Engineering Design Process

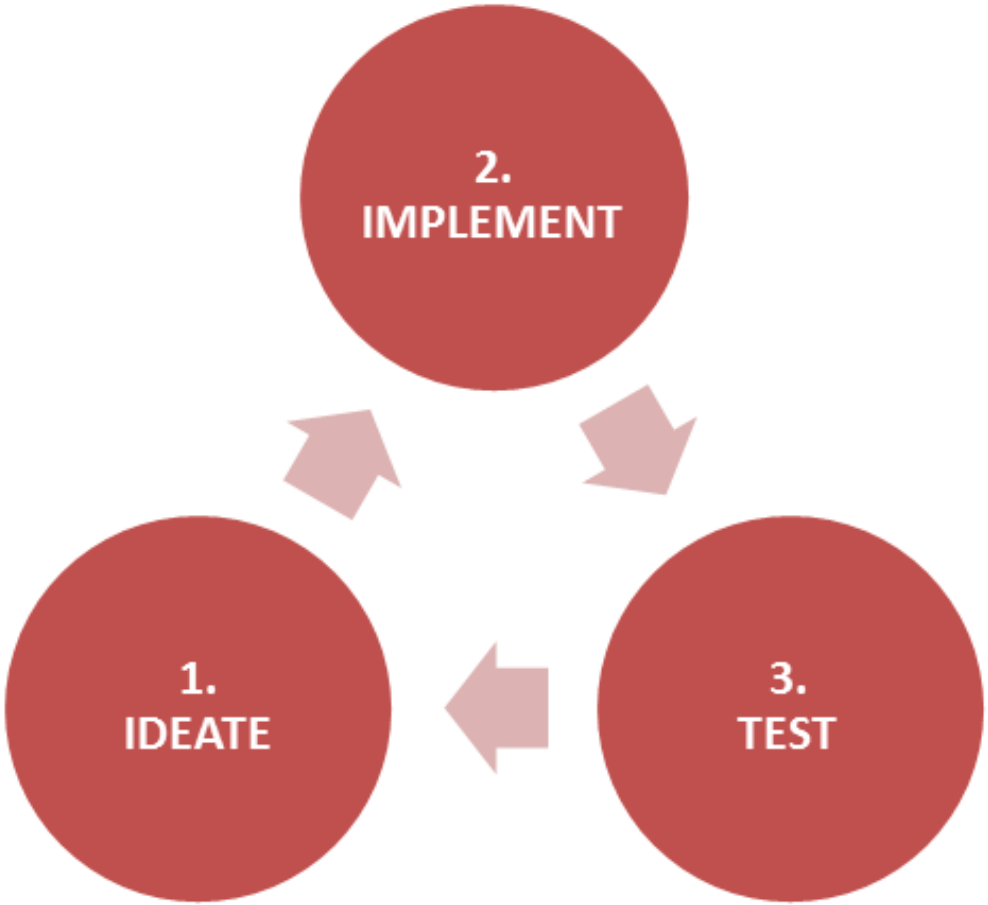
For Competitive Robotics

Explorer Post 1882/Club 42 – VEX Robotics Team

Engineering Design Process

- “Following a methodical process using available resources and experience to solve complex problems.”
- A series of steps that engineers follow when trying to solve a problem and design a solution for something…
- A methodical approach to problem solving.
  - Similar to “scientific method”.

Engineering Design Process



Source: Autodesk Curriculum
http://curriculum.vexrobotics.com/curriculum/intro-to-engineering/what-is-the-engineering-design-process

Engineering Design Process

- Step 1 – UNDERSTAND
- Step 2 – EXPLORE
- Step 3 – DEFINE
- Step 4 – IDEATE
- Step 5 – PROTOTYPE
- Step 6 – CHOOSE
- Step 7 – IMPLETEMENT
- Step 8 – TEST & REFINE
- Step 9 – REPEAT
- Step 10 - COMPETE

Step 1: UNDERSTAND

- Define the Problem
  - What are the competition rules?
  - How do we score points?
  - How do we win matches?
  - What challenges does the game field present?

Step 2: EXPLORE- Research

- Competition Rules
- Game Object Interaction
  - How can the robot pick up or move the game objects?
- Game Field Challenges
  - What challenges/opportunities are their related to the game field?

Step 2: EXPLORE

- Design Options/Ideas
  - Lifts, Drivetrains, Attachments, etc.

- VEX Parts Options

STEP 3: DEFINE Solution

- Design Specifications / Constraints
- Game Strategy
- Functional Requirements
- Prioritize

Specify *WHAT* the robot must do – NOT *how*

Specifications/Constraints

- What must the Robot do?
  - Score 50 balls a match.
- What must the Robot NOT do (constraints)?
  - Max. number of motors
  - Max. robot dimensions/size
- What are the design and game rules/restrictions?

Initial Game Strategy

- How do we win matches?
- How do we score as many points as possible?
- How do we score more points than our opponents?
- How fast does the robot need to move?
- How can the robot pick up the game object?
- How can the robot pick it up quickly?
- How many game objects does the robot need to hold?

Prioritize Specifications

- Rank design requirements, constraints and specifications
  - W = Wish
    - not that important, but it would be nice if it is possible
  - P = Preferred
    - important, but the project won't fail without it
  - D = Demand
    - critical to the project, MUST be included

Step 4: IDEATE - Brainstorm

- Brainstorm the *HOW*
  - How will the robot will meet design specifications, constraints and game rules
- Brainstorm design concepts
- Brainstorm game strategies

Lots of SKETCHES!

What is Brainstorming

- Group creativity technique
- Generate a LARGE number of ideas.
- Focus on *quantity* not *quality*.
  - *Many* ideas are generated in the hope that a *few* good ideas will develop.
- Critical part of solving any problem.

- Record EVERYTHING, no idea is too silly.
  - You never know what will spark a GREAT idea.

Step 5: PROTYPE

- Select the best IDEAS and start building!
  - Robot designs
  - Software programs / Virtual Worlds
- Test the IDEAS
- Refine the IDEAS

Sketch it, try it, tweak it... IMPROVE IT.

The Power of Prototyping

- No need to prototype everything, just the things you want to work.
- Test in “real world conditions”.
  - See how things interact.
  - Find improvements early
- GOAL
  - LEARN as much as you can about the concepts and how well each functions.
- Prototypes designed to be crude, but functional enough to be educational.

Step 6: CHOOSE

- Choose the RIGHT IDEA(s)
- Which IDEAS / prototypes
  - Worked best?
  - Scored the most?
  - Most stable?
  - Fastest?
  - Simplest?

Choose a Concept

- Take the lessons learned from prototyping and make a decision.
- Often the “right” solution just reveals itself. Find the elegant solution.
- Choose a concept to go forward with.

Step 7: IMPLEMENT

- Detailed Design
  - Model chosen design
  - Goal : A design that can actually be implemented or constructed.
  - CAD Models, Assembly Drawings, Manufacturing Plans, BOMs
- Build
- Program

Step 8: TEST & REFINE

- Bring it all together
  - Test
    - Check against your specifications
    - Check against expectations
  - Review
  - Refine

Repeat, repeat, repeat……

Design Reviews

- Does it meet our specifications?
- What other functionality would be easy to add?
- Why was it done this way?
- Did you think of doing it a different way?
- Why did you rule out other alternatives?
- How can we make it faster?
- How can we make it
  - Better
  - More robust
  - Weigh less
  - Smaller
  - Simpler
  - Easier to build/program
  - Efficient

Step 10: COMPETE

- Compete early and often
  - Never to early to enter a competition
  - Experience is life's best teacher
- Take notes
  - Your robot
  - Competitive robots