CE 361 Introduction to Transportation Engineering — Out: Mon. 13 September 2004

Homework 3 (HW 3) — Due: Mon. 20 September 2004

HIGHWAY DESIGN FOR PERFORMANCE

- You will be permitted to submit <u>this</u> HW with one or two other CE361 students. If the HW is submitted by more than one student, the signatures of those students must appear at the top of the front page of the materials submitted. By their signatures, the students certify that (a) they approve of what is being submitted, (b) they will accept the same grade that is awarded for the HW, and (c) each student is responsible for having the HW content available at a subsequent test.

- For every problem, identify the problem by its number and **name**, be clear, be concise, cite your sources, attach documentation (if appropriate), and let your methodology be known.

- "FTE" = *Fundamentals of Transportation Engineering*, the textbook for CE361.

1. (20 points) **Capacity and Level of Service.** Problem 3.7 in FTE. There are 20 access points in the one-mile-long "neckdown" segment. Attach a completed copy of Figure 3.4 to your HW and show your calculations.

2. **Analysis of Freeway Lane Blockage using Queueing Diagram.** Traffic on Freeway 16 is susceptible to even minor incidents during peak periods. According to the Greenshields-based model (see HW1 Problem 4), Freeway 16 has a capacity of 1800 vph per lane. Freeway 16 has 3 inbound lanes as it nears downtown. On a typical morning, the inbound flow rate is 4000 vph. One morning, a minor incident blocks one lane, reducing inbound capacity to 3200 vph. A 3-lane backup (queue) results, as drivers try to merge into two lanes. The queue continues to build for 15 minutes, at which time the queue reaches the last offramp upstream from the blockage. At this offramp, no driver is willing to join a queue that extends past the offramp. Instead, enough drivers exit, so that the queue on the freeway never extends past the offramp. Thirty minutes after the incident blocked a lane, the lane is reopened to traffic and the full capacity is restored.

A. (15 points) Draw a queueing diagram that begins at the time the blockage occurs and ends when the queue has dissipated. Label the arrival and departure curves clearly with "AC" and "DC", their respective vph values, and the (x,y) coordinates of key events.
B. (5 points) What is the maximum length of the queue?
C. (5 points) What is the maximum time any vehicle spends in the queue? When did that vehicle join the queue?
D. (5 points) To the nearest 0.1 minute, when will the queue dissipate? Show your procedure.
E. (5 points) What was the total delay to all vehicles who spent time in the queue? (Do not include the delay incurred by drivers who left the freeway at the offramp and had to use surface streets.)

3. **Analyzing a Stable Queue.** At the end of the offramp mentioned in the previous problem, a traffic signal is timed with a constant cycle, so that 960 vph can enter the surface streets from the ramp. Normally, 400 vph use the ramp during the morning peak period.

A. (10 points) During the time the freeway is blocked in the previous problem, how many extra vehicles will be diverted to the offramp? What is the arrival rate on the offramp before and after the freeway blockage? Is the queueing system "stable" in both cases?
B. (10 points) What type of queueing system (x/y/z) is the signalized ramp? Explain your decision.
C. For the cases in which a stable queue exists, answer the following questions.
   i. (5 points) To the nearest 0.01 vehicles, what is the average queue length?
   ii. (5 points) To the nearest 0.1 second, what is the average time spent waiting in a queue?

4. (15 points) **Poisson Calculations at River Bridge Toll Facility.** Problem 3.24 (a-c) in FTE.