#### **Question 1: Short Answers**

- a) When a bottleneck is activated, is the departure rate equal to capacity, or the arrival rate?
- b) Using basic traffic stream models, if the jam density of a particular roadway is 500 vehicles/mile, what is the density at capacity?
- c) What US President was most responsible for the development of the Interstate Highway System?

d) Give an example of a common form of mathematical model used to estimate the volume of trips an individual or household makes in a given time period. Provide the name of the model, and an example equation.

e) True or false: In User Equilibrium, travel times on all routes are equivalent.

f) True or false: In System Optimal Conditions, each travelers travel time is minimized.

#### **Question 2: Short Calculation**

If drivers arrive at a single toll booth at the average rate of 1 vehicle every 12 seconds, and the arrivals can be modeled as a poisson process. What is the probability of 2 vehicles arriving in 12 seconds?

Write the highway performance function for a link 10 miles long with a free flow speed of 60 miles and hour, where for each 1000 vehicles travel time is increased by 30 seconds.

Estimate the ESALs for a 3 axle truck. The total weight of the truck is 18,000 lbs.

As described in the schematic diagram below, imagine that during the morning peak hour there are 10,000 vehicles that travel from the suburbs to the city using route 1 or route 2. The highway performance functions for these routes are as follows:

Route 1:  $t_1 = 12 + 0.581x_1^2$ Route 2:  $t_2 = 14 + 1.623x_2$ 

Where  $t_i$  is the travel time on route i, and  $x_i$  is the volume on route i, in thousands of vehicles. Assuming these 10,000 vehicles can choose between these two routes, and these two routes only, find and report the following:

- 1. The user equilibrium (UE) distribution of traffic between the routes.
- 2. The system optimal (SO) distribution of traffic between the routes.
- 3. If the combined capacity of the two routes is 8,000 vehicles per hour is the HPF travel time prediction still valid? Why or why not? (1 3 sentences should suffice).



Just before I-5 intersects US 2 in Everett there is an automatic data counter (ADC) station (at mile post 193.29). I-5 characteristics at this station are:

- Urban freeway classification
- No HOV lanes
- 11 ft lane width
- 8 ft right-side shoulders
- 0.85 interchanges per mile
- Volume: 6,456 vehicles/hour
- PHF = 0.98
- 3 lanes in each direction
- 7% trucks and buses
- No recreational vehicles
- Level terrain
- Driver population adjustment factor = 1.0

Report the following:

- 1. Free flow speed for this section of freeway (to the nearest mile per hour).
- 2. The 15-minute passenger-car equivalent flow rate (v<sub>p</sub> in pcplph).
- 3. The freeway section level of service (LOS). Assume you have access to the LOS figure and charts.

It is proposed to make SR 522 between Woodinville and Monroe into a 4-lane divided highway. A Poisson regression trip generation model was developed to determine the number of additional morning peak hour person-trips per day anticipated on this new expanded highway. The table below shows this model and the variable values for one particular household in Monroe.

Based on the Poisson regression model below, report the following:

- 1. The average number of additional morning peak hour person-trips per day that this household would generate.
- 2. The probability that the time between these additional morning peak hour persontrips is greater than 2 days.

Variable	Coefficient	Household Profile
Constant	-1.5	0
Education (undergraduate degree or higher)	0.1	1
Income	0.0001	55
Household wants to work in Seattle	0.1	1
Number of autos owned in the last ten years	0.1	4
Number of non-workers	-1	1
Senior household (age>60 for all members)	-0.1	0
Number of kids	0.15	1.3

#### Poisson Regression Model: Number of additional morning peak hour trips/day

Assume the logit model shown below describes route choice for 10,000 vehicles in the SR 520 and I-90 bridges if a toll system were to be installed on the SR 520 bridge.

What toll should WSDOT charge (to the nearest cent) so that the resulting traffic distribution from these 10,000 vehicles results in 3,500 vehicles selecting the SR 520 route?

Variable	Coefficient	Profile values
SR 520 Route		
Constant	0.2	1
Distance from residence to nearest on ramp (miles)	-0.07	3
Toll (in dollars)	-0.3	???
Flexibility of work arrival time (1 if flexible, 0 if not)	-0.022	1
Income (in thousands of dollars)	0.0034	50
I-90 Route		
Distance from residence to nearest on ramp (miles)	-0.1	6
Income (in thousands of dollars)	0.0011	50
Work on the south end of Seattle (1 if yes, 0 if no)	0.4	1

A toll booth on a turnpike is open from 8:00 am to 12:00 midnight. Vehicles start arriving at 7:45 am at a uniform deterministic rate of 6 per minute until 8:15 am and from then on at two per minute. If vehicles are processed at a uniform deterministic rate of six per minute, determine when the queue will dissipate, the total delay, the maximum queue length (in vehicles), and the longest vehicle delay under FIFO.

You are designing the vertical alignment of Strander Blvd. extension in the Renton-Tukwila area. An equal tangent sag vertical curve must go under an existing north-south rail line. The centerline roadway surface must be at least 18 ft below the proposed rail bridge. Known grades, stationing and elevations are given in the drawing below. Design the curve for the highest possible design speed without violating the 18 ft clearance requirement.

Report the longest possible curve length and the associated design speed rounded down to the nearest 5 mph. (now where do I remember seeing a problem like this before?). Assume you have access to table 3.3.

