CEE 123 Transport Systems 3: Planning & Forecasting

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Homework #1 -- Review of Pre-requisite Material [Due: Monday, 8 April 2024]

Complete problems 1-3 and *either* problem 4 or 5. These problems represent pre-req material needed for this course. You must work independently to provide an accurate picture of your level of understanding [50 points].

Problem 1. [CEE121] Travel Forecasting (10 points)

Review your CEE121 notes or the textbook (Mannering *et al*. Chapter 8. Read 8.1-8.3; skim 8.4-8.5; read 8.6; skim 8.7 and Appendix 8A (note: similar material is available in most transportation texts and on-line (e.g., The Four Step Model (MGMcNally) or Travel Forecasting Primer (Bierborn)).

Answer the following questions ***in your own words***:

a. What are the **steps** in the sequential approach to forecasting future travel?
b. What are the inputs and outputs of each forecasting step?
c. What is a **link performance function**? What role does it play in travel forecasting?
d. What is the difference between **User Equilibrium** and **System Optimal** route choice formulations?
e. What is the Transportation Planning Process?

Problem 2. [CEE21/110] Statistical Methods (20 points)

The following speed and density data was collected on a local freeway segment.

Table 2. Speed and Density Measurements (2022)

Observation		Units	1	2	3	4	5	6	7	8	9	10
Speed	SMS	mph	50	45	40	30	25	50	35	35	25	20
Density	D	veh/mi	10	20	35	40	70	15	40	50	80	100

a. **Estimate** a linear speed-density regression model with X = density (D) and Y = Speed (u_s). You may perform the calculations by hand or use available software (identify software and **include** model input and output).
b. **Define** and **find** mean free speed (u_f) and jam density (D_j) and express the results in Greenshield's format:

   $u_s = u_f (1 - D / D_j)$

c. Is the model **significant**? What **specific tests** support your contention?

d. Consider four additional data points: {S,D} = {60,15},{15,125},{20,110},{55,10}. **How** will these points affect the estimated model? Does a **plot** suggest that the linear Greenshield's model might not be appropriate?

Problem 3. [CEE121] Performance-Demand Equilibration (10 points)

Two single-link paths connect an origin and destination with performance functions:

$t_1 = 1 + 0.5\, x_1$
$t_2 = 2 + 1.0\, x_2$

with time t in minutes (min.) and volume x in thousands of vehicles per hour (kvph).

a. Determine UE flows if the total origin-to-destination demand is 800 veh/hr
b. Determine UE flows if the total origin-to-destination demand is 3,000 veh/hr
c. Calculate the **total** vehicle-hours of travel for both case (a) and (b)
d. Referring to Problem 1, how does this problem fit the sequential forecasting process? What elements are demand and what elements are supply?

Problem 4. [CEE110] Project Evaluation (10 points)
In the final task of the CEE123 term project, teams will compare future alternative transportation systems in terms of system performance and system cost relative to a "No Build" alternative. There are several project evaluation techniques that can be utilized.

The following data summarize the estimated costs and benefits of a proposed Miasma Beach bus system for 6 alternatives defined by system length (total route-miles covered). What is the **preferred alternative** based on these benefits and costs? Show all work.

Table 4. Shuttle Bus Costs and Expected Benefits (Present Worth)

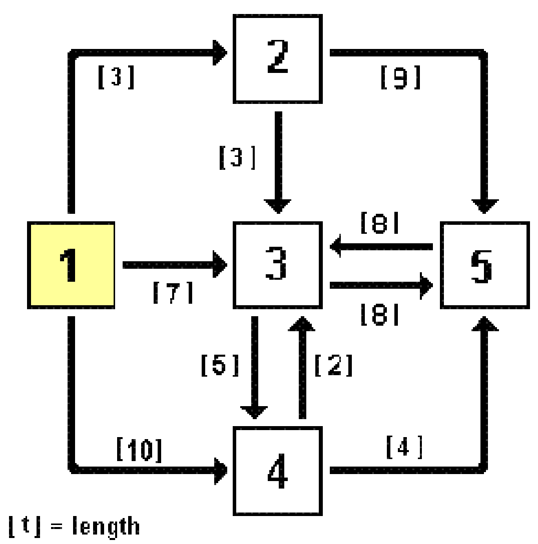
Alternative	1	2	3	4	5	6
System Length (miles)	5	10	15	20	25	30
System Costs ($M)	80	100	130	180	270	380
User Benefits ($M)	220	300	340	370	390	425

Problem 5. [CEE111] Network Models and Optimization (10 points)

Primal: Min $C = \Sigma_{ij} x_{ij} c_{ij}$
subject to:
$\Sigma_i x_{is} - \Sigma_j x_{sj} \geq -1$ . . . for each origin node s
$\Sigma_i x_{ik} - \Sigma_j x_{kj} = 0$ . . . for each intermediate node k
$\Sigma_i x_{it} - \Sigma_j x_{tj} \geq +1$ . . . for each destination node t

Dual: Max $D = w_t - w_s$
subject to:
$w_j - w_i \leq C_{ij}$ . . . for all links (i,j)

a. What do these equivalent mathematical program represent?
b. Pick one and define the variables and what the solution means.
c. For the network depicted, **formulate** the linear program using one of the formulations above.



Last Updated: 1 April 2024