# Engineering Design Workshop

*for teachers and students*


## Quality Design Projects for Engineering Fairs

Sponsored by

Santa Clara Valley Science and Engineering Fair Association

# Purpose

"…help teachers and students understand the engineering design process."

# Outline

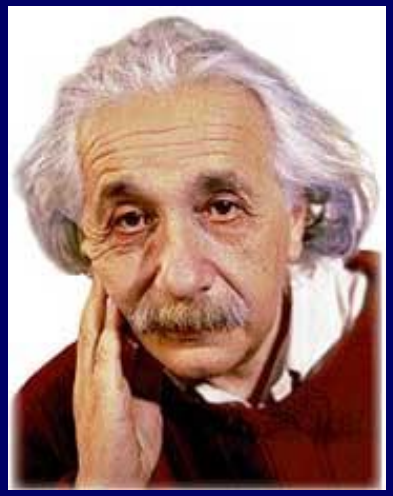
- Science Process vs. Engineering Design Process
- Engineering Fields of Studies
- Engineering Judging
- 7-Steps of the Engineering Design Process with Examples
- Pitfalls
- Summary

# Science and Engineering Processes

# Purpose and Nature

- Science is the search for knowledge and understanding
- Engineering is the application of scientific principles to satisfy human needs

***They are both creative problem solving methods!***



# SCIENCE & ENGINEERING

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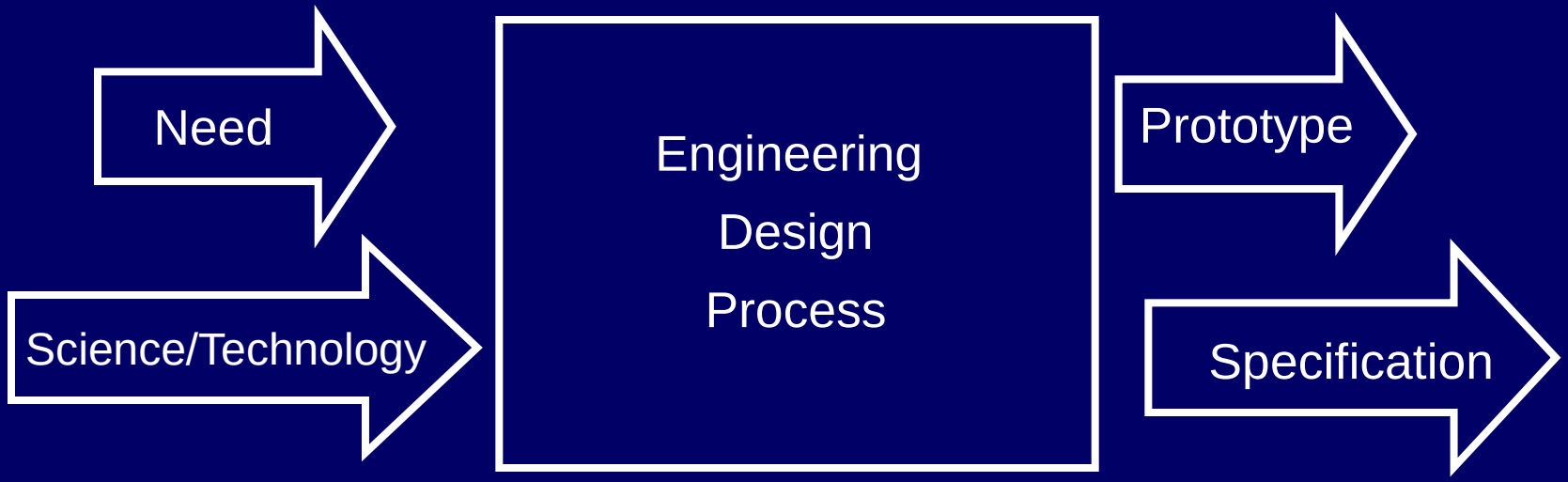


# Eng Fields of Studies

- 6 Fields of Studies for Engineering
  - Biomedical Engineering
  - Chemical/Environmental Engineering
  - Electrical Engineering
  - Mechanical Engineering
  - Software Engineering

# Engineering Project Judging

# Judging Guidelines

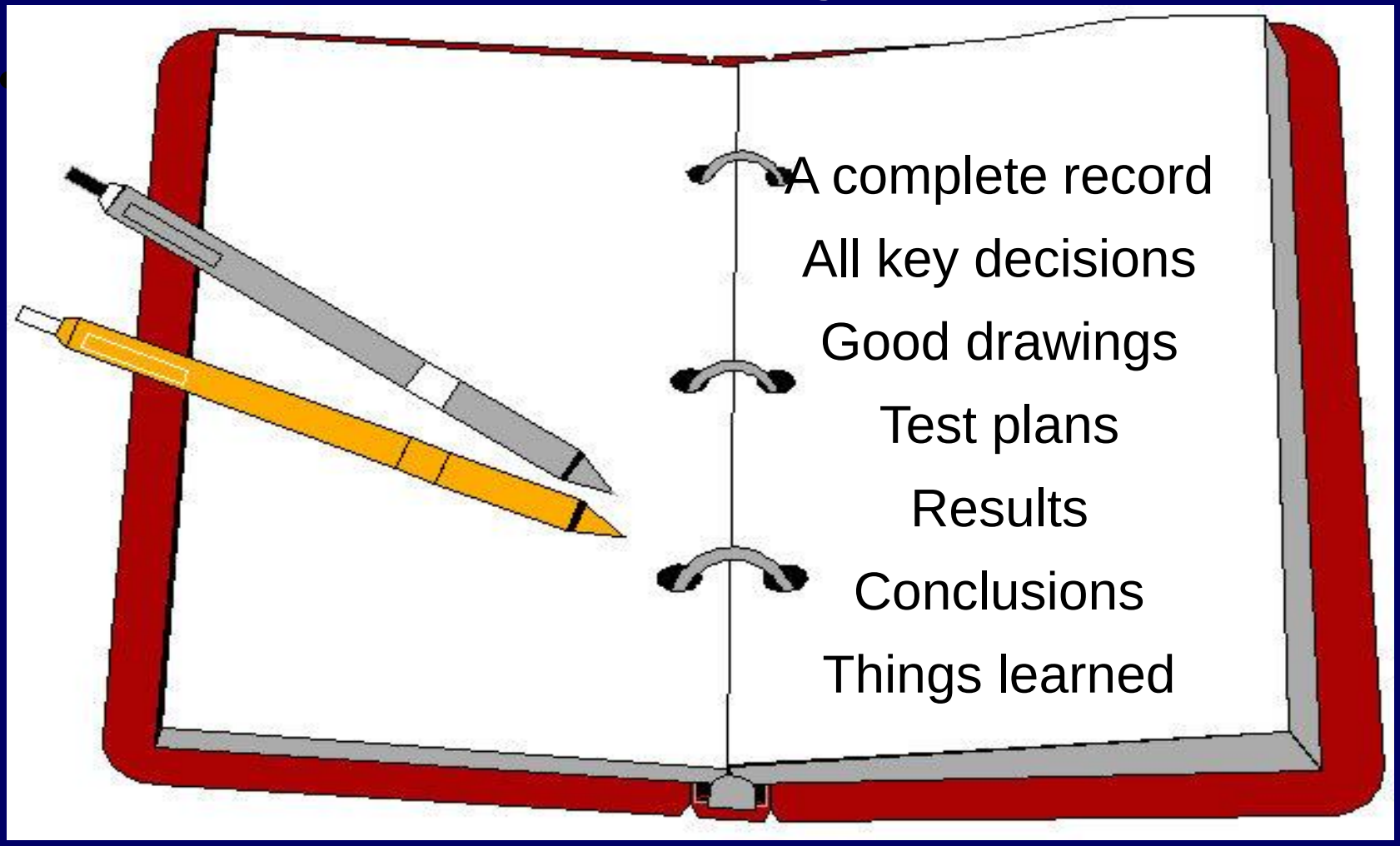
- Engineering Goals
- Creative Ability
- Thoroughness
- Skill
- Clarity
- Results

# The 7 Steps to the Engineering Design Process

# Engineering Design Process

1. Define a need
2. Establish criteria and constraints
3. Research, evaluate alternatives, test plan
4. Construct a prototype
5. Test against established criteria
6. Failure analysis, tweak, and re-test
7. Final documentation

# Step #1 through #7
# Generate a Project Book



# Step #1: DEFINE A NEED

- Have a need, a customer for the project
- Often stated as bigger (or smaller), cheaper, faster, lighter
- Engineering Goal template: *The design and construction of a* (engineering project) *for* (user) *to do* (some function).
- Project MUST have technical content

# GENERATING ENGINEERING PROJECT IDEAS

- Student interests
- ‘Cool’ ideas or improvements
- ScienceBuddies.org ‘Aptitude Test

# Helpful Links to Stimulate Project Ideas

- SCVSEFA website. Event dates and guidelines. Links to helpful sites. https://science-fair.org/
- Science Buddies Pick Your Topic. Like aptitude test. https://www.sciencebuddies.org/mentoring/project_topic.shtml
- Classroom stories on many topics. Targeted for teachers. https://educate.intel.com/odyssey/teacher.aspx
- Science Club Kids' Science Projects. Simple, medium, and advanced science projects. Tweak to become an engineering project! http://scienceclub.org/kidproj1.html
- HowStuffWorks Science Channel. Good topics and research. http://science.howstuffworks.com/

# Other Links to Stimulate Ideas

- Research sites:
  - https://www.asme.org - American Society of Mechanical Engineers
  - https://www.asce.org - American Society of Civil Engineers
  - https://www.ieee.org – Institute of Elecronic and Electrical Engineers
  - https://www.engineering.com - Interesting engineering articles
  - http://www.TryEngineering.org - Background info about engineering
  - http://www.TryNano.org - Background info about nanotechnology

*The design and construction of a* (project) *for* (user) *to* (function).

Project: solar powered scooter
User: children
Function: zip around the block

*Technical Content:*

*solar energy, energy storage, motor torque, mechanical gear ratios, brake system*

# ENGINEERING GOAL STATEMENT EXERCISE

# “The design and construction of a (*project*) for (*user*) to do (*function*).”

| *project* | *user* | *function* |
|---|---|---|
| Electromagnetic padlock opened by a specific light sequence | English speaking tourists and businessmen | Automatically turn on when the feet cool down to a certain temperature. |
| BBQ temperature sensor | Homeowners | Know when their meat is cooked |
| Spoken English input to Mandarin text output translator | Car washers | Mow using cheap and easy lawn care |
| Hose powered hub cap cleaner | People who get cold feet | Communicate with Mandarin speakers |
| Automated lawn mower | Outdoor chefs | Lock valuables without carrying a key |
| Sock heater | Businessmen with a laser pointer | Clean small crevices in hub caps |

# Step #2: Criteria & Constraints

"Design criteria are requirements you specify for your design that will be used to make decisions about how to build the product"

Size

Appearance

Physical Features

Performance

Use Environment

# Some Design Constraints

- Cost
- Time

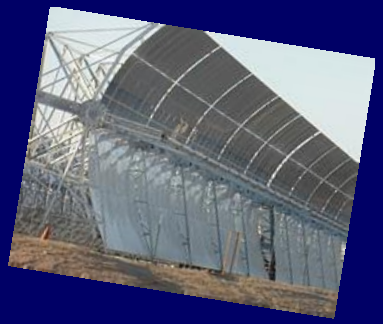
# Criteria & Constraints for Solar Powered Scooter

1. Transport up to 35 kg rider
2. Speed of at least 8 kph on level surfaces
3. Travels through 10 meters of shade
4. Material cost
5. Testing completed by Feb 28

# Step #3: List Alternatives

- Research reveals what has been done
- Likely to find good alternatives for cheapest, fastest, or lightest
- Create a test plan based on the design criteria from Step #2

# Web Researched Alternatives



Electrically powered scooter

# Solar Powered Scooter Test Plan

1. Transport up to 35 kg rider

Test Plan: Transport a 35kg load

2. Speed of at least 8 kph on level surfaces

Test Plan: 100m distance should take less than 45 seconds

3. Travels through 10 meters of shade

Test Plan: Charge up battery. With 35kg rider, ride through 10m of shade

# Mail in Your Application

Attachments should include:

- the Engineering Goal Statement with the technical component
- the design criteria and constraints
- the basic test plan for the design criteria
- construction diagrams including electrical circuits
- bibliography

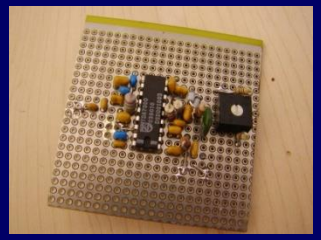
# Minimum Quality Requirements

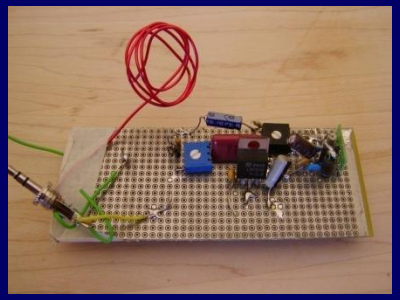
- Common application problems:
  - Lack of measurable criteria
    - ‘fast’ instead of ‘…velocity > 12km/hr…’
    - ‘heavy’ instead of ‘…mass of 44kg…’
    - ‘high accuracy’ instead of ‘…< 17 errors per 1000 samples…’
  - Inadequate bibliography

# Step #4: Construct Prototype

- Prototype is implementation of chosen design alternative
- It is a proof of design, production and suitability

# Project Construction





# Step #5: Test it Well

- Execute the developed Test Plan
- Learn beyond minimum requirements! Characterize the limits of your project.

# Solar Powered Scooter Testing

1. Transport 35 kg rider. *Exceeds Test Plan:* Maximum mass transported
2. Speed. *Exceeds Test Plan:* Measure and plot speed vs. rider mass.
3. Travels through shade. *Exceeds Test Plan:* Measure and plot distance in shade travel vs. rider mass.

- *Extra Knowledge:* solar energy, storing energy, electric motor torque, gears

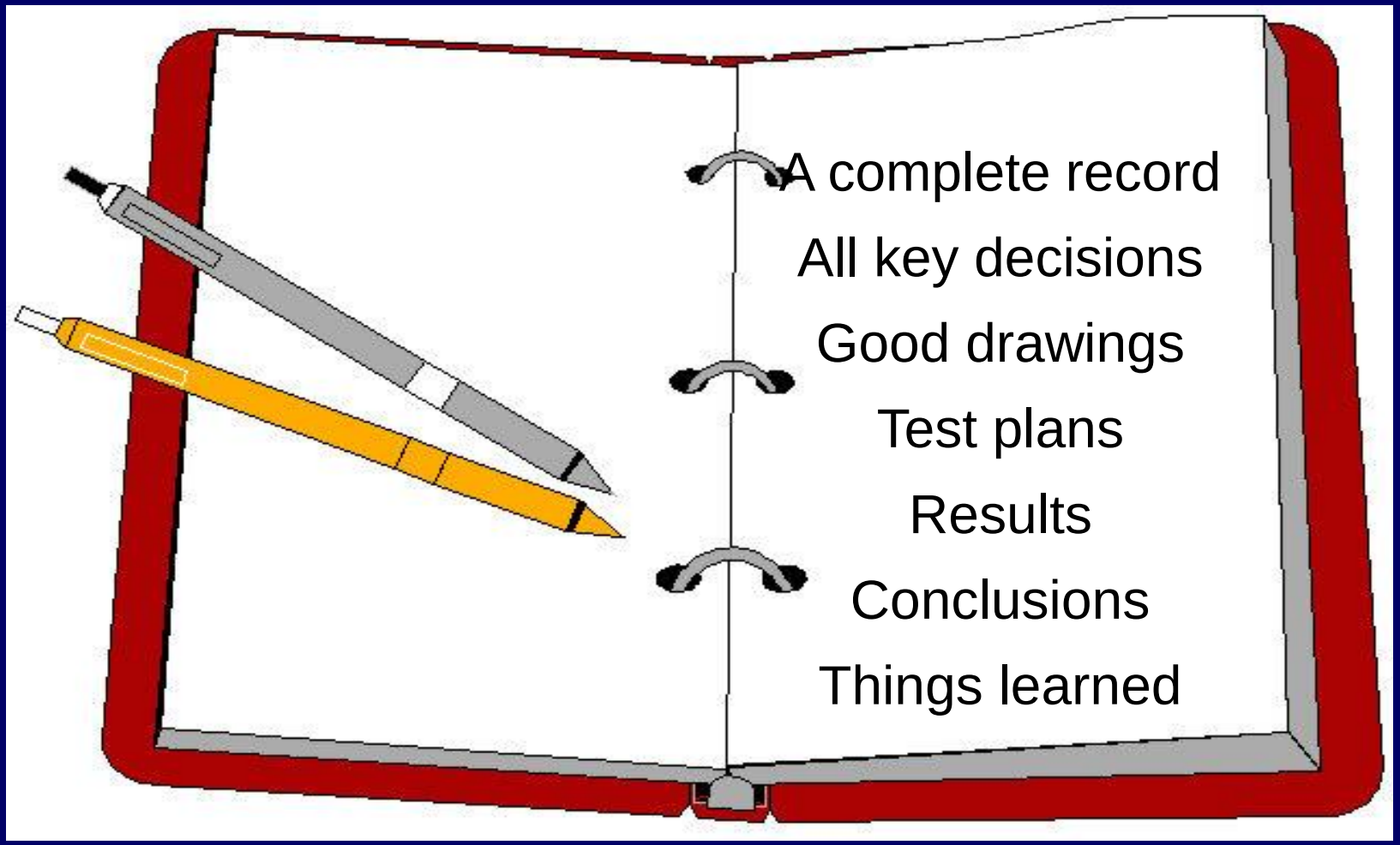
# Step #6: Failure Analysis and Tweak/Redesign Iterations

- Evaluate the test results. Do they satisfy design criteria?
- If not, can you tweak the process as opposed to a complete redesign?
- In reality, “Fail early, fail often!”
- This is the longest step….

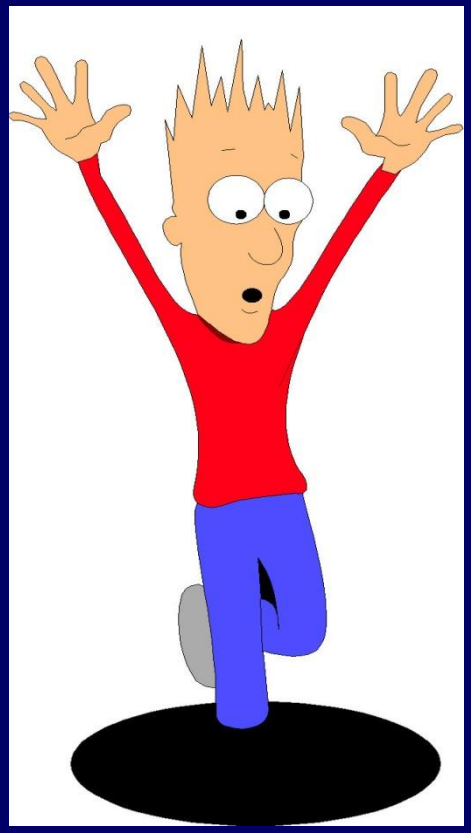
# Failure Analysis and Tweak/Redesign Examples

- Solar scooter cannot move 35kg ….
- Get a higher torque motor, increase gear ratio, reduce scooter weight
- Scooter speed only reaches 5kph…
- Get a motor with higher RPM, decrease the gear ratio, reduce scooter weight

# Step #7: Complete the Project Book (Started at project definition)

- 

# Avoid These Pitfalls



No need, no end product

Been done!

Analysis as a product

Ah ha!, gadgetry, kits

Testing without asking the user

Demonstrations (see next…)

Demonstration projects revolve around

'How ____ works.'

A common demonstration is the Magnetic Levitated Train.

If faced with this….

determine the interest

- If magnetic fields: induced electrical currents, earth's magnetic field, …
- If transportation: safety equipment improvements (helmets, seat belts…)

# Summary

# Design Features

1. Meets a need, has a “customer”
2. Design criteria and constraints
3. Evaluate alternatives and generate test plan
4. Build prototype
5. Test/evaluate against test plans
6. Analyze, “tweak” (☺), redesign (☹), retest
7. Project book: record, analyses, decisions, specs

# Best of Luck

Engineering is exciting!

Use creative problem solving!

Ignite your students' passion!