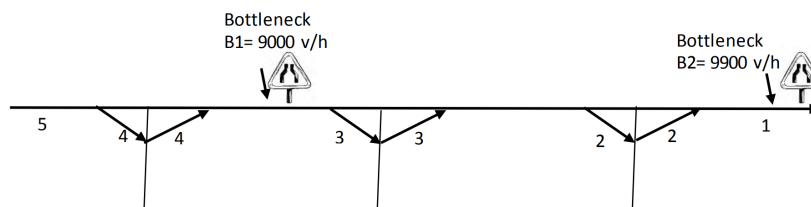


Traffic Engineering (CIVIL-349)
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Revision Problems

Problem 1: Multiple Ramp Metering

A freeway has the ramp configuration shown below. The origin-destination pattern (given the fraction of each input bound for a given output), demand input flows and minimum metering rates are as follows:

Input	Output 1	Output 2	Output 3	Output 4	Demand	Min. Rate
2	1.00				1200	600
3	0.97	0.03			1000	500
4	0.96	0.02	0.02		800	500
5	0.95	0.02	0.02	0.01	8400	



There are two bottlenecks: one between on-ramp 4 and off-ramp 3 of capacity $B_1 = 9000$ veh/h and another in location 1, with capacity $B_2 = 9900$ veh/h. The capacity of the rest of the freeway and of all ramps is considered unlimited.

Determine the optimal metering rates for each on-ramp, while avoiding the formation of any queues on the freeway (from 5 to 1).
Hint: Assume that the optimal decision in this case is to prioritize (i.e. reduce delay on the on-ramp) vehicles that will travel longer distance in the freeway.

Problem 2: Rail crossings design

A light train transit agency operates trains over a 25 km long single track line. During peak periods, it operates five trains at 15 mins headways. Trains travel at an average speed of 50 km/h. Each train has the following cycle:

Travel from A to B	30 mins
Layover (wait) at B	5 mins
Travel from B to A	30 mins
Layover at A	10 mins
Total cycle	75 mins

Using a space-time diagram, determine:

- a. How many double-tracked sections are needed in this connection to allow trains travelling in opposite directions on the scheduled described, to pass one another without experiencing any delay? ¹
- b. If each train is allowed to be as much as 5 mins behind schedule without causing delays to other trains, how long must the crossing sections be, in order to allow trains traveling in opposite directions to pass without delay (i.e. without waiting at the double-tracked section for the delayed train to pass first)? ²

¹ It is assumed that, in all cases, each double-tracked part will be at least as long as the maximum possible train length, so that there is enough space for the two trains to cross parallel to one another

² Book: 'Intro to Transportation Engineering' by James Bank