CIVL - 7904/8904

TRAFFIC FLOW THEORY

LECTURE -1

Agenda for Today

- Introduction
- Review of Syllabus
- Traffic Flow Theory Basics
- Text Book Example

Background

Traffic Engineering Course

Math Background

- o Algebra
- Calculus
- Introductory Probability / Statistics
- Introductory Optimization
- Field Surveys



By restricting the scope of analysis, we can take a much more detailed look at how transportation facilities function.

Few questions come to mind!

Typical operations questions:

- How long will people have to wait to turn left from a driveway?
- How much delay will people face at this signal?
- How do heavy vehicles affect traffic speeds?
- What is the "capacity" of a freeway?

Traffic Flow Basics (1)

Consider a long, uninterrupted, singlelane roadway:



No passing, no opposing traffic, no intersections











Traffic Flow Basics-Volume The number of trajectories crossing this line is the number of vehicles passing a fixed point on the road. istance (x)Time This is called the **volume** or **flow**, and has units of vehicles per time (usually veh/hr)



Traffic Flow Basics-Density

The number of trajectories crossing this line is **the number of vehicles on the road at one instant in time**



Traffic Flow Basics-Summary (1)		
Flow	Density	
veh/hr	veh/mi	
Measured over time at a fixed point	Measured over space at a fixed time	
How many vehicles are getting somewhere?	How crowded is the roadway?	
Can measure with a point detector	Can measure with an aerial photo	
q	k	

Traffic Flow Basics-Summary (2)

Individual vehicle	Traffic stream
Speed [L/T]	
	Flow [V/T]
	Density [V/L]





Traffic Flow Basics-Time Headway

The **time headway** is the time between two vehicles passing a point.



Traffic Flow Basics-Space Headway

On a space-time diagram, it is the **horizontal distance** between two adjacent trajectories





Traffic Flow Basics-Space Headway (1)

The **space headway** is the distance between two vehicles.



Traffic Flow Basics-Space Headway (2)

On a space-time diagram, it is the **vertical distance** between two adjacent trajectories



Traffic Flow Basics-Summary			
Let's try to fill in the rest of the table.			
	Individual vehicle	Traffic stream	
	Speed [L/T]	Average Speed [L/T]	
	Time Headway [T]	Flow [V/T]	
	Space Headway [L]	Density [V/L]	



Spacing

- Spacing is defined as the distance between successive vehicles in a traffic lane; measured from common reference
 - Front bumper or
 - Front wheels
- Average spacing in a traffic lane is related to density

$$d_a = \frac{5,280}{k}$$

Where, k = density in veh/mile/lane $d_a = Average \ spacing \ between \ vehicles \ in \ ft$



• Headway is defined as the time interval between successive vehicles as they pass along a lane

Also measured between common point of reference

$$h_a = \frac{3,600}{q}$$

Where, q = traffic volume in veh/hour/lane $h_a = Average headwayin the lane$ in sec

Example

- Traffic in an interstate at 7:15 AM is observed to have spacing of 250 feet; and average headway of 3 sec. Estimate
 - o Volume
 - o Density
 - o Speed

Solution

Step1: Calculate flow $q = \frac{3,600}{h_a} = \frac{3,600}{3} = 1,200 \text{ veh/hour/lane}$ Step-2: Calculate density $k = \frac{5,280}{d_a} = \frac{5,200}{250} = 20.8 \text{ veh/miile/lane}$ Step-3: Calculate Speed q = uk => u = q/k = 1200/20.8 = 57.69 miles/hour

Speed

• Time mean speed (spot speed)

• Arithmetic mean of all instantaneous vehicle speeds at a given "spot" on a roadway section

• Space mean speed (u)

• The mean travel speed of vehicles traversing a roadway segment of a known distance (d)

• More useful for traffic applications

Time Mean Speed

- Time mean speed is the average of all vehicles passing over a point over a duration of time.
- It is simple average of spot speed
- Mean speed is given by

$$v_t = \frac{1}{n} \sum_{i=1}^n v_i$$

• Often speeds are given as frequency tables. Then TMS is

$$v_t = \frac{\sum_{i=1}^n q_i v_i}{\sum_{i=1}^n q_i}$$

• Where q_i is the number of vehicles having speed v_i , and n is number of such speed categories

- Space mean speed also averages spot speeds but spatial weights is given instead of temporal. .
- Consider a unit length of road and let v_i is the spot speed, and let t_i is the time vehicles takes to complete unit distance and is given by $1/v_i$
- If we have *n* such vehicles, then average travel time is given by

$$t_s = \frac{\sum t_i}{n} = \frac{1}{n} \sum \frac{1}{v_i}$$

$$\frac{1}{t_s} = v_s = \frac{n}{\sum_{i=1}^n \frac{1}{v_i}} \qquad \text{or} \qquad v_s = \frac{\sum_{i=1}^n \frac{1}{v_i}}{\sum_{i=1}^n \frac{1}{v_i}}$$

or

Example

• Question: If the spot speeds are 50, 40, 60, 54 and 45, then find the time mean speed and space mean speed.

• Sol.

• Time mean speed is the average of spot speed. Therefore, = (50+40+60+54+45)/5 = 49.8

$$v_t = \frac{1}{n} \sum_{i=1}^n v_i$$

• Space mean speed is the harmonic mean of spot speed. Therefore, 5/[(1/50)+(1/40)...+(1/45)] = 48.82 mph

$$t_s = \frac{\sum t_i}{n} = \frac{1}{n} \sum \frac{1}{v_i}$$

