Physics 230: Computational Physics Lab 1
Advice for Lab Experiences

After reading the Syllabus, you may still have questions on the best way to proceed with the Lab Experiences which form such an important part of this course. This document will help you understand and exercise best practices for learning computational physics.

In this class, we will not only practice solving computational physics problems, but we will work on developing "metacognitive" skills… thinking about how you think. *Improving your metacognitive skills may be the most important thing you do in this class*.

Metacognitive skills are often divided into three types: planning, monitoring, and evaluating that happen before, during, and after the problem solving experience. From studies of the growth-mindset and neuroplasticity, we know that effective metacognition is a skill that can be learned and developed and practiced. Effective metacognition is what separates experts from novices and explicitly focusing on metacognitive skills is a challenging but helpful shortcut to developing expertise.

Metacognition can be portrayed as *questions you ask yourself in the problem solving process*. These rhetorical questions get you thinking about your thinking. The goal is to understand yourself better and to use this understanding to set yourself up for success as well as identifying areas to improve now or in the future. You will find that the TAs often ask these types of questions as they guide you toward a solution. These are also great questions to ask a colleague who is stuck on a problem.

Mastering the *many* metacognitive strategies given below is a lifelong pursuit that goes beyond this one credit class. Your first goal should be merely to read through these and learn what metacognition questions are like. Think about which ones might be most valuable to you. You should plan to refer back to these often.

I will encourage you to use inspiration/revelation to identify at least 1 metacognitive strategy in Planning, Monitoring, and Evaluating that you will focus on during each Lab. You'll be reporting which strategies you used in an online assignment. This can be a single question from below, it could be the same most of the semester, or whatever you feel will help you become better.

Planning
- Do I understand how I approach problems? Do I do best when you work backwards? Do I like trying many different things until something works? Do I like to see someone else's example before trying to solve the problem? Do I like drawing pictures? Talking out loud to myself?
- In our hyperconnected world, it can be easy to get distracted. Will I be more successful if I turn off my phone? Does it help to listen to music? Where is an effective place for me to get into a great problem solving flow?
- Incubation is the process by which my (unconscious) mind works on a problem; simply reading through the problems as soon as possible means I will have greater success when I work on them later. How much time should I spend going over the Lab Experience tutorial before watching the Supportive Video? How much attention am I paying to the Supportive Video? How much time should I spend on the Lab Experience before even attending class?
  - A former students writes "if I started working on the lab [early], I always seemed to do better. So maybe try and read through [the Lab Experience tutorials] a little before class."

- How am I budgeting your time to work on this assignment? Have I given myself a reasonable amount of quality time to complete the work? Does it work for me to do the whole Lab during class or should I start earlier? How many sessions am I going to use to finish, keeping in mind that taking breaks will help?
- Am I physically prepared to work on this activity by caring for my body through healthy food, lots of water, enough sleep, good exercise, etc. Am I mentally prepared?
- Am I spiritually prepared to work on this activity? Alma 34:24 could be interpreted as meaning that I can pray for inspiration and revelation to help me with Lab Experiences.
- Am I motivated to learn this material? Why or why not? Do I understand its future value for me? Do I understand why the instructor felt like this would be a useful experience?
    - A former student writes, "*Mathematica* will be your best friend in the entire world if you take the time to pay attention in the labs."
- How deeply do I want to understand the material?
    - A former student writes, "Focus on understanding *Mathematica* thoroughly and don't simply try to get the assignments done."
- Am I prepared to begin the Lab Experience? Do I have the materials I need? Do I have a plan for how I will save and record my work?
    - A former student writes, "Do the lab assignments in the same notebook as the lab. It is easier and keeps things more organized."
- Am I going to complete this activity on time? Should I turn it in a little late and receive a small penalty? Should I ask Dr. Ragozzine for an extension?
- Am I going to try to get Extra Credit on this Lab Experience by using *Mathematica* to solve a physics problem from another class?

Monitoring
- Use positive self-talk to encourage myself, recognizing that I should approach a challenge with the goal to learn. Every student runs into problems they can't solve, spending more time on harder problems is a good sign of a growth-mindset.
- As I am working, monitor my mood. Am I hungry? Is now a good time to take a break? Should I reward yourself for completing the next part? Is it time for some spiritual self-care?
    - A former student writes, "Pay attention to the details and don't rush things. Rushing it makes it easier to make mistakes and get frustrated. If you work at a steady pace, you'll be less likely to make mistakes that will be hard to find later on."
- Should I take complete some of these Assignments at home or in another section? Will it be more challenging since I won't have support of classmates or TAs? Keeping in mind that the Lab Experiences build on one another, will this put me behind on the Lab Experiences?
    - Recall from the Syllabus that the full Lab Experience is due half-hour into the next week's session and that partial credit will be given for a Lab when only some of the assignments are completed. Half-credit can still be earned for another week.
    - Information for how to access *Mathematica* outside of class is given below.
- One aspect of these problems is translating from the physics problem to the determining what computation is necessary, do I clearly understand the problem? Would it help to rewrite it in my own words (actually written or spoken aloud)?
- Have I broken up the larger Assignment into more manageable steps? Have I thought about the exact details of what each step entails?

- What do I know about the answer even without detailed calculation? (That is, do I know what the plot is going to look like when it is done or do I know what whether the output should be large or small or negative or complex or whatever is appropriate for this particular assignment.)
- Will physics problem solving strategies help me to solve this problem? These strategies include knowing the meaning and units/dimensions of all the quantities, drawing a diagram, consider special/extreme cases, reading ahead to see the next Assignment, etc.
  - An extremely valuable resource for physics problem solving strategies is this free online chapter: http://www.people.fas.harvard.edu/~djmorin/ProblemsChap1.pdf
- A crucial aspect of the Lab Experience assignments is using the correct syntax (e.g., letters and symbols) to get *Mathematica* to perform the desired task. Did you read the tutorial carefully enough to learn the correct syntax? Would the *Mathematica* Help pages support you? Am I testing each component individually to make sure it is doing what I think it is? Am I trying to keep too many pieces in my head and would benefit from writing things down?
- Am I keeping track of my progress and things I want to learn by taking notes? Am I storing these notes in my *Mathematica* notebook as comments or on separate paper notes?
- Am I enjoying the benefits of best practices in scientific computing by using good variable names and code comments? For more advanced problems, am I testing my code on a simple example or test case so that I can ensure that I'm getting the right answer?
- Am I saving my notebook **regularly** to avoid duplicating effort?
- What do I do when I get stuck? How will I know when I am stuck and should take a step back? Should I try a different strategy? Taking a break is often helpful when really stuck; is that a good strategy to use now? **Should I go back and study the metacognitive questions in this *Advice for Lab Experiences*?**
- Should I reach out to a classmate or TA? (Recall that Collaboration is encouraged once you have put in effort yourself to solve the question.) How will I know that I am at a point where help would be beneficial both for this particular Assignment and for my long-term skill development? Former students had lots of advice on this:
  - Don't be afraid to ask others for help. Some of the stuff is tough, and if you try to do it all on your own, you will struggle.
  - Go to class and get help from the TAs.
  - Talk to your neighbors if you get stuck.
  - Make a friend to work with on the labs.
  - All it took for me to stretch past what I thought was my limit, was accepting help from someone else rather than trying to do it all on my own.
- When I am giving help to others, do I focus on giving advice and metacognitive questions so that my friend can learn through experience?
- Is the way that I collaborate with others consistent with the instructions in the Syllabus to maintain academic honesty and intellectual integrity?
- How do I "debug" my assignments? Do I follow the metacognitive processes described in this document? Have I tried clearing the kernel, checked the *Mathematica* Help, and double-checked every piece of syntax (e.g., not mixing up brackets, braces, commas, or semi-colons)? Should I try to solve the problem a different way? What are my options for proceeding and how will I decide which one is best? Did I make any mistakes and how will I fix them? When is a good time to show my Assignments to the TAs to get credit?
  - Note that waiting until the end to show all the Assignments can lead to a bottleneck where everyone waits for the TAs. Instead check off Assignments as you go, perhaps a few at a time.

Evaluating
- For each Assignment, did I Answer Exactly What Is Asked (AEWIA)? Did I address every subpart? Does my answer make sense and seem reasonable? Do I think I'll get full credit?
- How am I keeping this file for future reference? (Recall that Affirming Growth Showcases are open-notes and you will want your completed Lab Experiences as a primary resource.) How am I keeping these files organized, including multiple versions of multiple files?
  - You can save files on the computers in the computer lab, but they will remain on that specific machine. So you might consider uploading them, emailing them to yourself, or using a flash drive to download them from the Lab computers.
- What have I learned about myself during this Lab Experience that will influence how I approach the next one? Do I need to budget more time? Reach out to a TA? Spend more time in metacognitive planning?

Accessing *Mathematica*

Mathematica is available on department computers. Department computer accounts are tied to university accounts (see http://www.physics.byu.edu/computersupport/accounts for more details). The primary department computer labs and study rooms are in N212 and N337 ESC, but many other computers on campus have *Mathematica*. The door code(s) for these rooms are given online after you update your research advisor status at http://www.physics.byu.edu/undergraduate/Advisors then go to the Study Rooms link (https://www.physics.byu.edu/undergraduate/doorcodes) to see the code(s). Please do not prop the room doors open or write the code down for others to see. **You may download *Mathematica* at no charge from http://software.byu.edu and install it on your personal computer.** Although this is only free while you are a student, you will probably find *Mathematica* useful in a variety of classes and having your own personal copy is very convenient. Alternatively, you may access it via the department Remote Desktop server by following the instructions at http://www.physics.byu.edu/computersupport/remote. Note that it is not essential to have/use the same version of *Mathematica* as in the computer labs; it has been similar for many years.