# Advice on Modeling

These are some steps that successful modelers often take, and questions that they ask themselves. You don't necessarily have to do all of these steps, or do them in order. Only do the parts that you think will help you make progress.

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|  | **Understand the Question**<br>Think about what the question means before you start making a strategy to answer it. Are there words you want to look up? Does the scenario make sense? Is there anything you want to get clearer on before you start? Ask your classmates or teacher if you need to. |
|  | **Refine the Question**<br>If necessary, rewrite the question you are trying to answer so that it is more specific. |
|  | **Estimate a Reasonable Answer**<br>If you don't have enough information to decide what's reasonable, try to come up with an answer that would be too low, and an answer that would be too high. |
|  | **Identify Unknowns**<br>• What are the meaningful quantities in this situation? Write them down.<br>• What information would be useful to know? In order to get that information, you could: look it up, take a measurement, or make an assumption. |
|  | **Gather Information**<br>Write down any of the unknown information that you find. As you work, organize your information in a way that makes sense to you. |

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|  | **Experiment!**<br>Try different ideas to make progress toward answering your question. If you are stuck, think about:<br>● Helpful ways to organize the information you have or organize your work<br>● Questions you *can* answer using the information you have<br>● Ways to represent mathematical relationships or sets of data (tables, equations, scatter plots, graphs, statistical plots)<br>● Tools that are available for representing mathematics, both digital and analog |
|  | **Check Your Reasoning**<br>Do you have a first answer to your question? Great! See if it's reasonable.<br>● Make sure you can explain what the answer means in terms of the original problem.<br>● Check your precision: Is your answer overly precise (do you really need all those decimal places)? Not precise enough (were you overly aggressive with your rounding)? |
|  | **Use and Improve Your Model**<br>● Did you make assumptions or measurements? How can you express your model more generally, so that it would work for a range of numbers instead of the specific numbers you used?<br>● What are the limitations of your model? That is, what are some ways it is not realistic? Does it only work for certain inputs but not others? Are there any meaningful inputs affecting the outcome that are not accounted for? If possible, improve your model to take these into account.<br>● What are the implications of your model? That is, what should people or organizations do differently or smarter as a result of what your model shows? What would be effective ways to communicate with them?<br>● What are the areas for further research? That is, what new things are you wondering about that could be investigated, by you or someone else? |

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| Skill | Score | | | Notes or Comments |
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| | Proficient | Developing | Needs Revisiting | |
| Decide What to Model | • Assumptions made are clearly identified and justified. Resulting limitations are stated when appropriate.<br>• Variables of interest are clearly identified and chosen wisely, and appropriate units of measure are used. | • Assumptions are noted but lacking in justification or difficult to find.<br>• Variables of interest are noted, but may lack justification, be difficult to find, or not be measured with appropriate units. | • No assumptions are stated.<br>• No variables are defined. | |
| | To improve at this skill, you could:<br>• Ask questions about the situation to understand it better<br>• Check the assumptions you're making to see if they're reasonable (Try asking a friend, or imagining that you're a person involved in the scenario. Would those assumptions make sense to you?)<br>• Double-check the variables you've identified: Are there other quantities in the situation that could vary? Is there something you've identified as a variable that is actually fixed or determined? (Remember that more abstract things like time and speed are also quantities.) | | | |
| Formulate a Mathematical Model | • An appropriate model is chosen and represented clearly.<br>• Diagrams, graphs, etc. are clear and appropriately labeled. | • Parts of the model are unclear, incomplete, or contain mistakes. | • No model is presented, or presentation contains significant errors. | |
| | To improve at this skill, you could:<br>• Check your model more carefully to make sure it really fits well<br>• Consider a wider variety of possible models, to find one that fits the situation better<br>• Think about the situation more deeply before trying to find a model<br>• Convince a skeptic: Pretend that you think your model is inadequate, or ask a friend to pretend to be skeptical of it. What would a skeptic find wrong with your model? Try to fix those things, or explain why they're not actually problems. | | | |

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| Skill | Score | | | Notes or Comments |
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| | Proficient | Developing | Needs Revisiting | |
| Use Your Model to Reach a Conclusion | • Solution is relevant to original problem.<br>• Reader can easily understand the reasoning leading to the solution.<br>• Relevant details are included like units of measure. | • Solution is not well-aligned to original problem, or aspects of the solution are difficult to understand or incomplete. | • No solution is provided. | |
| | To improve at this skill, you could:<br>• Double-check your calculations: Show them to someone else to see if they agree, or take a break and look at your calculations again later<br>• Make sure your calculations are justified by your model: Ask yourself how you decided what to calculate, and see if your reasoning matches up with your model<br>• Think more deeply about what your conclusions mean in the original scenario: Imagine you're a person involved in the scenario, or explain your conclusions to someone else and see if they have questions | | | |
| Refine and Share Your Model | • The model's implications are clearly stated.<br>• The limitations of the model and solution are addressed. | • The limitations of the model and solution are addressed but lacking in depth or ignoring key components. | • No interpretation of model and solution is provided. | |
| | To improve at this skill, you could:<br>• Think more creatively about what your conclusions mean: Ask yourself "If I was involved in this situation, what would I understand better because of these conclusions? What would I want to do next?"<br>• Be skeptical of your model: What don't you like about it, and what can you do to fix those things?<br>• Explain your model to someone else: Tell them how it works and why it's good. If you're not sure how it works or why it's good, you might need to change it. | | | |