Traffic Engineering (CIVIL-349)
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Exercise 3
Input-Output diagrams & LWR Theory
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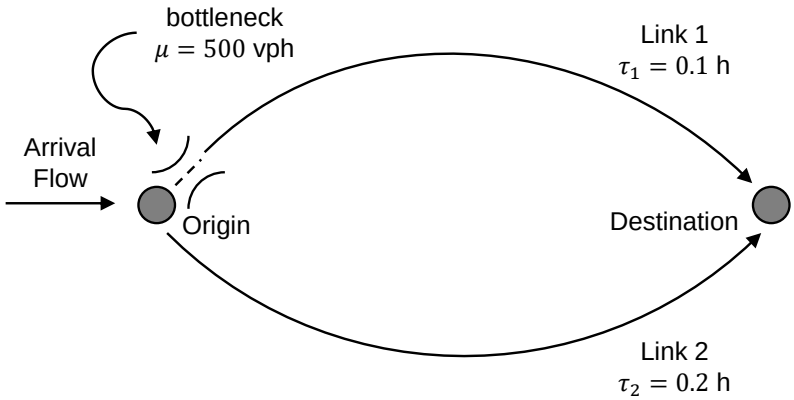
Problem 1



The network above consists of two separate links. Commuters choose a link as per Wardrop's Principle[1].

Link 1 has a bottleneck at its entry. This bottleneck's capacity, μ, is 500 vehicles/hour and its queue (FIFO)[2] does not block the entry of Link 2. Once commuters depart from this bottleneck, their travel time on Link 1, τ_1, is 0.1 hours. Link 2 has no capacity constraints and the travel time on this link, τ_2, is 0.2 hours. (Note that τ_1 and τ_2 are independent of flow).

Commuters arrive at the origin at a uniform rate of 200 vehicles/hour **except for** a one-hour period when they arrive at a uniform rate of 1,200 vehicles/hour.

a. Calculate the total number of commuters who use **Link 2**.

b. How much is the total travel time in vehicle-hours for all cars, on Links 1 and 2 altogether?

c. How much is the total travel time if Link 2 is closed because of construction?

All calculations should be done for a 4-hour time period, starting with the one-hour peak period.

[1] Wardrop's principle, referring to the spreading of trips between alternate routes because of congestion, states that journey times in all routes actually used are equal and less than those that would be experienced by a single vehicle on any unused route.

[2] First-in-first-out

Hint: sketch the queueing diagram for the bottleneck at Link 1's entry.

Problem 2

Traffic on a three-lane freeway is observed to follow a triangular flow-density relationship with free-flow speed $v_{\text{ff}} = 100$ km/h, capacity $c = 2000$ vh/hr/lane, jam density $k_j = 150$ vh/km/lane. The flow in the freeway from upstream is 5000 vh/hr, while the ramp flow is negligible (almost zero).

At 9:45 am, an accident occurs at point A (see Figure 1), which led to the closure of one lane of traffic (the capacity reduces to 4000 vh/hr) for 15 minutes and before the lane is reopened (total capacity returns to 6000 vh/hr). Lucy enters the freeway via the ramp at point B at 10:00 am.

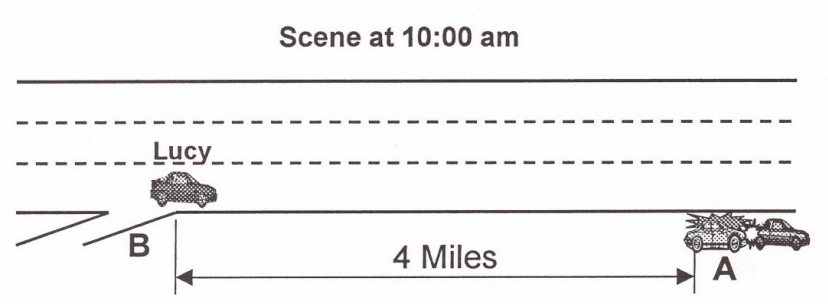


Figure 1: The scene of the accident at 10:00 am

a. How fast (i.e., at what speed) will congestion backup upstream of the accident site at 9:45 am? Draw all the shockwaves during the lane closure and the opening of the lane at 10:00 am. Distance AB is equal to 6.5 km = 4 miles.

b. When (i.e., at what time) will Lucy pass by the accident scene at point A?