CV3401 - SEM1 - 01/12

1 a) Time mean speed = arithmetic mean of spot speeds

Space mean speed = harmonic mean of spot speeds

- Space mean speed:

1. Apply $\bar{v}_s = \frac{1}{\frac{1}{N}\sum_{i}^{N}\frac{1}{v_i}}$ ~~directly to the spot speed measurements~~, or

2. Use information collected from two consecutive photographs, and calculate

$$v_s = \frac{\sum_{1}^{n} v_i}{n},$$

v_i is the individual speed of each vehicle by calculating distance travelled divided by time (interval of the two photographs taken), or

3. Use distance-time vehicle trajectories graph, draw a vertical line at time t and find the mean of the speeds that intercept the vertical line, or

4. etc.

- Time mean speed

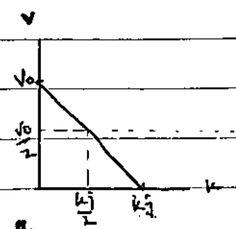
1. Using spot speed measurements $\bar{v}_t = \frac{\sum_{1}^{n} v_i}{n}$, or

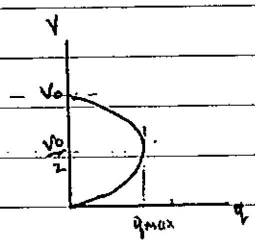
2. Use distance-time vehicle trajectories graph, draw a horizontal line at location d, and find the mean of the speeds that intercept the horizontal line.

b) Use these principles:

- zero flow at zero density
- zero flow at max density
- free-flow speed at zero density
- convex flow-density curve (i.e. there is a max flow)

Linear relationship v-k $v = A - Bk$

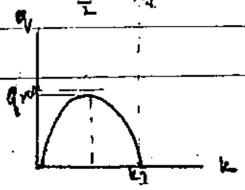




Notation: k_j = jam density

v_0 = free flow speed

q_{max} = maximum flow/capacity



1 c) Assumption:

- distribution of future trips proportional to the present trip distribution
- future distribution modified by the growth factor of the zone to which trips are attracted
- does not distinguish between productions and attractions; $Q_{ij} = Q_{ji}$

Limitation:

- cannot handle new zone that is built after the base year
- convergence to the target-year generation totals is not always possible
- does not account for impedance which has shown to affect significantly the trip distribution

2 a)

$$\text{No. bus passengers} = \frac{e^{-0.8t-1}}{e^{-0.8t} + e^{-0.8t-1}} \times 5000 \qquad \times \frac{\frac{1}{e^{-0.8t}}}{\frac{1}{e^{-0.8t}}}$$

$$= \frac{e^{-1}}{1 + e^{-1}} \times 5000$$

$$= 0.2689 \times 5000$$

$$= 1344.7$$

$$\approx \underline{1345} \text{ pbus/hr}$$

b) Q said flow bus 110/hr can accomodate all 1345 bus passengers.

No. car passengers = 5000 − 1345 = 3655 pcar/hr

↳ 1 to 1 → No of car flow = 3655 car/hr

Total q = 110 + 3655 = 3765 veh/hr

↳ t = 9 + 0.002 (3765) = <u>16.53 min</u>

c) Total q = 3000 veh/hr ⟶ t = 9 + 0.002(3000) = 15 min

↳ car flow = 3000 − 110 = 2890 car/hr

↳ 1 to 1 → car passengers = 2890 pcar/hr

bus passengers = 5000 − 2890 = 2110 pbus/hr

No. bus passengers $= 2110 = \dfrac{e^{-0.8(15)-1}}{e^{-0.8(15)-1} + e^{-0.8(15)-0.05c}}$ ~~$\times 5000$~~

$$\frac{211}{500} = \frac{e^{-13}}{e^{-13} + e^{-12-0.05c}}$$

$$e^{-13} + e^{-12-0.05c} = 5.356 \times 10^{-6}$$

$$e^{-12-0.05c} = 3.096 \times 10^{-6}$$

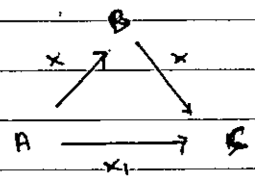
$$\ln\left(e^{-12-0.05c}\right) = \ln\left(3.096 \times 10^{-6}\right)$$

$$-12-0.05c = -12.685$$

$\hookrightarrow$ $c = \underline{\underline{13.71}}$

3 a)

Demand $A \to C$: 1400 veh/hr



2 routes : $A \to C$; $t_1 = 26 + \frac{x_1}{100}$

$A \to B \to C$; $t = t_2 + t_3 = 16 + \frac{x}{50}$ $\rightarrow$ $x_2 = x_3 = x$

UE: $x + x_1 = 1400$

$t_1 = t = T$

$t_1 = 26 + \frac{x_1}{100} \longrightarrow 100T = 2600 + x_1$

$t = 16 + \frac{x}{50} \longrightarrow 50T = 800 + x$

$150T = 3400 + 1400$

$T = 32$

$t_1 = 26 + \frac{x_1}{100}$ $\qquad$ $t = 16 + \frac{x}{50}$

$x_1 = (32-26) \times 100 = 600$ $\qquad$ $x = (32-16)\,50 = 800$

$\therefore$ Flow using Link 1 = 600 veh/hr

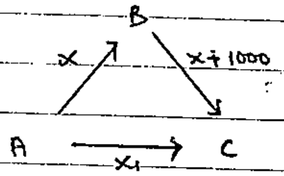
Link 2 = 800 veh/hr

Link 3 = 800 veh/hr

3 b)

Demand A→C = 1400

Demand B→C = 1000



$t_1 = 26 + \frac{x_1}{100}$

$t_2 = 10 + \frac{x}{100}$

$t_3 = 6 + \frac{(x+1000)}{100} = 16 + \frac{x}{100}$

2 routes : A→C : $t_1 = 26 + \frac{x_1}{100}$

A→B→C : $t = t_2 + t_3 = 26 + \frac{x}{50}$

eq. $x + x_1 = 1400$

$t_1 = t = T$

$t_1 = 26 + \frac{x_1}{100} \longrightarrow 100T = 2600 + x_1$

$t = 26 + \frac{x}{50} \longrightarrow 50T = 1300 + x$ +

$150T = 3900 + 1400$

$T = 35.33$

$t_1 = 26 + \frac{x_1}{100}$ $t = 26 + \frac{x}{50}$

$x_1 = (35.33 - 26)100 = 933.33 \approx 933$ $x = (35.33 - 26)50 = 467$

∴ Flow using Link 1 = 933 veh/hr

Link 2 = 467 veh/hr

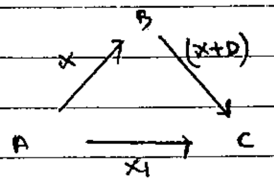
Link 3 = 1467 veh/hr

3 c)

Demand $A \to C = 1400$

$B \to C = D = 100(50 - t_3)$

$D = 5000 - 100 t_3$



$t_1 = 26 + \frac{x_1}{100}$

$t_2 = 10 + \frac{x}{100}$

$t_3 = 6 + \frac{x_3}{100}$

$t_3 = 6 + \frac{(x + 5000 - 100 t_3)}{100}$

$t_3 = 6 + \frac{x}{100} + 50 - t_3$

$2t_3 = 56 + \frac{x}{100}$

$t_3 = 28 + \frac{x}{200}$

2 routes: $A \to C \quad t_1 = 26 + \frac{x_1}{100}$

$A \to B \to C \quad t = t_2 + t_3 = 10 + \frac{x}{100} + 28 + \frac{x}{200} = 38 + \frac{3}{200}x$

eq. $t_1 = t = T$

$x_1 + x = 1400$

$t_1 = 26 + \frac{x_1}{100} \longrightarrow 100T = 2600 + x_1$

$t = 38 + \frac{3}{200}x \longrightarrow \frac{200}{3}T = 2533.33 + x$

$166.67T = 5133.33 + 1400$

$T = 39.2$

$t_1 = 26 + \frac{x_1}{100}$

$x_1 = (39.2 - 26)100 = 1320$

$t = 38 + \frac{3}{200}x$

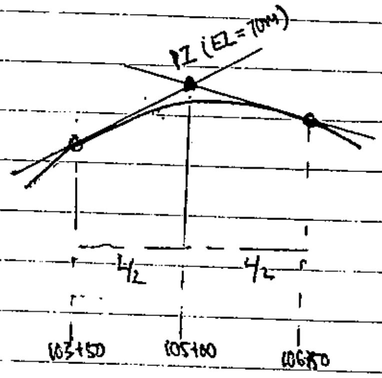
$x = (39.2 - 38)\frac{200}{3} = 80$

$t_3 = 28 + \frac{80}{200} = 28.4$

$\therefore$ Demand $B \to C = D = 5000 - 100(28.4) = 2160$

4 a)

$L = 300\,M$



$y = y_0 + g_1 x + \frac{r x^2}{2}$

(i) peak point : $\frac{dy}{dx} = 0 = g_1 + rx$

$0 = 0.04 + \frac{(-0.02 - 0.04)}{300} x$

$x = 200\,M$

STATION of peak point → $103+50 + 2 = \underline{105+50}$ station

$y_0 = 70 - 0.04(150) = 64\,M$

$y_{peak} = 64 + 0.04(200) + \frac{(-0.02-0.04)}{300} \frac{(200)^2}{2}$

$= 68\,M$

Elevation of peak point → $\underline{68\,M}$ above sea level

(ii) SSD $S = d_r + d_b$

$= \left(80 \times \frac{10}{36}\right) \times 2.5 + \frac{\left(80 \times \frac{10}{36}\right)^2}{(2)(9.81)(0.3 - 0.02)}$

$= 145.45\,M$

4 a)

(ii)

Assume $S \le L \rightarrow L_{min} = \dfrac{(6)(195.95)^2}{200(\sqrt{1.05}+\sqrt{0.15})^2}$

$= 318.33\ m$

$L_{min} > L_{provided} = 300m$

This curve doesnt have adequate SSD

(iii) – Clearance criteria

– Comfort criteria

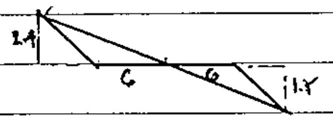
– Appearance criteria

b)

Station	Area	
	Cut	Fill
100+10	19.5 ①	
101+00	7.2 ②	4.5 ③
101+50		17.25 ④

① $(\frac{12}{4})(3+0) + (\frac{1}{2})(15+6) = 19.5$

② ③



Cut $= \frac{1}{2}(2.4)(6) = 7.2$

Fill $= \frac{1}{2}(6)(1.5) = 4.5$

④ $\frac{12}{4}(0+2.5) + (\frac{1}{2})(6+13.5) = 17.25$

Station	Volume	
	Cut	Fill
100+10		
	1201.5 ①	135 ②
101+00		
	120 ③	543.75 ④
101+50		
	Σ = 1321.5	678.75

① $\frac{19.5+7.2}{2} \times 90 = 1201.5$

② $\frac{4.5}{3} \times 90 = 135$

③ $\frac{7.2}{3} \times 50 = 120$

④ $\frac{4.5+17.25}{2} \times 50 = 543.75$

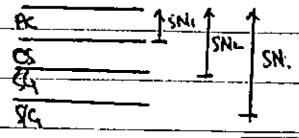
Volume

∴ Cut $= 1321.5\ m^3$

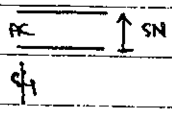
Fill $= 678.75\ m^3$

5 a)

Note SN_i depends on the overlaying soil layer



(i) If the pavement only use asphalt concrete + S/G.



$$SN = (0.45 \times 80 + 0.2 \times 1.2 \times 440 + 0.15 \times 1.1 \times 120)/25.4 = 3.52$$

$$D_1 = \frac{3.52}{0.45} \times 25.4 = 198.7 \approx 200\text{mm}$$

∴ Provide 200mm of AC

(ii) SI = average rating of pavement by panel ; rating 0~5, higher rating means better grade

initial SI = condition of pavement immediately after construction

terminal SI = condition of pavement at the end of its design life / before reconstruction

SI also relate to the performance of pavement.

Trend : SI will decrease along time

b) In flexible pvt : SUBBASE helps distribute the load into wider area so that the stress induced at the SUBGRADE is not overloaded, so that there will be no failure

In rigid pvt : SUBBASE is used as remedy for unsatisfactory S/G conditions
- control S/G volume change
- improves drainage of water
- controls mud pumping
- controls frost damage
- forms a working surface

e) Friction = f × Weight

$$A_s = \frac{f \times \text{weight}}{f_s} = \frac{1.4 \times (\frac{L}{2})(1)(0.25)(9.81 \times 2400)}{300 \times 10^6}$$

(per m wide)

$$= \frac{1.4 \times (\frac{15}{2})(1)(0.25)(9.81 \times 2400)}{300 \times 10^6}$$

$$= 206 \times 10^{-6}\ \text{m}^2$$

$\approx$ 206 mm² ≈ 210 mm² per m wide pavement