Chapter 5

Traffic Stream Parameters

Traffic Streams

- Individual vehicles and drivers make up the traffic stream
- Local characteristics and driver behavior are major factors on its performance
- Drivers and vehicles are not uniform in their make up or behavior

Traffic Streams

- Uninterrupted – freeways, two-lane rural roads
- Interrupted flow facilities – arterials, local roadways (have external devices that interrupted flow)

Interrupted Facilities

- Vehicles flow in platoons
  - A group of vehicles moving together with a significant gap between themselves and the next group of vehicles
- Signal timing plans try to take advantage of platoons for continuous flow
- Signals place less than 2 miles apart can be timed to allow for uninterrupted flow between signals

Traffic Stream Parameters

- Macroscopic parameters – describe the traffic stream as a whole
  - Traffic flow
  - Speed
  - Density
- Microscopic parameters - describe the behavior of the individual vehicle with respect to each other
  - Spacing
  - Headway

Macroscopic Parameters

- Traffic flow – number of vehicles that pass a certain point during a specified time interval (vehicles/hour)
- Speed – rate of motion in distance/time (mph)
- Density – number of vehicles occupying a given length of highway or lane (vehicles per mile per lane, vpmpl)

Spacing and Time Headway

- Spacing – the distance between successive vehicles in a traffic stream as they pass some common reference point on the vehicles
- Time headway – the time between successive vehicles in a traffic stream as they pass some common reference point on the vehicles

Traffic Flow and Time Headway

Traffic Flow given by:

$$q = \frac{n}{t}$$

q= traffic flow in vehicles per unit time
n= number of vehicles passing some designated roadway point during time t
t= duration of time interval
Flow measurements typically related to generalized period of time;
Volume of traffic refers to vehicles per hour

Time Headway given by:

$$t = \sum_{i=1}^{n} h_i$$

t= duration of time interval
h_i=time headway of the *i*th vehicle
n= number of measured vehicle time headways at some designated roadway point

Time Headway and Traffic Flow

- Time headway is defined as the time between the passage of successive vehicles (can be measured from front bumpers or rear bumpers)

Substituting *t* into the flow equation gives:

$$q = \frac{n}{\sum_{i=1}^{n} h_i} \quad or$$

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

Example Problem

Given the following headways, determine the average headway and the flow:

4.74s, 3.33s, 4.74s, 8.97s, 11.63s, 3.83s, 14.40s

Speed and Travel Time

- Time mean speed – point measure of speed
- Space mean speed – measure relating to length of roadway
- Average travel time – total time to traverse a highway
- Average running speed – total time during which vehicle is in motion while traversing a highway segment (no stop time included)

Speed and Travel Time

- Operating speed – maximum safe speed a vehicle can be driven without exceeding design speed
- 85^{th} percentile speed – speed at which 85% of vehicles are traveling at or below

Time Mean Speed

- Arithmetic mean of vehicles speeds is given by:

$$\bar{u}_t = \frac{\sum_{i=1}^{n} u_i}{n}$$

u_t=time-mean speed in unit distance per unit time
u_i=spot speed of the ith vehicle
n=number of measured vehicle spot speeds

Space Mean Speed

- Time necessary for a vehicle to travel some known length of roadway

$$\bar{u}_s = \frac{l}{\bar{t}}$$

u_s= space-mean speed in unit distance per unit time
l=length of roadway used for travel time measurements of vehicles
$t(bar)$= average vehicle travel time, defined as:

$$\bar{t} = \frac{1}{n}\sum_{i=1}^{n} t_i$$

t_i= time necessary for vehicle i to travel a roadway section of length l

Traffic Density

- Measure using aerial photographs; think of it as the number of vehicles that occupy a length of roadway

$$k = \frac{n}{l}$$

k=traffic density in vehicles per unit distance
n=number of vehicles occupying some length of roadway at some specified time
l=length of roadway

$$l = \sum_{i=1}^{n} s_i$$

s_i=spacing of the *i*th vehicle (the distance between vehicles *i* and *i*-1 measured from front bumper to front bumper

Spacing and Density

- Substituting the equation for roadway length into the density equation gives

$$k = \frac{n}{\sum_{i=1}^{n} s_i} \; or$$

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

Basic Traffic Stream Models

$$q = uk$$

Example: average headway is 2.5 s/veh on single lane roadway; average vehicle spacing is 200'; determine average speed of traffic.

$$q = \frac{1}{2.5 s/veh} = 0.40 veh/s$$

$$q = 0.40 veh/s \times 3600 s/hr$$

$$q = 1440 veh/hr$$

$$k = \frac{1}{200\, ft/veh} = 0.005 veh/ft$$

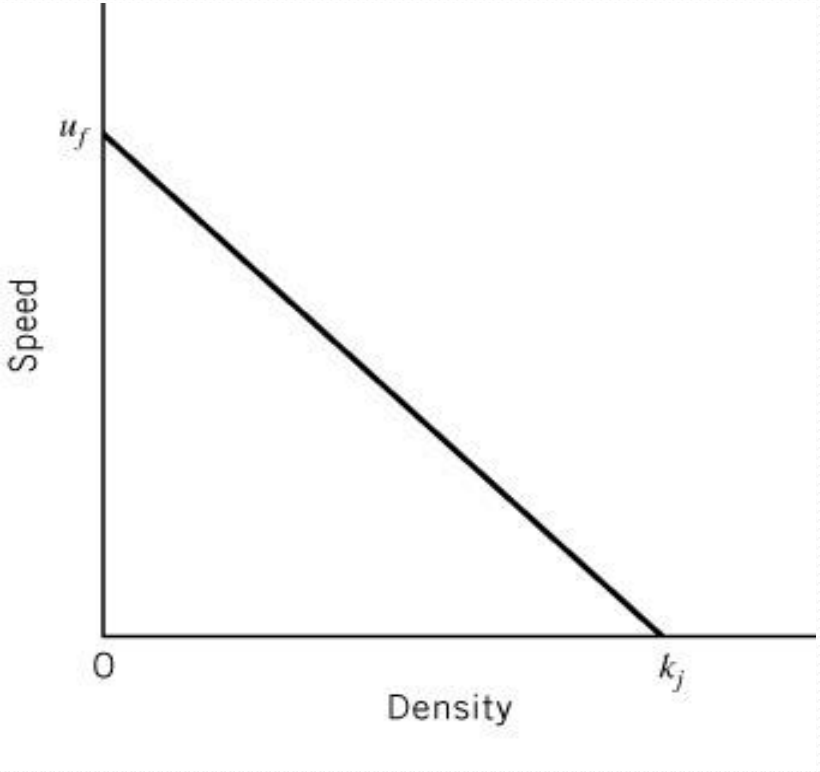
$$k = 0.005 veh/ft \times 5280\, ft/mi = 26.4 veh/mi$$

$$u = \frac{q}{k} = \frac{1440 veh/hr}{26.4 veh/mi} = 54.5 mi/hr$$

Speed-Density Model

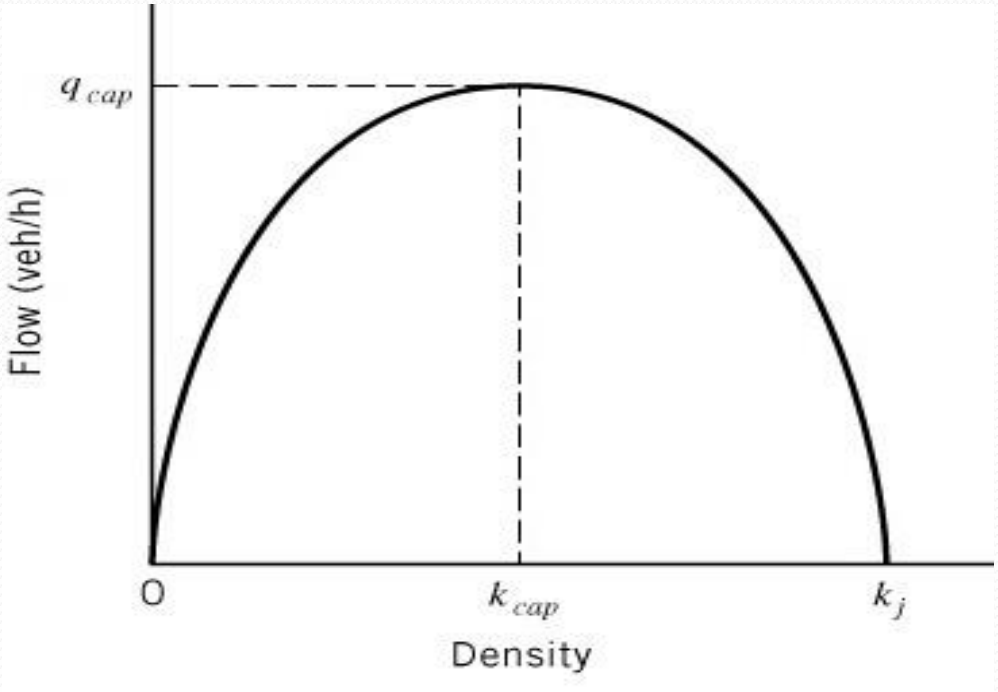
$$u = u_f\left(1 - \frac{k}{k_j}\right)$$

u=space mean speed in mi/hr
u_f= free-flow speed in mi/hr
k=density in veh/mi
k_j=jam density in veh/hr



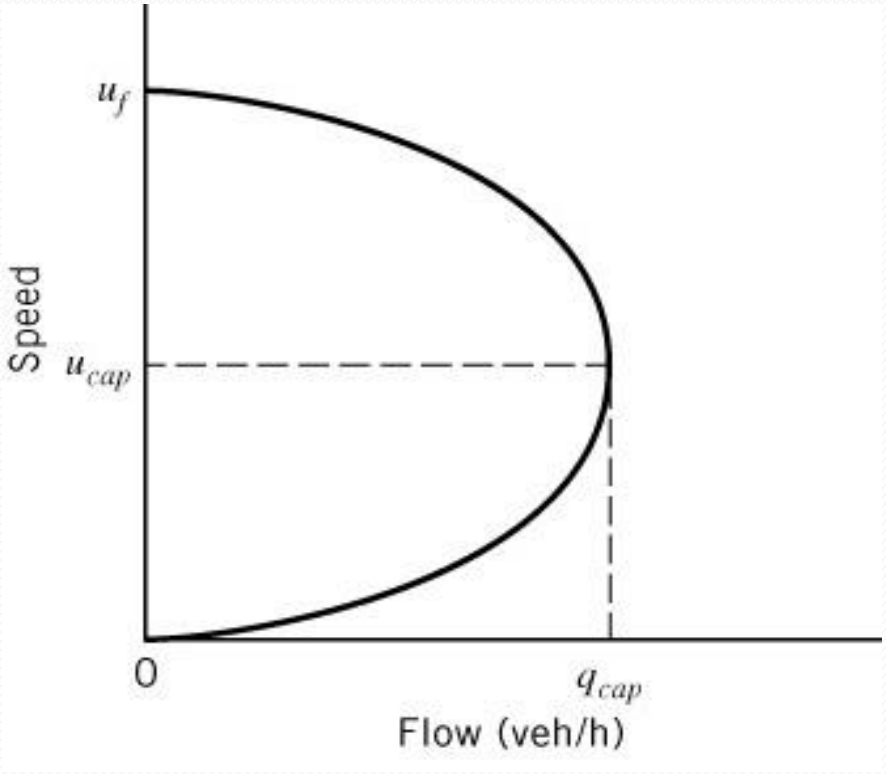
Flow-Density Model

$$q = u_f (k - \frac{k^2}{k_j})$$



Speed-Flow Model

$$q = k_j(u - \frac{u^2}{u_f})$$



Example Problem

- Given an estimate of density of 16.05 vpmpl at a speed of 60mph; determine the jam density and flow rate at 60mph. Assume car length is 15' and at jam density spacing between vehicles is 15'.

Volume

- Planning (non-directional) volume measures
  - Average annual daily traffic (AADT)
  - Average annual weekday traffic (AAWT)
  - Average daily traffic (ADT), average 24 hour volume that can be measured by season, month, week, day, etc.

Volume

- Hourly volumes – used for design and operational analysis
  - Peak hour volume – single highest hourly volume
  - Directional design hour volume –
    - AADT x K x D = DDHV (K = proportion of daily traffic during peak hour, D = proportion of peak traffic traveling in peak direction)

Volume

- Peak hour factor – describes the relationship between hourly volume and maximum rate of flow within the hour
  - PHF = hourly volume/maximum rate of flow OR
  - PHF = $V/(4 \times V_{15})$
- PHF range –

  1.0 (each 15 minute period equal) to

  0.25 (one 15 min period contains all traffic)

Peak Hour Factor Example

15 min period	Vehicle Count	Flow Rate (vph)
7:20AM	389	1556
7:35AM	495	1980
7:50AM	376	1504
8:05AM	363	1452
7:20-8:20AM	1623	1623

Peak Hour Factor Example

- Determine the Peak Hour Factor