

CEE 123 Transport Systems 3: Planning & Forecasting

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Homework #1 -- Review of Pre-requisite Material [Due: Wednesday, 6 April 2022 @ 12 noon]

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*:

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

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

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

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

- Determine UE flows if the total origin-to-destination demand is 800 veh/hr
- Determine UE flows if the total origin-to-destination demand is 3,000 veh/hr
- Calculate the **total** vehicle-hours of travel for both case (a) and (b)
- 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: $\text{Min } C = \sum_{ij} x_{ij} c_{ij}$

subject to:

$\sum_i x_{is} - \sum_j x_{sj} \geq -1 \dots$ for each origin node s

$\sum_i x_{ik} - \sum_j x_{kj} = 0 \dots$ for each intermediate node k

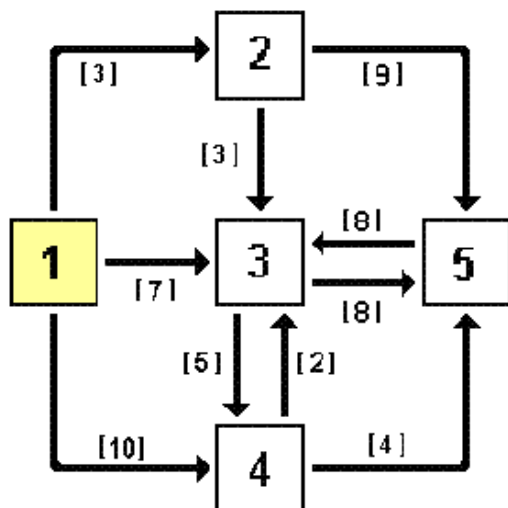
$\sum_i x_{it} - \sum_j x_{tj} \geq +1 \dots$ for each destination node t

Dual: $\text{Max } D = w_t - w_s$

subject to:

$w_j - w_i \leq C_{ij} \dots$ for all links (i,j)

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



[t] = length

Last Updated: 22 March 2022