9/15/08

HW 1: 2.6, 2.8, 2.11 due 9/22/08

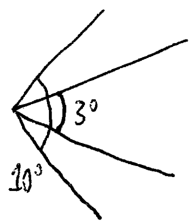
20/20 : normal vision

$H = \frac{1}{3}$ in $d = 20$ ft

20/40

$H = \frac{1}{3}$ in $d = 10$ ft

Vision Region(s)



Ex. 20/20 vision $H = 2$ in $d = 90$ ft

20/50 vision $H = 2$ in $d = ?$

$$x = 90 \text{ ft} \cdot \frac{20}{50} = 36 \text{ ft}$$

20/60 vision $H = ?$ $d = 90$ ft

$$H = 2 \text{ in} \cdot \frac{60}{20} = 6 \text{ in}$$

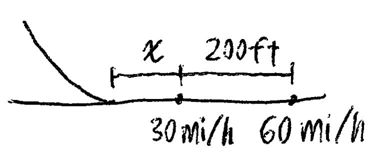
$90 : 6 = 36 : x$ Find H

$$x = \frac{36 \cdot 6}{90} = 2.4 \text{ in}$$

20/40 vision

$d = 50$ ft $H = 1$ in $V_0 = 60$ mi/h $V = 30$ mi/h

for 20/20 $H = 8$ in



$d = 8 \times 50 = 400$ ft (for 20/20)

$d = 200$ ft (for 20/40)

$V_0 = 88$ ft/s $V = 44$ ft/s

δ = perception reaction time

$$x = \frac{V_0^2 - V^2}{2g(f+G)} = \frac{88^2 - 44^2}{2(32.2)(0.3)} + \underbrace{V_0}_{88 \text{ ft/s}} \cdot \underbrace{\delta}_{1.5} = 433 \text{ ft}$$

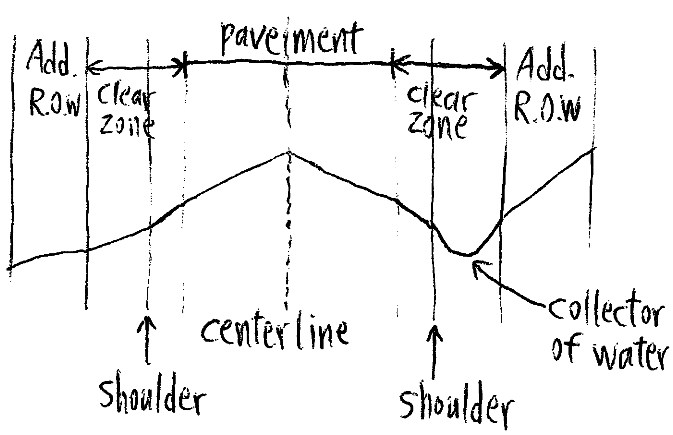
2 ways to classify highways:

1) functionality
2) entity

	Rural	Urban
Principal Arterials	Freeways Others	Interstate Freeways Freeways Others
Minor Arterials (Collectors)	Major Minor Local Roads	Collectors Local Streets

$\left\{\begin{array}{l}\text{cross-section}\\ \text{horizontal alignment}\\ \text{superelevation}\\ \text{vertical alignment}\\ \text{intersections}\end{array}\right.$

Cross-Section



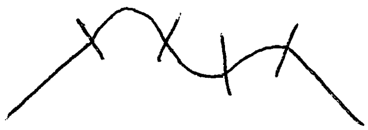
Slope = Normal crown

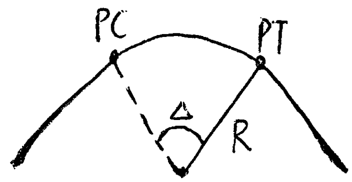
$\frac{1}{8}$ to $\frac{1}{4}$ in/ft

9/17/08

HW 1 postponed → due Fri 9/26

Horizontal Alignment





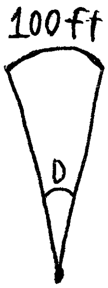
A is located:

14 sta from a ref. point

1400 ft

1 sta = 100 ft

$$L = 2\pi R \cdot \frac{\Delta}{360}$$

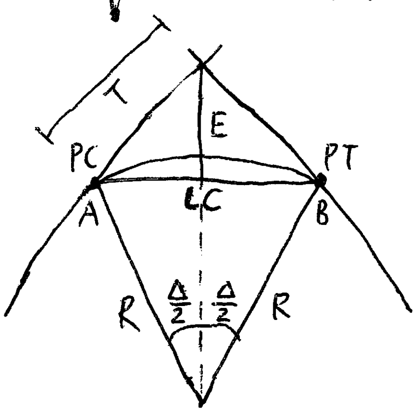


Arc definition

$$\frac{100}{2\pi R} = \frac{D}{360} \Rightarrow D = \frac{5729.58°}{R}$$

Chord definition

$$\sin\left(\frac{D}{L}\right) = \frac{50}{R}$$



M = middle ordinate distance

$$M = R - R\cos\frac{\Delta}{2} = R\left(1 - \cos\frac{\Delta}{2}\right)$$

T = length of tangent

$$T = R\tan\frac{\Delta}{2}$$

L = length of curvature

$$L = 100 \cdot \frac{\Delta}{D}$$

LC = long chord

$$LC = 2R\sin\frac{\Delta}{2}$$

$$e + f_s = \frac{V^2}{gR} \quad \text{OR} \quad e + f_s = \frac{V^2}{15R}$$

$e = 0.12$ ft/ft
→ 0.1
→ 0.08
max e

$f_s = 0.17$ 20 mi/h
0.10 70 mi/h
max f_s

$$R_{min} = \frac{V^2}{g(e_{max} + f_s)}$$

$R > R_{min}$

Ex. Calculate D & R_{min}

$\Delta = 100°$
$V = 50$ mi/h
$f_{max} = 0.14$

$$R_{min} = \frac{V^2}{15(e_{max} + f_s)} = \frac{50^2}{15(0.1 + 0.14)} = 695 \text{ ft}$$

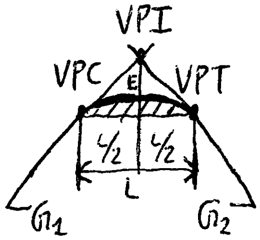
$$D = \frac{5729.58°}{R} = 8.24°$$

Ex. Calculate e

$R = 800$ ft
$V = 50$ mi/h
$f_s = 0.14$

$$e = \frac{V^2}{15R} - f_s = \frac{50^2}{15(800)} - 0.14 = 0.07 \text{ ft/ft}$$

Vertical Alignment



freeways 2%–6%
local streets 6%
railroad max 4%

percent grade $A = G_2 - G_1$ <0 crest curve; >0 sag curve

Absolute value of change in grade $k = \frac{L}{|A|}$ $E = \frac{A*L}{800}$ External Distance

offset => $y = 4E\left(\frac{x}{L}\right)^2$

Highest point $X = \frac{LG_1}{G_1 - G_2}$ Elevation of P = Elevation of VPC + $\frac{G_1 x}{100} + y$

Ex. $L = 600$ ft
$G_1 = 4\%$ $G_2 = -2\%$
25+60.55 sta. <= VPI(x)
VPC=?
Middle of the curve
Curve elevation at 24 and 27 sta.
VPI elev. 648.64 ft

	pt. Sta	x	tan elev.	off-set	curve elev.
VPC	22+60.55	0	636.64	0	636.64
24.00	24	139.45	642.21	-0.97	641.25
VPI	25+60.55	300	648.64	-4.5	644.14
27.00				-9.66	644.56
VPT				-18	642.64
High	26+60.55	400	652.64	-8.0	644.64

$A = G_2 - G_1 = -2 - (4) = -6\%$

$k = \frac{L}{|A|} = \frac{600}{6} = 100$ ft $E = \frac{AL}{800} = \frac{-6 \times 600}{800} = -4.5$ ft

$X = \frac{LG_1}{G_1 - G_2} = \frac{600 \times 4}{4+2} = 400$ ft $y = 4E\left(\frac{x}{L}\right)^2 = 4(-4.5)\left(\frac{400}{600}\right)^2 = -8.0$

Tan elev. VPC: $648.64 - 300(.04) = 636.64$

Tan elev. P: $636.64 + 400(.04) = 652.64$

x for 24 Sta: $2400 - 2260.55 = 139.45$ Tan elev. 24 Sta: $636.64 + 139.45 \times .04$

$y(24\text{ Sta}) = 4(-4.5)\left(\frac{139.45}{600}\right)^2$

9/24/08

Exercise 2.20

$L = 2000$ ft

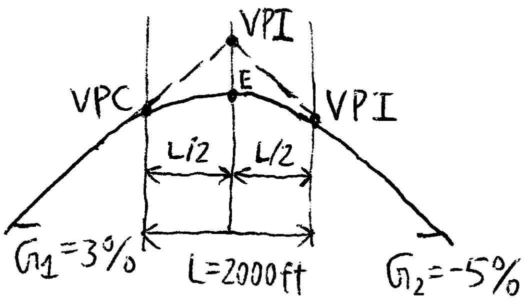
$G_1 = 3\%$ $\quad G_2 = -5\%$

VPI intersects at 52+60.55 sta

VPI elevation = 877.62 ft

Find:

* VPC
* VPT
* high point
* 54.00 sta



$$A = G_2 - G_1 = -5 - 3 = -8\%$$

$$K = \frac{L}{|A|} = \frac{2000}{8} = 250\ \text{ft}/^\circ$$

$$E = \frac{AL}{800} = \frac{-8 \times 2000}{800} = -20\ \text{ft}$$

		Point	x	Tangent elevation	y	Curve elevation y'
	VPC	42+60.55	0	847.62	0	847.62
high pt.		50+10.55	750	870.12	-11.25	858.87
	VPI	52+60.55	1000	877.62	-20	857.62
54.00		54.00	1139	881.79	-25.95	855.84
	VPT	62+60.55	2000	907.62	-80	827.62

Note:
$y' = T_E - y$

$$T_{E(VPC)} = \frac{L}{2} \times G_1 = 1000 \times 3\% = 30\ \text{ft}$$

$$y_{(VPT)} = 4E\left(\frac{x}{L}\right)^2 = 4 \times (-20)\left(\frac{2000}{2000}\right)^2 = -80\ \text{ft}$$

High Point $\rightarrow x = \dfrac{L G_1}{G_2 - G_1}$

$$x = \frac{2000 \times 3}{8} = 750\ \text{ft}$$

$$T_{E(HP)} = x * G_1 = 750 \times 3\% = 12.5\ \text{ft}$$

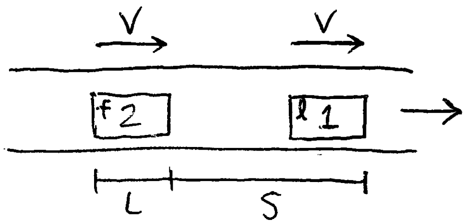
$$y_{(HP)} = 4E\left(\frac{x}{L}\right)^2 = 4 \times (-20)\left(\frac{750}{2000}\right)^2 = -11.25\ \text{ft}$$

$$T_{E(54.00)} = 1139 \times 3\% = 847.62$$

$$y = 4(-20)\left(\frac{1139}{2000}\right)^2 = -25.95$$

9/26/08

Uninterrupted



V_0 = initial speed of vehicle

d_ℓ = deceleration rate of leading vehicle

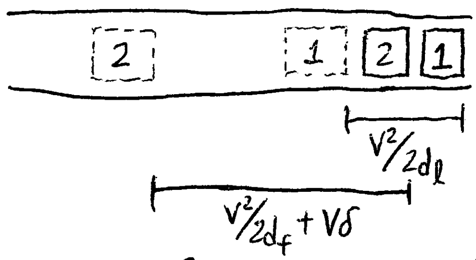
d_f = deceleration rate of following vehicle

δ = perception-reaction time

x_0 = safety margin after stop

L = length of the vehicle

N = number of vehicles in train



$$x_\ell = \frac{V^2}{2d_\ell} \qquad x_f = \frac{V^2}{2d_f} + V\delta \qquad S = x_f - x_\ell + NL + x_0$$

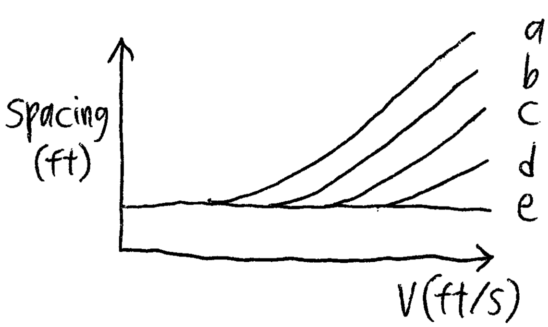
$$x_f = S + x_\ell - NL - x_0 \qquad S = V\cdot\delta + \frac{V^2}{2d_f} - \frac{V^2}{2d_\ell} + NL + x_0$$

d_n = normal deceleration rate

d_e = emergency " "

∞ = instantaneous stop

a best safety cond.
b
c
d
e worst safety cond.



$L = 20$ ft

$N = 1$

$x_0 = 3$ ft

$\delta = 1$ s

$d_n = 8$ ft/s²

$d_e = 24$ ft/s²

Regime	Decel. leading Veh.	Decel. following Veh.
a	∞	d_n
b	d_e	d_n
c	∞	d_e
d	d_e	$\neq$ d_f
e	no breaking	no breaking

Ex. (Prob 3.1)

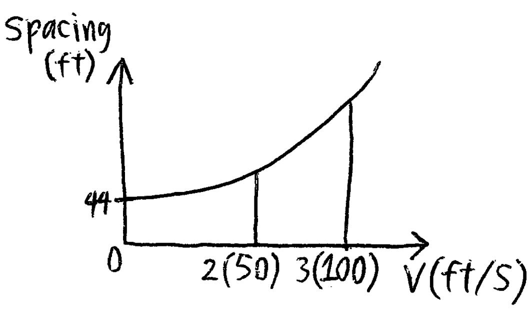
$N=1$ | $d_n = 8\ ft/s^2$ | Find:
b safety regime | $d_e = 32\ ft/s^2$ | $* S \leftrightarrow V$
$\delta = 1.5\ s$ | $L = 40\ ft$ |
 | $x_0 = 4\ ft$ |

$d_l = d_e$

$d_f = d_n$

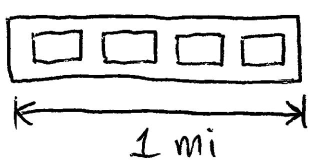
$$S = V \cdot \delta + \frac{V^2}{2d_n} - \frac{V^2}{2d_e} + NL + x_0$$

① $S = V(1.5) + \frac{V^2}{2(8)} - \frac{V^2}{2(32)} + 1(40) + 4$

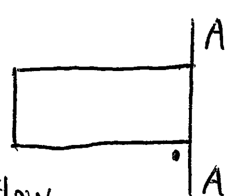


② $S = 50(1.5) + \frac{50^2}{16} - \frac{50^2}{64} + 44$

Concentration (K): number of vehicles per roadway length



$K = \frac{4\ veh.}{1\ mi} = 4\ veh./mi$ $\quad S = 1/K$



flow

q (veh/hr)

$h = \frac{1}{q}$ headway

Average Speed

Time Mean Speed

$$\mu_t = \frac{1}{N}\sum_{i=1}^{N} V_i$$

Space Mean Speed

$t_i = D/V_i$

$$t_{avg} = \frac{1}{N}\sum_{i=1}^{N}\frac{D}{V_i} \qquad \mu_s = \frac{1}{\frac{1}{N}\sum_{i=1}^{N}\frac{1}{V_i}}$$

9/29/08

HW 2 due 10/8

2.21, 3.9, 3.14, $\underset{?}{\underline{3.17}}$

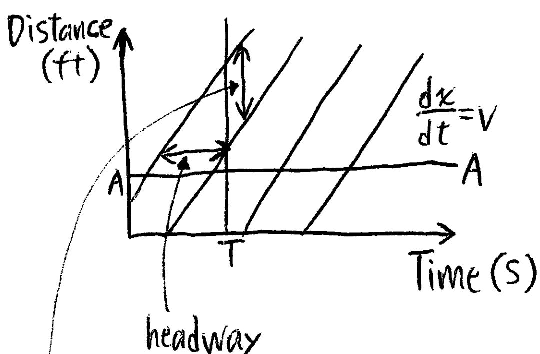
Ex.

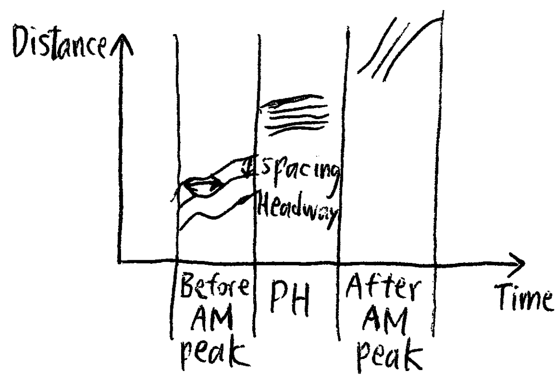
30, 40, 50, 60 ft/s

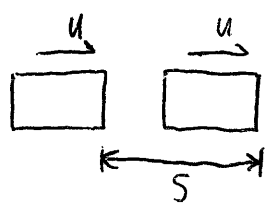
$$\mu_t = \frac{1}{4}\left(\frac{30+40+50+60}{}\right) = 45 \text{ ft/s}$$

$$\mu_s = \frac{1}{\frac{1}{4}\cdot\left(\frac{1}{30}+\frac{1}{40}+\frac{1}{50}+\frac{1}{60}\right)} = 42.1 \text{ ft/s}$$

μ_t & μ_s are different



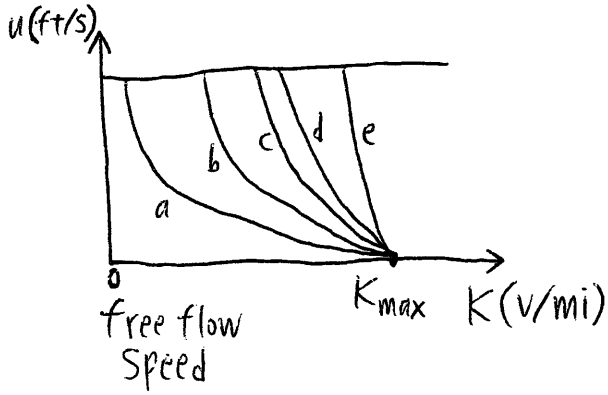




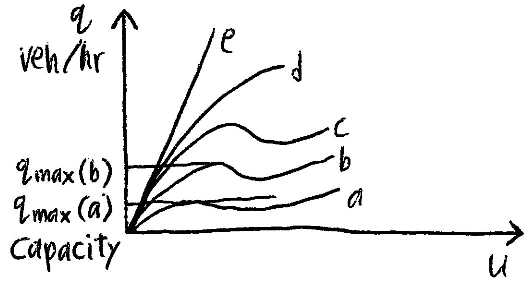
$$h = \frac{S}{u} \qquad h = \frac{1}{q} \qquad K = \frac{1}{S} \Rightarrow S = \frac{1}{K}$$

$$\frac{1}{q} = \frac{1}{K\cdot u} \qquad q = K\cdot u$$

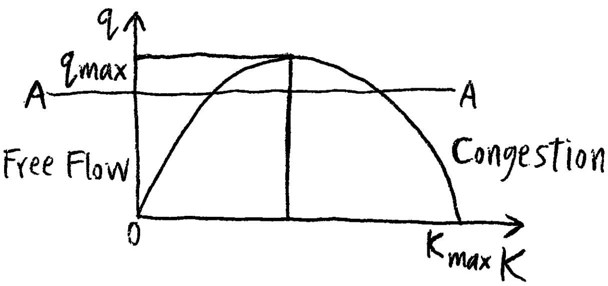
$$S = u\delta + \frac{u^2}{2d_f} - \frac{u^2}{2d_\ell} + NL + x_0 \qquad K = \frac{1}{S} = \frac{1}{u\delta + \frac{u^2}{2d_f} - \frac{u^2}{2d_\ell} + NL + x_0}$$

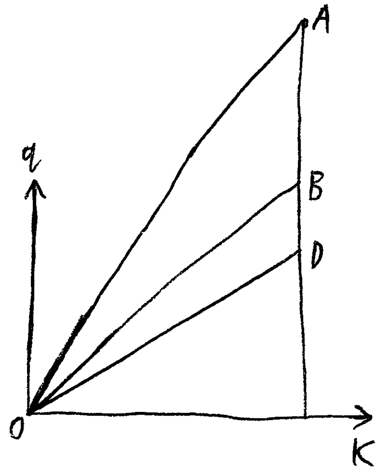


$$q = Ku = \frac{u}{u\delta + \frac{u^2}{2d_f} - \frac{u^2}{2d_l} + NL + x_0}$$

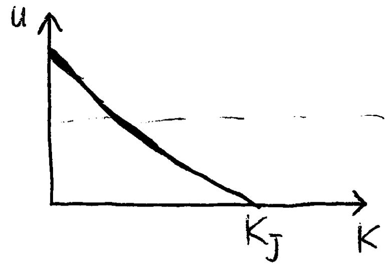


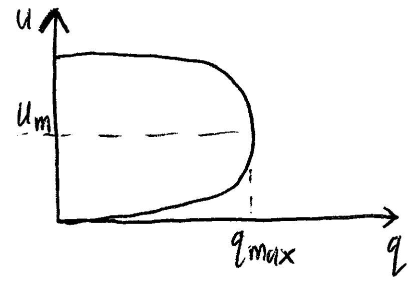
$$q = Ku \Rightarrow q = K \cdot u(K)$$

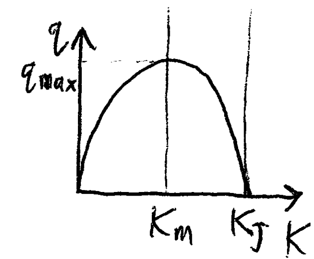




10/1/08





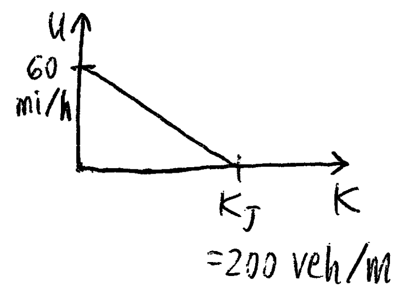


Ex. Exercise 3.4

$$S = \frac{0.30}{(60-u)}$$

Find
* $u-K$
* $u-q$
* $q-K$
* q_{max}

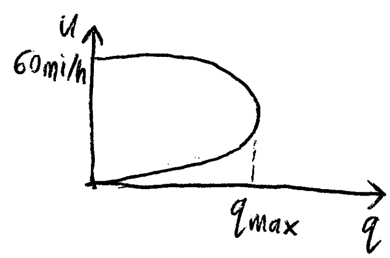
$$\frac{1}{K} = \frac{0.30}{60-u} \Rightarrow K = \frac{60-u}{0.30} = 200 - 3.33u$$



$$u = \frac{q}{K} = \frac{q}{60-u} \cdot 0.30$$

$$0.30q = 60u - u^2$$

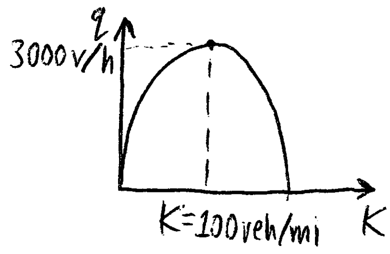
$$q = \frac{60u - u^2}{0.30} = 200u - 3.33u^2$$



$$K = 200 - 3.33\frac{q}{K}$$

$$K^2 = 200K - 3.33q$$

$$q = \frac{200K - K^2}{3.33} = 60K - 0.3K^2$$

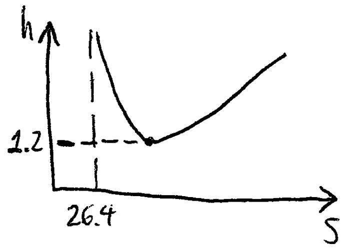


$$q_{max} \Rightarrow \frac{dq}{dK} = 0 \qquad 60 - 0.6K = 0$$

$$K = 100$$

$$q_{max} = 6000 - 3000 = 3000 \text{ veh/hr}$$

Ex.



jam conditions $\quad u=0 \quad K=\frac{60}{0.3}$

[redacted] $\quad S=\frac{1}{K}=\frac{0.3}{60}=0.005 \text{ mi}=26.4 \text{ ft}$

at capacity $\quad h=\frac{1}{q_{max}}=\frac{3600}{3000}=$ [redacted] 1.2

Ex. Exercise 3.8

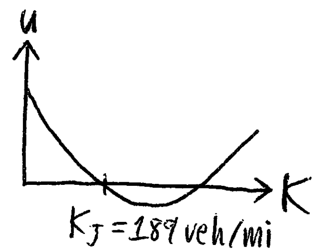
$u+2.6=0.001(K-240)^2$ $\qquad$ Find: $u_{ff}, K_J, q_{max}, u_m$

speed of free flow

$K=0 \Rightarrow u_{ff}=0.001(240)^2-2.6=55 \text{ mi/h}$

$u=0 \Rightarrow (K-240)^2=2.6$

$K_J=189$ or 291 veh/mi



$\frac{dq}{dK}=0 \qquad q=u\cdot K=\left(0.001(K-240)^2-2.6\right)K$

$=0.001K^3-0.48K^2+55K$

$\frac{dq}{dK}=0.003K^2-0.96K+55=0 \qquad K=75$ or 245

[redacted] $K_m=75 \qquad q_{max}=1846$ veh/hr

$u_m=\frac{q_{max}}{K_m}=\frac{1846}{75}=24.6 \text{ mi/h}$

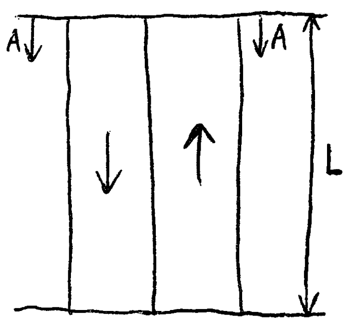
For Exam 1:

1. Rectilinear and Curvilinear Motion
2. Perception Reaction Time & Visual Acuity
3. Horizontal & Vertical Alignment
4. u-K-q
5. The moving observer
6. Shock Waves

10/3/08

The moving observer method

$q = u \cdot K$



1st case

$q = \frac{N_o}{T}$

2nd case

$K = \frac{N_p}{L}$

$N_p = KL = KVT$
$= K \times L = K \times V \times T$

3rd case

M_o: number of vehicles overtake by the observer

M_p: number of vehicles overtaken the observer

$M = M_o - M_p$
$= qT - KVT$

$\frac{M}{T} = q - KV$

$\downarrow \quad T_a \quad M_a$

$\uparrow w \quad T_w \quad M_w$

$q = \frac{M_w + M_a}{T_w + T_a}$

* M_o: car faster than obs.
* M_p: car slower than obs.

Ex. $L = 5$ mi

$\uparrow w$

	V	$M_o - M_p$
1	10	100
2	20	-150

Find:
* q
* K
* u_s
* S
* h

$\frac{M_1}{T_1} = q - KV_1$

$\frac{100}{T_1} = q - 10K$

$\frac{100}{0.5} = q - 10K \qquad \frac{-150}{0.25} = q - 20K$

$200 = q - 10K \qquad -600 = q - 20K$

$-600 = 200 + 10K - 20K$

$K = 80$ veh/mi

$200 = q - 800$

$q = 1000$ veh/hr

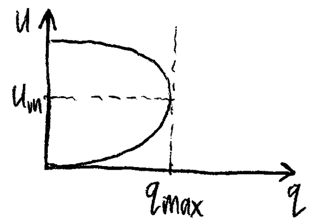
$h = \frac{1}{q} = \frac{1}{1000} = 0.001 \text{ hr} = 3.6 \text{ s}$

$S = \frac{1}{K} = \frac{1}{80} = 0.013 \text{ mi} = 66 \text{ ft}$

$u = \frac{q}{K} = \frac{1000}{80} = 12.5 \text{ mi/hr}$

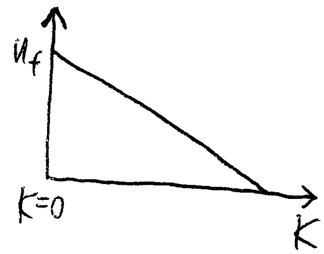
$q = q(u) \quad q = a + bu$

q_{max} & u_m , $K_m = \frac{q_{max}}{u_m}$



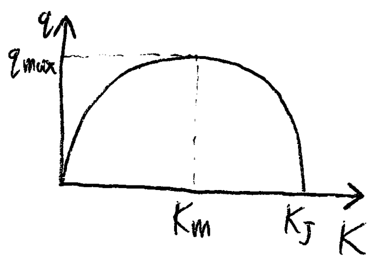
$\frac{dq}{du} = 0 \rightarrow u$

$u_{ff} \quad K=0 \quad u = u(K)$



To get q_{max}, need q-u or q-K

$K_J \quad q=0 \quad q = q(K)$



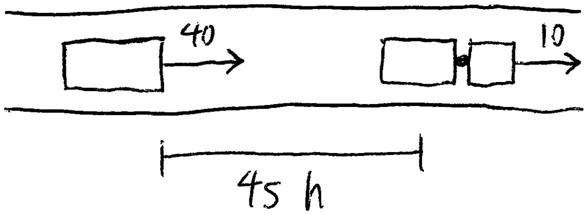
q_{max}?

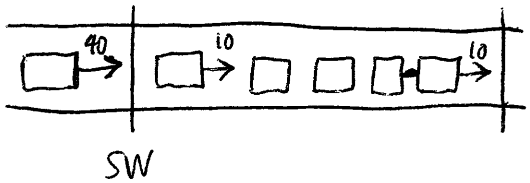
$\frac{dq}{dK} = 0 \rightarrow K_m \rightarrow q_{max} \qquad q=0 \rightarrow K_J$

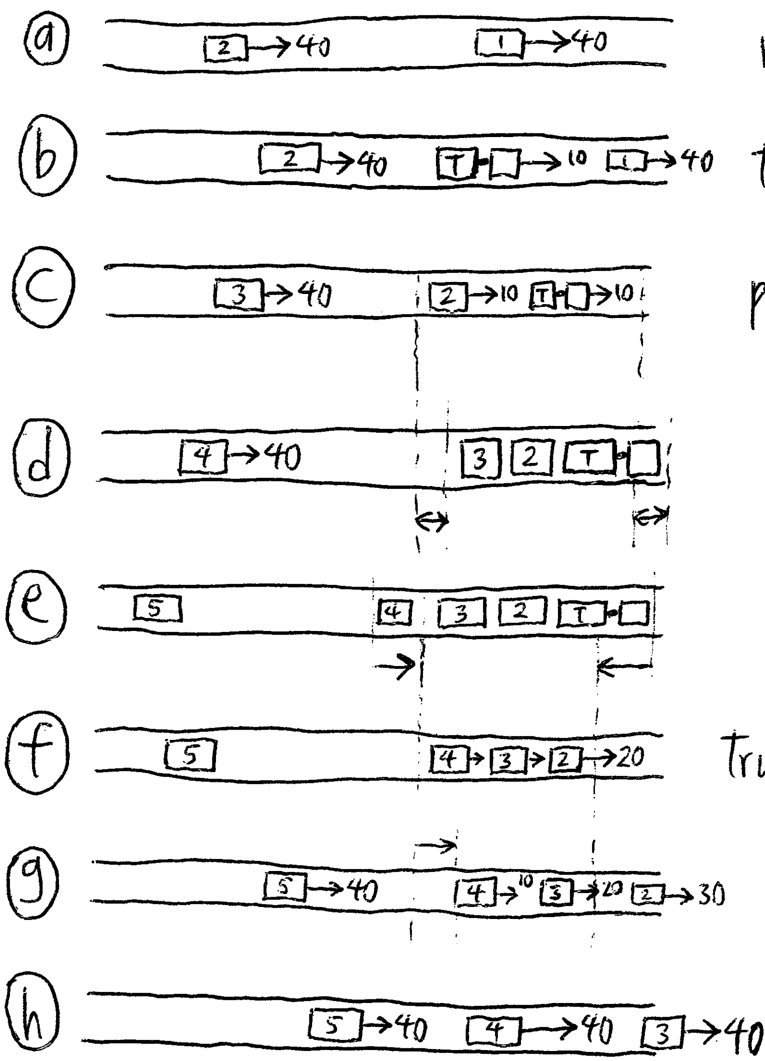
$u_m = \frac{q_{max}}{K_m}$

10/6/08

Shockwaves





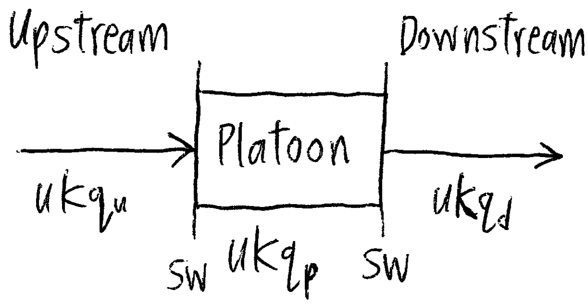


normal flow

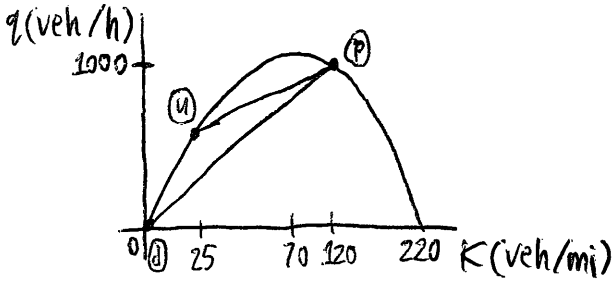
truck enters

platoon begins

truck exits



Graphical

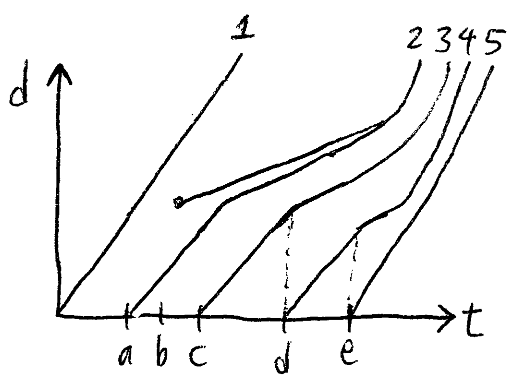


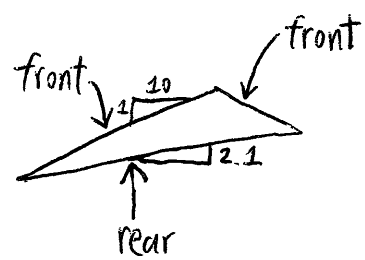
$u_{up} = 40$ mi/h
$q_{up} = 1000$ veh/h
$K_{up} = 25$ veh/mi

$u_p = 10$ mi/h
$q_p = 1200$ veh/h
$K_p = 120$ veh/mi

$u_d = 40$ mi/h
$q_d = 0$ veh/h
$K_d = 0$ veh/mi

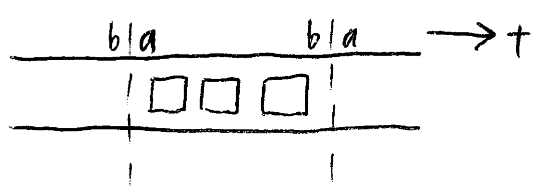
$$\frac{\Delta q}{\Delta K} = \frac{1200-1000}{120-25}$$
$$= 2.1 \text{ mi/h}$$





Analytical Method

$$u_{sw} = \frac{q_b - q_a}{K_b - K_a}$$ where b is the conditions upstream of a



$u_{sw} > 0$, shockwave $\longrightarrow$
< 0, shockwave $\longleftarrow$
$= 0$, stationary

① $u_x, u_Y > 0$

$u_Y > u_x$ forward

$u_Y < u_x$ backward

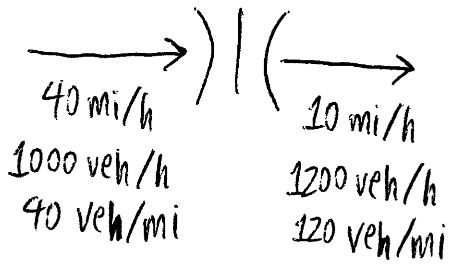
② $u_x > 0$, $u_Y < 0$

③ $u_x, u_Y < 0$

similar to ①

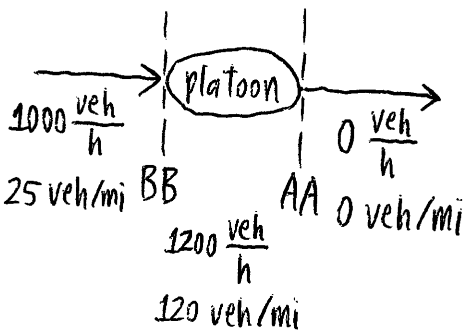
10/8/08

Review



Exam 1 Fri
* 5 or 6 problems
* open book

Example 3.5



Find:
* $u_{sw,BB}$
* $u_{sw,AA}$
* $u_{sw,AA} - u_{sw,BB}$

a | b

1200 veh/h   0 veh/h
120 veh/mi   0 veh/mi

$$u_{sw,AA} = \frac{q_b - q_a}{k_b - k_a}$$

$$= \frac{0-1200}{0-120}$$

$$= +10 \text{ mi/h}$$

a | b

1000   1200
25   120

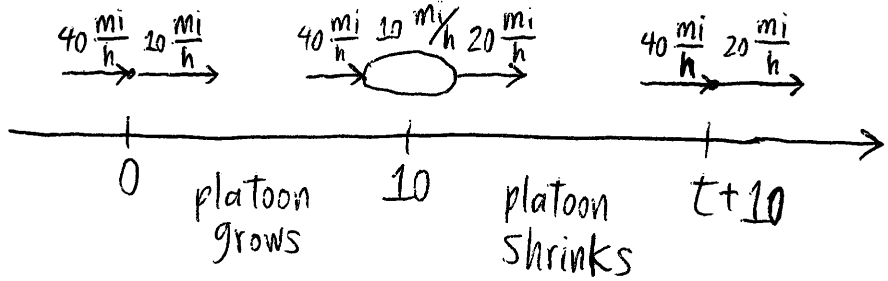
$$u_{sw,BB} = \frac{q_b - q_a}{k_b - k_a}$$

$$= \frac{1200-1000}{120-25}$$

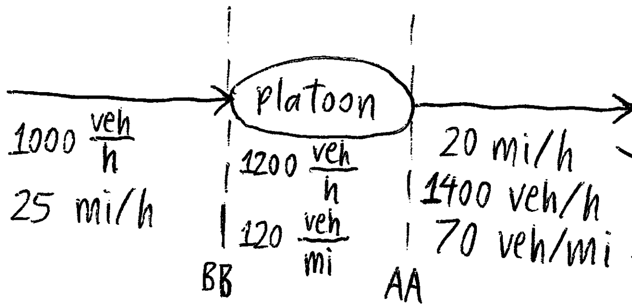
$$= +2.1 \text{ mi/h}$$

$$\Delta u_{sw} = u_{sw,AA} - u_{sw,BB}$$

$$= 10 - 2.1 = 7.9 \text{ mi/h}$$



Example 3.6



$q = uk$
$= 20 \times 70 = 1400$

From 3.5 Δu platoon $= 7.9$ mi/h

$$l = uT = 7.9 \frac{mi}{h} \times \frac{1}{6} h = 1.3 \text{ mi}$$

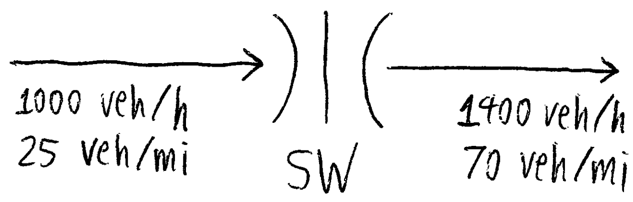
$$u_{sw,BB} = 2.1 \text{ mi/h}$$

$$u_{sw,AA} = \frac{1400-1200}{70-120} = \frac{200}{-50} = -4 \text{ mi/h}$$

$$\Delta u = -4 - 2.1 = -6.1 \text{ mi/h}$$

$$t = \frac{l}{u} = \frac{1.3 \text{ mi}}{-6.1 \text{ mi/h}} = 0.21 \text{ h} = 12 \text{ mins}$$

Example 3.7



$$u_{sw} = \frac{q_b - q_a}{k_b - k_a} = \frac{1400-1000}{70-25} = +8.9 \text{ mi/h}$$

Exercise 3.12

Test Run	Test Veh Speed (mi/h)	$M_o - M_p$ Veh
1	10	100
2	20	-150

eq 3.5.4 $\frac{M}{T} = q - kV$

where $M = M_o - M_p$

$T_1 = 0.5$ h $\quad V_1 = 10 \quad M_1 = 100$

$T_2 = 0.25$ h $\quad V_2 = 20 \quad M_2 = -150$

$$\frac{M_1}{T_1} = q - kV_1 \quad (1)$$

$$- \quad \frac{M_2}{T_2} = q - kV_2 \quad (2)$$

$$\frac{M_1}{T_1} - \frac{M_2}{T_2} = (q - kV_1) - (q - kV_2)$$

$$\frac{M_1}{T_1} - \frac{M_2}{T_2} = -kV_1 + kV_2 = k(V_2 - V_1)$$

$$\frac{100}{.5} - \frac{-150}{.25} = k(20-10)$$

$$k = \frac{\frac{100}{.5} + \frac{150}{.25}}{20-10} = 80 \text{ veh/mi}$$

$$\frac{100}{.5} = q - 80(10)$$

$$q = \frac{100}{.5} + 80(10) = 1000 \frac{\text{veh}}{\text{h}}$$

$k = 80$ veh/mi

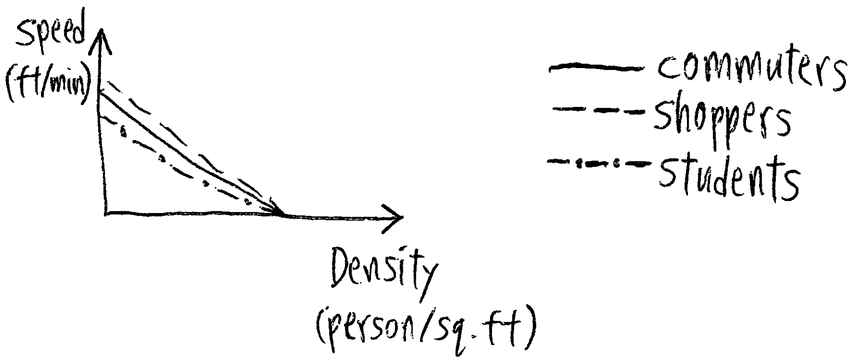
$q = 1000$ veh/h

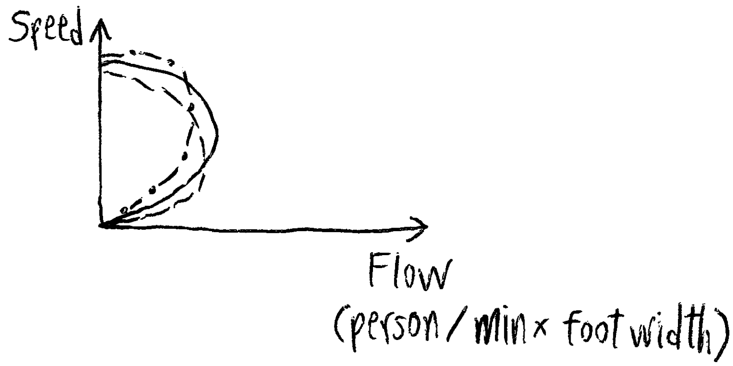
$u = q/k = 12.5$ mi/h

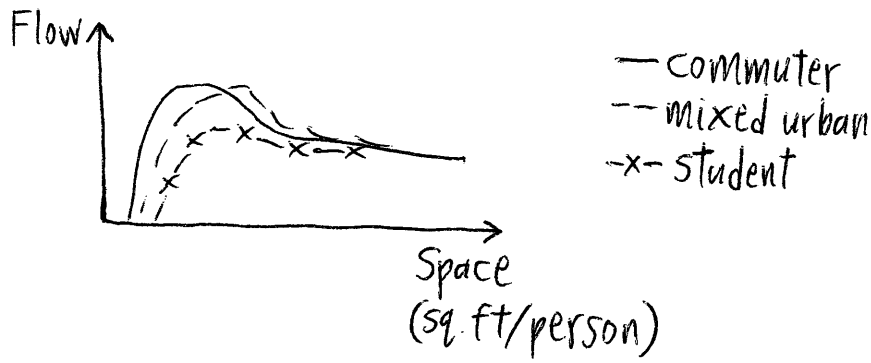
$s = 1/k = 0.013$ mi $= 66$ ft

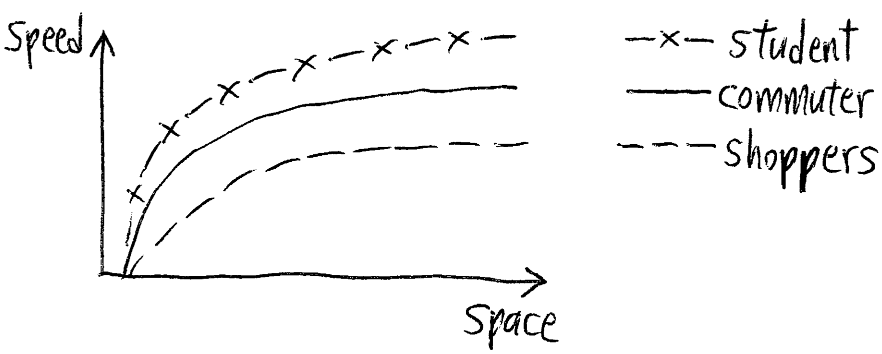
$h = 1/q = 0.001$ h $= 3.6$ s

10/13/08







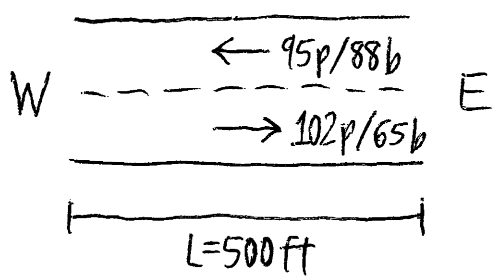


MP: number of events per hour that a bicylist experiences

$$MP_{exclusive} = V_o + 0.118\, V_s$$

$$MP_{shared} = 2.5 V_{po} + V_{bo} + 3 V_{ps} + 0.118\, V_{bs}$$

Ex.



Direction	Pedest. Vol	Biker Vol
EB	102	65
WB	95	88

Pedestrians EB

$MP_{EB} = \frac{3600}{95} = 37.9\,s$ LOS C

$3600s = 1\,hr$

Pedestrians WB

$MP_{WB} = \frac{3600}{102} = 35.3\,s$ LOS C

Bikers EB

$MP = V_o + 0.118\,V_s$

$= 88 + 0.118(65) = 95.7$

LOS C

Bikers WB

$MP = V_o + 0.118\,V_s$

$= 65 + 0.118(88) = 75.4$

LOS C

Ped & Bike EB

Ped

$\frac{3600}{95+88} = 19.6\,s$ LOS D

Bike

$MP = 2.5V_{po} + V_{bo} + 3V_{ps} + 0.118V_{bs}$

$= 2.5(95) + 88 + 3(102) + 0.118(65)$

$= 639.2$

Ped & Bike WB

Ped

$\frac{3600}{102+65} = 21.6\,s$ LOS D

Bike

$MP = 2.5V_{po} + V_{bo} + 3V_{ps} + 0.118V_{bs}$

$= 2.5(102) + 65 + 3(95) + 0.118(88)$

$= 615.4$

10/15/08

Transit Systems

q veh/h

$N = qT$ $\qquad$ T_{rt}: time to complete trip (roundtrip)

$F = N \cdot \frac{T_{rt}}{T}$ $\qquad$ $F = qT \cdot \frac{T_{rt}}{T} = qT_{rt}$ $\qquad$ T_{rt}: sum of travel time between stops and dwelling time (time at stop)

dwelling time: $d_w = 20 - 90$ s

Ex. 10,000 passengers

2h

$T_{rt} = 30$ min

75 average occupancy

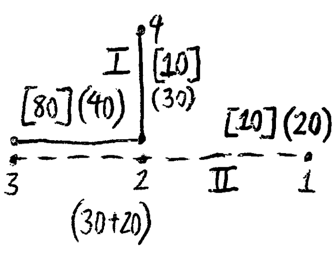
$N = \frac{\text{\# of passengers}}{\text{capacity of veh}}$

$N = \frac{10000}{75} = 134$ departures in 2 hrs

$q = \frac{134}{2} = 67$ veh/hr

$F = \frac{67}{2} = 34$ veh

Ex.



[ ] outbound mov. w.r.t 3

( ) inbound mov. w.r.t 3

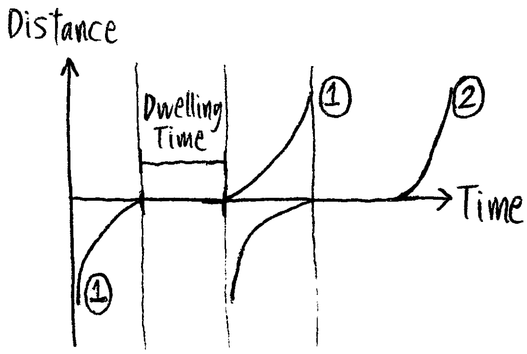
$N_I \geq 30$ departures

$N_{II} \geq 20$ departures

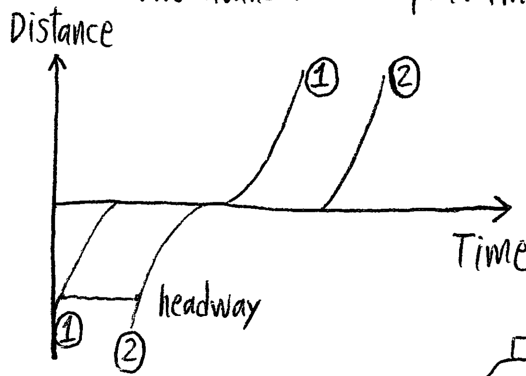
4-2 (I) 30 buses

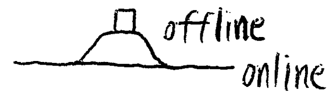
1-2 (II) 20 buses

2-3 add 30 buses



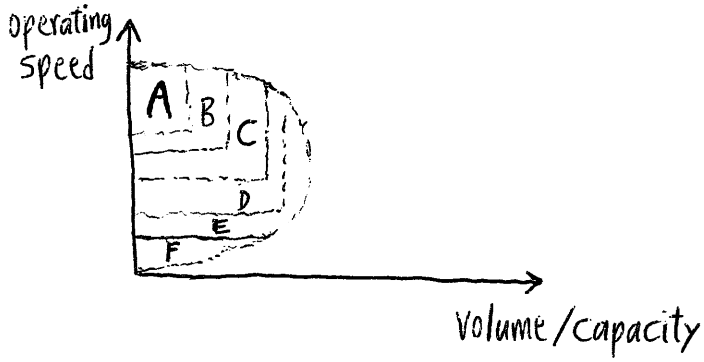
Two Trains on same platform





$$h_{min} = T_{dwell} + \left(\frac{2NL}{a_n}\right)^{1/2} + \delta + \frac{u}{2d_f} - \frac{u}{2d_\ell} + \frac{NL + x_0}{u}$$

10/17/08



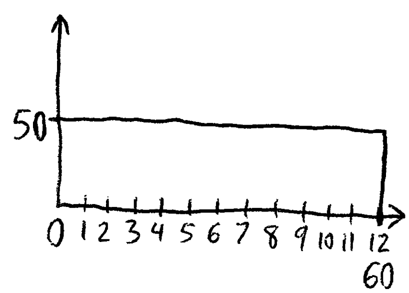
$$PHF = \frac{V}{q} = \frac{V}{N_t\left(\frac{60}{t}\right)}$$

PHF=1 uniform demand

PHF→0 peaked demand

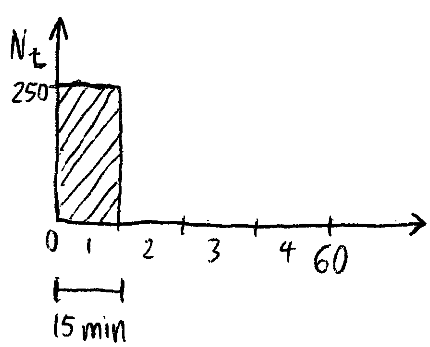
Ex. 50 vehicles
t=5 mins
12 intervals

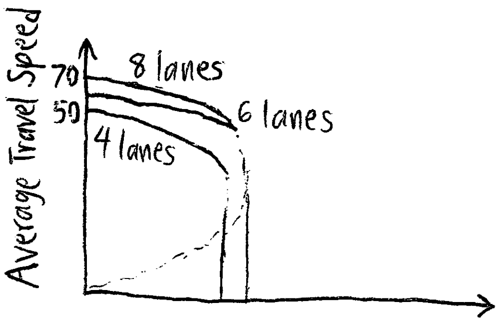
$$PHF = \frac{V}{q} = \frac{V}{N_t\left(\frac{60}{t}\right)} = \frac{600}{50\left(\frac{60}{5}\right)} = 1$$



Ex. N_t=250 veh
t=15 mins
V=250 veh

$$PHF = \frac{250}{250\left(\frac{60}{15}\right)} = 0.25$$





C = 2000 veh/h (70 mi/h)

C = 1900 veh/h (60 mi/h)

C = 1800 veh/h (50 mi/h)

$$D = \frac{V_p}{S} = \frac{\text{flow rate (pc/h/ln)}}{\text{average passenger car speed (mi/h)}}$$

$$V_p = \frac{V}{PHF \cdot N \cdot \underbrace{f_{HV}}_{\text{heavy vehicle}} \cdot f_{dp}}$$

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

$$f_{dp} = 0.8 - \underset{\text{all commuters}}{1.00}$$

FFS measured under LOS A

$$FFS = BFFS - f_{LW} - \underset{<60}{f_{LC}} - \underset{<5}{f_N} - f_{INT}$$

$$FFS = BFFS - 1.9(12 - W)^{1.8} - (2.4 - 0.4 \times LC) - (7.5 - 1.5 \times N) + 2.5 - 1.5\,\text{Access}$$

10/20/08

Ex. $N=3$ lanes per direction

$L=\underline{11}$ ft

3 ft lateral distance

1 interchange per mile

$V=3{,}080$ veh/h

$PHF=0.88$

$N_T=154$

Assume all of them are commuters

*Find E_{HV} on pg. 154

Table 4.5.1

$$D=\frac{V_p}{S}$$

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

$$=\frac{1}{1+0.05(1.5-1)}=0.976$$

$$V_p=\frac{V}{PHF\cdot N\cdot f_{HV}\cdot f_{dp}}$$

$$=\frac{3080}{0.88\times3\times0.976\times1}=\underline{1195}\text{ pc/h}$$

$$S\rightarrow FFS=70-1.9(12-W)^{1.8}-(2.4-0.4\,LC)-(7.5-1.5N)+(2.5-1.5ACC)$$

$$=70-1.9(12-\underline{11})^{1.8}-(2.4-0.4(3))-(7.5-1.5(3))+(2.5-1.5(1))$$

$$=64.9\text{ mi/h}$$

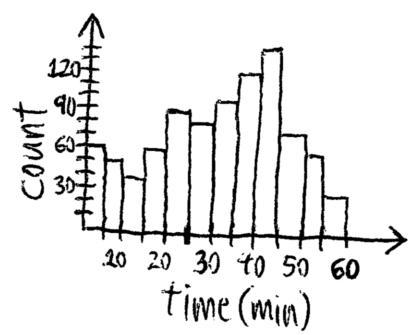
$$D=\frac{1195}{64.9}=18.4\text{ pc/h/}\ell\quad\text{LOS C}$$

Ex. $\underline{12}$

5 min $=t$

60 | 50 | 40 | 60 | 90 | 80 | 100 | 120 | 140 | 75 | 60 | 30

$$PHF=\frac{V}{N_t\left(\frac{60}{t}\right)}=\frac{925}{140\times\left(\frac{60}{5}\right)}=0.55$$



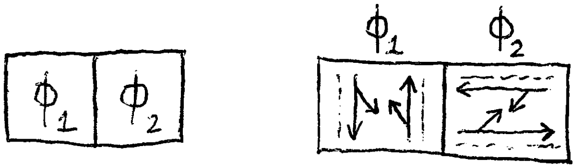
where: $V=$ sum of observed values

$N_t=$ max of observed values

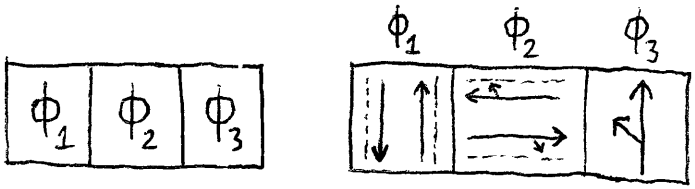
$$F_i=N_i\times\frac{60}{t}$$

$$F_1=60\times\frac{60}{5}=720\text{ veh/h}\qquad F_{12}=30\times\frac{60}{5}=360\text{ veh/h}$$

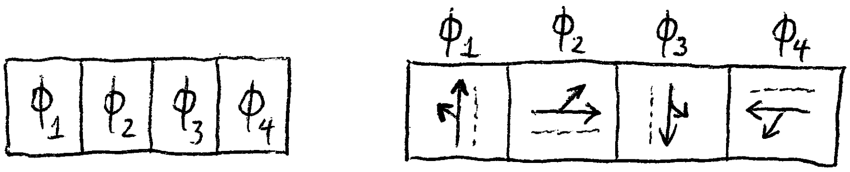
Ex.


ϕ_1 ϕ_2
ϕ_1 ϕ_2

Ex.


ϕ_1 ϕ_2 ϕ_3
ϕ_1 ϕ_2 ϕ_3

Ex.


ϕ_1 ϕ_2 ϕ_3 ϕ_4
ϕ_1 ϕ_2 ϕ_3 ϕ_4

10/22/08

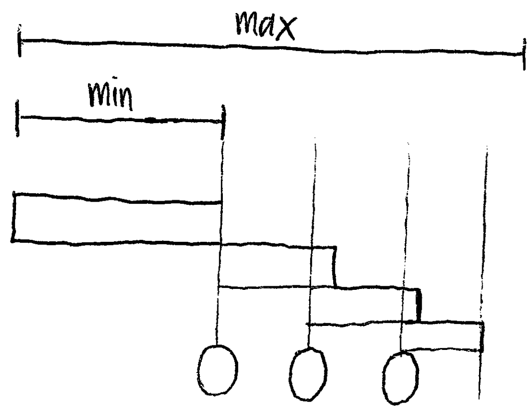
Project Topics

- LOS intersection
- Cycle Length
- Design Survey
- Mode Choice Model
- Parking
- GIS & Land Use
- Car Ownership
- HOT/HOV Lanes on Beltway

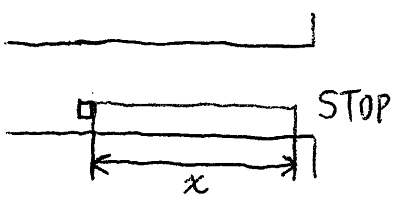
Cycle Length

Green → 30–60 s

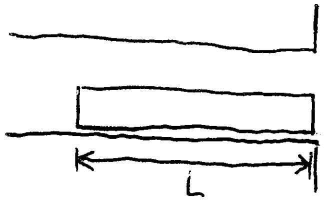
min < Green < max



Short Loop: detects if vehicle passes



Long Loop: detects how many vehicles



$$L = 1.47V(G - V_i) - L_v$$

L = length of the loop

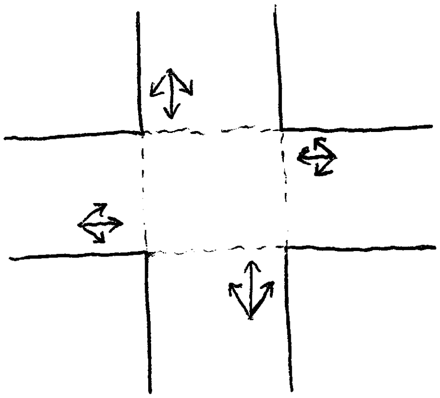
V = approach speed mi/h

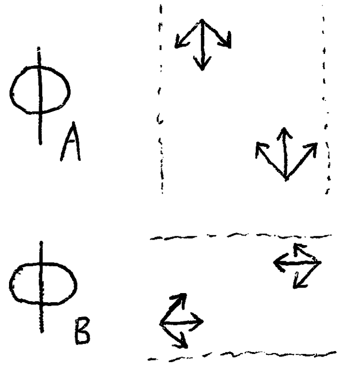
G = 2–5 s

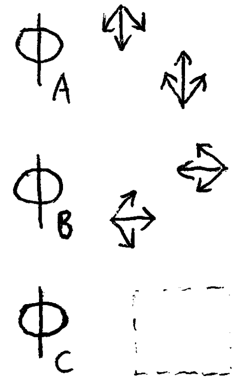
V_i = vehicle interval to travel distance L

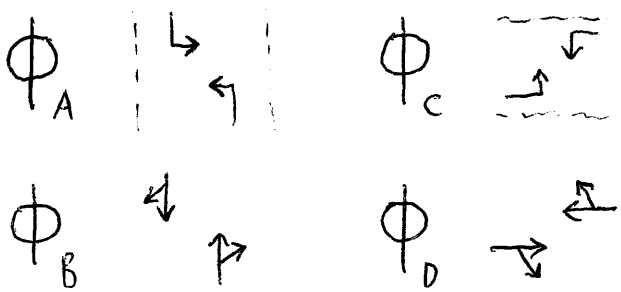
L_v = vehicle length

Minimum Green = 4s + 2n









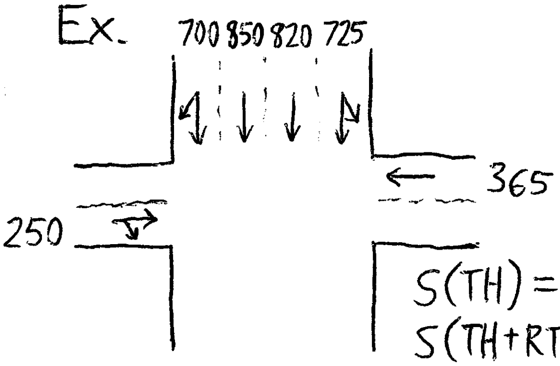
$$C_0 = \frac{1.5L+5}{1-CS}$$

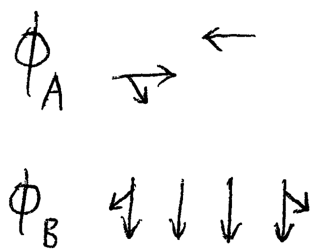
C_0 = optimal cycle length

L = total lost time (3-4s)

CS = flow ratio of critical movement

Ex.





$S(TH) = 1800$ veh/h

$S(TH+RT) = 1600$

$S(TH+LT) = 1700$

$$\Phi_A \quad \max\left\{\frac{365}{1800}, \frac{250}{1600}\right\} = \max\{0.147, 0.203\} = 0.203$$

$$\Phi_B \quad \max\left\{\frac{700}{1600}, \frac{850}{1800}, \frac{820}{1800}, \frac{725}{1700}\right\} = 0.464$$

$CS = 0.464 + 0.203 = 0.667$

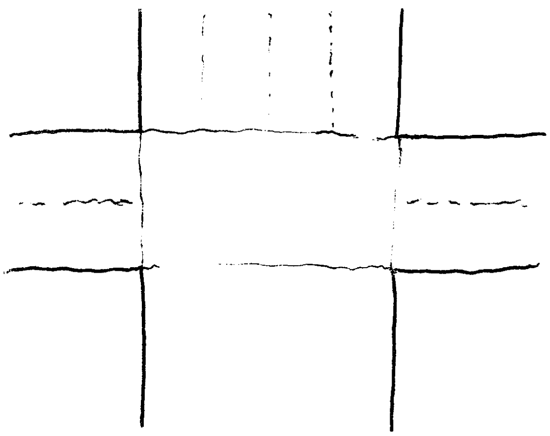
$L = 4s \times 2 = 8s$

$$C_0 = \frac{1.5L+5}{1-CS} = \frac{1.5(8)+5}{1-0.667} = 51\,s \left\langle \begin{matrix} 35\,s \\ 65\,s \end{matrix} \right.$$

10/24/08

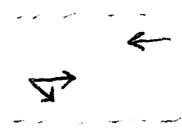
HW 3: 4.14, 4.22, 4.37 due 11/3

	Cycle Length	Y+AR	Avail. Cycle Length	Flow Ratio	CS	Green Allocation	Green	Pedestrians
E-W ϕ_A	51s	5	42s	0.203	0.667	30.4%	12.8 s	14 s
N-S ϕ_B		4		0.464		69.6%	29.2 s	9 s
	C_0	3-5s	$C_0-(Y+AR)$		ΣFR	FR/CS	Avail CL × (FR/CS)	



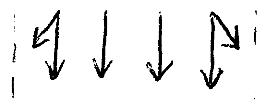
(Example from previous lecture)

$G_p = 7 + \frac{W}{4} - y$ use y=5



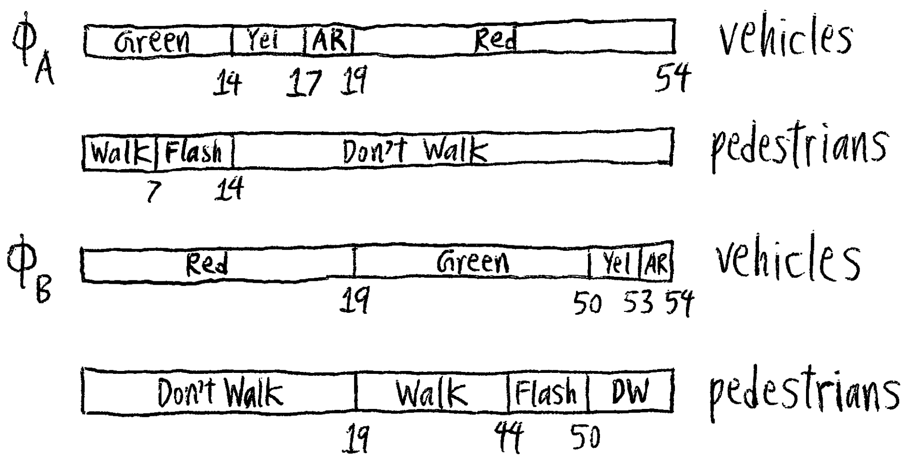
ϕ_A

$G_p = 7 + \frac{4\times 12}{4} - 5 = 14s$



ϕ_B

$G_p = 7 + \frac{2\times 12}{4} - 5 = 9s$



$C_0 = \frac{1.5L+5}{1-CS}$

6:30 – 8:30 am

6:30	15	100
	30	250
	45	300
7:30	60	400
7:31	15	250
	30	200
	45	150
8:30	60	50

7:00

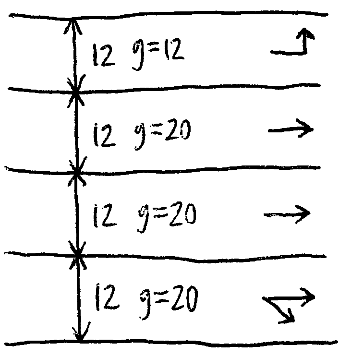
8:00

$\Rightarrow V = 1250$ veh

$$PHF = \frac{1250}{4 \times 400}$$

10/29/08

Ex.



$V_1 = 85$ veh/h S_i's < 1900
$S_1 = 1600$ "
$V_2 = 210$ "
$S_2 = 1700$ "
$V_3 = 240$ "
$S_3 = 1700$ "
$V_4 = 180$ "
$S_4 = 1200$ "

$C = 90\,s$
$PF = 0.95$

Approach	Movement	V	S	V/S	g	C	g/C	$c = s \times g/C$	$x = v/c$
EB	LT	85	1600	0.053	12	90	0.133	213	0.398
	TH	450	3400	0.132	20	90	0.222	755.6	0.596
	TH+RT	180	1200	0.150	20	90	0.222	266.7	0.675

capacity for each movement

degree of saturatio for each movement

$$d = d_1 + PF\,d_2$$

$$d_1 = \frac{0.38C(1-g/C)^2}{1-g/C \times \min(x, 1.0)} \qquad d_2 = 173x^2\left((x-1)+\sqrt{(x-1)^2 + m\frac{x}{C}}\right)$$

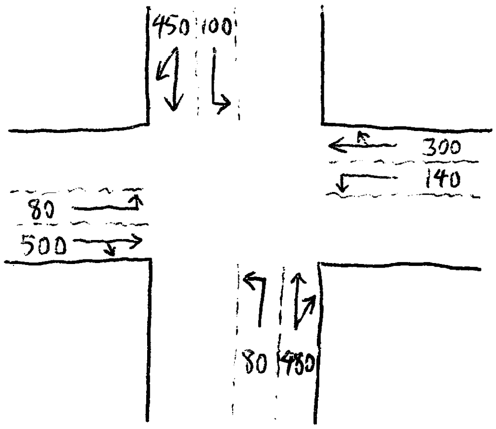
$m \rightarrow 1.0$

	d_1	d_2	d	LOS	Delay	LOS
LT	35.7	5.5	39.4	D		
TH	31.4	3.4	33.2	C	36.5	D
TH+RT	32.0	12.9	43.3	D		

$$d = \frac{d_{LT}V_{LT} + d_{TH}V_{TH} + d_{TH+RT}V_{TH+RT}}{V_{LT} + V_{TH} + V_{TH+RT}}$$

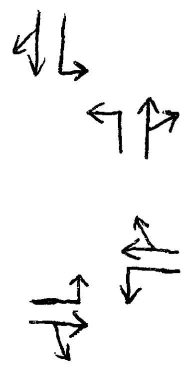
10/31/08

Ex 4.20.



ϕ_A N-S

ϕ_B E-W



Lost Time $= 3\ s/\phi$

Y+AR $= 4\ s$

$S(TH+RT) = 1700$

$S(LT) = 300$

C ? $\quad g < \begin{matrix}\phi_A \\ \phi_B\end{matrix}$? $\quad$ V pedestrians?

$$\phi_A = \max\left\{\frac{450}{1700}, \frac{100}{300}, \frac{480}{1700}, \frac{80}{300}\right\} = 0.333$$

$$\phi_B = \max\left\{\frac{500}{1700}, \frac{80}{300}, \frac{300}{1700}, \frac{140}{300}\right\} = 0.467$$

$CS = 0.333 + 0.467 = 0.8$

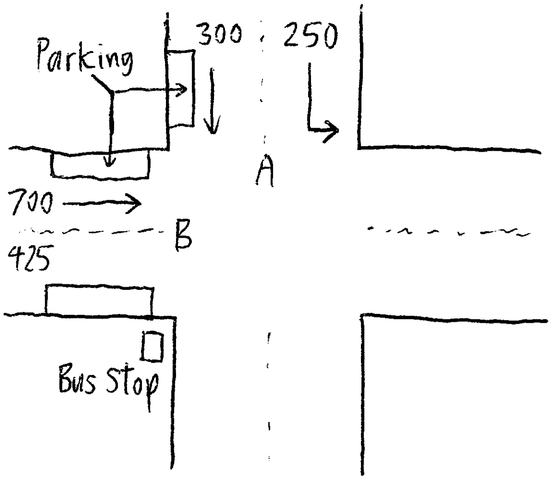
$$\text{Cycle} = \frac{1.5L+5}{1-CS} = \frac{1.5(2\times3)+5}{1-0.8} = 70\ s$$

Phase	Cycle	Avail. CL	Allocation	Green	G_p
ϕ_A	70	62	41.63%	26 s	13 s
ϕ_B			58.37%	36 s	13 s

$$G_p = 7 + \frac{W}{4} - (y+AR)$$

$$= 7 + \frac{40}{4} - 4 = 13$$

Ex 4.33.



ϕ_B E-W
12 ft lanes
15% HV
level grade
high parking
10 busses/hr
non CBD area

ϕ_A N-S
10 ft lanes
0% HV
5% downhill
medium parking
no bus stop
non CBD area

$S_0 = 1800$ veh/h

$S_0 = 2000$ veh/h

Approach	N	f_w	f_g	f_{HV}	f_p	f_b	f_a	f_{RT}	f_{LT}	S
A	2	0.93	1.03	1	0.8	1	1	1	0.85	2334
B	2	1	1	0.87	0.7	0.8	1	0.85	1	1593

$$f_{w_A} = 1 + \frac{W-12}{30} = 1 + \frac{10-12}{30} = 0.93 \qquad f_{g_A} = 1 - \frac{\%G}{200} = 1 - \frac{-5}{200} = 1.03$$

$$f_{HV_B} = \frac{100}{100 + \%HV(E_T - 1)} = \frac{100}{100 + 15(2-1)} = 0.87$$

$$f_{P_A} = \frac{N - 0.1 - {}^{18N_m}/_{3600}}{N} = \frac{2 - 0.1 - {}^{18(60)}/_{3600}}{2} = 0.8 \qquad f_{P_B} = \frac{2 - 0.1 - {}^{1800}/_{3600}}{2} = 0.7$$

$$f_b = \frac{N - {}^{144N_b}/_{3600}}{N} = \frac{2 - {}^{144\times 10}/_{3600}}{2} = 0.8$$

$$S = S_0 \times N \times f_w \times f_g \times f_{HV} \times f_p \times f_b \times f_a \times f_{RT} \times f_{LT}$$

$C = 60$ s $\quad$ $Y + AR = 7$ s $\quad$ $X_c = \dfrac{\Sigma V/S_{critical} \times C}{C - L} = \dfrac{0.942 \times 60}{60 - 7} = 1.06$

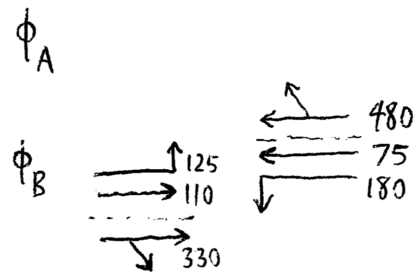
	V	S	V/S	CS	L	C	X_c
A	550	2334	0.236	0.942	7	60	1.06
B	1125	1593	0.706				

11/3/08

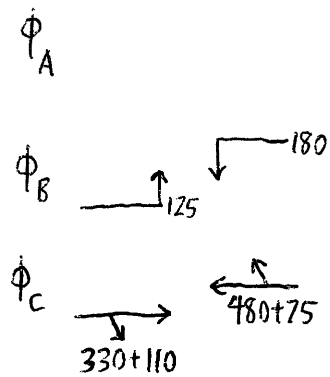
Homework Help

4.22.

A



B



Compute X_c, < 1 or smaller

$$X_c = \frac{\Sigma (V/S) \times C}{C - L} \quad (4.7.19)$$

A

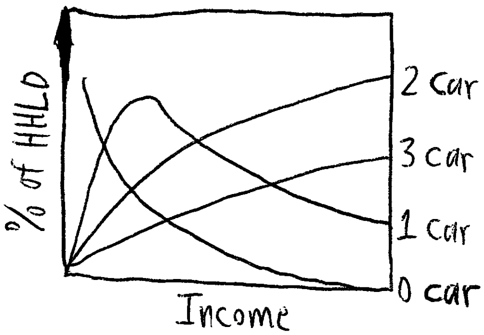
$$\phi_B: \max\left\{\frac{125+110}{500}, \frac{330}{1700}, \frac{480}{1700}, \frac{75+180}{500}\right\}$$

B

$$\phi_B: \max\left\{\frac{125}{1700}, \frac{180}{1700}\right\}$$

$$\phi_C: \max\left\{\frac{440}{1700}, \frac{555}{1700}\right\}$$

11/5/08

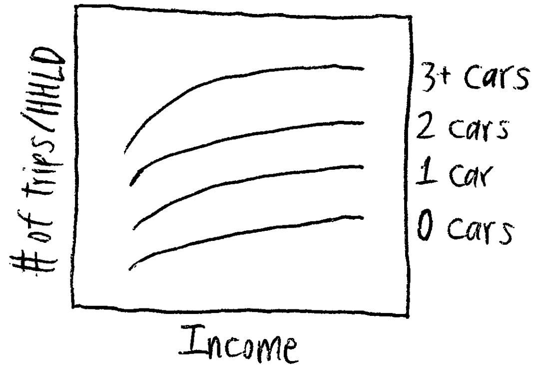


Percent of dwelling

Curve A

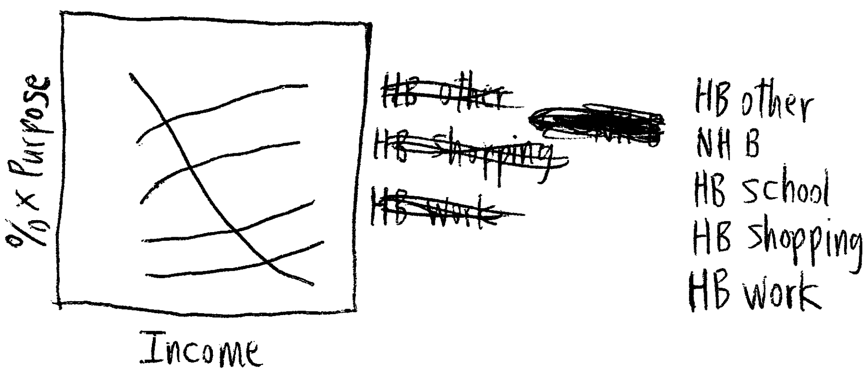
2%	of HHLD	→	0 cars
25%	" "		1 car
45%	" "		2 cars
28%	" "		3 cars

Curve B



# of trips = 5.5	0 cars
10	1 car
12	2 cars

Curve C



Ex 8.7.

1500 HHLD (household)
$12,000

Find:
- trips per household 0, 1, 2, & 3+ cars
- trips by purpose

Cars	% HHLD	HHLD	# of trips	Total Trips
0	2%	30	5.5	165
1	32%	480	12	5760
2	52%	780	15.5	12090
3+	14%	210	17.2	3612
	100%	1500		21627

Purpose	%	# of trips	
HB work	19	4109	home-based work
HB shop	11	2379	" Shop
HB school	14	3028	" School
NHB	22	4758	non home-based
HB other	34	7353	home-based other
	100%	21627	

Ex 8.3.

1,525,000 ft^2 residential ~~space~~
3,675,000 ft^2 service
2,100,000 ft^2 retail
650,000 ft^2 governmental buildings

use Table 8.2.1

generation → residential
attraction → all others

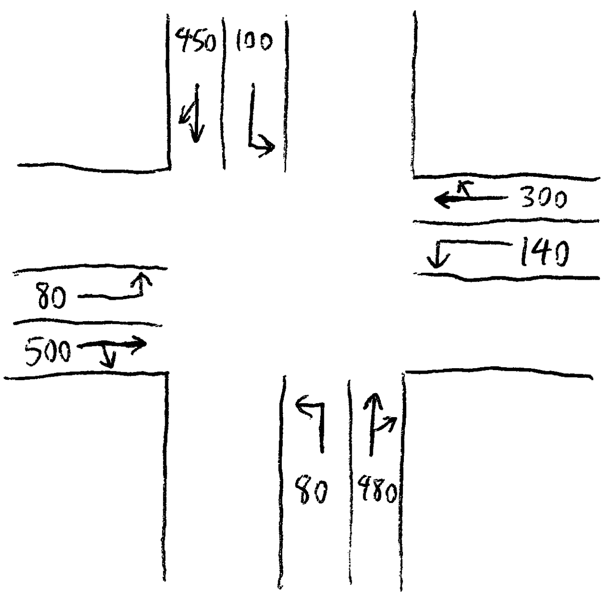
residential: $\times 2.4 = 3{,}660$ trips
retail: $\times 8.1 = 17{,}010$ trips
service: $\times 5.2 = 19{,}110$ trips
government: $\times 3.9 = 2{,}400$ trips

11/7/08

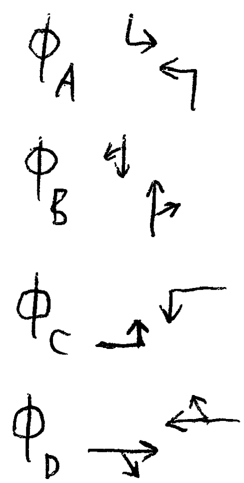
5 subjects for the exam

1) PHF
2) Cycle Length calculation
3) Delay
4) Saturation Flow
5) Trip Generation

Ex.



S=1700
10 ft lanes



$\phi_A = \max\left\{\frac{100}{1700}, \frac{80}{1700}\right\} = 0.059$

$\phi_B = \max\left\{\frac{450}{1700}, \frac{480}{1700}\right\} = 0.282$

$\phi_C = \max\left\{\frac{80}{1700}, \frac{140}{1700}\right\} = 0.082$

$\phi_D = \max\left\{\frac{500}{1700}, \frac{300}{1700}\right\} = 0.294$

$CS = 0.059 + 0.282 + 0.082 + 0.294 = 0.717$

$$C_o = \frac{1.5L+5}{1-CS} = \frac{1.5(3\times4)+5}{1-0.717} = 80\ s$$ (approx.)

	C	Avail. Green	% Green	Green Time	Pedest.	
ϕ_A			0.059/0.717=8.26	5	No	
ϕ_B	80	80-12=68	0.282/0.717=39.5	27	13	OK!
ϕ_C			0.082/0.717=11.48	8	No	
ϕ_D			0.294/0.717=41.18	28	13	OK!

$$G_p = 7 + \frac{W}{4} - y = 7 + \frac{40}{4} - 4 = 13$$

Ex 8.6. Use Table 8.2.3, Suburban area

Non Work home based trips

Person \ Veh. HH	0	1	2+
1	50	150	100
2,3	10	500	300
4	100	400	100

Area	Veh/HH	Person/HH		
		1	2,3	4
Urb.	0			
	1			
	2+			
Suburb.	0	0.97	2.54	5.04
	1	1.92	3.49	5.99
	2+	2.29	3.86	6.36
Rural	0			
	1			
	2+			

Total number of trips

$50 \times 0.97 = 49$

$150 \times 1.92 = 288$

$100 \times 2.29 = 229$

$10 \times 2.54 = 25$

$500 \times 3.49 = 1745$

$300 \times 3.86 = 1158$

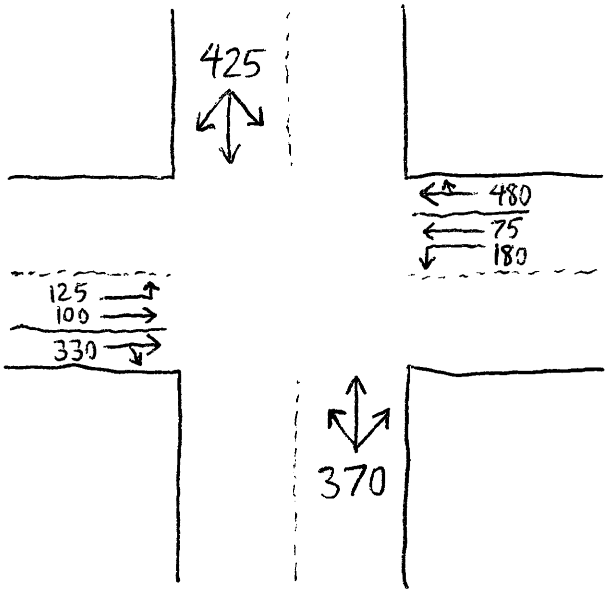
$100 \times 5.04 = 504$

$400 \times 5.99 = 2396$

$100 \times 6.36 = 636$

Total = 7030

Ex 4.35.



	C	A.G.	V/S	CS	g
ϕ_A	100	92	0.354	0.864	38
ϕ_B			0.51		54

S(all) = 1200
S(TH+RT) = 1700
S(TH+LT) = 500

Approach	Mvmt.	V	S	V/S	g	C	g/C
SB	all	425	1200		38		
NB	all	390	1200		38		
EB	TH + RT	330	1700		54	100	
	TH + LT	225	500		54		
WB	TH + RT	480	1700		54		
	TH + LT	255	500		54		

$c = s \times g/C$ $\quad V/c \quad d_1 \quad d_2 \quad d$ $\quad$ LOS $\quad$ weighted d $\quad$ Whole LOS

11/12/08

Trip Distribution

$$Q_{IJ} = K \frac{P_I A_J}{W_{IJ}^c}$$

$$P_I = \sum_x Q_{Ix}$$

$$P_I = K \sum_x \frac{P_I A_x}{W_{Ix}^c}$$

$$P_I = K P_I \sum_x \frac{A_x}{W_{Ix}^c}$$

$$K = \left(\sum_x \frac{A_x}{W_{Ix}^c} \right)^{-1}$$

$$Q_{IJ} = P_I \left(\frac{A_J / W_{IJ}^c}{\sum_x A_x / W_{Ix}^c} \right)$$

$$F_{IJ} = \frac{1}{W_{IJ}^c}$$

$$Q_{IJ} = P_I \left(\frac{A_J F_{IJ}}{\sum_x A_x F_{Ix}} \right)$$

Ex 8.8.

	Production	Attractiveness
1	1000	2
2	0	5
3	2000	1

W_{IJ} (I \ J)	1	2	3
1	5	20	10
2	20	5	10
3	10	10	5

K_{IJ}

I \ J	1	2	3
1	1.1	1.5	0.8
2	0.6	1.2	0.5
3	1.0	1.4	1.3

$$\ln F = -1.5 \ln W$$

$$\ln \frac{1}{W^c} = -1.5 \ln W$$

$$\ln W^{-c} = -1.5 \ln W$$

$$c = 1.5$$

$I = 1 \quad P_I = 1000$

J	A_J	F_{IJ}	K_{IJ}	$A_J \times F_{IJ} \times K_{IJ}$	Q_{IJ}
1	2	0.0894	1.1	0.1967	643
2	5	0.0112	1.5	0.084	274
3	1	0.0316	0.8	0.02528	84
				$\Sigma = 0.306$	$\Sigma = 1000$

$$F_{11} = \frac{1}{W_{11}^c} = \frac{1}{5^{1.5}}$$

Trips

	1	2	3
1	642	274	84
2	0	0	0
3	316	1104	580

$\Sigma = 3000$

Ex (cont.).

$I = 3 \quad P_I = 2000$

J	A_J	F_{IJ}	K_{IJ}	$A_J \times F_{IJ} \times K_{IJ}$	Q_{IJ}
1	2	0.0316	1.0	0.0632	316
2	5	0.0316	1.4	0.2212	1104
3	1	0.0894	1.3	0.1162	580

$$F_{31} = \frac{1}{10^{1.5}}$$

11/14/08

① Trip Generation
↓
② Trip Distribution
↓
③ Mode Choice

1) Disaggregate

2) Alternatives {car, PT}

{car driver, car passenger, bus, train}

3) Utility → linear in parameters β

4) Attributes
- Travel Time
- Travel Cost
- Frequency, No. of changes,

LOS attributes — Access Time, Egress Time

safety, lugguge

$\sum \beta \cdot X$

SEC: Social economic characteristic

- age
- education
- prof. status

Individual

- income
- No. of adults
- No. of kids
- No. of cars

HHLD

$$U_{car} = -\beta_{Time} \times \text{Travel T} - \beta_{Cost} \times \text{Cost} = \pm 0.01 + ASC_{car}$$

$$U_{PT} = +\beta_{Freq} \times \text{Freq} + \beta_{Time} \times \text{Time}$$

$$ASC \begin{cases} 0 \\ 1 \end{cases}$$

Alternative Specific Constant

$N\text{-}ASC = N_{ALT} - 1 \qquad N_{ALT} = 3 \quad N_{ASC} = 2$

VOT: value of time $= \beta_{Time} / \beta_{Cost}$

LOGIT

$$P(K) = \frac{\exp^{U_k}}{\Sigma_{x=1}^{n} \exp^{U_k}}$$

Ex. $U_k = a_k - 0.025X_1 - 0.032X_2 - 0.015X_3 - 0.002X_4$

	X_1 access+ egress time	X_2 waiting time	X_3 in veh. time	X_4 cost	ASC (a_k)
Car	5	0	20	100	—
Bus	10	15	40	50	-0.1

$$U_{car} = 0 - 0.025(5) - 0.032(0) - 0.015(20) - 0.002(100) = -0.625$$

$$U_{bus} = -0.01 - 0.025(10) - 0.032(15) - 0.015(40) - 0.002(50) = -1.530$$

$$P_{car} = \frac{e^{-0.625}}{e^{-0.625} + e^{-1.530}} = 0.71 \qquad P_{bus} = 1 - 0.71 = 0.29$$

$$VOT = \frac{-0.015}{-0.002} \times 60 = 4.50 \qquad a_{IJ} = 5000$$

$$P(car) = \frac{e^{U_{car}}}{e^{U_{car}} + e^{U_{bus}}} \qquad P(bus) = \frac{e^{U_{bus}}}{e^{U_{car}} + e^{U_{bus}}}$$

$U_{car} = -0.625$ $\qquad$ $U_{bus} = -1.530$

11/17/08

(same example from previous lecture expect train is added)

X_1 = access & egress Time

X_2 = waiting time

X_3 = in veh-Time

X_4 = cost

	X_1	X_2	X_3	X_4	a_k
Train	10	5	30	75	-0.06

$$U_{Train} = -0.06 - 0.025(10) - 0.032(5) - 0.015(30) - 0.002(75) = -1.070$$

$$P_{car} = \frac{e^{-0.625}}{e^{-0.625} + e^{-1.530} + e^{-1.070}} = 0.489$$

$$P_{bus} = \frac{e^{-1.530}}{e^{-0.625} + e^{-1.530} + e^{-1.070}} = 0.198$$

$$P_{Train} = \frac{e^{-1.070}}{e^{-0.625} + e^{-1.530} + e^{-1.070}} = 0.313$$

$Q_{IJ} = 5000$

$Q_{IJ\ Bus} = 5000 \times 0.198 = 990 \times 0.50 =$

$Q_{IJ\ Train} = 5000 \times 0.313 = 1565 \times 0.75 =$

\$1,669 Total Revenue

If cost of train is doubled,

$U_{train} = -1.22$

$P_{car} = 0.511 \quad P_{bus} = 0.207 \quad P_{train} = 0.282$

$Q_{IJ\ Bus} = 0.207 \times 5000 = 103.5 \times 0.50$

$Q_{IJ\ Train} = 0.282 \times 5000 = 1410 \times 1.50$ Total Revenue = \$2632

Incremental Logic

$$P_k = \frac{e^{U_k + \Delta U_k}}{\sum_x e^{U_x + \Delta U_k}} = \frac{e^{U_k} \times e^{\Delta U_k}}{\sum_x \left(e^{U_k} \times e^{\Delta U_k}\right)}$$

$$P_k' = \frac{\frac{e^{U_k}}{\sum_x e^{U_x}} \times e^{\Delta U_k}}{\sum_x \frac{\exp^{U_x}}{\sum_x \exp^{U_x}} \times e^{\Delta U_x}} = \frac{P_k \times e^{\Delta U_k}}{\sum_x P(x)\, e^{\Delta U_x}}$$

P_{Train} $C \rightarrow 0.75 - 1.50$

$$P_{Train} = \frac{0.313 \exp(\Delta U_k)}{0.489 \exp(\Delta U_k) + 0.198 \exp(\Delta U_k) + 0.313 \exp(\Delta U_k)}$$

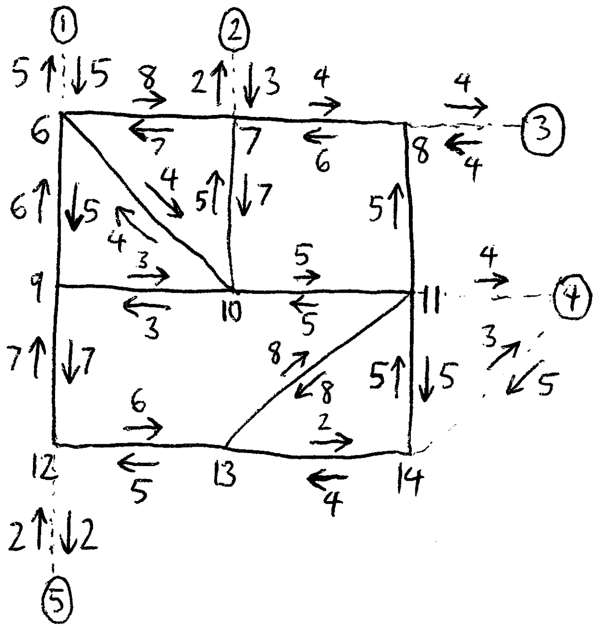
$\Delta U_k = -0.002 \times 75 = -0.15$

$$= \frac{0.313 e^{-0.15}}{(0.489 + 0.198 + 0.313)\, e^{-0.15}} = 0.282$$

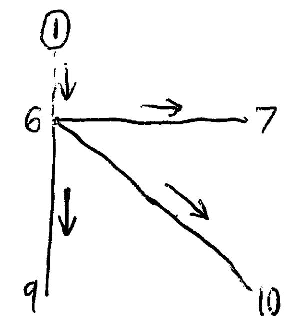
another method to compute probabilities

11/19/08

Ex.



Tree



Q_{1J}	2	3	4	5
	800	500	600	200

Stage	Link	Compute impedence	Compare impedence	Decide
I	1-6	5	5 < ∞	Accept
II	6-7 -9 -10	5+8=13 5+5=10 5+4=9		

Node	Impedence 0	I	II
1	—		
2	∞		
3	∞		
4	∞		
5	∞		
6	∞	5	
7	∞		13
8	∞		
9	∞		10
10	∞		9
11	∞		
12	∞		
13	∞		
14	∞		

Preceding	Node I	II
1		
2		
3		
4		
5		
6	1	
7		6
8		
9		6
10		6
11		
12		
13		
14		

11/21/08

Ex (from previous class).

Stage	Link	Impedence	Compare	Decide
III	7 2	13+2=15	$15 < \infty$	A
	8	13+4=17	$17 < \infty$	A
	10	13+7=20	$20 > 9$	R
	9 6	10+6=16	$16 > 5$	R
	10	10+3=13	$13 > 10$	R
	12	10+7=17	$17 < \infty$	A
	10 7	9+5=14	$14 > 13$	R
	9	9+3=12	$12 > 10$	R
	11	9+5=14	$14 < \infty$	A
IV	11 4	14+4=18	$18 < \infty$	A
	8	14+5=19	$19 > 17$	R
	10	14+5=19	$19 > 9$	R
	13	14+8=22	$22 < \infty$	A
	14	14+5=19	$19 < \infty$	A
V	8 3	17+4=21	$21 < \infty$	A
	7	17+6=23	$23 > 13$	R
	12 9	17+7=24	$24 > 10$	R
	13	17+6=23	$23 > 22$	R
	5	17+2=19	$19 < \infty$	A

A=Accept
R=Reject

J	Impedence J						Node Preceding J				
	0	I	II	III	IV	V	I	II	III	IV	V
1	∞										
2	∞			15					7		
3	∞					21					8
4	∞				18					11	
5	∞					19					12
6	∞	5					1				
7	∞		13					6			
8	∞			17					7		
9	∞		10					6			
10	∞		9					6			
11	∞			14					10		
12	∞			17					9		
13	∞				22					11	
14	∞				19					11	

HW #4: 8.9, 8.19, 8.22, 11.10 due M 12/8

11/24/08

Ex.

Alt	PW Benefits	PW Cost	NPW	B/C
A	1.8	1.2	0.6	1.5
B	2.9	2.2	0.7	1.32

B has better NPW
A has better B/C

Use incremental B/C analysis, have \$2.2 million to spend

$1.8 + 1.0 = 2.8$ Benefit for A
2.9 Benefit for B

Choose Alt B.

Ex.

Alt	PW Cost	PW Benefit	B/C	
A	100	150	1.5	No
B	150	190	1.27	No
C	200	270	1.35	
D	300	290	0.97	No
E	320	350	1.09	

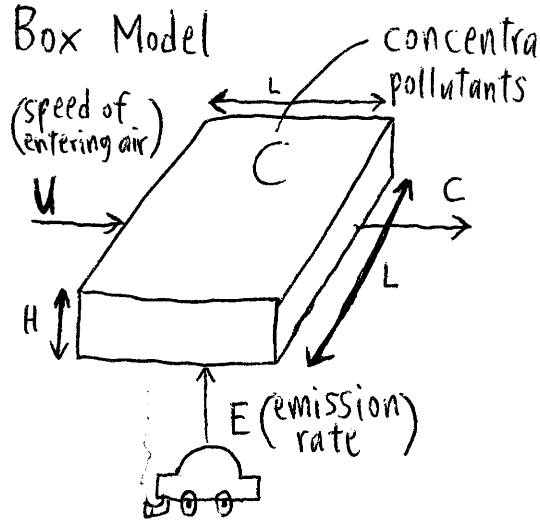
A-B $PWC = 150 - 100 = 50$
$PWB = 190 - 150 = 40$
$\frac{\Delta B}{\Delta C} = \frac{40}{50} < 1$ choose less cost Alt.

A-C $PWC = 200 - 100 = 100$
$PWB = 270 - 150 = 120$
$\frac{\Delta B}{\Delta C} = \frac{120}{100} = 1.2 > 1$

C-E $PWC = 320 - 200 = 120$
$PWB = 350 - 270 = 80$
$\frac{\Delta B}{\Delta C} = \frac{80}{120} < 1$

Choose Alt. C

Box Model



$V = L^2 H$ = box vol.

$F = ULH$ = air flow

$$V\left(\frac{dC}{dt}\right) = \underset{\substack{\uparrow \\ \text{pollutants entering}}}{E} - \underset{\substack{\uparrow \\ \text{pollutants exiting}}}{\underbrace{FC}}$$

$\uparrow$ rate of change of pollution inside box

Ex. 3 p. 524

$E = Ae^{-Bt}$ A & B are constants

$C @ t = 0 \Rightarrow K$

$$E - FC = V\frac{dC}{dt} \qquad \frac{A}{V}e^{-Bt} - \frac{FC}{V} = \frac{dC}{dt}$$

$$Ae^{-Bt} - FC = V\frac{dC}{dt} \qquad \frac{dC}{dt} + \frac{FC}{V} = \frac{A}{V}e^{-Bt}$$

$$\frac{Ae^{-Bt} - FC}{V} = \frac{dC}{dt}$$

Integration factor $= e^{(F/V)t} = \mu$

$$\int \frac{d(Ce^{(F/V)t})}{dt} = \int \frac{A}{V}e^{(F/V - B)t}$$

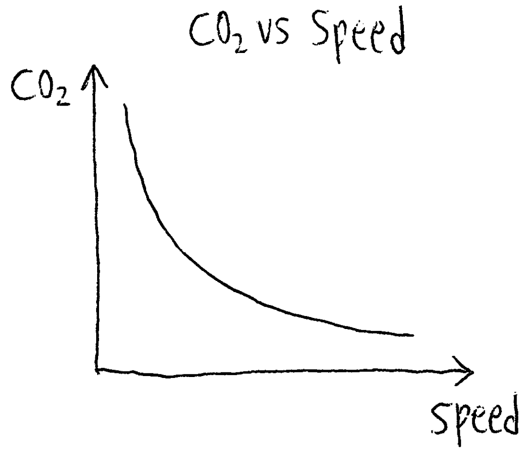
$$Ce^{(F/V)t} = \frac{A}{V}\cdot\frac{V}{F-BV}e^{\left(\frac{F-BV}{V}\right)t} + D$$

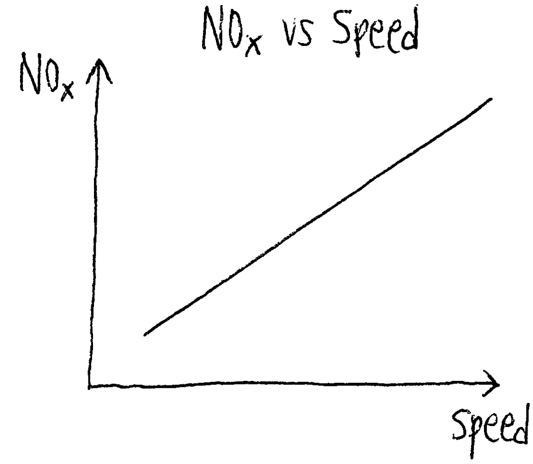
$$C = \frac{A}{F-BV}e^{B} + \frac{D}{e^{(F/V)t}} \qquad K = \frac{A}{F-BV}e^{-B(0)} + D$$

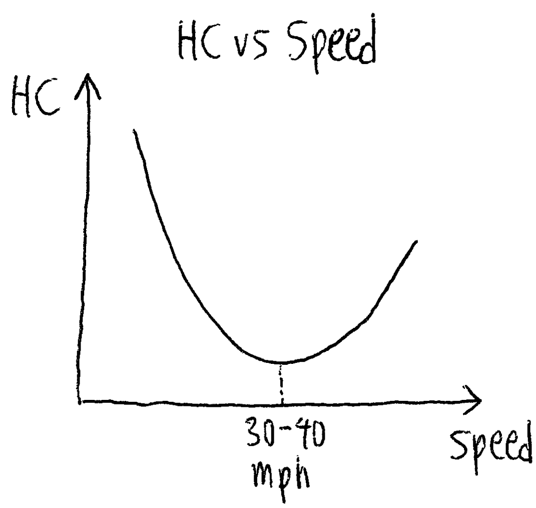
$$D = K - \frac{A}{F-BV}$$

$$C = \frac{A}{F-BV}e^{B} + \left(K - \frac{A}{F-BV}\right)e^{-Ft/V}$$

Air Pollution Graphs

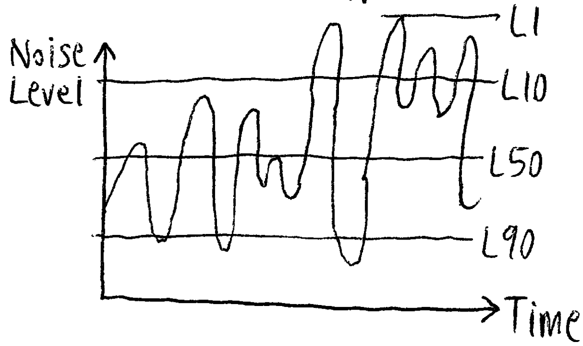






12/3/08

Noise Generation



Nomograph p. 513

Inputs: volumes & speeds of autos, med. trucks, heavy trucks

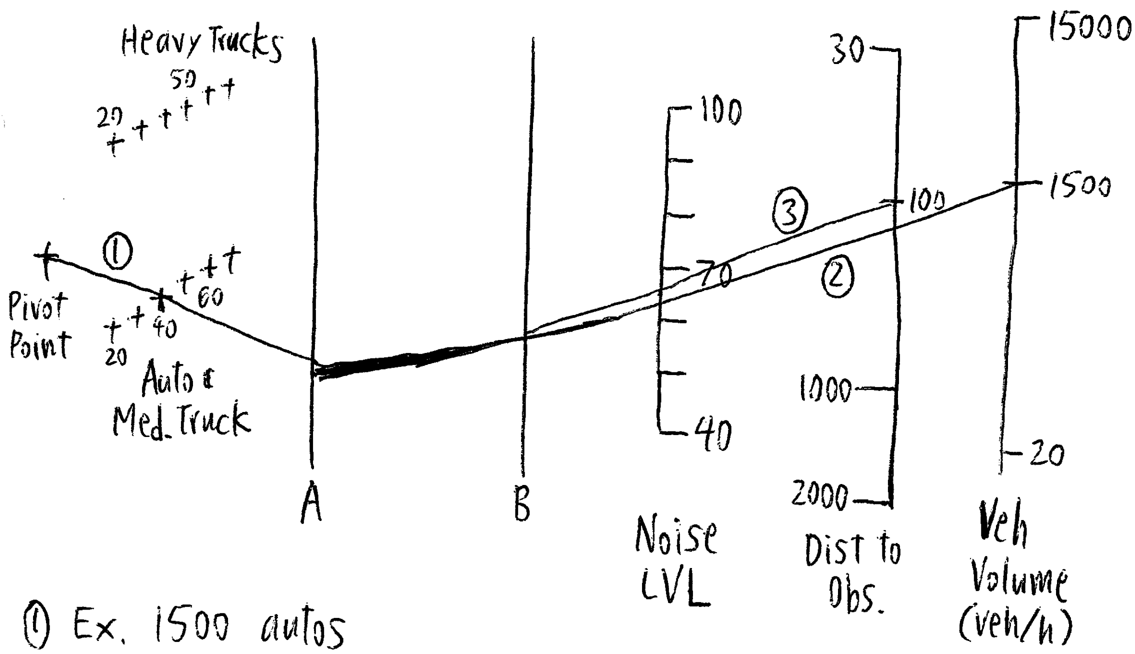
Output: estimate of L_{10} at a given distance away

1 med. truck = 10 automobiles

$U_{med.\ truck} = U_{auto} \Rightarrow V_{mt} + V_a$

add volumes

Heavy trucks are calculated separately



① Ex. 1500 autos
40 mi/h
L_{10} = ?
Obs is 100 ft away

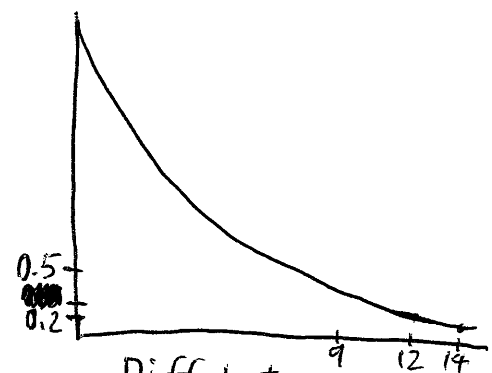
① Line from pivot thru corresponding spd to A
② Line from A to corresponding volume
③ Line from intercept to corresponding distance to Obs. and get L_{10} from intersection of this line & the noise LVL scale

Exercise 12.

100 heavy trucks, 50 mph
30 med. trucks, 40 mph
600 autos, 50 mph
hwy width - 80 ft
width of buffer to ensure ≤ 60 dB

$30\ MT \times 10\ \frac{auto}{MT} = 300\ autos$

D_c	Heavy Trucks	Medium Trucks	Cars	Total
600	60	46 +14	51 +9	60+0.2 +0.5=60.7
700	59	45.5 +14.5	50 +9	59+0.2 +0.5=59.7



Diff between 2 lvls
To be added

12/8/08

For final exam:

- Ch 8
  - Trip distribution
  - Mode choice
  - Assignment
- Ch 11
  - Evaluation
- Ch 10
  - Pollution / Noise

Ex.

	NPW	Asthetics	Electorate
A	6	70	Neutral
B	13	40	Favorable
C	14	90	Unfavorable

	NPW	Asth.	Elect.	Sum
A	1	2	2	5
B	2	1	3	6
C	3	3	1	7

where 1 = worst, ..., 3 = best

C is best, B is middle, & A is worst

W(NPW) = 2
W(Asth) = 1
W(Elect) = 4

Weighted Score

	NPW	Asth.	Elect.	Sum
A	2	2	8	12
B	4	1	12	17
C	6	3	4	13

B is best, C is middle, & A is worst

Convert to uniform scale

$\frac{6}{14} \times 90 = 40$ $\quad$ $\frac{13}{14} \times 90 = 85$

	NPW	Asthetics	Electorate	Sum
A	40	70	50	160
B	85	40	80	205
C	90	90	40	220

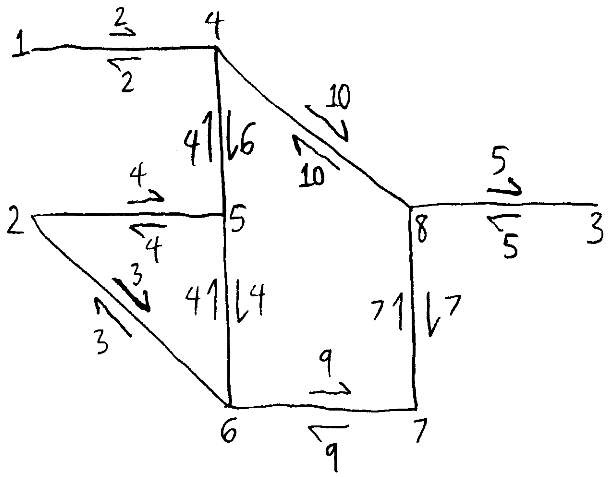
same result as the original

Ex. (cont.)

	NPW	Asth.	Elect.	Sum
A	80	70	200	350
B	170	40	320	530
C	180	90	160	430

same result
as the original

Ex.



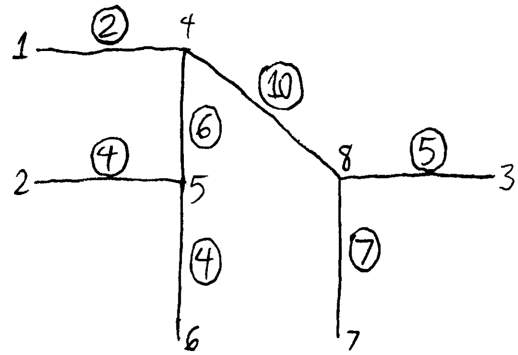
Stage	I–J	W	Compare	Decision
I	1–4	0+2	$2 < \infty$	Accept
II	4–5	2+6=8	$8 < \infty$	Accept
	–8	2+10=12	$12 < \infty$	Accept
III	5–2	8+4=12	$12 < \infty$	Accept
	–6	8+4=12	$12 < \infty$	Accept
	–4	8+4=12	$12 > 2$	Reject
	8–3	12+5=17	$17 < \infty$	Accept
	–4	12+10=22	$22 > 2$	Reject
	–7	12=7=19	$19 < \infty$	Accept
IV	2–5	12+4=16	$16 > 8$	Reject
	–6	12+3=15	$15 > 12$	Reject
	6–2	12+3=15	$15 > 12$	Reject
	–5	12+4=16	$16 > 2$	Reject
	–7	12+9=21	$21 > 19$	Reject

Ex. (cont.)

J	W: 0	I	II	III	IV
1	—				
2	∞			14	15
3	∞			17	
4	∞	2		22	16
5	∞		8		16
6	∞			12	15
7	∞			19	21
8	∞		12		

Preceding Node

	I	II	III
1			
2			5
3			8
4	1		
5		4	
6			5
7			8
8		4	



$P_1 = 2500$

$Q_{12} = ?$ $Q_{13} = ?$

$A_2 = 1.5$ $A_3 = 3.5$ $K_{12} = K_{13} = 1.0$

	A	W	F	K	AFK	%		
2	1.5	12	0.0069	1.0	0.0103	46	2500	1155
3	3.5	17	0.0034	1.0	0.0121	54		1345

$\Sigma = 0.0224$

12/10/08

Ex 10.2.

$q_{before} = 5100$ veh/h 3 lanes

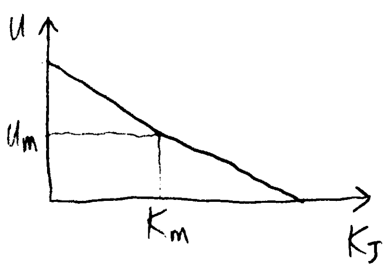
$q_{after} = 4200$ veh/h 0°F level of service F

$q = 42.0K - 0.25K^2$

Fig. 10.2.2 to calculate emission (in pg. 503)

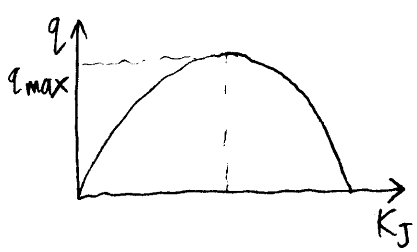
T(F), u need to compute these terms

$u = \frac{q}{K} = 42 - 0.25K$ $u = 0 \Rightarrow K_J = 168$ veh/mi



$K_m = K_J/2 = 168/2 = 84$ veh/mi

$u_m = 42 - 0.25 \times 84 = 21$ mi/hr



$q = \frac{5100}{3} = 1700$ veh/h

$1700 = 42K - 0.25K^2$

$K_1 = \begin{cases} 100 \text{ veh/mi} \\ 68 \text{ veh/mi} \end{cases}$ LOS F $\Rightarrow K_1 > K_m$

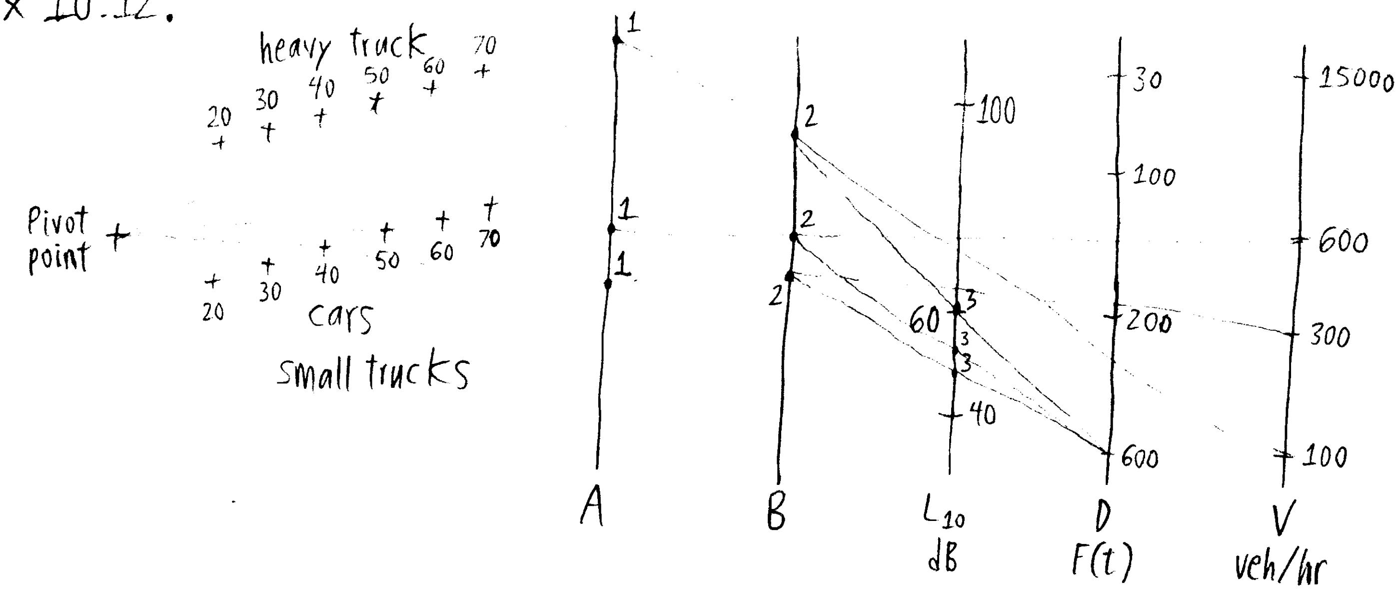
$E_1 = 5100 \times 114 = 581{,}400$ g/mi $K_1 = 100$ veh/mi $u_1 = 42 - 0.25 \times 100 = 17$ mi/hr

$q = 4200/3 = 1400$ veh/h

$K = \begin{cases} 122 \text{ veh/mi} \\ 46 \text{ veh/mi} \end{cases}$ better LOS $\Rightarrow K_2 = 46$ veh/mi $u_2 = 30.5$ mi/hr

$E_2 = 4200 \times 74 = 310{,}800$ g/mi

Ex 10.12.



100 heavy trucks 50 mi/h
30 medium trucks 40 mi/h
600 cars 50 mi/h

D (ft)	heavy veh L	medium truck L	cars L
600	60	46	51
		14	9
		+0.2	+0.5 =60.7
700			

60 dB
1 ST = 10 cars   30 MT = 300 cars

1) Pivot point to speed → A
2) A to volumes → B
3) B to distance → L_{10}

Fig. 10.3.4 for log scale