MATH MODELING REFERENCE CARDS

DEFINING THE PROBLEM STATEMENT

WHAT IS MY GOAL?

Real-world problems can be broad and complex. It's important to refine the conceptual idea into a concise problem statement which will indicate exactly what the output of your model will be.

TIPS FOR MOVING FORWARD...

1. Defining the problem statement requires some research and brainstorming. The goal is to have a concise statement that explains what the model will predict.

2. When brainstorming, let the ideas flow freely. Stay positive and be open-minded. This part of the modeling process is about creativity, so it is important that there is no criticism about anyone's ideas or suggestions. What seems like a ridiculous approach may later seem innovative after given some more thought, so make note of everything!

3. Since modeling problems are often open-ended, there is an opportunity for creative problem solving and interpretation. In some cases, it is up to the modeler to define the outputs of the model and what key concepts will be quantified.

MAKING ASSUMPTIONS

WHAT IS MY GOAL?

Early in your work, it may seem that a problem is too complex to make any progress. That is why it is necessary to make assumptions to help simplify the problem and sharpen the focus. During this process you reduce the number of factors impacting your model, thereby deciding which factors are most important.

TIPS FOR MOVING FORWARD...

1. Clearly document the assumptions you're making. The assumptions tell the reader under what conditions the model is valid.
2. Many assumptions will follow quite naturally from the brainstorming process and the questions asked during that process.

DEFINING VARIABLES

WHAT IS MY GOAL?

What are the primary factors influencing the phenomenon you are trying to understand? Can you list those factors as quantifiable variables with specified units? You may need to distinguish between independent variables, dependent variables, and model parameters. In understanding these ideas better, you will be able to both define model inputs and to create mathematical relationships, which ultimately establish the model itself.

TIPS FOR MOVING FORWARD...

1. Now is the time to pause and ask what is important that you can measure. Identifying these notions as variables, with units and some sense of their range, is key to building the model.

2. The purpose of a model is to predict or quantify something of interest. We refer to these predictions as the outputs of the model.

3. Another term we use for outputs is *dependent variables*. We will also have *independent variables*, or inputs to the model. Some quantities in a model might be held constant, in which case they are referred to as *model parameters*.

GETTING A SOLUTION

WHAT IS MY GOAL?

What can you learn from your model? Does it answer the question you originally asked? Determining a solution may involve pencil and paper calculations, evaluating a function, running simulations or solving an equation, depending on the type of model you developed. It might be helpful to use software or some other computational technology.

TIPS FOR MOVING FORWARD...

1. Begin to use your model to generate preliminary answers to the problem.
2. Look into your personal tool kit for a mathematical technique to use (for example, calculus, differential equations, or graphing data).
3. Sometimes, if you start with the incorrect approach, a better approach will naturally emerge.

ANALYSIS & MODEL ASSESSMENT

WHAT IS MY GOAL?

In the end, one must step back and analyze the results to assess the quality of the model. What are the strengths and weaknesses of the model? Are there certain situations when the model doesn't work? How sensitive is the model if you alter the assumptions or change model parameter values? Is it possible to make (or at least point out) possible improvements?

TIPS FOR MOVING FORWARD...

1. Take a step back from your work. Does your answer make sense? Sometimes, the results may indicate a mistake in the calculations. Other times you may find that additional or alternate assumptions are needed for the solution to be realistic.

2. Once you have verified that your model is correct, it is time to step back and consider the validity of your model. This includes identifying the strengths and weaknesses of your model and understanding at a deeper level the behavior of the model. Performing a sensitivity analysis, wherein you analyze how changes in the input and parameters impact the output, can contribute to understanding the behavior of your model.

REPORTING THE RESULTS

WHAT IS MY GOAL?

Your model might be awesome, but no one will ever know unless you are able to explain how to use or implement it. You may be asked to provide unbiased results or to be an advocate for a particular stakeholder, so pay attention to your point of view. Include your results in a summary/ abstract at the beginning of your report.

TIPS FOR MOVING FORWARD...

1. You are the expert on the problem. It is your role to explain what you did in detail to people unfamiliar with your solution approach.
2. Your paper will likely be several pages long. Break it up into sections and consider assigning each section to a member of your team.
3. Remember you are not telling a story, you are describing your solution, so pay attention to your tone. It should be consistent throughout.
4. Finally, write your summary page, or "abstract." This goes at the beginning of your paper. Here you will summarize your results and describe how you solved the problem. Keep it short.