Section IV: Problem Solving and Grading

Problem solving and homework grading is an important aspects of being a Teaching Assistant. The TA is no longer just working homework problems for himself/herself and his/her instructor, but the TA is now working problems for approximately 30 students per teaching section. This should completely change how the TA looks at his or her problem-solving skills and problem-solving process. The TA will also want to consider how he or she is going to grade 30 or more copies of the same homework assignment.

Problem Solving

Before we can discuss how to grade homework assignments, we need to address the question: "What is problem solving"? Problem solving is the process of using a set of learned skills and facts to transform a statement or situation into a final goal defined by the problem statement. This process is usually subject to a set of constraints.

The first step in the problem solving process is to recognize a problem statement. A good problem statement has three distinct characteristics, the given constants, a goal, and a list of obstacles, (Woods, 1987). The given is any information needed to fully describe the situation so that the reader can draw a physical and/or mental picture plus any constant needed to solve the problem. The goal is the desired or terminal state for the problem. In other words, it is the desired answer in a numeric, algebraic, or sentence form. The obstacles are steps that might be required to reach the goal, such as assumptions, derivations, solving for missing information, etc.

There are three components to the problem solving process: the thinking component, the strategy, and the attitudinal component, (Mayer, 1983). The thinking component encompasses thought processes such as identification, clarification, evaluation, analysis, etc. The strategy is a well-developed and well-organized set of steps that will help you achieve the goal when implemented. The attitudinal components are the feelings or behaviors that arise while solving the problem such as frustration, success, failure, elation, confusion, etc.

When solving problems it is easy to mix up general skills with strategies, (Woods, PRS Program Unit 2). A strategy often involves a skill but is not strictly limited to just skills. Skills are generally defined as the laws, concepts, and truths that you are introduced to during a lecture or in a lab setting. An example of a skill is long division. A strategy is a list of instructions and behaviors, in a certain order, that must be followed in order to arrive at the goal. If the strategy is not followed precisely then the incorrect goal is often achieved. An example of a strategy is the steps necessary to start a car. Most people do not need to understand the laws of physics involved in how an internal combustion engine works, they only need to be able to follow a strategy, the set of instructions that will cause the internal combustion engine to start.

When solving a problem a student will often go through a couple of different thought processes. Two such thought processes are inductive reasoning and deductive reasoning. Inductive reasoning

is a situation in which the problem solver must leap to a general rule given a series of examples or facts. Deductive reasoning is when the problem solver follows a series of logical thoughts to arrive at an answer. Deductive reasoning is usually the most-used reasoning process when working homework assignments, and inductive reasoning is most likely to be found in the lab.

Knowing how the students feel about all aspects of the course is important to helping you develop the learning environment. However, most course instructors are often not aware of the attitudes of their students. This is because we do not ask the students for attitudinal feedback except at the end of the semester in the form of an instructor evaluation. If the TA was aware that over 60% of his or her students were not grasping a new skill introduced in lecture because they could not read the instructor's handwriting, the TA might better understand why the students scored poorly on a recent homework assignment.

The TA can easily gather the necessary information on the attitudes of the students through a simple mid-semester survey. An example survey is provided.

Student Survey

Please answer the following questions concerning the teaching method and style of your TA. Your TA will be reading your responses. Please be honest so that your TA can make changes to his or her teaching method and style.

1. Can you understand your instructor's spoken English?
2. Does your instructor write so that you can easily read what has been written? If not why?
3. Does your instructor have any habits that interfere with your learning?
4. Does the instructor cover the material fully?
5. Does the instructor leave adequate time for the students to ask questions?
6. Is the instructor in his office during office hours?

This is just an example of the types of questions the TA could include in the survey. There are many resources available to TAs to help them improve as an instructor. Two such organizations on campus are The Teaching and Faculty Support Center and The Graduate School.

It is important to get the approval of the course instructor before giving a survey. The TA will also want to limit the survey to only the things that he or she can change. Such as, the time quizzes are given during the lab period, the length of lab reports, the way you present problem solutions on the chalkboard in the class, your office hours, etc.
It is important that the TA realizes that he or she is now expected to be an expert problem solver by the students. The TA will be expected to solve problems correctly on a chalkboard while thirty students sit and stare at him or her. This is not always an easy task, no matter the amount of experience the TA has gained as an undergraduate. In order to help the TA in this task, we must look at what the TA has become, an expert problem solver.

An expert problem solver is fully aware of the problem solving process, (The Complete Problem Solver). A person who carefully considers his or her strategy, stage by stage, and is aware of his or her attitudes toward the process, all of the things a novice problem solver does not do.

The following chart compares some of the characteristics of a novice problem solver and of an expert problem solver, (MacMaster, 1984).

NOVICE	EXPERT
▪ Emphasis on speed ▪ Unaware of mental process ▪ Mixes stages of the problem solving process ▪ Jumps into the problem ▪ Bases decisions on past experience without considering new facts ▪ Limits self to one solution ▪ Makes decision without measurable criterion	▪ Takes time ▪ Aware of process ▪ Considers the problem stage by stage ▪ Identify the problem and identifies all needed information ▪ Identifies the goal ▪ Identifies and selects the best method possible ▪ Establishes measurable criterion

The expert problem solver and novice problem solver are completely different in their processes. The list of actions carried out the by the expert problem solver are the actions and attitudes that we desire for the students to exhibit. However, since TAs are teaching introductory physics classes and/or labs, you cannot expect the students to show all of these behaviors and actions. It takes time, reinforcement, and encouragement to help the students make these changes.

Most TAs will not get a chance to require the students to solve their homework problems following a set format. So it is important that TAs set a good example of an expert problem solver by solving all problems that they present in class by following a format. The following is a suggested format.

- Draw a "good" diagram
- Define all variables used in the problem
- Show all steps to your solution listing the physical laws and concepts used, such as Newton's Second Law
- Box the answer so that the students can find it on the board.
- Be organized, do not jump around on the board.

Problem solving skills are an important tool in today's workplace. Many of the students are engineering majors who will someday be asked by their employer to solve complex problems on a daily basis. Some of the students may seldom use physics so the problem-solving skills taught by the TA will be the most beneficial thing they take with them. It is the TA's responsibility so see to it that as educators we help students develop strong problem-solving skills in the lab, skills that can also be applied to other situations.

The format presented in this handbook is only one of many formats for solving problems. For other formats see appendix F.

Making Mistakes and Using Them as a Learning Tool

TAs are not perfect and they make mistakes working problems at the chalkboard or when verbally answering a student's question. Acknowledge that you made a mistake and fix it right away; do not put it off. The TA may even be able to use the mistake as a teaching tool. For example if the TA improperly applied a physical law, explain how a students could easily have made the same mistake and why the mistake was made. The students will appreciate the fact that even TAs make mistakes sometimes.

Grading Problems

TAs are not only required to teach but also to GRADE. Grading is often the most dreaded part of teaching and is often the part of the course that the students complain about the most. But it is possible to make grading less painful if the TA develops a fair and consistent method for grading both homework assignments and lab reports.

To be consistent and fair all the time takes lots of practice. When grading homework it is important that the TA is familiar with the problem beforehand. This means that the TA will want to work the solutions to the homework assignments in advance. The TA will then be able to use his or her solutions as a key for grading.

When sitting down to grade the TA needs to have a plan. A plan will cut down on the amount of time that is spent grading. The plan should address the following questions: How many points are assigned for each problem? Is there more than one part to each problem? Are you grading for math or physics concepts? How you are going to handle the one person who solves the problem differently?

All of these questions should be kept in mind when the TA is making up the grading "key." A key should be a clearly written copy of the solution. Next to each problem to be graded write the point values assigned. Then circle the piece(s) of the solution to which points have been assigned and write next to it the amount that it is worth. For example, if a problem is worth 5 points and requires the student to show a diagram with axes labeled properly, make the diagram worth 2 of the 5 points possible.

Stick to the key but be prepared to deal with the one student who solves the problem differently from the others. It is possible that there is only one-way to solve it or that the problem statement required the student to use a certain method. If this is not the case, The TA will need to take some time to decide how to distribute the points. This information should also be recorded on the key, in case the TA runs into a similar solution, so he or she can justify the score.

When grading homework problems that ask for a quantitative answer the TA will find that students tend to make several different types of common mistakes. Some of these common mistakes are conceptual, mathematical, and/or a misunderstanding of the problem statement.

Many of these problems arise because the students have not developed a good set of problem solving skills. One of the most common errors the students make in their problem solving process is not drawing a "good" diagram. A "good" diagram is one in which all of the forces present are drawn and labeled, all of the givens in the problem statement are labeled, and all vectors are drawn to proper scale. It is important to model this behavior for your students in your own solutions.

Using the Chalkboard:

One thing that the TA will need to be aware of when using the chalkboard is that space is limited. The TA will need to practice presenting problems on the board so that he or she develops a method that will allow them to fully use the board. If a TA presents a problem solution in a clear and precise manner with well thought out reasoning, then the students will start to emulate the TA's methods. See appendix G for an example-grading key.

Grading Lab Reports

Writing lab reports is probably the most hated assignment you can give a student because of the time required. The TA should be prepared to spend a fair amount of time grading lab reports.

Many students do not realize how important it is to develop good written communication skills. Writing lab reports is a good way to build these skills. Many of the students will spend a good deal of their professional careers writing reports as part of their job.

There are many common mistakes and difficulties that students encounter when writing a lab report. The TA needs to keep track of these types of problems that occur frequently so that he or she can deal with them. The following list contains only some of the common mistakes and difficulties that students face.

- Misunderstanding the purpose of the laboratory experiment.
- Incomplete theory section
- Not fully understanding the procedure used to obtain the results
- Confusion about data analysis
- Misunderstanding about the results they are trying to obtain
- Not including reasons for error in data
- Lack of graphing skills and simple math skills
- Lacking full understanding about the physical concepts involved in the experiment

To help prepare students to write good lab reports it is important that the students fully understand what is expected of them. It is important that the TA is familiar with the guidelines set for the students when they are writing their lab reports. The TA will need these guidelines when he or she starts to grade. If the course instructor does not provide a set of guidelines, then the TA will need to develop a set of guidelines for the students. Be sure to include the guidelines in the course

syllabus. It is important that the TA and the students are 100% aware of what is expected of them when writing lab reports.

Grading thirty or more lab reports takes time; there is no way around it. The TA will need to develop a "key" for grading, similar to the key developed for grading homework problems. A key will not only cut down on the amount of time the TA spends grading but will help the TA grade consistently.

In order to develop a key, the TA will need to be familiar with each of the labs. Most TAs are only asked to grade lab reports if they instruct a lab section. If a TA is a grader for a lab section and he or she is not instructing the lab then the TA will want to ask the lab instructor to either provide a grading key or ask them to help develop a key.

Using the outline provided for the students in the course syllabus, start filling in the missing items on the outline. An example of this would be:

> **Purpose:** The purpose of this lab is to show that momentum is conserved even when energy is lost in a collision.

Do this for every part of the outline being sure to include every chart, graph, or plot required. Next assign point values to each section of the outline. [Similar to developing the key for grading homework problems, circle the parts, that you have filled in on the outline, that you are going to be grading and assign them point values.] The TA may not wish to assign the procedure part of the experiment too many points because the procedure is often written out in detail in the undergraduate lab manual. See appendix F for an example of a lab report-grading key.

The grading key is something that the TAs might want to develop as a group. Developing the key with other TAs in the course will help all of the TAs to grade fairly and consistently.

TA Activities for Section IV

TA Activity V – Writing "Good" Problems – The purpose of this assignment is to give you a chance to practice writing "good" problems. You will write three problems related to the course that you are assigned to instruct. Once you have written your problems you will gather in-groups of three and evaluate your problems using the characteristics of a good problem. You will then choose one problem to present to the other groups.