# Grading Procedure

1. Look at the solution to the problem. Does the solution involve the application of more than one major principle (e.g., forces and kinematics, energy and kinematics)? If yes, decide how many points should be awarded for each approach. (Note: The answer may depend on when the problem is given -- quiz or final).

2. For *each* major approach needed for a solution: Decide how you will divide the points between Physics Approach and Logical Execution (mathematics) based on the answer to the question: Does the problem solution involve mathematics that is difficult for the students (e.g., quadratics, simultaneous equations, difficult integral, etc.)?

   If the answer is no (e.g., the Enterprise problem), then you may want to assign most of the points (80% - 90%) to the Physics Approach. If the answer is yes (e.g., the Modified Atwood Machine problem), then you may want to assign fewer points to the physics (60 - 70%) and more points to the logical execution.

3. Start with 30 - 40 solutions. Spend about 30 - 40 minutes sorting the solutions into 4 - 6 stacks, using the criteria below (see also the Grading Flow Chart). Then go through your piles briefly, make a list of the types of physics approaches you found, and decide on the number of points you will assign to each approach. (Some people like to rank order the approaches from best to worst and then assign points, while other people like to decide how many points to subtract for each type of error.)

   **Criteria:**

   A. Communicates reasoning?

      Can you tell how students got their answer? If yes, then go on. If no, then student gets zero (0) points.

   B. Physics Approach (60% - 90%): Look at the combination of student's diagrams, general equation(s), and specific equation(s). Do **not** look at execution or numerical answers. Keep a list of the types of approaches you find, and how many points you decide to assign each approach.

      i. Correct Approach: 60% - 90%

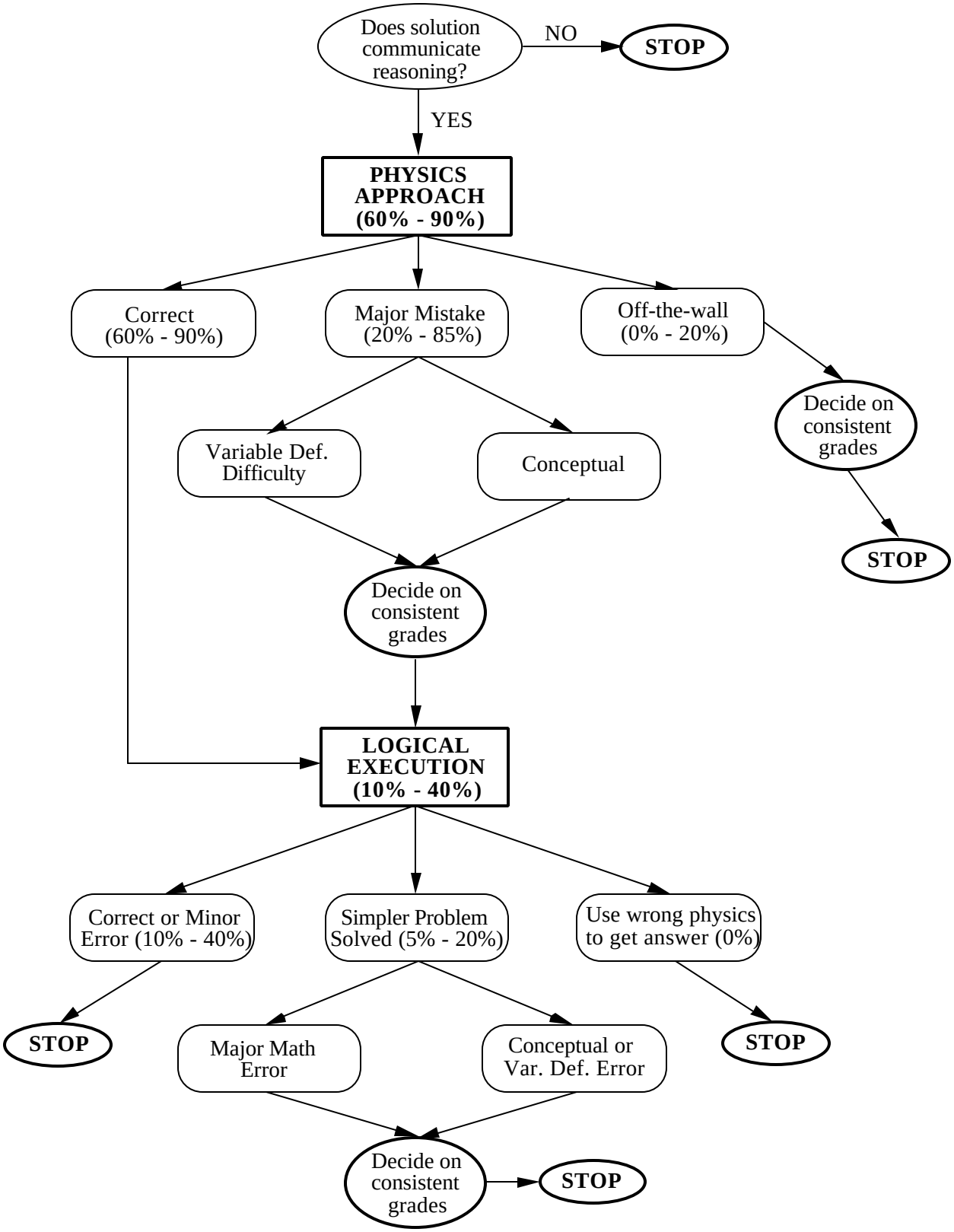
      ii. Major mistake of some kind: There are two kinds of mistakes, variable definition and conceptual mistakes.

         Variable definition errors are translation errors from diagrams (qualitative analysis) to equations:

         - sign errors (signs of variables inconsistent with defined or inferred coordinate axes)

- symbol errors (use same symbol for two different variables, for example "m" for both $m_1$ and $m_2$)
- component (trigonometry) errors (sines and cosines confused, etc.)
- carelessness in writing terms (e.g., forget to include a force in equations that was clearly shown on the diagram, etc.)

# GRADING FLOW CHART



Conceptual mistakes can take many forms -- omitting important physics (e.g., initial or final velocity, important force or energy term, etc.), wrong directions for vectors, etc.

Decide how many points to assign each type of approach you find. Be sure to keep a brief list, so you can add to it later, and remain consistent.

iii. Off-the-wall Approaches: Student takes a totally wrong approach. For example, student assumes a constant velocity for free fall. Or student states that the unknown force (tension, normal, friction) is the sum of all the known forces, and so on.

Depending on whether students show some understanding of the physics (e.g., a correct or nearly correct force diagram, a few energy terms correct), decide on some maximum amount of points to give. You probably will give no more than 20% for such solutions. Most weird solutions will get zero (0) points. Add to your brief list.

4. Now start grading these solutions, one pile at a time. As you grade, look for the logical execution errors listed below (see also Grading Flow Chart). Add to your brief list.

Logical Execution (10% - 40%): How did the student execute the approach?

A. Correct or Minor Error (10% - 40%): Minor math errors include a dropped sign late in the execution, or a calculator error.

B. Simpler Problem Solved (5% - 20%): There are two kinds of errors that result in the students solving a much *simpler problem than intended*:

Math Error: This includes any algebra or calculus mistake that greatly simplifies the problem, such as dropping a square so the quadratic equation does not have to be solved, or not knowing how to take a critical integral, etc.

Conceptual or Variable Definition Error: Some conceptual errors, such as the omission of certain forces, result in a much simpler problem solution (e.g., no simultaneous equations). Similarly, if a student uses "m" for both $m_1$ and $m_2$ in some force problems, s/he ends up solving simple equations rather than simultaneous equations.

Decide how many points to assign for each kind of execution error you find. Students who make a serious mathematical error trying to solve simultaneous equations or a difficult integral should get a higher score than the students who solve a different, simpler problem.

C. Use wrong physics to get an answer (0%). This includes setting a variable to a constant or to zero to get an answer, or doing some other weird physics. This mistake is seen a lot when students have to solve simultaneous equations. These students should get zero (0) points for logical execution. That is, they should receive no more points than a student who had the same physics approach, then quit (or said honestly that they did not know how to solve the equation(s) or take the integral).

Continue to grade the rest of the solutions. You will find new physics approaches and combinations of errors you did not see in your original sort. As you encounter these, check your list and decide on a

reasonable number of points to assign compared to the other approaches/errors on your list. Be sure to add to your list, so you can remain consistent.