# Lab: An Introduction to Mathematical Modeling

# *(Instructor Version)*

**Motivation:** Mathematical modeling is often a messy and iterative process. Usually a simple model is developed with clearly stated assumptions and then more complexity can be added into the model.

**Objectives:** Students will try to answer an ill-posed question by developing a mathematical model. Students will also become familiar with the process of mathematical modeling and learn how to communicate the answer using precise and mathematical language.

***Timeline:*** *Students should start this in class very early in the semester. You should allow 30-45 minutes for discussion and questions on the first day the activity is introduced. Student groups should then have at least a week to gather the information needed and prepare their presentations. Another class period should be reserved for student presentations.*

## When is using Uber or Lyft less expensive than owning a car?

In this assignment, your group will construct a mathematical model to answer the question above. This question is purposefully vague or, to use mathematical language, *ill-posed*. Ill-posed problems are typically what engineers and scientists deal with when solving problems in real life. With an ill-posed question, you must make certain assumptions.

**General modeling principles**

* It is usually easier to develop useful models by starting with a simplified version of a situation than with one that is closer to reality. The first model is rarely the final model.
* Pay attention to what you “want.” If you need a number, make up a value, but note what you did. That number may become a variable later.
* Be conscious of decisions/assumptions.
* Ask, “What if?” What would happen if (pick a number or assumption) changed?
* Ask, “What question are we trying to answer? How can I ‘measure’ that?”

1. Make sure that someone in your group has the Uber or Lyft app downloaded on a mobile device. If you don’t have either of the apps, you might want to download one yourself. Decide if your group is going to use Uber or Lyft as a comparison.

*As the instructor, you will want to familiarize yourself with the Uber and Lyft app. Make sure you know about the costs associated with each ridesharing service. For example, Lyft allows you to tip your driver in the app while Uber does not have an option for a tip. Students should recognize this and factor this into their model.*

1. With your group, discuss the question above. What assumptions do you need to make? What do you need to measure or estimate? What is the variable (or variables) in this problem? Decide on a timeframe. Should you compare a daily, weekly, monthly or yearly cost? Write down notes on your discussion. Make sure you write down all assumptions.

* *Students should discuss how they are going to determine the total cost of using Uber or Lyft.*
* *They will have to discuss a “typical day”.* 
  + *They should obviously include the cost of using a rideshare for their daily commute to school and/or work.*
  + *The group should decide where their person lives and use the app to estimate the cost. Students who have used the app before will hopefully recognize that in certain times of the day are more expensive than other times and build that into the cost of a typical day.*
* *Walk around during group discussions and ask thought provoking questions.*
  + *Should they include regular trips to the grocery store or other errands?*
  + *What about weekends?*
* *There is no right answer to this problem. Students should be graded based on how well they state their assumptions, the complexity of their model, and how well they communicate their answer. Please see the attached rubric for more details on grading.*

1. As a group, decide on a car that you will use for comparison and a typical day for the driver. Consider choosing a car that is similar to what someone in your group currently drives. What information will you need to gather? What costs are associated with owning and driving a car?

*Try to guide your students towards realizing the costs associated with owning a car other than a monthly payment. They should at least consider the cost of insurance, fuel, and maintenance. How are they going to estimate their fuel cost? Students may have more ideas for associated costs and that’s okay!*

1. Prepare a 5-minute presentation to answer the question. Be sure to include any information that will justify your mathematical argument. You may want to use charts or graphics to illustrate a point. You should clearly articulate your mathematical model, what assumptions you have made, and your final solution to the problem.

*Tell your students that they may want to start off with a very simple model: Only one trip per day - to and from work. They should make some assumption about weekends that is a simple solution. After this model is developed, groups should then see how they can improve their mathematical model by adding in more complexity. If groups start out too complex, they may get overwhelmed. You need to guide them to be able to first answer the question in some way and then they can decide if they want to their model more complex.*