Konsep Pengembangan Sains dan Teknologi (HUG112)

07- Metoda Rekayasa

Department of Electrical Engineering
Faculty of Engineering
Universitas Indonesia

SERTIFIKAT

ucapan terima kasih diberikan kepada

Agung Trisetyarso, Ph.D

atas partisipasinya sebagai

Dosen Tamu

mata kuliah

"Topik Khusus Komputer"

yang diselenggarakan oleh ***Departemen Teknik Elektro***
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Ketua Departemen Teknik Elektro

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Diskusi bersama Prof. Emil Salim

The Engineering Design Process and the Scientific Method

- While scientists study how nature works, engineers create new things.
- Because engineers and scientists have different objectives, they follow different processes in their work.
- Scientists perform experiments using the **scientific method**; whereas, engineers follow the creativity-based **engineering design process**.

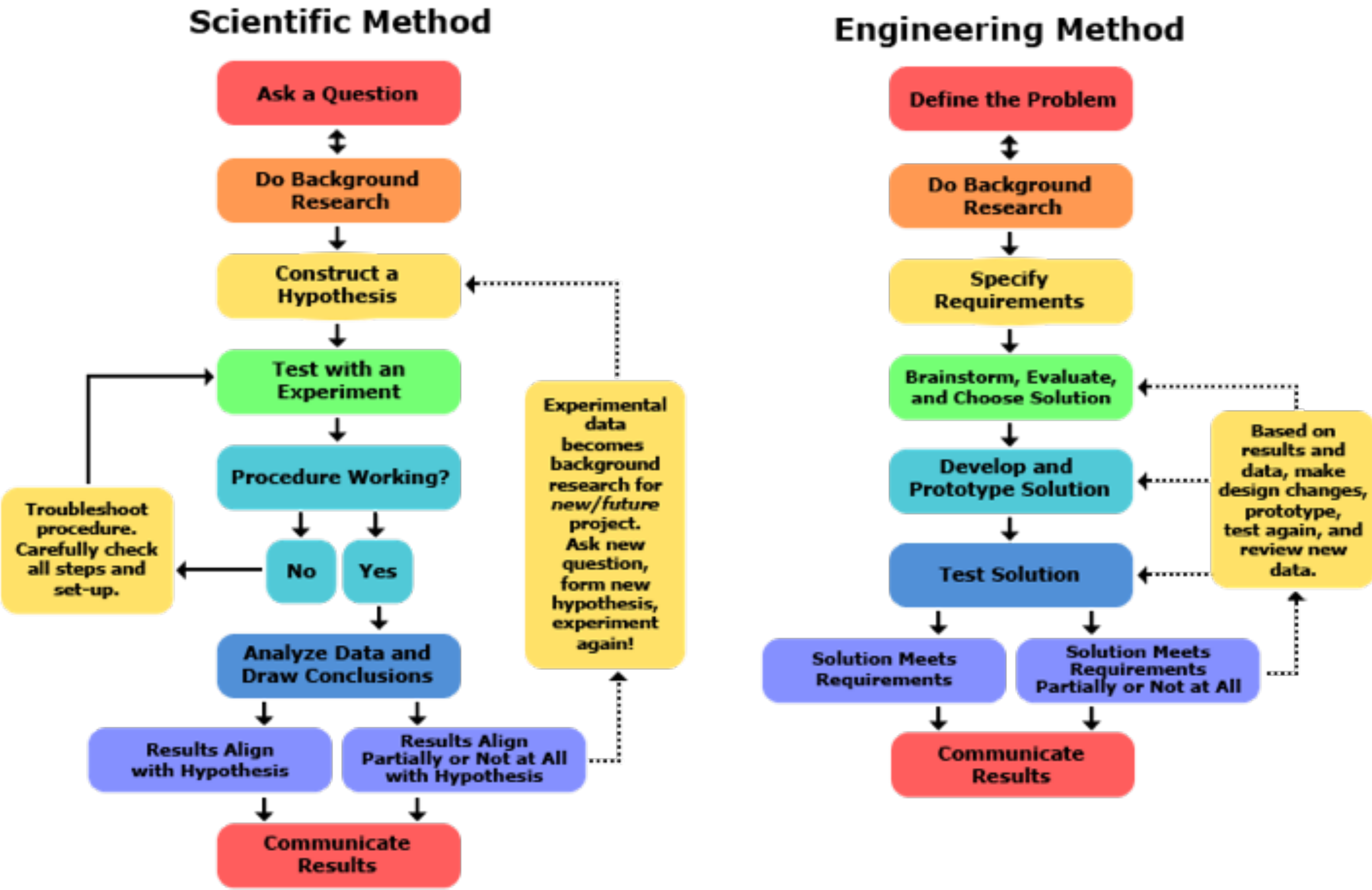
Analysis problems vs Design problems: an example

- “Determine the *maximum height* of a snowball given an initial velocity and release height.”
  - an analysis problem; it has only one answer
- "Design a *device* to launch a 1-pound snowball to a height of at least 160 feet“
  - design problem; the solution is open ended, since there are many possible devices that can launch a snowball to a given height

Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

Problem solving

- The engineering design process is a series of steps that engineers follow to come up with a solution to a problem.
  - Many times the solution involves designing a product (like a machine or computer code) that meets certain criteria and/or accomplishes a certain task.
- Involves designing, building, and testing something



http://www.sciencebuddies.org/engineering-design-process/engineering-design-compare-scientific-method.shtml

Iteration

- Engineers do not always follow the engineering design process steps in order, one after another.
- It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change to your design.
- This way of working is called **iteration**, and it is likely that your process will do the same!

Iteration: example

- The Wright brothers' airplane did not fly perfectly the first time.
- They began a program for building an airplane by first conducting tests with kites and then gliders.
- Before attempting powered flight, they solved the essential problems of controlling a plane's motion in rising, descending, and turning.
- They didn't construct a powered plane until after making more than 700 successful glider flights.

- Design activity is therefore cyclic or iterative in nature, whereas analysis problem solving is primarily sequential

Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

1. Define the Problem

- The engineering design process starts when you ask the following questions about problems that you observe:
  - What is the problem or need?
  - Who has the problem or need?
  - Why is it important to solve?

- [Who] need(s) [what] because [why].

How to start?

- One really great way to start the need-finding process is to make a "bug list."
- Think about all of the things that bug you or bug other people around you. Write them down.
- They may seem like small and silly problems, but they can spark ideas for a project or lead to larger problems that you may not have noticed otherwise.

Types of potential problem

- Unsolved Problems
  - Problem: food getting stuck in a vending machine
  - Need: a product that can be used to remove stuck foods from vending machines or a new vending machine that makes it impossible for food to get stuck

whereisant.net/2008/06/gambling-with-an-office-vending-machine/

- Poorly Solved Problems
  - Problem: cat or dog hair getting stuck on clothing
  - Current solution: the lint brush
  - Need: to make the lint brush more effective at removing hair from clothing or to design something better than the lint brush

en.wikipedia.org/wiki/Lint_remover

Develop a Problem Statement

- Formulate the problem in clear and unambiguous terms

- Example: "Design a better mousetrap“
- What is the definition of “better”?
- Should be compared with existing

Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

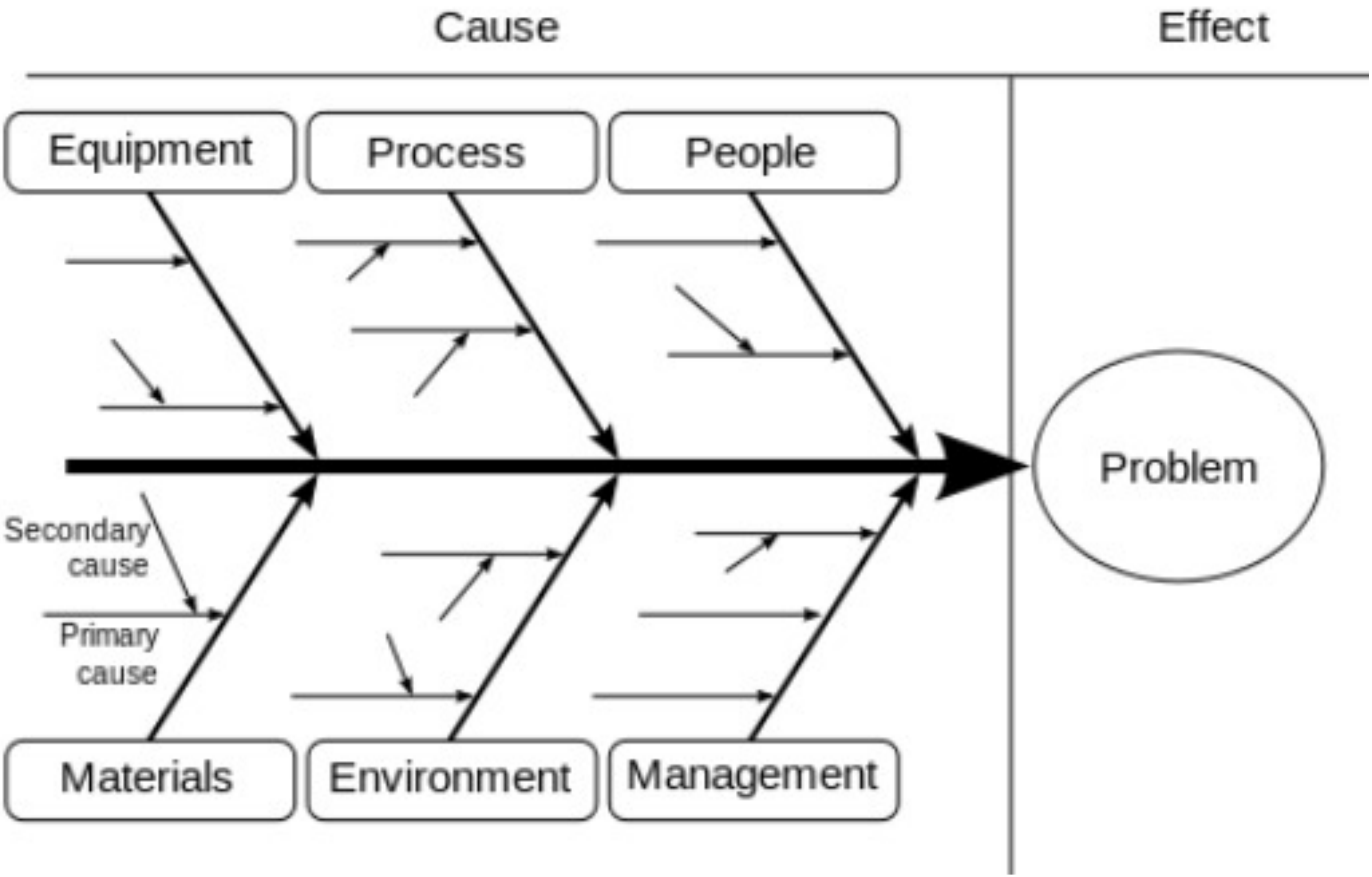
Example (cont'd)

Modify the problem statement:

"A Better Mousetrap: Certain rodents such as the common mouse are carriers and transmitters of an often fatal virus, the Hantavirus.
Conventional mousetraps expose people to this virus as they handle the trap and dispose of the mouse.
Design a mousetrap that allows a person to trap and dispose of a mouse without being exposed to any bacterial or viral agents

Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

Tool: Ishikawa Diagram



http://en.wikipedia.org/wiki/Ishikawa_diagram

Root cause: 5 whys

http://auto.howstuffworks.com/under-the-hood/diagnosing-car-p
mechanical/5-signs-alternator-problems.htm

- The vehicle will not start. (the problem)

- **Why?** – The battery is dead. (first why)
- **Why?** – The alternator is not functioning. (second why)
- **Why?** – The alternator belt has broken. (third why)
- **Why?** – The alternator belt was well beyond its useful service life and not replaced. (fourth why)
- **Why?** – The vehicle was not maintained

http://en.wikipedia.org/wiki/Five_whys

2. Do Background Research

- Learn from the experiences of others
  - this can help you find out about existing solutions to similar problems, and avoid mistakes that were made in the past.
- Do background research in two major areas:
  - Users or customers
  - Existing solutions

3. Specify Requirements

- Design requirements state the important characteristics that your solution must meet to succeed.
- One of the best ways to identify the design requirements for your solution is to analyze the concrete example of a similar,

Design requirements

- State the important characteristics that your solution must meet to be successful.

- Example: you want to design a better grocery store bag.
- A successful bag would use less expensive material than existing bags and function properly as a grocery

Examples: the bag needs to ...

- Have handles so that shoppers can carry multiple bags of groceries.
- Hold up to five pounds of food without breaking.
- Cost less than five cents to make.
- Collapse so that it can be stored in large quantities at grocery stores.

Another example: degradable plastic

www.oxium.net

eco-buddies.com

Effective design requirements are:

- **Needed** to solve your design problem.
  - If it is not needed, leave it out.
- **Feasible**. A good design requirement is not just a wish.
  - Ask if you have the time, money, materials, tools, and knowledge to make it happen.
- **Subject to change** as you do more research and design.
  - Always ask yourself, is this requirement needed and feasible? If your answers to those questions change, it is OK to change the requirement.

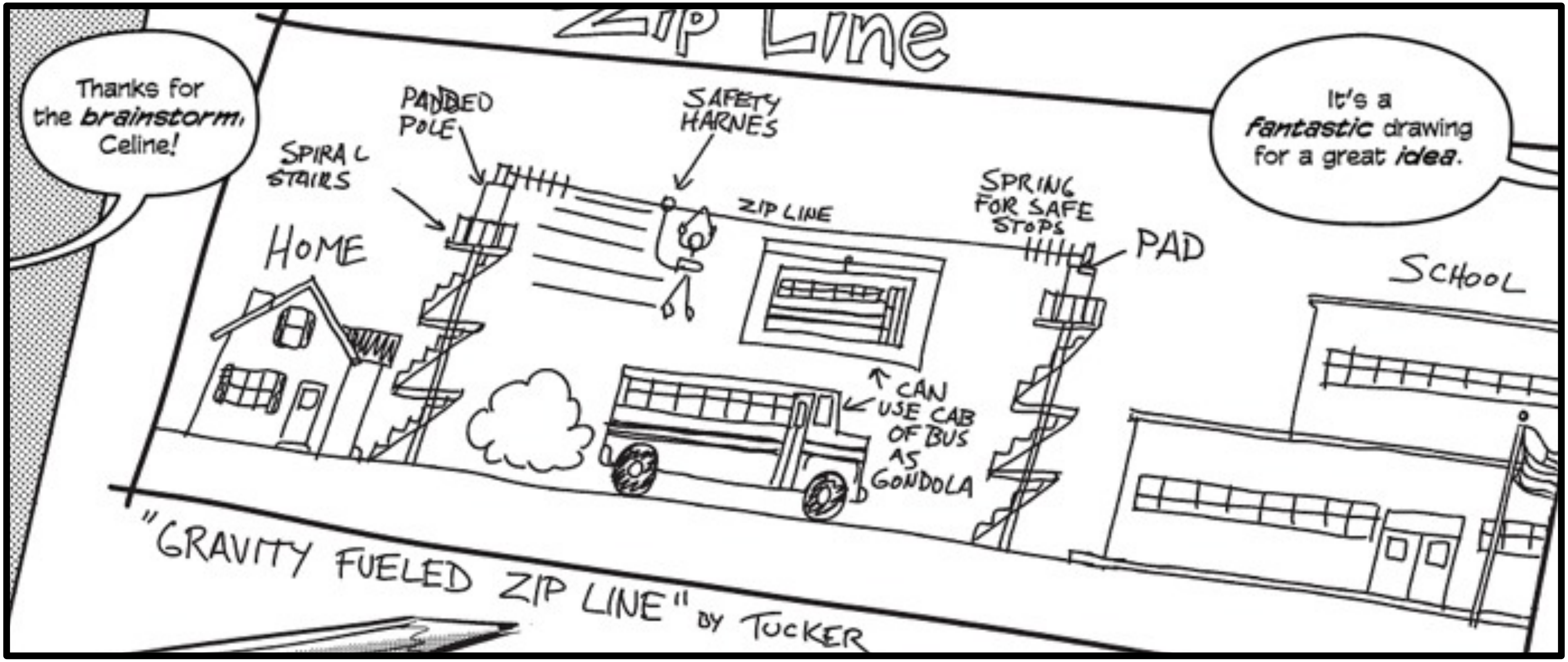
4. Brainstorm Solutions

- **DON'T SETTLE FOR YOUR FIRST IDEA!**
  - There are always many good possibilities for solving design problems.
  - If you focus on just one before looking at the alternatives, it is almost certain that you are overlooking a better solution.

Ideation (idea generation)

- The creative process of developing ideas
- Methods of ideation include:
  - Examining existing solutions
  - Creating and using analogies
  - Conducting brainstorming sessions
  - Sketching and doodling

Sketching



Howtoons & The Lemelson-MIT Inventeams, Seeing the Future!: A Guide to Visual Commur

Ideation (cont’d)

- One key rule for successful ideation is NO LIMITS.
- Start huge.
- Don't confine yourself to only one or two great ideas, and don't be afraid to think outside the box.
- No solutions are impossible during the ideation phase, so consider even the craziest of ideas.

Case of Casey

- Casey Golden, age 13, did this when he invented the BIOtee.
- Casey noticed that discarded and broken wooden golf tees littered golf courses, damaging the blades and tires of lawn mowers.
- He decided to design a new biodegradable tee.
- After experimenting with different mixtures, he devised a recipe made of recycled paper fiber and food byproducts coated with a water-soluble film. When the film is broken, moisture in the ground breaks down the tee within 24 hours.
- As a result of his creative efforts, Casey's family started a company to manufacture BIOtees producing several million tees per

Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

Casey Golden

- **Inventor & Co-founder Bio Dynamics, Ltd.**
- Produced our invention of the Bio-degradable golf tee (BioTees (tm)). Designed to save the 40,000+ trees per year that are chopped down to produce the current wooden golf tees. These tees have two patents and are made up of primarily recycled materials (newspaper) and a bonding agent that is a by-product of

www.golfimport.ch/en/everythingelse/tees/bio-tees-2-34-0009152/

www.linkedin.com/in/caseygolden

5. Choose the Best Solution

- Look at whether each possible solution meets your design requirements.
- Some solutions probably meet more requirements than others.
- Reject solutions that do not meet the requirements.

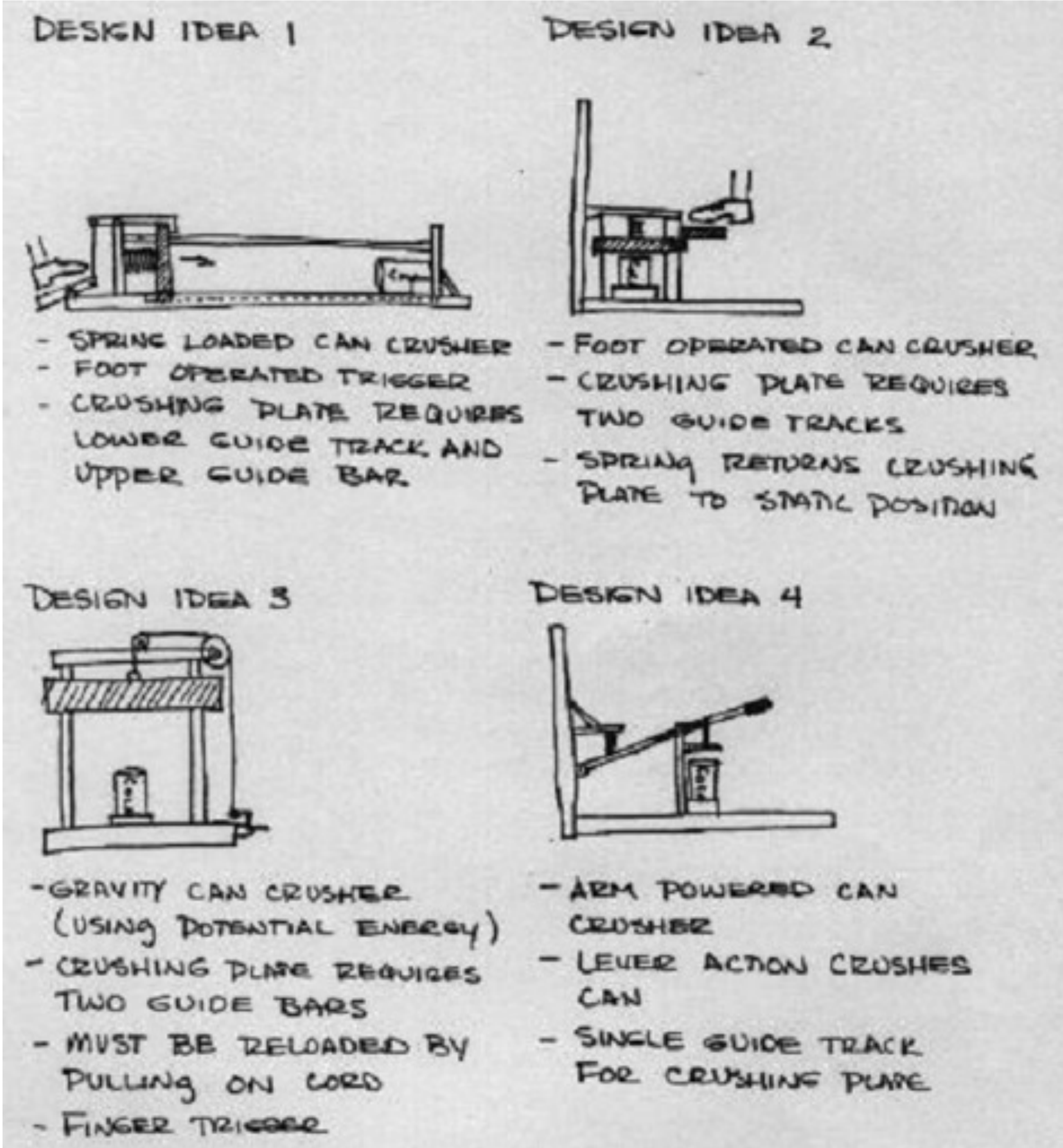
How to choose

- Requirements
- Nice to Haves, Desirables
- Universal Design Criteria

- Use Decision Matrix

Requirements and Criteria	Solution #1	Solution #2	Solution #3	Solution #4
Your requirement #1	1	2	2	1
Your requirement #2	1	1	2	1
Your requirement #3	2	2	2	2
Other criteria (nice-to-have and universal criteria)	1	1	2	1
Total Points	5	6	8	5

Example: Aluminum Can Crusher



Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

Table Decision matrix for evaluating alternative can crusher designs

Criteria	Weight(%)	Design 1	Design 2	Design 3	Design 4
Safety	30	2	9	2	9
R x Weight		60	270	60	270
Ease of Use	20	8	9	6	9
R x Weight		160	180	120	180
Portability	20	5	3	2	8
R x Weight		100	60	40	160
Durability	10	8	8	6	8
R x Weight		80	80	60	80
Standard Parts	10	7	7	8	8
R x Weight		70	70	80	80
Cost	10	6	5	7	8
R x Weight		60	50	70	80
Total	100	530	710	430	850

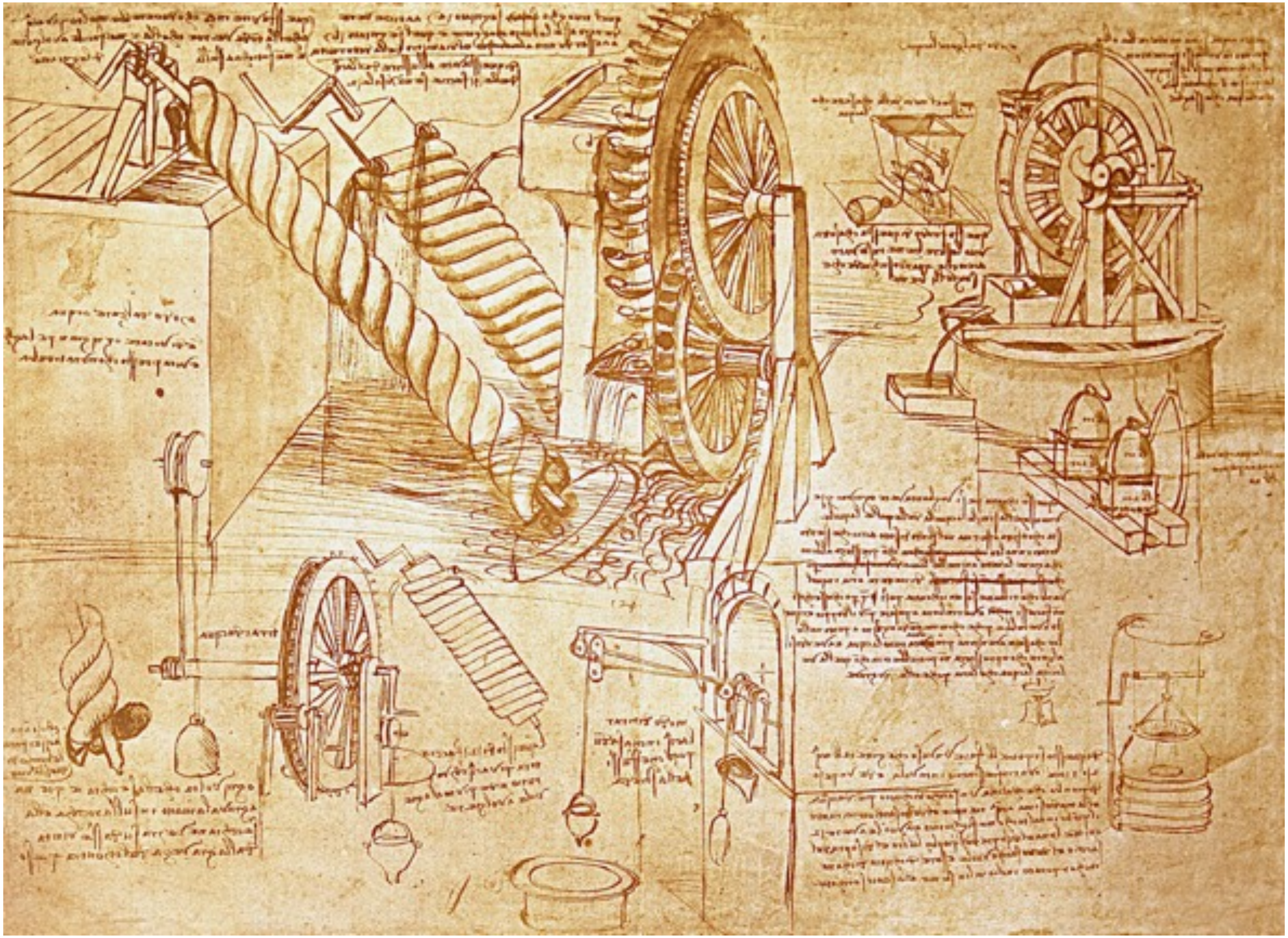
Seyyed Khandani, ENGINEERING DESIGN PROCESS, 2005, www.saylor

6. Develop the Solution

- Development involves the refinement and improvement of a solution, and it continues throughout the design process, often even after a product ships to customers.

Methods of Development

- Drawings
- Modeling: scale model, computer model, ...
- Prototyping
- Storyboards
- Analysis, Running the Numbers



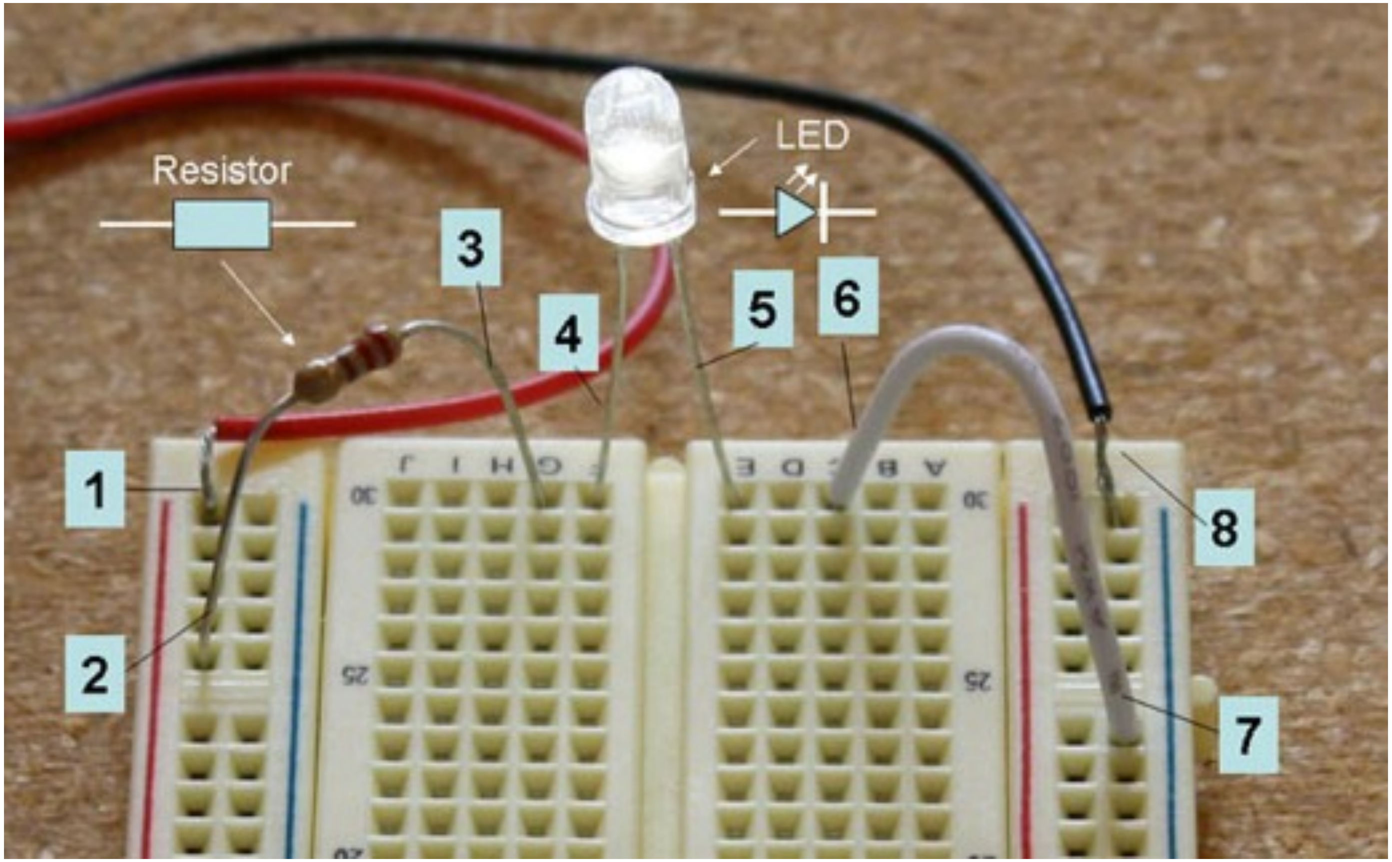
a 1503 page from Leonardo da Vinci's notebooks depicts his work on water wheels and Archimedes pumps

www.sciencebuddies.org

7. Build a Prototype

- A prototype is an operating version of a solution.
- Often it is made with different materials than the final version, and generally it is not as polished.
- Prototypes are a key step in the development of a final solution, allowing the designer to test how the solution will work.

Electronic prototype using breadboard



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Apple's hardware setup for testing early prototype iPhone software

www.macrumors.com/2014/03/26/secret-ios-room/

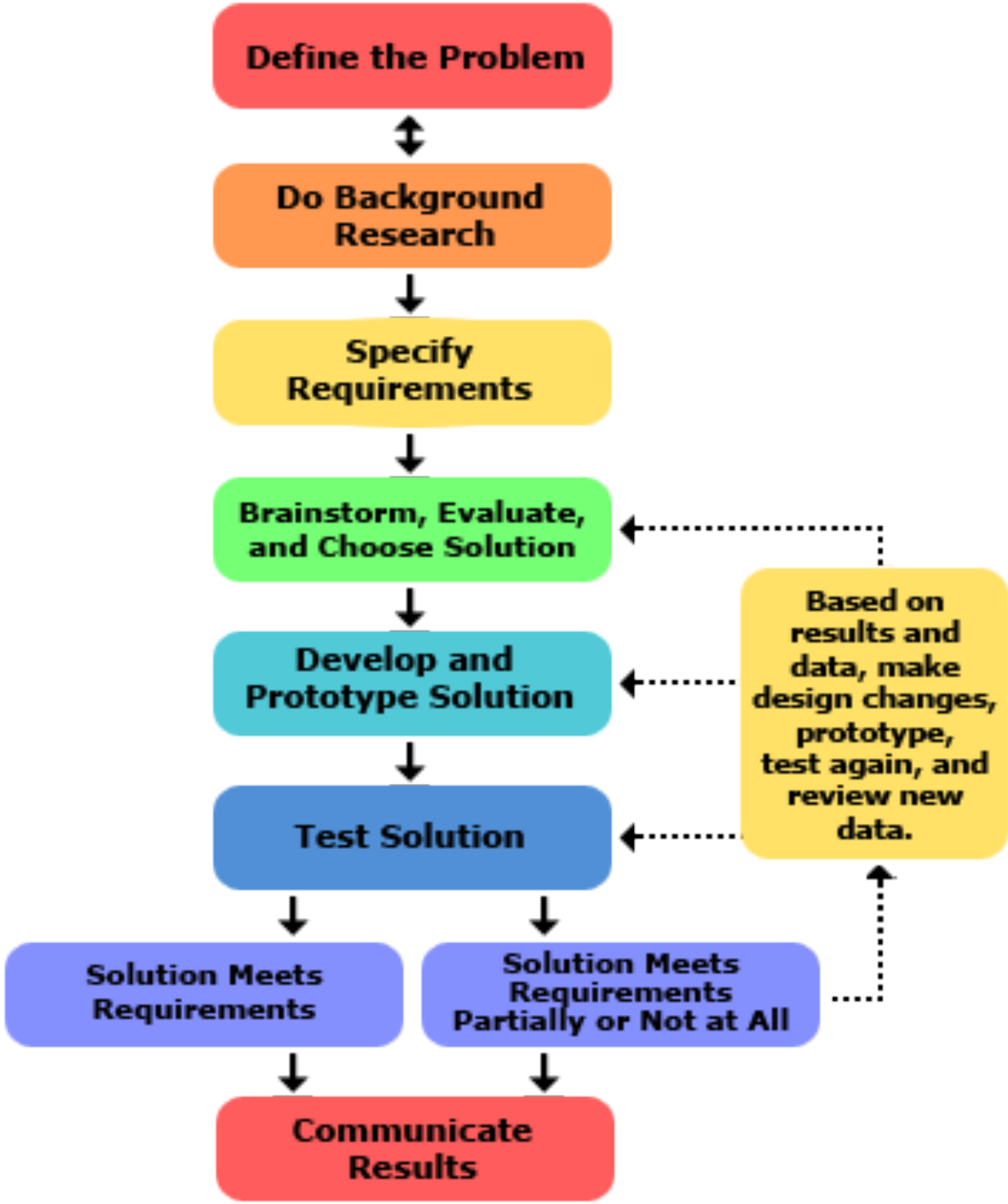
8. Test and Redesign

- The design process involves multiple iterations and redesigns of your final solution.
- You will likely test your solution, find new problems, make changes, and test new solutions before settling on a final design.

9. Communicate Results

- To complete your project, communicate your results to others in a final report and/or a display board.
- Professional engineers always do the same, thoroughly documenting their solutions so that they can be manufactured

Engineering Method



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