What Does "Introduction to Engineering" Mean?

Dr. Kenneth Reid

Acting Department Head

Assistant Dept. Head, Undergraduate Programs

Engineering Education

Virginia Tech

Ninth Annual (FYEE)

First Year Engineering Experience Conference

Enhancing the First Year of Engineering Education

Daytona Beach, FL


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- What does “Introduction to Engineering” mean?

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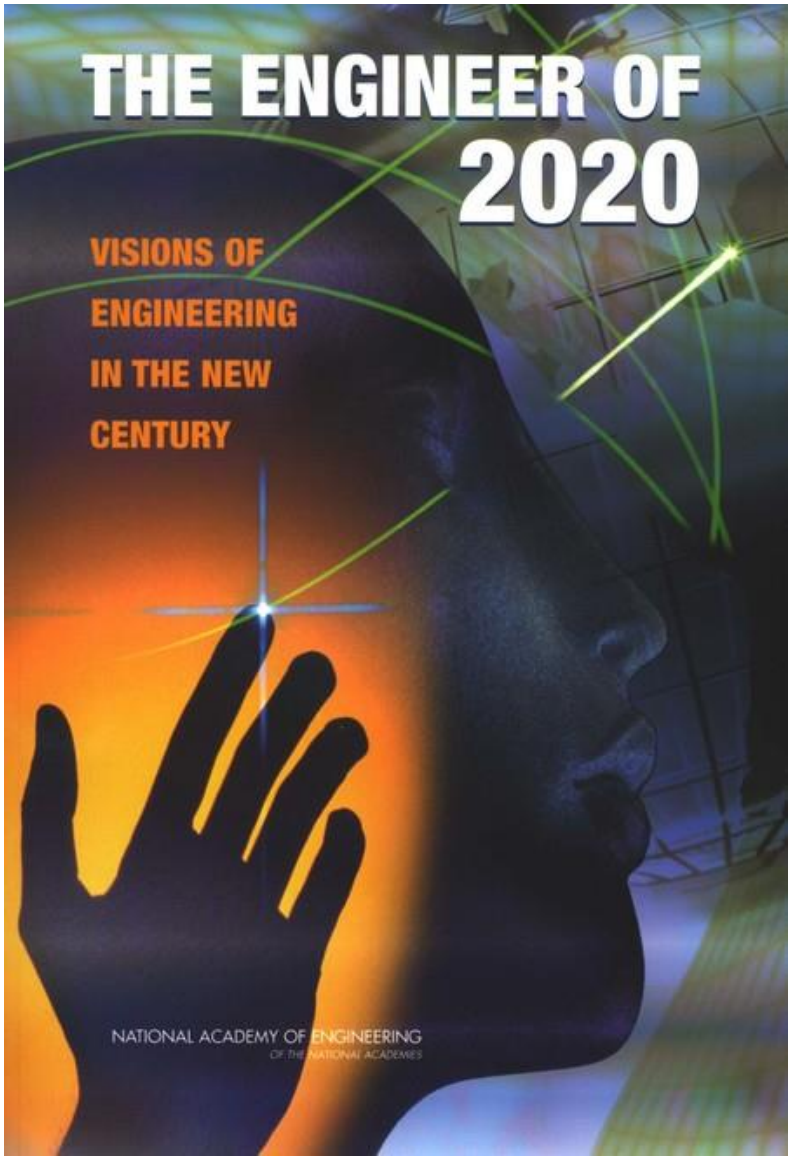
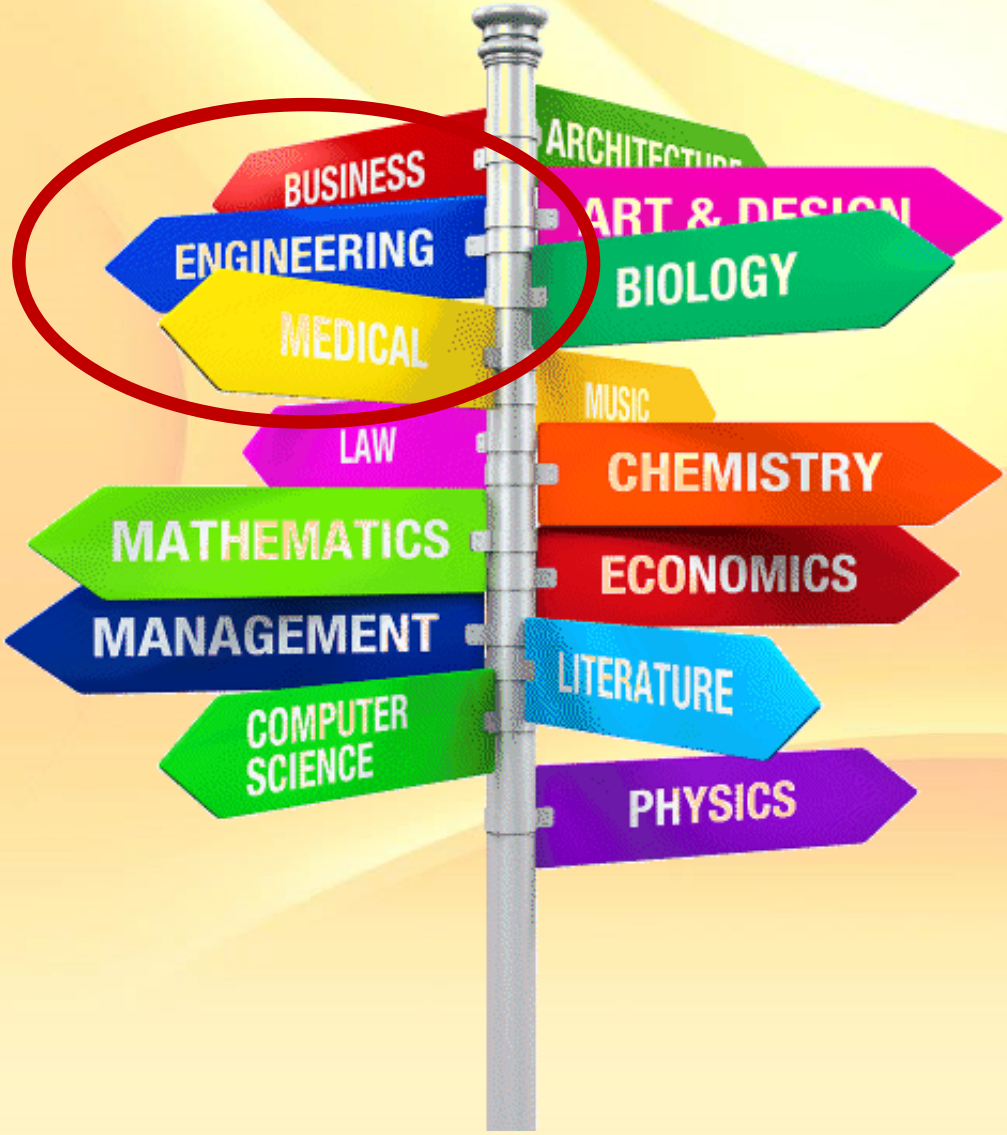
- Home to all **general engineering** students
- Build competencies through a common curriculum
- Discover and explore engineering disciplines
- Enrich and grow engineering fundamentals



- Strong analytical skills
- Practical ingenuity
- Creativity
- Communication
- Leadership
- Professional Ethics
- Dynamism, agility, resilience, flexibility
- Lifelong Learning

First Year Courses

ENGE 1215/1216	Foundations of Engineering
ENGL 1105/1106	First Year Writing
MATH 1225/1226	Calculus of a Single Variable
CHEM 1035/1045	General Chemistry & Lab
PHYS 2305	Foundations of Physics & Lab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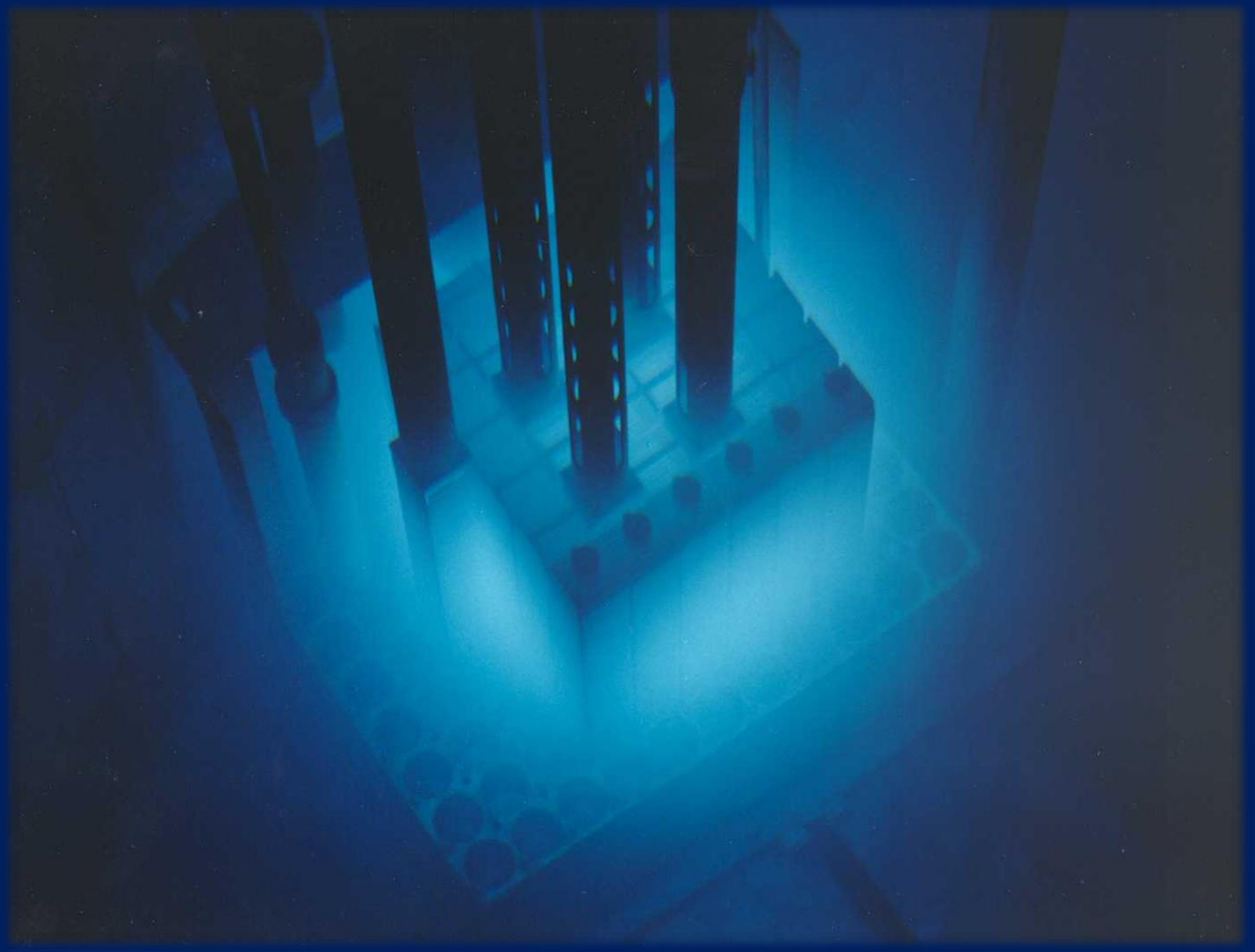

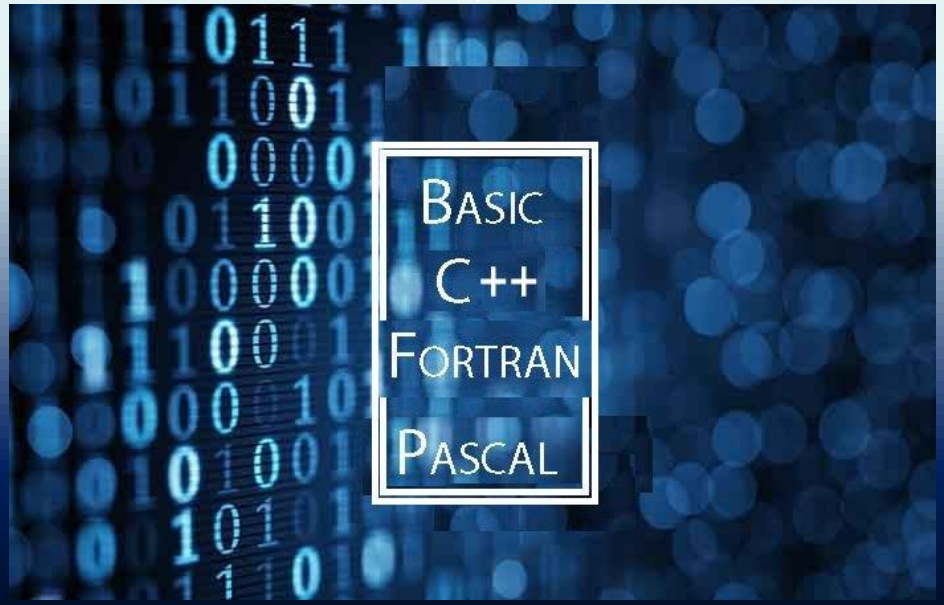
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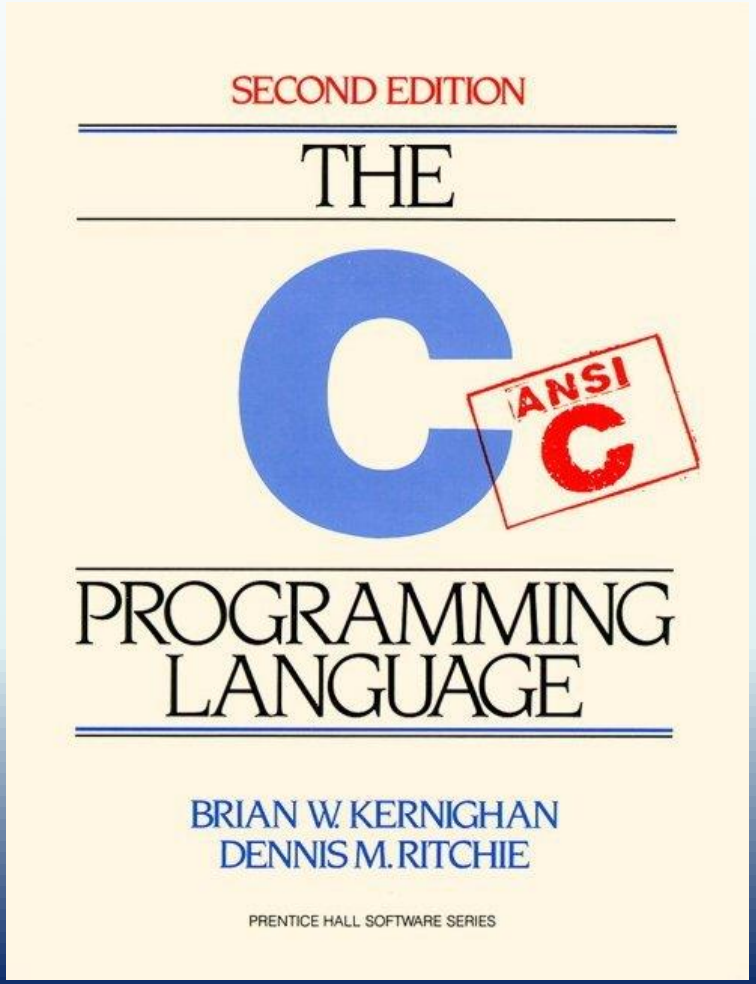
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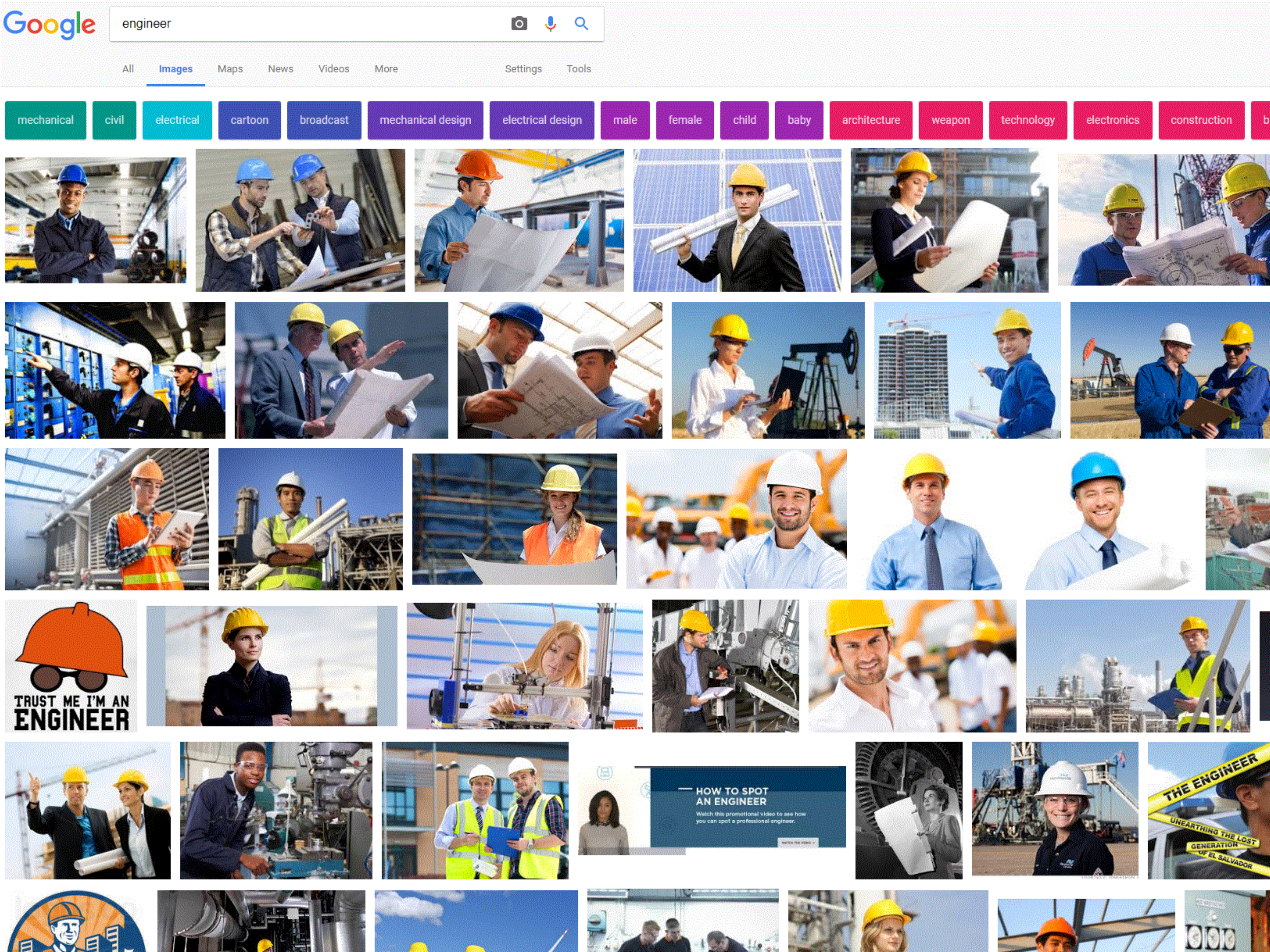
- What does “Engineering” mean?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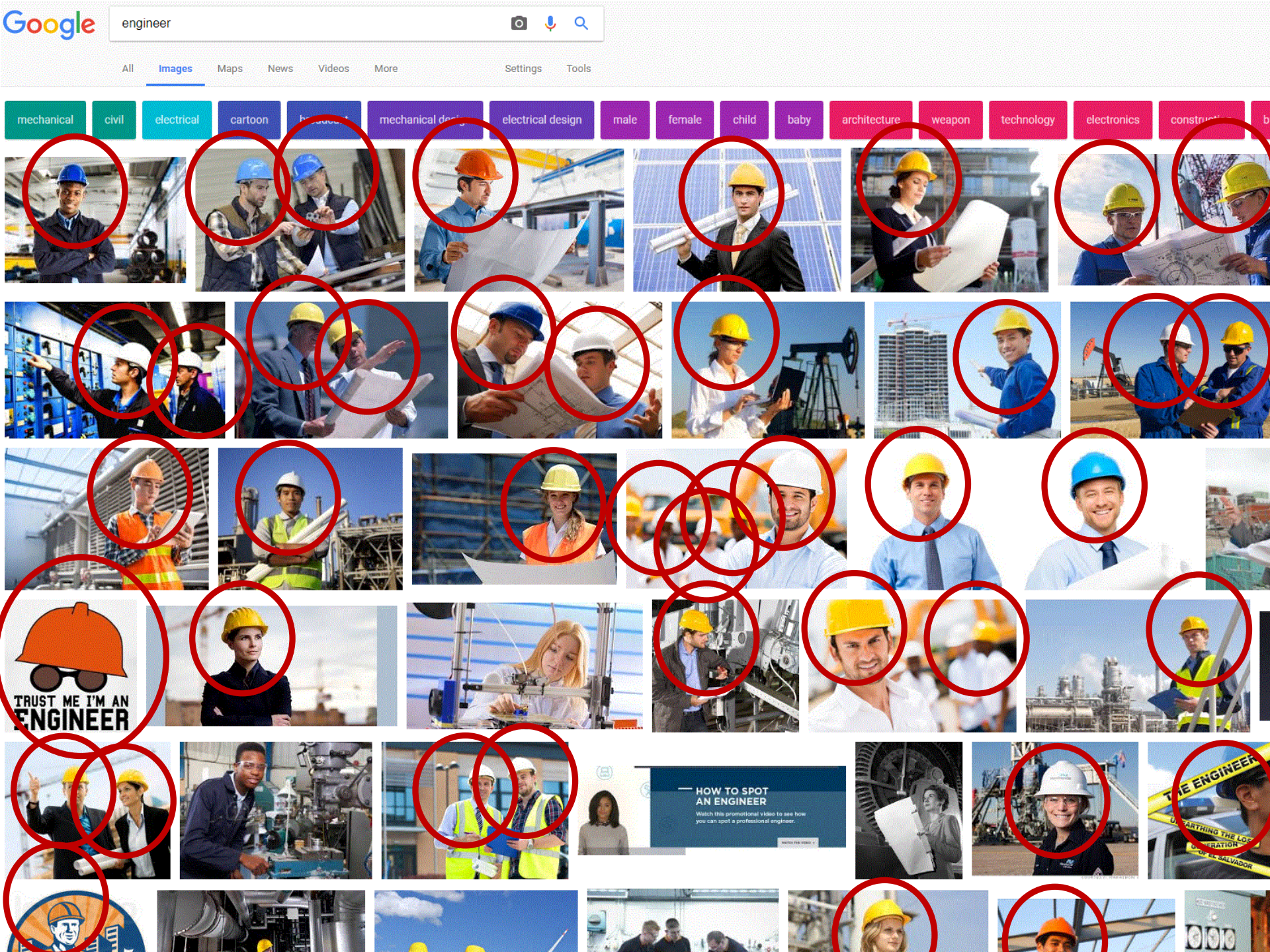
THE ENGINEER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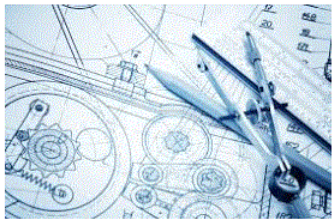
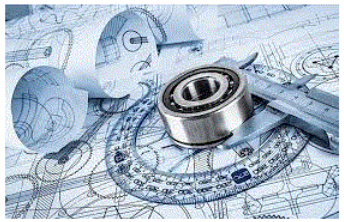
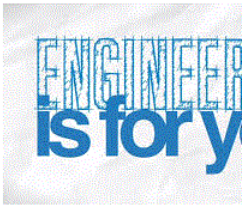
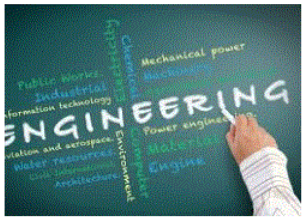
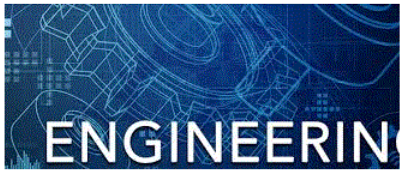
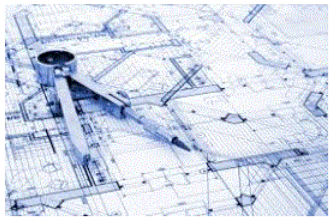


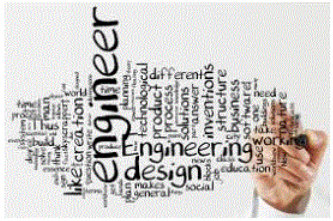





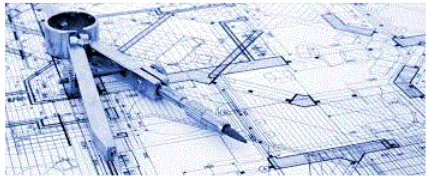
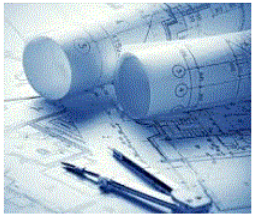
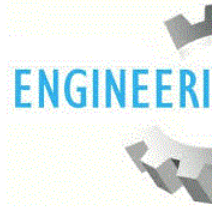


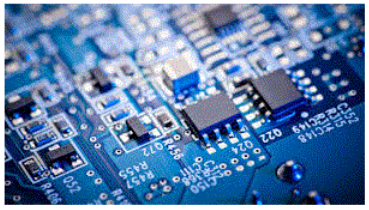


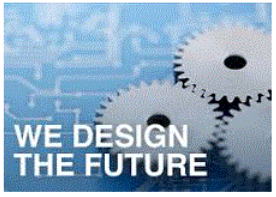


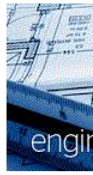


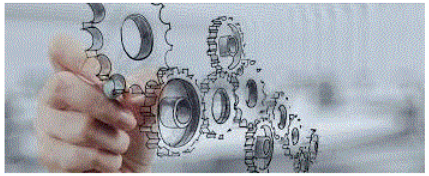
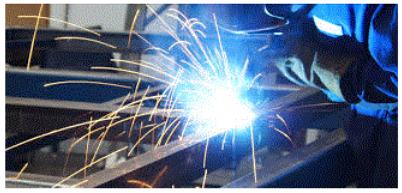


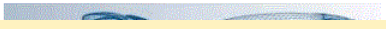








SPACEX
8:58
Heather
INCOMING CALL

9.16 Analyze the operation of the counter shown in Figure 9.108. Predict the count sequence by determining the J and K inputs and resulting transitions for each counter output state. Draw the state diagram and the timing diagram. Assume that all flip-flop outputs are initially 0.

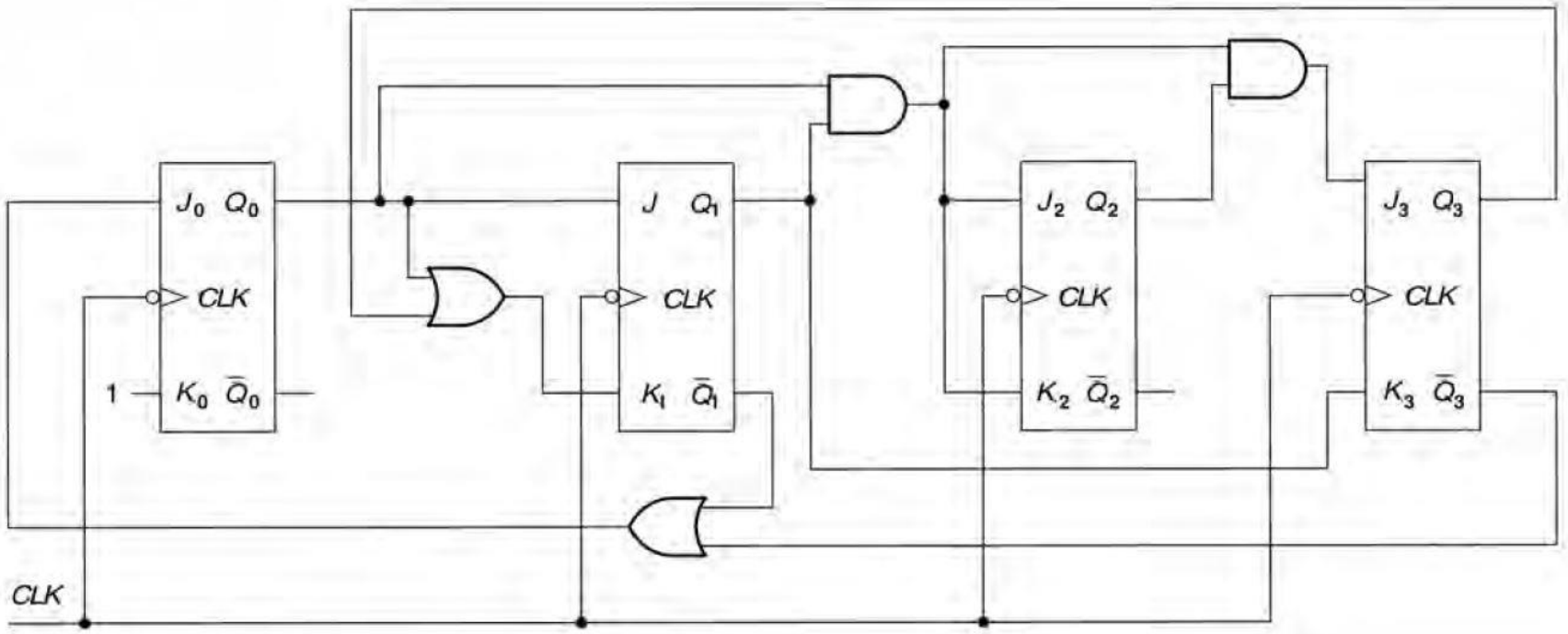
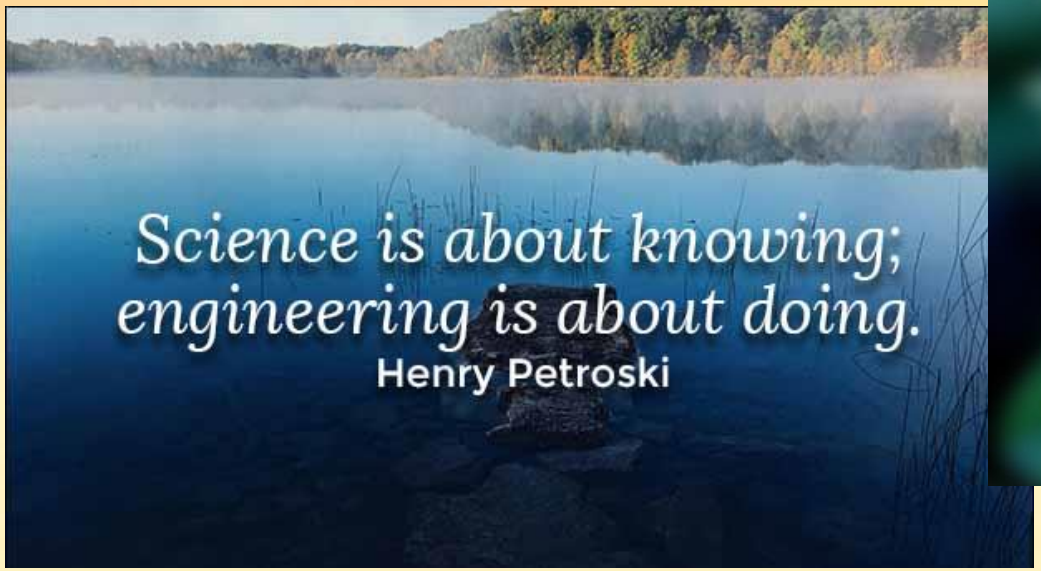


FIGURE 9.108 Problem 9.16: Counter

If it isn't based in vector calculus, it's not engineering. There is no engineering in K-12

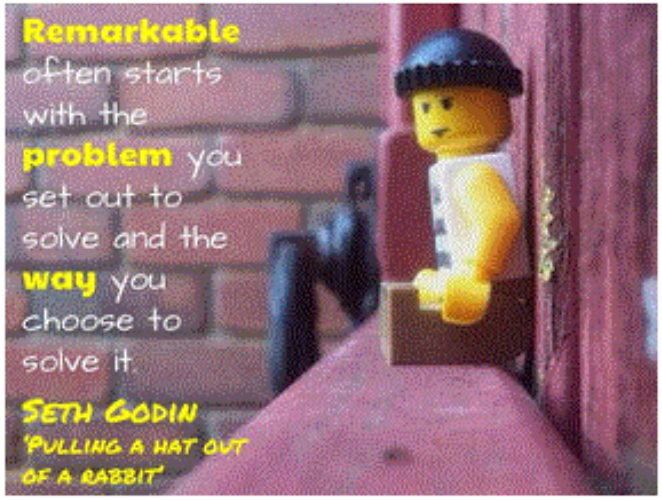
- a colleague



What is Engineering

DISCIPLINES DEGREES CAREERS WHAT IS? ABOUT

What is Engineering? – The Definition



Engineering is the application of scientific knowledge to solving problems in the real world. While science (physics, chemistry, biology, etc.) allows us to gain an understanding of the World and the Universe, Engineering enables this understanding to come to life through problem solving, designing and building things. The electronic device you are using to read this article was engineered from raw plastic, metal, silicon and lines of software code before being transformed into a usable device. Pretty cool!

engineer girl

ENGINEERS | WHAT THEY DO | HOW TO GET THERE

NATIONAL ACADEMY OF ENGINEERING

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INTERVIEWS
DAY IN THE LIFE

I'M AN ENGINEER

Women engineers work every day to shape the future and make the world a better, cleaner, safer place. These women are also actively involved in their communities, raising families, and enjoying all kinds of sports and hobbies.

Do you know someone who would make a great addition to this group of professionals? Recommend her for the Directory of Women Engineers, and we will send her a personal invitation.

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If you're looking to find more info about engineering and meet students like you, you've come to the right place. This blog is all about the latest and greatest in engineering, so come on in and take a look around. Go directly to the latest news by clicking here.

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10 Reasons to Love Engineering

Overview
10 Reasons to Love Engineering
Career Outlook
Engineering Careers
What Engineers Do
Cool Engineering Projects
Conversation Starters
Test Drive Engineering
Preparing for College
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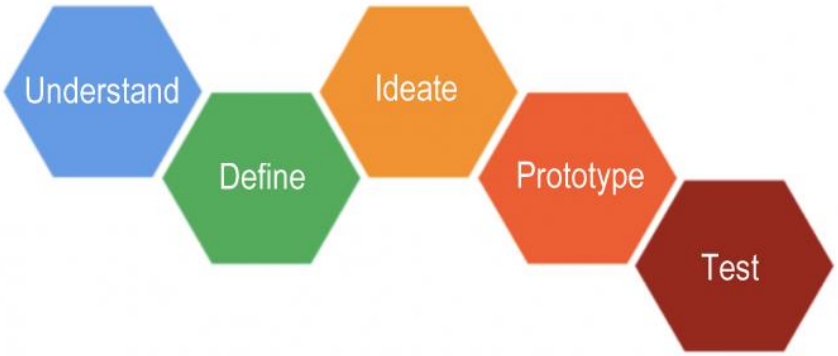
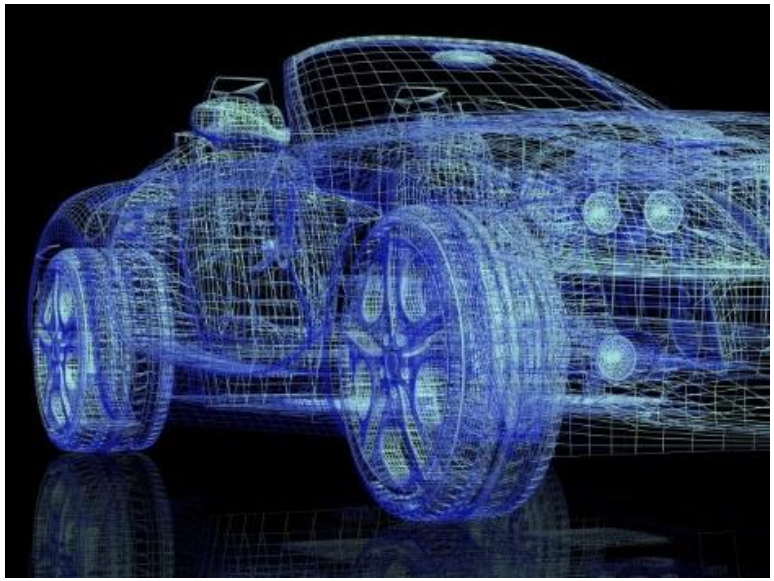
1. Love your work, and live your life too! Show More
2. Be creative Show More
3. Work with great people Show More
4. Solve problems, design things that matter Show More
5. Never be bored Show More
6. Earn a big salary Show More
7. Enjoy job flexibility Show More
8. Travel Show More
9. Make a difference Show More
10. Change the world Show More

- What does “Engineering” mean?

Design



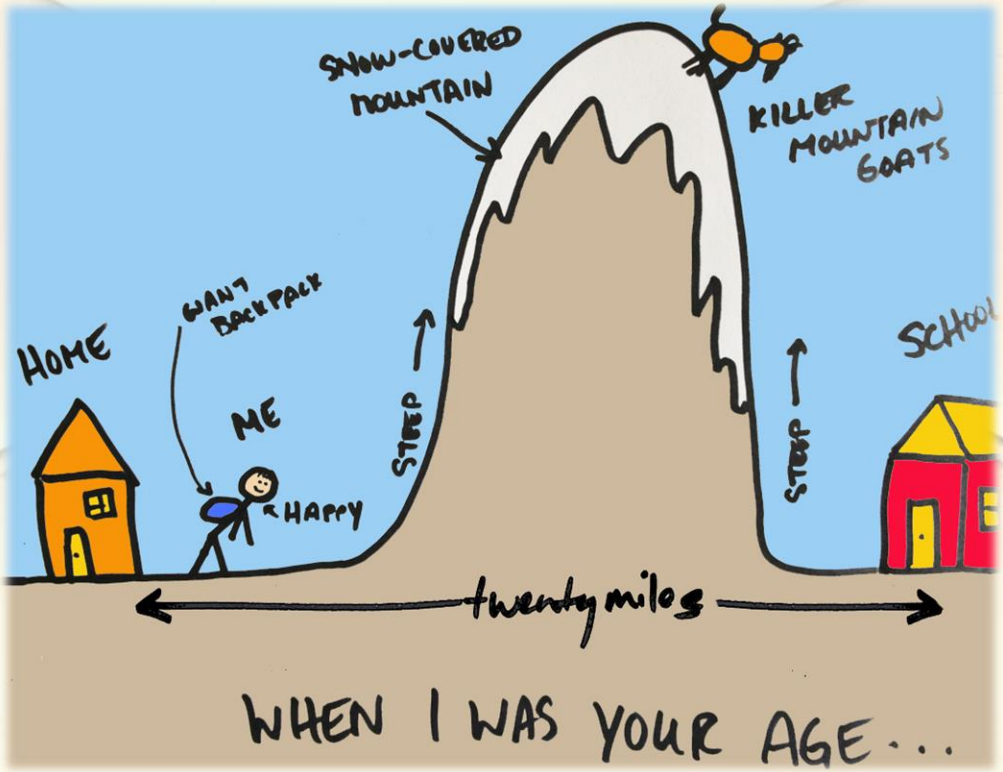


More than just math, science, or the application of technology

- What does “Introduction to Engineering” mean?
- To whom are we introducing “Engineering”?

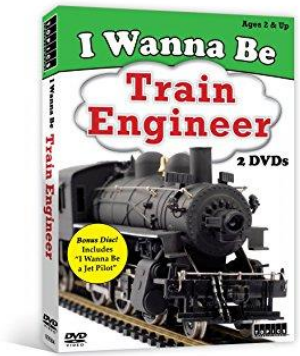
Kids today…

"When I went to school, we did 200 problems and liked it. If you couldn't do it, you weren't cut out for engineering."



Engineering in K-12

What do engineers do?



Although 85 percent of students said their teachers deserve at least a B when it comes to knowledge about science topics (55 percent of students gave their teachers an A),

63 percent of high school students said their teachers are not doing a good job of talking to them about engineering careers (C or lower), and

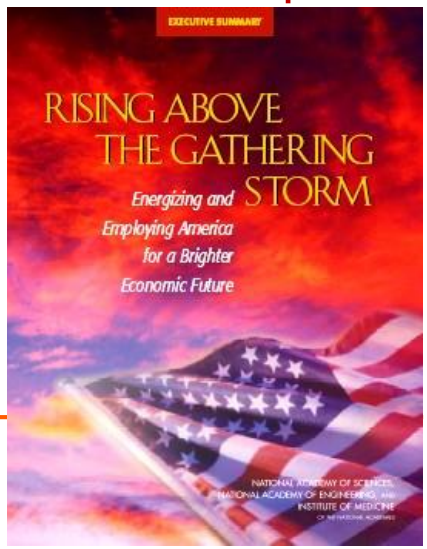
42 percent of high school students said their teachers don't ably demonstrate how science can be used in a career (C or lower).

ASQ study

National Academies

- *Rising above the Gathering Storm*

  "Education in science, mathematics, and technology has become a focus of intense concern within the business and academic communities. The domestic and world economies depend more and more on science and engineering. But our *primary and secondary schools* do not seem able to produce enough students with the interest, motivation, knowledge, and skills they will need to compete and prosper in such a world."

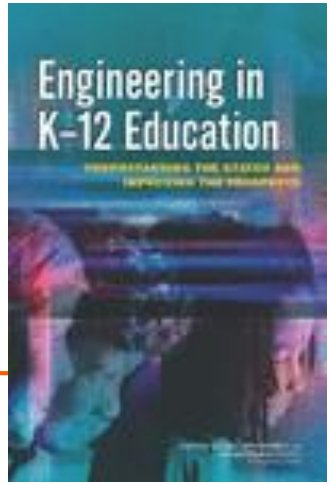


President's Council of Advisors on Science and Technology

- *Prepare and Inspire: K-12 Education in Science, Technology Engineering and Math (STEM) for America's Future*
  - "STEM education will determine whether the United States will remain a leader among nations and whether we will be able to solve immense challenges in such areas as energy, health, environmental protection, and national security."
  - "The most important factor in ensuring excellence is great STEM teachers, with both deep content knowledge in STEM subjects and mastery of the pedagogical skills required to teach these subjects well."

Engineering in K-12 Education

1. There are multiple perspectives about the purpose and place of engineering in the K–12 classroom. These points of view lead to emphases on very different outcomes.
2. There has not been a careful analysis of engineering education within a K–12 environment that looks at possible subject intersections.
3. There has been little if any serious consideration of the systemic changes in the U.S. education system that might be required to enhance K–12 engineering education.



Recommendations

- *Standards for K-12 Engineering Education?*
  - "The committee concluded that, **although it is theoretically possible to develop standards for K–12 engineering education, it would be extremely difficult to ensure their usefulness and effective implementation.** This conclusion is supported by the following findings: (1) there is relatively limited experience with K–12 engineering education in U.S. elementary and secondary schools, **(2) there is not at present a critical mass of teachers qualified to deliver engineering instruction**, (3) evidence regarding the impact of standards-based educational reforms on student learning in other subjects, such as mathematics and science, is inconclusive, and (4) there are significant barriers to introducing stand-alone standards for an entirely new content area in a curriculum already burdened with learning goals in more established domains of study."

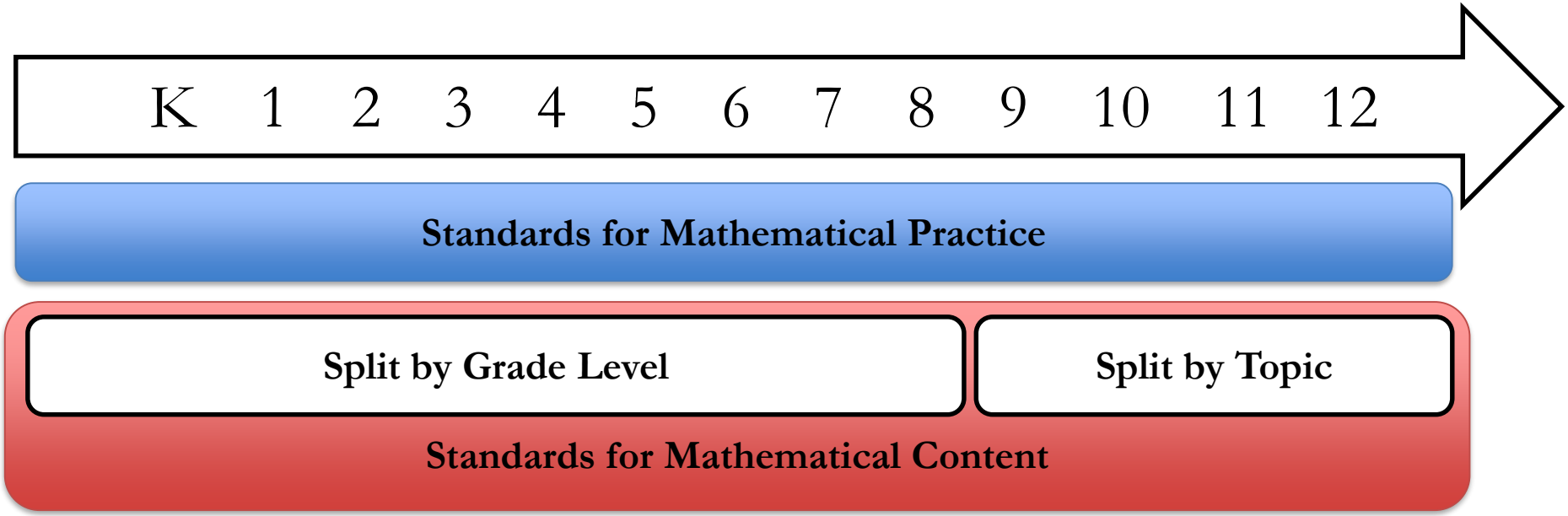
I work with a local, rural high school as mentor of their FIRST robotic team. I am appalled at how poorly prepared these kids seem to be by their school. There are a handful of exceptional learners who are learning quickly as they go along. The school has a weak physics program (they don't have textbooks for the course), so even students who are taking the course don't have the means to look up the way to calculate trajectories. Measuring parts with a ruler is a struggle for some of these kids. There is no CAD training taught here, so even though every participant can download Autodesk Inventor, there's not enough time to teach it, so I conducted a couple of drafting classes and gave them a bunch of paper and tools to use.

Am I expecting too much of these kids?

email 1/31/12:

Educational Standards

Structure of CCSS for Mathematics



Standards for Mathematical Practice

MP1: Make sense of problems and persevere in solving them.

MP2: Reason abstractly and quantitatively.

MP3: Construct viable arguments and critique the reasoning of others.

MP4: Model with mathematics.

MP5: Use appropriate tools strategically.

MP6: Attend to precision.

MP7: Look for and make use of structure.

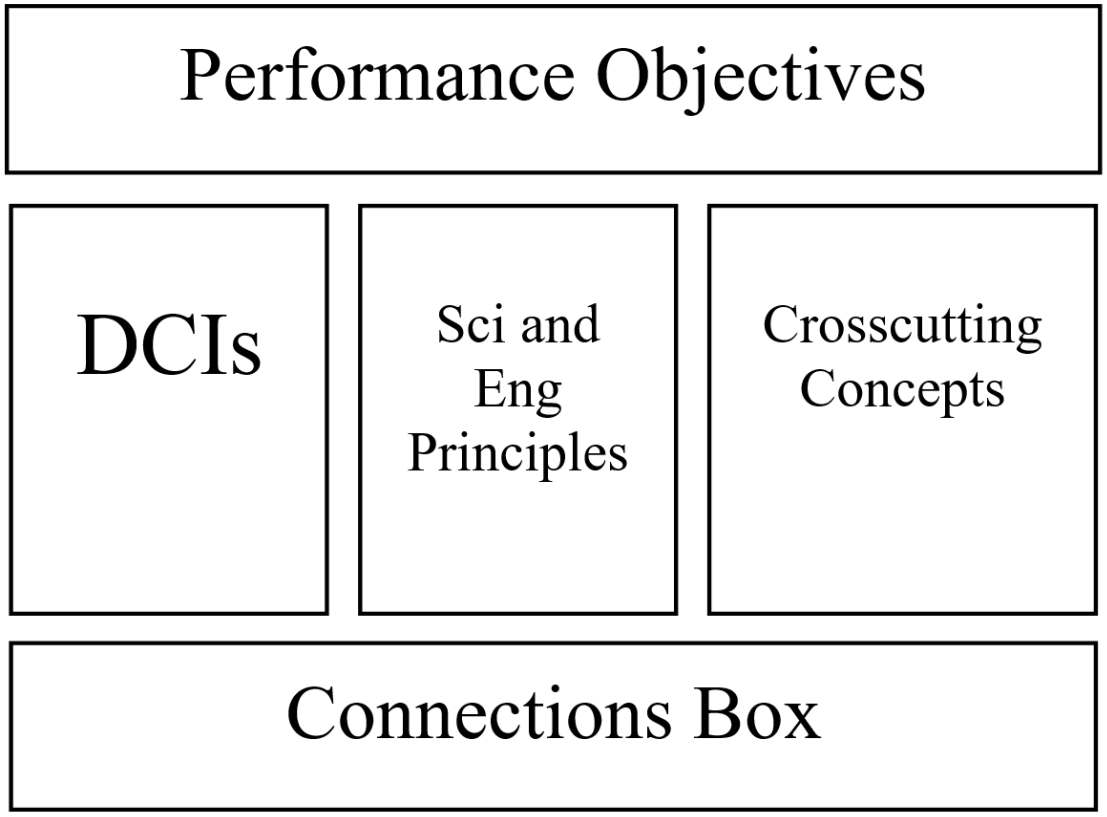
MP8: Look for and express regularity in repeated reasoning.

Standards for Mathematical Content

"**Prove** the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems."

"**Explain** why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational."

Next Generation Science Standards



Next Generation Science Standards

MS-ETS1 Engineering Design

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Students who demonstrate understanding can:

MS-ETS1-1. **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**

MS-ETS1-2. **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**

MS-ETS1-3. **Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**

MS-ETS1-4. **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences,

Texas TEKS: Princ of Applied Engineering

(1) The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:

(A) demonstrate knowledge of how to dress, speak, and conduct oneself in a manner appropriate for the profession;

(B) show the ability to cooperate, contribute, and collaborate as a member of a group in an effort to achieve a positive collective outcome;

(C) present written and oral communication in a clear, concise, and effective manner;

(D) demonstrate time-management skills in prioritizing tasks, following schedules, and performing goal-relevant activities in a way that produces efficient results; and

(E) demonstrate punctuality, dependability, reliability, and responsibility in performing assigned tasks as directed.

(10) The student demonstrates a knowledge of drafting by completing a series of drawings that can be published by various media. The student is expected to:

(A) set up, create, and modify drawings;

(B) store and retrieve geometry;

(C) demonstrate an understanding of the use of line-types in engineering drawings;

(D) draw 2-D single view objects;

(E) create multi-view working drawings using orthographic projection;

(F) dimension objects using current American National Standards Institute (ANSI) standards;

(G) draw single line 2-D pictorial representations;

(H) create working drawings that include section views; and

(I) demonstrate a knowledge of screw thread design per ANSI standards by drawing a hex head bolt with standard, square, and acme threads.

- How can we make a systemic difference?

ONU's Engineering Education Major

- Underlying Principles
  - Completion in 4 years
    - 128 credit hours maximum to be consistent with other engineering majors at ONU
  - ABET accredited as a General Engineering program
    - Students capable of sitting for Fundamentals of Engineering (FE) Exam
  - Accredited as an Education program through NCATE
    - Achieve State of Ohio AYA Mathematics Teacher Certification requirements

Plan of Study

- Engineering
  - Core of first 2 years, 19 credits
    - Intro, First-year cornerstone, Circuits, Statics, Dynamics, and Strength of Materials (or) Material Science
  - Additional 4 course concentration
- Education
  - 41 credit hours (with field service, student teaching)
- Mathematics
  - Core requirements for Math Education major
    - 3 courses outside of other Engineering disciplines
- New courses
  - Engr Educ 1 & 2, Senior Capstone (interdisciplinary)

Ohio Northern University
T. J. Smull College of Engineering

Engineering Education Major
Students Entering 2011-12

FALL - Freshman	Crd
Engineering Orientation	0
Introduction to Engineering 1	3
Writing Seminar	3
Calculus 1	4
Communication in the Classroom	3
Culture and Schooling	3
	16

SPRING - Freshman	Crd
Introduction to Engineering 2	3
Calculus 2	4
Physics 1	3
Physics 1 Lab	1
5 Day Field Experience 1	1
Exceptional Learners	3
	15

FALL - Sophomore	Crd
Electric Circuits	4
Statics	3
Differential Equations	4
5 Day Field Experience 2	1
Extra Disciplinary Seminar	3
	15

SPRING - Sophomore	Crd
Dynamics	3
Strgth of Materials or Eng Materials Sci	3
Calculus 3	4
Foundations of Mathematics	3
Development Across the Lifespan	3
	16

FALL - Junior	Crd
Statistics for Scientists & Engineers	3
Computer Applications	3
Curriculum and Assessment	3
Foundations in Geometry	3
Technical Elective 1	3
	15

SPRING- Junior	Crd
Engineering Education 1	4
Educational Psych & Instr Practices	3
Literacy Across Content Areas AYA/MA	3
Technical Elective 2	3
Technical Elective 3	3
	16

FALL - Senior	Crd
Senior Design 1	3
Engineering Education 2	4
Abstract Algebra 1	3
Integrated Mathematics Methods	3
Technical Elective 4	4
	17

SPRING - Senior	Crd
Senior Design 2	3
Leadership Seminar in Education	3
Student Teaching - Adolescent	12
	18

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Engineering: Areas of Concentration

- Technical Elective (4) Tracks
  - Robotics
  - Computers
  - Infrastructure (Civil)
  - System Design
  - General Engineering
  - *Other as defined by advisor*

Education: Required service hours

Curriculum and Assessment	30 hours of field experience
*Integrated Mathematics Methods	30 hours of field experience
*Educational Psychology	30 hours of field experience
*Literacy Through the Content Area	30 hours of field experience

** Admission to Center for Teaching required*

Current Status – is it working?

- David, Liz: Grad students (at VT)
- Tyler H, Graham, John: H.S. teachers
- Tyler B, Zach, Heather: Engineering positions

Why do students study engineering?

- Center for Advancement of Engineering Education (CAEE)
  - Intrinsic (psychological) factors
  - Intrinsic (behavioral) factors
  - Social good
  - Financial
  - Influence of mentors
  - Influence of parents

- What does “Introduction to Engineering” mean?

Introduction to Engineering

Design

Growth mindset

Ethics

Entrepreneurship

Communication

Societal aspects

Writing

Global considerations

Teamwork

Speaking

Visual

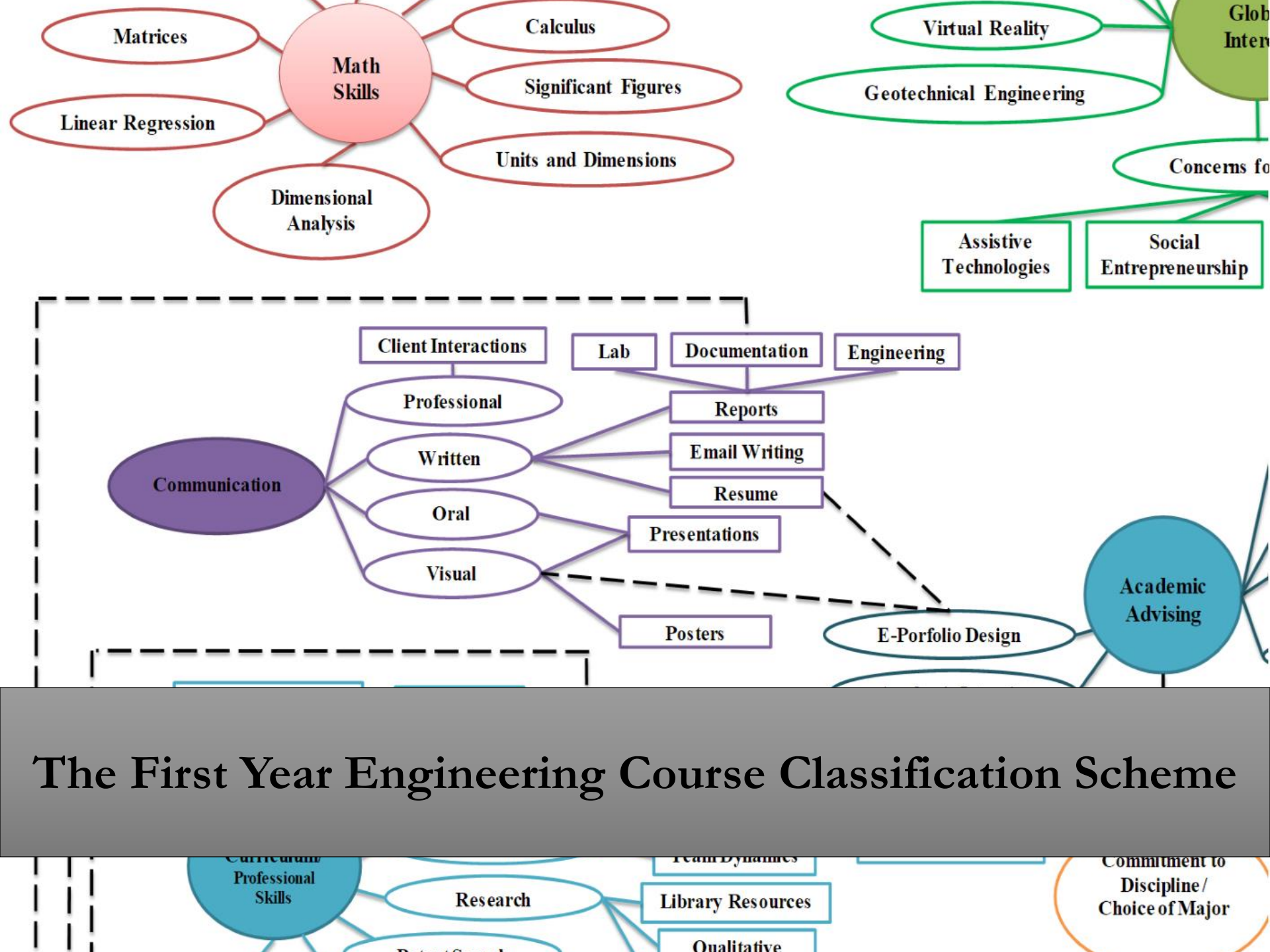
Physics

Programming/ coding

Engineering analysis

Math (Calc, etc.)

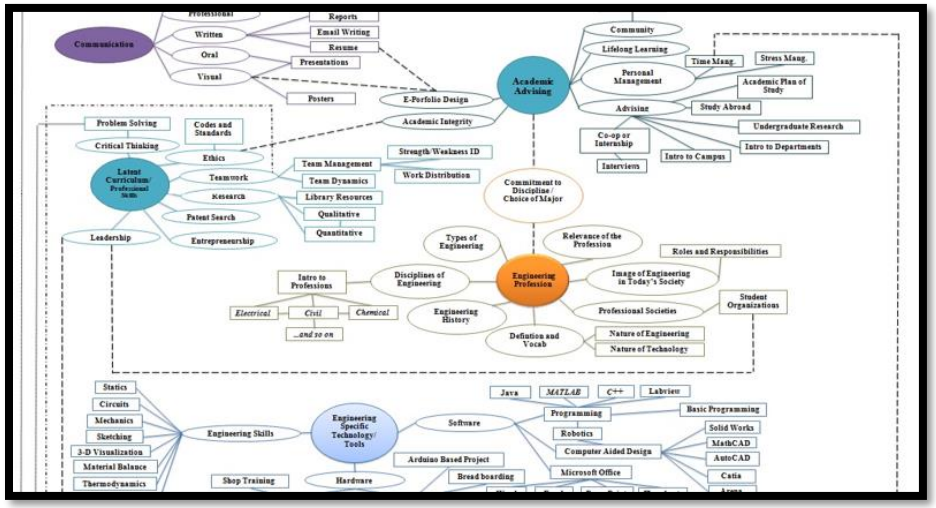
- What does “Introduction to Engineering” mean?
- What does “Introduction to Engineering” *include*?

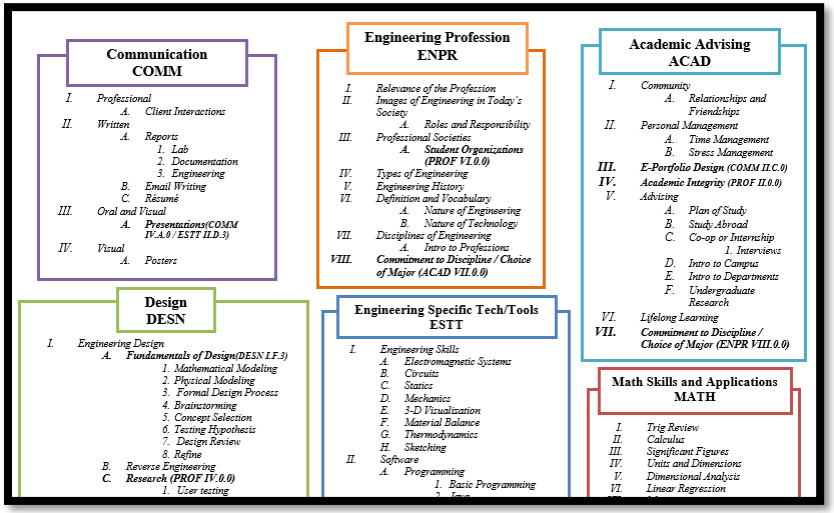


The First Year Engineering Course Classification Scheme

The First Year Engineering Course Classification Scheme

- A taxonomy that was developed to allow an instructor to describe his or her course using a common tool.





Motivation

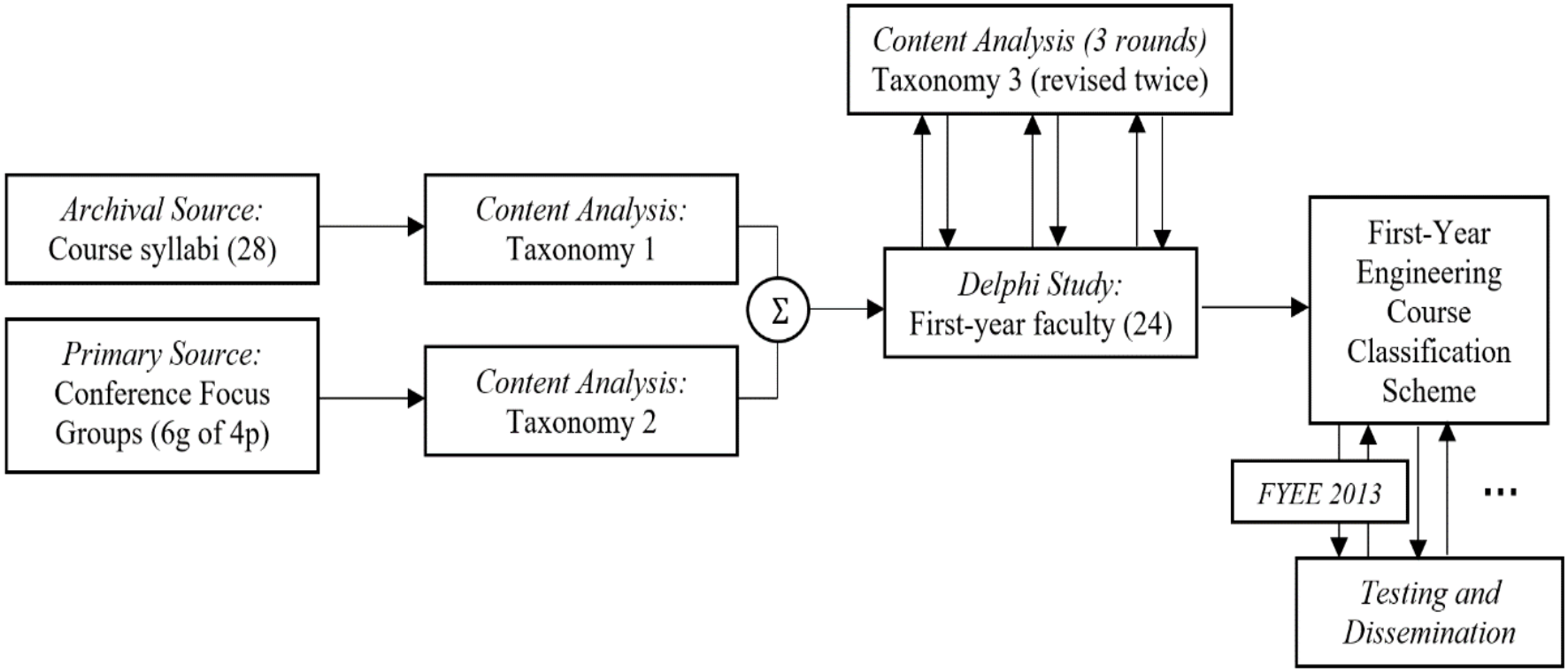
- “Introduction to Engineering”
- Content varies among institutions
- Often, the objectives of the course depend on the instructor

Issues

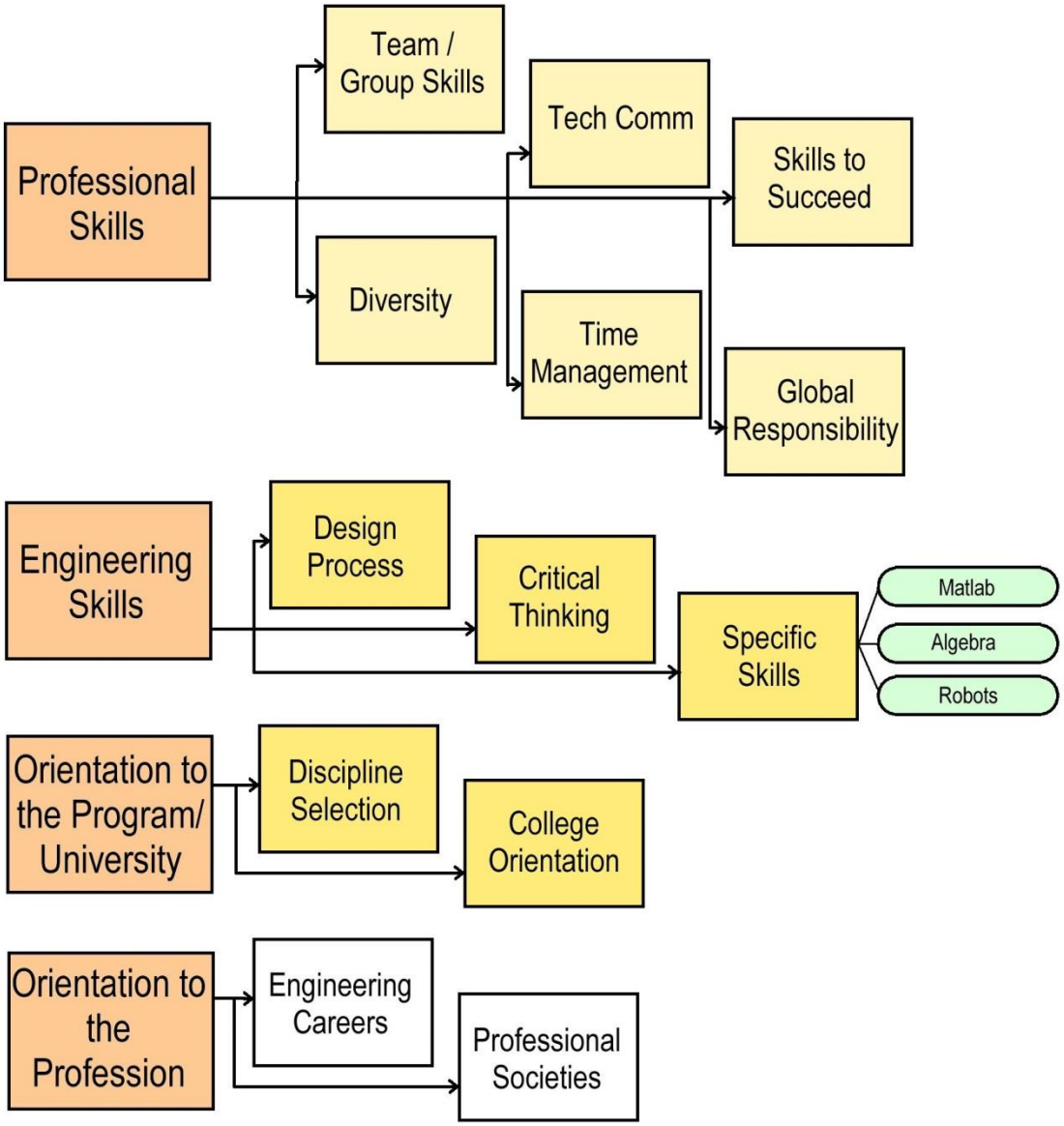
- Accurately awarding credit for students who transfer
- Community colleges offering introductory courses
- Assessment of course objectives

Methodology

1. Survey of syllabi available online
2. Catalyzing Collaborative Conversations (CCC) workshop, Frontiers in Education 2012
   - Defined preliminary schemes
3. Delphi study
   - 3 rounds
   - 22 participants


Content Analysis (3 rounds)
Taxonomy 3 (revised twice)
Archival Source:
Course syllabi (28)
Content Analysis:
Taxonomy 1
Σ
Delphi Study:
First-year faculty (24)
First-Year
Engineering
Course
Classification
Scheme
Primary Source:
Conference Focus
Groups (6g of 4p)
Content Analysis:
Taxonomy 2
FYEE 2013
...
Testing and
Dissemination

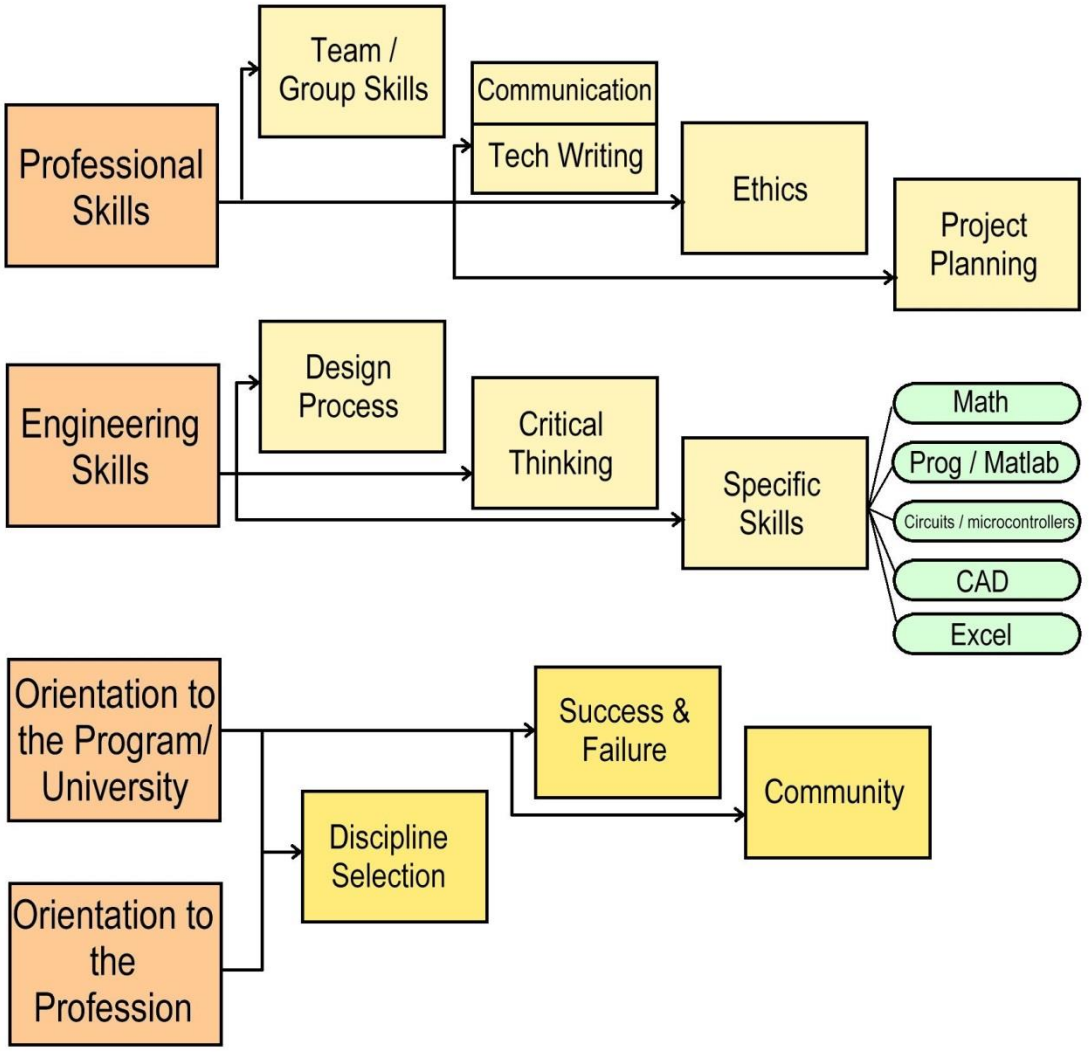
Scheme from online syllabi



Guiding questions for CCC workshop

- What are the objectives of the first-year engineering programs?
- Why isn't there a common set of objectives for the first year engineering courses?
- What would we consider to be the best practices for first year engineering program?
  - *For example, should we teach Matlab/Excel rather that introducing students to the disciplines?*
- If students were so successful in High School, why is there so much emphasis on success?
  - *What do we mean by success?*
- Are there any of these objectives that are hard to assess? How might we assess them?
  - *Is there anything that we think should be a best practice that isn't because it is too difficult to assess?*

Scheme from CCC workshop



Differences

- Professional Skills
  - “Ethics” emerged when in group discussions; yet this didn’t appear on 2 or more online syllabi.
  - Discussion on “communication” began to distinguish between written, verbal and visual communication.
- Engineering Skills
  - More specific topics emerged in the group conversation
- Orientation to the Profession
  - The difference between introducing specific disciplines as majors vs. long term pictures of disciplines within engineering began to blur

Delphi study: round 1

When answering the following questions, please answer them within the framework of Introduction to Engineering / First-Year Engineering course(s). Do not consider other required courses within the first year.

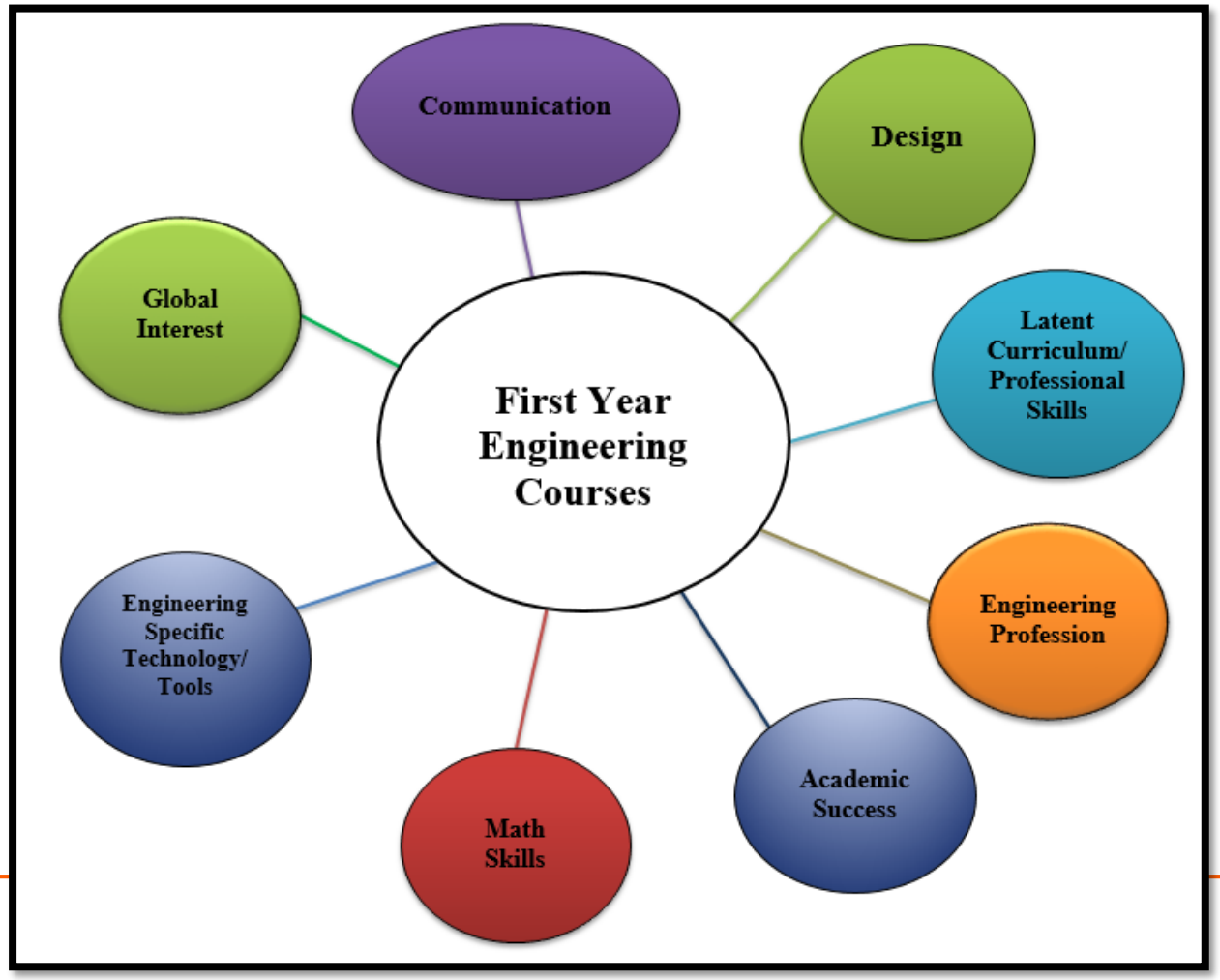
For example, please do not consider math, science or general education courses.

There are no right or wrong answers, and no specific number of items you must include. Please be as complete and descriptive as necessary to fully answer each question.

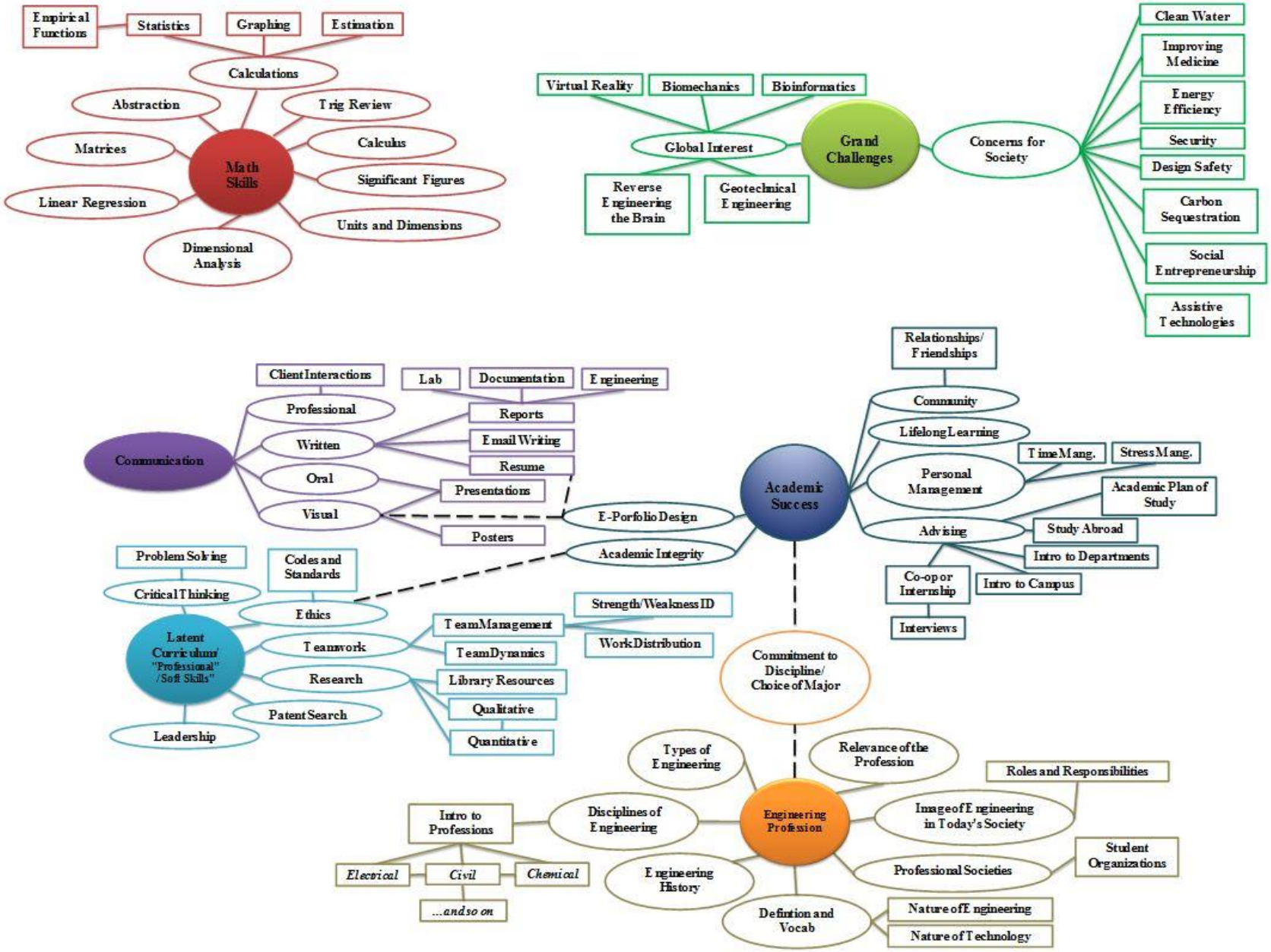
- **What topics are included (please list) in first-year engineering courses at your institution?**
- **Are there topics that are not, but should be included in first-year engineering courses at your institution?** Please list:
  - (please do not duplicate answers from the previous question)
- What are (please list) the expected student outcomes in first-year engineering courses at your institution?
- What other student outcomes should be included in first-year engineering courses? Please list:
  - (please do not duplicate answers from the previous question)

Classification Scheme

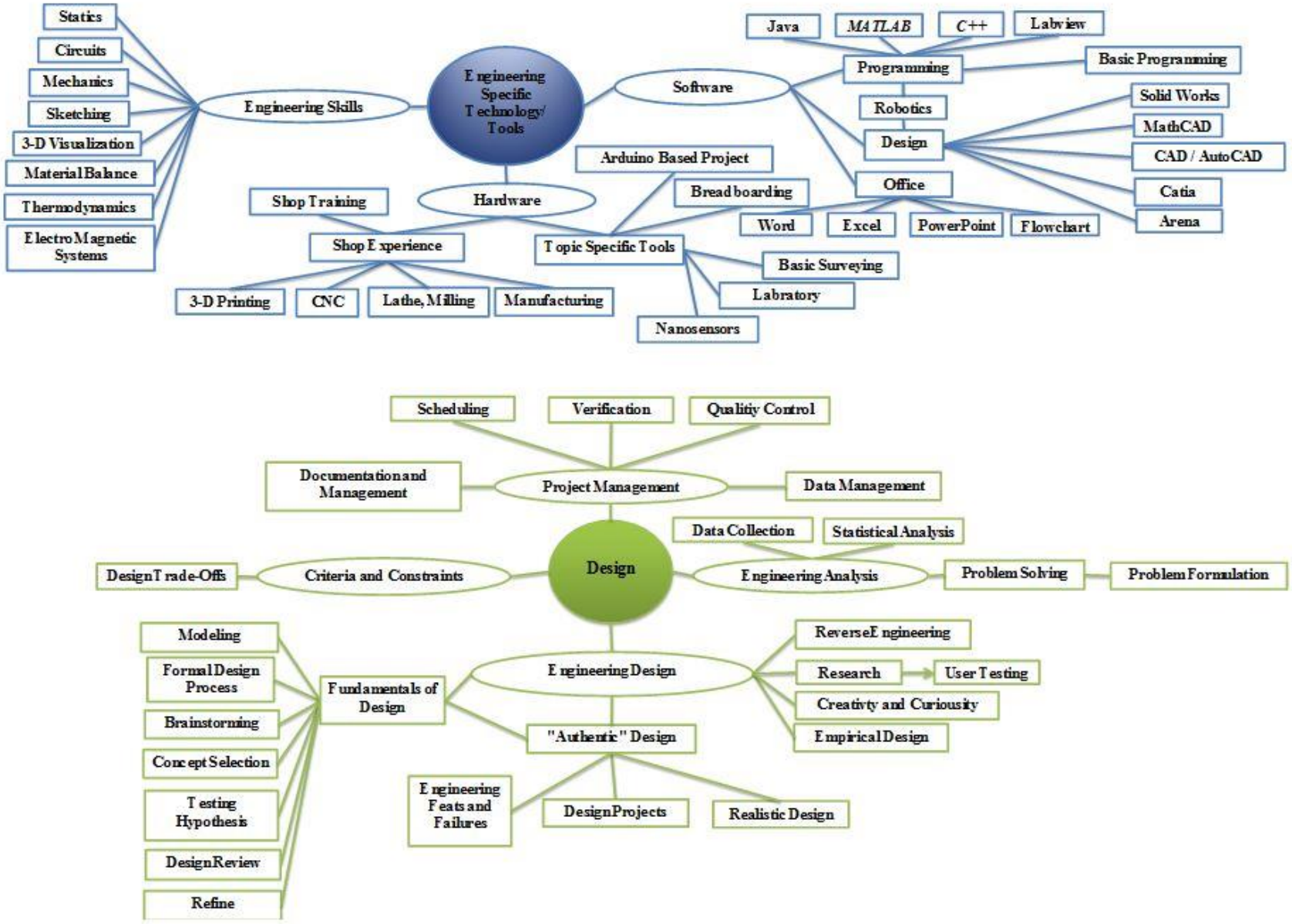
- Eight overarching categories



Results – graphical (part 1 of 2)



Results – graphical (part 2 of 2)



“Table” view

Communication COMM

- I. Professional
  - A. Client Interactions
- II. Written
  - A. Reports
    - 1. Lab
    - 2. Documentation
    - 3. Engineering
  - B. Email Writing
  - C Resume
- III. Oral and Visual
  - A. Presentations
- IV. Visual
  - A. Posters

Engineering Profession ENPR

- I. Relevance of the Profession
- II. Images of Engineering in Today's Society
  - A. Roles and Responsibility
- III. Professional Societies
  - A. Student Organizations
- IV. Types of Engineering
- V. Engineering History
- VI. Definition and Vocabulary
  - A. Nature of Engineering
  - B. Nature of Technology
- VII. Disciplines of Engineering
  - A. Intro to Professions
- VIII. Commitment to Discipline / Choice of Major

Academic Advising ACAD

- I. Community
  - A. Relationships and Friendships
- II. Personal Management
  - A. Time Management
  - B. Stress Management
- III. E-Portfolio Design
- IV. Academic Integrity
- V. Advising
  - A. Plan of Study
  - B. Study Abroad
  - C Co-op or Internship
    - 1. Interviews
  - D. Intro to Campus
  - E. Intro to Departments
- VI. Lifelong Learning
- VII. Commitment to Discipline / Choice of Major

Design DESN

- I. Engineering Design
  - A. Fundamentals of Design
    - 1. Modeling
    - 2. Formal Design Process
    - 3. Brainstorming
    - 4. Concept Selection
    - 5. Testing Hypothesis
    - 6. Design Review
    - 7. Refine
  - B. Reverse Engineering
  - C Research
    - 1. User testing
  - D. Creativity and Curiosity
  - E. Empirical Design
  - F. Authentic Design
    - 1. Engineering Feats and Failures
    - 2. Design Projects
    - 3. Realistic Design
- II. Engineering Analysis
  - A. Data Collection and Statistical Analysis
- III. Problem Solving
  - A. Problem Formulation
- IV. Criteria and Constraints
  - A. Design Trade-offs
- V. Project Management
  - A. Documentation and Management
  - B. Scheduling
  - C Verification
  - D. Quality Control
  - E. Data Management

Engineering Specific Tech/Tools ESTT

- I. Engineering Skills
  - A. Electromagnetic Systems
  - B. Circuits
  - C Statics
  - D. Mechanics
  - E. 3-D Visualization
  - F. Material Balance
  - G. Thermodynamics
  - H. Sketching
- II. Software
  - A. Programming
    - 1. Basic Programming
    - 2. Java
    - 3. MATLAB
    - 4. C++
    - 5. ~~Labview~~
  - B. Programming and Design
    - 1. Robotics
  - C Design
    - 1. Solid Works
    - 2. ~~MathCAD~~
    - 3. CAD / AutoCAD
    - 4. ~~Catia~~
    - 5. Arena
  - D. Office
    - 1. Word
    - 2. Excel
    - 3. PowerPoint
    - 4. Flowchart
- III. Hardware
  - A. Shop Experience
    - 1. Training
    - 2. Lathe, Milling
    - 3. 3-D Printing
    - 4. CNC
    - 5. Manufacturing
  - B. Topic Specific Tools
    - 1. Bread boarding
    - 2. ~~Arduino~~ Based Project
    - 3. Basic Surveying
    - 4. Laboratory
    - 5. ~~Accessories~~

Math Skills and Applications MATH

- I. Trig Review
- II. Calculus
- III. Significant Figures
- IV. Units and Dimensions
- V. Dimensional Analysis
- VI. Linear Regression
- VII. Matrices
- VIII. Abstraction
- IX. Calculations
  - A. Statistics
    - 1. Empirical Functions
    - 2. Graphing
    - 3. Estimation

Latent Curriculum/ Soft Skills SOFT

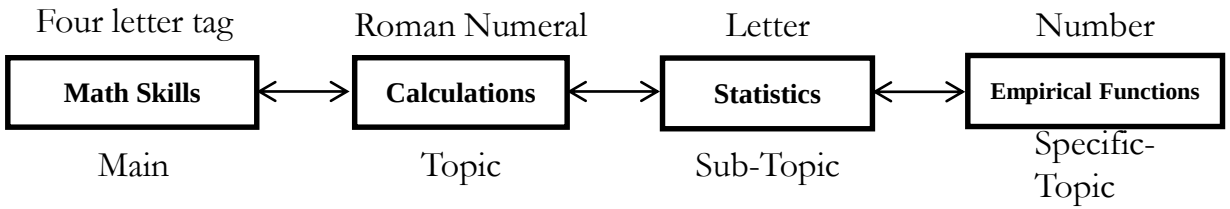
- I. Critical Thinking
  - A. Problem Solving
- II. Ethics
  - A. Codes and Standards
- III. Teamwork
  - A. Team Management
    - 1. Work Distribution
    - 2. Strength / Weakness ID
  - B. Team Dynamics
- IV. Research
  - A. Library Resources
  - B. Quantitative
  - C Qualitative
- V. Patent Search
- VI. Leadership

Grand Challenges GRCH

- I. Concerns for Society
  - A. Clean Water
  - B. Improving Medicine
  - C Energy Efficiency
  - D. Security
  - E. Design Safety
  - F. Carbon Sequestration
  - G. Social Entrepreneurship
  - H. Assistive Technologies
- II. Global Interest
  - A. Geotechnical Engineering
  - B. Reverse Engineering the Brain
  - C Virtual Reality
  - D. Biomechanics
  - E. Bioinformatics

How does it work?

- Topics are indexed under the eight main categories



Empirical Functions is designated by MATH.IX.A.1

- If a topic is covered, then it is marked with an X (or 1). If a topic is not covered, then the topic is not marked (receives a 0).

Using the classification scheme

Outcome Checklist

Directions:

If you feel your course adequately addresses the outcome described, then mark off that outcome on the checklist. *If a covered outcome is tied to one or more other outcomes, mark those outcomes as well.*

Covered	ID	Covered	ID	Covered	ID
---	ACAD I.0.0	---	COMM I.0.0	---	DESN I.0.0
	ACAD I.A.0		COMM I.A.0		DESN I.A.0*
---	ACAD II.0.0	---	COMM II.0.0		DESN I.A.1
	ACAD II.A.0	---	COMM II.A.0		DESN I.A.2
	ACAD II.B.0		COMM II.A.1		DESN I.A.3
	ACAD II.0.0*		COMM II.A.2		DESN I.A.4
	ACAD III.0.0*		COMM II.A.3		DESN I.A.5
	ACAD IV.0.0*		COMM II.B.0		DESN I.A.6
---	ACAD V.0.0		COMM II.C.0		DESN I.A.7
	ACAD V.A.0	---	COMM III.0.0		DESN I.B.0
	ACAD V.B.0		COMM III.A.0*		DESN I.C.0*
	ACAD V.C.0	---	COMM IV.0.0		DESN I.C.1
	ACAD V.C.1		COMM IV.A.0		DESN I.D.0
	ACAD V.D.0				DESN I.E.0
	ACAD V.E.0				DESN I.F.0*
	ACAD VI.0.0				DESN I.F.1
	ACAD VII.0.0*				DESN I.F.2
					DESN I.F.3

Where has it / should it been used?

- Program evaluation
  - Comparative among instructors
  - Comparative between instructor experience & syllabus
- Transfer credit evaluation

Which questions have been answered?

- Engineering in K-12?
  - Misperceptions, State Standards
  - Proposed solution? Systemic changes within K-12
    - B.S. Engineering Education
- Introduction to Engineering?
  - First-Year Classification Scheme
    - Taxonomy to examine a first-year program
    - Comparative, transfer credit

thank you

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