THINKING LIKE AN ENGINEER

AN ACTIVE LEARNING APPROACH

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MORE WISE WORDS: HOW DID YOU CHOOSE A MAJOR IN COLLEGE?

Since I knew I wanted to design computers, I had a choice between electrical and computer engineering. I chose computer engineering so I could learn about both the hardware and software. It was my interests in computers and my high school teachers that were the biggest influence in my decision.

E. D'Avignon, CpE

My first choice in majors was Mechanical Engineering. I changed majors after taking a drafting class in which I did well enough to get a job teaching the lab portion, but I did not enjoy the work. After changing to Electrical and Computer Engineering, I took a Statics and Dynamics course as part of my required coursework and that further confirmed my move as I struggled with that material.

A. Flowerday, EE

I was interested in aerospace engineering, but chose to pursue mechanical engineering, a broader field, that would keep more job options available to me upon graduation. I knew that I could place an emphasis on aerospace within my undergraduate degree, or pursue it further with a graduate degree. I chose ME because I thought it would give me a solid engineering background with a lot of flexibility for change in my future career.

M. Long, ME

Coming into college, I knew I wanted to pursue a career in medicine after graduation. I also knew that I did not want to major in chemistry, biology, etc. Therefore, bioengineering was a perfect fit. It provides a challenging curriculum while preparing me for medical school at the same time. In addition, if pursuing a career in medicine does not go according to plan, I know that I will also enjoy a career as a bioengineer.

D. Walford, BioE

1.3 CHOOSING A SPECIFIC ENGINEERING FIELD

Use multidisciplinary experience to help develop and commercialize new bioelectronic technologies and products; Invent new devices and technologies; Prepare presentation graphics and information; Coordinate with the FDA; Help implement Good Manufacturing Practices, compiling engineering files for products prior to sales launch.

J. Kronberg, EE

The following paragraphs briefly introduce several different types of engineering majors. By no means is this list completely inclusive.

Bioengineering (BioE) or Biomedical Engineering (BME)

BioE and BME apply engineering principles to the understanding and solution of medical problems. Bioengineers are involved in research and development in all areas of medicine, from investigating the physiological behavior of single cells to designing implants for the replacement of diseased or traumatized body tissues. Bioengineers design new instruments, devices, and software, assemble knowledge from many scientific sources to develop new procedures and conduct research to solve medical problems.

Typical bioengineers work in such areas as artificial organs, automated patient monitoring, blood chemistry sensors, advanced therapeutic and surgical devices, clinical laboratory design, medical imaging systems, biomaterials, and sports medicine.

I work with scientists and engineers to protect their innovations by writing patent applications describing their inventions and presenting the applications before the United States Patent & Trademark Office. I also assist clients in determining whether another party is infringing their patents and help my clients to avoid infringing other's patents.

M. Lauer, Environmental Engineer

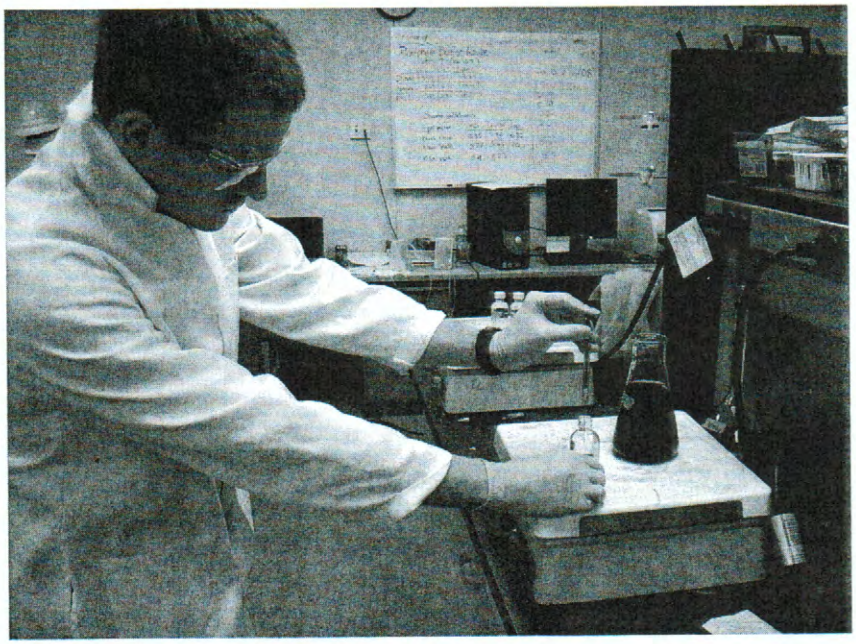
Bioengineers are employed in universities, industry, hospitals, research facilities, and government. In industry they may be part of a team serving as a liaison between engineers and clinicians. In hospitals, they select appropriate equipment and supervise equipment performance, testing, and maintenance. In government agencies, they are involved in safety standards and testing.

Biosystems Engineering (BE)

BE is the field of engineering most closely allied with advances in biology that intersect with engineering, including the biological production of pharmaceutical drugs and biofuels (hydrogen, ethanol) and design of biological machines, biosensors, and even biological batteries. Scientific emphasis is shifting toward the biosciences. Biosystems engineers participate in the application of these biotech advances to man's daily life in areas ranging from environment to medical sciences to agriculture.

Here are some activities of Biosystems Engineers:

- Design bioprocesses and systems for biopharmaceutical, bioplastics, biofuels, and food processing industries
- Develop sites and designs for storm water and sedimentation abatement
- Protect environmental quality and natural resources through environmental remediation/engineering
- Provide engineering expertise for agriculture, food production, and manufacturing
- Provide engineering support for biotechnology and biomedical activities
- Pursue medical or veterinary school or graduate school in wide range of disciplines



My research is part of a Water Research Foundation project which is investigating the formation of emerging disinfection byproducts in drinking water treatment.

Disinfection byproducts (DBPs) are undesirable, toxic compounds that are formed when water is chlorinated. I am investigating the effects of pH, bromide and iodide concentrations, and preoxidants on the formation of a specific family of DBPs.

D. Jones, BE

I am a project manager for new product development.

I oversee and coordinate the various activities that need to be completed in order to get a new product approved and manufactured, and ultimately in the hands of our consumers.

S. Forkner, ChE

Chemical Engineering (ChE)

ChE incorporates strong emphasis on three sciences: chemistry, physics, and mathematics. Chemical engineers are involved in the research and development, manufacture, sales, and use of chemicals, pharmaceuticals, electronic components, food and consumer goods, petroleum products, synthetic fibers and films, pulp and paper, and many other products. They work on environmental remediation and pollution prevention, as well as in medical and health-related fields. Chemical Engineers:

- Conduct research and develop new products; develop and design new manufacturing processes
- Earn additional degrees to practice medicine or patent, environmental, or corporate law
- Sell and provide technical support for sophisticated chemical products to customers
- Solve environmental problems; work in biotechnology
- Troubleshoot and solve problems in chemical manufacturing facilities

My team is responsible for implementing the engineered design in the field.

We install, tune, test, and accept into operations all of the electronics that allow customers to use our state of the art fiber optic network to run voice, video, and data for their residential needs.

L. Gascoigne, CE

My current responsibilities include

- Analysis of traffic signal operations and safety for municipal and private clients;
- Preparation of traffic impact studies;
- Review of plans and traffic studies for municipalities and counties;
- Design of traffic signal installations and traffic signing projects.

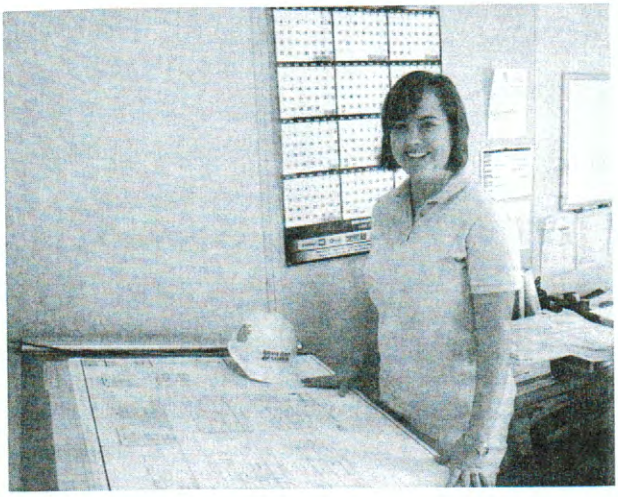
C. Hill, CE

Civil Engineering (CE)

CE involves the planning, design, construction, maintenance and operation of facilities and systems to control and improve the environment for modern civilizations. This includes projects of major importance such as bridges, transportation systems, buildings, ports, and water distribution systems.

Here are just a few of many opportunities available for CEs:

- Design and analyze structures ranging from small buildings to skyscrapers to offshore oil platforms
- Design dams and building foundations; develop new materials for pavements, buildings, and bridges
- Design improved transportation systems
- Design water distribution and removal systems
- Develop new methods to improve safety, reduce cost, speed construction, and reduce environmental impact
- Provide construction and project management services for large engineered projects throughout the world



I am responsible for assisting in the management of commercial and healthcare projects for Brasfield & Gorrie. Working closely with the owner and architect, I maintain open lines of communication and aim to provide exceptional service to the entire project team from the preconstruction phase of the project through construction. I assist in establishing and monitoring procedures for controlling the cost, schedule, and quality of the work in accordance with the construction contract.

L. Edwards, CE

I develop, manage, and support all software systems. I also deal with system scalability, customer satisfaction, and data management.

J. Comardelle, CpE

Computer Engineering (CpE)

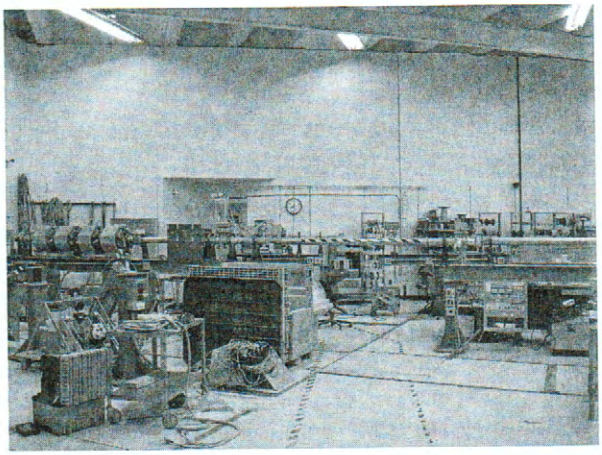
CpE spans the fields of computer science and engineering, giving a balanced view of hardware, software, hardware-software tradeoffs, and basic modeling techniques that represent the computing process involving the following technologies:

- Communication system design
- Computer interface design
- Computer networking
- Digital signal processing applications
- Digital system design
- Imbedded computer design
- Process instrumentation and control
- Software design

Digital designer working on the read channel for hard disk drives. The read channel is the portion of the controller SOC (system on a chip) that decodes the analog signal read from the hard disk and converts it to digital data.

I am responsible for writing Verilog RTL code, verification, synthesis into gates, and meeting timing requirements of my blocks.

E. D'Avignon, CpE



As a Radiation Effects Engineer I test the performance of electronic components in a specific application exposed to different types of radiation. Responsibilities include interfacing with design and system engineers, creating test plans, performing testing and data analysis, and authoring test reports.

A. Passman, EE

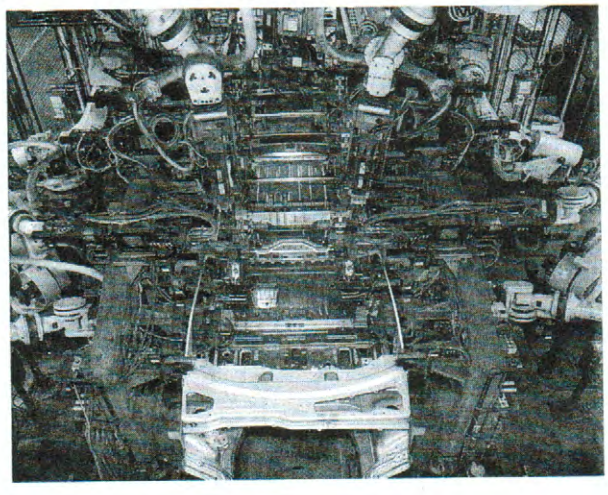
I manage global programs that help develop leadership capabilities and skills of our current and future leaders. I am a consultant, a coach, a mentor, and a guide. If leaders are interested in improving how they lead and the impact they have on their employees and on company results, we work with them to identify the best ways for them to continue their development.

A. Hu, EE

Electrical Engineering (EE)

EE ranges from the generation and delivery of electrical power to the use of electricity in integrated circuits. The rapid development of technology, based on integrated circuit devices, has enabled the pervasive use of computers in command, control, communication, and computer-aided design. Some systems Electrical Engineers work on include:

- Communication system design
- Control systems—from aircraft to automotive
- Electrical power generation and distribution
- Electromagnetic waves
- Integrated circuit design
- Process instrumentation and control
- Robotic systems design
- Telecommunications



My group supports [a major automotive manufacturer] decisions pertaining to where to put new plants around the world, what products to build in them, and at what volumes.

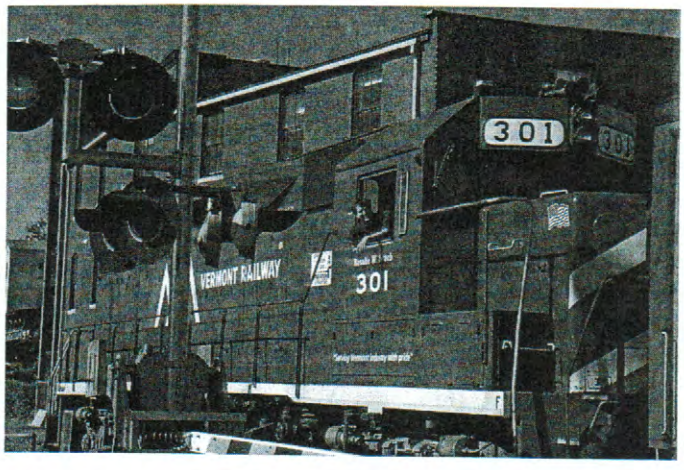
In particular, my work involves understanding what the other auto manufacturers are planning for the future (footprint, capacity, technology, processes, etc.), so that information can be used to affect decisions about how to compete around the globe.

M. Peterson, EE

Industrial Engineering (IE)

IE deals with the design and improvement of systems, rather than with the objects and artifacts that other engineers design. A second aspect of industrial engineering is the involvement of people in these systems—from the people involved in the design and production to the people who are ultimate end users. Industrial engineers use mathematical, physical, social sciences and engineering, combined with the analytical and design methods to design, install, and improve complex systems that provide goods and services to our society. Industrial Engineers are involved in:

- Analyze and model complex work processes to find system improvements
- Analyze how combinations of people and machines work together
- Analyze how the surroundings affect the worker, and design to reduce the negative effects of this environment
- Develop mathematical and computer models of how systems operate and interact
- Improve production and service processes from the perspectives of quality, productivity, and cost
- Work on teams with other professionals in manufacturing, service industries, government agencies



My primary job responsibilities include maintaining, upgrading, and designing all the computer systems and IT infrastructure for the Vermont Railroad. I handle all the servers and take care of network equipment. When needed, I also program customized applications and websites for customers or our own internal use. I also serve as a spare conductor and locomotive engineer when business needs demand.

S. Houghton, CpE

As the Business Leader for Central Florida at a major power company, I develop and manage a $42 million budget. I ensure that our engineering project schedule and budget match, and report on variances monthly. I also conduct internal audits and coach employees on Sarbanes-Oxley compliance requirements.

R. Holcomb, IE

Currently I am working on a project to determine patient priorities for evacuations from healthcare facilities during emergencies. The assumption of an evacuation is that there will be enough time to transfer all of the patients, but in the event of limited resources, there may not be enough time to move all of the patients to safety. Further—and depending on the emergency type—it may be an increased risk to transport some patient types. Based on certain objectives, we are developing guidelines to most ethically determine a schedule for choosing patients for emergency evacuations.

A. Childers, IE

Material Science Engineering (MSE)

MSE focuses on the manufacture and study of materials. Nature supplied only 92 naturally occurring elements to serve as building blocks to construct all modern conveniences. A Materials Engineer works to unlock the relationship between atomic, molecular, and larger-scale structure and the resultant properties. This category includes majors such as Ceramic Engineering or Metallurgical Engineering.

Here is a partial list of products designed and manufactured by MSE:

- Brick, tile, and whitewares research and manufacturing for the home and workplace
- Ceramic spark plugs, oxygen sensors, and catalytic converters that optimize engine performance
- Insulating tiles that keep the extreme heat of launch and reentry away from the space shuttle astronauts
- Metal and ceramic materials that enable biomedical implants and prosthetics
- Microwave ceramics that stabilize and filter cellular phone reception
- Superconducting ceramics that provide zero-loss transfer of electricity over great distances
- Ultra-pure glass optical fibers that carry telephone conversations and Internet communications

Consulting Metallurgical Engineer, duties include

- Consulting firm management/administration
- Failure analysis;
- Subcontracted metals testing services;
- Metallurgical quality systems design/auditing;
- Metallurgical expert in litigation cases; and
- Materials selection and design consultant, in-process and final inspection and testing services.

E. Basta, Metallurgical Engr

Implement technology to protect national assets against adversaries.

J. Dabling, ME

Mechanical Engineering (ME)

ME involves areas related to machine design, manufacturing, energy production and control, materials, and transportation. Areas supported by Mechanical Engineers include:

- Construction
- Energy production and control
- Environmental systems
- Food production
- Management
- Materials processing
- Medicine
- Military service
- Propulsion and transportation systems
- Technical sales

In my job as a management consultant, I address CEO-level management decisions as part of a project team by helping clients identify, analyze and solve business-related problems. My responsibilities include generating hypotheses, gathering and analyzing data, conducting benchmarking and best practices assessments, recommending actions, and working with clients to develop implementation plans.

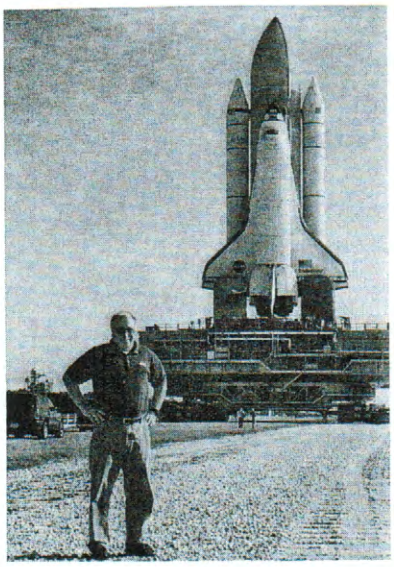
M. Cuica, ME

As Plant Engineering Manager I report directly to the Plant Manager. My primary responsibilities are managing all the capital investments; providing technical support and expertise to the plant leadership team; and mentoring and developing the plant's engineering staff and technical resources.

J. Huggins, ME

I am a salesman, so at the end of the day I'm looking to grow my market share while trying to protect the market share I already have. I help companies maintain a safe, reliable, and efficient steam and condensate system by utilizing the many products and services that we have to offer. This is mostly done by designing and installing upgrades and improving my customer's existing steam systems.

T. Burns, ME



I am an aerospace engineering manager responsible for developing unique astronaut tools and spacewalk procedures and for testing and training for NASA's Hubble Space Telescope servicing missions. My job ranges from tool and procedure design and development to underwater scuba testing to real-time, on-console support of Space Shuttle missions.

R. Werneth, ME

WISE WORDS: WHAT DID YOU DO YESTERDAY MORNING AT WORK?

I worked on completing a failure analysis report for an industrial client.

E. Basta, CME

I reviewed the results of the overnight simulation runs. There were several failures, so I analyzed the failures and devised fixes for the problems.

E. D'Avignon, CpE

On any given day, my morning might be spent this way: in meetings, at my computer (e-mail, drafting documents/reports), making phone calls, talking to other project members, running a test on the manufacturing lines. Not glamorous, but necessary to solve problems and keep the project moving forward.

S. Forkner, ChE

I continued to design a 150′ x 120′ warehouse/office building on a nuclear expansion project.

T. Hill, CE

Yesterday morning I started the day by checking and responding to e-mail. I then designed a spreadsheet to assist in more precisely forecasting monthly expenditures.

R. Holcomb, IE

I attended the Plant Morning Meeting and the Boardmill Leadership Team Meeting, following by the Plant Budget Meeting. In between meetings I returned e-mails and project-related phone calls. Typically I spend about 50% of my time in meetings. I use the information I receive at these meetings to direct and focus the efforts of the engineering staff.

J. Huggins, ME

Testing some failed prototype biostimulators returned by a trial user, to determine why and how they failed and how to prevent it from happening in coming production versions.

J. Kronberg, EE

Yesterday, I worked on a patent infringement opinion involving agricultural seeding implements, a Chinese patent office response for a component placement and inspection machine used in circuit board manufacturing, and a U.S. patent office response for database navigation software.

M. Lauer, Enviro E

In my current position, I spend much of my time reading technical manuals and interface control documents. I attended a meeting detailing lightning protection for the Ares rocket.

E. Styles, EE

Table 1-1 Sample career paths and possible majors. Shaded boxes indicate a good starting point for further exploration.

CAREERS	ENGINEERING										SCIENCE				
	Aerospace	Bioengineering	BioSystems	Civil	Chemical	Materials	Electric/computer	Environmental	Industrial	Mechanical	Chemistry	Computer Science	Geology	Mathematics	Physics
GENERAL															
Energy Industry				■	■		■	■		■	■		■		■
Machines		■					■		■	■					
Manufacturing					■	■	■		■	■					
Materials	■	■		■	■	■					■				
Structures	■			■		■			■	■			■		
Technical Sales		■	■	■	■	■	■		■	■		■			■
SPECIFIC															
Rocket/airplane	■			■		■	■			■					■
Biomedical		■								■	■				
Coastal Engineering			■	■	■			■					■		
Computing							■					■		■	
Cryptography							■					■		■	
Defense	■	■		■	■		■		■	■		■		■	
Environment			■	■	■			■						■	■
Fiber optics						■	■						■		
Forensics					■		■				■	■			
Groundwater			■	■	■			■					■		
Human Factors	■								■	■		■			
Industrial Sensors	■				■		■		■						
Intelligent Systems		■					■					■		■	
Management	■	■	■	■	■	■	■	■	■	■					
Operations Research									■			■		■	
Outdoor Work			■	■				■					■		
Pharmaceutical		■	■		■						■				
Plastics					■	■				■	■				
Robotics	■						■			■					
Semiconductors	■					■	■		■						■
Telecommunications	■					■	■					■		■	
Transportation				■				■	■	■			■		
Waste Management			■	■	■			■							

Table 1-2 Website research starting points

Society	Abbreviation
American Ceramic Society	ACerS
Association for Computing Machinery	ACM
Audio Engineering Society	AES
American Institute of Aeronautics and Astronautics	AIAA
American Institute of Chemical Engineers	AIChE
American Nuclear Society	ANS
American Society of Agricultural and Biological Engineers	ASABE
American Society of Civil Engineers	ASCE
American Society for Engineering Education	ASEE
American Society of Metals International	ASM Int'l.
American Society of Mechanical Engineers	ASME
Biomedical Engineering Society	BMES
Engineers Without Borders	EWB
Institute of Biological Engineering	IBE
Institute of Electrical and Electronics Engineers	IEEE
Institute of Industrial Engineers	IIE
Institute of Transportation Engineers	ITE
Materials Research Society	MRS
National Academy of Engineers	NAE
National Society of Black Engineers	NSBE
National Society of Professional Engineers	NSPE
Society of Automotive Engineers International	SAE Int'l.
Society of Hispanic Professional Engineers	SHPE
Society of Petroleum Engineers	SPE International
Society of Plastics Engineers	SPE
Society of Women Engineers	SWE
Tau Beta Pi, The Engineering Honor Society	TBP