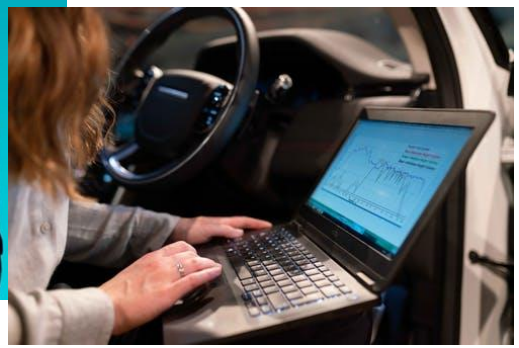
ENGINEERING PRINCIPLES

MODULE 3

TYPES OF ENGINEERING

A WORLD OF OPPORTUNITY

- **STEM Fields of Study:**
  - Aerospace
  - Software
  - Electrical
  - Forensics
  - Military
  - Structural
  - Nuclear
  - Systems
  - Biomedical
  - Civil
  - Chemical
  - Environmental
  - Genetics
  - Mechanical



MAJOR DISCIPLINES IN ROBOTICS

- **Design & Systems Engineering:**
  - Use system-thinking principles to design and manage a complex system
  - Evaluate how the components will work together to perform
  - Produce innovative and practical design ideas that anticipate and solve engineering problems down the line
- **Mechanical Engineering:**
  - Understand thermodynamics, mechanics, structural analysis, electrical systems, and material science
  - Use tools such as CAD (Computer-Aided Design) and CAM (Computer-Aided Manufacturing) to make designs
  - Design the robot's structure, joint mechanisms, bearings, etc.
  - Work closely with the electrical and computer engineerings
- **Computer & Software Engineering:**
  - Work together on both the hardware and software
  - Understand programming and how machines operate
  - Work with the mechanical team in translating the design principles into the code

ENGINEERING PROCESS

WHAT IS IT?

- The engineering design process is a series of steps that engineers follow to come up with a solution to a problem
- Many times, the solution involves designing a product (like a machine or computer code) that meets certain criteria and/or accomplishes a certain task
- The engineering design process is an ITERATIVE PROCESS!

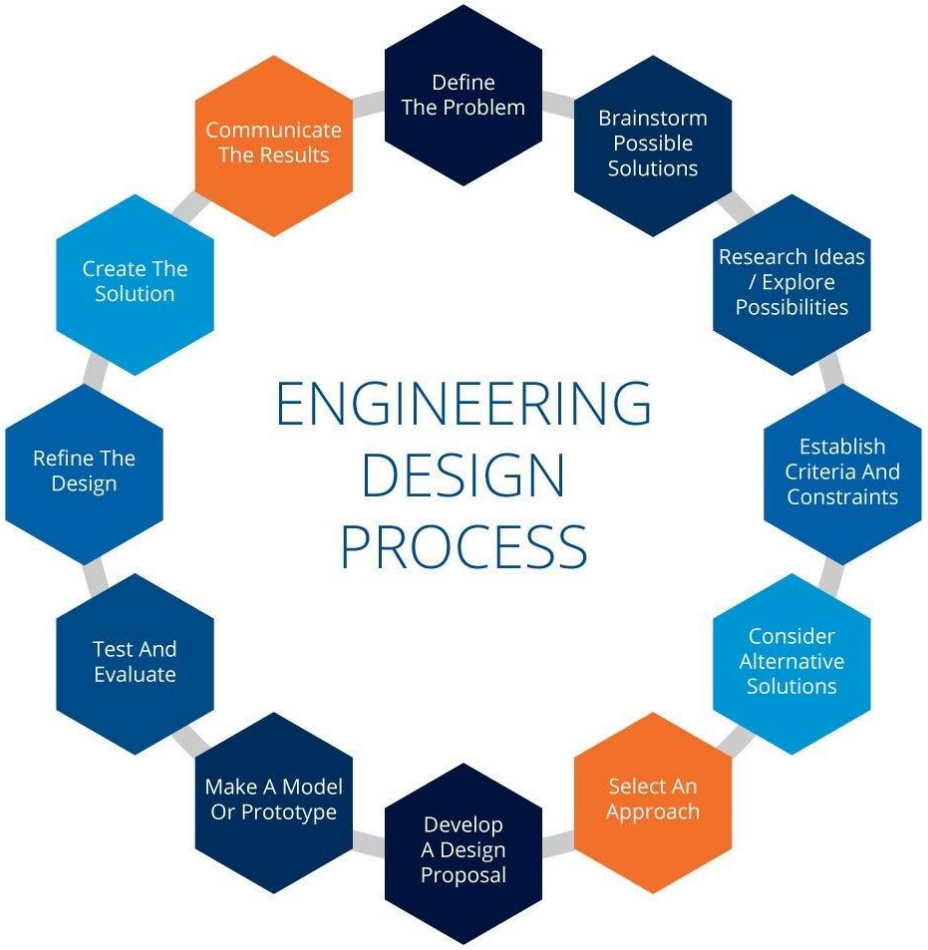


Figure 1. Engineering Design Process

ITERATIVE PROCESSES

- **Iterate:**
  - "Make repeated use of a mathematical or computational procedure" (Oxford Dictionary)
  - If at first you don't succeed, try try again!!!
- Our first ideas often can be improved, so we iterate

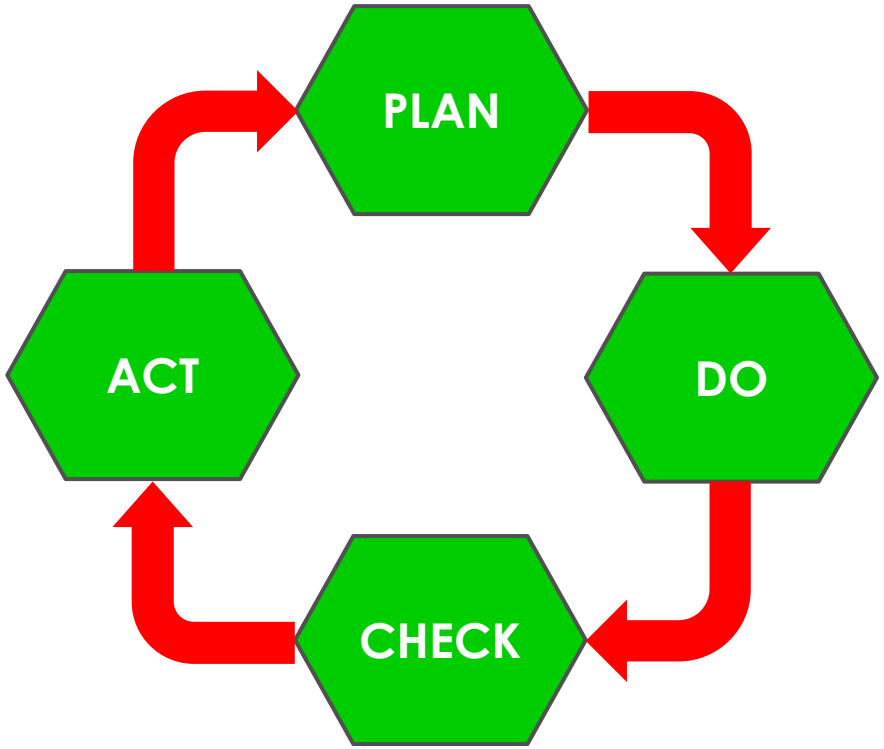


Figure 2. Iterative Process

ENGINEERING DESIGN PROCESS STEPS

1. **Define the Problem:**
   - What is the problem that needs to be solved?
   - Who is the design product for?
   - Why is it important to find a solution?
   - What are the limitations and requirements?
2. **Brainstorm Possible Solutions:**
   - List many possible solutions before starting a design
   - It is best to avoid judging the designs and instead just let the ideas flow
3. **Research Ideas/Explore Possibilities:**
   - Use the experience of others to explore possibilities
   - By researching past projects, you can avoid the problems faced by others
   - You should speak to people from various backgrounds, including users or customers
   - These steps may allow you to find some solutions that you had not considered originally

ENGINEERING DESIGN PROCESS STEPS

4. **Establish Criteria and Constraints:**
   - Establish any factors that may constrain your work
     - This can be done by revisiting the requirements and bringing together your findings and ideas from previous steps
5. **Consider Alternative Solutions:**
   - You may wish to consider further solutions to compare the potential outcomes and find the best approach
     - This will involve repeating some of the earlier steps for each viable idea
6. **Select an Approach:**
   - Once you have assessed your various options, you can determine which approach best meets your requirements
     - Reject those that don't meet your requirements!

ENGINEERING DESIGN PROCESS STEPS

7. **Develop a Design Proposal:**
   - Having chosen your approach, the next step is to refine and improve the solution to create a design proposal
   - This stage can be ongoing through the length of your project and even after a product has been delivered to customers
8. **Make a Model or Prototype:**
   - Use your design proposal to make a prototype that will allow you to test how the final product will perform
   - Prototypes are often made from different materials than the final version and are generally finished to a lesser standard
9. **Test and Evaluate Prototype:**
   - Each prototype will need testing, re-evaluation and improvement
   - Testing and evaluation allows you to see where any improvements are needed

ENGINEERING DESIGN PROCESS STEPS

10. **Refine the Design:**
    - Once testing has been completed, the design can be revised and improved
    - This step can be repeated several times as more prototypes are created and evaluated (iteration!)
11. **Create the Solution:**
    - After your refinements have been completed and fully tested, you can finally decide upon and create your finished solution
    - This may take the form of a polished prototype to demonstrate to customers
12. **Communicate the Results:**
    - This can be in the form of a report, presentation, display board, or a combination of methods
    - Thorough documentation allows your finished product to be manufactured to the required quality standards

ROBOTICS IN INDUSTRY

THE FATHER OF ROBOTICS

- **Joseph Engelberger** used robotics to automate the manufacturing industry. He was the developer of the first industrial robot in the US also known as THE UNIMATE!
  - 1946: Engelberger received his B.S. in physics
  - 1949: Engelberger received his M.S. in Electrical Engineering from Columbia
  - 1959: The first robot prototype, the Unimate #001, was developed and first installed on an assembly line at a General Motors diecasting plant in New Jersey
  - 1961: The Unimate series became the first mass produced robotic arm for factory automation

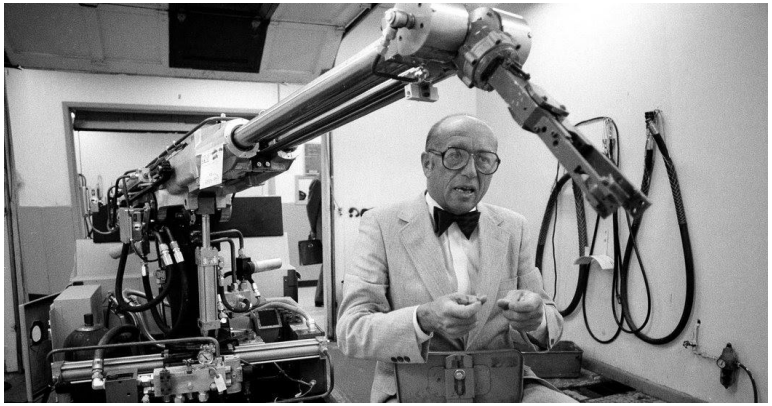


Figure 3. Joseph Engelberger

LOCKHEED MARTIN ONYX

Figure 4. Onyx Exoskeleton

AIRCRAFT PRODUCTION LINES

Figure 5. F-35 Production Line

Figure 6. C-130J Production Line

6-AXIS ROBOTS

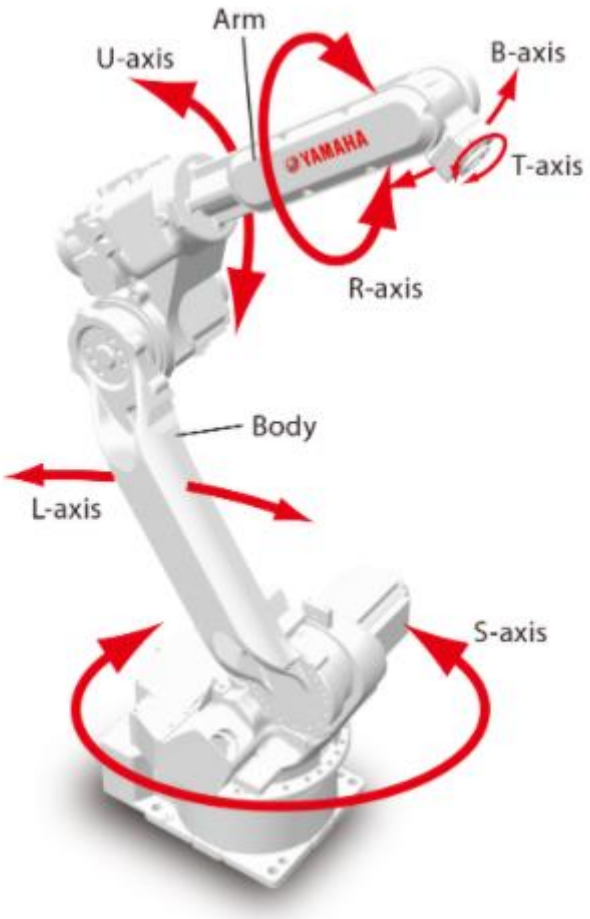


Figure 7. Robotic Arm Rotations

Figure 8. Robotic Arm Axes

UNMANNED SYSTEMS

Figure 9. General Atomics Gray Eagle

Figure 10. Lockheed Martin Special Projects

RESOURCES

MORE RESOURCES

- **Types of Engineering:** https://www.bestcolleges.com/engineering/types-of-engineering/
- **What a Robotics Career Looks Like:** https://mitadmissions.org/blogs/entry/what-a-robotics-career-looks-like/
- **The Engineering Design Process:** https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps
- **Intro to Industrial (Factory) Robots:** https://robotsdoneright.com/Articles/introduction-to-industrial-robots-for-beginners.html
- **Lockheed Martin Unmanned Projects:** https://www.lockheedmartin.com/en-us/products/isr-uas.html

SOURCES

SOURCES

- **Figure 1:** https://www.twi-global.com/technical-knowledge/faqs/engineering-design-process
- **Figure 3:** https://www.nytimes.com/2015/12/03/business/joseph-f-engelberger-a-leader-of-the-robot-revolution-dies-at-90.html
- **Figure 4:** https://www.facebook.com/lockheedmartin/videos/2421686854771142/
- **Figure 5.** https://www.defenceconnect.com.au/strike-air-combat/3344-lockheed-martin-meets-2018-f-35-production-target
- **Figure 6:** https://www.bizjournals.com/atlanta/news/2012/01/30/c-130j-hercules-hits-new-record.html
- **Figure 7:** https://global.yamaha-motor.com/business/robot/lineup/ya/ya-6/
- **Figure 8:** https://gfycat.com/anyjitterybluetonguelizard
- **Figure 9:** https://www.ga.com/new-generator-coming-online-for-gray-eagle-er-uas
- **Figure 10:** https://www.lockheedmartin.com/en-us/products/isr-uas.html