CE 430
Transportation Systems

Tutorial #4

(Ch. 3: Traffic stream flow models)

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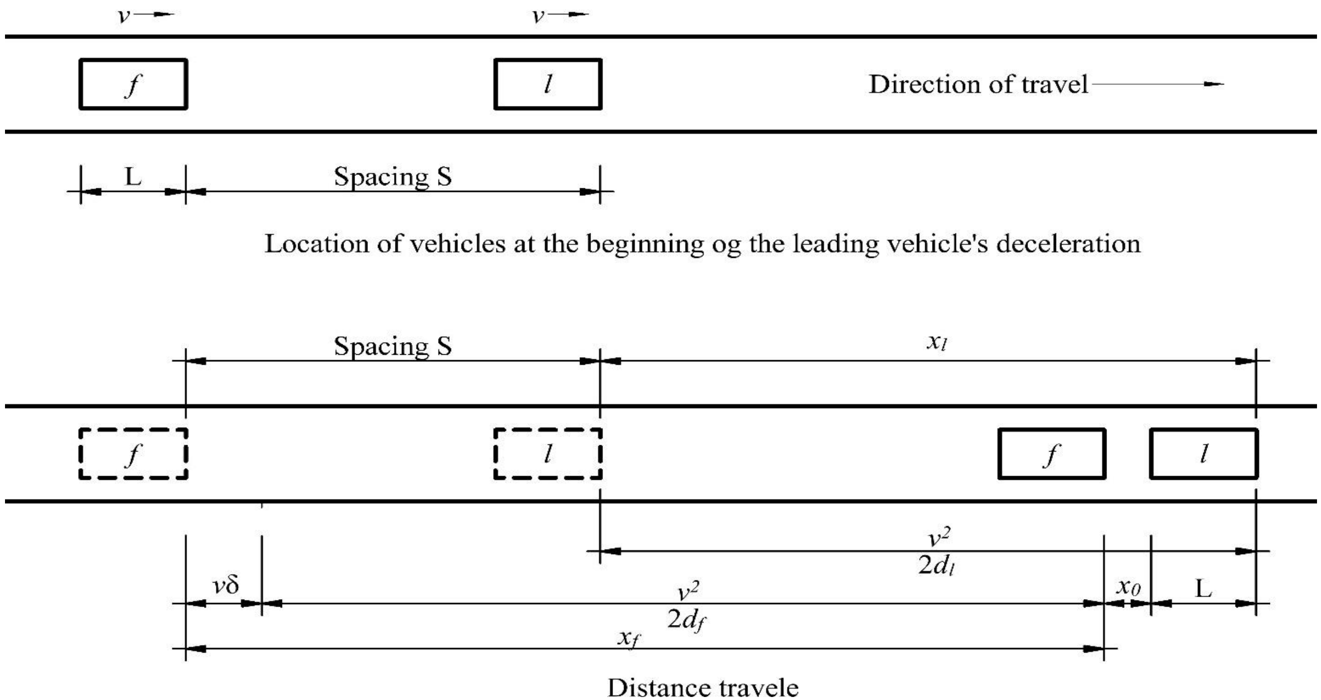


Figure 3.2.1 Vehicle following concept

- $S_{min} = V\,\delta + \dfrac{V^2}{2d_f} - \dfrac{V^2}{2d_l} + NL + X_0$

TABLE 3.2.1 Safety Regime Definitions

Regime	Deceleration of leading vehicle	Deceleration of following vehicle
a	∞	d_n
b	d_e	d_n
c	∞	d_e
d	$d_1 = d_f$	
e	(no braking)	

Note: For $d_e < 2d_n$, regime c is safer than regime b.
Source: Vuchic [3.1].

Two vehicles are traveling at speed limit of 60 mph. The safety margin after stop is 3ft and the length of the vehicles are 18ft. Assume the perception reaction time of the following vehicle 1.5 second, normal deceleration 8ft/s^2 emergency deceleration 24ft/s^2. Determine the minimum spacing between the vehicles to develop a safety regime (a) , (b) & (C).

$V = 60$ mph $= 88$ ft/s

$X_0 = 3$ ft

$L = 18$ ft

$N = 1$

Safety regime A :

$d_L = \infty$, $d_f = d_n = 8\text{ft/s}^2$

$$S_{min} = V\,\delta + \frac{V^2}{2d_f} - \frac{V^2}{2d_l} + NL + X_0$$

$$S_{min} = 88*1.5 + \frac{88^2}{2*8} - \frac{88^2}{2*\infty} + 1*18 + 3$$

$$S_{min} = 673 \text{ ft}$$

Safety regime B :

$d_L = 24 \text{ ft/s}^2$, $d_f = d_n = 8\text{ft/s}^2$

$$S_{min} = V\,\delta + \frac{V^2}{2d_f} - \frac{V^2}{2d_l} + NL + X_0$$

$$S_{min} = 88*1.5 + \frac{88^2}{2*8} - \frac{88^2}{2*24} + 1*18 + 3$$

$$S_{min} = 475.67 \text{ ft}$$

Safety regime C :

$d_L = \infty$, $d_f = d_e = 24\text{ft/s}^2$

$$S_{min} = V\,\delta + \frac{V^2}{2d_f} - \frac{V^2}{2d_l} + NL + X_0$$

$$S_{min} = 88*1.5 + \frac{88^2}{2*24} - \frac{88^2}{2*\infty} + 1*18 + 3$$

$$S_{min} = 314.33 \text{ ft}$$

The post speed of 8 vehicles were observed to be

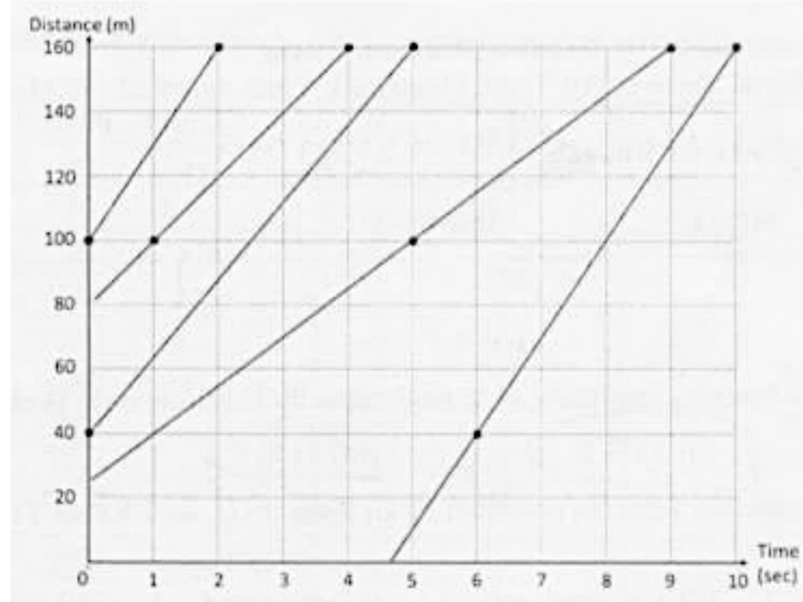
25, 30, 40, 45, 35, 33, 28, 50 mph, respectively.

Compute the time mean speed U_t & space mean speed U_s .

$$U_t = \frac{\sum v}{N} = \frac{25 + 30 + 40 + 45 + 35+33+28+50}{8} = 35.75\ mph$$

$$U_s = \frac{1}{\frac{1}{N}\sum\frac{1}{v}} = \frac{1}{\frac{1}{8}\left(\frac{1}{25} + \frac{1}{30} + \frac{1}{40} + \frac{1}{35} + \frac{1}{33} + \frac{1}{28} + \frac{1}{50}\right)} = 37.57\ mph$$

From the following time – distance graph, find the the time mean speed U_t & space mean speed U_s

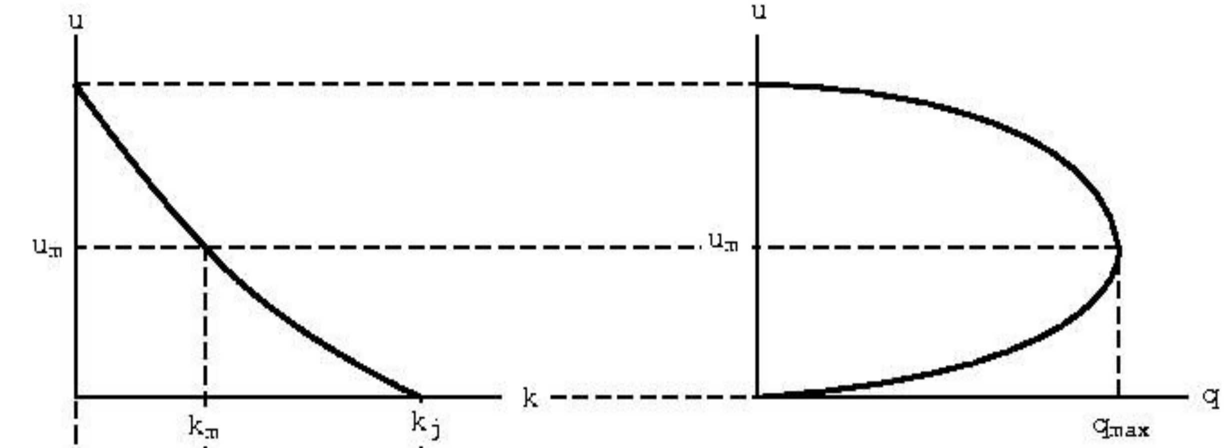


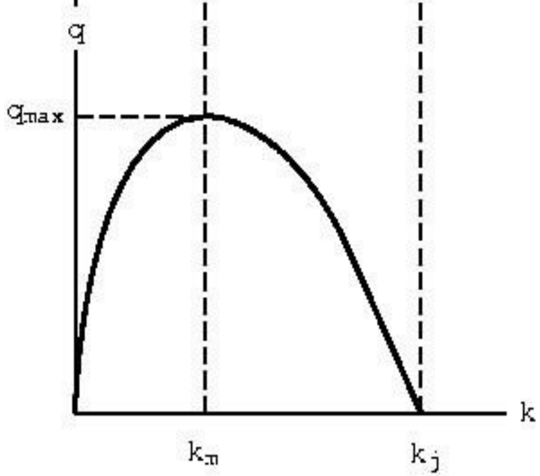
Slop = Speed = $\frac{d_2 - d_1}{t_2 - t_1}$

Speeds : 30, 20, 24, 15, 30 m/s

$$U_t = \frac{\sum v}{N} = \frac{30+20+24+15+30}{5} = 23.8\ m/s$$

$$Us = \frac{1}{\frac{1}{N}\sum\frac{1}{v}} = \frac{1}{\frac{1}{5}\left(\frac{1}{30}+\frac{1}{20}+\frac{1}{24}+\frac{1}{15}+\frac{1}{30}\right)} = 22.22\ m/s$$





- Speed (u) - mph , Km/hr
- Flow (q) - vph
- Density (k) - vpm , vpk
- Spacing (S) - mpv , kpv
- Headway (h) - sec/veh

- **K =** $\frac{1}{S}$ **, S =** $\frac{1}{K}$
- **h =** $\frac{1}{q}$ **, q =** $\frac{1}{h}$
- **S = h x u**

Given s = $\frac{1}{0.30(60-u)}$, where the spacing in miles and u is the speed in mph.

Derive the relationships: u-k, q-u and q-k. and find saturation flow rate q_{max} , speed at saturation U_m and maximum density k_j

$K = \frac{1}{s} = \frac{1}{\frac{1}{0.30(60-u)}}$

$K = 0.3(60 - u) = 18 - 0.3u$

$0.3u = 18 - k$

$\rightarrow \boldsymbol{u = 60 - 3.333\, k}$ **(u-k)**

$q = u\,k$

$q = u\,(18 - 0.3u)$

$\rightarrow \mathbf{q = 18\,u - 0.3\,u^2}$ **(q-u)**

$q = u\,k$

$q = (60 - 3.333k)\,K$

$\rightarrow \mathbf{q = 60\,k - 3.333k^2}$ **(q-K)**

K_j happen when u=0

$k_j = 18 - 0.3u$

$\rightarrow \mathbf{K_j = 18\ Vpm}$

$\mathbf{K_m = \frac{K_j}{2} = \frac{18}{2} = 9\ Vpm}$

U_f happen when k=0

$U_f = 60 - 3.333\,k$

$\mathbf{U_f = 60\ mph}$

$\rightarrow \mathbf{U_m = \frac{U_f}{2} = \frac{60}{2} = 30\ mph}$

q_{max} happens at K_m & U_m

$q_{max} = 60\,k_m - 3.333k_m^2$

$q_{max} = 60*9 - 3.333*9^2$

$\rightarrow \mathbf{q_{max} = 270\ Vph}$

$q_{max} = 18\,u_m - 0.3\,u_m^2$

$q_{max} = 18*30 - 0.3*30^2$

$\rightarrow \mathbf{q_{max} = 270\ Vph}$