Describing Motion with Equations

Read from **Lesson 6** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L6a.html
http://www.physicsclassroom.com/Class/1DKin/U1L6b.html
http://www.physicsclassroom.com/Class/1DKin/U1L6d.html

MOP Connection: None

Motion can be described using words, diagrams, numerical information, equations, and graphs. Describing motion with equations involves using the three simple equations for average speed, average velocity, and average acceleration and the more complicated equations known as kinematic equations.

Definitional Equations:

$$\textbf{Average Speed} = \frac{\textbf{distance traveled}}{\textbf{time}} \qquad \textbf{Average Velocity} = \frac{\textbf{displacement}}{\textbf{time}}$$

$$\textbf{Acceleration} = \frac{\textbf{change in velocity}}{\textbf{change in time}}$$

Kinematic Equations:

You should be able to use the following kinematic equations to solve problems. These equations appropriately apply to the motion of objects traveling with a constant acceleration.

$$v_f = v_i + a\,t \qquad d = \frac{v_i + v_f}{2}\,t \qquad d = v_i\,t + \frac{1}{2}\,a\,t^2 \qquad v_f^2 = v_i^2 + 2\,a\,d$$

A Note on Problem Solving

A common instructional goal of a physics course is to assist students in becoming better and more confident problem-solvers. Not all good and confident problem-solvers use the same approaches to solving problems. 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.

Habit #1 - 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. 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.

Habit #2 - Organization of Known and Unknown Information
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). 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 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.

Habit #3 - 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. 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 multi-step 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.

Habit #4 - 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. The process of identifying formula is simply the natural outcome of an effective strategy-plotting phase.

Habit #5 - 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.

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 performance of actual mathematical operations. 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. Even the best algebra students in the course will have difficulty solving physics problems if they lack the habits of a good problem-solver.