Faculty of Applied Science and Engineering

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Final Examination, December 2001
Civ332F, Transport II, Performance
Exam Type: C
Examiner: Baher Abdulhai

Attempt all questions. Use clear and identifiable steps.
(Total marks = 60)

Problem # 1: (10 marks)

An urban sub-network is composed of an arterial street running parallel to a freeway as shown, connecting an origin zone I to a destination zone II. The performance function of the freeway segment is given by t = 3 + 2 (x/P), where P is the freeway capacity of 4000 vph, t is the travel cost is minutes and x is the volume using the freeway in vph. Each of the surface street links #2 to #6 has a performance function given by t = 1 + (x/P), where P is the capacity of 2500 vph. If the total demand from zone I to zone II is 5000 vph:

1. Formulate the link-path incidence matrix.
2. Formulate the performance function for each path in the form of c = ψ(f) where c is the path cost and f is the path flow.
3. Under User Equilibrium (UE), using the above path cost functions, what would be the path flows and travel times (costs).
4. Solve the above UE problem by using the link performance functions directly via a constrained optimization formulation (mathematical program).
5. If an accident occurs on the freeway cutting down the capacity by half, how much traffic should be diverted to the parallel arterial using an upstream Changeable Message Sign (CMS), in order to restore UE. What is the percentage of time the diversion message should appear on the CMS.

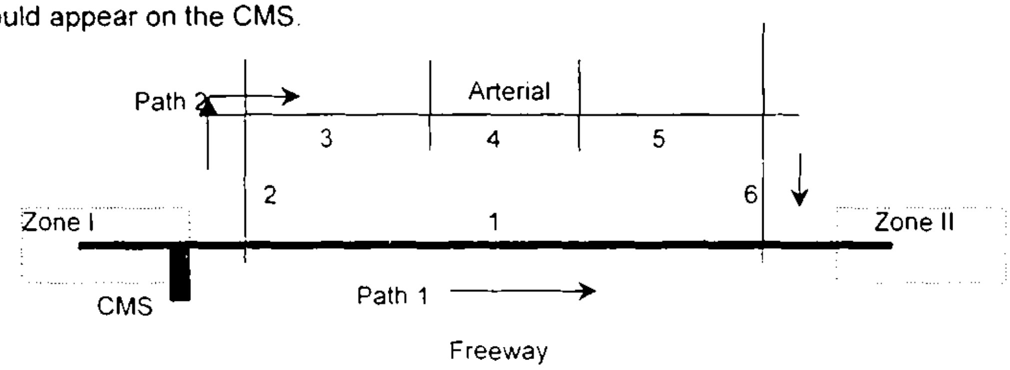


Figure 1

Problem # 2: (10)

The Greenshield speed-density (u-k) relationship for a given highway link is given by:

$u = 100 - 1.25\,k$
where speed u is in km/hr and density k is in vehicles/km

while traffic is flowing at a speed of 85 km/hr, a slow truck joins the stream, travels at a speed of 15 km/hr for 6 km then exits the highway. Due to heavy traffic in the opposite direction, vehicles can not pass the truck and have no choice but to queue up behind it.

1. Compute the speeds of the congestion and clearing shock-waves.
2. Sketch the above scenario using a flow-density (q-k) diagram and a time-space diagram showing all speeds, shock-wave speeds, maximum queue length and dissipation time.
3. Determine the maximum length of the queue (platoon) behind the truck (in meters)
4. How long would it take for the formed queue (platoon) to dissipate, measured from the instant the truck leaves the highway?

Problem # 3: (6)

Two adjacent signalized intersections (see Figure 2) have been reported to be problematic. Due to the poor coordination between the two intersections, frustrated motorists have been observed to frequently run the red light at the second intersection. To remedy this situation, the City has recently installed red-light-runner cameras to capture and penalize drivers entering the intersection within red. At the intersection shown, one violator challenged her ticket in court alleging that at the onset of the yellow phase she was caught in a dilemma zone in which she could neither stop safety before the intersection nor proceed to clear the intersection before red. You are asked to express your expert opinion in court.

If the current yellow interval is 3 seconds, the intersection is 20 m wide, the approach speed is 50 km/hr, vehicle length is 6 m, reaction time is 1.0 second and the design deceleration rate is 0.27g where g is the acceleration of gravity:

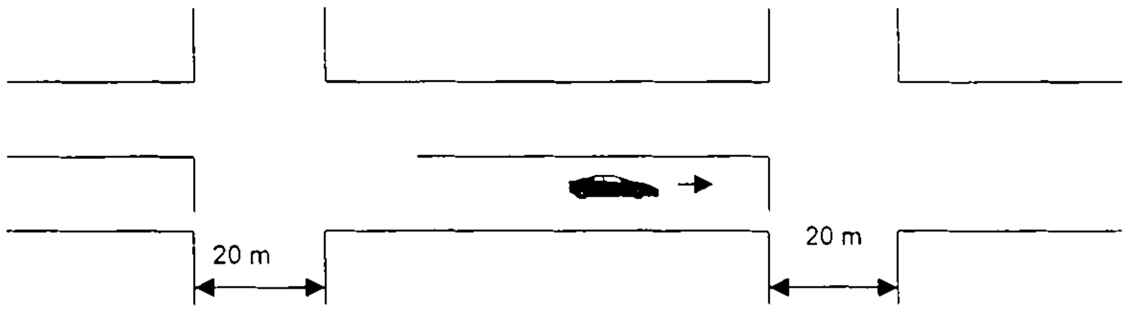


Figure 2

1. Does a dilemma zone exist?
2. If yes, how long this zone is and how far is it from the intersection stop line? Summarize your results on a sketch of the intersection.
3. How can you rectify the situation in order to avoid such a case in the future?

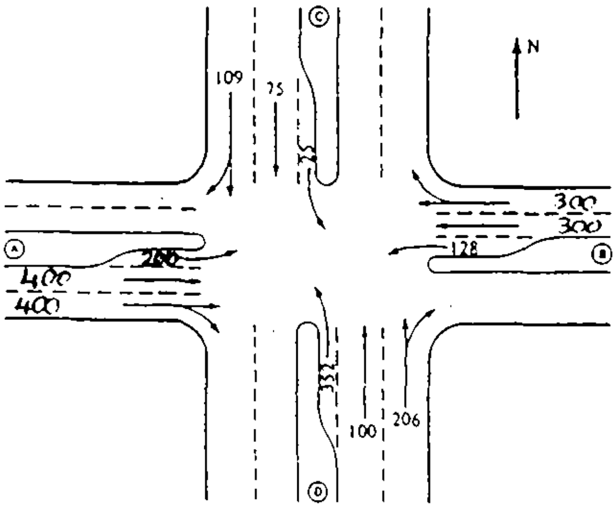
Problem # 4: (14)

For the same intersections shown in Figure 2, the City is asking you to provide an alternate design for the two signal timing plans in order to enhance coordination. Assuming that volumes are identical at the two intersections as shown in Figure 3.

1. Determine a suitable signal timing using Webster method, assuming a four-phase system is desired, one phase for each intersection leg. Sketch results on a signal timing summary diagram.
2. Determine the ideal eastbound offset between the two intersections. Sketch to a reasonable scale the resulting green band on a time space diagram both in the eastbound and westbound directions

• Saturation flow rate = 2000 vphgpl,	• PHF = 0.95,
• Left turn factor = 1.4,	• PCE for buses and trucks = 1.6,
• Right turn factor = 1.0,	• % trucks and buses from south = 5%
• Lost time per phase (l_i) = 4 sec	• All lane and median widths = 4 m.
• Yellow interval (τ_i) = 3 sec.,	• Pedestrian speed = 1 m/sec.
• All red = 0 sec.,	• Minimum pedestrian walk interval = 5 sec.

Figure 3



Problem # 5: (10 marks)

In Figure 4, the speeds (in meter/sec) and gaps (in meters) shown are constant in each lane:

1. Compute the volumes (vph) in each lane
2. Compute the Time Mean Speed (TMS)
3. Compute the Space Mean Speed (SMS)
4. Which of the two speeds is higher?
   Is this always the case? Why or why not?

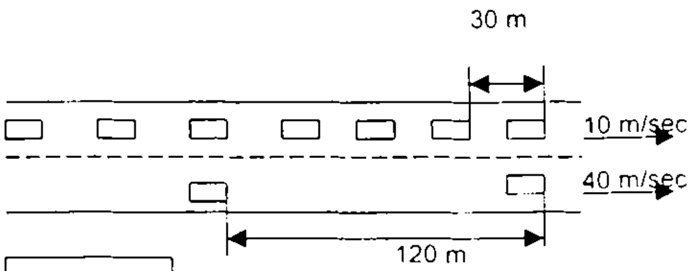


Figure 4

Problem # 6: (10 marks)

Traffic on the freeway shown in Figure 5 can be described by a Greenburg model of the form q=50.k.ln(350/k), where q is flow in vph and k is density in veh/km. If the measured mainline flow is 6065 vph and density is 175 veh/km, what should be the maximum allowable ramp inflow and why?

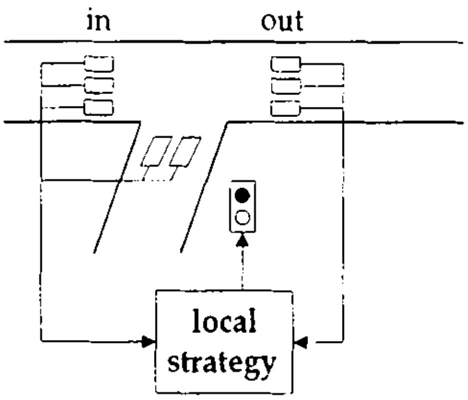


Figure 5

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