EECS 509 – WINTER 1997

Problem Set #4 – Assigned Feb. 6 – Due in class Feb. 13

1. After observing arrivals at a toll both over a 60 min. time period, a transportation student notes that the arrival and service rates are deterministic, but instead of being uniform, they change over time according to the following functions:

$$\begin{aligned} \lambda(t) &= 2.2 + 0.17t - 0.0032t^2 \quad \text{for } t \geq 0 \\ \mu(t) &= 1.2 + 0.07t \quad \text{for } t \geq 0 \end{aligned}$$

   where t is in minutes after the beginning of the obsevation period.

   (a) When does the queue start and when does it dissipate?

   (b) Determine the total vehicular delay at the toll both from time 0 and until all traffic has cleared.

   (c) Determine the longest queue. At what time is this queue realized?

2. An approach to an intersection has a saturation flow of 1700 VPH. The signal's pre-timed cycle length is 60 sec. and the effective red is 40 sec. During three consecutive cycles, 15, 8, and 4 vehicles arrive, respectively. Determine the total vehicular delay over the three cycles. Assume uniform arrivals *within* each cycle. (Note that there will be queue overflow.)

3. A traffic light is planned for the intersection of a major one-way street with a minor one-way street. The flows on these streets are $\lambda = 800$ VPH for the major one and $q = 500$ VPH for the minor one. The green splits are set in direct proportion to the flow, thus $\frac{g_1}{g_2} = \frac{\lambda}{q}$, where g_1 is the green split on the major street and g_2 is the green split on the minor street. The problem is to set the cycle length c so that the total delay is minimized. Assume further that 10 sec. are taken from each cycle for yellow periods, pedestrian crossings, and other lost times, and that it takes 2.1 sec. for each car to go through the light. Using Webster's formula, plot the total vehicular delay (for both approaches) and determine from this plot the best cycle length.

4. *Integration.* Simulate an arterial network that consists of a two-way arterial (say, E-W) and three parallel one-way streets (say, N-S) that cross the arterial. Thus the network model consists of 14 links, three signalized nodes, two O/D nodes for the E-W traffic, and three O nodes and three D nodes for the N-S traffic.

   Assume that all the links have equal length of 500 meters and are single-lane. The free flow speed on each link is 60 km/h and the saturation flow is 1800 VPH. The speed at capacity is 40 km/h. The jam density is 100 veh/km/lane.

   There are five separate routes that the vehicles follow: east to west on the arterial, west to east on the arterial, and north to south on each of the three cross-streets. The

east to west demand is 600 VPH from 1 to 1200 seconds; the west to east demand is also 600 VPH from 1 to 1200 seconds. The north to south demand is 300 VPH from 1 to 1200 seconds for each of the cross-streets. No further vehicles join the network after 1200 seconds.

Simulate the above network. Print out the input files that you used. Through trial and error (or some other means...), determine fixed-cycle signal timing plans for the three signalized interections that "minimize" the total travel time. Make sure that your simulations run long enough to ensure that all vehicles are cleared from the network. Provide the relevant output data.