Mechanical Engineering

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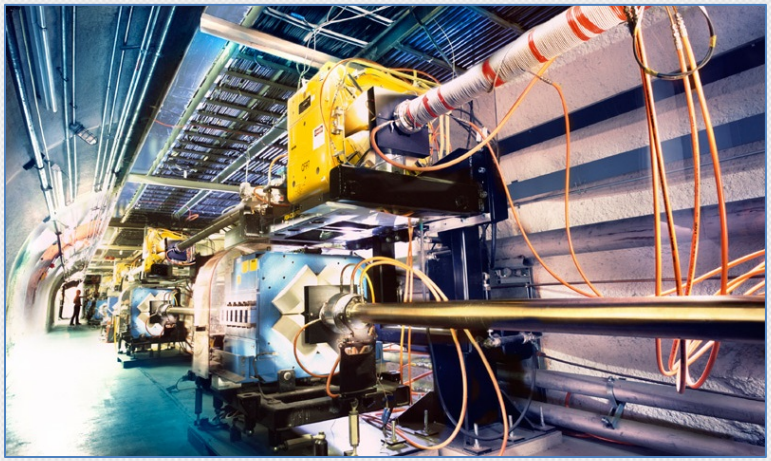
(father of Sara, class of 2018)

Where do I work?

- SLAC National Accelerator Laboratory
  - Research fundamental forces of nature and work to understand the mechanisms involved in molecular and atomic processes
- B.S.M.E. from Stanford University
- As a mechanical engineer at SLAC, I work with many people
  - Physicists and astronomers: to take their ideas for an experiment and turn them into a design and actual hardware
  - Other engineers: to solve problems that span different fields
  - Technicians, machinists, welders: to get the hardware built

Positron-Electron Project

- 1.5 mile counter-rotating beams, running through vacuum tubes
- Electromagnets bend and focus the particles
- Particles collide inside a giant detector, containing systems to detect the mass, charge, trajectory, and speed of the products

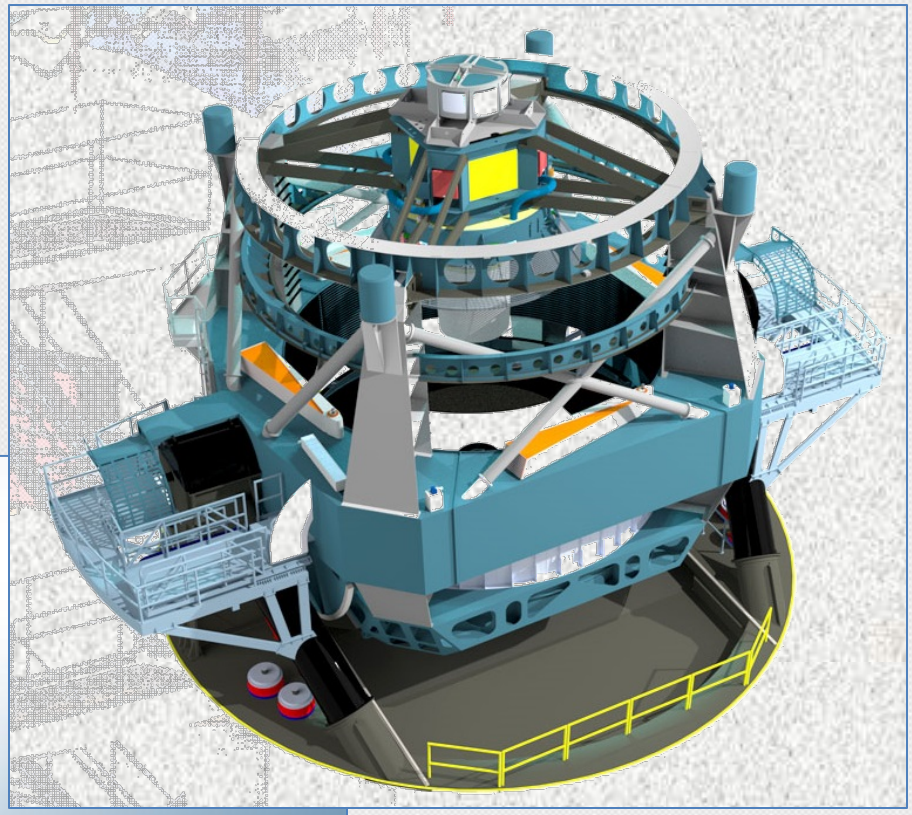


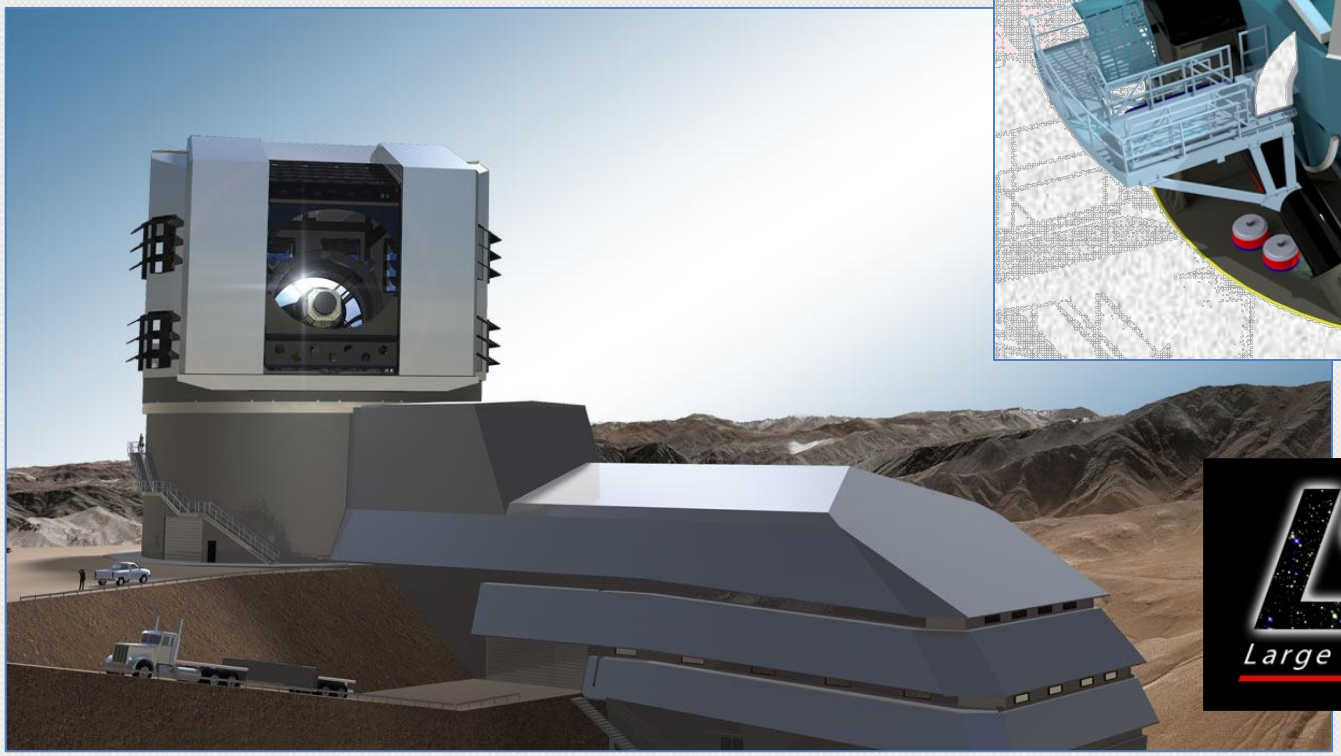
Fermi Gamma Ray Space Telescope

- Detects position, energy, and flux of gamma ray sources throughout the universe
- In low earth orbit to avoid the atmosphere
- SLAC built the detectors and data system

Large Synoptic Survey Telescope (LSST)

- A new telescope, located in Chile
- SLAC is developing and building the camera for this telescope
- The camera is 6 feet in diameter with 3 giga-pixels worth of CCDs





Responsibilities, challenges, and rewards

- My responsibility is to make sure that when we put this big camera together, that everything:
  - Fits together
  - Functions the way it needs to
  - Performs well to allow the scientists to do their research
- Challenges:
  - Working with many different people—from other cultures, educations, and disciplines (scientists, managers, engineers)
  - Solving problems with many variables
- What I find most rewarding:
  - Working in a group to solve a difficult inter-disciplinary problem
  - Explaining something complicated to non-technical people

Really big projects
-Many people working on it
-Spread out all around the world
-Very complicated
-Pushing the technological limit

What is an engineer, and what do they do?

- Engineers turn ideas into reality
  - Ideas come in the form of problems, opportunities, or improvements for a company, a market, or people

- Engineers use tools to solve problems
  - Creativity
  - Simulations of physical processes using math and physics
  - Experimentation and testing
  - Experience based on past work in the field

- Engineers work together to improve the world in which we live
  - …with engineers of different disciplines
  - …with people from different fields

Why did I decide to be a Mechanical Engineer?

- When I was in high school:
  - I liked to build things: models, woodworking, fixing my bike, …
  - I liked solving problems: math and science, but also logic problems, puzzles, and ones that took creativity
  - I was good at thinking in 3-D
- About mechanical engineers:
  - M.E.'s build things—hardware that you can see and touch
  - M.E.'s use creativity, originality, and tools to solve problems
  - M.E.'s need to think in 3-D to solve real-world problems

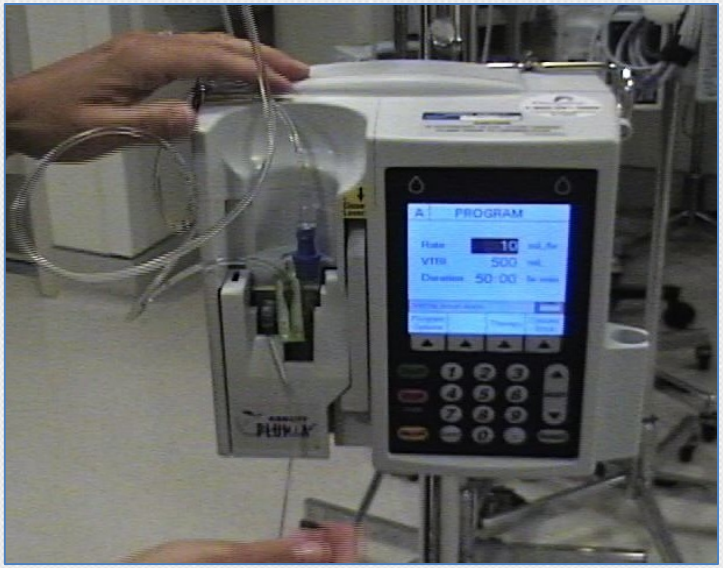
- What I wish I had known earlier:
  - M.E.'s need to have good communication and social skills!
  - M.E.'s are most effective when they are working together!

Mechanical engineers show up in many fields and industries

Let’s look at examples of fields where mechanical engineers play a role

Medicine and bio-technology

Intravenous pump

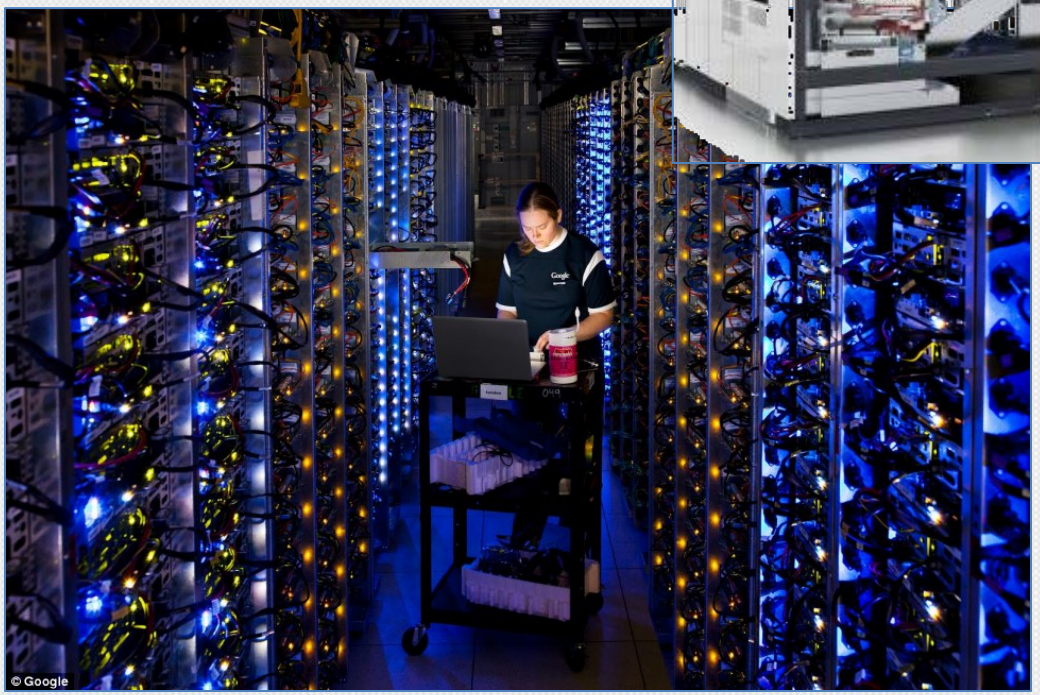


MRI machine

Tools for arthroscopic surgery

Computers and electronics

Cooling systems for high-density data centers



Chip manufacturing equipment

Alternative energy and environmental impact

Wind turbine blades and generators

Wave power generation

Desalination and water treatment

Sports science and sports medicine

Advanced composites

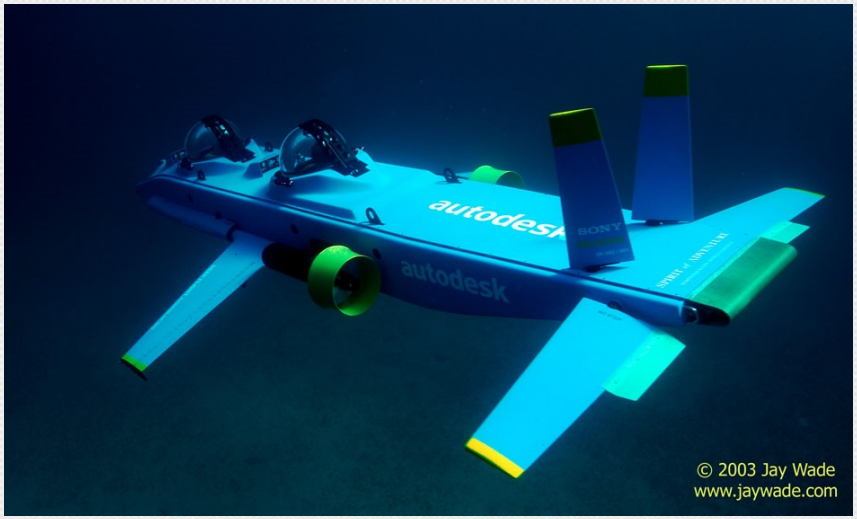
Sailboats

Concussion research

Helmets

Aeronautics

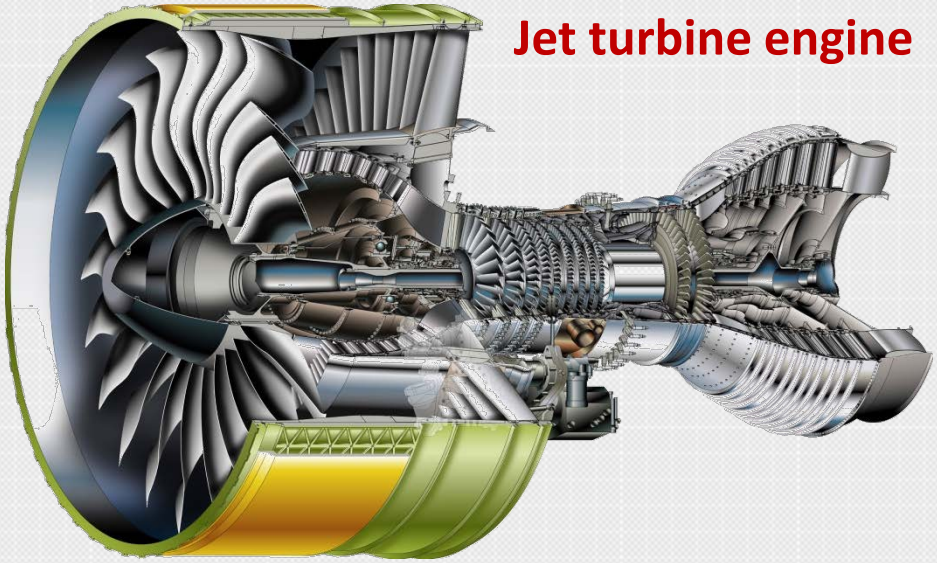
Jet wing and fuselage



Submarine control surfaces

Sports car drag testing

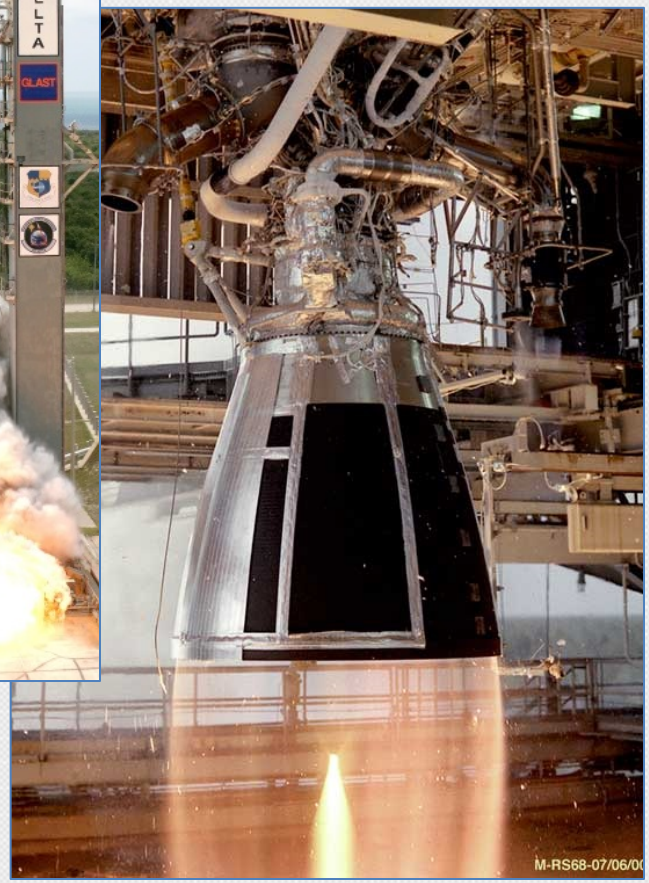
Jet turbine engine

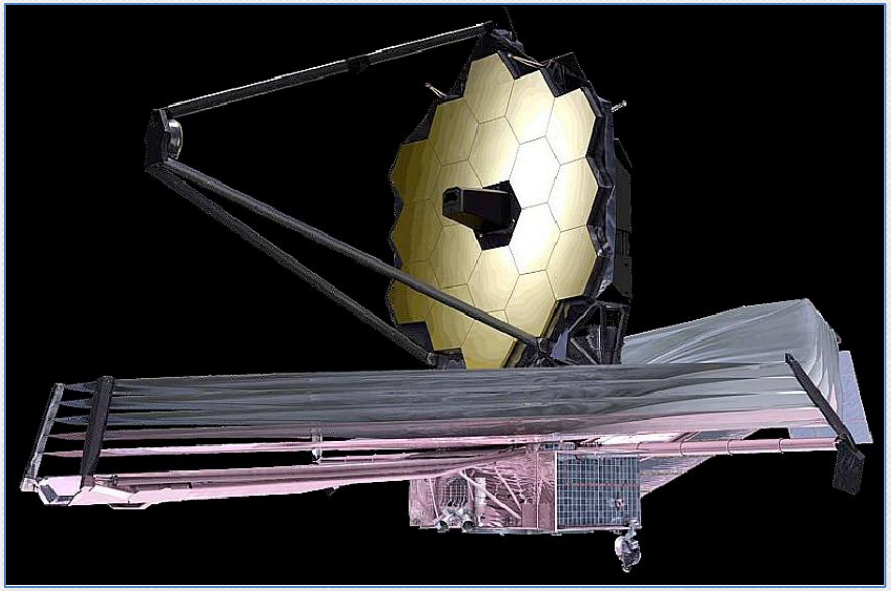


Aerospace

Spacecraft and space structures

Launch vehicle rocket

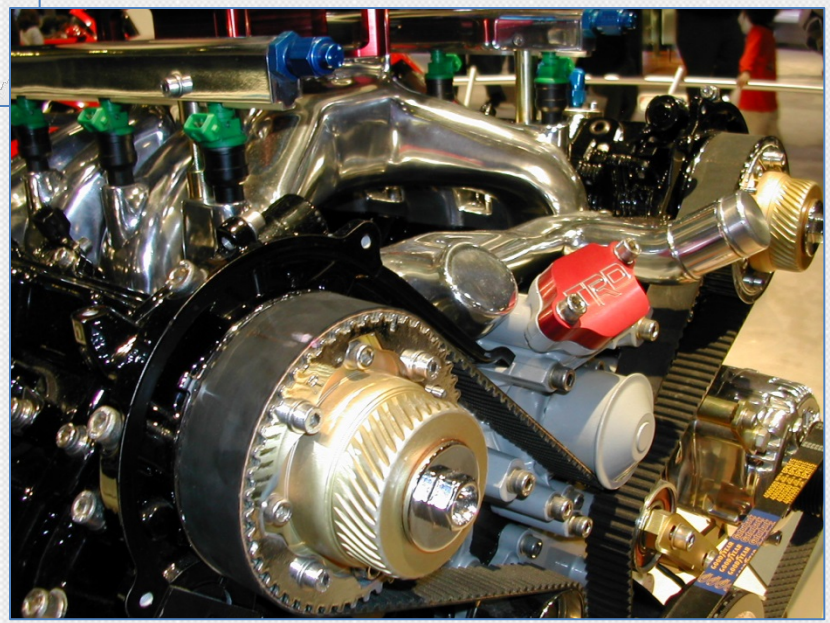




Thermal control systems

Automotive

Braking systems in an electric vehicle



High-compression engine

Advanced safety systems

Architecture and Construction

High-speed express elevators

Construction equipment

Heating and cooling systems

Pumping and delivery system for fountains

Design and Manufacturing

Industrial/Product Design

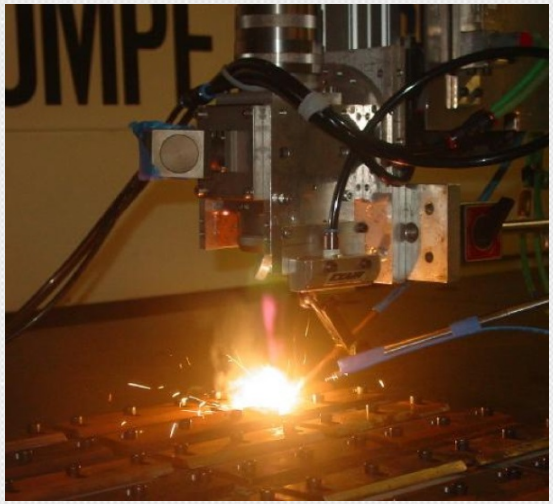
Electronics packaging

Toys, consumer products

Manufacturing Engineering

Engineered materials

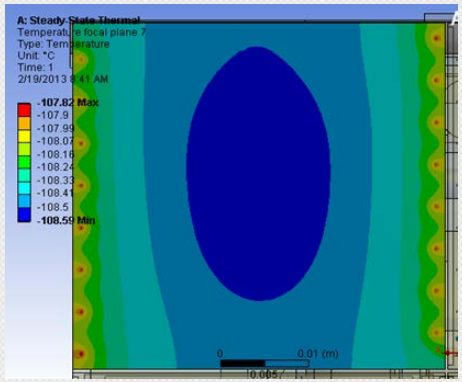
Manufacturing process controls



Mechanical engineering disciplines

Thermal

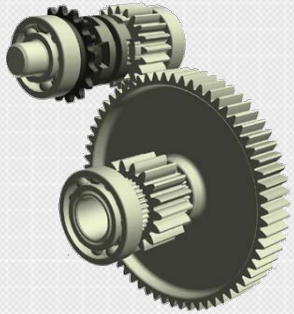
Heat transfer by conduction, convection, and radiation

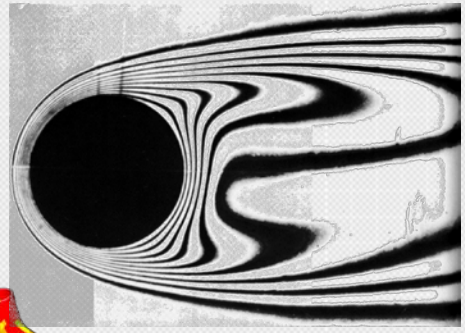


Mechanisms and Control Systems

Drive system design

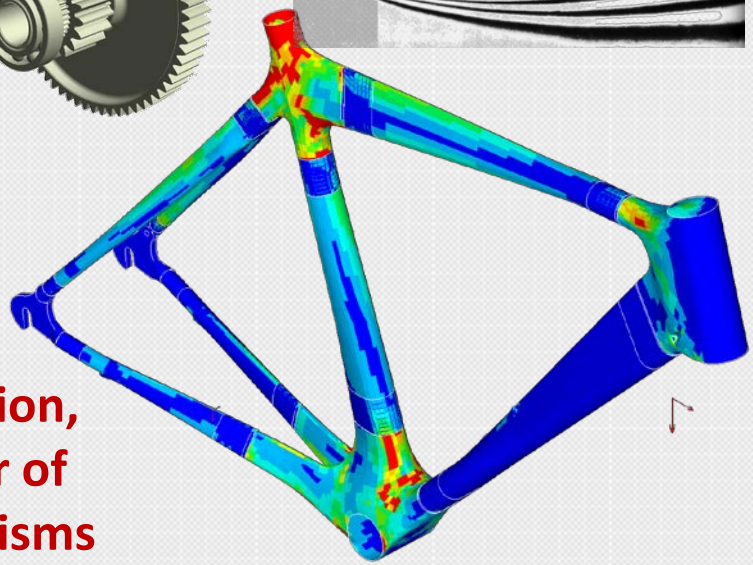
Feedback control, robotics





Fluids

Air and fluid flow, pressure changes, interactions with structures



Structural

Stresses, static deflection, and dynamic behavior of structures and mechanisms

Where is the field of M.E. going?

- Fully integrated CAD/CAE/CAM in the engineering lifecycle
  - CAD: fully-immersive 3-D design and modeling software
  - CAE: thermal, structural, and fluids engineering analysis
  - CAM: rapid prototyping, automated manufacturing, inspection
- Interdisciplinary systems
  - M.E.'s are getting involved in markets and industries that cross many disciplines
  - Engineering processes are providing competitive advantages in many industries and fields
  - Traditional mechanical systems are evolving into smart systems
- Embedded systems
  - Control systems are being integrated into mechanical actuators
  - MEMS: micro-sensors and processors on a chip

Career Outlook

- Prospects for job availability, career advancement
  - There are many fields that use M.E.'s, but not all are doing well
  - Developing a specialty can help you change fields as the economy changes, but may make it harder to stay in one field

- Different types of employment situations
  - Large companies: many projects involving M.E.'s are big-budget, managed by big companies
  - Smaller or specialty firms: specialty companies with a small group of engineers specializing in a product
  - Consulting: contractors with technical expertise who join a project for a short time to solve specific problems

Compensation and Working Conditions

- Salary ranges
  - Engineering, in general, compensates well
  - M.E.'s typically rank under electronic and software engineers in salary, and can vary by industry
  - Top end salaries flatten out unless you get into management
- The nature of the job
  - M.E. work load is tied closely to the product development cycle, so it can be very fast-paced
  - Travel depends on the job: much production is offshored, so you may need to follow your product to where it is built
  - In many fields, specialization is preferred, so as your career develops, you may become a specialist in a particular area

Personal and Other Characteristics

- Type of personality best suited for this career
  - Self-motivated problem-solver: good at working on your own
  - Team player: good at working in groups
  - Creative: like to make things and dream up ideas
  - Thick-skinned: able to take criticism, and learn and grow from it
- How can you practice being a mechanical engineer?
  - Be curious: get interested in things around you that we take for granted (e.g.: how is stuff made?)
  - Take something apart: how does it work?
  - Learn how to learn: don't just accept new information, but ask "why?"; teach yourself something
  - Practice solving problems: find more than one way to do something; think up 10 "dumb" ideas before deciding on 1

Education and Training Requirements

- Formal education
  - BSME is the gateway to the field
  - I recommend against BA degrees, and those in “Engineering Technology” and other fields without the analytical rigor
  - Plan for an MS in a specialty, since the field is so broad
- What to look for in a school/program
  - Look for schools offering a range of engineering programs
  - Multi-disciplinary programs can help you channel your interests, but may not offer you much career flexibility
  - Not all programs are designed to produce engineers, but instead focus more on preparation for PhD programs
  - Colleges: Stanford, MIT, Carnegie-Mellon
    Michigan, UC Berkeley, Oregon State, Cal Poly SLO

Other things to consider

- College internships
  - Paid and unpaid positions on campus or at local businesses
  - Schools with lots of graduate students won't have as many undergraduate internships available
- Ways to get related job experience
  - Good colleges have great clubs (solar car, Formula 1 car, energy-efficient house, engineers without borders, …)
  - Look for related summer jobs (counselor for summer tech programs for kids, lab research assistant)
- Professional requirements
  - Professional Engineer license is often required in industries selling products to the public (automotive, HVAC, structural)

Wrap-up

- Professional organizations, schools, websites, etc. to contact for further information
  - www.asme.org: American Society of Mechanical Engineers
  - http://www.discovere.org/: Discover Engineering; with information about all types of engineering
  - http://societyofwomenengineers.swe.org/: Society of Women Engineers; focuses on women's contributions to engineering

- Mechanical engineers you may know:
  - Tony Stark—yes, Ironman is an M.E.
  - Matt Damon plays Mark Watney, an M.E. and botanist stranded on Mars in *The Martian*
- Questions?