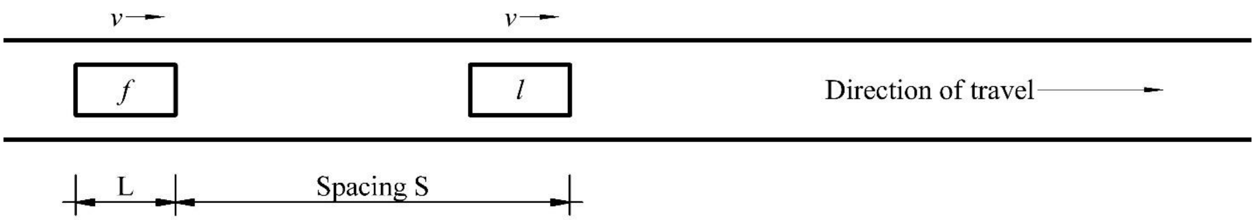
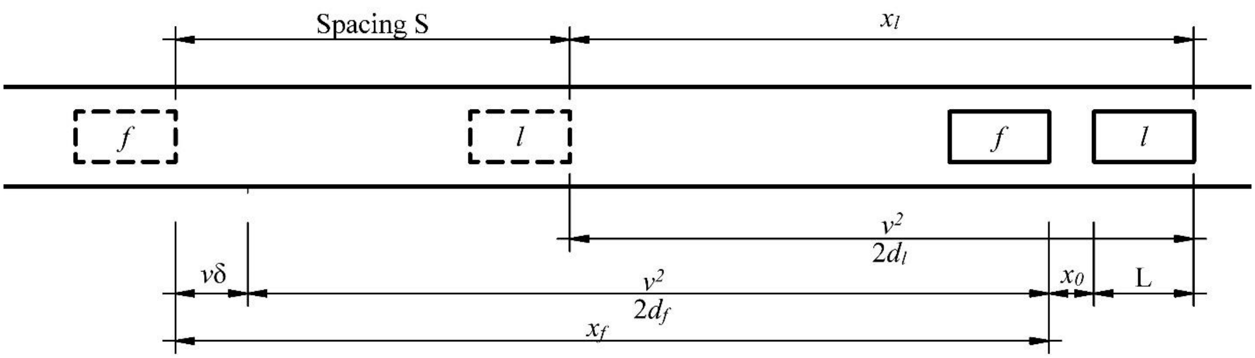
Vehicular Following:



Location of vehicles at the beginning og the leading vehicle's deceleration



Distance travele

$$x_l = \frac{v^2}{2d_l} \qquad \rightarrow (3.2.1)$$

$$x_f = v\delta + \frac{v^2}{2d_f} \qquad \rightarrow (3.2.2)$$

$$x_f = s + x_l - NL - x_0 \qquad \rightarrow (3.2.3)$$

$$s = v\delta + \frac{v^2}{2d_f} - \frac{v^2}{2d_l} + NL + x_0 \qquad \rightarrow (3.2.4)$$

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 in uninterrupted flow are traveling at speed limit of 100 km/hr. The safety margin after stop is 1m and the length of the vehicles are 6m. Assume the perception reaction time of the following vehicle to be 1 second. Determine the minimum spacing between the vehicles to develop a safety regime (b) and (c).

Given:

v = 100 km/hr = 27.78 m/s x_0 = 1m L = 6m   δ = 1 sec. N = 1

Safety regime (b):

$d_l = d_e$ = 7.3 m/s^2 $d_f = d_n$ = 2.4 m/s^2

$$s = v\delta + \frac{v^2}{2d_f} - \frac{v^2}{2d_l} + NL + x_0$$

$$s = 27.78 \times 1 + \frac{27.78^2}{2 \times 2.4} - \frac{27.78^2}{2 \times 7.3} + 1 \times 6 + 1 = 142.7m$$

➔ To develop a safety regime (b), vehicles should be at least 142.7m apart.

Safety regime (c):

d_l = ∞ = ∞ m/s^2 $d_f = d_e$ = 7.3 m/s^2

$$s = v\delta + \frac{v^2}{2d_f} - \frac{v^2}{2d_l} + NL + x_0$$

$$s = 27.78 \times 1 + \frac{27.78^2}{2 \times 7.3} - \frac{27.78^2}{2 \times \infty} + 1 \times 6 + 1 = 87.6m$$

➔ To develop a safety regime (c), vehicles should be at least 87.6m apart.

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Stream Variables:

- Microscopic:
  - Time Mean Speed — (u_t) – ft/sec or mph (m/s or kph)
  - Spacing — (s) – ft/veh (m/veh)
  - Headway — (h) – sec/veh

- Macroscopic:
  - Space Mean Speed — (u_s) – ft/sec or mph (m/s or kph)
  - Flow — (q) – veh. /sec or vph
  - Density — (k) – veh. /ft or vpm (v/m or vpk)

$$s = \frac{1}{k} \qquad \rightarrow (3.3.1)$$

$$h = \frac{1}{q} \qquad \rightarrow (3.3.2)$$

$$u_t = \frac{\sum v}{N} \qquad \rightarrow (3.3.3)$$

$$u_s = \frac{1}{\frac{1}{N}\sum \frac{1}{v}} \qquad \rightarrow (3.3.6)$$

A traffic counter on highway A counted 1200 vehicles passing by in one hour. Simultaneously, an aerial image showed that there are 80 vehicles on a stretch of 1 kilometer in highway B. Calculate the headway in highway A and the spacing in highway B.

Highway A:

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

$$h = \frac{3600}{1200} = 3\ seconds$$

Highway B:

$$s = \frac{1}{k}$$

$$s = \frac{1000}{80} = 12.5\ m$$

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Given the following speed data, calculate the time mean speed and the space mean speed.

Vehicle number	1	2	3	4	5	6	7
Speed, km/hr	120	105	125	100	130	120	115

$$u_t = \frac{\sum v}{N} = \frac{120 + 105 + 125 + 100 + 130 + 120 + 115}{7} = 116.43\ km/hr$$

$$u_s = \frac{1}{\frac{1}{N}\sum\frac{1}{v}} = \frac{1}{\frac{1}{7}\left(\frac{1}{120} + \frac{1}{105} + \frac{1}{125} + \frac{1}{100} + \frac{1}{130} + \frac{1}{120} + \frac{1}{115}\right)} = 115.5\ km/hr$$

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Vehicular Stream Equations and Diagrams:

$$distance = time \times speed$$

$$s = h \times u$$

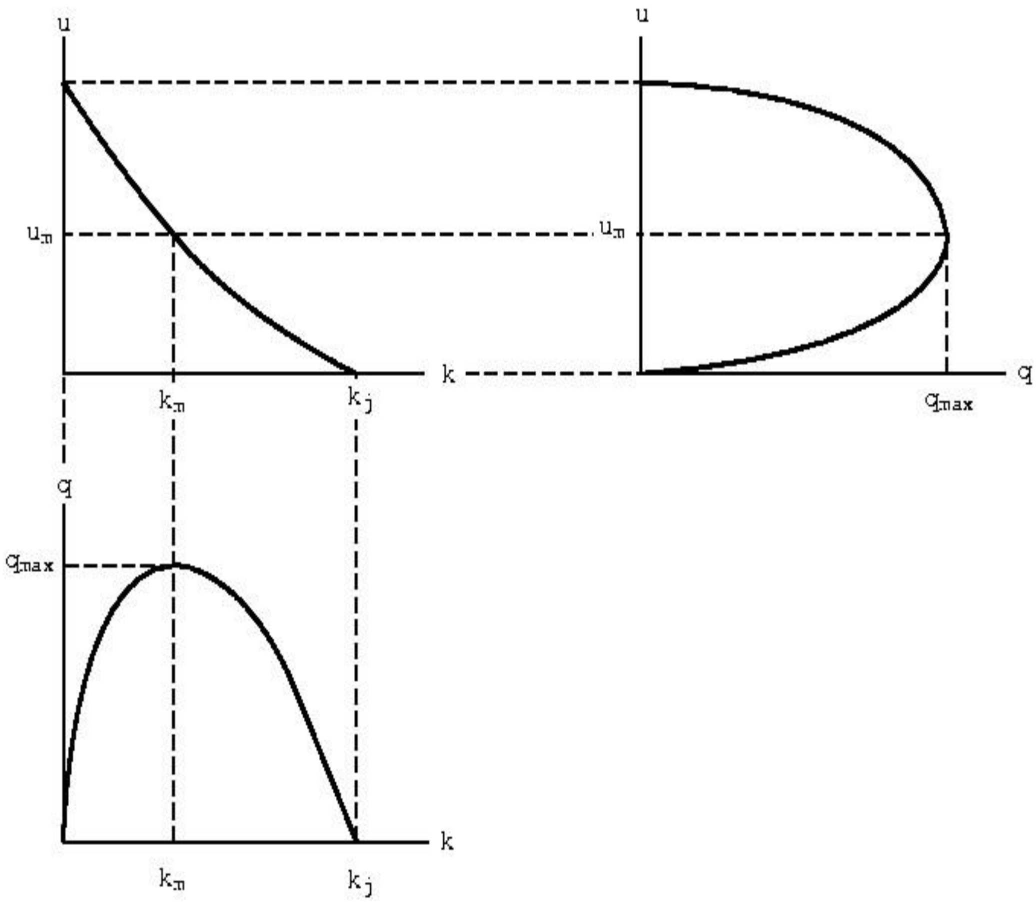
$$\frac{1}{k} = \frac{1}{q} \times u_s$$

$$q = u_s k \qquad \rightarrow (3.4.1)$$

$$k = \frac{1}{s} = \frac{1}{u\delta + \frac{u^2}{2d_f} - \frac{u^2}{2d_l} + NL + x_0} \qquad \rightarrow (3.4.2)$$

$$k = u_s q = \frac{1}{u\delta + \frac{u^2}{2d_f} - \frac{u^2}{2d_l} + NL + x_0}$$

$$q = \frac{u_s}{u\delta + \frac{u^2}{2d_f} - \frac{u^2}{2d_l} + NL + x_0} \qquad \rightarrow (3.4.3)$$



Example 3.2: Assume that drivers follow the rule of the road of keeping a gap of one car length for each 10 mile/hr increment of speed. Assuming a car length of 20 ft, develop the equation of stream flow and draw *u-k, q-u* and *q-k* diagram.

For every 10 mph, the spacing will be the gap of one car length plus the length of the leading car.

$$s = \left(\frac{u}{10}\right) L + L$$

- *u-k:*

$$s = \left(\frac{u}{10}\right) L + L$$

$$s = \left(\frac{u}{10}\right) 20 + 20 = 2u + 20$$

$$k = \frac{1}{s} = \frac{1}{2u + 20} \qquad veh/ft$$

$$k = \frac{5280}{2u + 20} \qquad vpm$$

$$k = \frac{2640}{u + 10} \qquad vpm$$

$$k(u + 10) = 2640$$

$$uk + 10k = 2640$$

- *q-k:*

  since *q=uk*, substitute in the above equation:

$$q + 10k = 2640$$

$$q = 2640 - 10k \qquad vph$$

- *q-u:*

$$q = 2640 - 10 \times \frac{2640}{u + 10} \qquad vph$$

$$q = 2640 - \frac{26400}{u + 10} \qquad vph$$

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Example 3.3: Given the relationship between speed and concentration obtained from actual data is $u=88–0.62k$, estimate q_{max}, u_m, and k_j.

- *q-k:*

$$u = 88 - 0.62k$$

Multiply both sides by k and apply $q=uk$,

$$uk = k88 - 0.62k^2$$

$$q = k88 - 0.62k^2$$

- *k-u:*

$$u = 88 - 0.62k$$

$$0.62k = 88 - u$$

$$k = 142 - 1.61u$$

- *q-u:*

Multiply both sides of the above equation sides by u and apply $q=uk$,

$$uk = 142u - 1.61u^2$$

$$q = 142u - 1.61u^2$$

- k_j: jam concentration happens at u=0

$$k = 142 - 1.61u$$

$$k_j = 142\ veh/km$$

- u_f : free flow speed happens at k=0

$$u = 88 - 0.62k$$

$$u_f = 88 \quad km/h$$

- k_m and u_m:

$$k_m = \frac{k_j}{2} = \frac{142}{2} = 71\ veh/km$$

$$u_m = \frac{u_f}{2} = \frac{88}{2} = 44 \quad km/h$$

- q_{max}:

$$q_{max} = u_m k_m = 44 \times 71 = 3124\ vph$$

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