# Traffic Stream Parameters 8/31/11

## Interrupted Versus Uninterrupted flow

- Uninterrupted flow:
  - No interruptions to traffic stream
  - refers to type of facility not quality of flow
  - facility is available to the user at all times (physically available, doesn't mean quality of service)
- Interrupted flow
  - has fixed external interruptions such as traffic signals, stop or yield control, etc.
  - facility is restricted from user at certain times (i.e. during red phase)
  - more complex than uninterrupted flow

## Traffic Flow Elements

- Flow (*q*)
  The equivalent hourly rate at which vehicles pass a point on a highway during a time period less than 1 hour

$$q = \frac{(n \times 3600)}{T}$$

Where;

n=# of vehicles passing a point in T seconds

*q*=equivalent hourly flow rate (veh/hour)

## Volume

- number of vehicles, pedestrians, etc. passing a point during a specific period of time
- for vehicles, usually expressed as veh/hour (vph) or veh/hour/lane (vphpl)
- an indicator of demand, but not a surrogate for demand

- **Demand:**
  - number of vehicles, pedestrians, etc. that desire to travel between locations during a specific period
  - Frequently higher than volume during certain peak times
  - Trips are diverted or not made when there are constraints in the system
  - difficult to measure actual demand because capacity constrains the demand
- **Capacity:**
  - maximum number of vehicles that can pass a point during a specific period
  - A characteristic of the roadway or facility

# Characteristics of Traffic Flow

- Highly variable
  - Time of day
  - Day of week
  - Season
  - Road characteristics
  - Direction

# Hourly volumes

- Peak hour
  - single hour with highest hourly volume used
  - Used for design and operations
  - Usually directional
  - Design peak hour is the hour used for design
- Often estimated from AADT

  DDHV = AADT * K * D

Where

DDHV = design hour volume

K = proportion of daily traffic occurring during the peak hour (proportion of AADT occurring during the $30^{th}$ highest peak hour during the year)

D = proportion of peak hour traffic traveling in the peak direction of flow

- Best collected in field
- Need to forecast to future condition (20 year design)

# Peak Hour

- single hour of the day with the highest hourly volume (HHV)
- generally directional
- peak hourly volumes are the basis for highway design and many types of operational analysis
- highways designed to serve the peak hour volume in the peak direction of flow (design for peak hour in both directions)
- PHV (def) – maximum number of vehicles that pass a point on a highway during a period of 60 consecutive minutes, PHV for intersections similarly typically defined for entire intersection.
- Uses: func. class. of highways, design of geometrics (number of lanes, intersection signalization, and channelization), capacity analysis, development of traffic operation programs, parking regulations.

# Sub-Hourly Volumes

- Volumes fluctuate even within an hour, may cause breakdown if not accounted for
- Often look at smaller increments for signal timing, etc.
- Adjust volume from smaller intervals to hourly volume (vph)
- Peak 10 minutes volume of 1,500 vehicles = 6 x 1500 = 9,000 vph (this is flow rate not volume, volume is the actual count for the hour

# Peak Hour Factor (PHF)

$$PHF = \frac{\text{peak-hour volume}}{4(\text{peak 15-min volume})}$$

Flow is not uniform throughout an hour

HCM considers operating conditions during most congestion 15-minute period of the hour to determine service level for the hour as a whole

# Example

Peak 15 minutes flows

100 veh/ 15 min

125 veh/ 15 min

110 veh/ 15 min

130 veh/ 15 min

What is peak hour factor

$$PHF = \frac{(100 + 125 + 110 + 130)}{4 * 130} = \mathbf{0.89}$$

# Traffic Flow Elements

- Speed ($u$) – Distance traveled by a vehicle during a unit of time. For individual vehicle:

  $u = d/t$

Where

$u$ = speed (mph, ft/s)

$d$ = distance traveled (miles or feet)

$t$ = time to traverse distance $d$ (hours or sec)

# Speed

- Second macroscopic flow parameter
- Speed for a traffic stream (average of individual speeds)
  - Time mean speed
  - Space mean speed
  - Average speed

# Time mean speed

- Arithmetic mean of the speeds of vehicles passing a point on a highway during an interval of time (*radar gun or road tube study*)

- Space mean speed
  - average speed of all vehicles occupying a given section of highway or lane over some specified interval
  - Weights the amount of time a vehicles occupies a highway section, a vehicle at 25 mph occupies twice as much time as a vehicle at 50 mph

$$u_s = \frac{nd}{\sum t_i}$$

Where

$n$ = number of observed vehicles

l = distance traversed (ft)

$d_i$ = time for $i^{th}$ vehicle to traverse the section

**TMS always > SMS**

# Density (k)

- Concentration
- Number of vehicles traveling over a unit length of highway at an instant in time
- measures quality of traffic flow (how close vehicles are) relates to ability to maneuver and psychological comfort level
- Usually veh/mile or vpmpl

- Example:
- 4 vehicles over 600 feet of roadway

  Over a mile

$$k = \frac{4 \text{ veh.}}{600 \text{ ft}} \times \frac{5280 \text{ feet}}{\text{mile}} = \mathbf{35.2 \text{ veh/mi}}$$

**Headway** = time interval between vehicles

$$V = \frac{3600}{h_a}$$

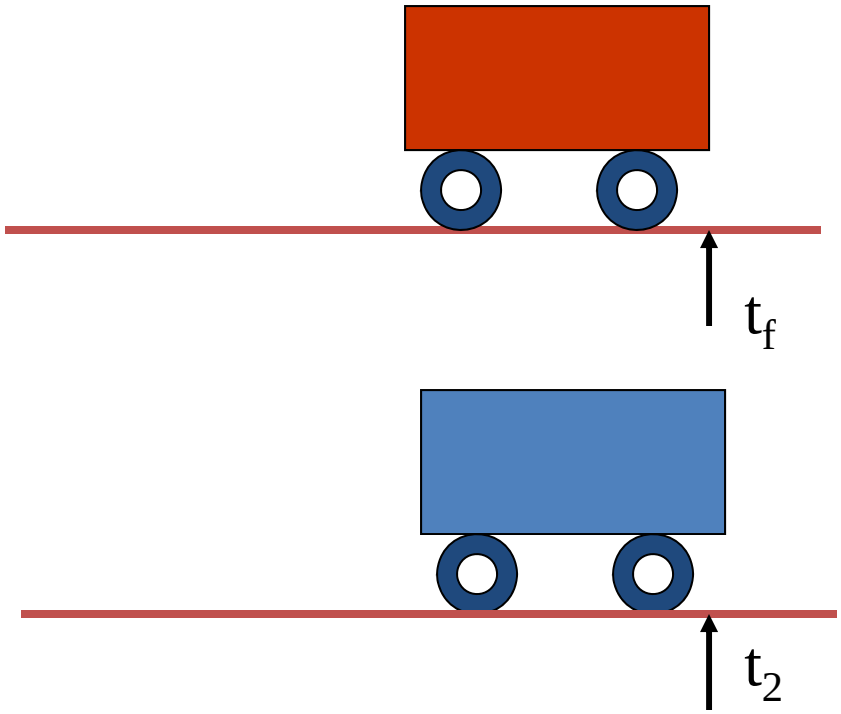
where

v = rate of flow, veh/hr/ln

$h_a$ = average headway in lane

# Time Headway (*h*)

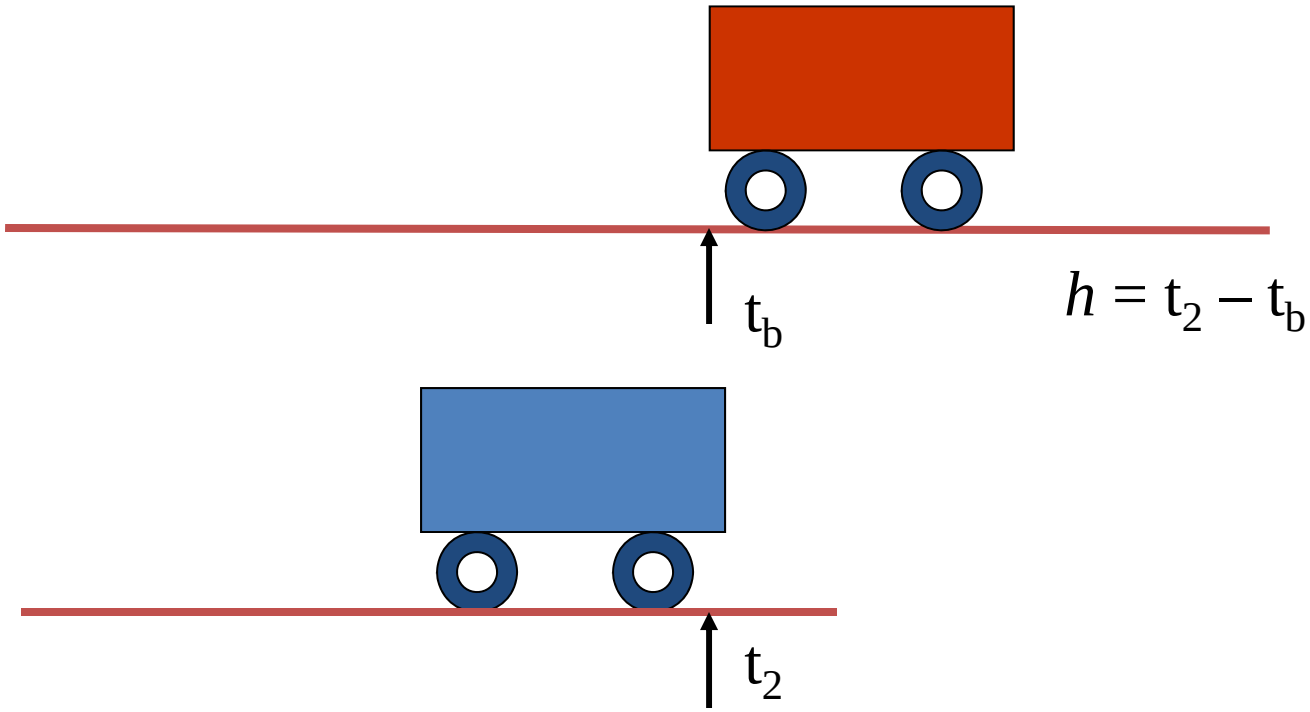
- The difference between the time the front of a vehicle crosses a point on the highway and the time the front of the next vehicle crosses the same point (seconds)




$$h = t_2 - t_f$$

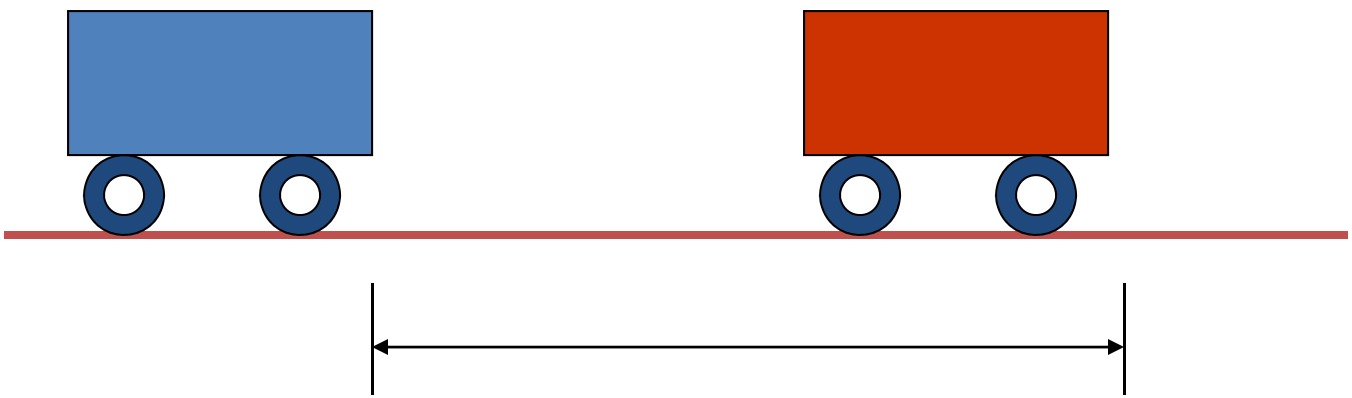
# Gap

- The time between the back of a vehicle and the front of the following vehicle (sec)



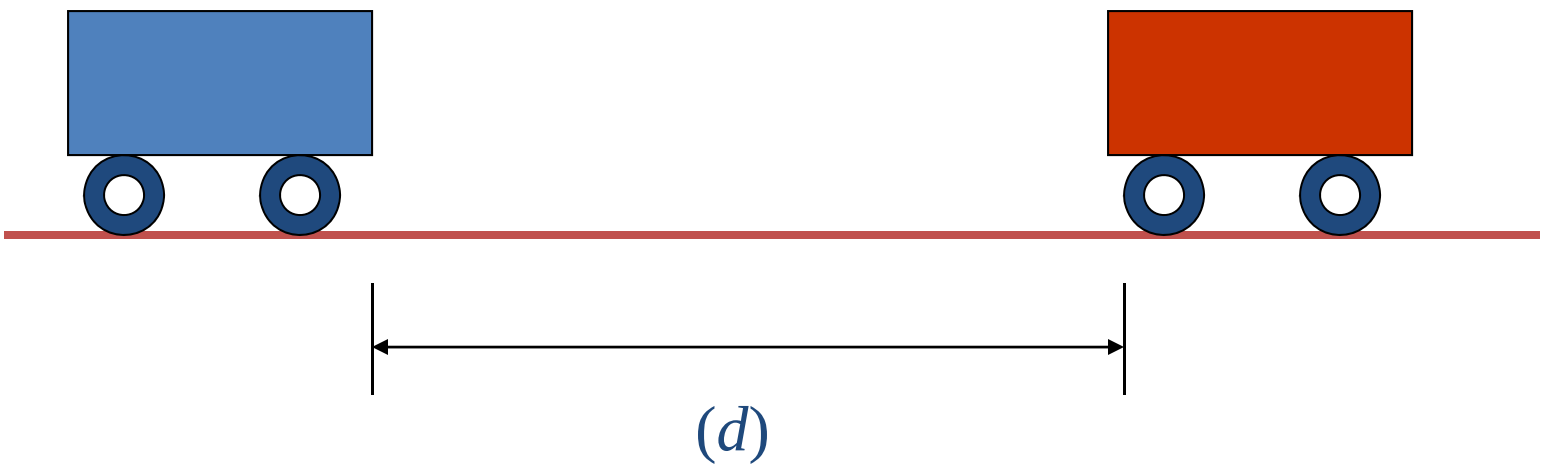
# Space Headway (*d*)

- The distance between the front of a vehicle and the front of the following vehicle (ft)



# Gap (distance)

- The distance between the back of a vehicle and the front of the following vehicle (ft)



# Daily Volume

- Uses
  - General planning
  - Pavement performance
  - Crash rates
- Annual average daily traffic (AADT): average volume counted for 24 hours over 365 days
- Average daily traffic (ADT): average 24-hour volume at a given location that is counted for some period > 1 day and < 365)
- usually extrapolated to represent traffic over the year
- Classification counts: fleet mix

# Design Hourly Volume

DHV is a representation of peak hour traffic, usually for the future, or horizon year

K-factor represents proportion of daily traffic occurring during the peak hour

$$\text{K-factor} = \frac{\text{DHV}}{\text{AADT}} \times 100$$

K = 8 to 12% urban, 12 to 18% rural

# Traffic Demand (cont.)

- D = directional distribution = one way volume in peak direction (expressed as a percentage of two-way traffic) Rural 55 to 80%
- Can also adjust for how traffic is distributed between lanes (e.g., 3 lanes, highest/outside lane may be 40% of total directional flow)

# Traffic Demand

- Design Hourly Volume (DHV) – future hourly volume (both directions) used for design - typically 30$^{th}$ HHV (highest hourly volume) in the design year
- Why 30$^{th}$ HHV?
  - Breakpoint of 2-28
  - Compromise: too high is wasteful, too low poor operation
  - Approximately median weekly peak hour volume (top highest week peak hours)

(30$^{th}$ HHV exceed 29 times in year)

# Design Volume

- Usually hourly volume
- Which hour?
  - Average hourly volume – inadequate design
  - Maximum peak hour – not economical
  - Hourly volume used for design should not be exceeded very often or by very much
  - Usually use 30$^{th}$ highest hourly volume of the year
  - On rural roads 30 HHV is ~ 15% of ADT
  - Tends to be constant year to year

# Traffic Demand (cont.)

- T = percentage of heavy vehicles during design hour (Iowa interstate 35% plus)
- Affects capacity, ability to pass on two-lane rural roads, etc.
- Larger, occupy more space
- Should determine % during design hour (truck patterns may not be same as passenger vehicles)

# Relationship between flow, speed, and density

$$V = S \times D$$

Where

V = rate of flow, veh/hr or veh/h/lane

S = space mean speed, mph

D = density, veh/mi or veh/mi/lane

Must apply to the same section of road

usually used to estimate density, hardest to get in field, why?

# Relationship between flow, speed,

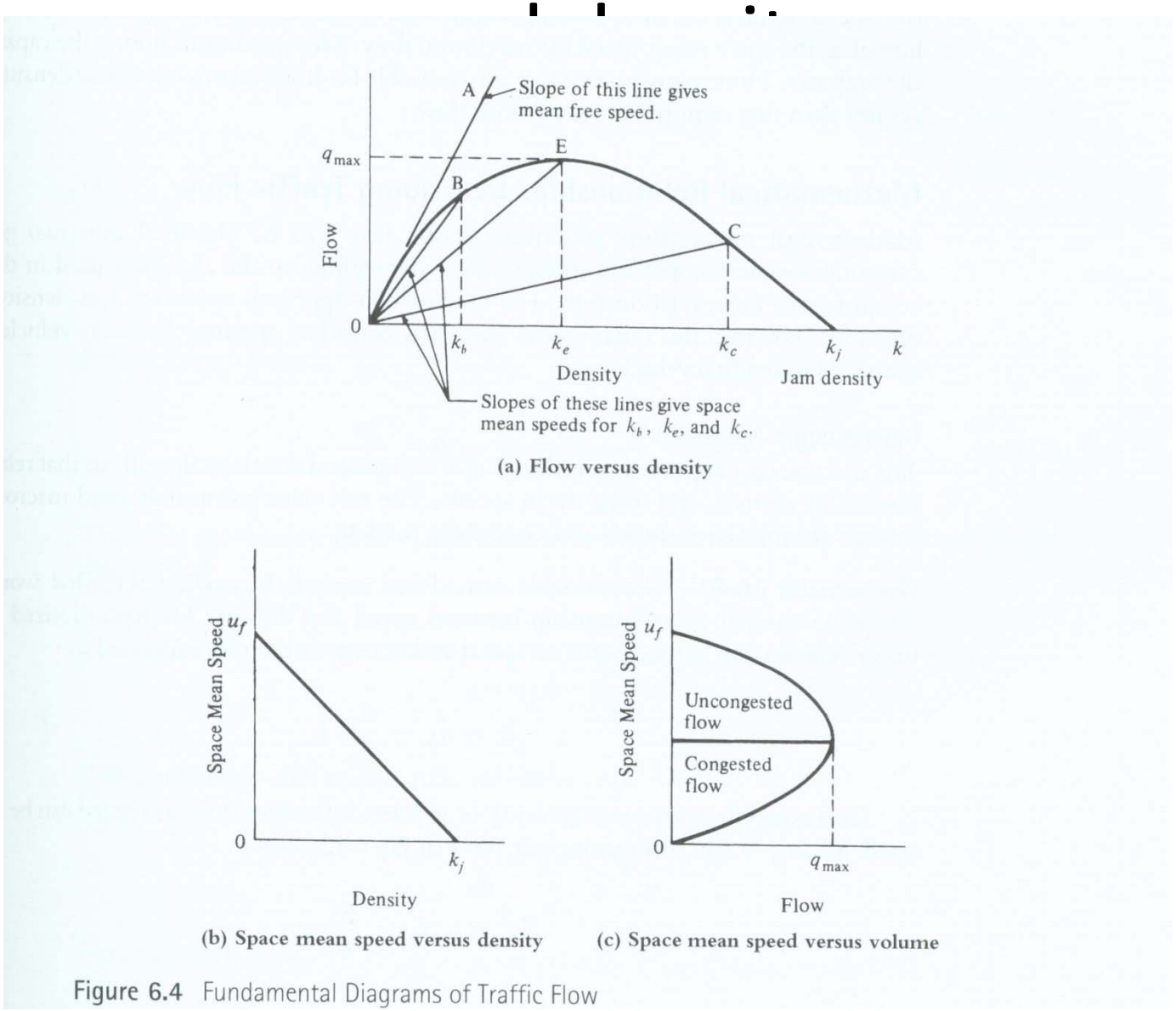



Figure 6.4 Fundamental Diagrams of Traffic Flow

# Relationship between flow, speed, and density

- Fundamental diagram of traffic flow on uninterrupted facilities
- Actual form depends on prevailing traffic and roadway conditions on the roadway under study and on the length of the segment
- zero flow occurs at two points
- when there are no cars on the facility, density and flow rate are zero, speed is whatever the first driver would select, this is freeflow speed (sf)
- when density becomes so high that all vehicles are forced to stop (speed = zero), flow rate is also zero because there is no movement (vehicles cannot “pass” a point), density is jam density (Dj)
- between 2 extreme points, as density increases from zero, flow rate also increases (more vehicles on the roadway) and speed declines (interaction of other vehicles)

# Relationship between flow, speed, and density

- low decline in speed at low and medium densities
- as density continues to increase, speed decreases significantly before capacity is reached
- capacity occurs at the optimum speed (uo) and optimum density (Do)
- any flow other than capacity can occur under 2 different conditions
- high speed and low density
- high density and low speed
- Level of service related to speed, density, and flow (will discuss later)
- Other descriptions of these interrelationships have been modeled by Greenberg, Underwood, Northwestern, and Edie (plus) – logarithmic, two regimes

# Time—Space Diagram

- Portrays trajectory of individual vehicles in motion
- Distance (y axis)
- Time (x axis)

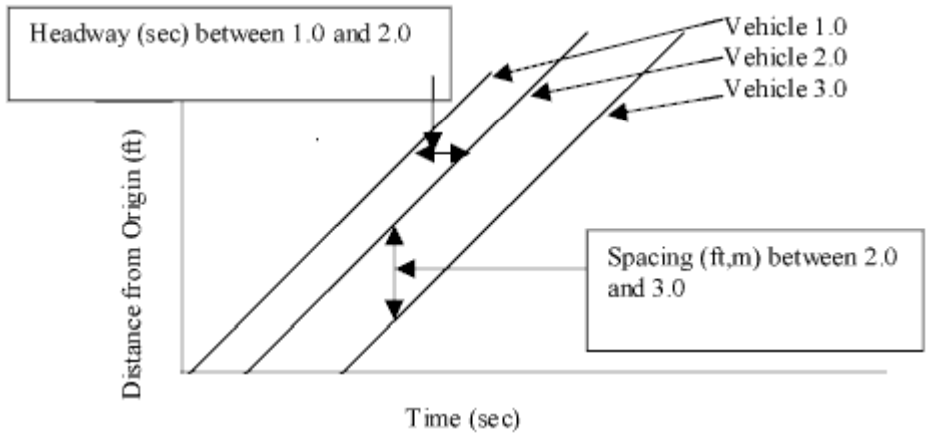



Image source: http://www.webs1.uidaho.edu/niatt_labmanual/Chapters/trafficflowtheory/theoryandconcepts/TimeSpaceDiagram.htm

# Homework

- Do Problems:
  - 5.1 - don't plot
  - 5.2
  - 5.4
  - 5.5