Highway Capacity

1. A traffic stream is carrying 4500 veh/hr in three lanes in one direction. What is the average headway per lane?

2. With the 4500 veh/hr in three lanes;
   a. What is the density per lane if the operating speed is 60 mi/hr?
   b. What is the spacing between vehicles in each lane for these conditions?

3. What is the capacity of a 4-lane freeway in one direction if the density at capacity is 45 veh/mi/lane, and the speed at capacity is 53 mi/hr?

4. A multi-lane highway is operating in a high mountain valley on a typical grade of about 1%, or grades representing level terrain conditions. It is carrying 10% trucks. The passenger car equivalent is 1.5 for level terrain, and 2.5 for rolling terrain and 4.0 for mountainous terrain. What is the heavy vehicle factor, \( f_{HV} \), for this location?

5. For a 6-lane freeway the operating speed is 57 mph and the demand volume is 4800 vph with a peak hour factor of 0.9. Assuming this is for the peak period on a commuter route when no trucks are present, what is the level of service based on the following criteria?

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<tr>
<th>Level of Service</th>
<th>Density, pass. cars/mile/lane</th>
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<tr>
<td>A</td>
<td>10</td>
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<td>E</td>
<td>( \leq 45 )</td>
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<tr>
<td>F</td>
<td>&gt;45</td>
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6. For the intersection shown below;
   a. What is the sum of the critical movements?
   b. Are those volumes likely to exceed the capacity of a signalized intersection?

7. A stop controlled intersection of one way streets carries 800 veh/hr/lane in 2-lanes on the major street and has a demand to cross the major street from the stop-controlled minor street of 100 vehicles. Assuming a critical gap of 6 seconds for entering vehicles, is it likely that the 100 vehicles could cross?
1. A traffic stream is carrying 4500 veh/hr in three lanes in one direction. What is the average headway per lane?

\[ h = \frac{3600 \text{ sec/hr}}{4500 \text{ vph/3 lanes}} = 2.4 \text{ sec/veh} \]

2. With the 4500 veh/hr in three lanes;
   a. Density (veh/mi) = \( \frac{\text{volume (veh/hr)}}{\text{speed (mi/hr)}} \)

   Density (veh/mi/ln) = \( \frac{4500 / 3 \text{ vph/ln}}{60 \text{ (mi/hr)}} \)

   Density = 25 veh/mi/ln

   b. Spacing (ft/veh) = \( \frac{5280 \text{ (ft/mi)}}{\text{Density (veh/mi)}} \)

   Spacing (ft/veh) = \( \frac{5280 \text{ (ft/mi)}}{25 \text{ (veh/mi)}} \)

   Spacing (ft/veh) = 211 ft/veh

3. What is the capacity of a 4-lane freeway in one direction if the density at capacity is 45 veh/mi/lane, and the speed at capacity is 53 mi/hr?

   \[ \text{Volume (veh/hr)} = \text{speed (mi/hr)} \times \text{density (veh/hr)} \]

   Volume \( \left( \frac{\text{veh/hr}}{\text{lane}} \right) = 53 \text{ mph} \times 45 \text{ vpm/ln} \)

   Volume \( \left( \frac{\text{vph}}{\text{lane}} \right) = 2385 \text{ vph/ln} \)

   Capacity = 2385 vph/ln \times 3 \ln = 4770 vph
4. A multi-lane highway is operating in a high mountain valley on a typical grade of about 1%, or grades representing level terrain conditions. It is carrying 10% trucks. The passenger car equivalent is 1.5 for level terrain, and 2.5 for rolling terrain and 4.0 for mountainous terrain. What is the heavy vehicle factor, $f_{HV}$, for this location?

$$f_{HV} = \frac{\text{mixed vehicles}}{\text{equivalent passenger cars}}$$

$$f_{HV} = \frac{100\%}{P_{PC} + P_T E_T + P_{RV} E_{RV}}$$

where

$P_{PC} = \% \text{ passenger cars, trucks, RVs}$

$E_T, E_{RV} = \text{passenger car equivalent for trucks, RVs}$

$$f_{HV} = \frac{100\%}{90\% + (10\%) \times 1.5} = 0.95$$

ALTERNATIVE METHOD:

$$f_{HV} = \frac{1}{1 + P_T (E_T - 1) + P_{RV} (E_{RV} - 1)}$$

where $P_T, P_{RV} = \% \text{ trucks, RVs}$

$$f_{HV} = \frac{1}{1 + 0.10 \times (1.5 - 1)} = 0.95$$

5. For a 6-lane freeway the operating speed is 57 mph and the demand volume is 4800 vph with a peak hour factor of 0.9. Assuming this is for the peak period on a commuter route when no trucks are present, what is the level of service based on the following criteria?

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\[ v_p = \frac{\text{demand volume}}{\text{PHF} \times N \times f_{HV} \times f_p} \]

*Note:*

\( f_{HV} = 1 \) since there are no trucks

\( f_p = 1 \) for commuter traffic

\[ V_p = \frac{4800 \text{ vph}}{0.9 \times 3 \times 1 \times 1} = 1778 \text{ Pass Cars per lane as peak 15 min. flow} \]

\[ \text{Density} \frac{\text{PC}}{\text{Mi}} = \frac{\text{Volume (PC Hr)}}{\text{Speed (Mi Hr)}} \]

\[ \text{Density} \frac{\text{PC}}{\text{Mi}} = \frac{1778 \text{ PCPH}}{57 \text{ mph}} = 31.2 \frac{\text{PC}}{\text{Mi}} \]

since \( 31.2 \leq 35 \frac{\text{PC}}{\text{Mi}} \) \( \therefore \) LOS “D”

6. For the intersection shown below;
   a. Critical movements

\[ \sum \text{critical movements} = 1250 \text{ vph} \]
b. Capacity of intersection

Rule of thumb: Capacity = 1450 veh/hr

1250 vph \leq 1450 vph \therefore \text{under capacity}

7. A stop controlled intersection of one way streets carries 800 veh/hr/lane in 2-lanes on the major street and has a demand to cross the major street from the stop-controlled minor street of 100 vehicles. Assuming a critical gap of 6 seconds for entering vehicles, is it likely that the 100 vehicles could cross?

\[ P_R (h \geq t_c) = e^{-qt} \]

where

\( (h \geq t_c) \) = probability of headway \geq critical gap

\( q = \) flow rate, veh/sec

\( t = \) critical gap, sec

\[ q = \frac{\text{Veh}/\text{Hr}}{3600 \text{ sec}/\text{hr}} \]

\( q = 0.444 \text{ veh/sec} \)

\[ P_R (h \geq t_c) = e^{-qt} = e^{-0.444(6)} = 0.0695 \]

= 111 gaps > 100 veh

Yes, gaps exceed number of vehicles