Vanderbilt University + College of Engineering
CS 3250 Algorithms, Spring 2025
Homework #3 (Stop-and-Go)
Sections 01/02/03/04

Honor Statement:
By submitting this homework under your personal Gradescope account, you attest that you have neither given nor received unauthorized aid concerning this homework. You further acknowledge the instructors are the copyright owners of this HW. Any posting/uploading of HW questions for distribution (e.g., GitHub, Chegg) will be considered an honor code violation (even after finishing this class) and submitted to the honor council.

HWS are 60% of your final grade. HW3 is worth 9%			
Component	**Due date**	**Details**	**Percent of final grade**
HW3 Stop: Brightspace Online Quiz	Wednesday, 2/12, 9:00 AM	Detailed instructions and link to the quiz can be found in Brightspace—HW3 Stop. **No** late homework accepted.	~3%
HW3 GO: Gradescope Submission with SlideDoc	Wednesday, 2/26, 9:00 AM	Upload to Gradescope Late homework rules apply.	~6%

Reminders:

- You must **type your answers** (or you lose 50% on the exercise). Each new exercise should begin on a new page (you can put multiple parts to the same exercises on the same page). Save your file as a PDF and upload the PDF document in an electronic format to Gradescope (https://www.gradescope.com/).

- When you submit your work to Gradescope, be sure to designate the corresponding page(s) of your submission for each question (or risk losing 5 points). See the following video at the 0:46 mark: https://www.gradescope.com/get_started#student-submission

SlideDoc Requirements:
Your SlideDoc must include, at a minimum:

- Title slide with your name(s) and the Letter and title of the problem you are solving
- Table of Contents; since you are turning in a PDF of your PPT, it won't be navigable as suggested by Duarte
- Section heads, as described by Duarte
- Section Signifiers as described by Duarte
- Text emphasis as described by Duarte (be sure to use at least once in your SlideDoc)

The sections of your SlideDoc must include the following:

- A description of the problem
- A description of your algorithm
- An example run of your algorithm
- I discourage novice algorists from submitting examples with their HW because a common error is to develop an algorithm that only works for a few examples. However, now that you are no longer a novice, you will use this example to describe your well-crafted algorithm to other readers.
- Run time analysis

Here are the HW3 Stop-and-Go Problems:
When you take the HW3-STOP Brightspace Multiple-Choice Quiz, you will be presented with 3 of the following 6 graph problems randomly. You are to choose the known algorithm you would use to best solve the given problem. As we have discussed in lecture, a known algorithm alone may not be enough to completely solve a graph problem. So, in terms of this quiz, you should make your choice by selecting the option that best reflects what you would use for the basis of your algorithm design.

Problem A: Rural Route Optimization in Nepal

In Nepal, a new public transportation system has been introduced to connect remote villages with larger towns. This system consists of minibuses traveling along predefined routes, stopping at various villages and key market hubs. Due to the hilly terrain and varying weather conditions, travel times between villages can differ significantly. Efficient travel routes can significantly impact villagers' economic opportunities and access to resources.

Your task is to help the local government optimize this transportation network by determining the quickest route for a villager to travel between any two locations. Each route has specific travel times between stops, and villagers may need to transfer between minibuses at shared stops to reach their destination. The goal is to minimize total travel time rather than physical distance. You may further assume that any transfer times between minibuses at shared stops are negligible due to efficient station design.

Consider the following scenario: A villager needs to travel from Kathmandu to Pokhara to sell goods at a market. The goal is to determine the combination of minibus rides that minimizes the total travel time, as delays could mean missing critical market hours.

Problem B: Safeguarding Jamaica's Suspension Bridges

In hurricane-prone Jamaica, bridges connecting villages and regions play a vital role in providing access to essential resources such as markets, schools, and healthcare facilities. With the hurricane season approaching and the devastation caused by Hurricane Beryl in 2024 still vivid, the government is taking proactive steps. To enhance disaster preparedness and ensure reliable supply chains during emergencies, the Jamaican government needs to determine which bridges are vital for connectivity. Specifically, you must identify critical bridges, defined as those whose removal would isolate certain regions or disrupt access to vital resources.

Your task is to analyze the network of bridges and paths to pinpoint these critical bridges. This analysis will help prioritize inspections, repairs, and strategic reinforcement of vital infrastructure, ensuring equitable access to resources, which can save lives and minimize disruptions for vulnerable communities during crises.

Problem C: Optimizing Fire Department Response in Panajachel

In the town of Panajachel, Guatemala, the volunteer fire company is working to improve its emergency response capabilities. The town is laid out in an nxm grid of intersections, where every block in the grid is equidistant from the next (see example below). At each intersection, there is a fire hydrant, and the fire company wishes to determine the quickest route to each hydrant from the fire station. This initiative highlights how computational algorithms can improve resource allocation and emergency response in underserved towns like Panajachel.

Example: Consider a 3x3 grid (numbered 1-9) of intersections, where the fire station is located at the top-left corner in location 1:

1 | 2 | 3
4 | 5 | 6
7 | 8 | 9.

The responders would like to calculate the optimal path to each fire hydrant via this grid layout. Since the grid represents two-way streets, responders can only travel left, right, up, or down, but not diagonally. For example, there are multiple optimal routes to get to the fire hydrant in grid 5. We can go 1 – 2 – 5, or 1 – 4 – 5. A non-optimal route would be 1- 2 - 3 - 6 - 5.

Problem D: Digital Connectivity for Rural Schools in Colombia

A global nonprofit organization has launched a new initiative to connect rural schools in mountainous regions of Colombia to a central internet hub. The goal is to establish a network that ensures all schools have internet access with minimal infrastructure cost. This requires laying fiber optic cables along existing pathways and roads between schools. If fiber were laid along every viable path, every school could communicate directly or indirectly with every other school. However, due to budget constraints, the organization must determine the minimal total length of cable required to connect all schools while ensuring no unnecessary redundancy in the network.

Efficient connectivity is critical for enhancing educational opportunities in these remote regions, enabling access to online resources and digital tools for both students and teachers.

Your task is to design an efficient algorithm to determine the minimal length of cable needed to achieve full connectivity between all schools.

Problem E: Lighting the Way Home

Prof. Dan’s daughter, Mia, a Criminology and Sociology major, often invites her friends over to watch True Crime Documentaries when she’s home from college. However, by the end of the night, all her friends are too afraid to walk home alone. As a concerned parent, Prof. Dan wants to help them find a safer and less scary way home, focusing less on the shortest path and more on maximizing the number of streetlights for their safety. He plans to provide each of Mia's friends with a map of the neighborhood highlighting the best road segments to use. The ideal set of road segments must meet two conditions:

1. It must ensure a connected path from every friend's house to every other, so no one is stranded or unable to get home.
2. The total number of streetlights on the highlighted segments should be maximized. In cases where two road segments lead to the same location and have an equal number of streetlights, the one with the shorter distance will be preferred.

Your task is to determine the safest and most well-lit route, ensuring connectivity while maximizing the total number of streetlights along the way.

Problem F: Music City Metro

Nashville is experiencing a decade of rapid growth and is developing a new rapid transit system to keep up with the rising demand for efficient public transportation. The proposed network features one-way routes connecting various stations across the city. Your task is to optimize this system for maximum efficiency and connectivity.

Suppose there are eleven stations in this network, labeled A through K. The network includes one-way lines like A → B, B → C, and so on, with certain stations (like I and K) being terminal stations. The goal is to identify the minimum number of stations that can remain closed while still allowing the remaining open stations to form a fully connected sub-network, where each open station is reachable from any other open station.

For example, if the smallest number of stations that can remain closed is 6, then the network of remaining open stations still retains full connectivity among those open stations. This analysis ensures Nashville's new rapid transit system is both comprehensive and efficient, providing seamless travel throughout the city.