Traffic Theory

CEE320

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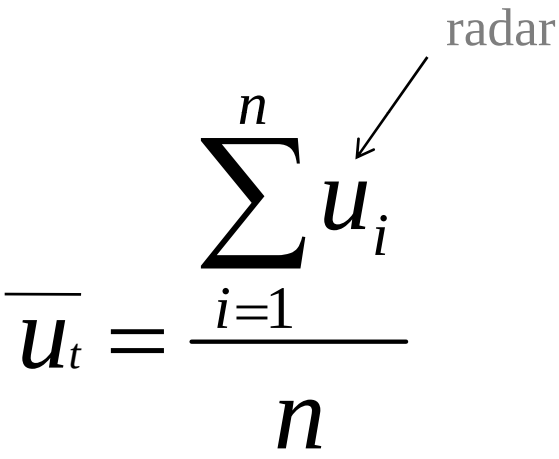
Measuring Speed

- **Time mean speed**
  - **Taken at a specific point**
  - **Average of instantaneous speeds**
- **Space mean speed (u)**
  - **Harmonic speed**
  - **Look at a segment of roadway**
  - **Average speed of all vehicles in that segment over a specified period of time**
  - **Inverse of travel time for all vehicles**

Time Mean Speed

- **Arithmetic mean of speeds observed at some point**
- **Easy to measure**



Space Mean Speed

- **It is the harmonic mean**

$$\overline{u_s} = \frac{nl}{\sum_{i=1}^{n} t_i}$$

$$\bar{t} = \frac{1}{n}\left(t_1 l_1 + t_2 l_2 + \ldots + t_n l_n\right)$$

- **Used in traffic models, but harder to measure**
- **t_i is time necessary for vehicle *i* to travel roadway section of length *l***

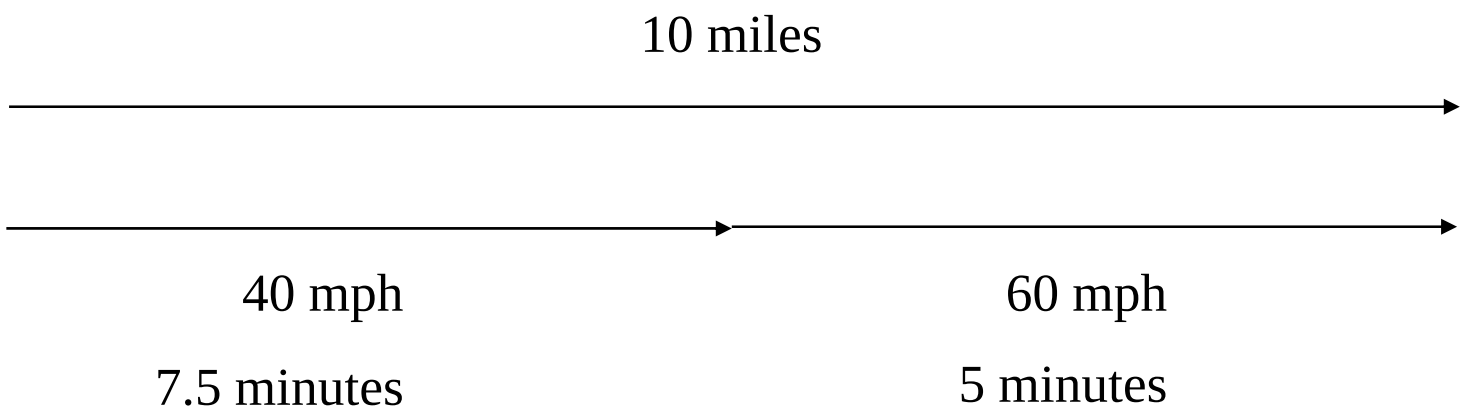
Example 1

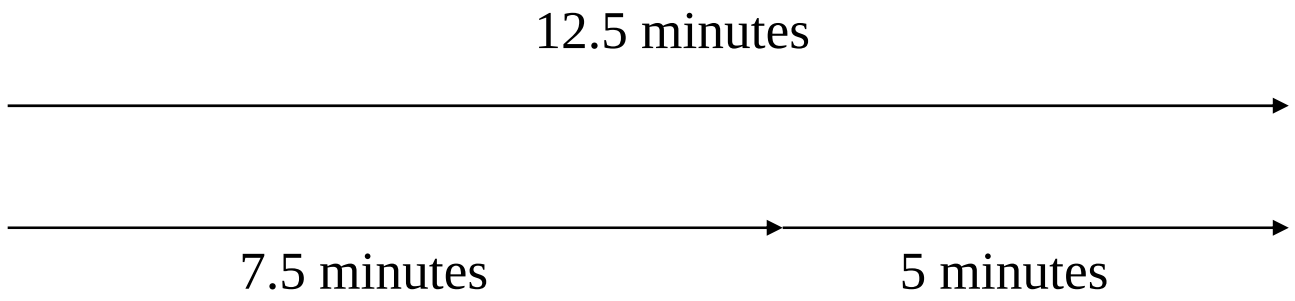
- **You are in a vehicle traveling a total of 10 miles.**
  - **the first 5 miles you travel at 40 mph**
  - **the next 5 miles you travel at exactly 60 mph**

- **What is your average speed over the *time* you spent traveling that 10 miles?**

- **What is your average speed over that *distance*?**

Average speed over time and average speed over distance are different





Example time

- **You are in a vehicle traveling a total of 10 miles.**
  - **the first 5 miles you travel at 40 mph**
  - **the next 5 miles you travel at exactly 60 mph**

- **What is your average speed over the *time* you spent traveling that 10 miles?**

- **5 miles at 40 mph = 7.5 minutes**
- **5 miles at 60 mph = 5 minutes**
- **weighted average = (40(7.5) + 60(5))/(7.5 + 5) = 48 mph**

Example 2

- **You own two cars, they are both driven an equal distance and one gets 20 mpg and the other 50 mpg**
- **Is the average mpg 35(50+20)/2?**

Example 2?

- **Say they are each driven 100 miles.**
- **How much gas does the 50 mpg vehicle consume?**
- **How much gas does the 20 mpg vehicle consume?**

Example 2

- **This gives 7 gallons for 200 miles, or 28.75 mpg (not 35 mpg).**

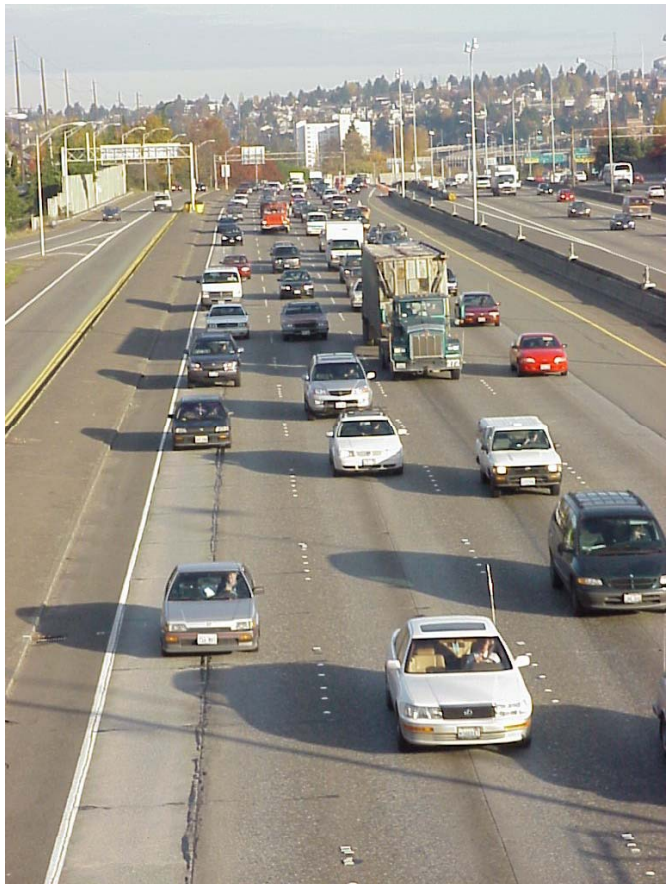
- **Must use the harmonic mean:**

$$u_s = \frac{1}{\frac{1}{n}\sum_{i=1}^{n}\left[\frac{1}{(l/t_i)}\right]} = \frac{1}{\frac{1}{2}\left[\frac{1}{50}+\frac{1}{20}\right]}$$

Density (k - konzentration)

- **The number of vehicles (n) occupying a given length (l) of a lane or roadway at a particular instant**
- **Unit of density is vehicles per mile (vpm).**

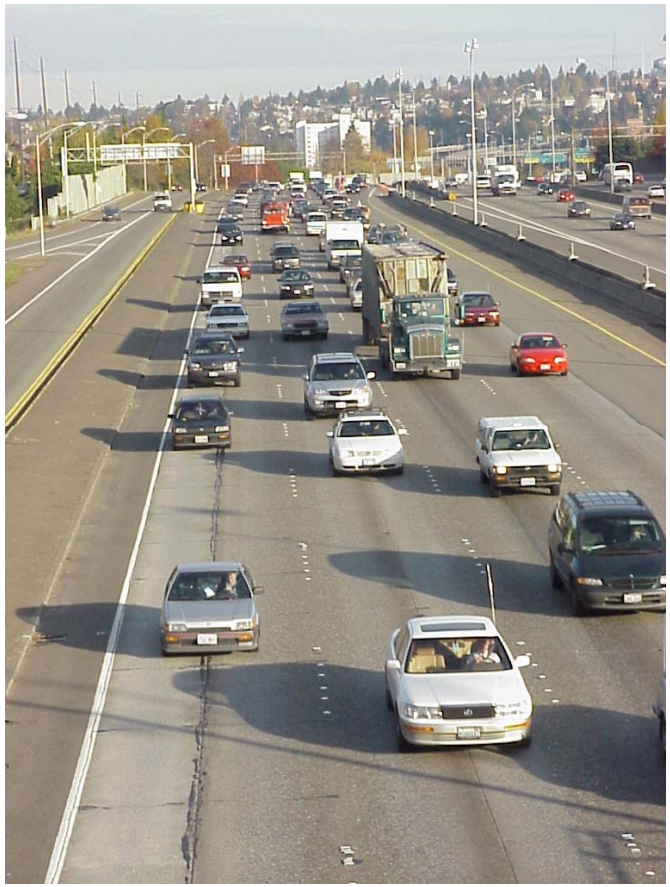
$$k = \frac{n}{l} = \frac{q}{u}$$



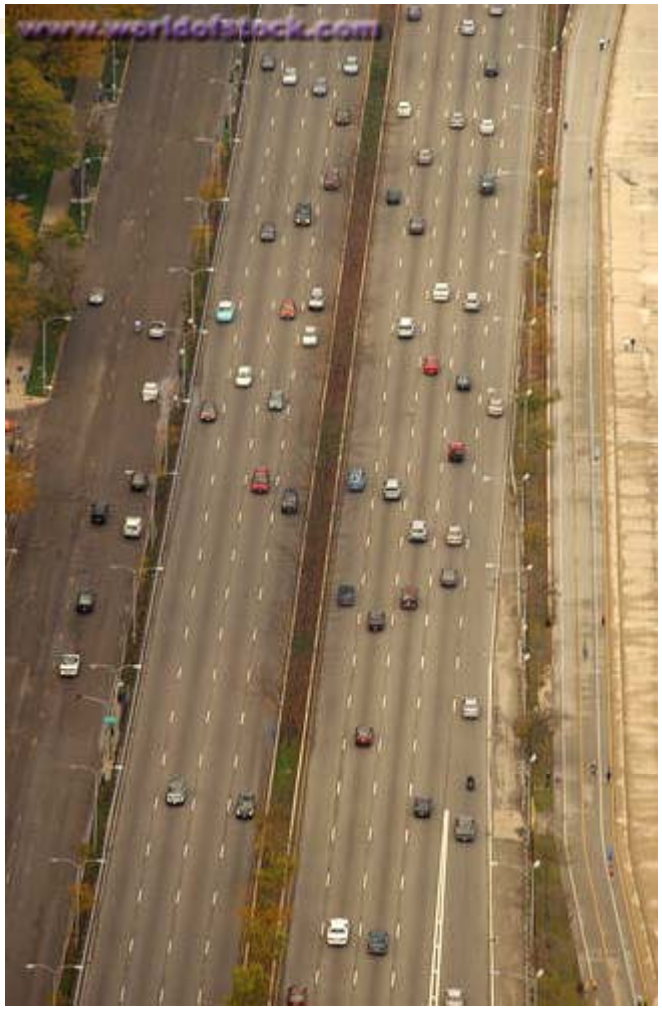
Density (k)

- **Number of vehicles in length of segment**
- **Inverse of average spacing**

$$k = \frac{n}{\sum_{i=1}^{n} s_i} = \frac{1}{\bar{s}}$$



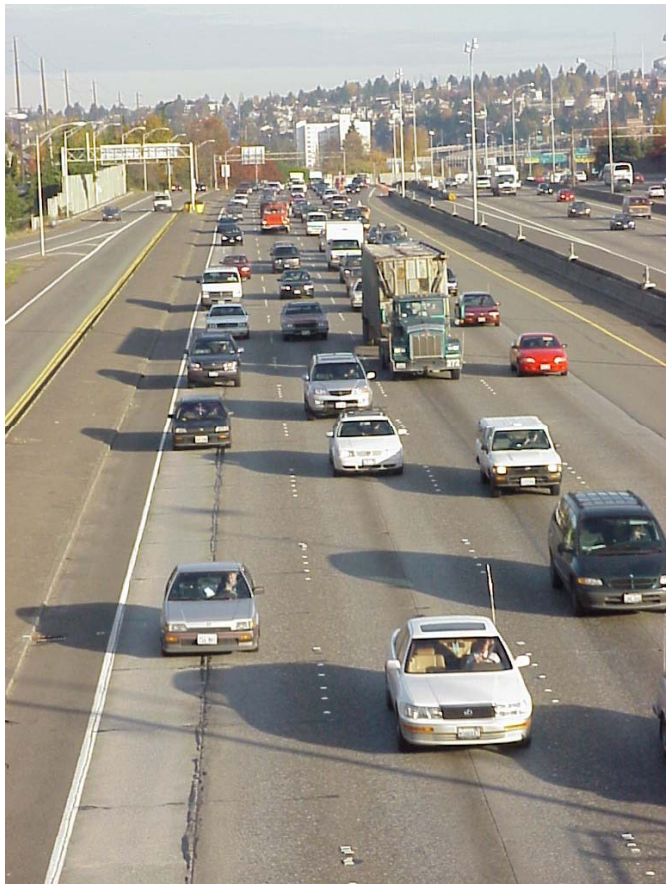
Density



$$k = \frac{q}{u}$$

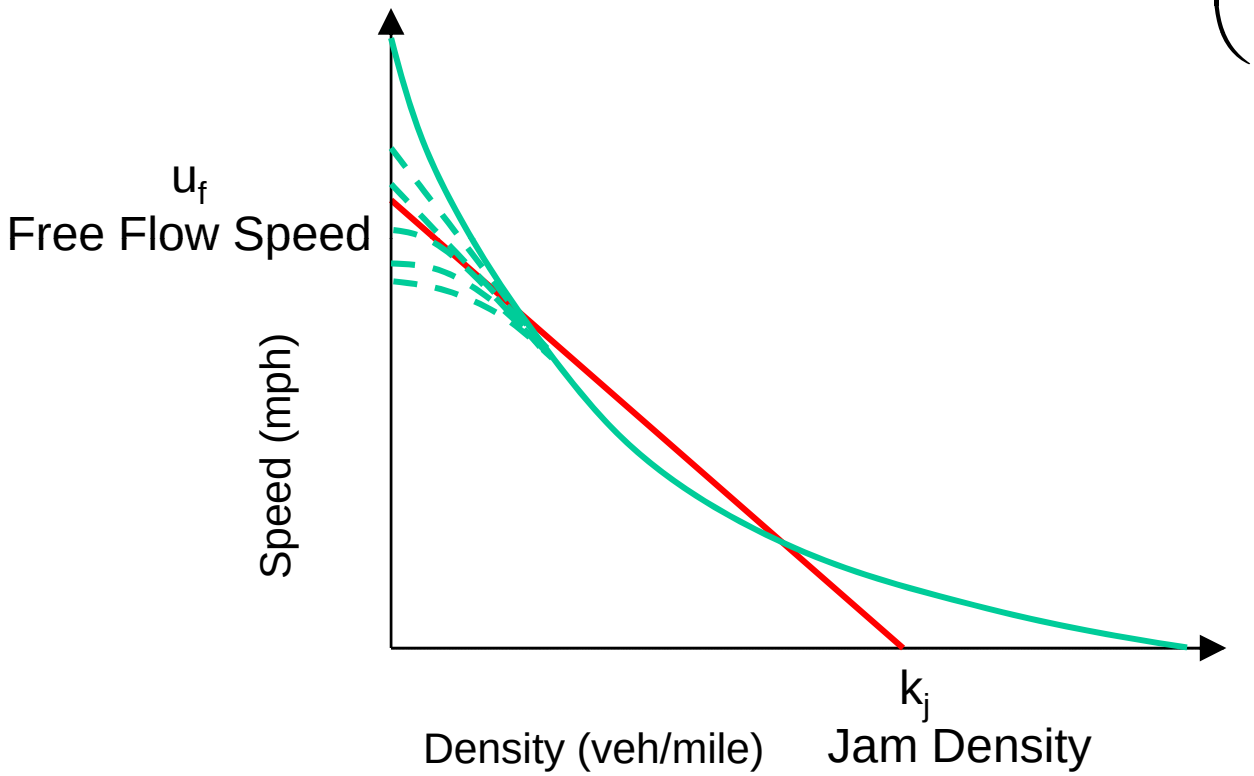
Traffic Flow Theory

- **A model for the relationship between flow, density, and speed**
- **Represents idealized behavior and fundamental relationships**
- **Useful for traffic analysis**



Speed vs. Density

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

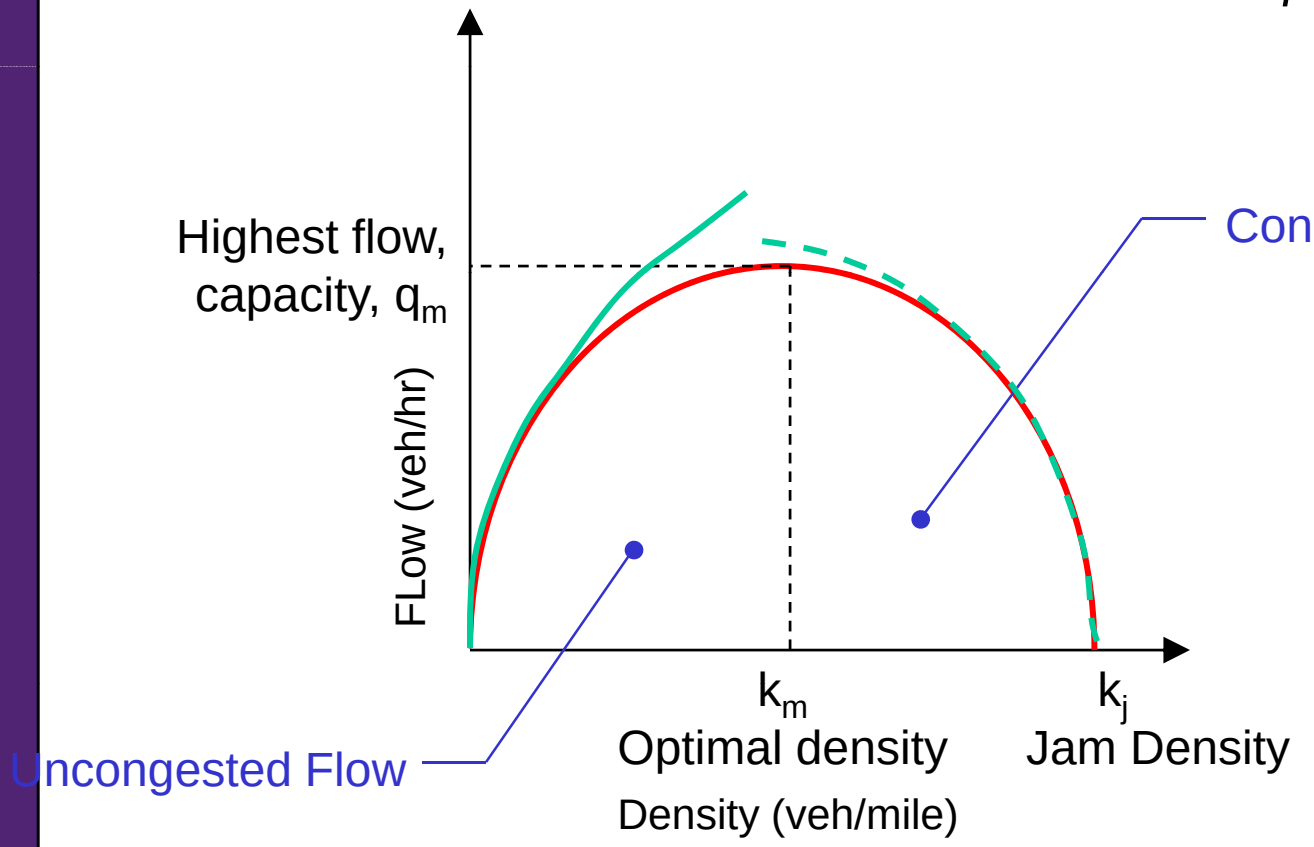


Additional definitions

- **Free-flow speed (u_f)**
  - **The speed at which vehicles will travel unimpeded**
- **Jam density (k_j)**
  - **The density of vehicles in stopped traffic**
- **Capacity (q_m)**
  - **The maximum flow a section of roadway can maintain**

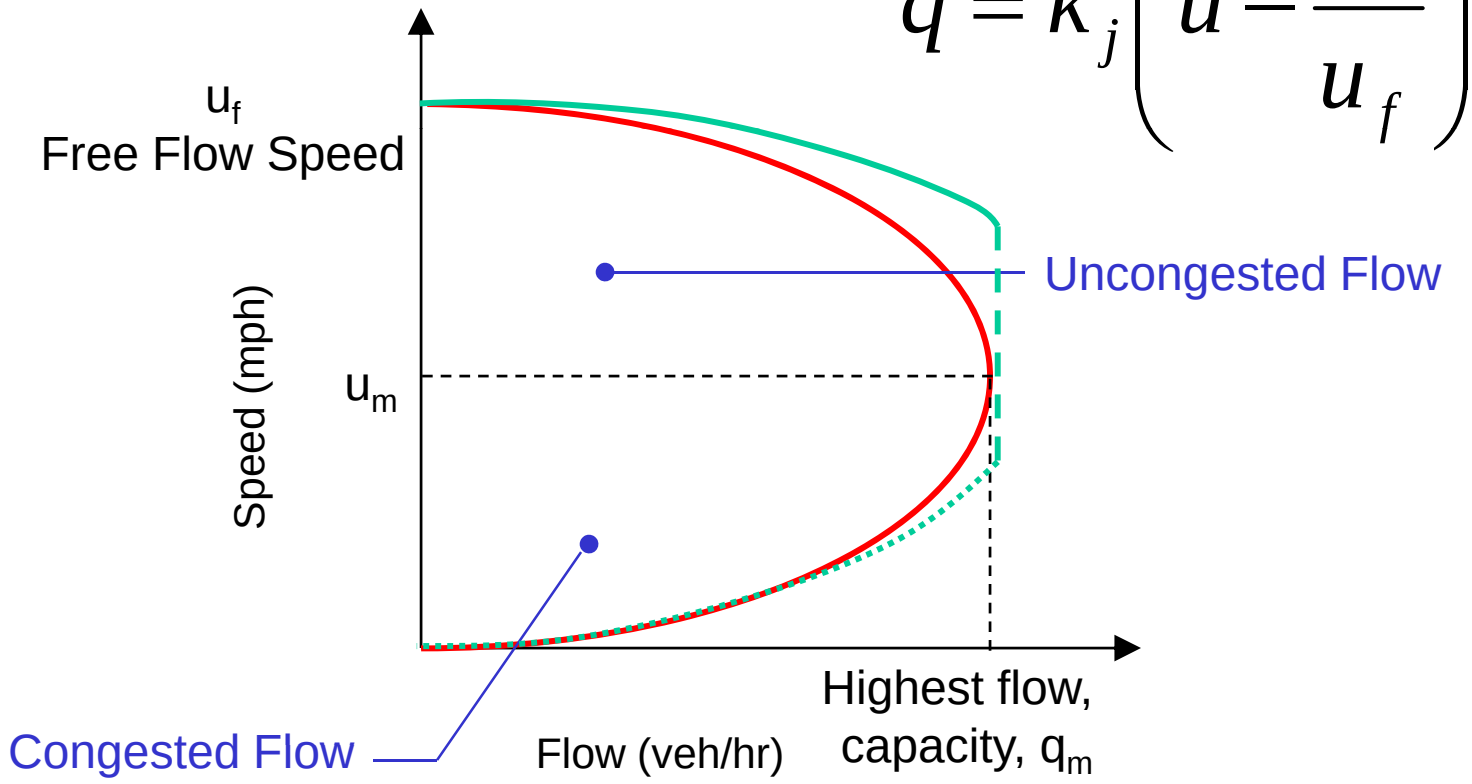
Flow vs. Density

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



Speed vs. Flow

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

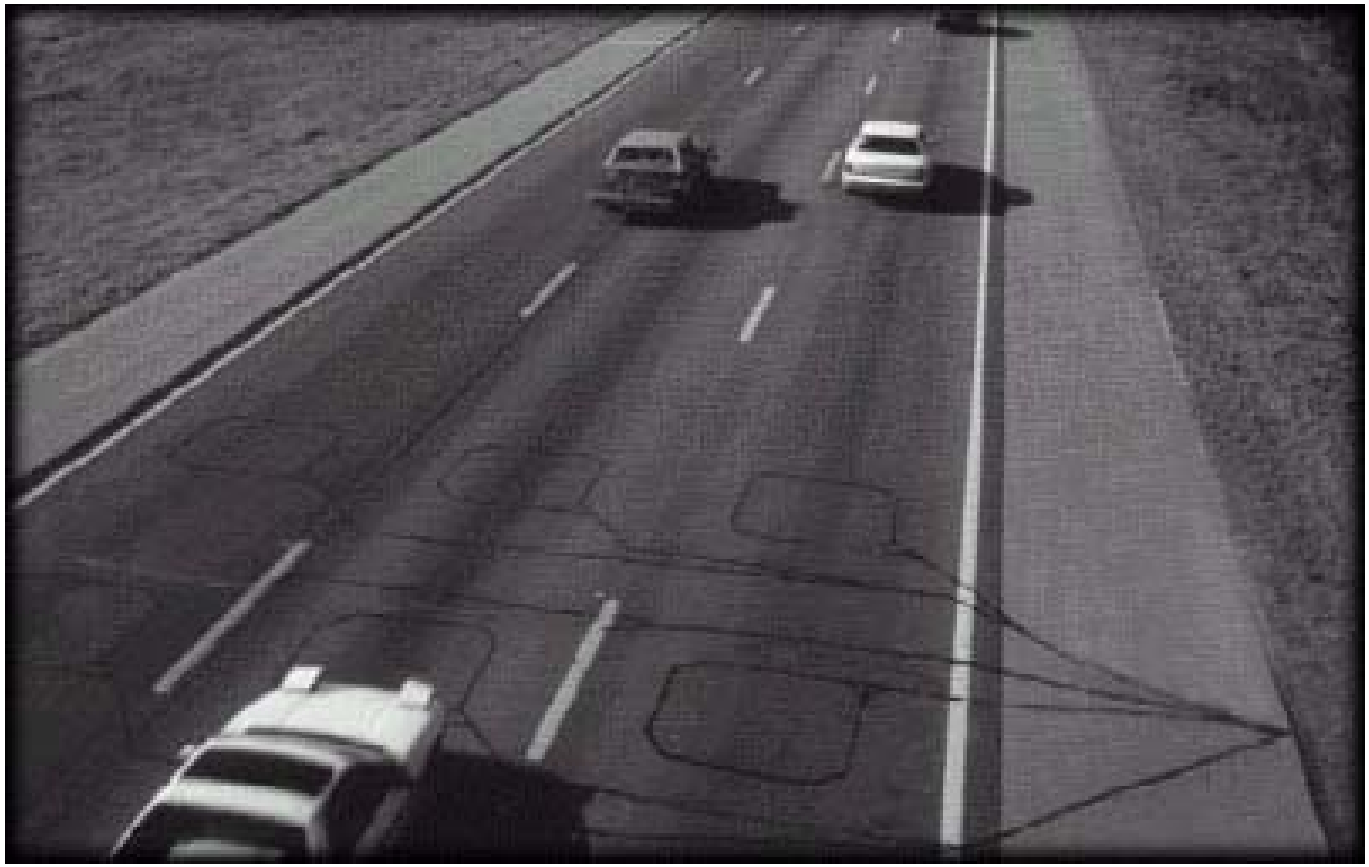


q_m is bottleneck discharge rate

Measurement

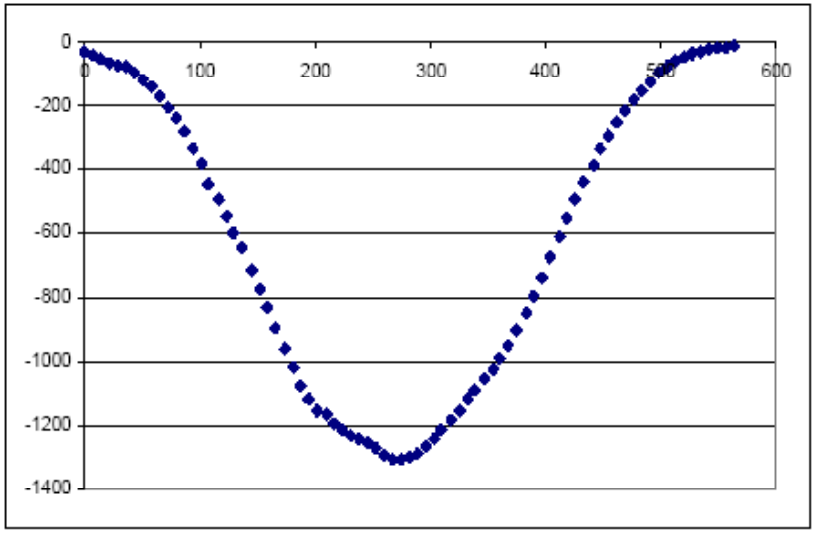
- **Density can easily be measured by remote sensing, but has historically been difficult to measure**
  - **Use occupancy obtained from loop-detectors**
- **TMS more easy to measure than SMS**
  - **Use correction or approximation**
  - **Easy to measure with remote sensing (GPS)**
- **Flow is easy to measure**
- **Occupancy is measure of density**
- **Only need to measure 2 of 3**

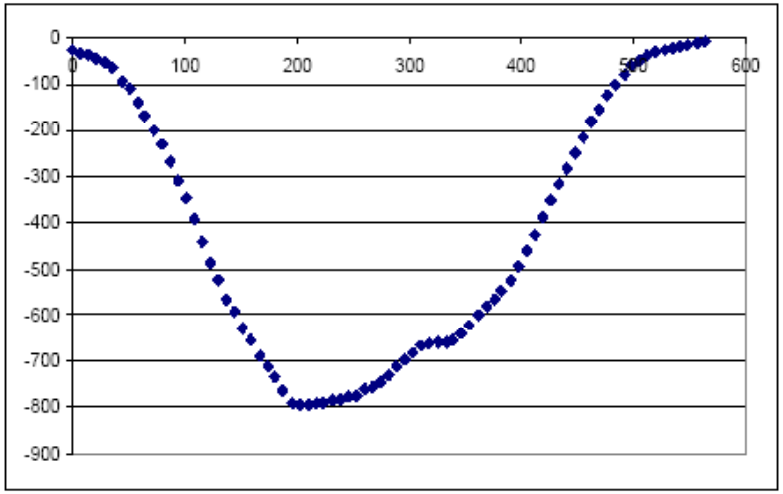
Loop Detector



Freeway Monitoring

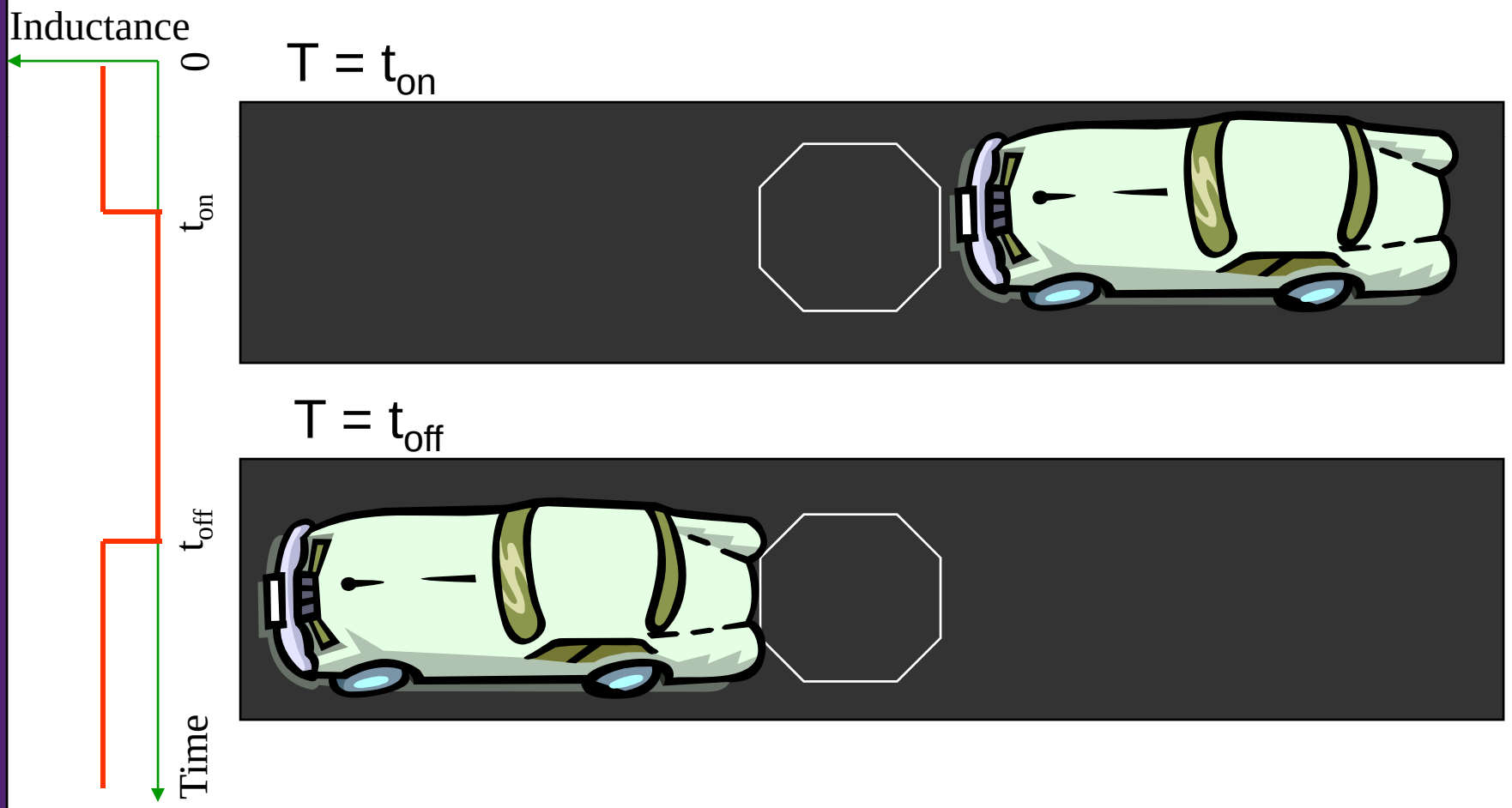
Loop Detector Signatures





Inductance Loop Detectors

Loop inductance decreases when a car is on top of it.



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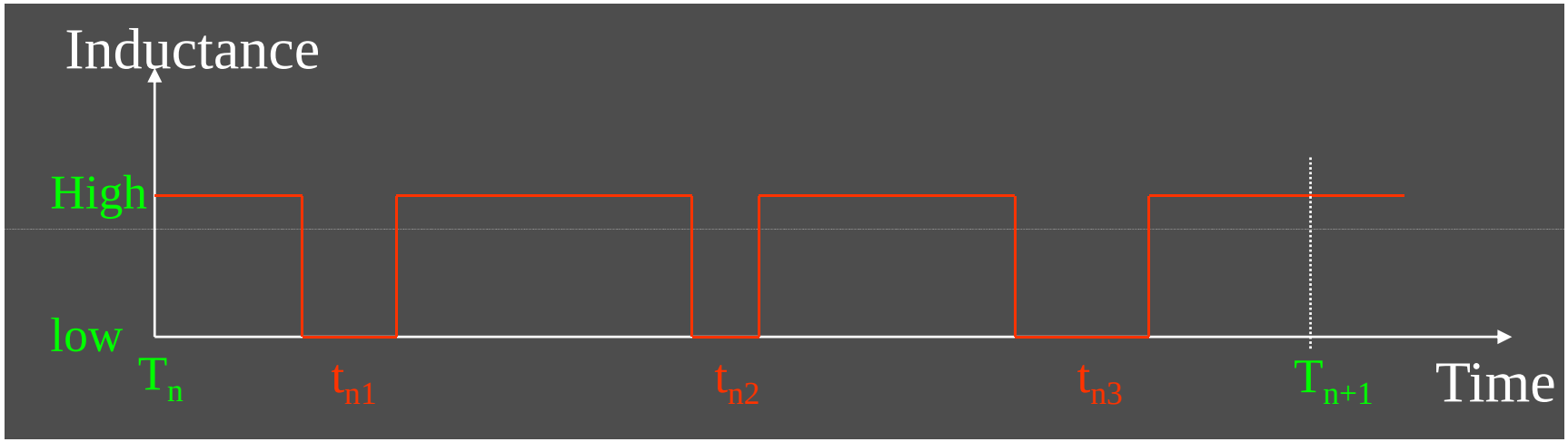

- Single loops can measure:
  - Occupancy (*O*): % of time loop is occupied per interval
  - Volume (*N*): vehicles per interval