

Team Homework

Due Date for Jupyter Notebook: 9:30 AM on November 20, 2025

Due Date for Presentation File: 5:00 PM on November 24, 2025

A. Team Information and Presentation Schedule:

The tables below show your assigned team:

<u>Team 1</u>	<u>Team 2</u>	<u>Team 3</u>
<ul style="list-style-type: none"> • Hajra Shahab • Brooke Janssen • Yi Tai 	<ul style="list-style-type: none"> • Harish Kathi • Keyang Zhong • Dainel Hunsaker 	<ul style="list-style-type: none"> • Letian Cheng • Keke Li • Praveen Muthukrishnan
<u>Team 4</u>	<u>Team 5</u>	<u>Team 6</u>
<ul style="list-style-type: none"> • Noah Tang • Maria Santaliz-Carmona • Haotian Jiang 	<ul style="list-style-type: none"> • Pichamon Anukulkarnkusol • Alina Sullivan • Farshid Khan 	<ul style="list-style-type: none"> • Jing Qi • Zekun Yang • Brady Cossaboom

The presentation schedule is as follows:

<u>Nov 25, 2025</u>	<u>Dec 2, 2025</u>
Team 1	Team 4
Team 2	Team 5
Team 3	Team 6

B. Submission details:

- (a) Submit **one zip file per team** by 9:30 AM on Nov 20, 2025, on Canvas. The name of the zip file must reflect your team number, e.g., Team_1_Homework. Your zip file must contain the following:

- A Jupyter notebook that includes your analysis and interpretations associated with the assigned problem. Please be thorough in your explanations and interpretations.
- Additional Python or other files used in your analysis (if any).

Please add comments (using # symbol) in your codes whenever needed so that we can understand them clearly. An example follows:

```

### Initialization
pre_node = dict() # immediate predecessor node
cost = dict()     # travel time

```

If needed, please add an instruction file (could be a text file or a doc file) containing any special instructions needed to run your codes and/or your Jupyter notebook.

- (b) Submit **one presentation file per team** (in PowerPoint format) by 5:00 PM on November 24, 2025, on Canvas. We will use this exact file on the day of your presentation. No changes will be allowed after the deadline.

- Each member of a team must present part of that team's presentation in class. Make sure that the presentation is an integrated document.

- Each team will have a total of 25 minutes for the presentation distributed as follows:
 - 15 minutes to present analysis and findings.
 - 10 minutes for questions/comments/discussion.
- Grading will be based on the following:
 - Presentation content (55 points): It should include a brief introduction to the problem, your analysis, and the corresponding insights/findings (i.e., the answers to the questions that have been asked in the Team Homework PDF file sent to you via email).
 - Presentation organization and communication (25 points): It should include well-organized slides and flow, clear articulation, and clear figures/tables.
 - Q & A (20 points)

These presentations are intended to be interactive. So, you should attend both presentation sessions (i.e., on November 25 and December 2); not doing so will be penalized through deductions of points. Each team should ask at least one question when other teams make their presentations; this is an opportunity to earn extra points.

C. Overview:

In previous homework assignments (homework 2 and homework 3), we built the single-class user equilibrium static traffic assignment (UESTA) program step by step. It can solve large-scale single-class UESTA problems. However, to model and analyze the potential changes arising from various emerging technologies, we employ multiclass traffic assignment. In this team homework, you will work with your team members to extend the single-class UESTA implementation to a multiclass UESTA and a multiclass system optimal STA (SOSTA) program, and analyze the potential changes related to the emerging technologies assigned to your team. You can develop your own implementation (e.g., writing codes), or you can find our implementation in the “Single-class STA” folder for single-class UESTA and extend it for multiclass UESTA and SOSTA.

Please go through the specific information identified for your team in section **D** and answer the questions listed in section **E**.

D. Team-Specific Information:**Team 2**

	Scenario 1	Scenario 2	Scenario 3
Demand	100% HDV	50% HDV and 50% CV	50% HDV and 50% CV
Network	SiouxFalls	SiouxFalls	SiouxFalls with two links with roadside unit (RSU)

The link costs functions for link $a \in A$ for HDVs and CVs are:

$$c_{a,H}(x_{a,H}, x_{a,C}) = \frac{l_a}{v_a} \left[1 + \left(\frac{x_{a,H}}{Q_{a,H}} + \frac{x_{a,C}}{Q_{a,C}} \right)^4 \right],$$

$$c_{a,C}(x_{a,H}, x_{a,C}) = \frac{l_a}{v_a} \left[1 + \left(\frac{x_{a,H}}{Q_{a,H}} + \frac{x_{a,C}}{Q_{a,C}} \right)^4 \right] \left(1 - \eta_C \max \left(\frac{x_{a,C}}{Q_{a,C}}, \delta_{a,RSU} \right) \right),$$

respectively, where $x_{a,H}$ and $x_{a,C}$ are HDV link flow and CV link flow, l_a is the link length (defined in the TNTN network file), v_a is the free flow speed on link a (can be derived by using the link length and link free-flow travel time defined in the TNTN network file), $\delta_{a,RSU}$ is the RSU indicator (1 when RSU exists on link a , otherwise 0), $\eta_C = 0.1$ is the cost reduction coefficient (information provided through connectivity can help smoothen vehicle movements), $Q_{a,H}$ is the link capacity for HDV-only traffic (defined in the TNTN trips file), and $Q_{a,C}$ is the link capacity for CV-only traffic. It is important to note that, in the current *link.py* file in the “Single-class STA” folder, we have considered the BPR function to calculate link costs. You need to consider the aforementioned link cost functions instead of BPR functions when you develop your own implementation or extend the provided single-class UESTA implementation for this multiclass STA problem. You can derive $Q_{a,C}$ from $Q_{a,H}$ using the following equation (Levin and Boyles, 2016):

$$Q_{a,C} = Q_{a,H} \left(\frac{v_a \Delta t_H + \ell}{v_a \Delta t_C + \ell} \right),$$

where the reaction time of CV is $\Delta t_C = 1$ sec, the reaction time of HDV is $\Delta t_H = 1.5$ sec, and the vehicle length $\ell = 15$ ft.

In Scenario 3, assume that the RSUs are installed on the following links: links from node 4 to node 11 and from node 10 to node 15.

E. Analysis Questions:

- (a) Provide a detailed list of changes you made to extend the single-class UESTA implementation to multiclass UESTA and SOSTA.
- (b) Compare the UE objective values and the corresponding total system costs across the three scenarios and interpret the results.
- (c) Compare the SO objective values across the three scenarios and interpret the results. Compare these values with the corresponding total system costs obtained under UESTA.
- (d) Perform sensitivity analysis (i.e., how UE and SO objective values change) by:
 - i. Varying the AV/CV/EV penetration rates
 - ii. Varying the number of AV-dedicated lanes/RSU links/EV-dedicated lanes
 - iii. Varying the technology-specific parameters
 - [1] For AV scenarios: change Δt_A value to 0.6 and 1 for different AV setting
 - [2] For CV scenarios: change η_C value to 0.05 and 0.15 for different information effectiveness
 - [3] For EV scenarios: change κ_E value to 0.3 and 0.05 for different energy consumption reduction

Reference:

Levin, M.W. and Boyles, S.D. (2016). "A multiclass cell transmission model for shared human and autonomous vehicle roads," *Transportation Research Part C: Emerging Technologies*, Vol. 62, pp. 103-116.