CVG4150 Fall – 2017
Highway & Transportation
ASSIGNMENT #2
Solution

**Q1.**

Data and equation used in this question:
$\delta$ = 2.5 s, $d_n$ = 2.5 m/s$^2$, $d_e$ = 10 m/s$^2$, $L$ = 12.2 m, $N$ = 1, $x_0$ = 1.3 m.

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

| Regime | Deceleration of leading vehicle | Deceleration of following vehicle |
|---|---|---|
| a | ∞ | $d_n$ |
| b | $d_e$ | $d_n$ |
| c | ∞ | $d_e$ |
| d | $d_l = d_f$ | |
| e | no braking | |

**For safety regime *a***, $d_l = \infty$ and $d_f = d_n$ = 2.5 m/s$^2$

$$s = 2.5u + \frac{u^2}{2\times 2.5} - 0 + 12.2 + 1.3 \blacktriangleright\ s = 2.5u + \frac{u^2}{5} + 13.5 \quad (1)$$

**For safety regime *b***, $d_l = d_e$ = 10 m/s$^2$, and $d_f = d_n$ = 2.5 m/s$^2$

$$s = 2.5u + \frac{u^2}{2\times 2.5} - \frac{u^2}{2\times 10} + 12.2 + 1.3 \blacktriangleright\ s = 2.5u + \frac{3u^2}{20} + 13.5 \quad (2)$$

**For safety regime *c***, $d_l = \infty$, and $d_f = d_e$ = 10 m/s$^2$

$$s = 2.5u + \frac{u^2}{2\times 10} - 0 + 12.2 + 1.3 \blacktriangleright\ s = 2.5u + \frac{u^2}{20} + 13.5 \quad (3)$$

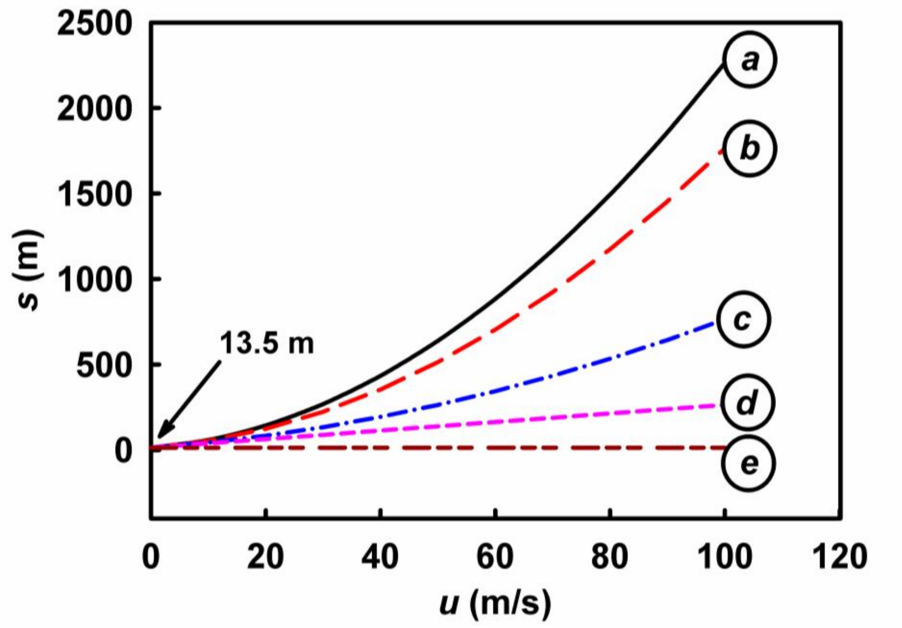
**For safety regime *d***, $d_l = d_f$

$$s = 2.5u + 12.2 + 1.3 \blacktriangleright\ s = 2.5u + 13.5 \quad (4)$$

**For safety regime *e***, no braking

$$s = 13.5 \quad (5)$$

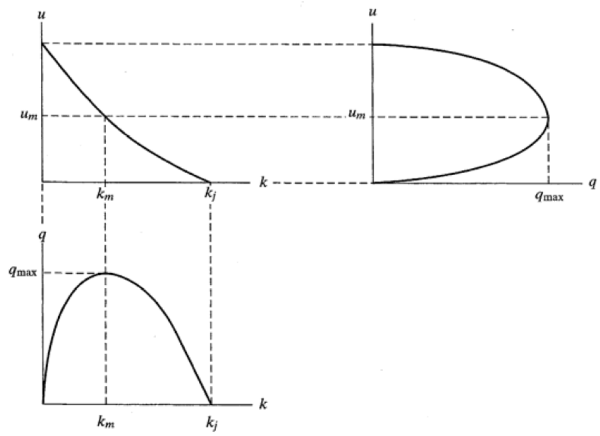
Plot Equations (1) through (5) in the following figure.



**Q2.**

Data and equation used in this question:

$u = 92.4 - 1.32k$ , $q = uk$




a) Free flow speed $u_f$ occurs at $k$ = 0.

$u_f = 92.4$ km/h .

b) Jam concentration $k_j$ occurs at $u$ = 0.

$92.4 - 1.32k = 0$

Thus, $k_j$ = 69.7 veh/km

c) $q = uk = 92.4k - 1.32k^2$

$$\frac{dq}{dk} = 0 \Rightarrow 92.4 - 2.64k = 0 \Rightarrow k = 35$$

Thus $k_m$ = 35 veh/km, $q_{max} = 92.4 \times k_m - 1.32 \times k_m^2$ = 1617 veh/h

d) $u = \frac{1617}{35} = 46.2\ km/h$

**Q3.**

Data and equation used in this question:

$$q = \frac{M_w + M_a}{T_w + T_a} \qquad T_{ave} = T_w - \frac{M_w}{q}$$

$V_a = V_w$ = 70 km/h, $L$ = 5 km,

$M_w$ = 17, $M_a$ = 303, $T_w = T_a$ = 5/70 = 0.071 h

a) Substitute $T_w$, $T_a$, $M_w$, $M_a$ into Eq. 1, we have $q$ = 2240 veh/h,
Substitute $T_w$, $M_w$, $q$ into Eq. 2, we have $T_{ave}$ = 0.0638 h,
Then $u = L/T_{ave}$ = 78.31 km/h

b) Based on $T_{ave} = T_w - \frac{M_w}{q}$ we have $\frac{M_w}{T_w - T_{ave}} = q$

(i) For vehicles with speed 100 km/h,
$q_{100}$ = 0.4 × 2240 = 896 veh/h, $T_w$ = 5/70 h, $T_{ave(100)}$ = 5/100 h,
$M_{w(100)}$ = 896 × (5/70 - 5/100) = 19 vehicles.

(ii) For vehicles with speed 80 km/h,

$q_{80}$ = 0.3 × 2240 = 672 veh/h, $T_w$ = 5/70 h, $T_{ave(80)}$ = 5/80 h,
$M_{w(80)}$ = 672 × (5/70 - 5/80) = 6 vehicles.

c) $q_{60}$ = 0.3 × 2240 = 672 veh/h, $T_w$ = 5/70 h , $T_{ave(60)}$ = 5/60 h,
$M_{w(60)}$ = 672 × (5/70 - 5/60) = -8 vehicles
i.e., Vehicles driving at 60km/h overtaken by observer = 8 vehicles