CPE/EE 322
Engineering Design VI
Lesson 1: Overview

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Outline

1. Definitions of engineering
2. The engineering design process
3. Nth-generation designs
4. Current practices in engineering design
5. Writing technical reports
6. Teamwork
7. The value of perseverance in design

Objectives

[G. Voland, Engineering by Design, Chapter 1]

- Identify some of the attributes that an engineer should possess to be successful
- Describe the stages of the engineering design process used to develop innovative solutions to technical problems
- Explain why engineers must be methodical when solving technical problems
- Discuss the reasons for current practices in engineering such as life-cycle design, design for manufacturing and assembly, design for quality, faster design cycles, engineering without walls, and design for export
- Explain why modern engineers often work in teams and why it is important to maintain a working environment of mutual trust, accountability, and respect
- Explain why engineering design and the study of engineering requires that we be patient and diligent in our work even if no apparent progress is visible on the surface, and that we persevere until success finally is achieved
- Explain the need for technical reports to be well organized and well written, and describe the general format often used for such reports

Lab 1 — GHDL and GTKWave

- Go to the [GitHub repository] of Digital System Design (DSD)
  - Study VHDL and GHDL
- Go to the [GHDL] folder
  - Install GHDL and GTKWave
  - Run the Half Adder example
  - Run another example such as D Flip-Flop or 4-to-1 Multiplexer
  - Document the results on your GitHub repository
- Exploration: [Icarus Verilog]

Assignment 1 — Project Site

Group Assignment

- Open Chrome browser and go to the course site
- Click "i" at the bottom left to select "Google Sites"
- Click "+" at the bottom right to create a new site
- Enter site name and page title, and click "Publish" at top right
    - Enter Web address with only lowercase letters, numbers, and dashes
    - Under "Who can view my site," click MANAGE
        - Draft — Specific people can edit
        - Published — Anyone can find and view
        - Click "Done"
    - Click "Publish"
- Submit the published Google site link via Canvas

Program Outcome 3: (Communications)
3.1 (Communication) Students will be able to write technical reports with sufficient clarity and accuracy.

Definitions of Engineering

- Engineering is the profession in which a knowledge of the mathematical and natural science, gained by study, experience, and practice, is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind
- An innovative and methodical application of scientific knowledge and technology to produce a device, system, or process, which is intended to satisfy human needs

Definitions of Engineer

- Engineers, as practitioners of engineering, are professionals who invent, design, analyze, build, and test machines, complex systems, structures, gadgets and materials to fulfill functional objectives and requirements while considering the limitations imposed by practicality, regulation, safety, and cost
- The word engine derives from the root of the word ingenious
- Pre-industrial weapons of war were called siege engines, and knowledge of how to construct them was often treated as a military secret
- Civil engineering is defined to distinguish non-military engineering from military engineering

Industry 4.0

Industry 4.0

	Year	Industrial Revolution
1.0	1784	Water- and steam-powered mechanical production facilities
2.0	1870	Electrically powered mass production based on division of labor
3.0	1969	Electronic and information technology systems that further automate production
4.0	2010	Cyber-physical systems (CPS), the internet of things (IoT), cloud computing, and cognitive computing

Engineering vs. Inventing

Engineering

- Engineers should always be methodical in their work and able to apply scientific principles as needed
- Engineers seek to solve a specific technical problem in the best possible manner even if this solution neither new nor patentable

Inventing

- Inventors may neither follow a methodical approach nor apply scientific knowledge
- Inventors seek to develop a new and usually patentable idea

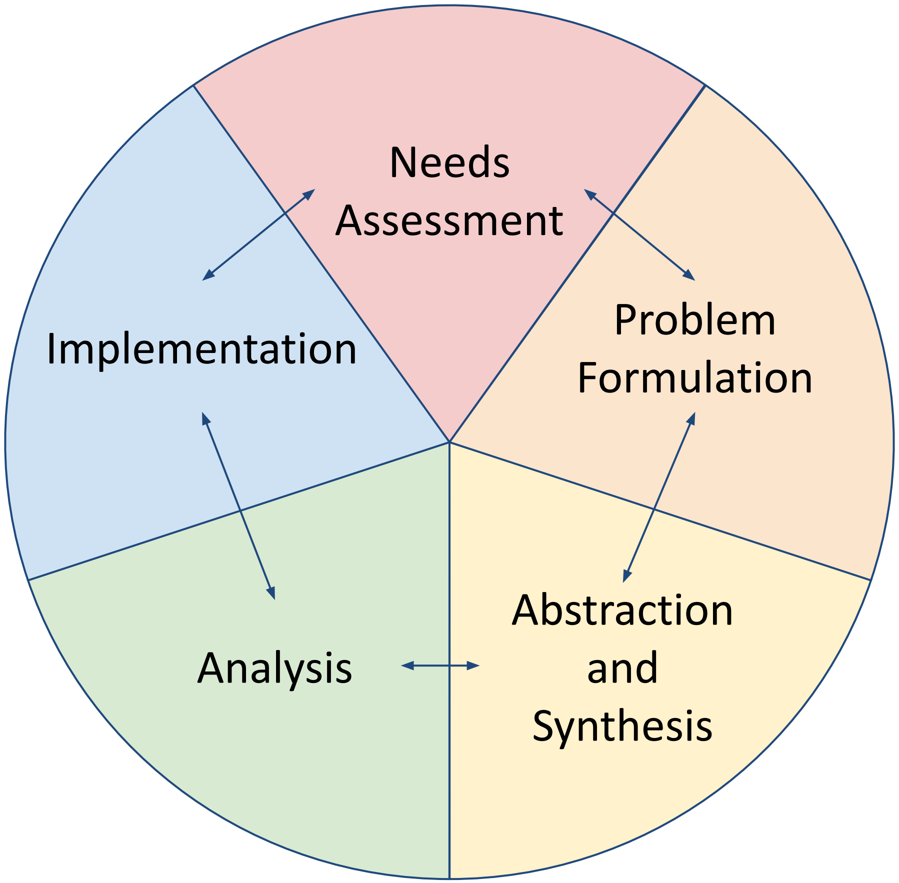
Ten Attributes of Engineers

1. Problem-solving skills
2. Effective communication skills
3. Highly ethical and professional behavior
4. An open mind and positive attitude
5. Proficiency in math and science
6. Technical skills
7. Motivation to continue learning
8. Knowledge of business strategies and management practices
9. Computer literacy
10. Understanding of world affairs and cultures

Meaning in an Engineering Career

- Engineers find the meaning of their career in the mundane, not in success and glamour
- Engineers feel a stronger sense of purpose when contribute to something bigger than themselves
- Engineers who see their occupations as an opportunity to serve their immediate community find more meaning in their work, regardless of income or responsibility
- Engineers don't have to change the world or find one's true purpose to lead a meaningful career
- A meaningful career is something anyone can aspire to, no matter their dreams or circumstances

Engineering Design Process



Phase 1: Needs Assessment

First establish the need for a solution

1. Identify the objectives to be achieved by a solution
2. Identify who will benefit from the solution
   In what ways?
   How do you know?
3. Begin with the end in mind; know where you are going

Phase 2: Problem Formulation

Define the real problem to be solved in the form of design goals to achieve by any viable solution

1. Does the real problem differ from the problem as initially perceived or presented and in what ways?
2. What or who was the source of the original problem statement? Did this source bias the statement in some way because of a unique perspective? If so, is the statement then incorrect or incomplete? In what ways?
3. Structure the search for a solution; identify as many different pathways leading to possible solutions as you can
4. Acquire and apply technical knowledge as appropriate; one must make informed and knowledgeable decisions to formulate the problem correctly and completely and to structure the search for a solution
5. Identify the design specifications both explicit and implicit constraints or boundaries within which the solution must lie
6. Identify the resources such as time, money, and personnel that will be needed to obtain a solution
7. Prioritize the design goals; continually review this list and modify it as needed during the remainder of the design process; be aware that your initial prioritization may be incorrect; be open to change in your goal list; focus primarily on those goals deemed most important, but recognize that all goals should be achieved by the final solution

Phase 3: Abstraction and Synthesis

Develop abstract (general) concepts or approaches through which the problem could be solved, and then generate detailed alternative solutions or designs for the problem

1. Recall related solved problems or experiences, pertinent theories, and fundamental approaches (if any exist) to solving this type of problem
2. Expand your thinking as to what is possible and what is not possible
3. Seek to develop solutions that are fully acceptable to all involved — What approaches can be taken to solve the problem? Which of these approaches is most valid? Why?
4. Reconsider the problem statements — Is it still valid or must it be modified?
5. Be creative — use established and appropriate techniques for generating as many detailed solutions as possible
6. Combine ideas for achieving each of the individual design goals into total solutions; seek to make the whole (i.e., the complete design) greater than the sum of the parts (i.e., the individual ideas or subsolutions)
7. Once again, expand your thinking as to what is possible and what is not possible — be adaptable
8. Again reconsider the problem statement — Is it still valid or must it be modified? Does your goal list need to be modified? If so, in what way?

Phase 4: Analysis

Compare and evaluate alternative designs

1. Choose a basis for comparing your alternative design solution by establishing objective evaluation criteria
2. Be critical of your work; try to see your design objectively and recognize each of their weaknesses/shortcomings and strengths
3. Consider fabrication/implementation requirements for each solution, e.g., raw materials, standard parts, or off-the-shelf components to be used; manufacturing processes needed to shape the raw materials into final form; the impact that production, distribution, operation, and disposal of the fabricated design may have on the environment, *etc*. — compare and contrast the requirements for each proposed design
4. Are each of the proposed solution ethical in concept and operation (safe, environmentally responsible, *etc*.)?
5. Eliminate alternatives that do not satisfy critical design goals (i.e., those goals that must be satisfied for the problem itself to be solved)

Phase 4: Analysis

6. Anticipate and avoid failure or inherent hazards by eliminating weaknesses in your designs; focus on others and their needs and expectations — Are there any inherent hazards in your design? Can these hazards be eliminated or minimized?
7. Does each design alternative satisfy appropriate ergonomic requirements (human-machine system design goals and specifications)? If not, why not? Improve and refine each of your proposed designs if possible
8. Construct prototype of the most promising designs if possible and test/evaluate/refine these solutions
9. Select the best alternative from among these designs that remain as viable solutions to the problem
10. Revise and refine this best design as appropriate; eliminate or minimize weaknesses and shortcomings of the design — Can this "best" design be improved by combining it with elements from any or all of the other (rejected) alternatives?

Phase 5: Implementation

Develop the final solution and distribute it to your intended clients, customers, or users

1. After successfully fabricating, testing, and evaluating a design prototype (if such testing is possible), proceed with full production
2. Distribute to user population and obtain feedback for the next-generation design

Nth-Generation Designs

- Engineering design does not end with an optimal solution because of the compromises that one usually must make to obtain an acceptable balance among conflicting design goals
- The design process is repeated again and again as new and better solutions are developed
- List of mobile phone generations
- Comparison of mobile phone standards

Six Engineering Design Practices

1. Life-cycle design
2. Design for manufacture and assembly
3. Design for quality
4. Faster design cycles
5. Engineering without walls
6. Design for export

Elements of Export Process

- Get ready to export
  - Overview of the U.S. Export Control System
  - Export.gov managed by the International Trade Administration (ITA), the U.S. Department of Commerce
  - Export Administration Regulation (EAR)
  - Export Control Classification Number (ECCN)
  - International Traffic in Arms Regulations (ITAR)
- Plan market entry strategy
- Start finding foreign buyers
- Determine terms of payment
- Understand the steps required to successfully ship goods and complete the transaction
- Research and confirm duties, taxes, and shipping and insurance costs

IoT Systems Design Steps

IoT Chapter 5: IoT Platforms Design Methodology

1. Specify purpose and requirements
2. Specify process model or use cases
3. Specify domain model with user, physical entity, virtual entity, service, resource, and device
4. Specify information model with attributes and values of virtual entities
5. Specify service types (***web*** or ***native***), input, and output
6. Specify IoT system complexity level
7. Specify functional view with devices, communications, services, management, security, and applications
8. Specify operational view with communications, service hosting, storage, and devices
9. Integrate devices and components
10. Develop applications

Writing Technical Reports

- Need
- Purpose
- Audience
  - Submit Thesis/Dissertation
- Grammar, syntax, and punctuation
  - *IEEE Editorial Style Manual*
- Review and rewrite

Ten Most Critical Writing Problems

1. Poor organization
2. Spelling and capitalization
3. Grammar and punctuation
4. Misused words
5. Redundancy
6. Hedging (i.e., being noncommittal and unwilling to clearly state one's position on an issue)
7. Lengthy paragraphs
8. Lengthy sentences
9. Passive languages (e.g., "it is recommended that . . ." instead of "I recommend . . .")
10. Inappropriate tone

Sections of Technical Reports

- Cover Letter
- Title page
- Abstract
- Table of contents
- List of figures
- List of tables
- Introduction
- Relevant background information
- Methodology
- Alternative solutions developed
- Final design solution
- Conclusions
- Recommendations
- References
- Bibliography
- Appendices

Teamwork

Technical problems can be quite complex, often requiring broad interdisciplinary solutions by people working together effectively in teams to develop innovative solutions quickly and efficiently

1. Common goals
2. Equitable workloads
3. Mutual accountability
4. Collegial environment
5. Being effective as a team member
6. Being effective as a team leader
7. Successful meetings
8. Maintaining strong communication linkages

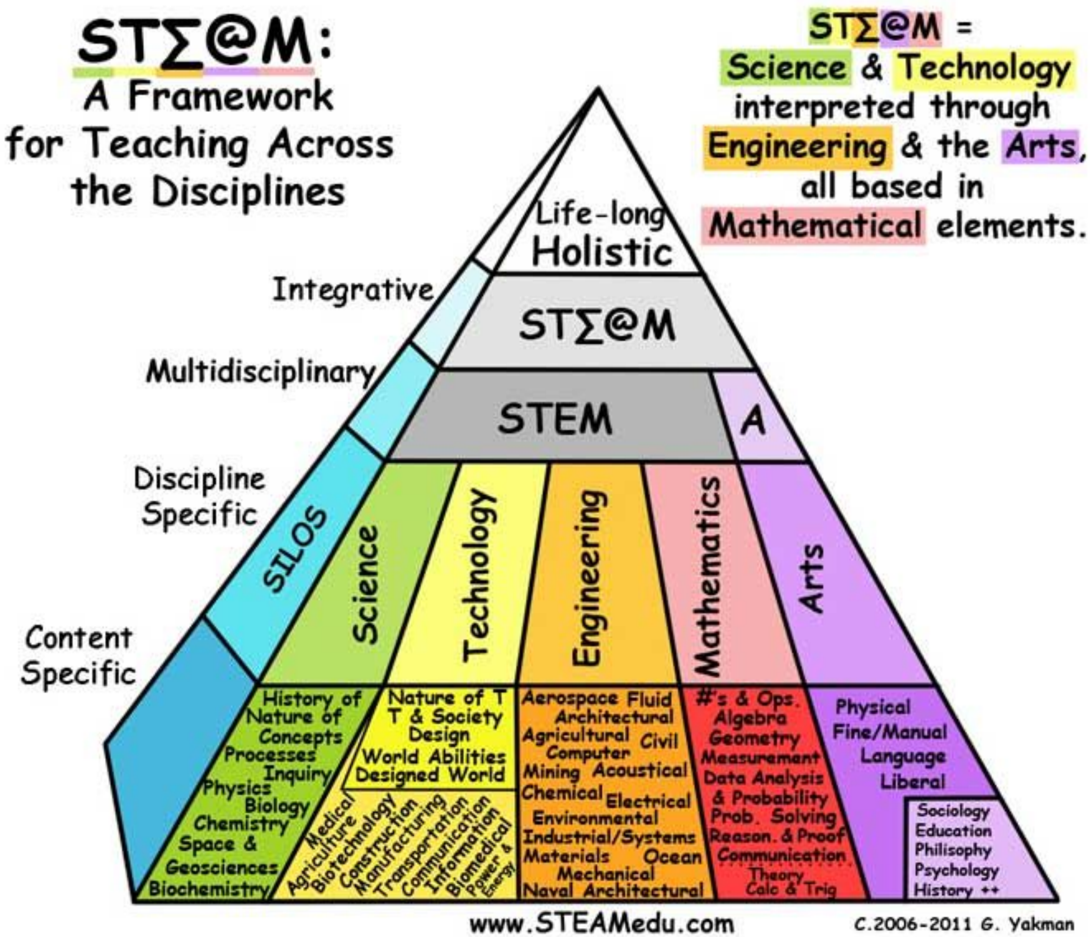
Value of Perseverance in Design

- One can master engineering design only through practice with patience, diligence, and perseverance
- All engineers must work within deadlines and other constraints; projects seldom succeed without significant levels of dedication and commitment by engineers
- As engineers acquiring a robust understanding of a problem, developing a solution may appear slow or even absent; skipping certain tasks to accelerate progress can have negative impact on the final design

Lesson 1 Summary

- Reflect on the ten attributes of engineers
- Deepen the understanding of each engineering design phase
- Nth-generation design efforts allow one to iteratively refine and improve a technical solution to a problem
- Reflect on the six engineering practices
- Technical reports must be well organized and written to serve the need of the intended audience
- Teamwork requires mutual trust, accountability, and respect among all members
- Successful engineering design require patience, diligence, and perseverance

STEM + Arts = STEAM



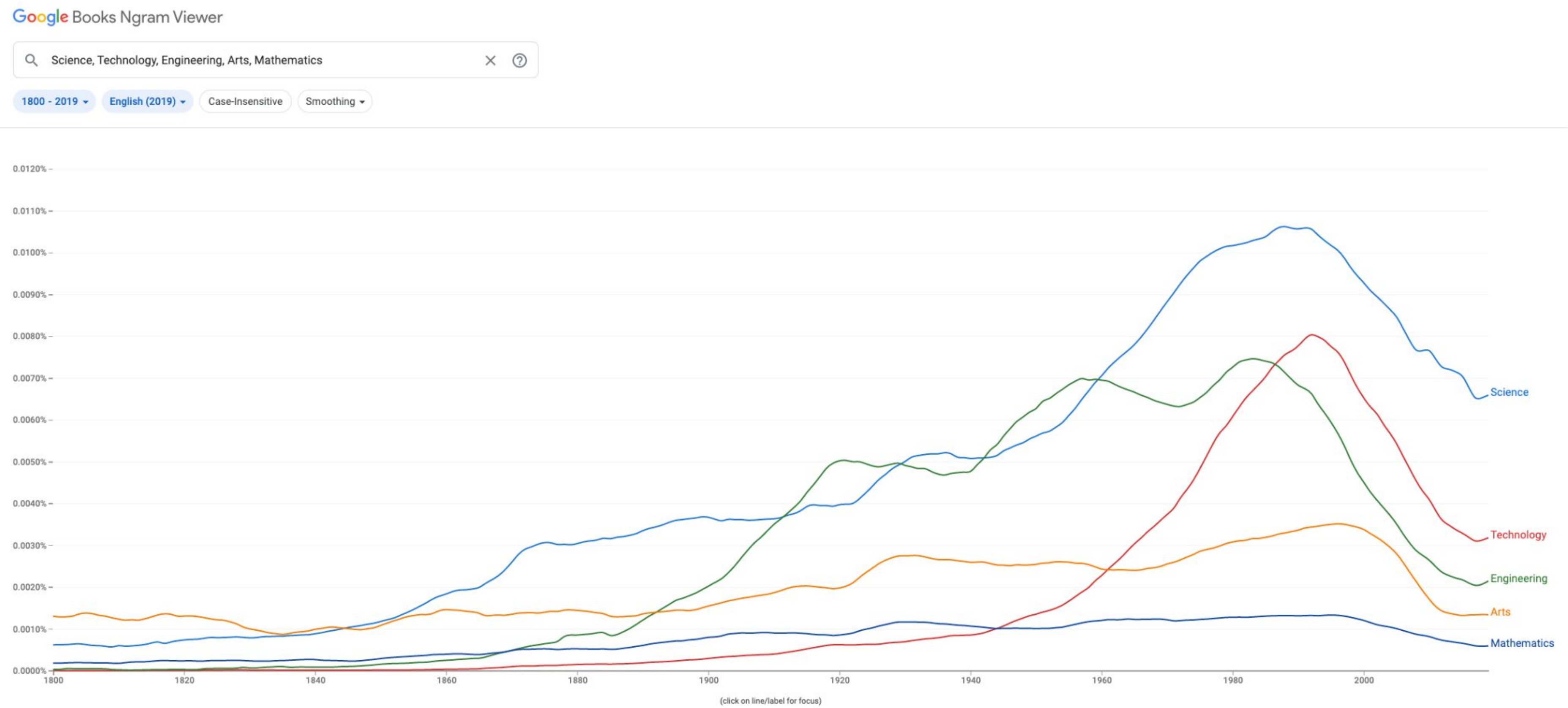
Georgette Yakman developed the [STEAM](#) education framework in 2006, adding arts to the [STEM](#) (science, technology, engineering, and mathematics) curriculum by drawing on design principles and encouraging creative solutions

[STEAM education](#) process:

1. Investigate
2. Discover
3. Connect
4. Create
5. Reflect

A Picture Is Worth 500 Billion Words

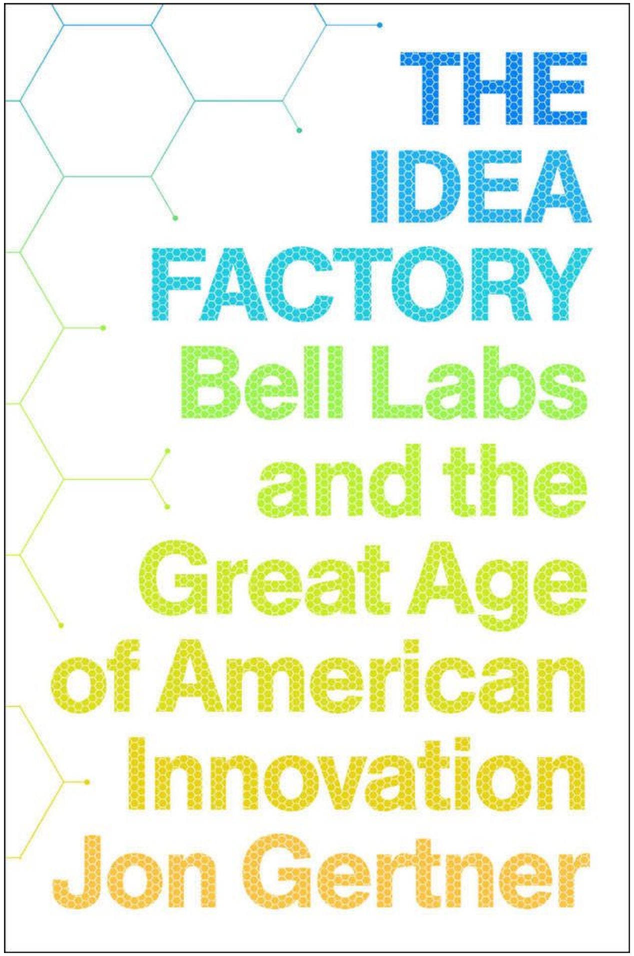
[Google Books Ngram Viewer]



Digital Twin

[Digital Twin]

The Inventors of the Transistor



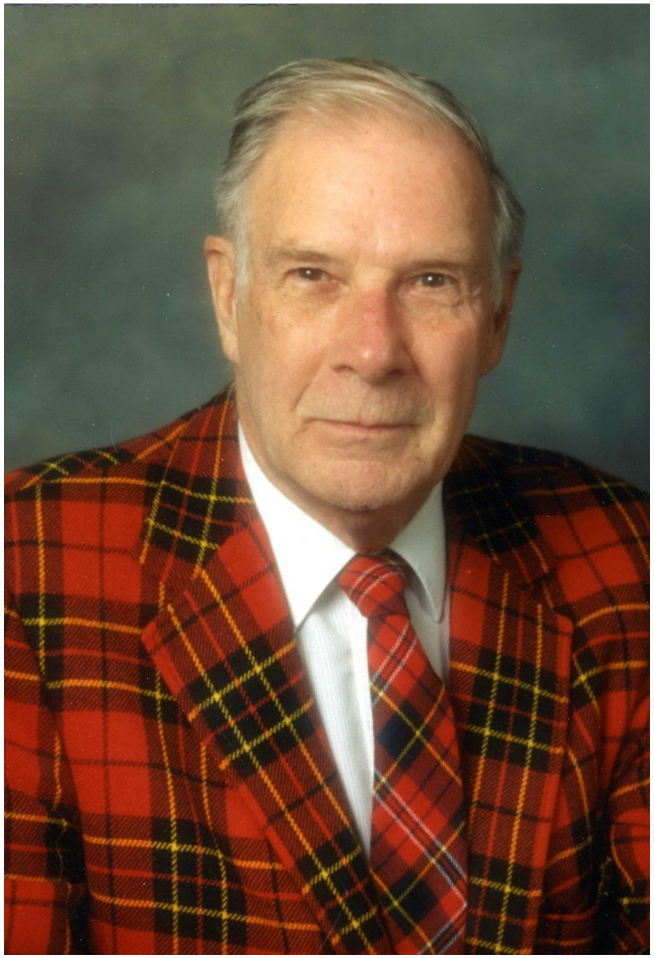
Jon Gertner, "True Innovation," The New York Times 2012-02-25
"Bell Labs: A Hive of Invention," The New York Times 2012-02-26

John Bardeen 1908—1991, William Shockley 1910—1989, and Walter Brattain 1902—1987, the inventors of the transistor, 1948

Eponyms and Namesakes

- An eponym is a person, place, or thing for whom or for which something is named, or believed to be named
- A namesake is a person named after another, or a thing (such as a company, place, ship, building, or concept) named after a person
- Engineering and Technology History Wiki (ETHW)
- Alexander Graham Bell 1847—1922
  - Bell Labs
- Sidney Darlington 1906—1997
  - Darlington transistor or Darlington pair
- Ralph Hartley 1888—1970 and Claude Shannon 1916—2001
  - Shannon-Hartley theorem
- Richard Hamming 1915—1998
  - Hamming bound, Hamming code, Hamming distance, and Hamming window
- Brian Kernighan, Dennis Ritchie 1941—2011, and Kenneth Thompson
- Stephen Bourne, Brian Fox, and David Korn
  - Bourne shell, Bourne again shell (Bash), and Korn Shell

Richard W. Hamming 1915—1998



- Richard Wesley Hamming was an American mathematician whose contributions include the Hamming code that makes use of a Hamming matrix, the Hamming window, Hamming numbers, sphere-packing or Hamming bound, and the Hamming distance
- He shared an office for a time with Claude Shannon 1916—2001 at the Bell Labs where its Mathematical Research Department also included John Tukey 1915-2000
- Transcript of his 1986-03-07 speech at Bellcore Colloquium Seminar and video of his 1995-06-06 lecture at Naval Postgraduate School on "You and Your Research," in *The Art of Doing Science and Engineering: Learning to Learn*, 1997 [PDF], chapter 30, pp. 209-215

Modes of Persuasion

The modes of persuasion include

- Ethos is how well the presenter convinces the audience that the presenter is qualified to speak on the subject
- Pathos is most effective when the author or speaker demonstrates agreement with an underlying value of the reader or listener
- Logos is normally used to describe facts and figures that support the speaker's claims or thesis
- Kairos is used to persuade the audience to act now

ARCADIA

- ARCADIA (ARChitecture Analysis and Design Integrated Approach), created by Thales in 2007, is a system and software architecture engineering method, based on architecture-centric and model-driven engineering activities to break the "walls" between different engineering specializations
- In the development cycle of a system, former practices focused more on the definition of requirements, their allocation to each component of the system component and associated traceability
- Current approaches rather focus on functional analysis, system design, justification of architectural choices and verification steps
- The design takes into account not only the functional point of view, but also other points of view, which affect the definition and breakdown of the system
- For example, constraints relating to system integration, product line management, safety, performance, and feasibility
- Systems engineering is therefore not just about managing the system requirements, but is a complex design activity

Teaming Dynamics

- As a defence against the cold, a colony of emperor penguins forms a compact huddle ranging in size from ten to several hundred birds, with each bird leaning forward on a neighbour
- As the wind chill is the least severe in the center of the colony, all the juveniles are usually huddled there
- Those on the outside upwind tend to shuffle slowly around the edge of the formation and add themselves to its leeward edge, producing a slow churning action, and giving each bird a turn on the inside and on the outside

Shared Leadership

- Geese learned V-formation flying from each other
- It isn't just about staying in the right place
- It's also about flapping at the right time
- Geese at the back of the V have slower heart rates than those in the front, and flapped less often
- Geese rotate leadership

- Hierarchical leadership resides predominantly with an individual
- Shared leadership broadly allocates leadership responsibility such that people within a team lead each other

Strengths and Contributions

Sled dog racing involves the timed competition of teams of sled dogs that pull a sled with the musher standing on the runners

- Lead dogs apply the musher's commands, set the pace, and ensure correct direction
- Swing dogs ensure the team follows turns initiated by the lead dogs
- Team dogs pull the sled and help maintain speed
- Wheel dogs play the crucial role of pulling and steering the sled

Henry M. Robert 1837—1923

- In 1876, Henry Martyn Robert published the first edition of his manual of parliamentary procedure, Robert's Rules of Order
- It is a guide for conducting meetings and making decisions as a group
- The current edition of the series became effective on September 23, 2011 under the title *Robert's Rules of Order Newly Revised* (*RONR*), Eleventh Edition
- In 2004, a shorter reference guide, *Robert's Rules of Order Newly Revised In Brief* (abbreviated *RONRIB*), was published in accord with the Tenth edition of RONR
- A second edition of *RONRIB* was published in 2011 to conform with the current Eleventh Edition of *RONR*

RONR

1	The Deliberative Assembly: Its Types and Their Rules	11	Quorum; Order of Business and Related Concepts
2	The Conduct of Business in a Deliberative Assembly	12	Assignment of the Floor; Debate
3	Description of Motions in All Classification	13	Voting
4	Meeting and Session	14	Nominations and Elections
5	The Main Motion	15	Officers; Minutes and Officers' Reports
6	Subsidiary Motions	16	Boards and Committees
7	Privileged Motions	17	Mass Meetings; Organization of a Permanent Society
8	Incidental Motions	18	Bylaws
9	Motions That Bring a Question Again Before the Assembly	19	Conventions
10	Renewal of Motions; Dilatory and Improper Motions	20	Disciplinary Procedures

RONRIB

1	The "Why and Wherefore" of Meeting Rules	11	How Are Rules Enforced and How Are They Suspended?
2	What Happens at a Meeting?	12	Looking Up the Rules: How to Use RONR
3	How Decisions Are Made at a Meeting: Handling Motions	13	Frequently Asked Questions
4	Debate	14	A Summary of Motions
5	Amendments	15	President or Vice-President
6	Postponing and Referring to a Committee	16	Secretary
7	How Can a Group Change Its Mind	17	Treasurer
8	Voting	18	Board Member
9	Nominations and Elections	19	Committee Chairman or Member
10	What Are the Basic Types of Rules?	20	Convention Delegate or Alternate