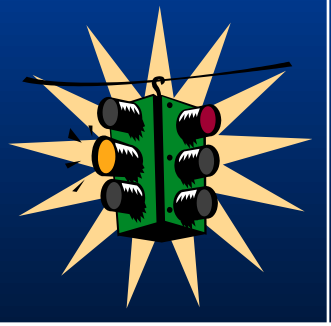
Chapter 5: Traffic Stream Characteristics

Chapter objectives: By the end of these chapters the student will be able to:

- Explain the difference between uninterrupted flow and interrupted flow
- Explain the three principal traffic-stream parameters and how to obtain them
- Explain the relationship among the three macroscopic principal traffic-stream parameters

5.1 Types of traffic facilities

Uninterrupted flow facility 	
Interrupted flow facility 	

Remember it does not mean the quality of operation.

5.2 Traffic stream parameters

Macroscopic parameters	Microscopic parameters

5.2.1 Volume and flow rate

What's the difference between "Volume" and "Flow (or Flow rate)"?

Can you define these?

- **AADT**
- **AAWT**
- **ADT**
- **AWT**
- **DDHV = AADT * K * D**

(Review Tables 5.1 and 5.2 & 5.3 queuing)

- **Sub-hourly volume and flow rate**
- **Define PHF = (peak hourly volume) / (max. rate of flow for that hour)**

PHF = $V/(4 * V_{15})$

What does this tell you?

***v* = V/PHF**

= peak flow rate for the 15-minute peak period

Illustration of Daily Volume Parameters

Table 5.1: Illustration of Daily Volume Parameters

1. Month	2. No. of Weekdays In Month (days)	3. Total Days in Month (days)	4. Total Monthly Volume (vehs)	5. Total Weekday Volume (vehs)	6. AWT 5/2 (veh/day)	7. ADT 4/3 (veh/day)
Jan	22	31	425,000	208,000	9,455	13,710
Feb	20	28	410,000	220,000	11,000	14,643
Mar	22	31	385,000	185,000	8,409	12,419
Apr	22	30	400,000	200,000	9,091	13,333
May	21	31	450,000	215,000	10,238	14,516
Jun	22	30	500,000	230,000	10,455	16,667
Jul	23	31	580,000	260,000	11,304	18,710
Aug	21	31	570,000	260,000	12,381	18,387
Sep	22	30	490,000	205,000	9,318	16,333
Oct	22	31	420,000	190,000	8,636	13,548
Nov	21	30	415,000	200,000	9,524	13,833
Dec	22	31	400,000	210,000	9,545	12,903
Total	**260**	**365**	**5,445,000**	**2,583,000**	—	—

AADT = 5,445,000/365 = 14,918 veh/day

AAWT = 2,583,000/260 = 9,935 veh/day

Table 5.2: General Ranges for *K* and *D* Factors

Facility Type	Normal Range of Values	
	K-Factor	*D*-Factor
Rural	0.15–0.25	0.65–0.80
Suburban	0.12–0.15	0.55–0.65
Urban:		
Radial Route	0.07–0.12	0.55–0.60
Circumferential Route	0.07–0.12	0.50–0.55

Volume, Flow Rate, and Queuing

Table 5.3: Illustration of Volumes and Rates of Flow

Time Interval	Volume for Time Interval (vehs)	Rate of Flow for Time Interval (vehs/h)
5:00–5:15 PM	1,000	1,000/0.25 = 4,000
5:15–5:30 PM	1,100	1,100/0.25 = 4,400
5:30–5:45 PM	1,200	1,200/0.25 = 4,800
5:45–6:00 PM	900	900/0.25 = 3,600
5:00–6:00 PM	Σ = 4,200	

If capacity is 4,200 vph, then the 15-min capacity volume is 4,200/4 = 1,050.

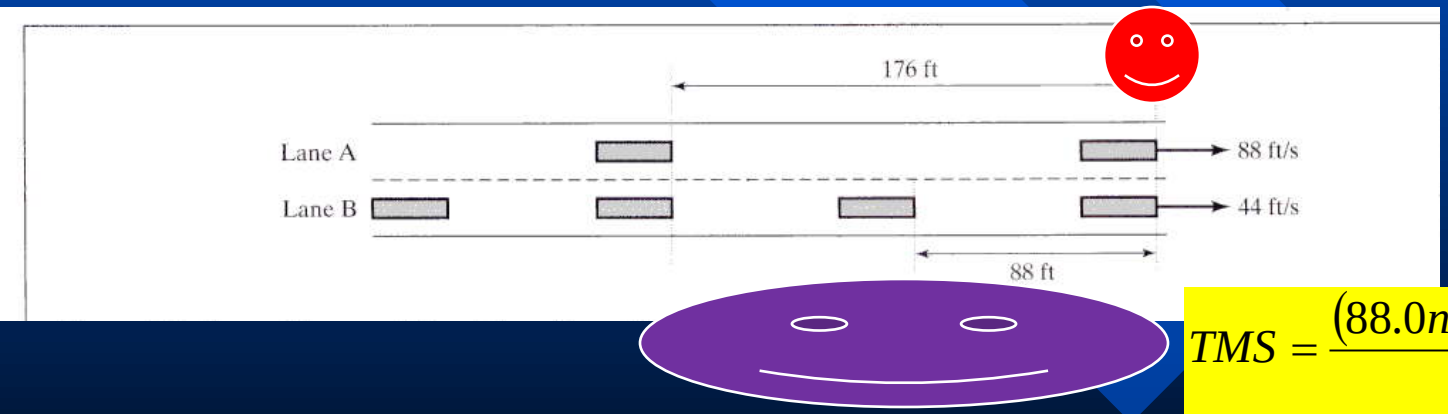
Table 5.4: Queuing Analysis for the Data of Table 5.3

Time Interval	Arriving Vehicles (vehs)	Departing Vehicles (vehs)	Queue Size at End of Period (vehs)
5:00–5:15 PM	1,000	1,050	0
5:15–5:30 PM	1,100	1,050	0 + 1,100 − 1,050 = 50
5:30–5:45 PM	1,200	1,050	50 + 1,200 − 1,050 = 200
5:45–6:00 PM	900	1,050	200 + 900 − 1,050 = 50

5.2.2 Speed and travel time

Time mean and space mean speed: Know the difference?

Time mean speed (TMS)	Average speed of all vehicles passing a point over some specified time period $TMS = \sum (d/t_i)/n$
Space mean speed (SMS)	Average speed of all vehicles occupying a given section over some specified time period or harmonic mean of individual speeds. $SMS = d/(\sum(t_i)/n) = nd/\sum(t_i)$



$$TMS = \frac{(88.0n + 44.0n))}{2n} = 66.0\ ft/s$$

$$SMS = \frac{(88.0n + 44.0 * 2n))}{3n} = 58.7\ ft/s$$

(See page 112 and Table 5.5)

Illustrative Computation of TMS and SMS

Table 5.5: Illustrative Computation of TMS and SMS

Vehicle No.	Distance d (ft)	Travel Time t (s)	Speed (ft/s)
1	1,000	18.0	1,000/18 = 55.6
2	1,000	20.0	1,000/20 = 50.0
3	1,000	22.0	1,000/22 = 45.5
4	1,000	19.0	1,000/19 = 52.6
5	1,000	20.0	1,000/20 = 50.0
6	1,000	20.0	1,000/20 = 50.0
Total	**6,000**	**119**	**303.7**
Average	**6,000/6 = 1,000**	**119/6 = 19.8**	**303.7/6 = 50.6**

TMS = 50.6 ft/s

SMS = 1,000/19.8 = 50.4 ft/s

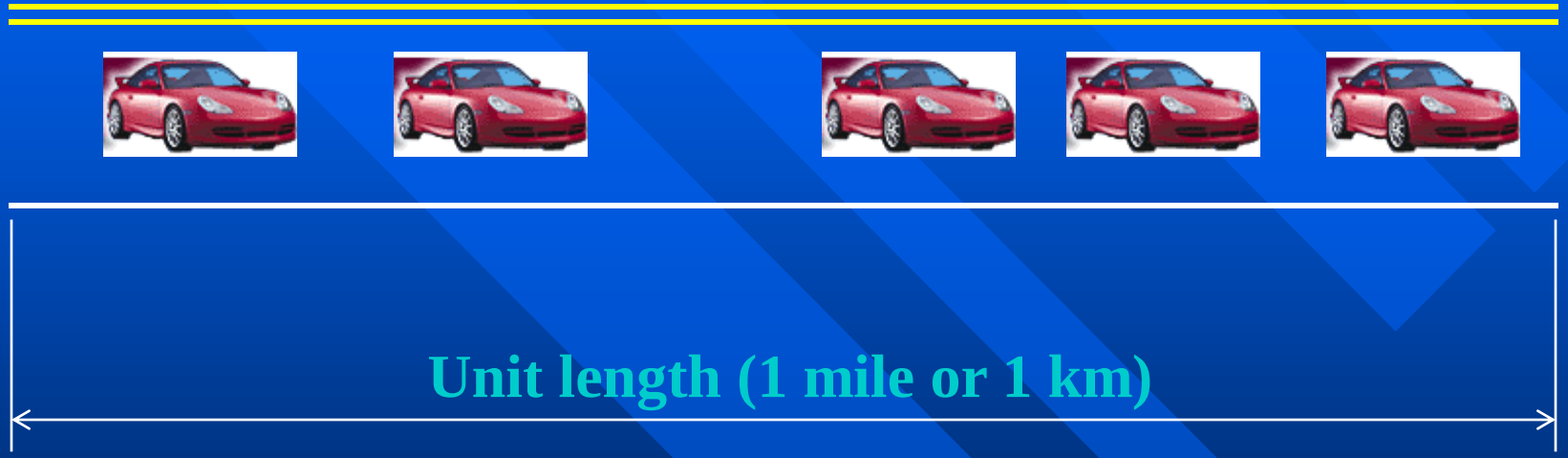
Speed types

Do you know the difference among these speeds?

- **Average travel speed**
- **Average running speed**
- **Operating speed = Max safe speed , without exceeding the design speed of the highway segment**
- **Percentile speed = a speed below which the stated percent of vehicles in the traffic stream travel**

5.2.3 Density and occupancy

Definition: the number of vehicles occupying a given length of highway or lane (vpm, vpmpl, v/km, v/km/lane)



Relationship among *v, S, D:*

$$v = S * D$$

Flow rate = Speed * Density

Occupancy as a surrogate parameter for density

- Density is difficult to measure. So, we use "occupancy" as a surrogate measure for density. This can be obtained by traffic detectors of any kind.
- Occupancy: the percent of the roadway (in terms of time) that is covered (occupied) by vehicles.

Apparent occupancy

$$t(p) = \frac{L_v + EL}{Speed}$$

Actual occupancy

$$t'(p) = \frac{L_v}{Speed} = t(p) - \frac{EL}{Speed}$$

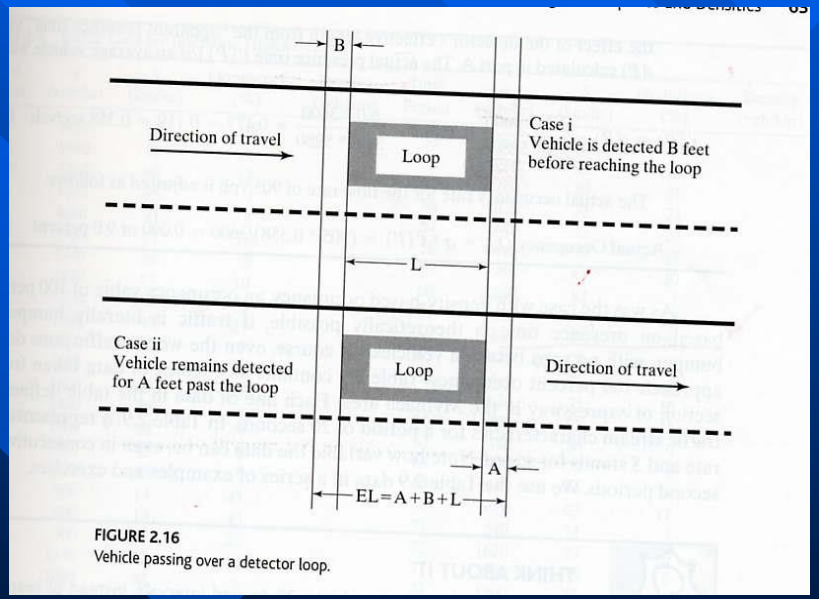


FIGURE 2.16
Vehicle passing over a detector loop.

This is the occupancy measured at a point.

Flow rate, speed and occupancy are given; estimate density

Typically occupancies given by the detectors are apparent occupancies.

$$D = \frac{O_{app} * 5280\ ft/mi}{L_v + EL} \qquad D = \frac{O_{app} * 5280\ ft/mi}{L_v + L_d} \qquad \text{(Eq.5-7)}$$

But if average flow rate and average speed for a certain time period are given, density can be computed as:

$$D = \frac{Flow_rate}{Speed} = \frac{q}{S} = \frac{veh/hour}{mi/hour} = \frac{veh}{mi}$$

Derivation of the Density-Occupancy Relationship

$$S_{SMS}[mph] = \left(\frac{(L_V + EL)/5280}{\bar{t}_{(p)}/3600}\right) = \frac{3600}{5280}\left(\frac{L_V + EL}{\bar{t}_{(p)}}\right)$$

$$T_o[hr] = N\left(\frac{\bar{t}_{(p)}}{3600}\right)$$

$$\bar{t}_{(p)} = \frac{3600}{5280}\frac{L_V + EL}{S_{SMS}}$$

$$T_o = N\frac{1}{3600}\frac{3600}{5280}\frac{L_V + EL}{S_{SMS}}$$

$$= \frac{N}{5280}\frac{L_V + EL}{S_{SMS}}$$

$$O_{app} = \frac{T_o}{T} = \frac{N}{T}\frac{1}{5280}\frac{L_V + EL}{S_{SMS}}$$

$$= \frac{q}{S_{SMS}}\frac{L_V + EL}{5280}$$

$$= D\frac{L_V + EL}{5280}$$

$$D = O_{app}\frac{5280}{L_V + EL}$$

- Estimate SMS using detector data
- Compute total time occupied (not occupancy) by N vehicles detected in time period T
- Solve the first equation for average time occupied by each vehicle
- Plug in the 3rd eq into 2nd eq
- Compute the occupancy O_{app}. N/T turned out to be flow rate, q. Also q/SMS is density by definition. Now the relation between occupancy, O_{app}, and density, D, was established.
- Solve for D. Voila, you get Eq. 5.7)

5.2.4 Connection between macroscopic and microscopic measures

These are in English units.

D (Density) = 5280 / d_a where d_a is average spacing

v (Flow rate) = 3600 / h_a where h_a is average headway

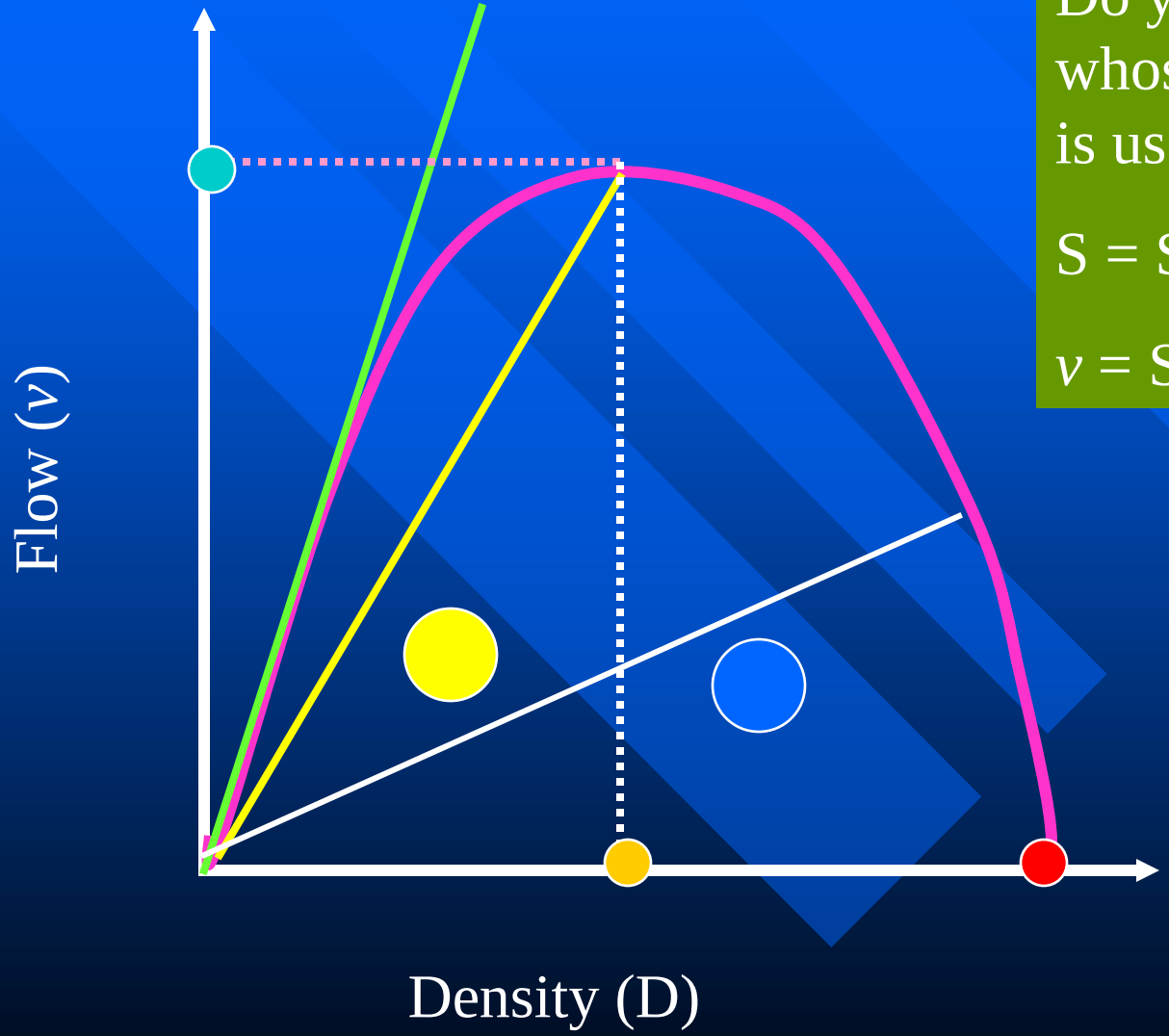
S (Average speed) = d_a / h_a



Spacing or Space headway

Headway or Time headway

5.3 Relationships among flow rate, speed, and density

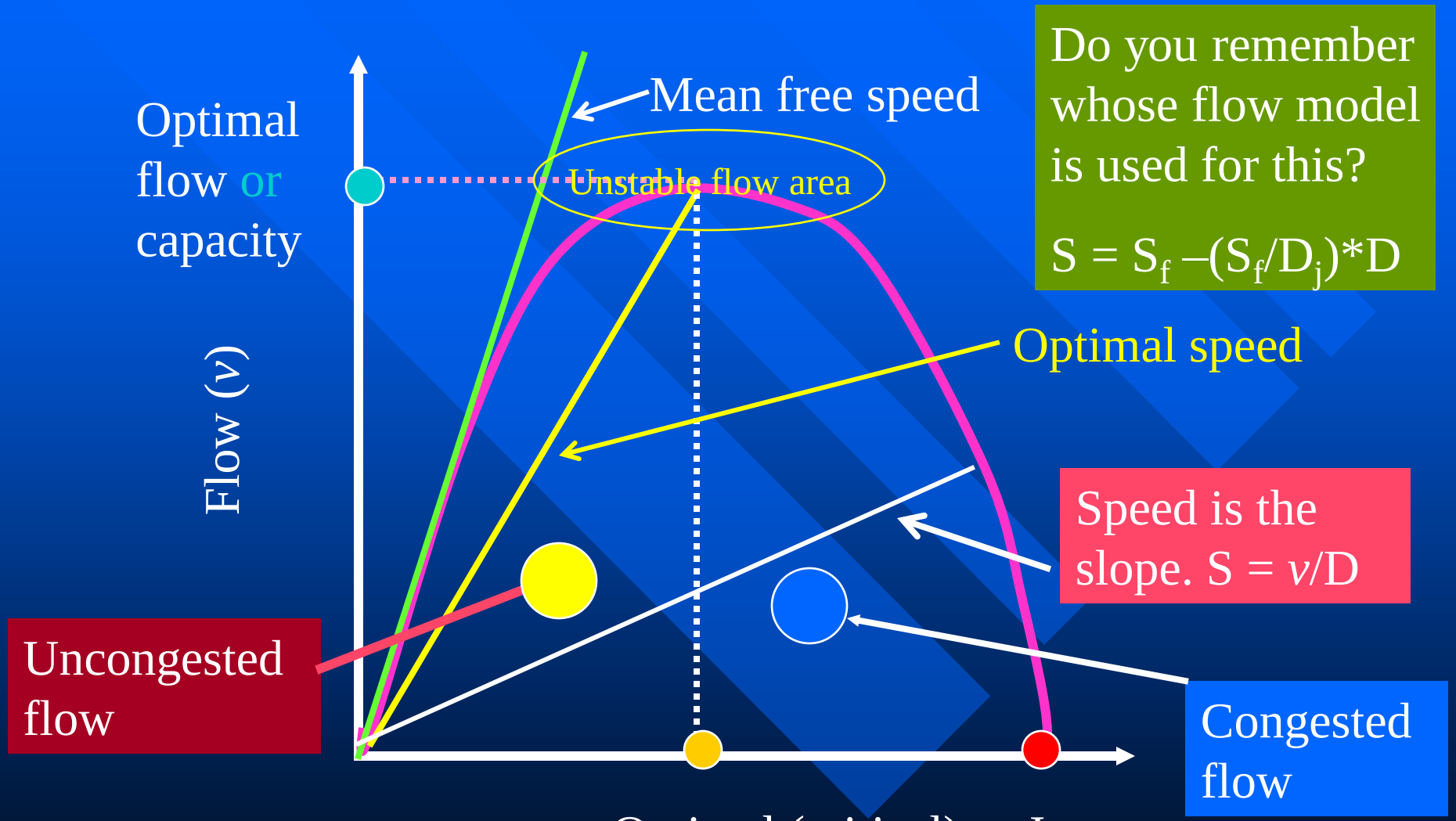


Do you remember whose flow model is used for this?

$S = S_f - (S_f/D_j)*D$

$v = S*D$

5.3 Relationships among flow rate, speed, and density



Do you remember whose flow model is used for this?

$S = S_f - (S_f/D_j)*D$