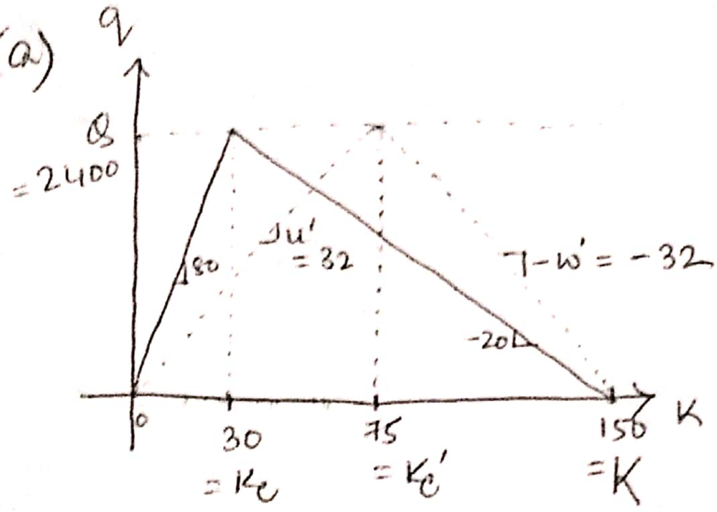
2.1. (a)



We make transformation as shown here to ensure actual solution.

Based on the excel sheet for CTM,

$$\text{capacity} = \frac{2400 \times 19}{52} \approx 877 \text{ vph}.$$

For travel time, we take 100 ft on each side of the two intersections. $\delta = 300$ ft.

$$T = T' - (K_e' - K_e) \times \delta$$

$$= \left[\frac{300 \text{ ft}}{32 \text{ Km/hr}} + \frac{300 \text{ ft}}{32 \frac{\text{Km}}{\text{hr}} \times \frac{19}{52}} \right] - (75-30) \text{ /Km} \times 300 \text{ ft}$$

$$= 17.87 \text{ s} \quad - 4.11 \text{ s}$$

$$= 13.76 \text{ s}$$

(b) Based on the sheet, capacity loss can avoided by offset less than 5 time cells.

$= 5 \times 1.15 \text{ s} = 5.75 \text{ s}$

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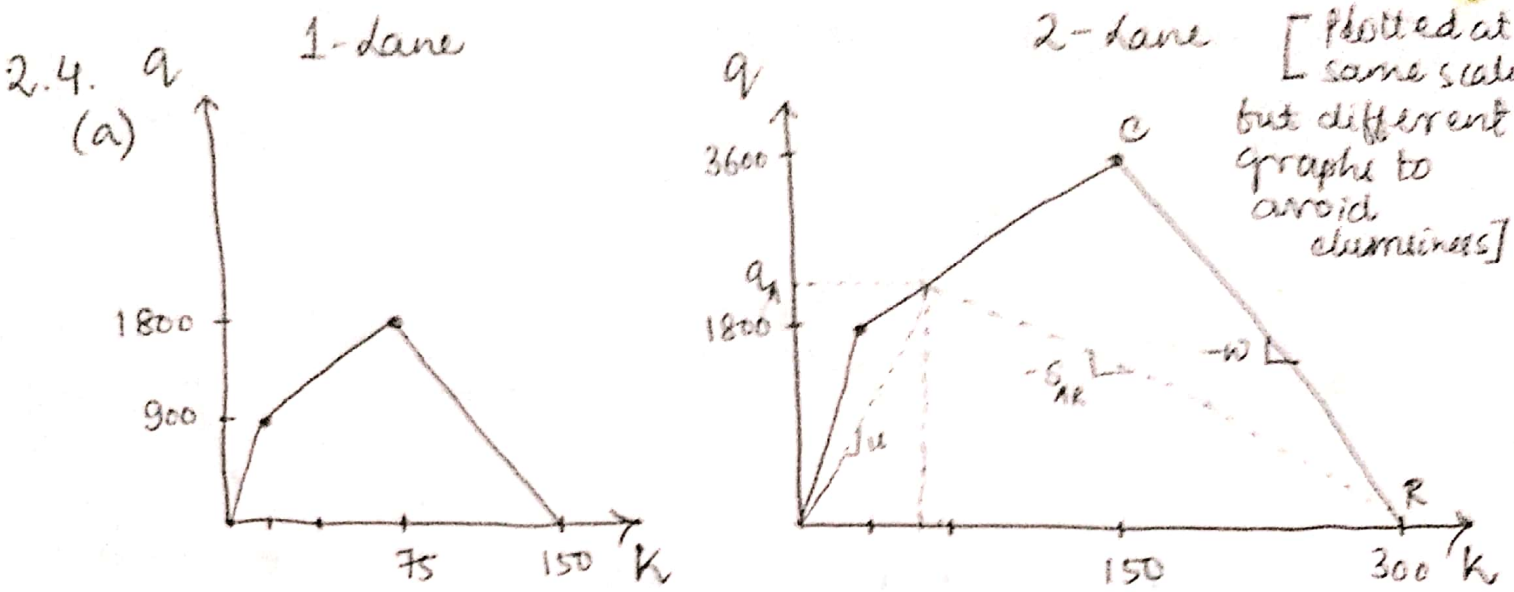
2.4.
(a)

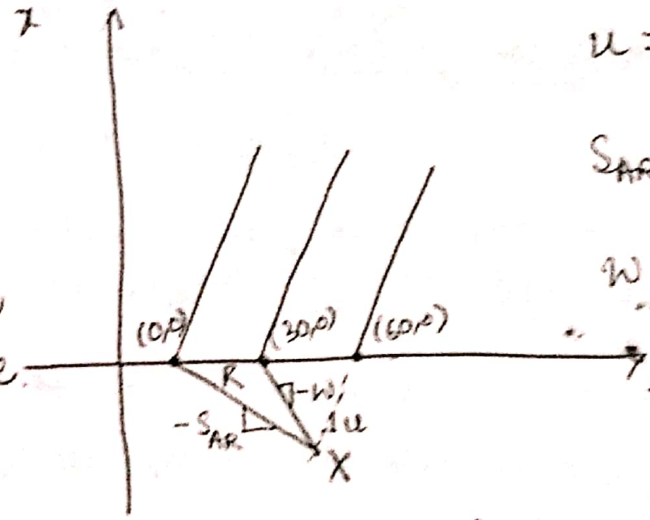


(b) Since the signal stays RED half the time, the maximum effective flow into the lane drop is half the maximum capacity. Therefore, the lane drop will be able to handle the incoming flow without causing any disruption in the signalized intersection.

$$u = \frac{16 q_A}{q_A - 1200}$$

$$S_{AR} = \frac{16 q_A}{6000 - q_A}$$

$$w = 24$$



Based on the value of q_A, the graph will change. However, to accomodate and clear off the entire queue in one GREEN, we need a point X as shown in the x–t diagram. Solving the equations for the lines, slope 'u' = line joining (60,0) and X.

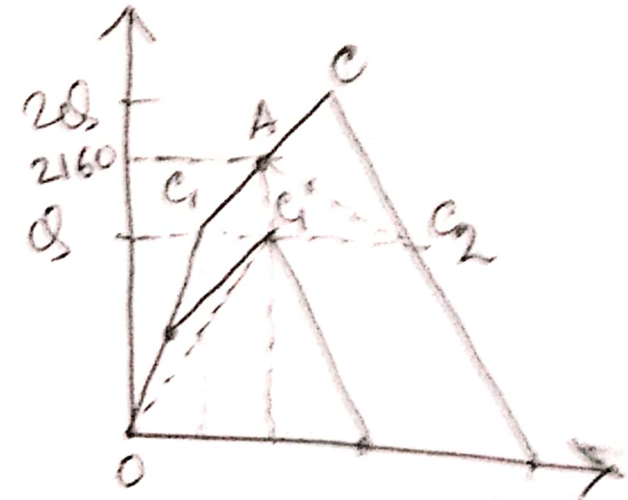
$$18(q_A - 1200) = 18(q_A - 6000) - 60(q_A - 3600)$$

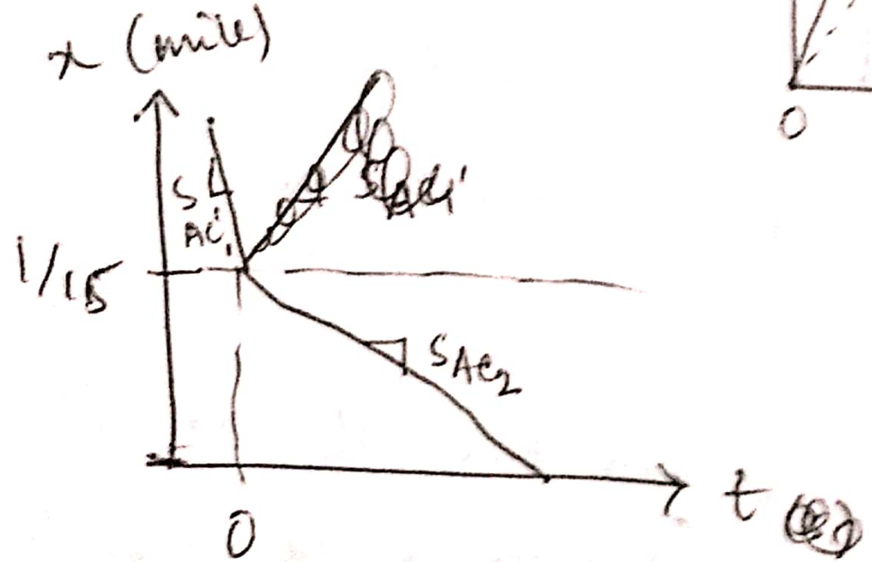
$\Rightarrow q_A = 2160$. So, effective capacity $= \frac{2160 \times 30}{60} = 1080$ vph

To summarize, a flow of ~~8~~ 2160 vph can be ~~can~~ handled by the signal without piling up queues with time. Eventually, an effective 1080 vph is handled by lane drop spot without any queue formation there.

2.4. (b) (continued)

Beyond that signal, there is a reduction in speed at the lane drop





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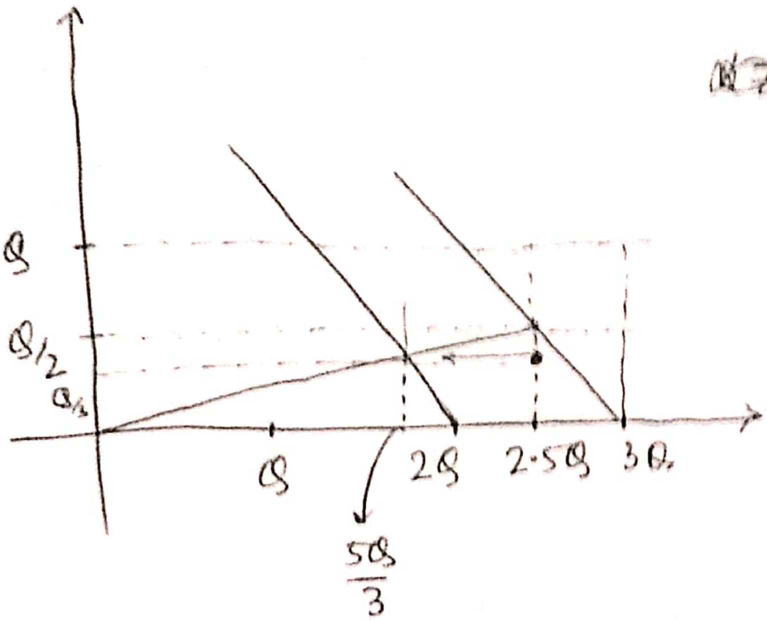
2.5.

1. ~~First 30 minutes then for 20 minutes~~ $\alpha = \frac{1}{2n-1} = \frac{1}{5}$



Initially, everything flows well, without queues on either FW or OR.

After 30 mins, $\frac{5Q}{3}$ is allowed out of $2.5Q$ in freeway and $Q/3$ is allowed out of $0.4Q$ in on-ramp

After 20 mins of that, $\frac{5Q}{6} \times 20$ mins vehicles wait.

$$\# \text{ vehs in FW queue} = \frac{5 \times 2400}{6} \times \frac{1}{60} \times 20$$

$$\approx 667$$

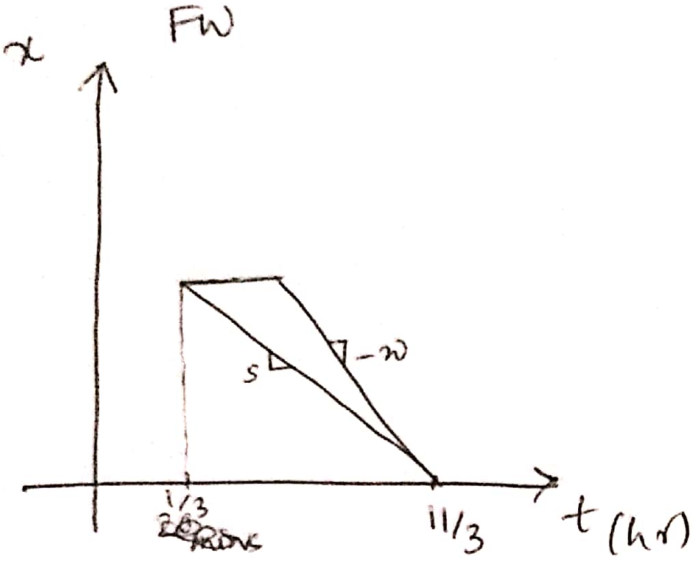
$$\# \text{ vehs in OR queue} = \frac{2400}{15} \times \frac{1}{60} \times 20$$

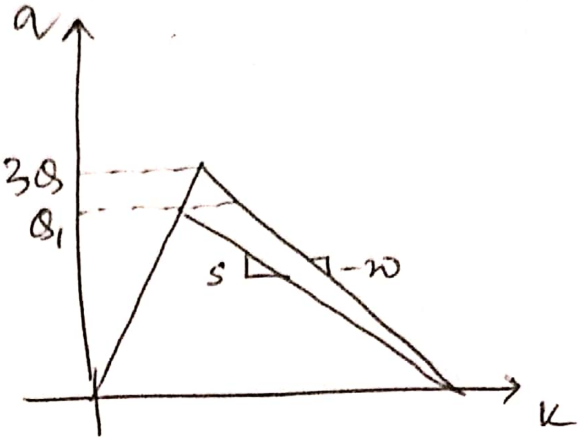
$$\approx 53$$

The queues will disperse based on the α value (i.e. $1/5$), so, $(2.5Q + \frac{Q}{12})$ flow on FW, and $(0.4Q + \frac{Q}{60})$ flow on the on-ramp.

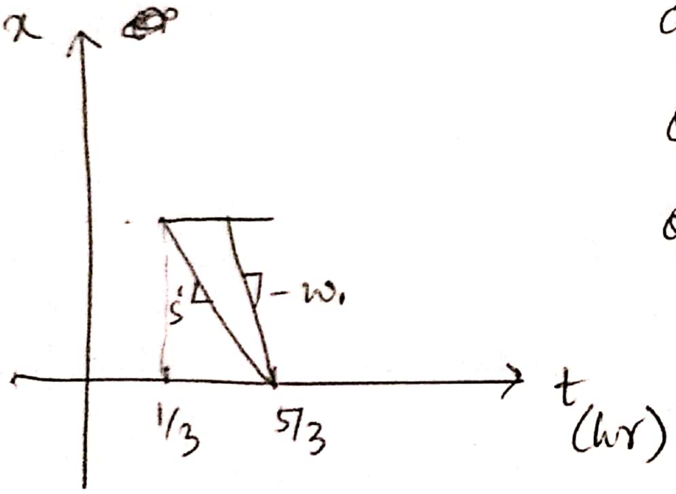
$$\text{Time to clear FW} = \frac{667}{Q/12} = \frac{10}{3} \text{ hours}$$

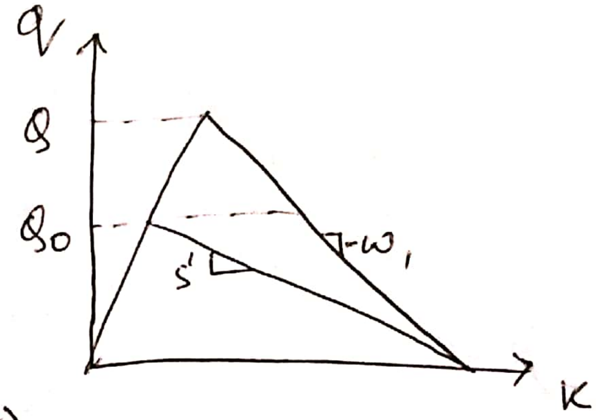
$$\text{Time to clear OR} = \frac{53}{Q/60} = \frac{4}{3} \text{ hours}$$





OR





(b) ~~Travel time over the first 11/3 hr for FW~~ Without merge, on-ramp would not have queues, for FW, travel time will increase

(c) With capacity drop, the queues will increase causing increase in travel time.

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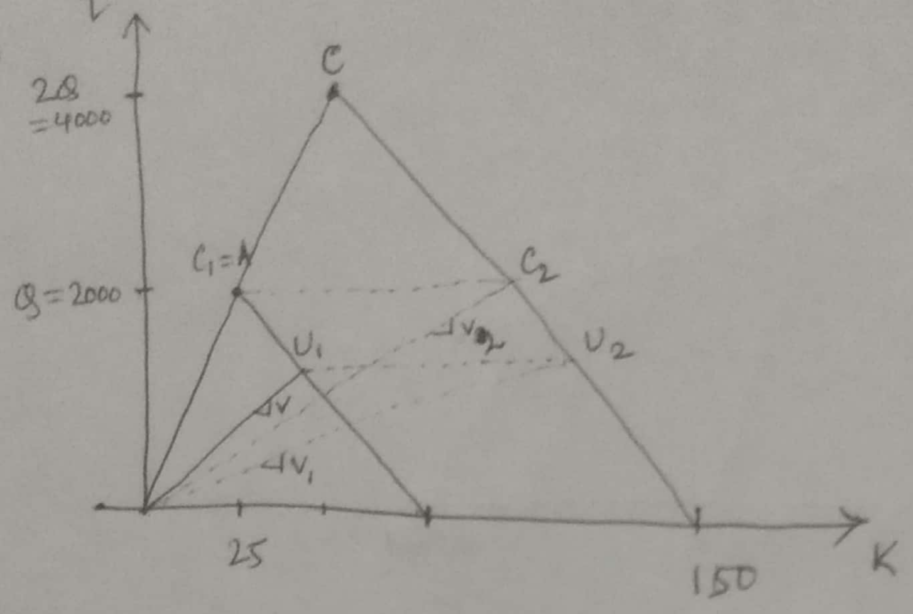
2.8.

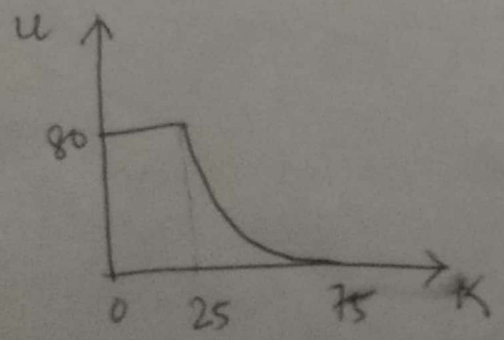
(a)



(b) $q = \begin{cases} 80K & 0 < K < 25 \\ 3000 - K \cdot 40 & \text{elsewhere} \end{cases}$

$Ku = \begin{cases} 80K & 0 < K < 25 \\ 3000 - K \cdot 40 & \text{elsewhere} \end{cases}$

$\Rightarrow u = \begin{cases} 80 & 0 < K < 25 \\ \dfrac{3000}{K} - 40 & \text{elsewhere} \end{cases}$



linear till K=25
non-linear beyond that

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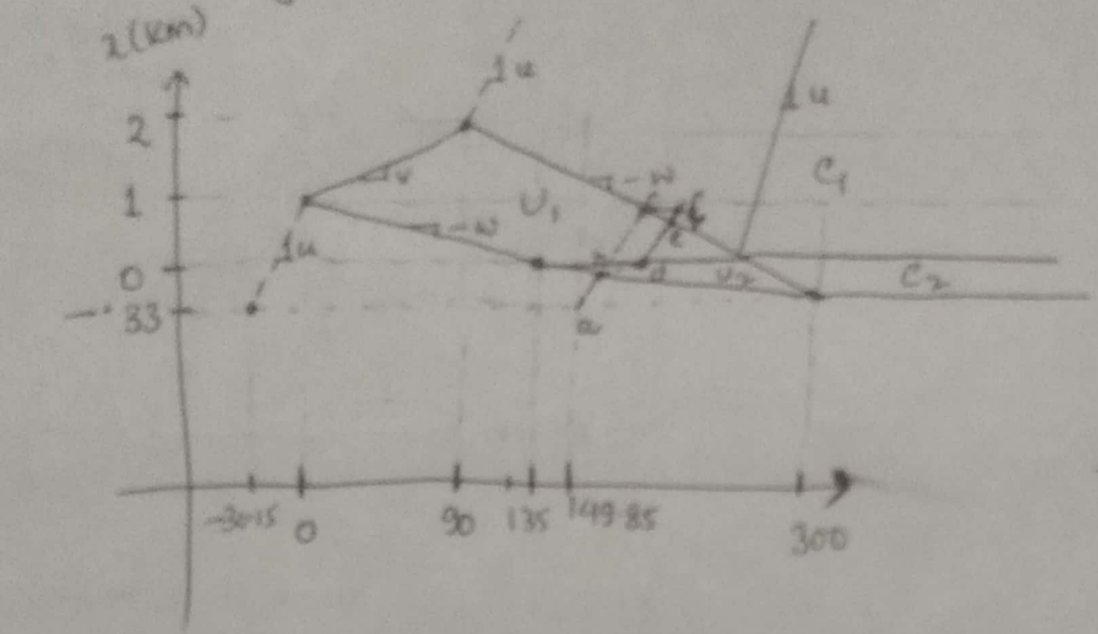
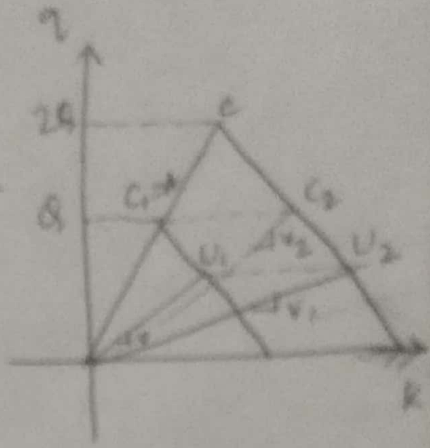
2.8. Solving parts (c) → (g)



u = 80



U_1(37.5, 1500)
U_2(112.5, 1500)
C_2(1000, 2000)
$v_1 = 40$; $v_2 = \frac{40}{3}$

a (149.85, −.33)
b (162.414, −0.055)
c (200.35, 0.77)
d (177.264, 0)
e (223.632, .575)
f (235.107, 0.77)

(c) Due to the truck, there will be a moving bottleneck that will disrupt traffic beyond the lane merge.

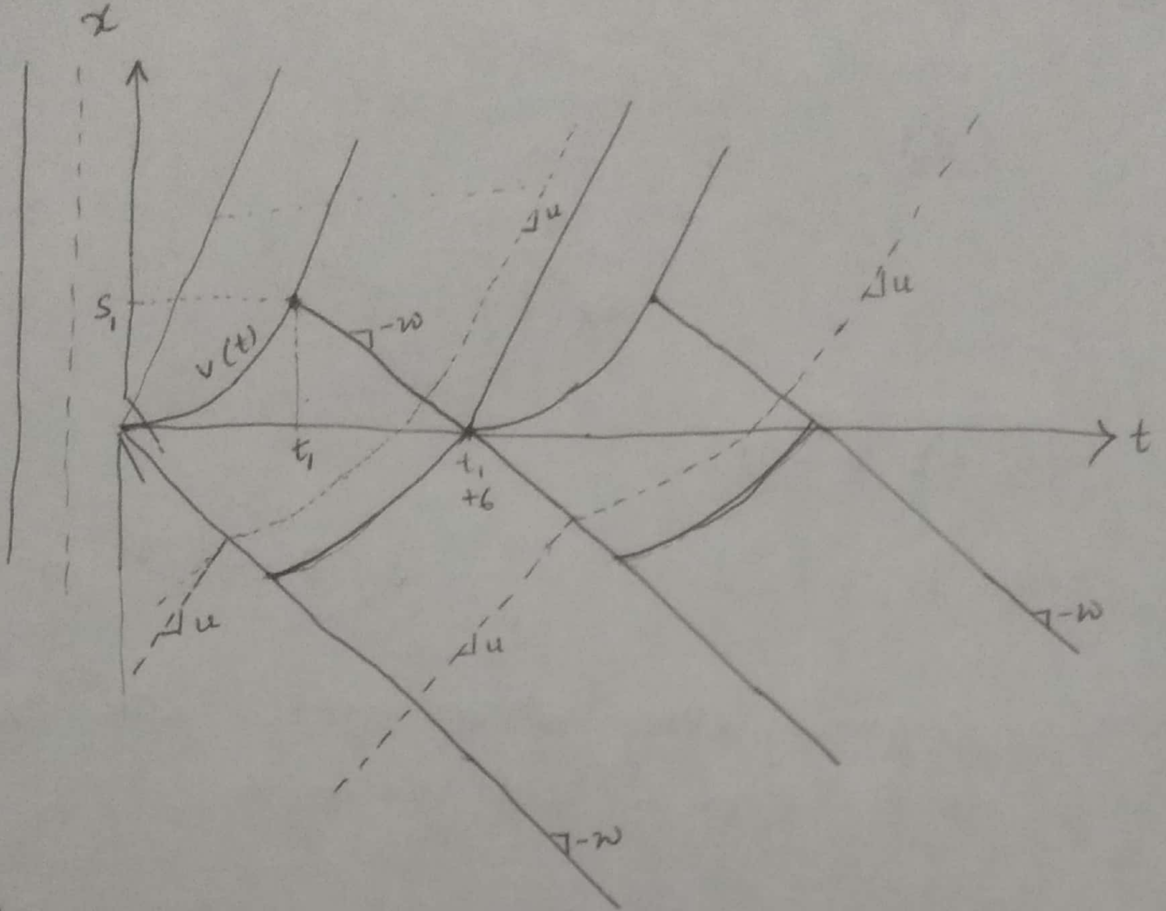
(d) At $x=0$, the effect of speed reduction is felt at $t = 135$ s.

(e) Based on the diagram, no effect is felt beyond $x = -.33$

(f) Diagram is drawn
vehicles hitting U_1 go at speed v_1 at U_2 @ v_1 and @ v_2 in C_2. Everywhere else it is u.

(g) At $x = .33$, $t = -30.15$ s, the truck is seen
The hundredth veh reaches at $x = 0.33$ at $t = -30.15 + \frac{100\times3600}{2000} = 149.85$ s
Ideally it should go a→b→c @ u with delay
But it goes a→b @ u, b→d @ v_1, d→e @ v, and e→f @ u to reach same location.
Delay = dist(c, f) = (235.107 − 200.35) = 34.757 s

2.14



(a) (i) $u = v_0 + at \Rightarrow t = \dfrac{u - v_0}{a}$

∴ Time for DLC to attain max^m speed $= \dfrac{u - v_0}{a}$

$$t_1 = \left(\frac{120 - v_0}{2}\right) \times \frac{5}{18} \text{ s}$$

$u^2 = v_0^2 + 2as$

∴ Distance covered $(S_1) = \dfrac{u^2 - v_0^2}{2a} = \dfrac{120^2 - v_0^2}{4} \times \dfrac{25}{324}$ m

(ii) $T = t_1 + \dfrac{u}{w} = t_1 + \dfrac{120}{20} = t_1 + 6$

In shoulder lane

capacity $= \dfrac{0 \times t_1 + Q \times 6}{t_1 + 6} = \dfrac{6Q}{t_1 + 6}$

Total capacity

$$Q' = Q + \frac{6Q}{t_1 + 6} = \frac{12Q + Qt_1}{t_1 + 6} = Q\left(2 - \frac{1}{1 + 6/t_1}\right)$$

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$$\text{percentage drop (cd)} = \frac{2Q - Q'}{2Q} \times 100$$

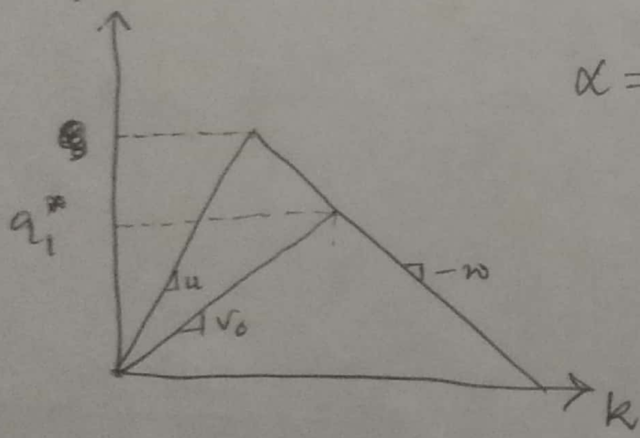
$$= \frac{50}{\left(1+\frac{6}{t_1}\right)} \%$$

(iv) If $a \uparrow \Rightarrow t_1 \downarrow \Rightarrow \frac{50}{1+\frac{6}{t_1}} \downarrow \Rightarrow cd \downarrow$

So, capacity drop reduces with increase in acceleration a and vice versa

2.14.

(b)



$$\alpha = \frac{1}{2n-1} = \frac{1}{3}$$

$$\text{Percentage drop} = \frac{\alpha}{1+\alpha} \times 100$$

$$= 25\%.$$

(c) $\frac{50}{\left(1+\frac{6}{t_1}\right)} = 5 \Rightarrow 1 + \frac{6}{t_1} = 10 \Rightarrow t_1 = \frac{2}{3}s$

$$\Rightarrow 120 - v_0 = \frac{2}{3} \times \frac{36}{5} = 4.8$$

$$v_0 = 115.2 \text{ Km/hr.}$$