} = \left(\frac{g_{I}}{g_{III}}\right)_{after}$

* عشان تقطع شارع (الشارع الثاني اجعلو اعلم).
(Gp maple Comp. with Gi vine)

⟹ C_{new} = غير دقيقه لم نأخذ AL,Y بعين ~~الاعتبار~~ الاعتبار

Level of Service determination:

⊛ LOS should be deter. before implementing any signal phasing & timing plan

⊛ Service measure is delay → calculated for all lane groups

⊛ delay value aggregated (تجميعها) to get overall LoS of intersection.

▰ Delay at signalized intersection → uniform & random arrivals & signal control influences on this arrival pattern.

Lane group ← appr. → intersection

$$\boxed{d = d_1 * PF + d_2 + d_3}$$

↳ to each Lane group in intersection.

d: ~~(veh/s)~~ (s/~~s~~veh) avg. signal delay

d_1: avg. delay/veh due to uniform arrival

d_2: due to random arrivals

d_3: due to initial queue at start of analysis time $= \boxed{0}$

PF: progression adj. factor. $= \boxed{1}$

● Uniform delay:

$$\boxed{d_1 = \frac{0.5\,C\left(1 - \frac{g}{C}\right)^2}{1 - \left[\min(1, X)\,\frac{g}{C}\right]}}$$

→ Lane group لكل phase كابديل

for each lane group

[C: Cycle Length (sec)

g: effictive green time for Lane group.

X = (Volume capacity ration) $= V/C = \boxed{\frac{V}{S * g/C}}$

V: flow rate, (veh/h)

S: satu. flow rate, (veh/h)

▰ isolated intersection (progression neutral) ⇒ $\boxed{PF = 1.0}$

● Random delay:

$$\boxed{d_2 = 900\,T\left[(X-1) + \sqrt{(X-1)^2 + \frac{8KIX}{CT}}\right]}$$

T: duration of analysis period in hr. ($\overset{\text{اذا لم تعطى}}{T = 0.25\text{ h}}$) ⇒ دائما $\textcircled{0.25}$

$X = V/C$ ratio for lane group

K: delay adj. factor $\xrightarrow{\text{depend}}$ signal controller mode (pretimed mode, k = 0.5)

I: upstream filtering/metering adj factor, I = 1 → Poision

C: lane group capacity (veh/h)

■ Assumed there is no initiaL queue , $d_3 = 0.0$

Ex : Lane group on Eest approact. : $d_{E\ T/R}$
$d_{E\ L}$

$$d_{Eest\ app} = \frac{d_{EL} * V_L + d_{ET/R} * V_{T/R}}{V_L + V_{T/R}}$$

■ overall intersection delay :

$$\boxed{d_I = \frac{\sum_A d_A * V_A}{\sum_A V_A}}$$

dI : intersection
dA : approa.

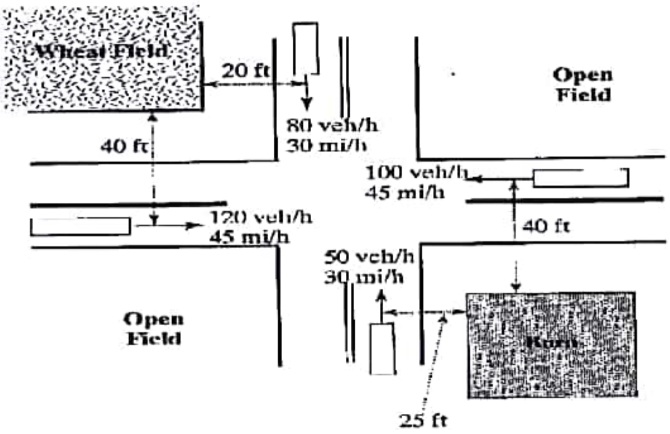
■ aggregated lane group delay for each approach :

$$\boxed{d_A = \frac{\sum_i d_i V_i}{\sum_i V_i}}$$

d_A : avg. delay /Veh for approach A
d_i : " " for Lane group i on app. A
V_i : analysis flow rate for lane group i in Veh/h

Solve the problems 16-1 to 16-7 from chapter 16 from (Traffic Engineering textbook, Roess)

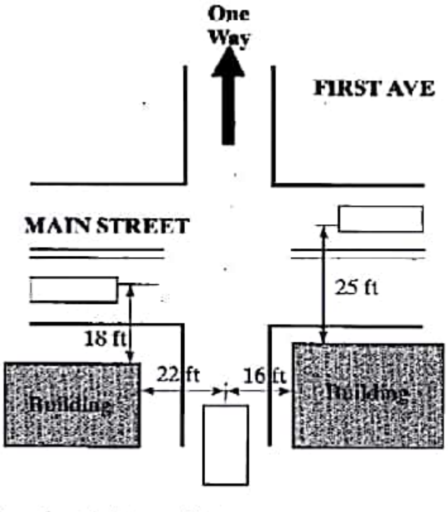
16-1. For the intersection of two rural roads shown in Figure 16.11, determine whether or not operation under basic rules of the road would be safe. If not, what type of control would you recommend, assuming that traffic signals are not warranted?



Reaction time, $t = 2.5$ s
$F = 0.348$; $G = 0.0\%$

Figure 16.11: Intersection for Problem 16-1

16-2. Determine whether the intersection shown in Figure 16.12 can be safely operated under basic rules of the road. If not, what form of control would you recommend, assuming that signalization is not warranted?



	Main St	First Ave
Design Speed:	50 mi/h	40 mi/h
Grade:	Level	+4.0%

$F = 0.348$
$T = 2.5$ s

Figure 16.12: Intersection for Problem 16-2

Scanned by CamScanner

16-3. Determine whether the sight distances for the STOP-controlled intersection shown in Figure 16.13 are adequate. If not, what measures would you recommend to ensure safety?

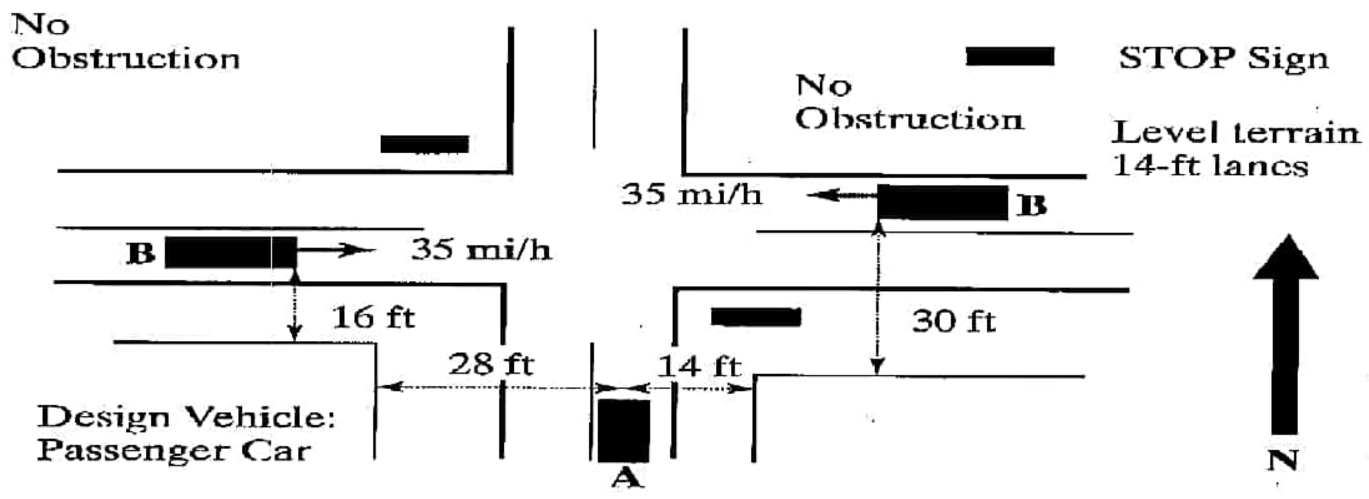


Figure 16.13: Intersection for Problem 16-3

16-4—16-7. For each of the intersections shown in the following figures, determine whether the data supports each of the eight signal warrants. For each problem, and each warrant, indicate whether the warrant is: (a) met, (b) not met, (c) not applicable, or (d) insufficient information given to assess.

For each problem, indicate: (a) whether a signal is warranted, (b) the type of signalization that should be considered, and (c) whether pedestrian signals and/or push-buttons are recommended.

In all cases, assume that no warrants are met for the hours that are not included in the study data.

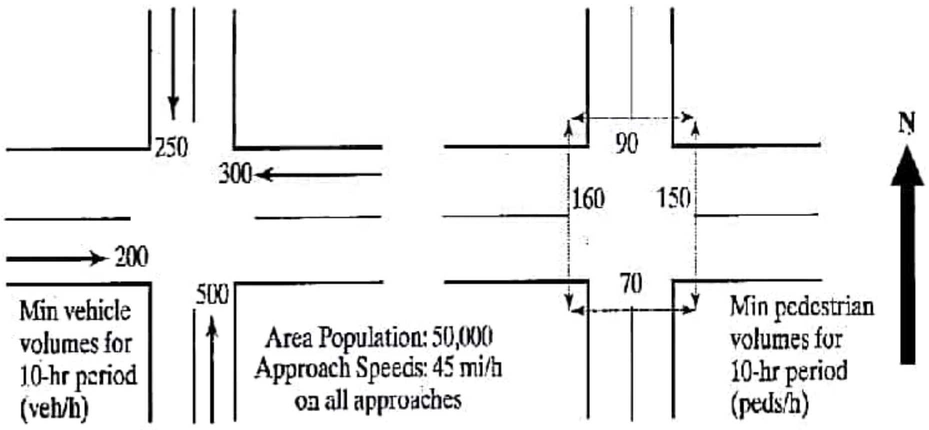


Figure 16.14: Intersection for Problem 16-4

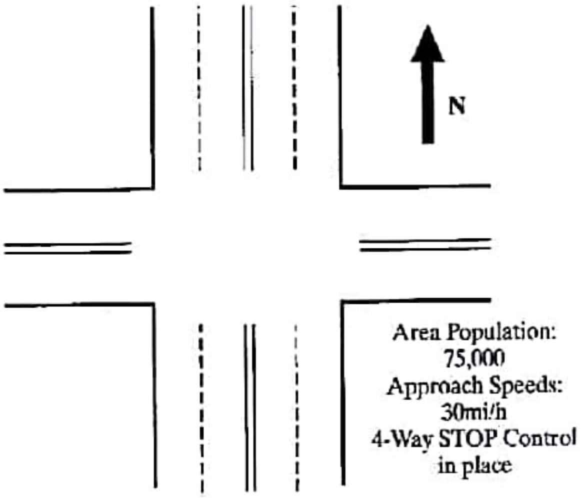
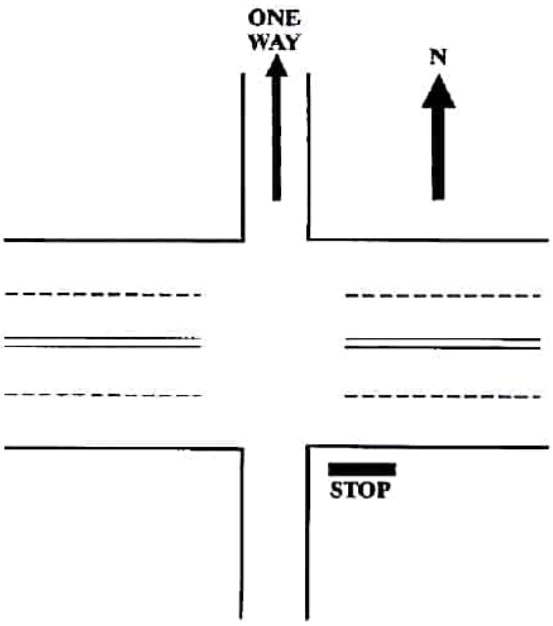


Figure 16.15: Intersection and Data for Problem 16-5

	Volumes (veh/h)			
Hour	**EB**	**WB**	**NB**	**SB**
1	30	30	25	25
2	30	30	50	50
3	50	50	75	100
4	50	50	150	150
5	75	100	250	200
6	100	250	400	300
7	125	400	500	350
8	150	450	500	350
9	200	375	450	300
10	250	300	200	200
11	200	300	150	150
12	150	150	150	150
13	100	100	150	150
14	100	100	150	200
15	100	75	150	200
16	250	100	200	250
17	325	125	350	250
18	375	150	400	300
19	400	150	350	450
20	425	150	350	450
21	325	100	200	200
22	150	75	100	100
23	100	50	50	50
24	50	25	50	50



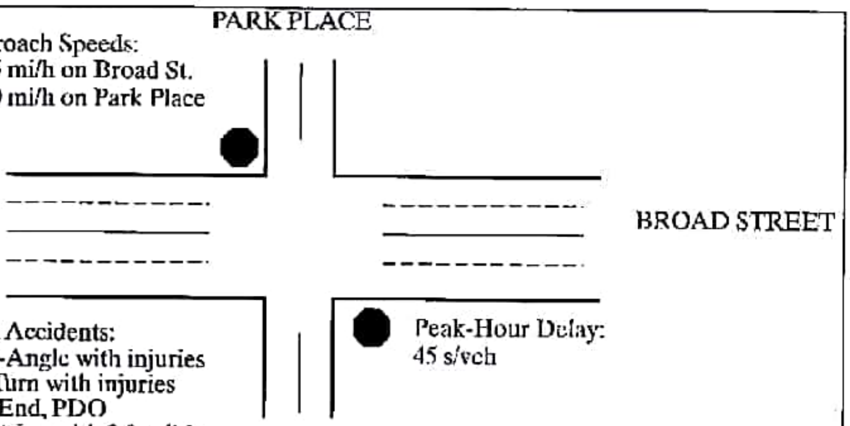
Area Population = 40.000
Approach Speeds: 35 mi/h (E-W); 30 mi/h (N)
Accidents (Last 12 Months, Reportable):
- 8 right-angle
- 6 rear-end
- 3 left-turn
- 4 pedestrian

Delay to STOP-Controlled Vehicles: 65 s/veh

Volumes By Hour

Time Period	(Veh/h) Major St Total	(Veh/h) Minor St Total	(Peds/h) Peds Xing Major St	Acceptable Gaps
1–2 PM	850	100	200	50
2–3 PM	875	100	210	45
3–4 PM	925	110	205	48
4–5 PM	1050	140	193	35
5–6 PM	1250	108	180	32
6–7 PM	1100	125	170	44
7–8 PM	1000	100	180	46
8–9 PM	950	90	200	55
9–10 PM	900	80	150	60
10–11 PM	900	80	100	65

Figure 16.16: Intersection and Data for Problem 16-6



Approach Speeds:
45 mi/h on Broad St.
30 mi/h on Park Place

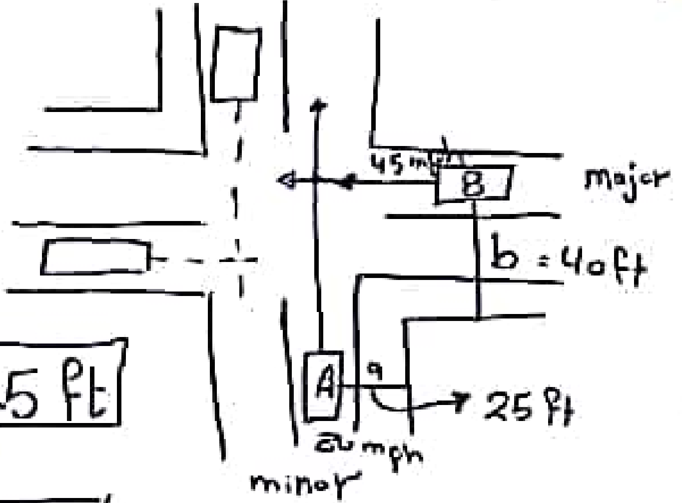
Annual Accidents:
3 Right-Angle with injuries
5 Left-Turn with injuries
4 Rear-End, PDO
6 Pedestrian with 2 fatalities

Peak-Hour Delay:
45 s/veh

Time	Broad Street Volume (veh/h)			Park Place Volume (veh/h)			Pedestrian Volume (ped/h) Crossing Broad	No. of Acceptable Gaps
	EB	WB	TOT	NB	SB	High Volume		
11 AM – 12	300	400	**700**	100	90	**100**	120	65
12 – 1 PM	325	450	**775**	110	125	**125**	115	55
1 – 2 PM	400	475	**875**	140	150	**150**	109	50
2 – 3 PM	450	480	**930**	150	165	**165**	122	61
3 – 4 PM	455	475	**930**	155	170	**170**	135	55
4 – 5 PM	445	425	**870**	160	160	**160**	140	50
5 – 6 PM	400	380	**780**	152	155	**155**	125	49
6 – 7 PM	385	350	**735**	140	150	**150**	121	45
7 – 8 PM	350	350	**700**	145	152	**152**	120	53
8 – 9 PM	350	375	**725**	130	156	**156**	105	62
9 – 10 PM	325	325	**650**	122	120	**122**	85	70
10 – 11 PM	300	300	**600**	120	95	**120**	85	72

Figure 16.17: Intersection and Data for Problem 16-7

16-1 :



Check for Level 1 :

Rule 1 :

$$d_A = 1.47 * 2.5 * 30 + \frac{30^2}{(0.348) * 30} = \boxed{196.5\ ft}$$

$$d_{B\,act} = \frac{d_A * a}{d_A - b} = \frac{196.5 * 25}{196.5 - 40} = \boxed{31.4\ ft}$$

$$d_{B\,min①} = 1.47 * 2.5 * 45 + \frac{45^2}{30 * 0.348} = \boxed{359.3\ ft}$$

$\Longrightarrow d_{B\,act} < d_{B\,min①} \Longrightarrow$ not safe as passive Control

also from rule 2 :

$$d_{B\,min} = (196.5 + 18) * \frac{45}{30} + 12 = \boxed{333.75\ ft} > d_{B\,act}$$

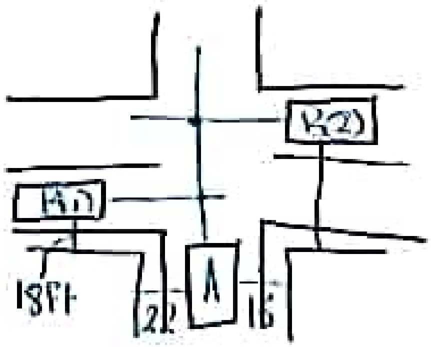
- no information to check level 2 or warrant traffic signal $\Rightarrow$ you can :

① reduce the speen on major street.

② remove or reduce sight obstruction

③ use stop or yield or signal traffic

16-2 :



Check for Level 1 :

$$d_A = 1.47 * 2.5 * 40 + \frac{40^2}{30 * (0.348 + 0.04)} = \boxed{278.6\ ft}$$

$$d_{B①\,act} = \frac{278.6 * 22}{278.6 - 18} = \boxed{23.5\ ft}$$

$$d_{B\,rule①} = 1.47 * 2.5 * 50 + \frac{50^2}{30(0.348)} = \boxed{423.21\ ft}$$

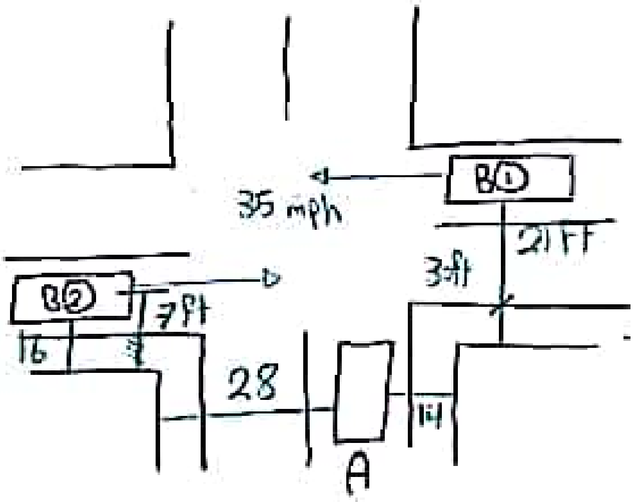
$$d_{B\,rule②} = (18 + 284.5)\frac{50}{40} + 12 = \boxed{390.125\ ft}$$

$d_{B\,act} < d_{B\,min\,①\,\&\,②}$ ⟹ not safe as Level 1

- no information to check Level ② & ③ ⟹ as problem

<u>16 – 1</u> ⟶ three recomended use it.

$\boxed{16-3}$:



$$d_{A-Right} = 18 + 21 = \boxed{39\ ft}$$

$$d_{A-Left} = 18 + 7 = \boxed{25\ ft}$$

$$d_{B\,min} = 1.47 * 7.5 * 35 = \boxed{385.9\ ft}$$

$$d_{act\,B①} = \frac{39 * 14}{39 - 21} = \boxed{30.3\ ft}$$

$$d_{act\,B②} = \frac{25 * 28}{25 - 16} = \boxed{77.78\ ft}$$

⟶ $d_{act} < d_{B\,min}$ ⟶ not safe

⟹ use 2-way stop sign at minor street since we don't have information to check all-way stop.

16-4: 1 Lane -1 Lane

Since Speed = 45 mph > 40mph → Use

W1: Use 70% Column in Condition A only since it minimum Volume :

Cond. A :	major Σ	highest minor
	350	~~300~~ 105
exist	750	300

⟹ **Met W 1**

W2: Use figure 4C-2 : 1 Lane - 1 Lane Curve, plot the point 750 | 300 ⟹ **W2 met** Since all hrs above the curve.

W3: Use figure 4C-4 : 1 Lane-1 Lane Curve → **W3 met** Since the peak hours (750, 300) Locate above the curve.

W4: insufficient data since we don't have the gap/hr.

W5, W6, W7, W8 → insufficient data

⟹ install traffic signal since W1,2,3 met

16-5:

	NB	SB	Σ	EB	WB	highest minor
6	400	300	700	100	250	250
7	500	350	850	125	400	400
8	500	350	850	150	450	450
9	450	300	750	200	375	375
17	350	250	600	325	125	325
18	400	300	700	375	150	375
19	350	450	800	400	150	400
20	350	450	800	425	150	425

W1 :

Check Cond. A → 100% Column :

major	minor highest
600	150
~~exist~~ all 8hr ≥600	≥150

⟹ W1 is met since each of highest 8hr is met.

W2 : Use figure 4C-1 , 2Lane - 1 Lane curve , plot each highest 4 hrs . * (700 , 250) above curve then all of it above.

⟹ W2 is met since all 4hr is above the curve

W3 : Criterion A : no information

Criterion B : use figure 4C-3 , 2Lane - 1 Lane curve

⟹ W3 is met since the highest hour (850 - 450) is Locale & above curve.
(peak)

* install traffic signal since W1, 2, 3 are met

W4, 5, 6, 7, 8 : insufficient data .

16-6 :

- The highest 8 hrs is from 3 PM → 11 PM
- 2 Lane - 1 Lane
- Check :

W1 :

Cond. A → 100% Column

Σ major	highest minor
600	150

⟹ not ok since the hours & all of it < 150 minor volume

Cond. B → 100% Column

Σ major	highest minor
900	75

⟹ ok since all of 8 hrs ≥ 900 at major and ≥ 75 at minor

⟹ W1 is met

W2 : Use figure 4C-1, 2Lane - 1 Lane Curve

→ after check for highest 4 hrs $\left(\begin{matrix} 4-5 & 6-7 \\ 5-6 & 7-8 \end{matrix}\right)$

$\boxed{W_2 \text{ not met}}$ since hr(1000, 100) Locate below the curve.

W3 : highest hr (1250, 108)

Criterion A : $\left(\frac{108 * 65}{3600}\right) = 1.95$ Veh-hr < 4 veh-hr → not ok

↳ not met

Criterion B : Use curve 4C-3 : 2lane-1Lane curve

→ not met since the point (1250, 108) below the curve

⟹ $\boxed{W_3 \text{ not met}}$

W4 : A : at 3-4 pm : Ped. volume = 205 ≥ 190 ✓

B : at same hour gap/hr = 48 < 60 ✓

⟹ $\boxed{W_4 \text{ is met}}$

W7 : $\boxed{A}$ trail alternative "stop sign" but fail. ✓

$\boxed{B}$ 8+3+4 = 15 Crashes > 5 within 12-month ✓

$\boxed{C}$ W_1 at 80% is met ✓

⟹ $\boxed{W7 \text{ is met}}$

W5, 6, 8 → insufficient data

▪ install Traffic signal since W4, 7, 1 are met

16-17 :

hours	major Total	highest minor	Ped. Volume	no. of gap
12-1	775	125	115	55
1-2	875	150	107	50
2-3	930	165	122	61
3-4	930	170	135	55
4-5	870	160	140	50
5-6	780	155	125	49
6-7	735	150	121	45
8-9	725	156	105	62

- 2 Lane - 1 Lane
- Speed 45 mph > 40 mph
- Delay = 45 s/Veh

W1 & W2 : not applicable since the area has a high-occupancy vehicle facilities "parking".

W3 : highest hour : (930, 170) :

Criterion A :

$\boxed{1}$ $\left(\frac{170 * 45}{3600}\right) = 2.125$ Veh-hr < 4 Veh-hr → not ok

Criterion B : use figure 4C-4 , 2 Lane - 1 lane curve ⇒

⟹ $\boxed{\text{W3 is met}}$ since the point (930, 170) above curve.

W4 :

hr	Ped.	gap
1-2	109	55
3-4	135	50
4-5	140	55
5-6	125	50

$\boxed{\text{W4 is met}}$ since each of 4 hrs Ped. ≥ 100 & gap < 60 .

W7 : ~~[illegible]~~ $\boxed{A}$ ~~[illegible]~~ trial of alternative "stop sing" fail to reduce the crash frequency ✓

$\boxed{B}$ 3+5+6=14 crash >5 within 12-month ✓

$\boxed{C}$ 80% of 100 ped./hr/4hrs is met ✓

$\Longrightarrow$ $\boxed{\text{W7 is met}}$

W5,6,8 : insufficient data

- install traffic signal since W3,4,7 are met.

▨ Two Lane Highways :

* undivided hyw with 2 Lane → 1 Ln/direction

* Passing a slower Veh → requ. using opp. Lane a Sight Dis. & gaps in opp. traffic stream.

* Homogenous TLH : same cross section, sholder, volume & veh.

TLH Two way segment → Level or rolling terrain

→ mountainous terrain OR $G \geq 3\% \rightarrow L \geq 0.6$ mi

→ Can't analyzed as Two-way segment → specific upgrade & downgr segment

⊛ Two way segment → Performance measure for both direction.

▨ Limitation :

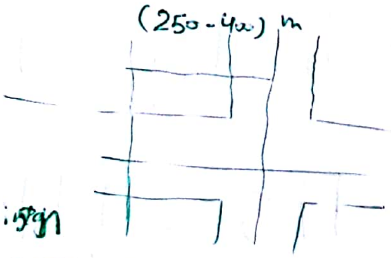
اذا وجدت احدهم لا استطيع استخدام الطريقة

① there is passing or climbing Lane.

② TLH with signalized intersection

→ if there is sign. inter. → (250-400)m Sign

rest of road → Tw Seg.



▨ Capacity of TLH : ⇙ بكل سؤال Vp خطوه مهمه دائما بعد حساب **

always check : if not → LOS F

Vp of ~~both~~ each Lane ≤ 1700 pc/h/Lane

Vp for both lane ≤ 3200 pc/h → extended Length

≤ 3400 pc/h → if there are (Tunnels or bridges)

▨ Class I , Class II : راجع

1

▨ Base Condition :

1- $L_w \geq 12$ ft (3.6m)
2- Shoulder wider ≥ 6 ft
3- no-Passing Zone
4- All PC
5- no impediment to through traffic "traffic control or turning Veh"
6- Level terrain ($g \leq 2$)
7- 50/50 directional split

▨ الحل

$\boxed{1}$ Determine FFS :

⊛ Field :

- mean speed for traffic under Low flow condition ($V_p < 200$ pc/h)
- measure speed for all pc or systmic sample (every 10th)
- at Least 100 sample

⊛ Estimating FFS :

$$\boxed{\underset{\text{~~(mi/h)~~}}{FFS} = \underbrace{BFFS}_{\text{base}} - \underbrace{f_{LS}}_{\text{Lane \& sholder width}} - \overset{\text{access point}}{f_A}}$$

$\boxed{2}$ Determine Vp :

$$\boxed{V_p = \frac{V}{PHF * f_G * f_{HV}}}$$

V → full Peak hour (veh/h)

f_G → grade

f_{HV} → heavy-veh.

V_p → (pc/h) both direction

PHF → Peak 15-min

Proportion for Peak hour for [illegible]

$$DHV = V = AADT * K\%$$

لـ يوم رقم 30 من الاعلى تنازلي في سنة

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

P_T : Truck نسبة
P_R : RV.S نسبة

* تختلف حسب { ATS, PTSF

$\boxed{3}$ Determine ATS : ** لا تستعمل Check على Vp بعد خطوة $\boxed{2}$

$$\boxed{ATS = FFS - 0.00776\,V_{p(ATS)} - f_{np}}$$

0.0125

↳ both direction (mi/h)

→ no passing zone

$\boxed{4}$ Determine PTSF :

PTSF

$$\boxed{BPTSF = 100\left(1 - e^{-0.000879\,V_p}\right)}$$

$$\boxed{PTSF = BPTSF + f_{d/np}}$$

↳ both direct.

→ direction distribution + no passing

$\boxed{5}$ Determine LOS :

Vp > Capacity → F

for Class I → use AST, PTSF (worst case)

Class II → use only PTSF

Performance measure :

$$\boxed{V/C = \frac{V_{p\,(ATS)}}{C}}$$

→ 3200 Two-way segment

↳ 1700

- total-travel on extended Two-way segment during Peak 15min

$$\boxed{\underset{(veh\text{-}mi)}{VMT_{15}} = 0.25\left(\frac{V}{PHF}\right)L_t}$$

→ total length of segment (mi)

- Peak hour :

$$\boxed{VMT_{60} = V \times L_t}$$

● مهم Total travel Time during Peak 15 min :

$$\boxed{TT_{15} = \frac{VMT_{15}}{ATS}}$$

اذا طلب في Class II حساب ال TT_{15}
فقط نحسب ATS وقتها

indication of delay

(Veh-h) // $TT_{15} = 4.5$ (Veh-h)

4.5 سياره متأخره بكل ساعة .

مهم

الاسئلة :-

① دائمًا افرض فرض بدائي $\boxed{V_p = \frac{V}{PHF}}$ ← اختار بناء عليها الـ range

واحسب الـ f_g, f_{HV} من جداول بعدين احسب Vp اصلية وأشوف

تشيك على فرضك ← OK ← اعمل تشيك على Capacity -

② [illegible]

MultILANE HiGHways :

** assume

- uninterrupted (no ramps) flow rural & suburban multilane hwy segm.
- Vehicles may enter or Leave the roadway at-grade intersection and driveways "donot have full access control".
- MLH may or may not be divided (by barrier, medians separating opp. direction of flow"
- Traffic signals may be present
- Design standard "Speed" Sometimes Lower than freeway
- Visual setting and development along MLH more distracting to driver than freeway.
- at Least 4 or 6 Lane in both direction → passing & turnning Lane, accer. dece Lane donot counnt ما بعدهم من المسارب
- Posted speed Limits (40 & 60 mph)

● freeway :

- must be devided
- more than 6 Lane
- uninterrupted-flow facilites allow acsses solely (فقط) through asystem of on-ramp & off-ramps from grade seperations or service road

chapter 23 :

■ Chapter 15 : Urban street if one of more following exist interruption :

1- flow signif. influenced by other signals (Singal spacing ≤ 3km)

2- signifi. presence of on-street parking

3- presence of bus stops that have signifi. use

4- signifi. Pedestrain activity.

اذا وجدت ما بعتبره

MLH rural or suburban uninterrupt

⟶ Limite of MLH

الحل :

$\boxed{1}$ Measuring FFS :

■ Field :

* mean speed of PC operating in Low to moderate flow condition ($v_p \leq 1400$ pc/h/Ln)

* measure the speed of all PC or a systematic sampling of PC (every 10th pc).

* must measure both of unimpeded Vehicles and a representative no. of impeded Vehic.

* at least sample of ≥ 100 PC.

■ Estimating FFS :

$$\boxed{\underbrace{FFS}_{(km/h)} = \underbrace{BFFS}_{\text{base FFS}} - \underbrace{f_{LW}}_{\text{Lane width}} - \overbrace{f_{LC}}^{\text{Lateral clearance}} - \underbrace{f_M}_{\text{median type}} - f_A} \rightarrow \text{Access Point}$$

● Base Conditions :

- Lane width ≥ 12 ft "3.6 m"
- Lateral clearance total "LCR+LCL" ≥ 12 ft from roadside ~~effects~~ objective in travel direction (right shoulder and median).
- only PC
- no direct access Point along roadway
- Level terrain (grade $\leq 2\%$)
- Driver Population of mostly familiar roadway users $f_p = 1$
- BFFS ≥ 60 mph (100 km/h).

/ BFFS :

* when it is not possible to use data from Similar roadway
↳ Speed Limit is one factor that affects FFS :

⇒ for MLH FFS :

BFFS = Speed Limit (65 or 70) + 11 km/h
= Speed Limit (80 or 90) + 8 km/h
↳ default = 100 km/h

2/ FLW : from EX 21-4 .

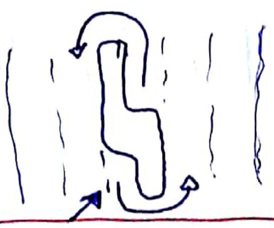
3/ FLC : Lateral clearance :

⊛ Fixed obstruction : Light poles , Signs , trees , abutments bridge rails , traffic barriers , retaining walls
⟶ standard raised Curbs are not obstruction .

$$\boxed{TLC_{(m)} = LC_R + LC_L}$$
Total

LC_R : from right edge of travel Lane to roadside obst. (Sholder) .
↳ $\boxed{\text{if it} > 1.8_m \rightarrow \text{use } 1.8}$

LC_L : from left .... to obst. of median :
- $\boxed{\text{if it} > 1.8^m \rightarrow \text{use } 1.8 \text{ m}}$ ⟶ divided
- if there is median with two-way left turn Lanes (TWLTLs) : $\boxed{LC_L = 1.8 \text{ m}}$ $\boxed{F_M = 0.0}$



* for undivided design :
Use $LC_L = 1.8$ and $F_m = 2.6$

كل التصحيح بروح جال median type adjus.

4/ FM : from Ex 21-6

5 FA : Access Point 8

⇒ For divided roadway

$$= \frac{\text{total number of access point (intersection / driveway) on right side of roadway in direc. of travel}}{\text{Segment total number (KM)}}$$

2 Determine flow rate 8

$$\boxed{V_p = \frac{V_{\rightarrow \text{hourly } V \ (veh/h)}}{PHF * N * f_{HV} * f_p}}$$

↳ 15-min Peak PC equivalent flow rate [PC/h/Ln]

N : no. of Lane / direction
↳ analysis → معروف
↳ design → مش معروف

Fp: drive pop. factor
↳ familier = 1 → designer use it
↳ non-familier → [0.85 – 1]

to reflect weekday Commuter traffic

$$\boxed{V = DDHV = ADDT * K\% * \%D}$$

K% → proportion of AADT in Peak hour

%D ↳ Peak direction in Peak hour

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

E_T, E_R : PC equavalents for Truck, buse & RVs

P_T : % of truck & buses

P_R : RV.s %

⊛ Ei for 2-Conditions 8

1 Extended general highway Segments :

along MLH if 8
- no grade exceeding ($g \ngtr 3\%$) / $\ngtr$ 0.8 Km (0.5 mile) .
- grades $\leq \pm 3\%$ / $\leq$ 1.6 Km (1 mile) .

→ use Ex 21-8 ,

if not , Spicific grades should be Considered

3] Determining LOS :

(pc/km/ln)

FFS, Vp → Curve → find Avg. speed → $D = \frac{V_p}{\text{Avg. Speed}}$ → LOS

density

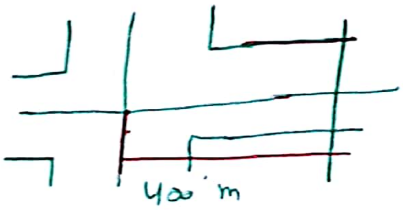
** ارسم كيرف تقريبي بنفس اشكال الكيرفات حسب ال FFS الي حسبتها بحيث يقطع ال y عند ال FFS .

** من ال Vp ← اقرأ الكيرف الي رسمته واحسب ال Avg.speed + ال LOS المقابله للسرعه

Note :

* Length of segment in MLH should be ≥ 2500 ft (762 mm)
  if not → don't use ~~pass~~ analsis.

* Limits of study segments ≥ 0.25 mi (400 m) to signalized intersection.



spacer from nearst intersection dosent less than 400 m

* $\boxed{\text{at LOS E} \longrightarrow \frac{V}{C} = 1}$ for all FFS

  Los (A – D) → $V/C < 1$, Los F → $V/C > 1$

افكار :

① Find no. of Lane the meet LOS :

* Determin FFS (assume any factor with no informaction = 0 such FLW, FLC, FM)
* Find $V_{p\,max}$ from table at LOS "interpolation based on FFS"
* Find V, then find $N = \boxed{}$ ← قربها لاكبر عدد صحيح

** وصول ال Capacity ، اضافه شاحنات اضافيه ، هل نحتاج Lane اضافي

⟸ كل يعتمد على ال Vpmax عند ال E ⟸ يجب ان لا نتعداه والا نحتاج lane .

$$\boxed{P\,R_{Vs} \Rightarrow \frac{\text{no.of } R_{Vs}}{\begin{array}{c}\cancel{\text{no.of Track} + \text{no.of } R_{Vs}} \\ V(\text{total Pc}, T, R_{Vs})\end{array}}} \quad \underline{\underline{**}}$$

Freeway :

* Freeway has a fully Access (Access ↑ → FFS ↓).
* no at-grade intersection
↳ just from right

Basic freeway segments : segments of fw that are outside of influence area of ramps or weaving area.
(between ramps)

* proprites :
- divided hwy having ≥ 2 Lane/direction.
- full access Control "no at-grade intersection".
- Traffic not affected by merging/diverging near ramps.

Basic Condition :

1) Lw ≥ 12 ft (3.6 m)
2) LCR (shoulder) ≥ 1.8 m
3) LCL (median) ≥ 0.6 m
4) all PC

* rural ≥ 2 Lane/dirc

5) ≥ 5 Lanes/direction in urban ~~Street~~ areas
6) interchang Spacing ≥ 3 km
7) Level terrain
8) regular users
9) BFFS ≥ 110 km/h

Basic Capacities under ideal Condition :

ffs = 120 kph → 2400 PC/hr/Ln
110 → 2350
100 → 2300
90 → 2250

Limitation of methodology : راجعهم من السلايدات

● Basic freeway can be charact. by 3 performance meas

1. Density (PC/mile/Ln)
2. Speed (mean PC speed) , FFS (90-120) km/hr
3. V/C

⟹

Density ⟶ use to estimate LOS

** the Perf. meac. is interrelated (اذا عرفت قيمتين منهم بتقدر تعرف الثالثة)

▨ الحل

1 Find FFS :

⊛ Field :

- mean speed of PC at Low-moderate flow ≤ 1300 (PC/h/Ln)
- measure all PC or systmic sampling (every 10th PC)
- at Least 100 PC sample
- measurment should be across all Lanes

⊛ Estimating :

Lane width   interchange density

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

↳ only for right sholder

BFFS : 70 mph ⟶ urban , 75 mph ⟶ rural   ثابتات إلا اذا بتغيرهم هي بالسوال

f_N : no. of Lane adj.

↳ urban ⟶ based on N/direc.

↳ rural ⟶ $F_N = 0.0$

] Determine flow rate :

$$V_p = \frac{V}{PHF * N * f_{HV} * f_p}$$

V → (veh/hr) → direction DDHV

f_p → driver pop. factor

V_p → (pc/hr/Ln)

$$f_{HV} = \frac{1}{1+P_T(E_T-1)+P_{RV}(E_{RV}-1)}$$

▨ Type of Segments :

⟹ to find E_T & E_R :

[1] Extended freeway segment :

⊛ an extended length of freeway containing a no. of upgrade & downgrade & LvLg. as a single uniform segment.

⟹ $G \geq \pm 3\% \longrightarrow L \leq 0.25$ mi

$G < \pm 3\% \longrightarrow L \leq 0.25$ mi

→ use Ex (23-8)

* no grade ≥ 3% longer 0.25 mi

تأكد من الدكتور

[illegible]

[2] Specific Grade segment :

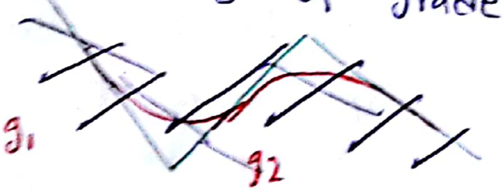
Spicific grade حسب اتجاه الحركة

$G > \pm 3\% \longrightarrow L > 0.25$ mi → ~~upgrade~~ (23-9,10)

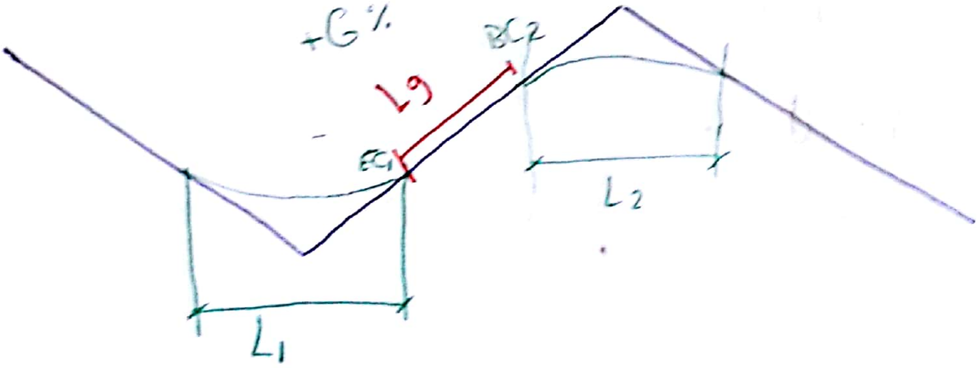
$G < 3\% \longrightarrow L > 0.25$ mi → ~~downgrade~~ (23-11)

↳ analysis seperate because of it's significent effect on traffic flow

▨ For upgrade → 25% of vertical curve length at begining and end of grade be included in length of grade

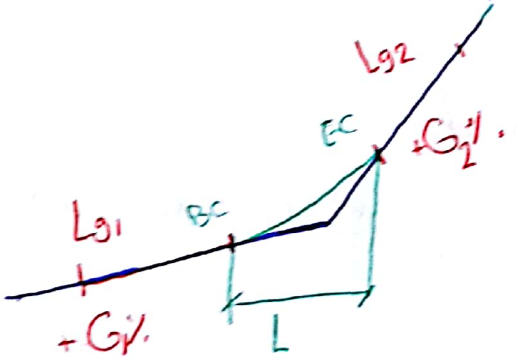


Scanned by CamScanner



$$\boxed{\text{Length of upgrade} = L_g + 0.25\,L_1 + 0.25\,L_2}$$

⊛ for two consecutive upgrades → 50% of VCL between them is assigned to the Length of each upgrade.



seg1 : $L_{g_1} + 0.5L$ $G_1\%$

seg2 : $L_{g_2} + 0.5L$ $G_2\%$

▨ [if downgrade do not cause truck shift to Low gear] → Et → LeveL
[for RVs downgrades maybe treated as LeveL] → ERv → LeveL

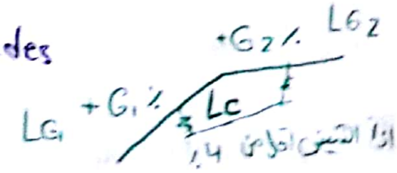
or grade = 0
also = 1.5

Ex(23-8)

3 Composite Grades:

⊛ Avg. grade : total rise from begining of composite grade divided by Length of grade :

→ only for upgrade : weighted Avg. for all grades



→ all of grade < 4%

OR

→ total compined length of the grades $L_1 + L_2 + \dots < 4000$ ft (1220 m)

⊛ equivalent factor $= \dfrac{{}^{+}G_1 \times L_1 + {}^{+}G_2 \times L_2}{\Sigma L} \times 100 = \boxed{}$ using upgrade Ex. to find ET, ERv

$\Rightarrow$ Length $= \Sigma\boxed{}$

Determine LOS :

1. احسب ال FFS ومن ثم ارسم curve تقريبي الها بحيث تقطع ال y-axis
2. احسب ال Vp ثم قاطعها مع الكيرف المرسوم و جد ال Avg speed
3.

$$\text{Density}\ (pc/mi/ln) = \frac{V_p\ (pc/h/ln)}{S\ (\text{avg. pc speed})\ (mi/h)}$$

⇒ Compare Density with the range in Ex. 23-2 and Find Los

⊛ Boundaries for freeway segment : ادرسهم من السلايدات

مهم

مهم

⊛ grade change of 2% or more (upgrade)

Constant upgrade Longer than 4000 ft

⇒ road Length = 10000 ft with Constant upgrade

3 segment (4000, 4000, 2000)

تأكد من صحته من الدكتوره

segment كل واحد

⊛ Commuter traffic : $f_p = 1$

⊛ no. of Lane to meet LOS : احسب ال FFS ← طول ال max Vp حسب ال Los

احسب Capacity مباشرة

طول ال N منها

افكار :

افرض فرض اولي لل N ((2) min. 5) ← جرب احسب ال Vp

وقارنها مع اكبر ماكسيمم ل D ← 2170

** دائمًا بسؤال المسارب ، $F_{LW}=0$ $f_{LC}=0$ لكن $F_N=?$;

rural $=0$ suburban $\neq 0$

(*) افرض عدد N ~~[illegible]~~ ابتدائاً بـ 2 و جرب الحل :-

حسب ال $V_{p\,max}$ لل LOS المطلوب

(*) FFS adju. = BFFS - 0 - 0 - f_N f_{ID}

(*) check → avg. FS → Density

⟵ اعمل عليها check LOS

**

** حساب ال LOS للجمهور الموجوده حاليًا .

* متى نحتاج حسب D رابع ←

when ~~Vp~~ ~~Vp max of E using~~ ~~Vp~~

$$\boxed{V > V \text{ using } V_{p\,max} \text{ of LOS E \& no. of existing lane}}$$

** راجع فكره السنوات .

Q1 :- Find Level of service for :

- Class I - two way highway
- Level terrain
- D% = 70/30
- 50 % no of passing zone
- FFS = 65 mph
- PHF = 0.9
- %T = 15%
- PH volume = 180 Veh/hr

Sol :

$\boxed{1}$ FFS = 65 mph → given no need for adjustment.

$\boxed{2}$ $V_p = \dfrac{V}{PHF * f_G * f_{HV}}$, assume $V_p = \dfrac{V}{PHF} = \dfrac{180}{0.9} = \boxed{200\ pc/h}$

⟹ range (0 - 600) → ~~fG = based on Level~~

** Class I → need AST, PTSF.

$\boxed{1}$ AST :

f_G "Level (0 - 600)" = 1 , $f_{HV} = \dfrac{1}{1 + 0.15(1.7 - 1) + 0} = \boxed{0.905}$

$V_{P\,AST} = \dfrac{180}{0.9 * 1 * 0.905} = \boxed{221\ V/h} \longrightarrow (0 - 600)\ V/h$ ok ✓

Check for Vp :

$0.7 * 221 < 1700 \rightarrow$ ok → المسرب الاكبر

$221 < 3200 \rightarrow$ ok → المسربين

$\boxed{3}$ $AST = FFS - 0.00776\ V_{P\,AST} - f_{np}$ → 50 no passing zone

$= 65 - 0.00776 * 221 - 1.9 = \boxed{61.4\ mph}$

	40	50	60
200	1.4		2.4

↳ = $\boxed{1.9}$

$\boxed{1}$

$\boxed{2}$ PTSF :

f_G "Level (0-600)" = 1 , $f_{HV} = \frac{1}{1+0.15*(1.1-1)+0} = \boxed{0.985}$

$$V_{P_{PTSF}} = \frac{180}{0.9*1*0.985} = \boxed{203 \ V/hr} \longrightarrow (0-600) \text{ ok } \checkmark$$

also check of capacity 1700 3200

$\boxed{4}$ PTSF = BPTSF + $f_{d/np}$ = 16.34 + 21.915 = $\boxed{38.255}$

$BPTSF = 100(1-e^{-0.000879 \, VP}) = 16.34$

$F_{d/np}$ = 50% no passing zone, 70/30 D% → interpolation Twice :

	40	50	60
200	19.1	21.95	24.8
203			
400	17.3	19.65	22

= $\boxed{21.915}$

$\boxed{5}$ Determine LoS :

Since the Class is I use AST & PTSF to Determine LoS

AST = 61.4 , PTSF = 38.255

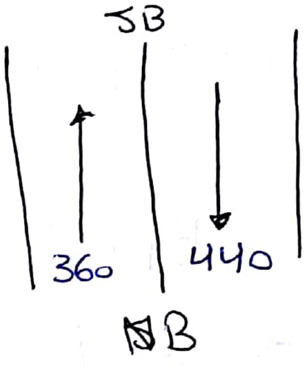
LoS is $\boxed{B}$

Q2 : Find LOS for :

- Class I two - Lane Hyw
- Level terrain with Passing Permitted throught "no Passing Zone $= \boxed{0\%}$
- Lane width = 11'
- Sholder = 4'
- Access/mi = 16
- BFFS = 60 mi/hr

** Hyw oriented north & south during Peak hour

- 440 Veh go north bound
- 360 Veh go south bound



PHF = 0.87

- %T = 4% , RV% = 1% , %Buses = 3%

Sol :

الفكره انه معطى بالسؤال ال D% بطريقة اخرى

$D\% = \frac{360}{360+440} = \boxed{45\%}$

$V_{\text{Peak hour}} = 360 + 440 = \boxed{800 \text{ Veh/h}}$

$D\% = \frac{440}{360+440} = \boxed{55\%}$

interpolation $\frac{20-10}{20-16} = \frac{5-2.5}{5-\underline{\underline{X}}}$

$\boxed{1}$ $FFS = 60 - 1.7 - 4 = \boxed{54.3 \text{ mi/h}}$

من الجدول

ATS :- assume $V_P = \frac{V}{PH} = \frac{800}{0.87} = \boxed{919.54 \text{ Veh/h}}$ range (600-1200)

$f_G = 1$, $E_T = 1.2$, $E_{RV} = 1$, $f_{HV} = \frac{1}{1+\underline{\underline{0.07}}(1.2-1)+0.01(1-1)} = \boxed{0.986}$

$\boxed{\%P_T = \%T + \%Buses}$ مهم

$\boxed{2}$ $V_{P\,ATS} = \frac{800}{0.87*1*0.986} = \boxed{932.6 \text{ Pc/hr}}$

→ check range (600 - 1200) ok

→ check capacity

932.6 < 3200 → ✓

932.6×0.55 < 1700 → ✓

$\boxed{3}$

$\boxed{3}$ $ATS = 54.3 - 0.00776 * 932.6 - \underline{\underline{0}} = \boxed{47.1 \text{ mi/h}}$

passing is permitted

$\boxed{\text{PTSF}}$

$f_G = 1$, $E_T = 1.1$, $E_R = 1$, $f_{HV} = 0.993$

$$V_p = \frac{800}{0.87 * 1 * 0.993} = \boxed{926 \text{ pc/}\cancel{\text{h}}\text{hr}}$$ → check → check

$\boxed{4}$ $PTSF = BPFST + f_{D/np} = 55.3 + 0 = \boxed{55.3}$

$\boxed{5}$ Los is $\boxed{C}$

Q3 :- 2-way-2Lane Hyw is correctly operating at its <u>Capacity</u>, Located at rolling terrain and the traffic consist of cars & truck <u>only</u>, a recent traffic count indicate that 720 veh/hr (total of two direction) move in the most congestion "Peak" 15 min interval, what is %T based on ATS ?

<u>Sol</u> : based on Count find PHF $= \dfrac{V_{Peak\ hour}}{4 * V_{Peak\ 15\ min}} = \dfrac{4*720}{4*720} = \boxed{1}$

$\underline{4*V_{15}}$ = لانها غير معطاه ، من بالضروره تكون نفسها

at capacity the Vp for road $= \boxed{3200 \text{ Veh/hr}} \Rightarrow f_G = 0.99$, $E_T = 1.5$

$$F_{HV} = \frac{1}{1 + P_T * (E_T - 1) + 0 \sim \text{no RVs}} \Rightarrow 0.909 = \frac{1}{1 + T\%(1.5 - 1)} \Rightarrow \boxed{T\% = 20\%}$$

$$3200 = \frac{V}{PHF * f_G * f_{HV}} \Rightarrow 3200 = \frac{2880}{1 * 0.99 * f_{HV}} \Rightarrow \boxed{f_{HV} = 0.909}$$

note :

if the Hyw is Class I
- → AST — T%
- → PTSF → T%

$\boxed{4}$

Scanned by CamScanner

Q4 : 2-way Hyw, Class I is rolling terrain and has a hourly Peak Volume $\boxed{V = 500 \text{ Veh/hr}}$ with PHF = 0.94 and T% = 5%, B% = 2%, RV = 6%, determine the analysis flow rate "Vp" for AST & ~~PTSF~~ ?

Sol :

$\boxed{AST}$: assume $Vp = \frac{V}{PHF} = \frac{500}{0.94} = 532 \rightarrow$ range (0 − 600)

$f_G = 0.71$, $E_T = 2.5$, $E_{RV} = 1.1$, $f_{HV} = \frac{1}{1+0.07(2.5-1)+0.06(1.1-1)} = \boxed{0.9}$

$$Vp = \frac{500}{0.94 * 0.71 * 0.9} = 832.42 \text{ Veh/hr} \rightarrow \text{range } (600-1200) \text{ not ok}$$

assume Vp range (600−1200), $f_G = 0.93$, $E_T = 1.9$, $E_R = 1.1$, $f_{HV} = 0.935$

$$Vp = \frac{500}{0.94 * \cancel{0.71} \, 0.93 * 0.935} = \underline{\underline{611.7 \text{ veh/hr}}} \rightarrow \text{range } (600-1200) \rightarrow \text{ok}$$

↳ use it for analysis

~~PTSF~~ ~~Try it~~, ~~answer is Vp = 500 / 0.94 * 0.94 *~~

Q5 :- find LOS for :

سلايات الحل

- four Lane freeway (2 Lane/direction)
- rural Area *28
- rolling terrain
- Speed Limite
- 11 ft Lane width
- 2 ft Lateral cleanance
- 5% T
- 0.92 = PHF

- Commeter traffic
- 2000 Veh/h Peak-hour Volume~~s~~ Per direction مهم
- I interchange/mi

لانه الحسابات هون لكل direction.

Freeways

mi 70

(1) six-lane urban HW, on [illegible] 11ft Lanes, obsutction 2 ft from right edge, A drictional week day peak hour volume of 2300 veh is observed in the most congested 15 min min period: 700

15% Trucks, no RV, what LOS??

Some point along the roadway there is 6% up grade that is 1.5mi

---

(a)

Extra
proplems
for

$\boxed{FFS}$

3 Lan/direction

$FFS = 70 - 1.9 - 1.6 - 3 - 0 = 63.5$ mi/h

BFFS = 70 mph → ihurba

$f_{LW} = 1.9$

$f_{LC} = 1.6$

$f_N = 3$

$f_{ID} = 0$ →

$PHF = \frac{2300}{4 \times 700} = 0.82$

$f_p = 1$ → commuters

$\boxed{v_p}$

$v_p = \frac{2300}{0.82 \times 1 \times 3 \times 0.727} = \underline{1286 \text{ pc/h/ln}} \rightarrow$

$f_{HV} = \frac{1}{1 + 0.15(3.5 - 1)} = 0.727$ → E_T

$G \geq 3 + L > 0.25$

$6 \geq 3 \rightarrow 1.5 > 0.25$ → specific grad (upward)

From table (23-9) → grade >(5-6) → leng > 1 mi → %15

$E_T = 35$

From curve (23-3) → Avg travel speed = 63.5 = FFS

$$D = \frac{1286}{63.5} = \underline{20.25} \rightarrow LOS\ C$$

(b) How many veh can be added befor capacity is reach
↳ LOS F

% truck remain constant , PHF remain constan
FFS construct

$$2330 = \frac{2300 + V_{new}}{0.821 \times 1 \times 3 \times 0.727} \Rightarrow V_{ne} = 1872.1 \text{ veh/h}$$

FFS = 60 → capacity = 2300
FFS = 63 → X
FFS = 65 → 2350
→ assum linear interpolation

capacity = 2330

(2) AADT = 35,000 veh/day , k = 0.148

FFS = 70 mi/h

$f_p = 1$ → commuters

PHF = 0.85

65% peak hour traffi travling in peak direction

determine the no of lane requird provide LOSC using the higest annual hourly volume and 30th higest annual

---

$$v_p = \frac{v}{PHF \times f_p \times N \times f_{HV}}$$

$$1770 = \frac{3367}{0.85 \times 1 \times N \times 1} \Rightarrow N = 2.23 \approx 3 \text{ lanes}$$

capacity at LOS C → based FFS = 70 mi/h → $v_p = 1770$

$$f_{HV} = \frac{1}{1+0} = 1$$

No information a bout % Truck and % RV = 0

$$v = 35000 \times 0.148 \times 0.65 = 3367 \text{ veh/h}$$

--- v_p based N=3

$$= \frac{3367}{0.85 \times 1 \times 3 \times 1} = 1320$$

FFS = 70 mi/h

from curve will Avg trav speed = 70 m

$$D = \frac{1320}{70} = 18.8 \rightarrow \text{LOS C} \text{ --- ol}$$

other Methods

by assume number of lane assum Min = 2Lane/directio

$$v_p = \frac{3367}{0.85 \times 1 \times 1 \times 2} = 1980.6$$

because I know FFS so
I can difference currently

في سؤال سابق قارنا في أقل capacity
لأنه لم نكن أعلم FFS

$$1980.6 > \underline{\underline{1770}}$$

$$v_p = \frac{3367}{0.85 \times 1 \times 1 \times 3} = 1320 > 1770$$

FFS = 70

→ Avg = 70

$$D = \frac{1320}{70} = 188.8$$

$\underline{\underline{\text{LOSC}}}$

(6.2)

- 6 lane free way (3 lan / direction)
- ~~Lo~~BFFS = 105 kph, l_w = 11 ft, LCR = 4 ft, No RV
- [illegible] 10% Truck
- PHF = 0.9, V = 5435
- one point along free way is 4% up grade
- How long can this grade be without the freeway LoS droppin F

FFS = 105 − 1.9 − 1.3 − 0 − 0 = 101.8 kph

$f_N = 0$ → rural Hyw

$f_{LD} = 0$

LOS E → at FF 101.8 kph

96.56 → capacity 2300
101.8 → x
[illegible] → 2350

⇒ capacity =

$$2332.54 = \frac{5435}{0.9 \times 3 \times f_{HV}}$$

$f_P = 1$ → family

$f_{HV} = 0.863$

$$0.863 = \frac{1}{1 + 0.1(E_T - 1)} \Rightarrow E_T = 2.587$$

table (23-9) → Len (0.75−1) mi

G ≥ 3 → $E_T = 2.587$ → 10%   3-4   10   2.5

6.5

- 6 lane freeway (3 lan/direction)
- in secenic area
- FFS = 55 mi/h
- PHF = 0.8
- 8% Trucks and buse , 6% RV
- one upgrade is 5% and 0.5 mi along
- FFS measured at capacity
- V = 3900 veh
- what value for driver population factor

---

at FFS = 55 mi/) → LOS E → cap = 2250

$$2250 = \frac{3900}{0.8 \times f_p \times 3 \times 0.833} \Rightarrow f_p = 0.867$$

$$f_{HV} = \frac{1}{1 + 0.08(2-1) + 0.06(3-1)} = 0.833$$

$E_T = 2$ Ex (23-9)

$E_R = 3$ Ex (23-10)

5% ≥ 3 + 0.5 > 0.25 mi → specific grade

Asegment Four-lane Hyw (2lane/direction) urban

- 3% upgrade that is 1500ft Long
- followed by 1000ft 4% upgrade
- LW = 12ft
- 3ft shoulders , V = 2000veh
- 5% Trucks , no RV

- BFFS = 65mph
- no interchages exist along the segment
- PHF = 0.9
- fp = 1 → find LOS ??

FFS

$FFS = 65 - 0 - 1.8 - 4.5 - 0 = 58.7 mph$

$f_{LW} = 0 \rightarrow 12 ft$

$f_{LC} = 1.8$

$f_N = 4.5$

$f_{LD} = 0$

ND

$= \frac{2000}{0.9 \times 2 \times 0.952} = 1167$ pc/[illegible]/m

→ ET = 2 → $f_{HV} = 0.952$

$f_{HV} = \frac{1}{1+0.05(2-1)}$

$4\% \leq 4\%$

$3\% \leq 4\%$

$1000 + 1500 = 2500 < 4000$

composite grad $= \dfrac{4 \times 1000 + 3 \times 1500}{1000 + 1500} = 3.4\%$

at 2500

1 mil → 5280'

0.473 mil

$3.4\% > 3$ + $0.473 > 0.25$

Ex (23-9) → $E_T = 2$

From curve → ATS = FFS = 58.7

$D = \dfrac{1167}{58.7} = 19.88$ → LOS C

6.8

consider 6.2
in which wass determine that 1908 vels could be added to the peak hour befor capacity reach Assuming Rolling terrain as 6.1, How many passenger car could be added to orignal traffic mix

---

Assume only passenger car adde. that the number of large trucks originly in traffic stream reams constant

$v_{orig} = 5435$

FFS = 101.8 kph → reamin the same → $v_p = 2332$

PHF = 0.9 the same

$$2332 = \frac{\overset{5435}{V_{orign}} + V_{pc}}{0.9 \times 1 \times 3 \times \frac{1}{\left(1 + \frac{543.5}{5435+v_{pc}} \times 1.5\right)}}$$

$\text{volum Truck}_{orig} = 10\% \times 5435 = 543.5$

E_T Ex(23.5)

Rolling terrain = 2.5

$$f_{HV} = \frac{1}{1 + \frac{543.5}{5435+v_{pc}} \times [2.5 - 1]}$$

$$\Downarrow$$

$$6206.4 = (5435+v_{pc})\left(1 + \frac{543.5}{5435+v_{pc}} \times 1.5\right)$$

$v_{pc} = 46.15$

(6.10)

a +5% grade on a 6lan urban freeway that is 1.25 miles long with DDHV= 3800 veh

%T = 2% , %B = 4% , PHF = 0.9 , fp = 1 , BFFS = 65 mph

Lw = 12' , no lateral obsutrction with 10' of Roadway

ID = 1.5/mile , Abus strike will eliminate all bus traffic , but it estimated that for each bus removed from the roadway six additinal pc will be added. as travel seek other means of traffic

what is the LOS befor and after strike??

→ 3lane/direction

→ specific grade

→

$FFS = 65 - 0 - \overset{LC\geq 6}{0} - 3 - 5 = 57 mph$

befor

$v_1 = 3800$ → $P_T = 2\%$

→ $PB = 4\%$

→ $v_{1\,Bus} = 0.04 \times 3800 = 152$ Bus

→ $v_{Truck} = 0.02 \times 3800 = 76$

after

$v_2 = 3800 - 152 + 6 \times 152 = 4560$ veh

$\% B = \phi$ → v_{Bus} = zero

$v_{Truck} = 76$ → $\% T = \frac{76}{4560} = 0.017$

→ f_{HV} befor $= \dfrac{1}{1+(0.02+0.04)(4-1)} = 0.847$

5>3 , 1.25 > 0.25

speed grade

up ~~way~~ward

$E_T =$

(23-9)

→ f_{HV} after $= \dfrac{1}{1+(0.017+0.0)(5-1)} = 0.936$

$E_T = 5$

→ v_p befor $= \dfrac{3800}{0.9 \times 1 \times 3 \times 0.847} = 1661.6$ pc/h/ln

$\left.\begin{matrix} v_p \text{ befor} \\ \text{FFS} \end{matrix}\right] \rightarrow$ Avg = 57 → $D = \dfrac{1661.6}{57} = 29.15$ → LOS D

→ v_p after $= \dfrac{4560}{0.9 \times 1 \times 3 \times 0.936} = 1804.36$

$\left.\begin{matrix} v_p \text{ after} \\ \text{FFS} \end{matrix}\right] \rightarrow$ Avg speed = 57 → $D = \dfrac{1804.36}{57} = 37$ → LOS D

6.26

$\boxed{AADT=??}$, 4 lane Hwy (2 lane/direction), operated at capacity

11 ft lane, 4 ft shoulder, $f_p=1$, 8% Truck no RV

rolling terrain, PHF = 0.85, k = 12% → 12% of AADT occurring

%D = 60%, $f_p=1$

urban

FFS = 70 − 1.9 − 1.2 − 4.5 − 0 = 62.4 mi/h

v_p = capacity

at 60 → 2300

62.4 → x → v_p = 2324

65 → 2350

$$2324 = \frac{v}{0.85\times 1\times 2\times \cancel{0.446}\ 0.893}$$

f_{HV} → $E_T = 2.5$

= 0.893

v = 35275

---

v = AADT × k × %D

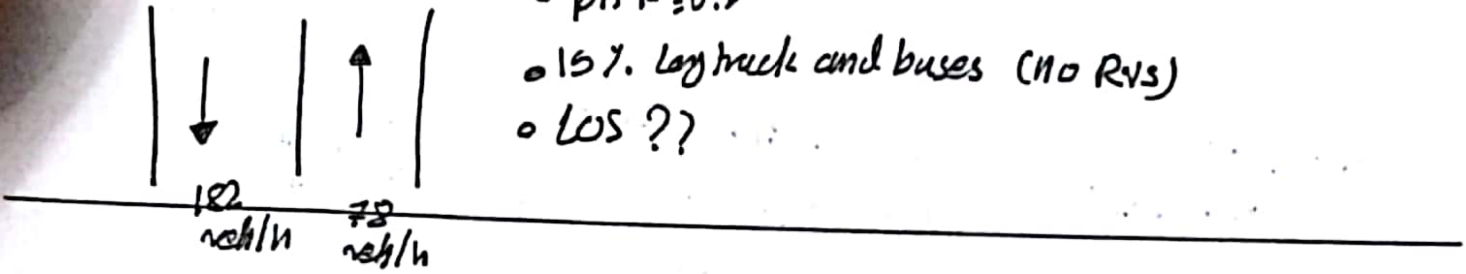
35275 = AADT × 0.12 × 0.6 ⇒ ADDT = 48993

~~6.20~~

Extra proplem for tow-lane Hyw

6.20

- class I , Level terrian , FFS =65mi/h , 50% no passing zone



- PHF =0.9
- 15% Long truck and buses (no RVs)
- LOS ??

- FFS = 65mi/h
- total flow (both direction) = 78+182 = 260 veh/h
- $\%D = \frac{78}{260} = 30\%$ other direction $= \frac{182}{260} = 70\%$

→ first guses $\frac{v}{PHF} = \frac{260}{0.9} = 288.8$ with [0-600]

- based ATS

$$v_p = \frac{260}{0.9 \times 1 \times 0.905} = 319 \rightarrow \text{with } [0\text{-}600]$$

319 ≤ 3200 --ok

319×0.7 = 223 < 1700 --ok

$f_g = 1$

$$E_T = 1.7 \rightarrow f_{HV} = \frac{1}{1+0.15(1.7-1)} = 0.905$$

$ATS = 65 - 0.00776 \times 319 - 2.6 = \underline{60 \text{ mi/h}} \rightarrow$ LOS A

$f_{np} = \underline{2.6}$ Line interpolation

قيمة تقريبية

PTS

$v_p = \frac{260}{0.9 \times 1 \times 0.985} = 293 \rightarrow$ with [0-600]

$293 < 3200$
$293 \times 0.7 = 205 < 1700$] ok

$f_g = 1$

$E_T = 1.1 \rightarrow f_{HV} = 0.985$

$PTSF = 22.7 + 21.9 = \underline{44.6\%} \rightarrow$ LOS B

$BPTSF = 100(1 - e^{-0.000879 \times 293}) = 22.7$

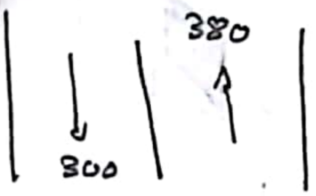
$f_{d/np} = 21.9$

take worst → LOS B . for the segment

تلخيص مرور

6.23

Class II , two lane Hyw , rolling terrian



PHF = 0.92

8% Trucks

2% Bus

no RV

% no passing zone that can be built in to LOS C

---

basel PTS

N = 380 + 300 = 980

$\%D = \frac{380}{980} = 38.7\%$

$\frac{N}{PHF} = \frac{980}{0.92} = 1065$ → [600 - 1200]

$Np = \frac{980}{0.92 \times 0.94 \times 0.952} = 1190$ with

→ $f_g = 0.94$

→ $E_T = 1.5$ → $f_{HV} = \frac{1}{1 + 0.1(1.5-1)} = 0.952$

PTSF = B BTSF + $f_{d/np}$

70% = 64.87%
from table

→ $f_{d/np} = \underline{5.13}$ → 40%

$BPTSF = 100(1 - e^{-0.000879 \times 1190}) = 64.87$

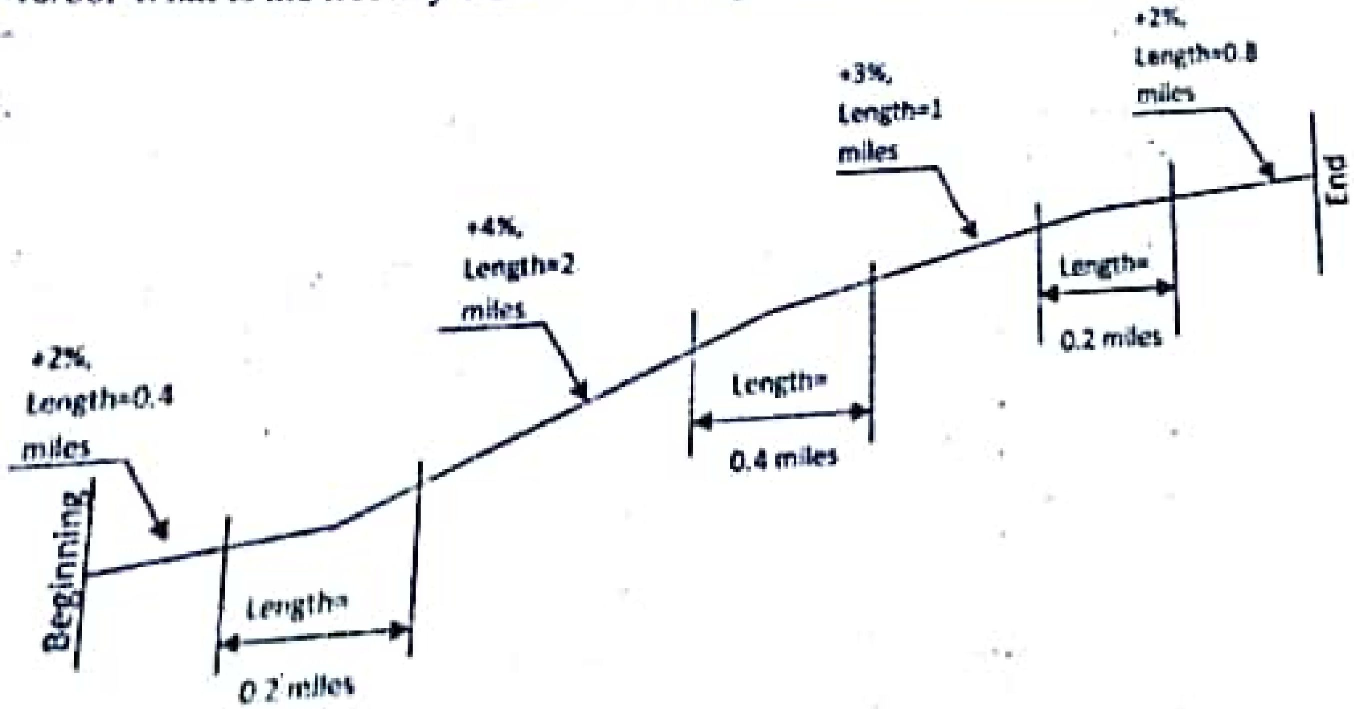
what the maximum no passing zone in LOS C → to maximized maximum no passing zone and still LOS C → take max [55 - 70] → 70%

~~Ptest of service , % no passing zone~~

Q4. A four-lane rural freeway has a volume 30000 vehicles during the peak hour. It has 12-ft lanes and 6-ft shoulders. The freeway has only regular users and there are 6% large trucks and buses, where the freeway has the following characteristics:

The freeway begins with a 0.4 miles that is +2% upgrade, then it is followed with a +4% upgarde with a length of 2 miles, the sag vertical curve between the two grades is 0.2 miles long, now the +4% grade is followed with a +3% upgrade that is 1 mile long, the crest vertical curve between the two grades is 0.4 miles. And finally, the +3% grade is followed with a 2% upgrade that is 0.8 miles long, where the crest vertical curve between the two grades is 0.8 miles long.

There is one interchange every 2 miles and it is known that 12% of the AADT occurs in the peak hour. The peak hour factor is 0.85 and the directional split in peak hour is 40/60. What is the freeway's LOS from its beginning to its end? (12 Points):



Q4 :-

1 Find FFS :

BFFS = 75 mph "rural"

$FFS = 75 - f_{LW} - f_{LC} - f_N - f_{ID} = 75 - 0 - 0 - 0 - 0 = \boxed{75}$

12' 6' rural 0.5/mi

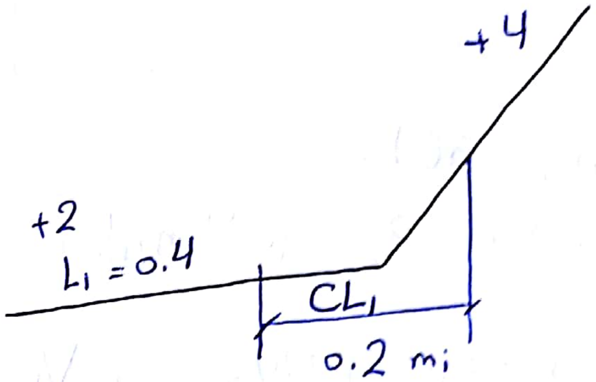
2 $V_{\text{at peak hour \& peak direction}} = 30,000 * 0.12 * 0.6 = \boxed{2160 \text{ veh}}$

☒ first seg. :

seg. Length $= L_1 + 0.5\,CL_1$

$= 0.4 + 0.2 * 0.5$

$= \boxed{0.5 \text{ mi}}$



$g = +2\,\%$

$\Rightarrow E_T = 1.5 \Rightarrow F_{HV} = \frac{1}{1 + 0.06(1.5-1)} = 0.971 \Rightarrow V_P = \frac{2160}{0.85 * 2 * 1 * 0.971}$

$= \boxed{1308 \text{ pc/h/Ln}}$

Ex (23-2) $\longrightarrow$ LOS B

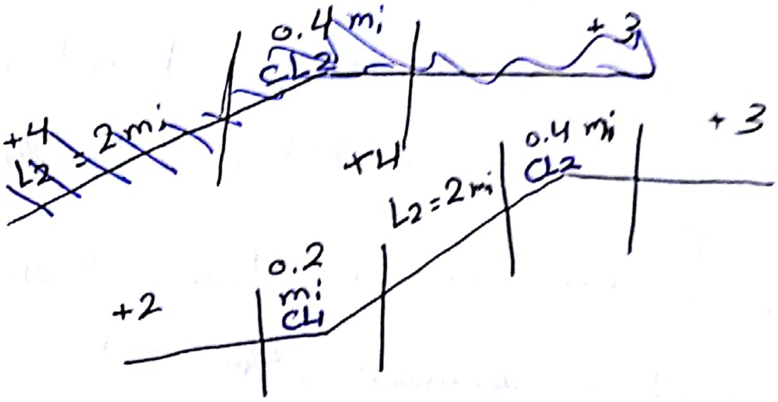
☒ Second seg. :

seg. Length $= L_2 + 0.5\,CL_2 + 0.5\,CL_1$

~~$= 2 + 0.4/2 = \boxed{2.2 \text{ mi}}$~~

$= 2 + 0.5 * 0.2 + 0.5 * 0.4$

$= \boxed{2.3 \text{ mile}}$

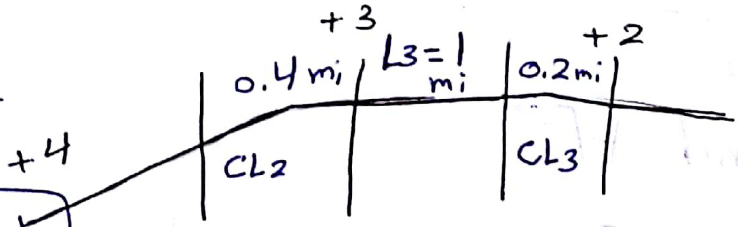


$g = +4\,\%$

$ET = 3 \longrightarrow F_{HV} = 0.893 \longrightarrow V_P = \frac{2160}{0.8 * 2 * 1 * 0.893} = \boxed{1423 \text{ pc/h/l}}$

LOS . C

[*] Third seg. :



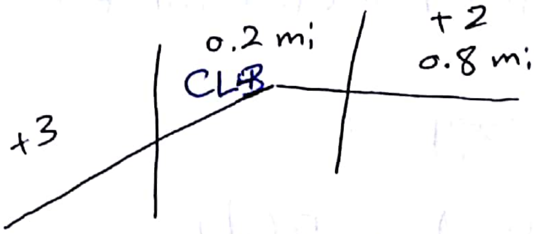
$$\text{Seg. Length} = L_3 + \frac{CL_2}{2} + \frac{CL_3}{2}$$

$$= 1 + \frac{0.4}{2} + \frac{0.2}{2} = \boxed{1.3 \text{ mile}}$$

$g = +3\ \%$

$$E_T = 2.5 \longrightarrow f_{HV} = 0.917 \longrightarrow V_p = \frac{2160}{0.85 * 1 * 2 * 0.917} = \boxed{1386 \text{ pc/h/Ln}}$$

LOS $\underline{\underline{C}}$



~~Seg~~ [*] fourth seg. :

$$\text{Seg. Length} = L_4 + 0.5\,CL_3$$

$$= 0.8 + 0.2/2 = \boxed{0.9 \text{ mile}} \qquad g = +2\ \%$$

$$E_T = 2 \longrightarrow f_{HV} = 0.943 \longrightarrow V_p = 1347 \longrightarrow LOS = \underline{\underline{B}}$$

$\Longrightarrow$ as worst case for the freeway $\longrightarrow$ LOS = $\underline{\underline{C}}$

** لاحظ بالسؤال الدكتوره حددت طريقه المشي Begining ← End عشان هيك
كان كله upgrade + هي حددت انه كل spicific grade ، ممكن ماتحدد
ولازم انت تقارن حسب L > 0.25 mi & %9 .

** فكره سؤال الفصل الماضي ؛ طلبت عدد ال Lane بـ freeway حسب LOS B capacity
و اعطت ال D % للمسارب رايح جاي ، ف ~~بحسب~~ كانت للرايح
upgraded والجاي downgrade + كل اتجاه كان اله ∇ معينة
حسب ال %D اله ، حسبنا عدد مسارب كل seg. واخذت
اكبر عدد .

▨ Highway Safety :- سؤال ✱ دائم بالسنوات

● Direct Comparison of Crash rates :

1 rate per million of entering vehicles (RMEV's) is ~~the~~

$$\boxed{RMEV = \frac{A * 1,000,000}{V}}$$

A : عدد الحوادث في فترة زمنية معينة (بالسنوات)

$$\boxed{V = ADT * 365 * \text{عدد السنوات}}$$

حسب المعطى بالسؤال

2 rate per 100 million vehicle miles (RMVM) :

$$\boxed{RMVM = \frac{A \times 100,000,000}{VMT}}$$

A : عدد الحوادث خلال مدة زمنية معينة {Total / or by type

$$\boxed{VMT = ADT * (\text{no. of day}) * \text{Length of road}}$$

● Expected Value analysis :

$$\boxed{EV = \bar{X} \pm ZS}$$

Z → number - - -

S → estimated standard deviation of Crash freq.

$\bar{X}$ → avg. no. of crach per Location

EV → expected range of crash Freq.

▨ overrepresented : if the number of crash type of ~~certain~~ site is out of EV range for spicific control sites

not overrepresented : in the range

← راجع مثال السلايدات

Statistical Comparsion : مهم جداً جداً ان تفرق بين

الانواع ، ويتم ذلك حسب نص السؤال في الغالب او المعطيات

1 The t-test : difference between the avg. number of crashes ⇖ مهم

2 Propotionaltity test : Compare between proportion of Crashes ⇖ مهم

3 Kruskal-wallis H test : Compare between distribution of crashes ⇖ مهم

** شرح عام عن الموضوع :- نقوم بفرض فرضيه تسمى null hypothesis وهي عباره عن مساواه بين احد القيم التي ذكرت بالاعلى (avg. / proportion, distri.) و تعطى الرمز Ho ، لذلك سوف تكون الفرضيات البديله لهذه الفرضيه هي وتعطى الرمز H_1 .

$\square_1 > \square_2$ → حسب نوع السؤال

$\square_2 > \square_1$

$\square_1 \neq \square_2$

→ H_1

$\square_1 = \square_2 \rightarrow H_o$

** المطلوب بالسؤال هو ان تحدد هل احد فرضيات ال H_1 "حسب السؤال شو طالب" مقبوله ام لا وذلك عن طريق قبول او رفض ال H_o وتتم عن طريق حساب قيمه احصائيه معينه ومقارنتها مع قيمه معطاه او موجوده بجداول تعتمد على نسبه عدم الدقه " α " و تحدد قبول او رفض ال H_o .

1 The T - Test :-

تكون لنفس المشروع قبل وبعد التطوير
او بين مشروعين بنفس الخصائص.

" average (mean) number of Crashes "

null hypothesis

$\mu_1 = \mu_2 : H_0$

مهم

$H_1 : \mu_1 > \mu_2$ (one tail test)
$H_1 : \mu_1 < \mu_2$ (one tail test)
$H_2 : \mu_1 \neq \mu_2$ (two - tail test)

****** القيمه التي نحسبها

$$\boxed{T = \frac{\bar{X}_1 - \bar{X}_2}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}}$$

$\bar{X}_1 , \bar{X}_2$: Sample means
n_1 , n_2 : sample size
$S_p = \cdots$

$$\boxed{S_p^2 = \frac{(n_1 - 1) S_1^2 + (n_2 + 1) S_2^2}{\underbrace{(n_1 + n_2 - 2)}_{\text{degree of freedom}}}}$$

S_1 , S_2 : Varianse of the populations

****** بالسؤال يذكر في النص اي الفرضيات " H_1 " المطلوبه عنطريق :.

① determine it can be concluded that Crashes1 (نوع او منطقه معينه) are significantly higher (or Lower تأكد منها) than the crashes 2 $\Rightarrow H_1$ is $\mu_1 > \mu_2$ مهم
or $\mu_1 < \mu_2$

مهم جداً عند اختيار قيمه ال t التي تريد المقارنه معها تختار t_α

if
② there is significantly difference between 1 & 2

H_1 is $\mu_1 \neq \mu_2$

قيمه ال t نختار $t_{\alpha/2}$

α : significant Level

3 ممكن تكون or if the difference are the same .

⇐ بعد حساب ال T و ال t نقوم بالمقارنه

if H_1 is حسب السؤال	reject H_0
$\mu_1 > \mu_2$	$T > t_\alpha$
$\mu_1 < \mu_2$	$T < t_\alpha$
$\mu_1 \neq \mu_2$	$\lvert T \rvert > t_{\alpha/2}$ ⟶ $T > t_{\alpha/2}$ او $-T < -t_{\alpha/2}$

** اذا تحقق الشرط يعني تم رفض فرضيه ال H_0 و بالتالي فرضيه ال H_1 صحيحه.

$\boxed{2}$ proportionality test :

"between Independent proportions"

$H_0 : P_1 = P_2$

$H_1 : P_1 > P_2$, $P_1 < P_2$ (one tail test)

$P_1 \neq P_2$ (two-tail test)

$\boxed{**}$ القيمه المطلوب حسابها للمقارنه

$$\boxed{Z = \frac{P_1 - P_2}{\sqrt{P(1-P)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}}$$

$$P = \frac{X_1 + X_2}{(n_1 + n_2)} , \quad P_1 = \frac{X_1}{n_1} , \quad P_2 = \frac{X_2}{n_2}$$

n_1 : total number of observation in data set i

مهم X_1 : successfull observation in data set i

n → total كل الانواع

X → النوع المطلوب بالسؤال

** نفس مقارنات النوع الاول راجعهم و لا تنسى

$Z_{\alpha/2}$ → two tail test

$\boxed{4}$

$\boxed{3}$ Kruskal - wallis H test :

" between <u>distribution</u> of crashes "

null hypothesis :

H_0 : the probability distributions for crashes is the same .

H_1 : the probability distributions are no the same .

$\boxed{**}$ القيمه المطلوب حسابها للمقارنة

$$\boxed{H = \frac{12}{n(n+1)} \left(\sum \frac{R_j^2}{n_j} \right) - 3(n+1)}$$

n_j : number of measurments in th
jth sample

n = total sample size

R_j = rank sum for sample j

** طريقة الحل : ترتيب الحوادث تصاعدياً ومن ثم اعطاء اقل عدد rank "1" ومن ثم الاستمرار لاكبر عدد " يجب ان يكون اكبر rank = عدد العينات "
عند وجود تشابه في عدد الحوادث بين منطقتين ، نأخذ اوسط الـ rank للمنطقتين و نوحده الهم الثنتين مثال :

1		2	
no. of crashes	rank	no of crashes	rank
7	~~8~~(8.5)	7	~~9~~(8.5)

$\frac{9+8}{2} = 8.5$ "

** degrees of freedom = $k - 1$
↳ number of dirstri. ~~bei~~ being considere

** نقارن بين الـ H و $X^2_{\alpha,dF}$ ⇐

$H < X^2_{\alpha,\text{degree of freedom}}$ ⟶ accept null hypothesis

$H > X^2_{\alpha,\text{doF}}$ ⟶ reject null hypothesis

$\boxed{5}$

Q6: The number of crashes occurring over a period of three years for different injuries (Fatal, Severe, Slight) at a rural freeway and an urban freeway with the same characteristics are given in the table below. Determine whether it can be concluded that the fatal crashes occurring on rural freeways follow the same distribution as those that occur on urban freeways. Use a significance level of 5 percent. (10 points)

Knowing that for the given data: $t_{0.05}$= 1.943, $Z_{0.05}$= 1.645, $X^2_{0.05}$= 3.84146

$t_{0.025}$=0.065, $Z_{0.025}$=1.96, $X^2_{0.025}$=5.02389

Site	Rural freeway			Urban freeway		
	Fatal	**Severe**	**Slight**	**Fatal**	**Severe**	**Slight**
1	5	15	40	6	20	31
2	3	20	30	5	23	42
3	2	12	26	0	15	21
4	4	13	19	4	22	20

~~ex: 5.9~~

Question 4 (10 Points):

It is required to test whether large trucks are significantly more involved in serious crashes on two lane primary highways than on multilane primary highways. Using the *t* **test** and the data on crash rates for serious crashes given in the table below, **determine whether you can conclude that large trucks are more involved in serious crashes on two-lane primary roads than on multi-lane primary roads.** Use a significance level of 5 percent. (T-tables are on the last page)

Truck Crash Rates per 100MVMT

Two Lane Primary Highways	*Multilane Primary Highways*
0.256	0.188
0.342	0.312
0.842	0.421
1.021	0.285
0.361	0.225
0.262	0.183
0.861	0.341

Q6 :

$\Rightarrow$ the same distribution $\rightarrow$ Kruskal - walls H test :

rural		urban	
no. of crashes "fatal"	rank	no. of crashes (fatal)	rank
2	2	0	1
3	3	4	4(4.5)
4	~~5~~(4.5)	5	6(6.5)
5	7(6.5)	6	8
	Σ 16		Σ 20

$\alpha = 5\%$, $n = 8$

$$H = \frac{12}{8(8+1)} * \left(\frac{16^2}{4} + \frac{20^2}{4} \right) - 3*(8+1) = \boxed{0.333}$$

$X^2_{0.05} = 3.84 > H \rightarrow$ same distribution "accept null hypothesis"

Q4 :

$\Rightarrow$ using the t-test معطى بالسؤال

$\bar{X}_1 = 0.564$

$\bar{S}_1^2 = 0.1085$

$n = 7$

$\bar{X}_2 = 0.2793$

$\bar{S}_2^2 = 7.591 * 10^{-3}$

, H_1 is $\mu_1 > \mu_2 \rightarrow t_\alpha$

$Sp^2 = 0.05804 \rightarrow Sp = 0.241$

$$T = \frac{0.564 - 0.2793}{0.241 \left(\frac{1}{7} + \frac{1}{7} \right)} = \boxed{2.12}$$

$t_{0.05} = 1.782$

$T = 2.12 > t_{0.05} = 1.782$

$\rightarrow$ reject Ho , there are significant difference between 1 & 2.

[illegible]

The number of crashes occurring for over a period of three years for different urban roadway types (local, arterial, and freeway) are given in the table below. Determine whether it can be concluded that the distribution of crashes at these roadways are the same. Use a significance level of 5 percent.

Knowing that: $t_{0.05}= 9.925$, $Z_{0.05}= 1.645$, $X^2_{0.05}= 5.991$

No.	**Number of Crashes**		
	Local	**Arterial**	**Freeway**
1	6	34	13
2	35	28	35
3	3	42	19
4	17	13	4
5	11	40	29
6	30	31	0
7	15	9	7
8	16	32	33
9	25	39	18
10	5	27	24

Q :

⇒ distribution ⟹ Kruskal – H test :

no. of crashes Local	R_1	no. of crashes Arterial	R_2	No of crashes freeway	R_3
3	2	9	7	0	1
5	4	13	~~9~~ (9.5)	4	3
6	5	27	18	7	6
11	8	28	19	13	~~16~~ (9.5)
15	11	31	22	18	14
16	12	32	23	19	15
17	13	34	25	24	16
25	17	39	28	29	20
30	21	40	29	33	24
35	~~27~~ (26.5)	42	30	35	~~26~~ (26.5)
	Σ 119.5		Σ 210.5		Σ 135

$n = 30$

$$H = \frac{12}{30(30+1)} * \left(\frac{119.5^2}{10} + \frac{210.5^2}{10} + \frac{135^2}{10} \right) - 3(30+1)$$

$$= \boxed{6.117}$$

$X^2_{0.05} = 5.991 < H$ → reject Ho "not same"