

## CE 3201

## Homework #5 (Due March 12, 2008)

1. Problem 5.1 pp. 167, MKW.

Determine space-mean speed and free-flow speed.

$$u = u_f \cdot \left[ 1 - \left( \frac{k}{k_j} \right)^{3.5} \right] \quad k_j := 225 \quad q_{\text{cap}} := 3800 \quad (\text{given})$$

$$q = k \cdot u = u_f \cdot \left[ k - k \cdot \left( \frac{k}{k_j} \right)^{3.5} \right] \quad (\text{Eq. 5.14})$$

at capacity,  $\frac{d}{dk}q = 0$

$$0 = \left[ 1 - 4.5 \cdot \left( \frac{k_{\text{cap}}}{k_j} \right)^{3.5} \right]$$

$$k_{\text{cap}} = 146.4$$

$$q_{\text{cap}} = k_{\text{cap}} \cdot u_{\text{cap}} \quad (\text{Eq. 5.14})$$

$$u_{\text{cap}} := \frac{q_{\text{cap}}}{k_{\text{cap}}} \quad u_{\text{cap}} = 25.96 \quad \frac{\text{mi}}{\text{h}}$$

$$u_f := \frac{q_{\text{cap}}}{\left[ k_{\text{cap}} - k_{\text{cap}} \cdot \left( \frac{k_{\text{cap}}}{k_j} \right)^{3.5} \right]} \quad u_f = 33.37 \quad \frac{\text{mi}}{\text{h}}$$

2. Problem 5.3, pp. 167, MKW.

Determine the capacity, speed at capacity, and density at one quarter capacity.

$$q(k) := (50 \cdot k - 0.156 \cdot k^2) \quad (\text{given})$$

$$\frac{d}{dk} q(k) \rightarrow 50 - .312 \cdot k$$

$$0 = 50 - .312 \cdot k_{\text{cap}}$$

$$k_{\text{cap}} := 160$$

$$q_{\text{cap}} := q(k_{\text{cap}}) \quad q_{\text{cap}} = 4006.4 \quad \frac{\text{veh}}{\text{h}}$$

$$u_{\text{cap}} := \frac{q_{\text{cap}}}{k_{\text{cap}}} \quad u_{\text{cap}} = 25.04 \quad \frac{\text{mi}}{\text{h}}$$

at 25% of capacity

$$q := \frac{q_{\text{cap}}}{4}$$

$$q = 1001.6 \quad \frac{\text{veh}}{\text{h}}$$

$$50 \cdot k - 0.156 \cdot k^2 - \frac{q_{\text{cap}}}{4} = 0$$

$$k_1 = 21.5 \quad \frac{\text{veh}}{\text{m}}$$

$$k_2 = 299 \quad \frac{\text{veh}}{\text{m}}$$

## 3. Problem 5.4, pp. 167, MKW

Calculate the flow, average speed, and density of the traffic stream in this lane.

$$h_{\text{bar}} := 3 \quad s_{\text{bar}} := 150$$

(given)

$$q := \frac{1}{h_{\text{bar}}}$$

(Eq. 5.4)

$$q = 0.333 \quad q \cdot 3600 = 1200 \quad \text{veh/hr/ln}$$

$$k := \frac{1}{s_{\text{bar}}}$$

(Eq. 5.13)

$$k = 0.007 \quad k \cdot 5280 = 35.2 \quad \text{veh/mi/ln}$$

$$u := \frac{q \cdot 3600}{k \cdot 5280} \quad u = 34.09 \quad \text{mi/hr}$$

Also

$$q := \frac{3600}{h_{\text{bar}}} \quad q = 1200 \quad \text{veh/hr/ln}$$

$$k := \frac{5280}{s_{\text{bar}}} \quad k = 35.2 \quad \text{veh/mi/ln}$$

$$u := \frac{s_{\text{bar}}}{h_{\text{bar}}} \quad u = 50 \quad \text{ft/s} \quad u \cdot \frac{3600}{5280} = 34.09 \quad \text{mi/hr}$$

**Problem 5.4**

## 4. Problem 5.5, pp. 167, MKW

Determine the time-mean speed and space-mean speed.

Lane 1	Lane 2	Lane 3
30 mi/h	45 mi/h	60 mi/h
1 vehicle every 60 sec	1 vehicle every 40 sec	1 vehicle every 30 sec

For 30 minutes

$$t := 30$$

$$\text{Num}_1 := 60 \quad \text{Num}_2 := 40 \quad \text{Num}_3 := 30$$

$$\text{Lane}_1 := t \cdot \left( \frac{60}{\text{Num}_1} \right) \quad \text{Lane}_1 = 30$$

$$\text{Lane}_2 := t \cdot \left( \frac{60}{\text{Num}_2} \right) \quad \text{Lane}_2 = 45$$

$$\text{Lane}_3 := t \cdot \left( \frac{60}{\text{Num}_3} \right) \quad \text{Lane}_3 = 60$$

$$\text{Speed}_1 := 30 \quad \text{Speed}_2 := 45 \quad \text{Speed}_3 := 60$$

$$u_{t\_bar} := \frac{\text{Speed}_1 \cdot \text{Lane}_1 + \text{Speed}_2 \cdot \text{Lane}_2 + \text{Speed}_3 \cdot \text{Lane}_3}{\text{Speed}_1 + \text{Speed}_2 + \text{Speed}_3}$$

$$u_{t\_bar} = 48.33 \quad \text{mi/h}$$

$$u_{s\_bar} := \frac{1}{\frac{1}{60 + 45 + 30} \left[ 60 \cdot \left( \frac{1}{60} \right) + 45 \cdot \left( \frac{1}{45} \right) + 30 \cdot \left( \frac{1}{30} \right) \right]}$$

$$u_{s\_bar} = 45 \quad \text{mi/h}$$