XXX 487
Senior Design Phase I

Design Process
and
Design Analysis

Some material adapted from a presentation by

Dr. Sumner

Fall 2010

A Design process seeks a preferred solution

- Design problems are open ended and typically complicated
  - Open-ended problems have many possible feasible solutions
  - Problems involve many different needs and performance characteristics (various measures of success)
- A design process seeks a preferred solution in some way
  - This requires more than an educated guess among feasible alternatives but **a credible and substantiated better solution**.
- A design process constitutes a series of
  questions, investigations, and decisions

Engineering Design applies engineering principles

- It is a decision-making process leading to the specification of a (device, system, and/or process) that meets stated functionality and performance objectives.
- It applies knowledge of the
  - basic sciences,
  - mathematics, and
  - engineering

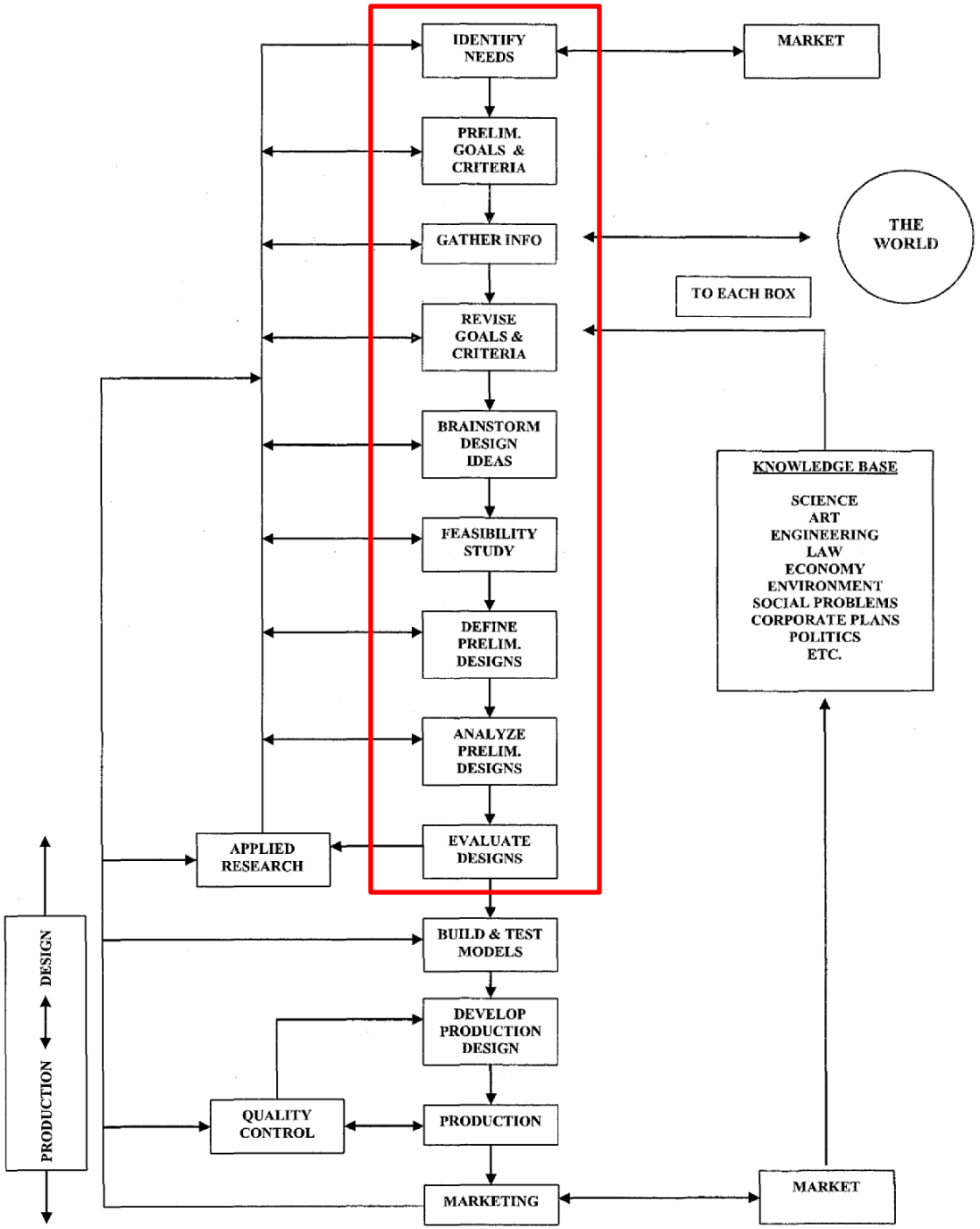
  to optimally convert resources for a desirable solution

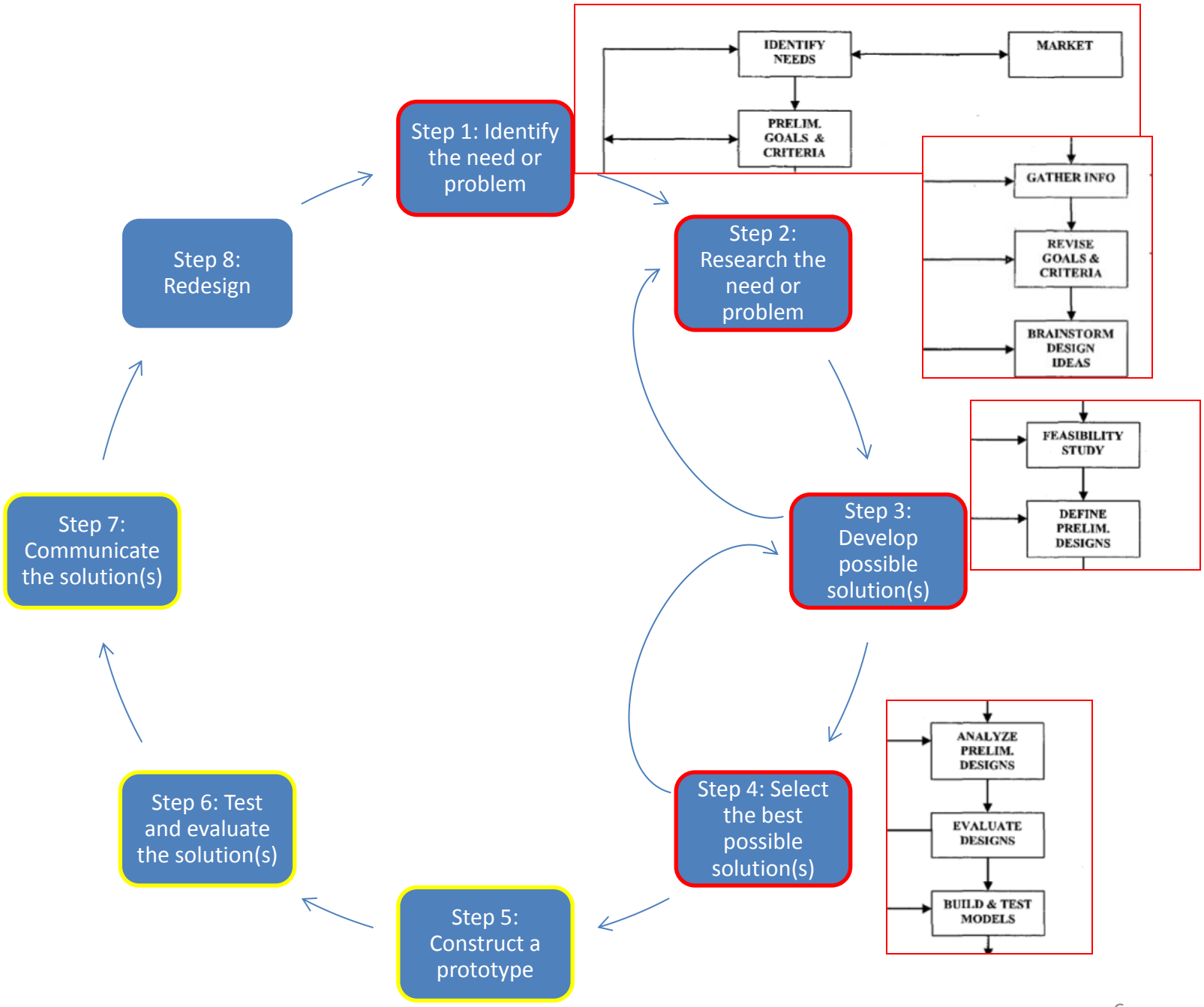
Refs: ABET Criteria for Accrediting Engineering Programs 2012-13, criterion 5.

Haik and Shahin, Engineering Design Process, 2nd ed., CENGAGE Learning, 2011.

Possible deliverables of engineering design

- Computer Software Files, Data files, Written Programs, etc.
- Prototype, instrumentation, tools, etc.
- Documentation such as
  - Working drawings
  - Detailed set of specifications of final product and components
  - Recommendations, Substantiated Decisions
  - Explanations (needs analysis, performance predictions, etc)
  - Report of background research (technology review)
  - Findings (from analyses, technology reviews, etc)
  - Graphics of results, concepts, budget, etc
  - Interpretation of Findings
  - Instructions and/or hardware manuals


IDENTIFY NEEDS
MARKET
PRELIM. GOALS & CRITERIA
GATHER INFO
THE WORLD
TO EACH BOX
REVISE GOALS & CRITERIA
BRAINSTORM DESIGN IDEAS
KNOWLEDGE BASE
SCIENCE
ART
ENGINEERING
LAW
ECONOMY
ENVIRONMENT
SOCIAL PROBLEMS
CORPORATE PLANS
POLITICS
ETC.
FEASIBILITY STUDY
DEFINE PRELIM. DESIGNS
ANALYZE PRELIM. DESIGNS
APPLIED RESEARCH
EVALUATE DESIGNS
DESIGN
PRODUCTION
BUILD & TEST MODELS
DEVELOP PRODUCTION DESIGN
QUALITY CONTROL
PRODUCTION
MARKETING
MARKET


Step 1: Identify the need or problem
IDENTIFY NEEDS
MARKET
PRELIM. GOALS & CRITERIA
Step 2: Research the need or problem
GATHER INFO
REVISE GOALS & CRITERIA
BRAINSTORM DESIGN IDEAS
Step 3: Develop possible solution(s)
FEASIBILITY STUDY
DEFINE PRELIM. DESIGNS
Step 4: Select the best possible solution(s)
ANALYZE PRELIM. DESIGNS
EVALUATE DESIGNS
BUILD & TEST MODELS
Step 5: Construct a prototype
Step 6: Test and evaluate the solution(s)
Step 7: Communicate the solution(s)
Step 8: Redesign

Needs identification and analysis

- Discovering/verifying the **“real” needs**
- Find and remove preconceptions
- Analyze the needs as to **not preclude solutions** due to a biased understanding
- Effectiveness of the conceptual design depends on how well the need is understood
- Important to **overtly ensure objectivity** in the early stages
- Develop **engineering requirements and objectives** for the project
- Plan a design process to arrive at **a preferred solution**

Engineering: Demonstrated application of what you've learned at MUSE

- Analog Filter Design
- Bioremediation
- Biological Fluids
- Biomechanics
- Chemical Processes
- Diagnostic Imaging
- Digital Logic and Comp. Organization
- **Dynamics**
- **Electrical Fundamentals/ Circuits**
- Electromagnetic Field Theory
- **Engineering Design**
- **Engineering Economy**
- Ergonomics
- Feedback Controls
- Fluid Mechanics/ Hydraulics
- Heat Transfer
- Human Factors Engineering
- Instrumentation/ Data acquisition
- Manufacturability
- Materials
- Mirocomputer Fundamentals
- **Probability and Statistics**
- Power Electronics
- Robotics
- Signal Processing
- Solid Mechanics/ Structural analysis
- Quality Control
- **Statics and Solid Mechanics**
- **Thermodynamics**
- Vibrations

Industry design examples: Large volume product

- Every year the USA produces:
  - 1 billion foil-lined fruit juice boxes
  - 25 billion styrofoam cups
  - 1.6 billion disposable pens
  - 2 billion disposable razors
  - 16 billion disposable diapers

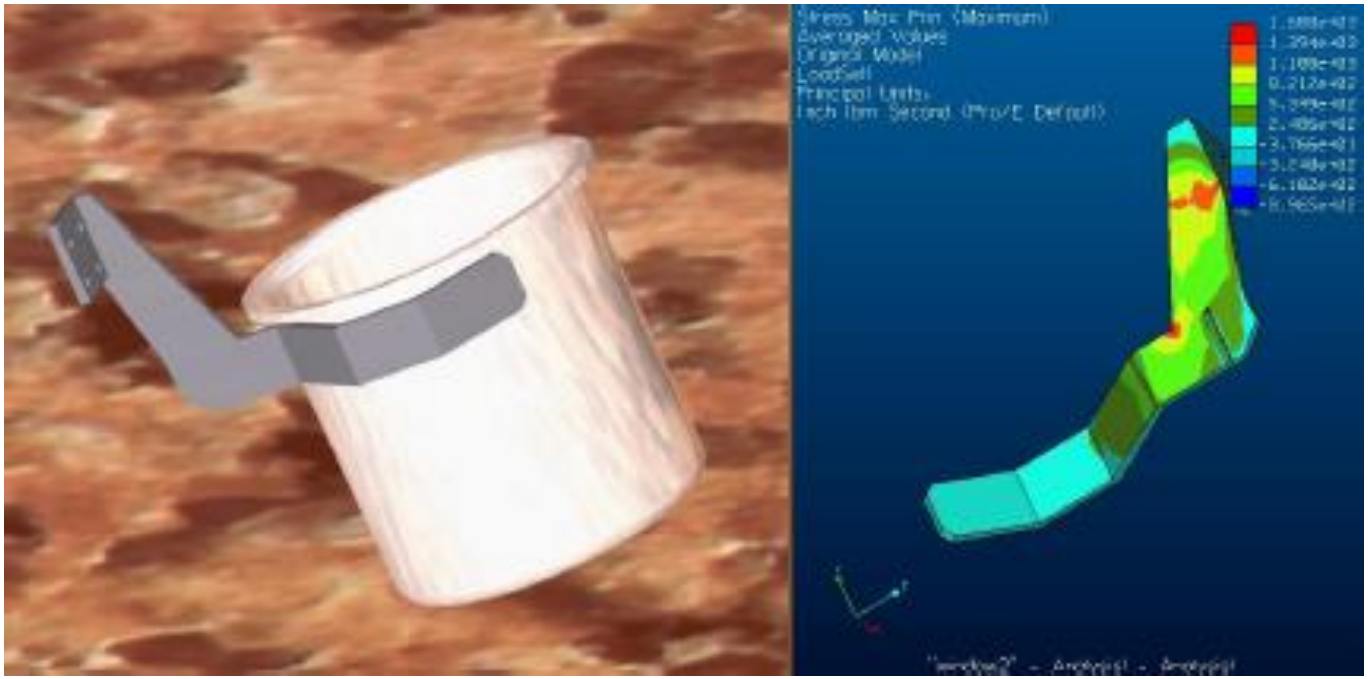
- High volume allows the cost of design and analysis to be spread over a large number of pieces.
- A mistake would be repeated millions or billions of times.
- Manufacturing tooling is expensive.

The Design and Analysis approach changes with technology

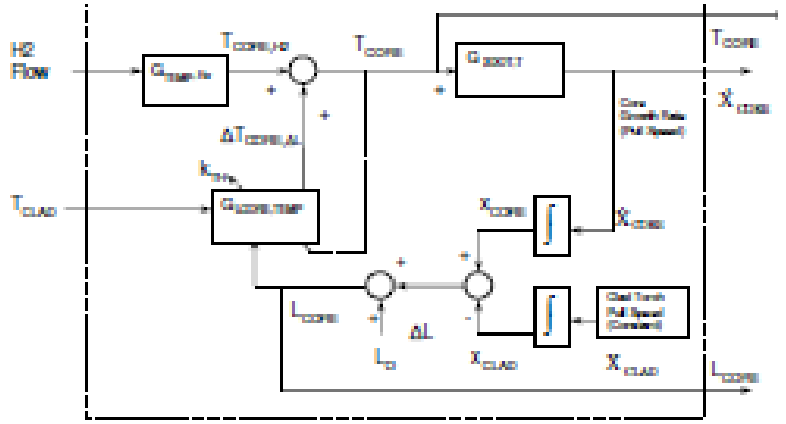
- New design software tools.
- New easy integrated analysis software
  - (e.g.,P-spice, Pro/Engineer, Ansys, CFX, Simulink…..)
- Skill level requirements are lessening.
- Smaller cost to analyze.
- More cost to create and test than to virtual prototype.
- Direct Digital Manufacturing

Modeling and analysis time decreases as technology improves!

MODEL → ANALYSIS

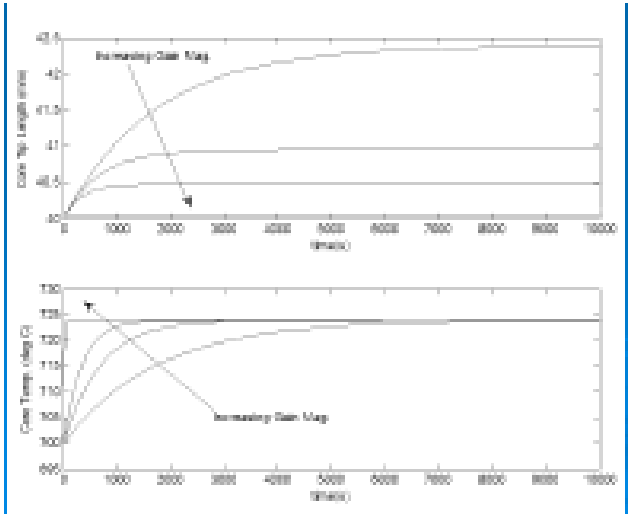


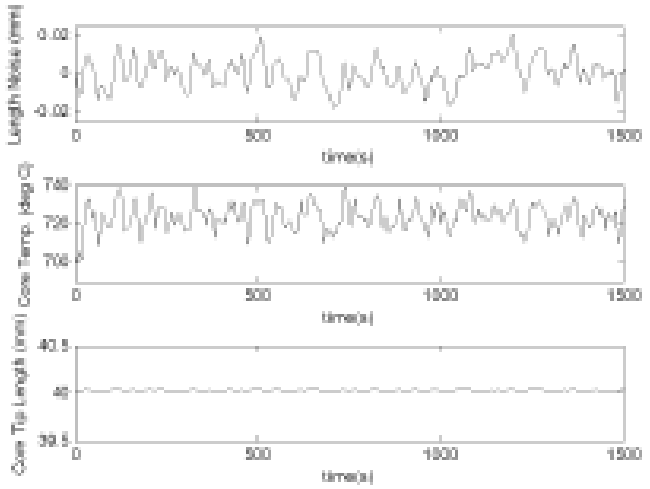
Simulate design before building



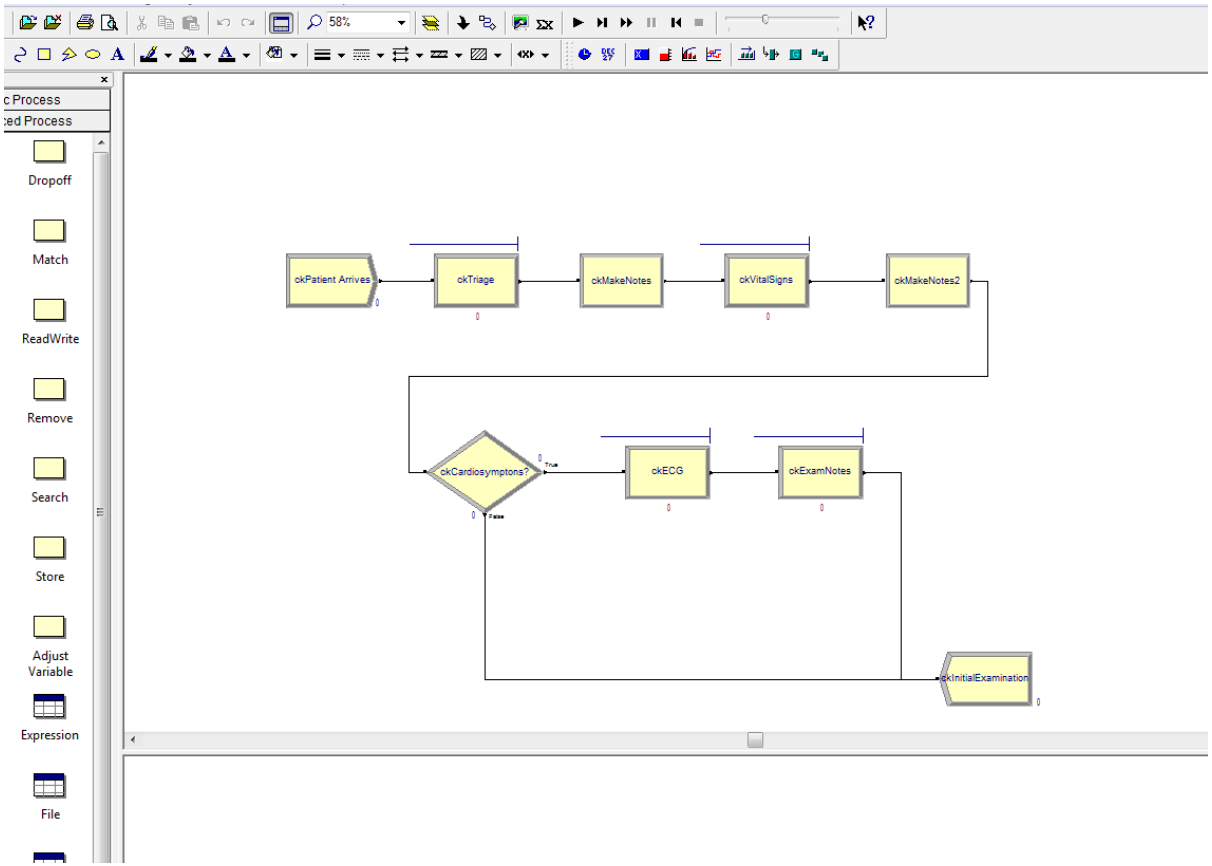
Fix errors

Optimize Parameters





Simulate as part of the design process



Identify opportunities

Evaluate alternatives

But beware …

- Inaccurate /over simplified models
  - Results may have convergence error
  - Model input may not be correct, or correctly applied
  - Boundary conditions, assumptions, etc.
  - Physical world differences from model
- Misapplied analysis and assumptions
  - Analysis limitations (linear, non-linear)
  - FEA, simulation, etc. make a good engineer better… makes a bad engineer dangerous
- Testing is still required!

In conclusion …

Obtain Successful New Design through **Planned** Design, Analysis & Testing:

- Good team
- Understanding of current systems and opportunities
- Thorough design and analysis
- **Changing/Designing as a system.**
  - **Not just a collection of well-designed parts**
- Effective exchange of information to all groups affected by a proposed change
- Extensive testing and evaluation
- Detailed planning & continuous project monitoring

Questions?

- Thanks for your attention.
- Reminders:
  - No class meeting on Thursday (meet with your client and/or technical advisor)
- Next class meeting: Tuesday, February 2.
- Be sure to discuss your proposal with your client
  - Make changes ASAP!
  - Submit an addendum or revision document (You don't need to submit a new proposal, but be sure to communicate any changes to the original)