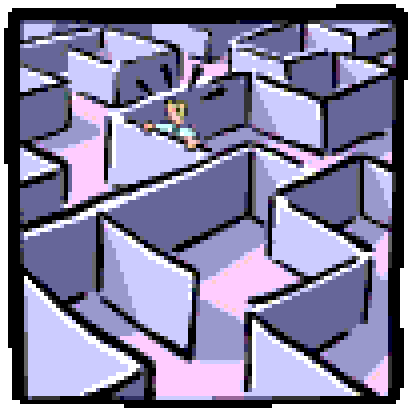
Solving Problems with Methods Questions

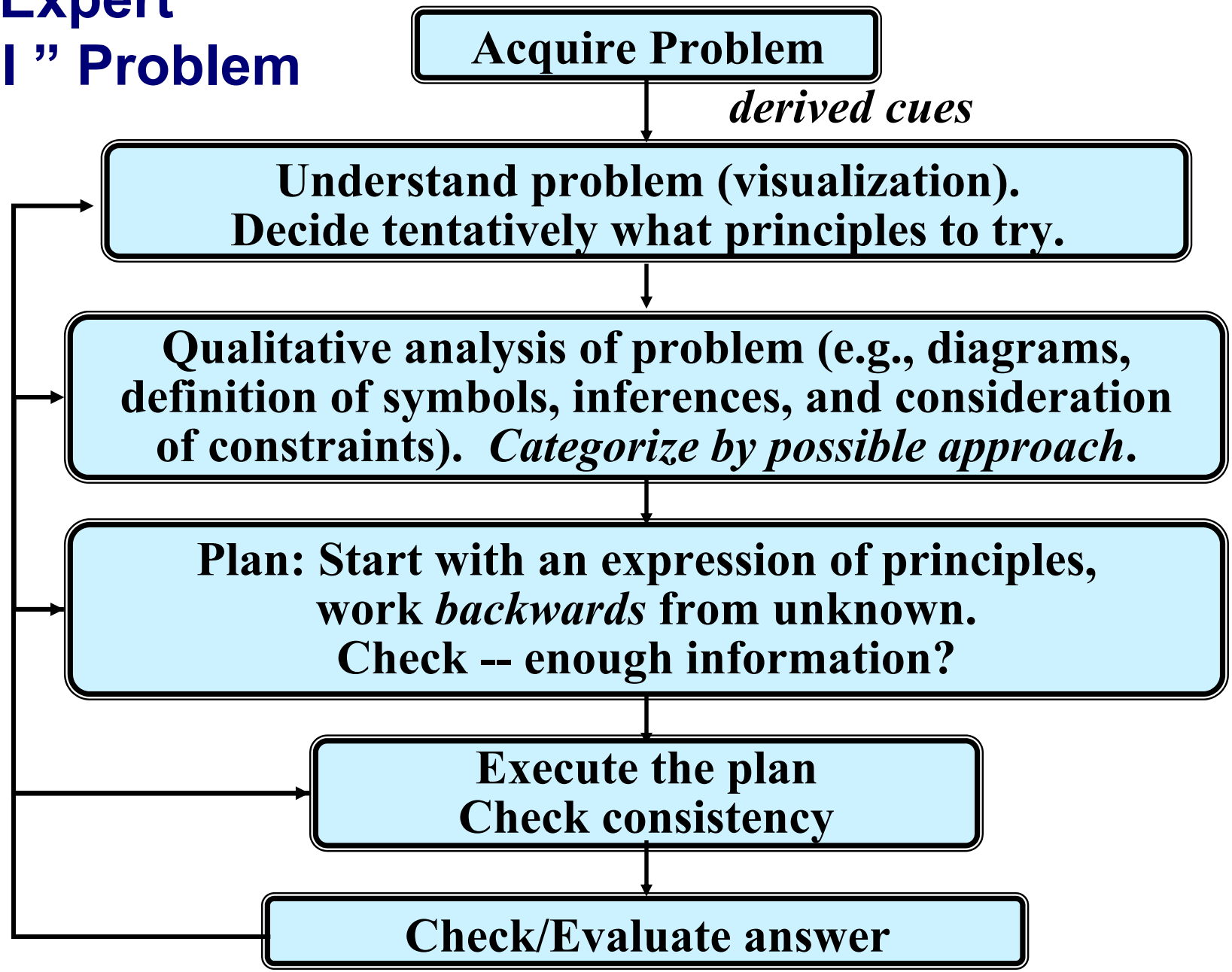
Problem solving is a process similar to working your way through a maze.



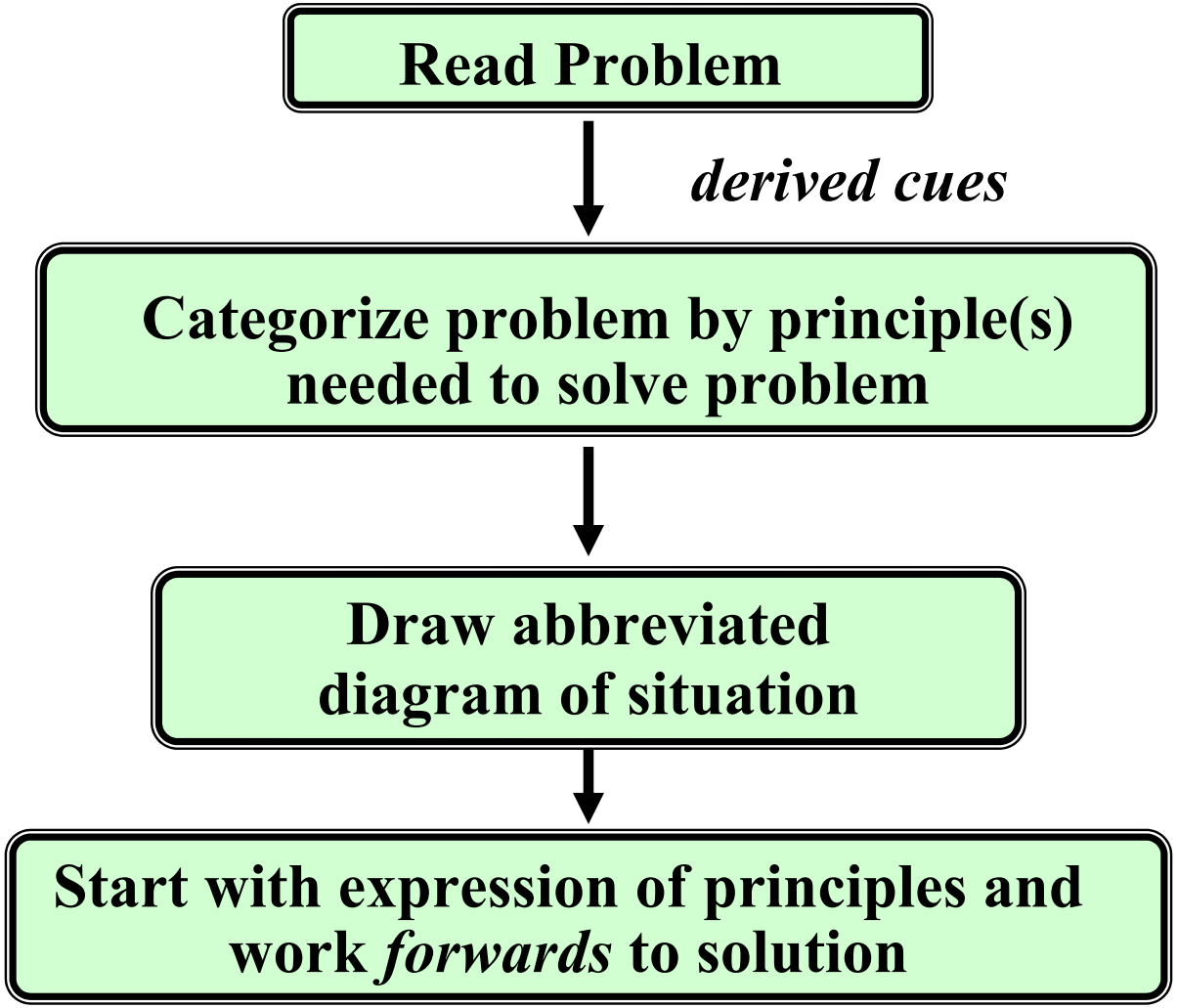
You navigate your way through a maze toward your goal (solution) *step by step*, making some false moves but gradually moving closer toward the goal.

But what are these "steps" and what guides your decisions?

Expert "Real " Problem



Expert -- "Exercise"



Textbook solution to Cowboy Bob Problem

Principles of Mechanics

Conservation of Energy

Newton's Laws of Motion

Conditions of Application

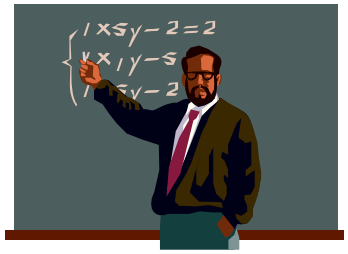
Alternative Coordinating Axes

If Acceleration

$\Sigma F = ma$

If Equilibrium

$\Sigma F = 0$



Incline Plane

plane

block

surface property

forces

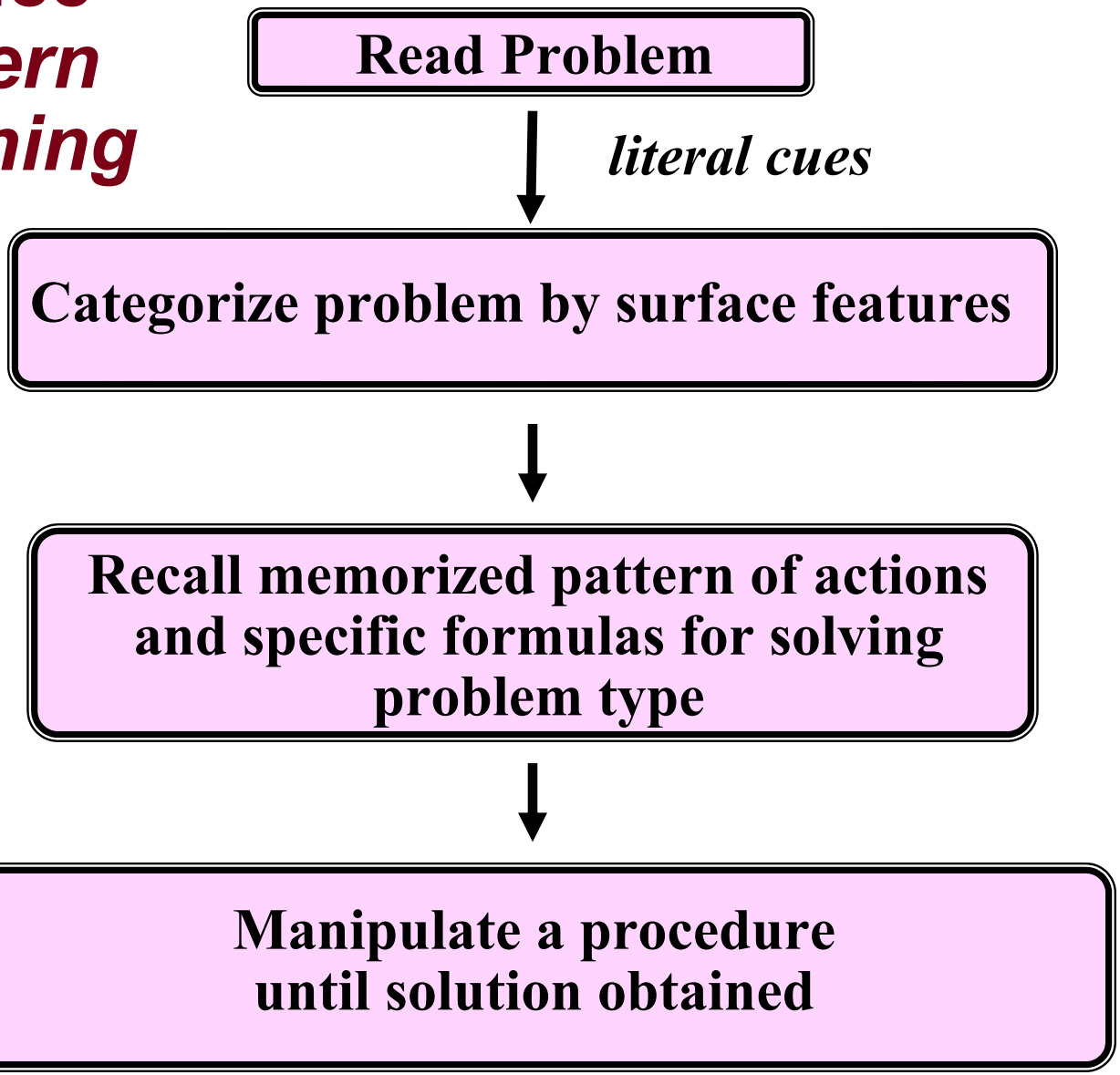
gravity

normal forces

friction

Knowledge Organization of Expert

Novice *Pattern Matching*



Knowledge Organization of Novice

For freshmen, many physics problems are real problems, not exercises.

So how can students be coached in using a logical, organized process for solving real problems?

1. **Discussion Section:** Focus of final discussion is on the *qualitative analysis of the problem*, not on the mathematics.

2. **Laboratory Section:**

(a) Students answer *Methods Questions* (before lab) that provide a guide or framework for how to solve each laboratory problem in a logical, organized fashion.

(b) Focus of discussion is on Methods Questions that are part of the qualitative analysis of the problem.

All problem-solving guides or frameworks *in any field* are:

- **based on expert-novice research;**
- **similar to on George Polya's (1957) framework for mathematics problem solving.**

Physics problem-solving frameworks by different authors:

- **divide the framework into a different number of steps;**
- **Have different ways to say essentially the same thing;**
- **Emphasize different heuristics depending on the backgrounds of the students.**

Polya (1957) Framework

1. Understand the Problem

2. Devise a Plan

3. Carry Out the Plan

4. Look Back

Describe the problem:

- **Translate the situation and goals into the fundamental concepts of your field.**
- **Decide on the reasonable idealizations and approximations you need to make.**

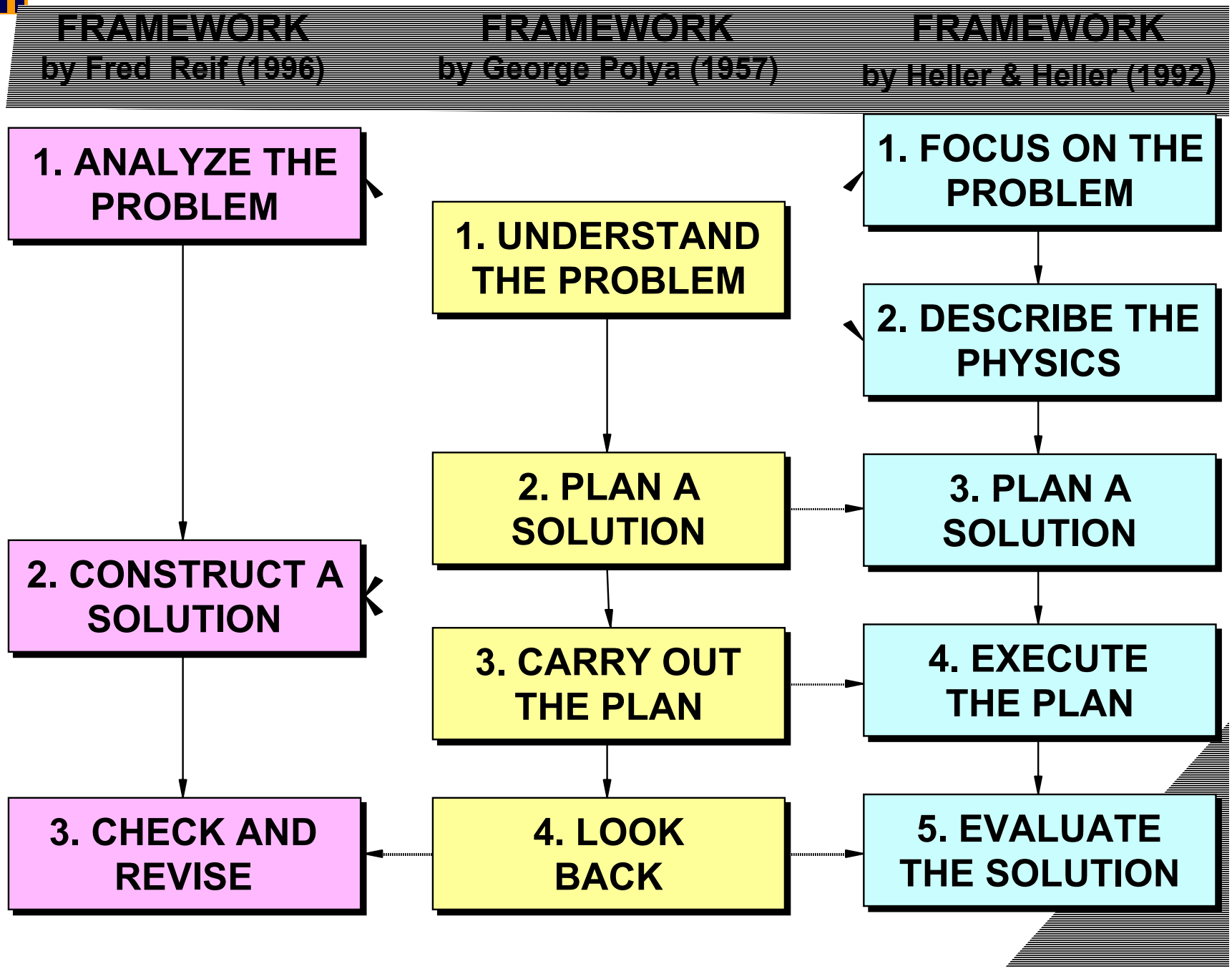
Apply the specialized techniques (heuristics) of your field to develop a plan, *using the concepts of your field to connect the situation with the goal.*

Re-examine the description of the problem if a solution does not appear possible.

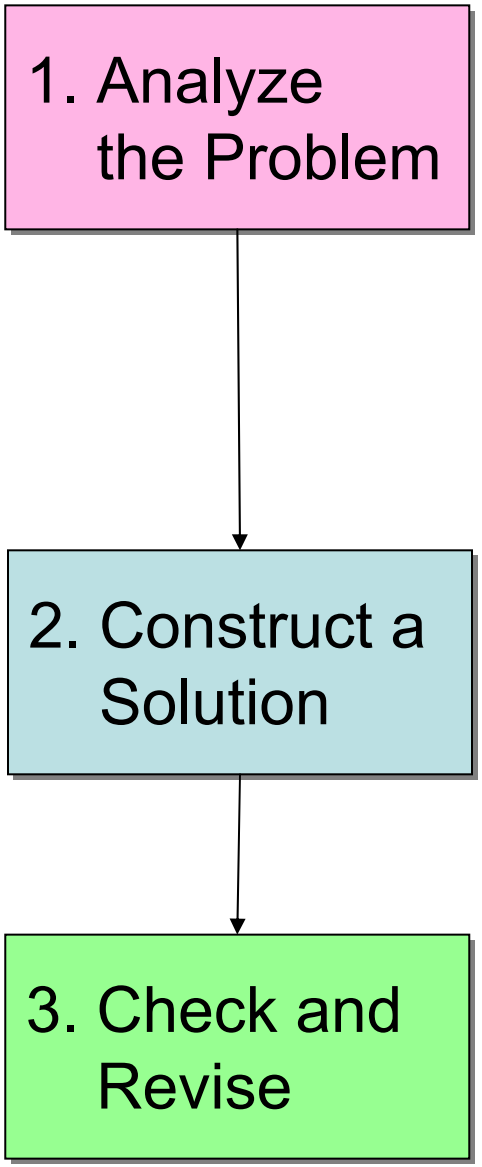
Follow your plan to the desired result.

Re-examine your plan if you cannot obtain the desired result.

Determine how well your result agrees with your knowledge of similar behavior, within limits that you understand.


FRAMEWORK
by Fred Reif (1996)
1. ANALYZE THE PROBLEM
2. CONSTRUCT A SOLUTION
3. CHECK AND REVISE
FRAMEWORK
by George Polya (1957)
1. UNDERSTAND THE PROBLEM
2. PLAN A SOLUTION
3. CARRY OUT THE PLAN
4. LOOK BACK
FRAMEWORK
by Heller & Heller (1992)
1. FOCUS ON THE PROBLEM
2. DESCRIBE THE PHYSICS
3. PLAN A SOLUTION
4. EXECUTE THE PLAN
5. EVALUATE THE SOLUTION

Framework by Reif



Basic Description: **draw diagram(s) to summarize situation; specify knowns and wanted (target) unknown(s) both symbolically and numerically.**

Refined Description: **Specify time sequence of events and identify time intervals where situation is different; use physics concepts to describe situation (e.g., velocity, acceleration, forces, etc.)**

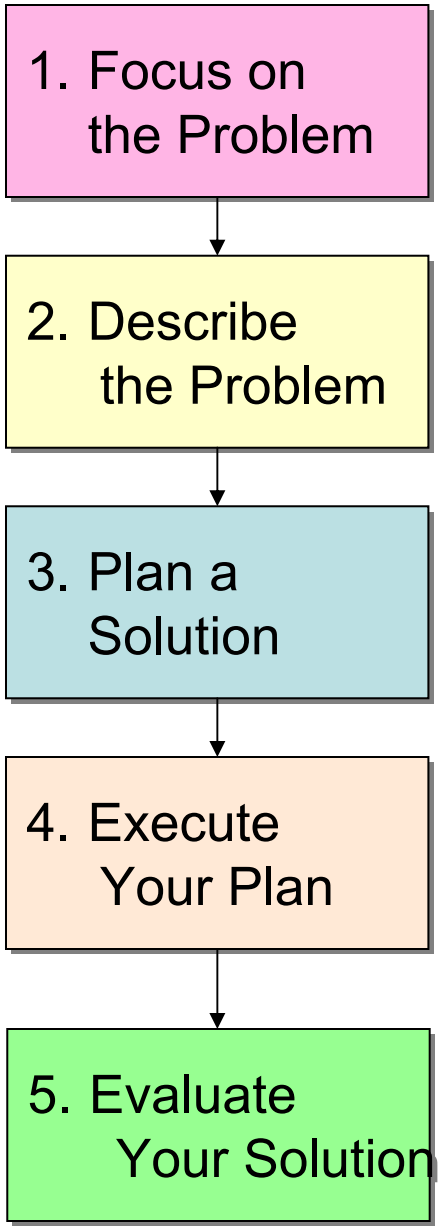
Solve simpler subproblems *repeatedly*:

Examine status of problem for obstacle;
Select suitable sub-problem to overcome obstacle (e.g., apply basic relation)
Eliminate unwanted quantity

Check for Errors and Revise:

Goals attained? Well Specified? Self-consistent? Consistent with other known information? Optimal?

Framework by Heller and Heller



Focus: **visualize the objects and events by drawing picture; identify given information; state question to be answered; and identify physics approach(es)**

Describe: **Draw physics diagrams and define symbols; identify target variable(s); and assemble appropriate equations**

Plan: **Construct a logical chain of equations, starting with equation that contains target variable and working backwards. Outline mathematical solution.**

Execute: **Follow outline to arrive at algebraic solution; check units; and calculate answer.**

Evaluate: **Answer question? Answer properly stated? Answer unreasonable??**