Habits of an Effective Problem Solver - http://www.physicsclassroom.com/calcpad/habits

One of the instructional goals of the honors physics is to assist students in becoming better and more confident problem-solvers. If all students who are good problem-solvers could be observed doing problems, then one would not necessarily observe that they use the same approaches to solving problems. Most good problem-solvers have unique little practices, which make them different from other good problem-solvers. Nonetheless, there are several habits, which they all share in common. While a good problem-solver may not religiously adhere to these habitual practices, they become more reliant upon them as the problems become more difficult.

The list below describes some of the habits which good problem-solvers share in common. The list is NOT an exhaustive list; it simply includes some commonly observed habits which good problem-solvers practice. Anyone can be a good problem-solver; because of personality and learning style differences, some will certainly be better than others. Nonetheless, anyone who puts effort into disciplining them selves to be successful at solving problems can learn how to be proficient at the task. A student who devotes some time and attention to the list below and makes an effort to personalize it into their own approach to problems will improve their problem-solving ability. The use of these problem-solving practices which they promote will not only assist you in completing your problem sets but will also make you a better and more confident problem-solver.

Reading and Visualizing

All good problem-solvers will read a problem carefully and make an effort to visualize the physical situation. Physics problems begin as word problems and terminate as mathematical exercises. Before the mathematics portion of a problem begins, a student must translate the written information into mathematical variables. Many errors (and perhaps even most) can be traced back to this translation process. These errors are usually the result of a failure to visualize the physical situation described in the verbal statement of the problem or of a failure in missing some strategic information during the reading process. A good problem-solver will often construct a diagram of some form to assist in this critical visualization task. The actual diagram will depend upon the topic, which the problem pertains to. If the topic pertains to forces, a force diagram might be drawn. If the problem pertains to mirrors, a ray diagram or object-image diagram may be drawn. And if the problem pertains to vector addition, a vector addition diagram may be drawn. But regardless of the topic, a good problem-solver typically begins the translation of the written words into mathematical variables by an informative sketch or diagram, which depicts the situation.

Organization of Known and Unknown Information

As mentioned earlier, physics problems begin as word problems and terminate as mathematical exercises. During the algebraic/mathematical part of the problem, the student must make substitution of known numerical information into a mathematical formula (and hopefully into the correct formula). The mathematical formula is written in the form of symbols, which represent some physical quantity such as focal length, distance, acceleration or force. Before performing such substitutions, the student must first equate the numerical information contained in the verbal statement with the appropriate physical quantity. It is the habit of a good problem-solver to carefully read the verbal statement and to combine the attention to units (meters, kilograms, Joules, etc.) with their understanding of the meaning of physical quantities in order to accurately extract the numerical information and equate it with the appropriate symbol. Furthermore, good problem-solvers will conduct this task by writing down the quantitative information with its unit and symbol in an organized fashion, often recording the values on their diagram. This task will also include observing strategic and meaningful phrases such as "a magnified and virtual image", "a diverging lens", "starting from rest", "with a constant velocity", and "in the absence of air resistance." While such phrases do not explicitly provide numerical information, they do go a long way towards offering information, which implies a particular solution strategy. In addition to identifying the known information, good problem-solvers also practice the habit of identifying the quantity to be solved for, recording it in terms of its appropriate symbol.

Plotting a Strategy for Solving for the Unknown

Once the physical situation has been visualized and diagrammed and the numerical information has been extracted from the verbal statement, the strategy plotting stage begins. During this stage of a problem, the student ponders the question: "How can I use the known information - both explicit and implied - to determine the unknown quantity?" More than any other stage during the problem solution, it is during this stage that a student must think critically and apply their physics knowledge.

Difficult problems in physics are multistep problems. The path from known information to the unknown quantity is often not immediately obvious. The problem becomes like a jigsaw puzzle; the assembly of all the pieces into the whole can only occur after careful inspection, thought, analysis, and perhaps some wrong turns. In such cases, the time taken to plot out a strategy will pay huge dividends, preventing the loss of several frustrating minutes of impulsive attempts at solving the problem. Good problem solvers use their background knowledge of physics and physics formulae to think about how the known information is related to each other and how it is related to the final unknown quantity. They know through practice and through observation of other expert problem-solvers (such as their teacher) that there are likely some intermediate unknown quantities, which will have to be calculated before finding the final unknown quantity. By comparing the known information (which they have previously written down in an organized manner) to known mathematical formulae, they are able to determine the intermediate quantities, which will allow them to subsequently determine the final quantity. They record their thoughts as they think through possible steps for solving the problem; they often sketch a schematic plan that depicts how to put the individual pieces together to solve the problem as a whole.

Often times, difficulties arising in the strategy-plotting phase of a problem solution is the result of the lack of knowledge about the topic. A good problem-solver understands that if they know very little about the topic, there is no sense in attempting the problem. Rather than waste valuable time trying, they spend their time learning about the topic, looking for relevant mathematical formulae and studying pertinent concepts and principles. Good problem-solvers are resourceful enough to know where to look to find the formulae and other information, which they need to know to solve the problem. They may look in their notes from class, in their instructional packets, in their textbooks or at online resources. Once a good problem-solver has filled their minds with information, they return to the problem to apply their new physics knowledge, asking once more "How can I use the known information - both explicit and implied - to determine the unknown quantity?"

Even with suitable understanding of the physics behind a problem, a student can still get stuck and become in need of help. Good problem-solvers are not typically caught off guard by such sticking points; they understand them to be natural to any strategy plotting process. In such instances, good problem-solvers will often take the time to look at previously done problems which are similar or identical to the one that they are trying to solve. They will compare the current problem to previous ones in terms of known and unknown quantities and observe the solution process to these similar problems, pondering if a similar strategy could be used. They may look at previous problems, which they have done, sample problems from the textbook or from online resources, or problems done in class. Because they have taken careful notes from class and organized their own solutions to problems, good problem-solvers benefit tremendously from such comparisons. Often times, the current problem can use the same solution as a previous one. Often times, the mere practice of looking through previous solutions triggers a thought about how one can proceed with the current solution. Considerable learning occurs during this comparison process, which allows a good problem-solver to not only solve the current problem but also internalize the mathematical relationships between quantities in physics. This effort makes good problem-solvers into even better problem-solvers, confident to approach any problem that subsequently arises.

Identification of Appropriate Formula(e)

Once a strategy has been plotted for solving a problem, a good problem-solver will list appropriate mathematical formulae on their paper. They may take the time to rearrange the formulae such that the unknown quantity appears by itself on the left side of the equation. They will take the time to inspect the units in which the given information was stated and make conversions to standard metric units if necessary. The process of identifying formula is simply the natural outcome of an effective strategy-plotting phase.

Algebraic Manipulations and Operations

Finally the mathematics begins, but only after the all-important thinking and physics has occurred. In the final step of the solution process, known information is substituted into the identified formulae in order to solve for the unknown quantity. Following the carefully plotted strategy, the good problem-solver takes the time to manipulate the equations and solve for the unknown. They record strategic algebra steps on paper in the event that their answer is wrong. If wrong, they can quickly inspect their algebra to determine if the error occurred during the mathematical phase of the problem or during the planning/thought/physics stage of the problem.

It should be observed in the above description of the habits of a good problem-solver that the majority of work on a problem is done prior to the actual mathematical operations are performed. Physics problems are more than exercises in mathematical manipulation of numerical data. Physics problems require careful reading, good visualization skills, some background physics knowledge, analytical thought and inspection and a lot of strategy-plotting.