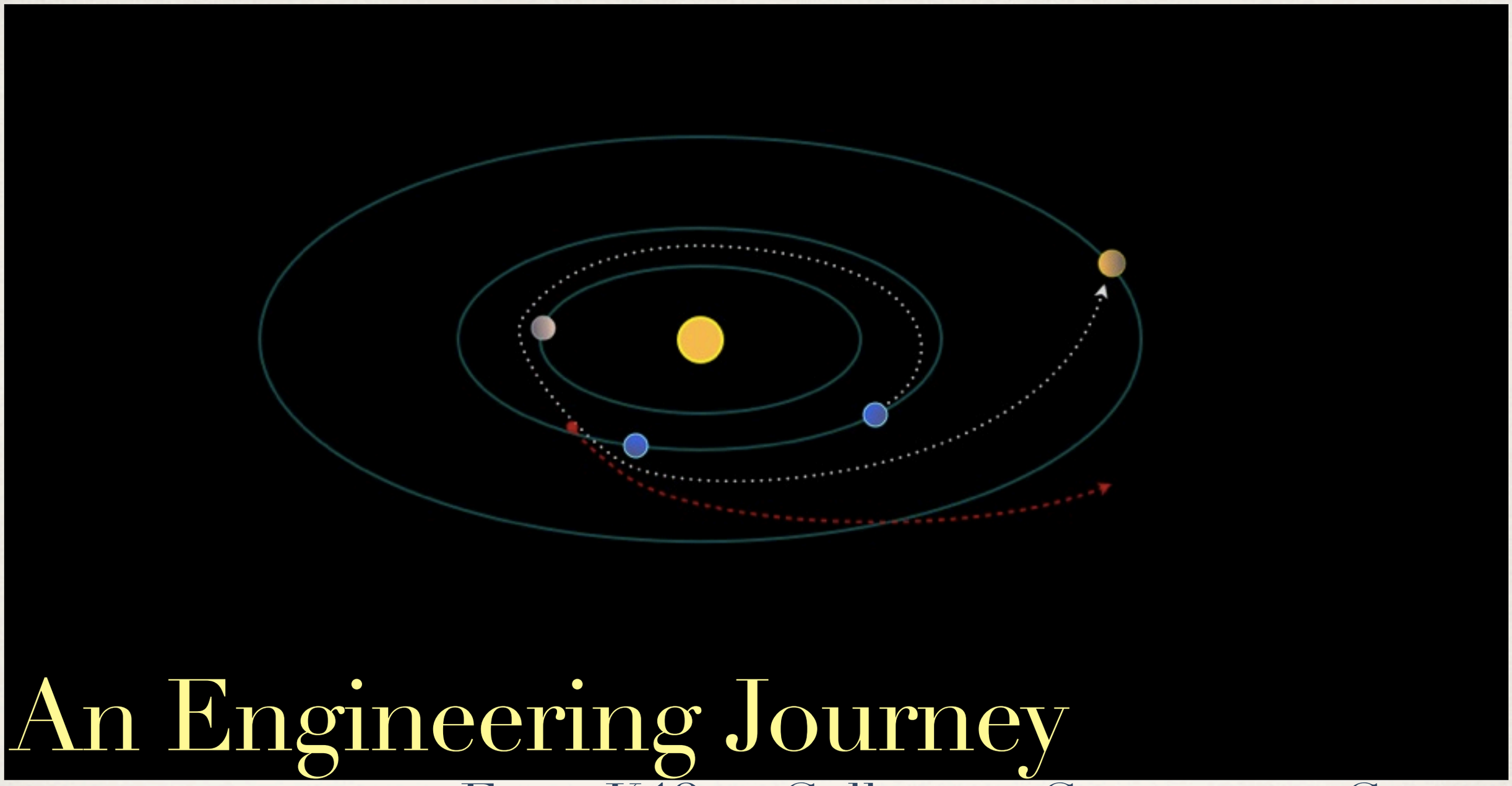


An Engineering Journey

From K12 to College to Capstone to Career

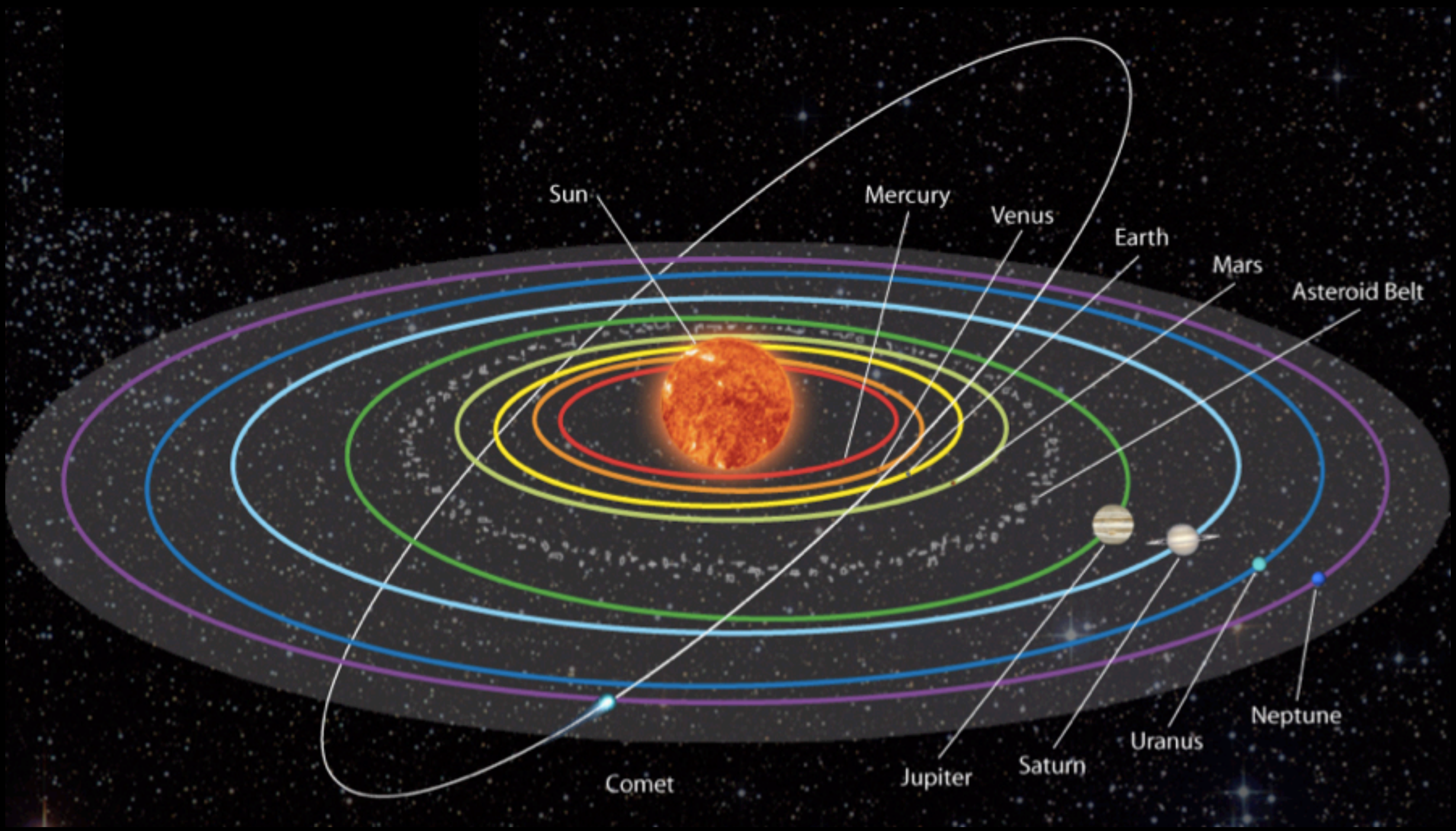
An Engineering Story

Kenneth R. Hardman, P.E.

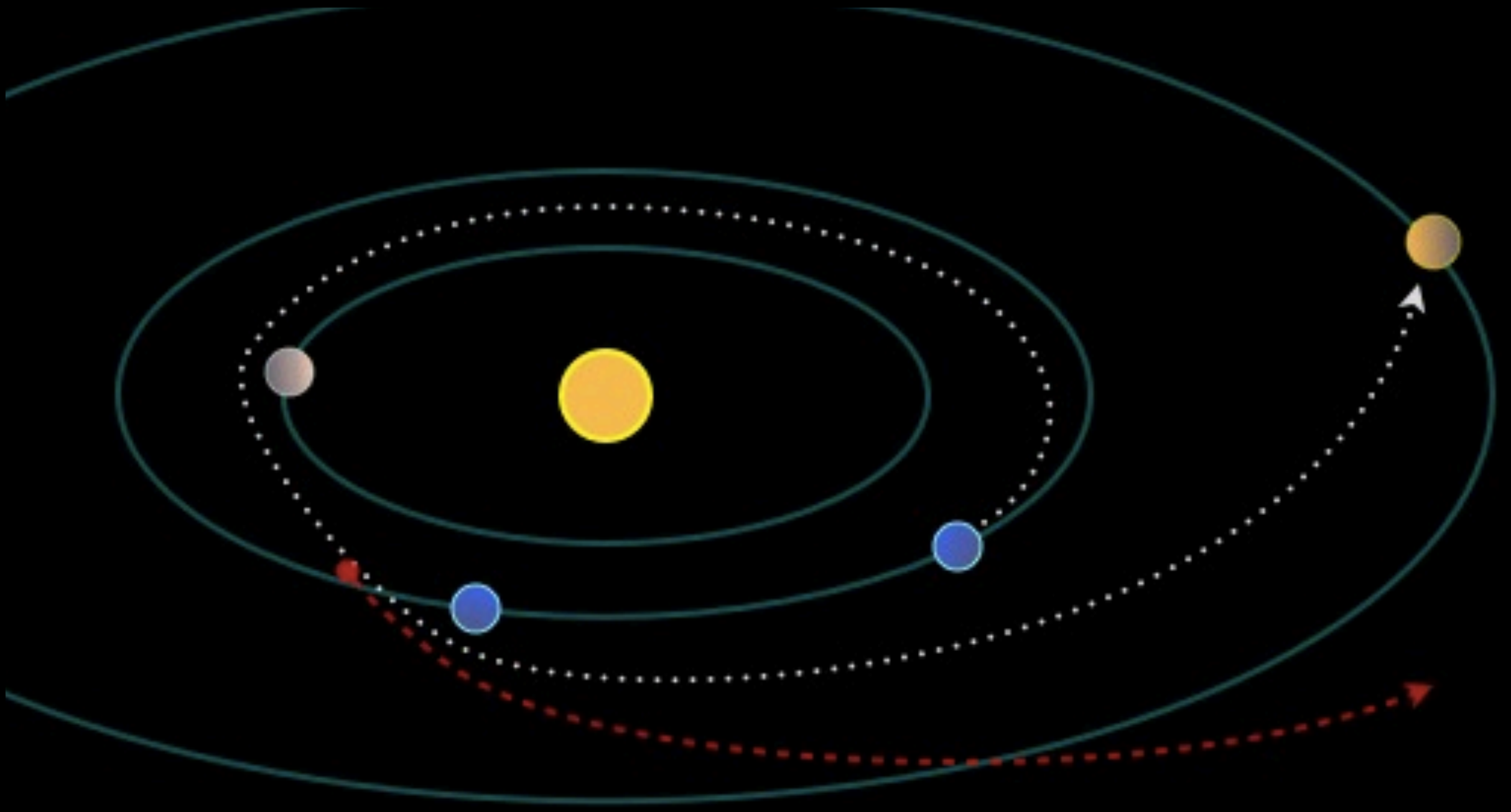
An Engineering Story

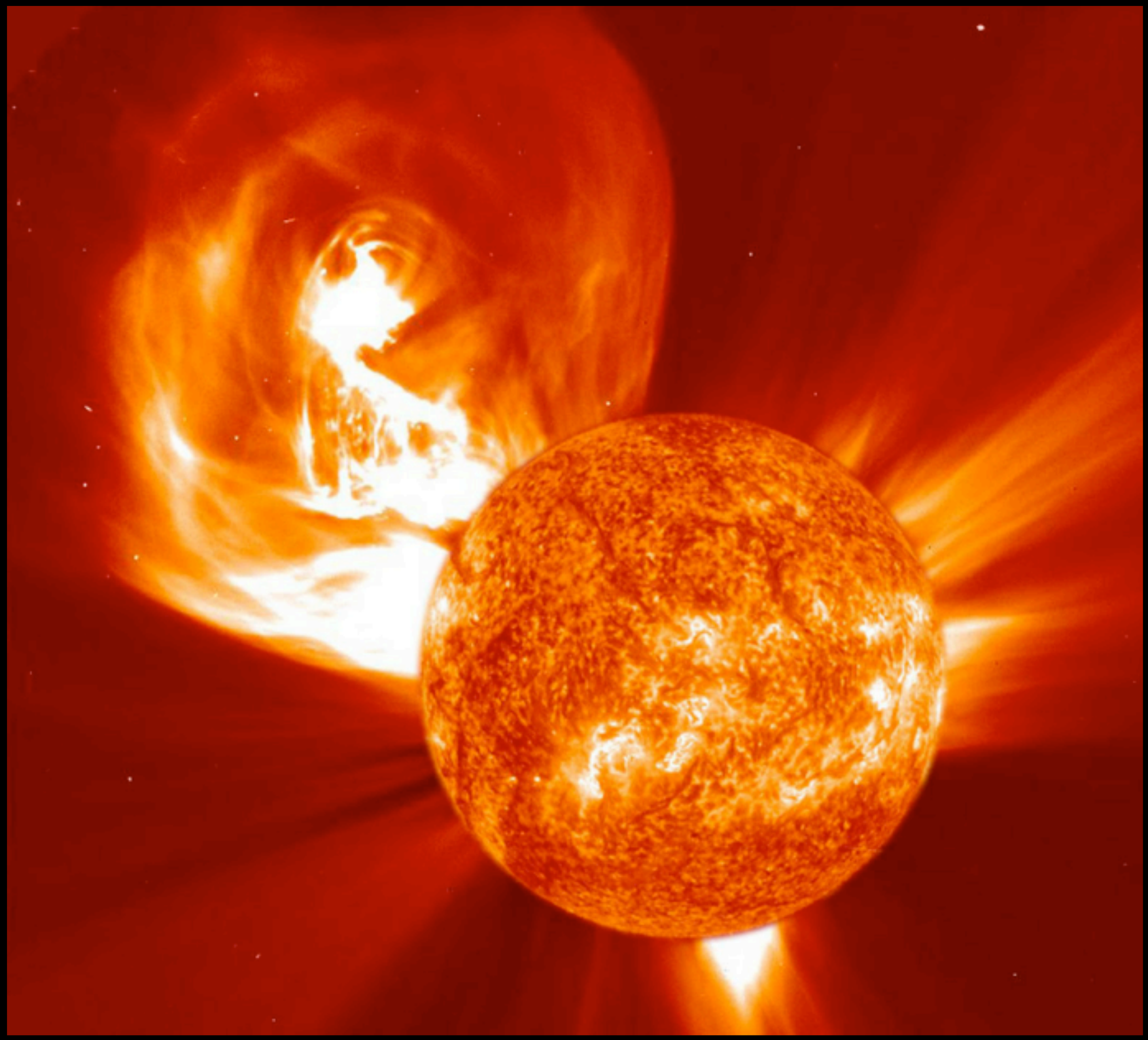
The Orbital Mechanic

Ref: 30daysoftravel.com/2012/05/09/office-of-wernher-von-braun

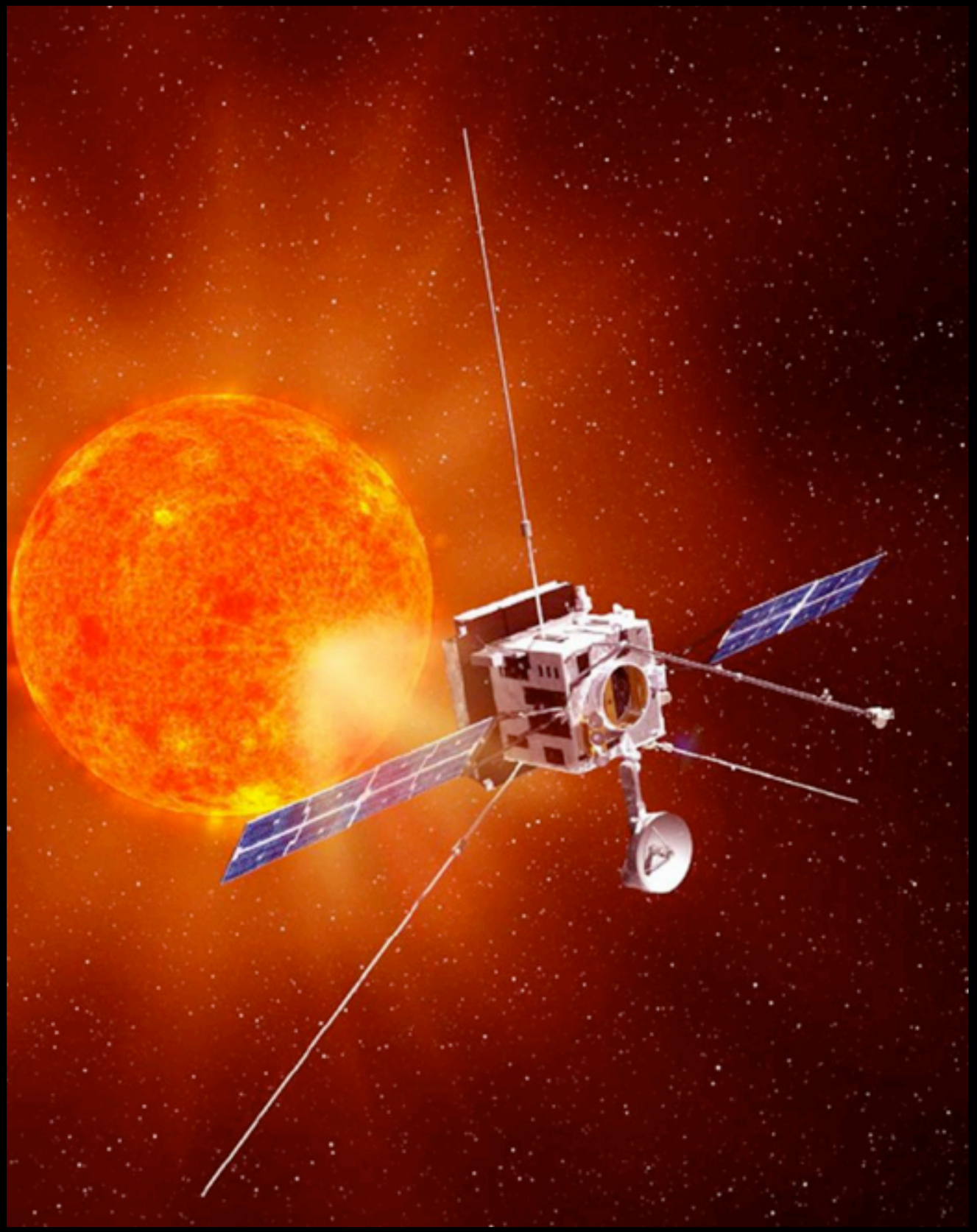


Ref: education.nationalgeographic.com

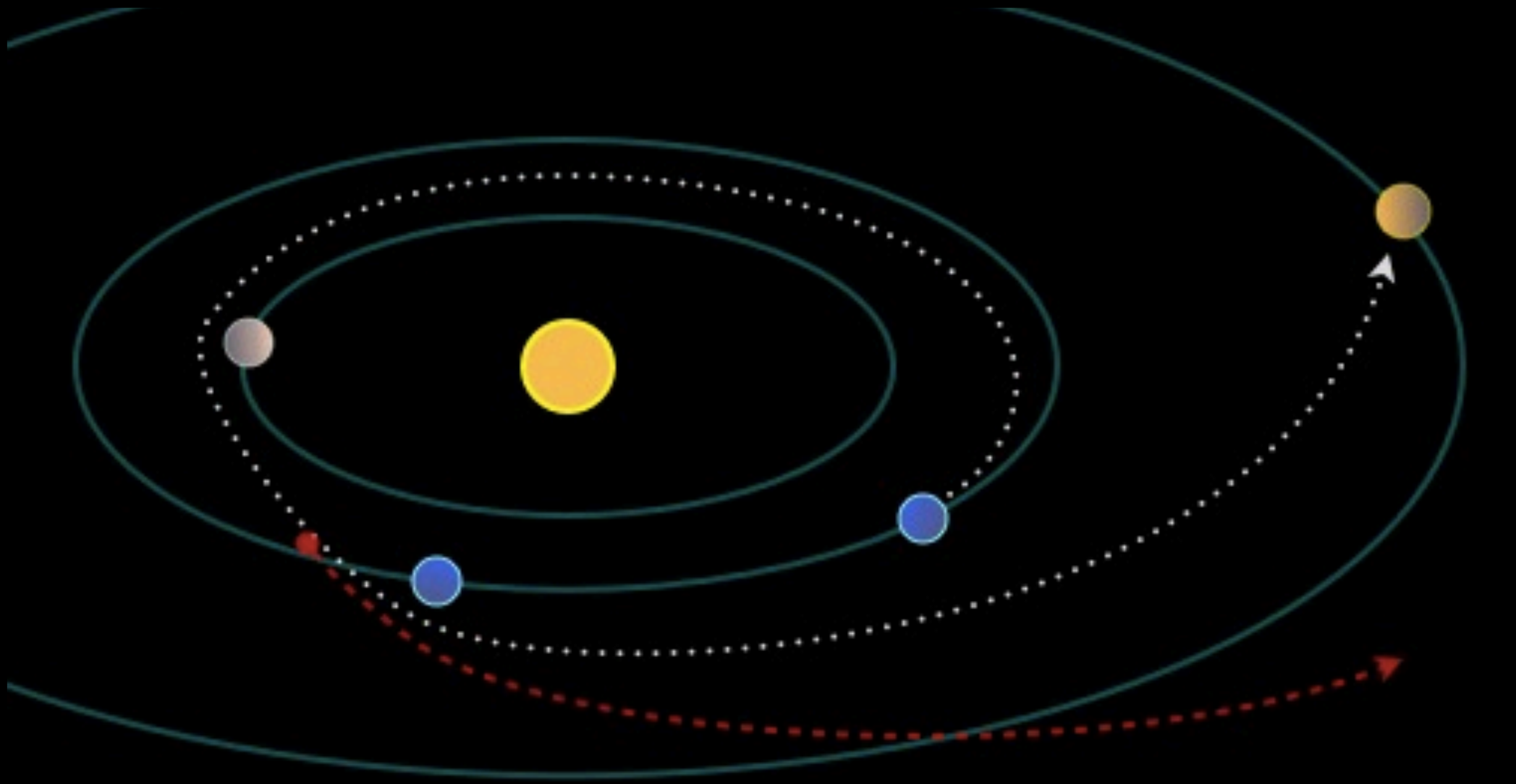




Ref: 4.bp.blogspot.com



Ref: 4.bp.blogspot.com



Kenneth R. Hardman

- BS Mechanical Engineering, BYU 1984
- MS Mechanical Engineering, BYU 1995
- Licensed Professional Engineer, Utah 1995
- Capstone Coach, Adjunct Faculty, BYU since 2003
- Associate Technical Fellow (2005), Major Aerospace Company 1984
- Author, Engineering Stories
- Husband, Father of 8

What is Mechanical Engineering?

BYU

- Mechanical Engineering is a broad discipline, encompassing areas such as:
- Materials
- Dynamics
- Vibrations
- Controls
- Computer Aided Engineering
- Design
- Manufacturing
- Biomechanics
- Thermal Sciences
- Fluid Sciences

Mechanical engineers are employed in almost every kind of industry. They are involved in Aerospace, Automotives, Bio-medical, Construction, Consumer Products, Energy, Electronics & Computers, Consulting, Entertainment, Government, and Manufacturing. As a mechanical engineer you can design and produce products that could change the world. In fact, most products you see in your life were developed by a mechanical engineer. A great strength of mechanical engineering education is the flexibility for future employment.

(Ref: BYU, Mechanical Engineering Dept.)

What is Mechanical Engineering?

Mechanical Engineering (ME) is about controlling the movement of matter and energy. If it rolls, flies, flows, or produces sound, a mechanical engineer has probably had a hand in designing it. Machines designed by mechanical engineers keep you warm in winter and cool in the summer, put men on the moon (and bring them home alive), propel you at 500 miles an hour 7 miles above ground (while you sleep), allow surgeons to operate on you though a small tube inserted in a vein, and will improve your life in wonderful ways in the future. Those wizardly feats didn't spring from guess-work. They were the result of taking ideas and arranging them in new ways, then applying scientific principles to ensure the machines will work the way we want them to work.

What do Mechanical Engineers do?

Mechanical Engineers (ME's) spend their time creating, problem solving, analyzing, testing, evaluating and researching. MEs look at the products, systems, and materials existing in the world and devise ways to make them more efficient, more user-friendly, stronger, faster, and more sustainable – all around BETTER! ME's will invent new products and machines that will surely improve your life. Basically, ME's are in the business of bettering our world.

http://mech.utah.edu/about-mechanical-engineering/

ABET Requirements
Recognized by the Council for Higher Education Accreditation (CHEA)

- Engineering - The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include.

- (a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline. Basic sciences are defined as biological, chemical, and physical sciences.

- (b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

- (c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

- Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.

- Mechanical Engineering - The curriculum must require students to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations); to model, analyze, design, and realize physical systems, components or processes; and prepare students to work professionally in both thermal and mechanical systems areas.

BYU Mechanical Engineering
Example

1. Complete the following basic science core:
   - BIO 100 : Principles of Biology. (3:3:0)
   - CHEM 105 : General College Chemistry. (4:5:0)
   - PHSCS 123 : Principles of Physics 2. (3:3:1)
   - PHSCS 220 : Principles of Physics 3. (3:3:1)

   Note: Students without high school physics should start with Phscs 121.

2. Complete one of the following mathematics core sequences:
   a. MATH 112 : Calculus 1. (4:5:0)
      MATH 113 : Calculus 2. (4:5:0)
      MATH 302 : Mathematics for Engineering 1. (4:4:0)
      MATH 303 : Mathematics for Engineering 2. (4:4:0)
   b. MATH 112 : Calculus 1. (4:5:0)
      MATH 113 : Calculus 2. (4:5:0)
      MATH 313 : Elementary Linear Algebra. (3:3:0)
      MATH 314 : Calculus of Several Variables. (3:3:0)
      MATH 334 : Ordinary Differential Equations. (3:3:0)

3. Complete the following preprofessional engineering courses:
   - CE EN 103 : Engineering Mechanics--Statics. (3:3:0)
   - CE EN 203 : Engineering Mechanics--Mechanics of Materials. (3:3:0)
   - CE EN 204 : Engineering Mechanic--Dynamics. (3:3:0)
   - EC EN 301 : Elements of Electrical Engineering. (3:3:1)
   - ME EN 172 : Engineering Graphics--Principles and Applications. (3:2:2)
   - ME EN 191 : New Student Seminar. (.5:1:0)

4. Complete the following professional mechanical engineering core:
   - ME EN 250 : Science of Engineering Materials. (3:3:0)
   - ME EN 282 : Manufacturing Processes. (3:2:3)
   - ME EN 312 : Fluid Mechanics. (3:3:1)
   - ME EN 321 : Thermodynamics. (3:3:0)
   - ME EN 335 : Dynamic System Modeling and Analysis. (3:3:1)
   - ME EN 340 : Heat Transfer. (3:3:1)
   - ME EN 363 : Elementary Instrumentation. (3:3:1.5)
   - ME EN 372 : Mechanical System Design Fundamentals. (3:2:3)
   - ME EN 373 : Introduction to Scientific Computing and Computer-Aided Engineering. (3:2:3)
   - ME EN 475 : Integrated Product and Process Design 1. (3:2:3)
   - ME EN 476 : Integrated Product and Process Design 2. (3:2:3)

5. Complete the following supporting courses:
   - ENG T 231 : Foundations of Global Leadership. (3:3:0)
   - ENGL 316 : Technical Communication. (3:3:0)
   - STAT 201 : Statistics for Engineers and Scientists. (3:3:0)

6. Complete 15 hours (five courses) of technical electives.

Mathematics
Probability & Statistics
Statics & Dynamics
Mechanics of Materials
Fluid Mechanics
Thermodynamics
Heat Transfer
Biology
Chemistry
Materials Science
Measurement & Controls
Economics
Computer & Software
Chemical Engineering
Civil Engineering
Electrical Engineering
Industrial Engineering
Mechanical Engineering

Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering

Applied Professional Experiences

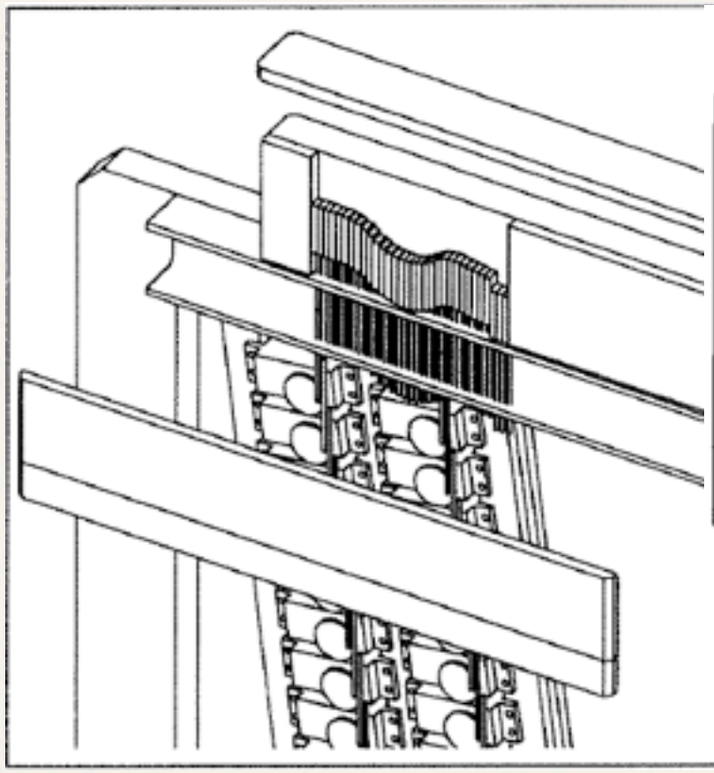
experience & academics

	Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering
Hardman Cabinets	Design & build tools and simple machines	✔		✔	✔						✔	✔	✔			✔	✔	✔
Aerospace Satellites	Design & test actuators and gimbal structure	✔	✔	✔	✔			✔			✔						✔	✔
Aerospace Test	Develop test procedures and execute	✔		✔	✔	✔		✔			✔	✔		✔			✔	✔
Aerospace Aircraft	Resolve production issues & redesign	✔		✔	✔	✔	✔	✔				✔						✔
Aerospace Electronics	Design how electronics are installed					✔		✔				✔		✔			✔	✔	✔
BYU Thesis	Develop flexible forming methods	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔		✔	✔	✔	✔
Aerospace Systems	Manage interfacing designs	✔		✔								✔		✔			✔		✔
Amtech Automation	Develop PCB material handling automation	✔	✔	✔	✔	✔		✔		✔	✔	✔	✔	✔	✔		✔	✔	✔
Aerospace Guidance	Analyze inertial guidance instruments	✔	✔	✔	✔	✔	✔	✔			✔	✔		✔			✔	✔	✔
Aerospace Controls	Analyze missile flight control units	✔	✔	✔	✔	✔		✔			✔	✔		✔			✔	✔	✔
Aerospace Sensors	Develop fault trees and maintenance	✔	✔	✔				✔				✔		✔		✔	✔		✔
BYU Capstone	Coach 10 teams on diverse projects	✔	✔	✔	✔						✔	✔	✔	✔			✔	✔	✔
Iterations Consulting	Develop innovative orthotic methods	✔		✔	✔						✔		✔				✔	✔	✔
Technical Writing	Internal and External Journal papers	✔	✔	✔							✔		✔					✔	✔
Mentoring	Science Fairs, individuals, and publications	✔		✔							✔		✔					✔	✔
Values	Integrity, work, optimism, demeanor, respect	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Thesis - flexible surfaces

Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering

- Hardman Cabinets
- **Aerospace Satellites**
- Aerospace Test
- Aerospace Aircraft
- Aerospace Electronics
- **BYU Thesis**
- Aerospace Systems
- **Amtech Automation**
- **Aerospace Guidance**
- **Aerospace Controls**
- **Aerospace Sensors**
- **BYU Capstone**
- **Iterations Consulting**
- Technical Writing
- Mentoring
- Values



Given

Geometry, I (moment of inertia)
Material Properties, E (modulus of elasticity)
Load Configuration, F
- Point Loads
- Uniformly Distributed Loads
- Moments

Determine

Deflection, $y = f(x)$

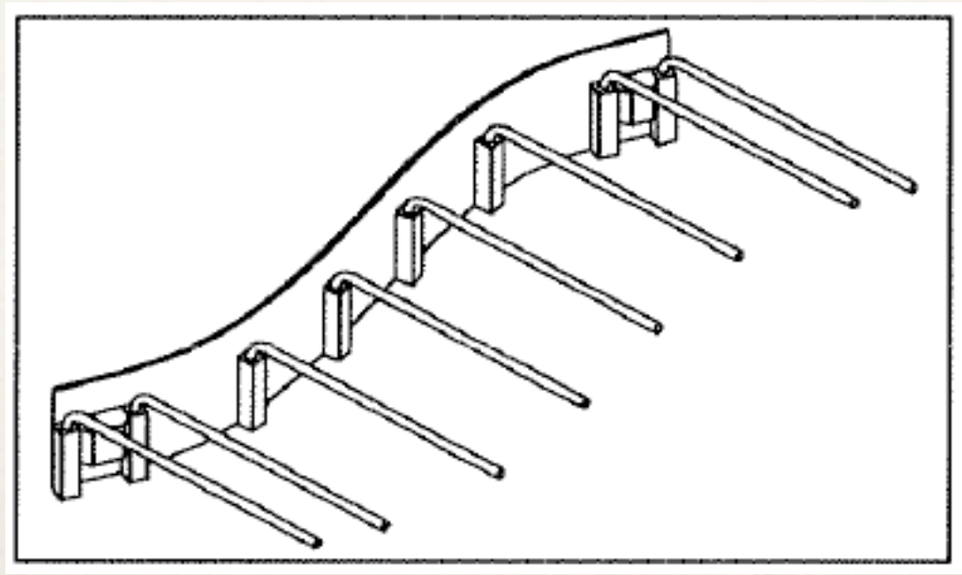
Slope, $y' = f(x)$

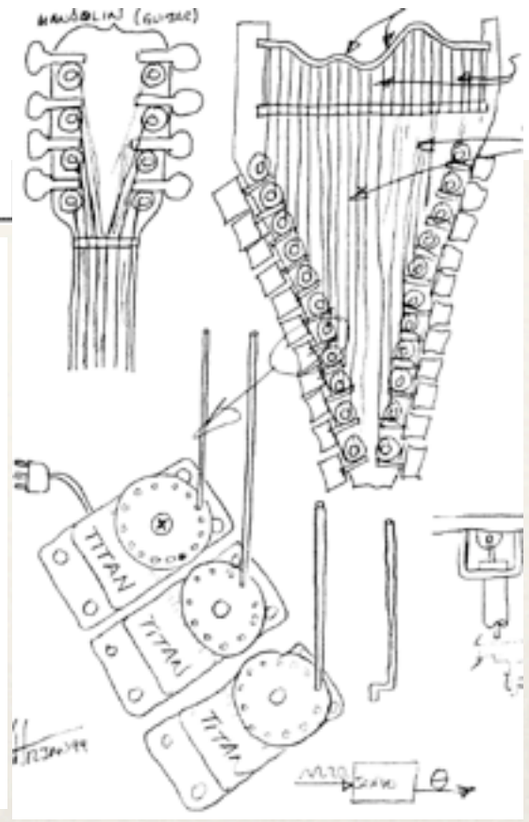
Moment, $M = EI\dfrac{d^2y}{dx^2}$

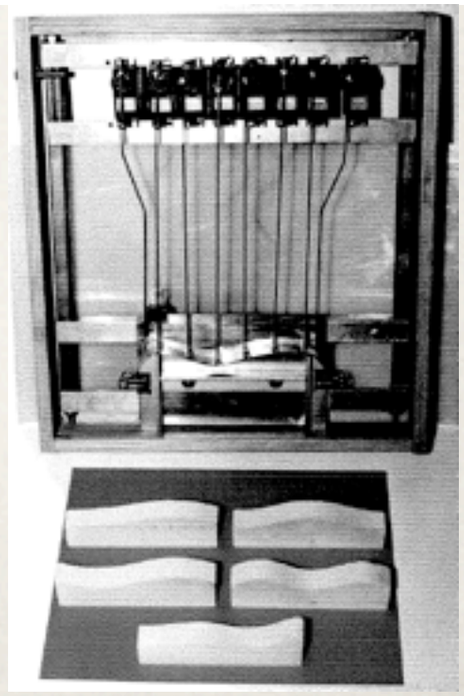
Shear, $V = \dfrac{dM}{dx}$

Load, $\dfrac{dV}{dx}$

Stress, $\sigma = \dfrac{Mc}{I}$



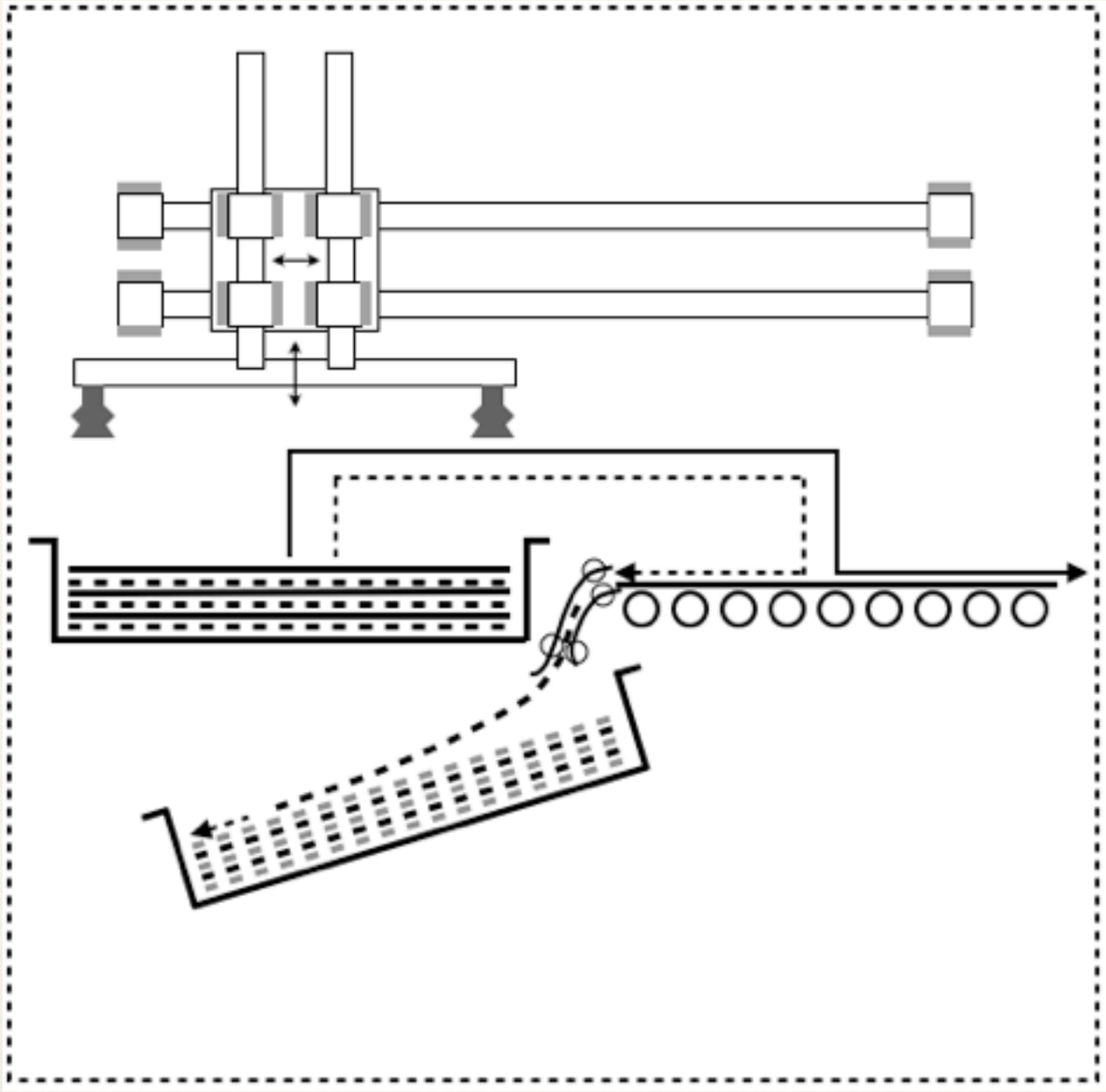




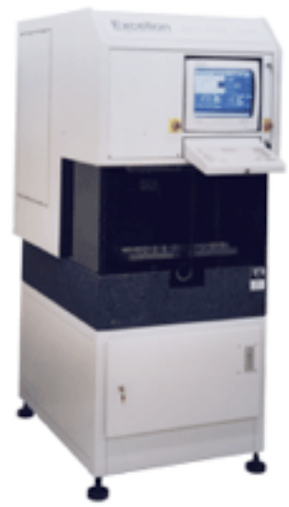
Industrial Automation

Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering

- Hardman Cabinets
- **Aerospace Satellites**
- Aerospace Test
- Aerospace Aircraft
- Aerospace Electronics
- **BYU Thesis**
- Aerospace Systems
- **Amtech Automation**
- **Aerospace Guidance**
- **Aerospace Controls**
- **Aerospace Sensors**
- **BYU Capstone**
- **Iterations Consulting**
- Technical Writing
- Mentoring
- Values



ATI 101CM
Description | Specs



Excellon 105DP
Description | Specs

Flight Control & Test Equip.

Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering

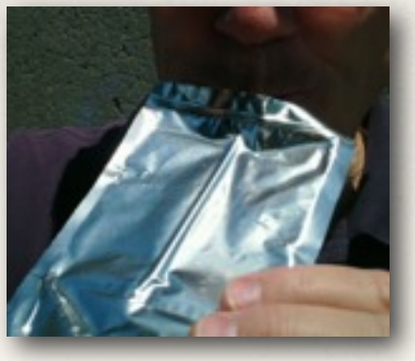
- Hardman Cabinets
- **Aerospace Satellites**
- Aerospace Test
- Aerospace Aircraft
- Aerospace Electronics
- **BYU Thesis**
- Aerospace Systems
- **Amtech Automation**
- **Aerospace Guidance**
- **Aerospace Controls**
- **Aerospace Sensors**
- **BYU Capstone**
- **Iterations Consulting**
- Technical Writing
- Mentoring
- Values

- Automated Test Equipment
  - Requirements Analysis
  - Development Specification
  - S/W and H/W Trade Studies
  - Design Reviews
  - Brainstorm Test Methods
  - Detailed Design w/Supplier
  - Assembly & Integration
  - Monte Carlo Schedule Risk Analysis
  - Test Planning & Execution
  - Team: Supplier <--> Customer
  - Analysis & Test Report
  - Lots of Presentations

www.aiicorp.com

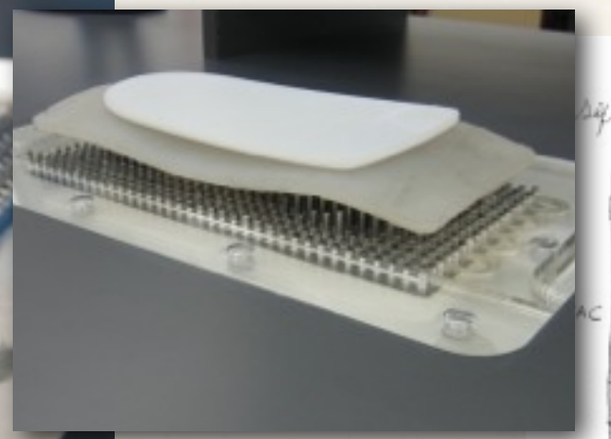
http://www.youtube.com/watch?v=BYFDrsZIXPw

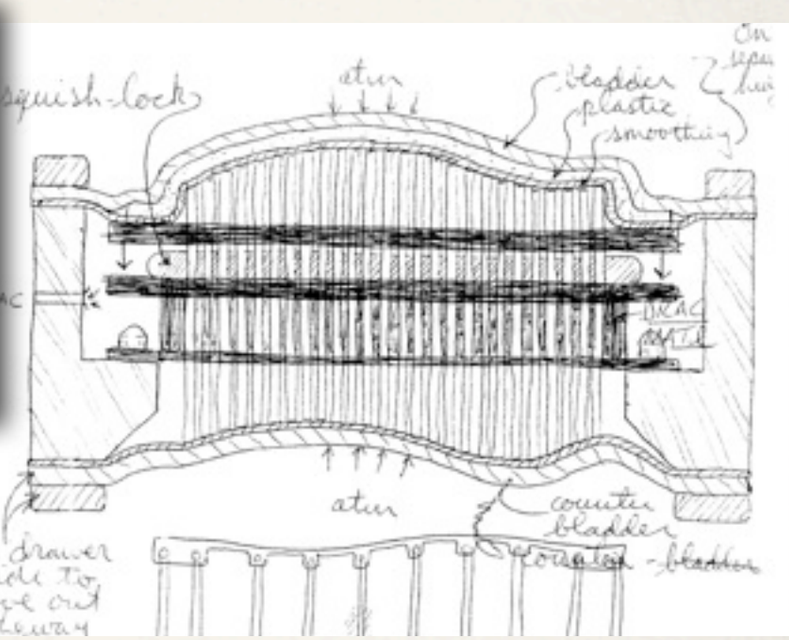
BYU Capstone



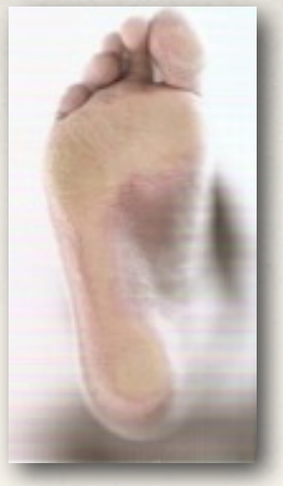
Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering

- Hardman Cabinets
- **Aerospace Satellites**
- Aerospace Test
- Aerospace Aircraft
- Aerospace Electronics
- **BYU Thesis**
- Aerospace Systems
- **Amtech Automation**
- **Aerospace Guidance**
- **Aerospace Controls**
- **Aerospace Sensors**
- **BYU Capstone**
- **Iterations Consulting**
- Technical Writing
- Mentoring
- Values



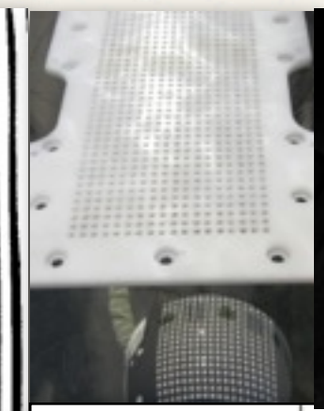


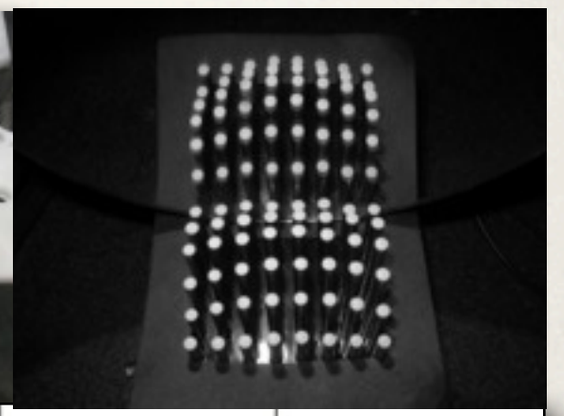
Consulting

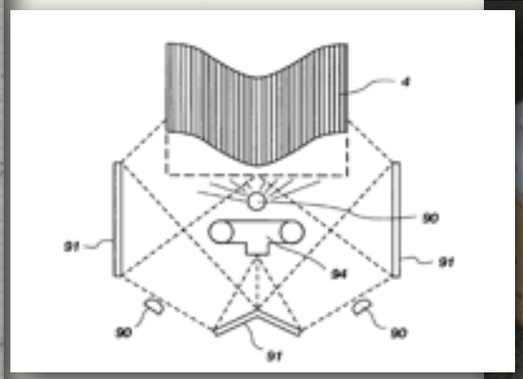


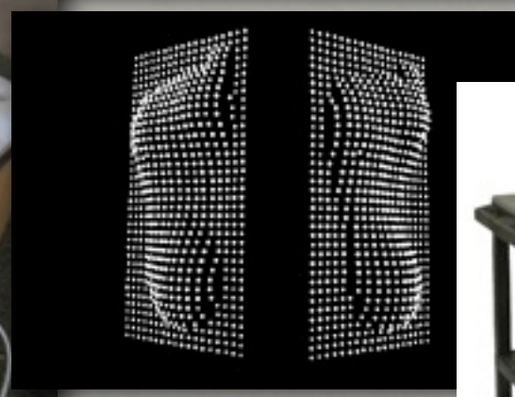
Mathematics	Probability & Statistics	Statics & Dynamics	Mechanics of Materials	Fluid Mechanics	Thermodynamics	Heat Transfer	Biology	Chemistry	Materials Science	Measurement & Controls	Economics	Computer & Software	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Mechanical Engineering

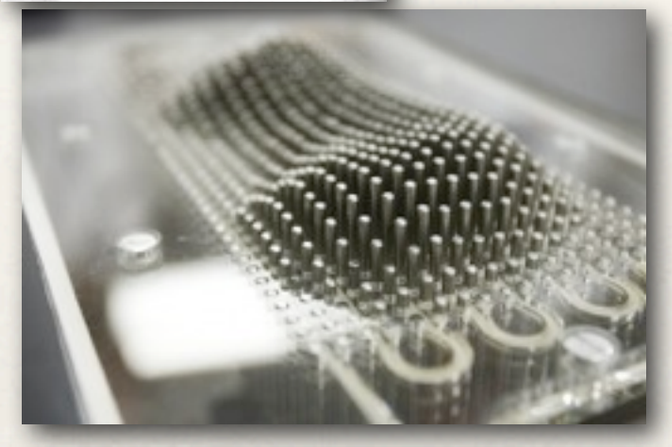
- Hardman Cabinets
- **Aerospace Satellites**
- Aerospace Test
- Aerospace Aircraft
- Aerospace Electronics
- **BYU Thesis**
- Aerospace Systems
- **Amtech Automation**
- **Aerospace Guidance**
- **Aerospace Controls**
- **Aerospace Sensors**
- **BYU Capstone**
- **Iterations Consulting**
- Technical Writing
- Mentoring
- Values

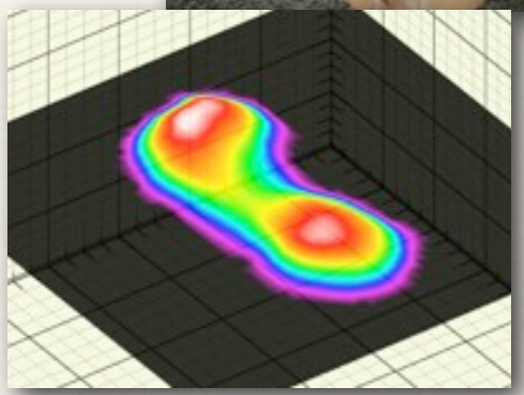












Engineering Stories

Short Stories (Realistic Fiction) in
Science, Technology, Engineering, and Math (STEM)
with Mentor Discussion and Exercises

A fabulous collection of realistic engineering adventure stories! Ken Hardman connects the design and development process we teach in engineering school to the exciting challenges faced every day in real engineering practice.
Steven D. Eppinger, Professor of Engineering Systems at MIT, co-author *Product*

"A fabulous collection of realistic engineering adventure stories!" (Steven D. Eppinger)

Ken Hardman's stories about engineering are a joy to read. In them he captures the excitement of real engineering problems. By describing the engineering process through fictional characters in fictional settings, Hardman invites the reader to participate in the adventure of invention and discovery.
Henry P[illegible] University, and author of, among other books, *To Engineer Is Human*, *To Forgive Design*, and *An Engineer's Alphabet*

Ken Hardman has done a masterful job—even spellbinding—in depicting what real Science, Technology, Engineering, and Math (STEM) projects, and the people and circumstances involved in them, are actually like in the real world!

Having myself been involved for more than fifty years in the types of projects that Ken writes about—and the use of case studies in engineering education for more than forty years—I can say without equivocation that Ken's case writing ability is superb!

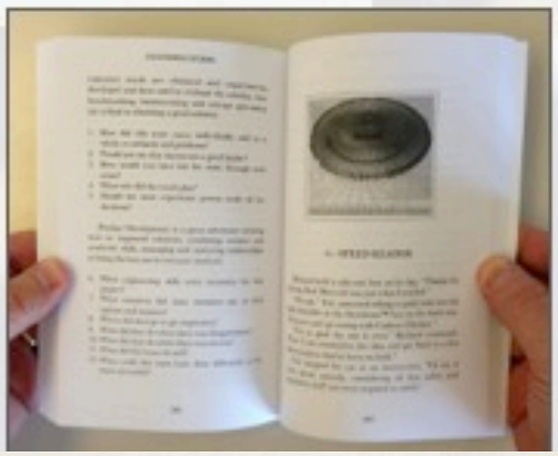
Page after page challenges you to use your creative juices, and you feel as if you are right in the lab, conference room, or computer, building and testing hardware as part of a team [illegible] through the [illegible] issues, to get the problem solved! Each engineering story has been carefully chosen to share important skills, topics and essential abilities of great engineers and scientists at work!

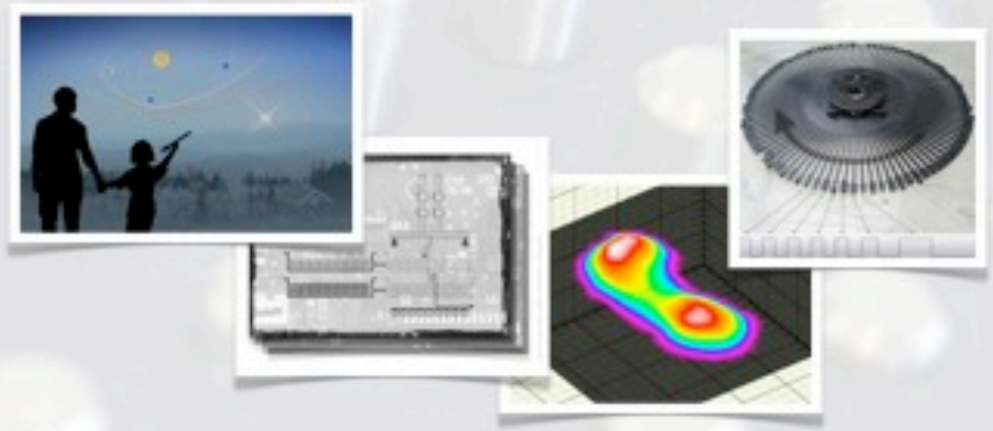
These stories will help you experience—just about as close to first hand as possible—the joys of creation and problem solving which result from learning and applying skills in a wo[illegible]
Robert H. [illegible], PhD, P.E., Fellow of the American Society of Engineering Education, Professor Emeritus Department of Mechanical Engineering Brigham Young University

"I know of no better introduction for engineering students" (Braden Hancock)

Engineering Stories has boiled down the relationship between an engineering education and real-world engineering situations to its core! I know of no better introduction for engineering students preparing to work in industry. Anybody seriously considering a career in engineering will benefit from and enjoy reading *Engineering Stories*!
Braden Hancock, Mechanical Engineering Student at Brigham Young University, ASME 2012 Kenneth Andrew Roe Scholarship recipient

Kenneth R. Hardman, P.E., MSME, Adjunct Faculty - BYU, Associate Technical Fellow at a major aerospace company, 30 years applied engineering experience





KENNETH R. HARDMAN