Part III – Robot Design Step Detail

Objectives

1. Understand Concept development
   A. Process and tools

2. Understand Prototype development
   A. Process and tools

Golden Rules of FIRST

1. Read the rules! – Understand the game!
2. Game strategy dictates robot design
3. Continuous Acquisition - Rollers to gather objects
   with Large Acquisition area
4. Leverage from the best and Invent the rest
5. Cycle Time wins events => Reliable/Fast robot modules
6. Fail Faster / Fail Earlier

What is a Good Design in FIRST-Part I

1. **Is it reliable** – Does the module do the same thing over and over again?

2. **Is a simple design** – Does the module use minimal parts, minimal controls?

3. **Is it fast** – Does the module operate with the “Cycle Time” allotted for the module?

What is a Good Design in FIRST-Part II

1 Game object acquisition module has continuous acquisition - rollers

2 Gather mechanism has a large access

3 Robot alignment – Quick alignment is key to scoring

4 Low Center Of Gravity (COG)

Robot Concept Development

IT IS NOT A BRAIN STORM

Three Stages to Concept Development

1. Analysis
   a. Organize related functions and link to robot model
   b. Understand “Game Object” characteristics
   c. Understand game physics

2. Synthesis (Create a Concept)
   a. RESEARCH – Has anyone done something like this before?
   b. Use “Convergent Thinking”
   c. Draw a picture
   d. Do a “SWOT” analysis

3. Iteration
   a. Play with concept……Pizza Dough thinking(What if?)

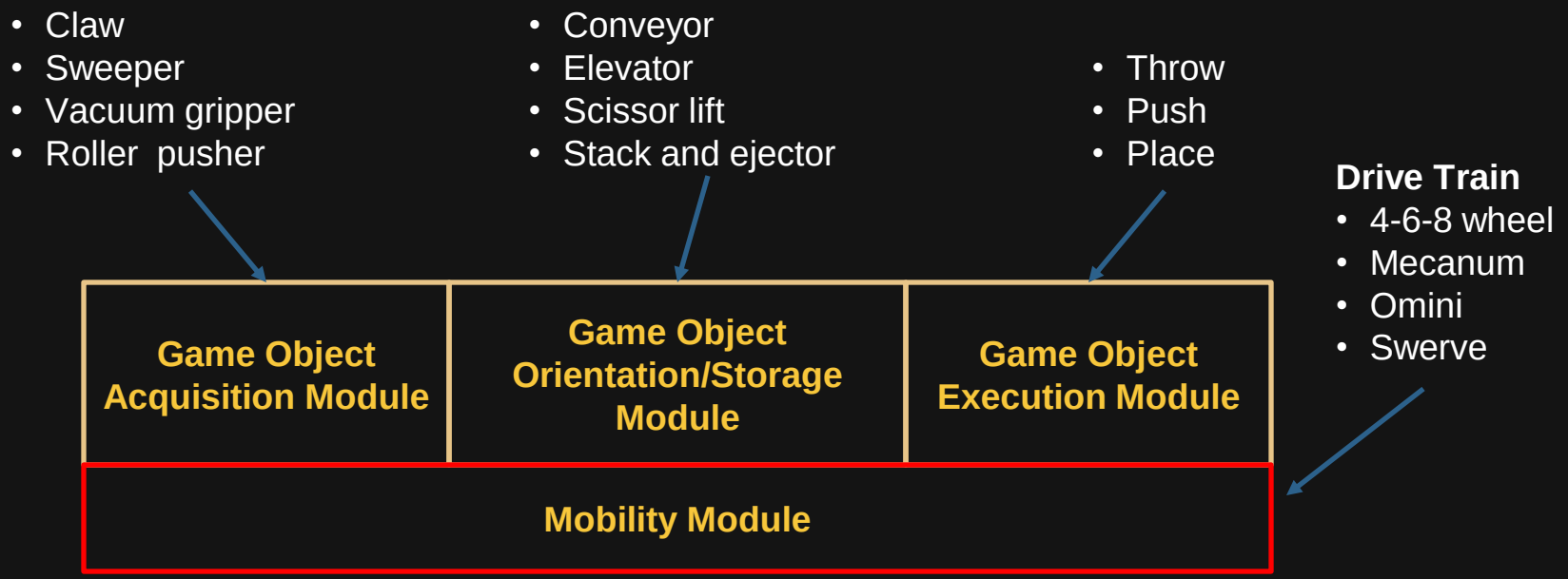
Knowledge Challenge

1. What are the major tasks in developing a concept? – there are three

Concept Development - Stage1

Stage 1: Analysis

- Organize robot functions and constraints with respect to the robot model
- Understand “game object” characteristics, Execution physics



Knowledge Challenge

1. What are the four major robot modules?

Concept Development - Stage2

Stage 2: Synthesis (Create a Concept)

- Through **Convergent Thinking** develop a concept
  - ✓ Has any one done something like this before?
  - ✓ Can you modify some other concept?

- **Develop a sketch** of the concept

- **SWOT analysis** of concepts:
  - ❑ Strengths - Does it meet requirements?
  - ❑ Weaknesses – Are there concept limitations?
  - ❑ Opportunities - Can it integrate other functions?
  - ❑ **Threats – How can concept fail? - Can you resolve the issues?**

Convergent Thinking

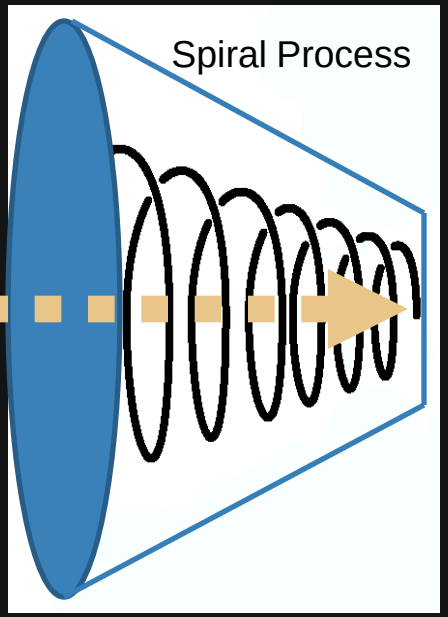
“Informed Creative Thinking” – Woodie Flowers

Problem Definition-Understanding:

- Robot functions developed(needs)
- Robot constraints from FIRST
- Your experience
- Physics of the actions

Tools:

- Mechanical parts available
- Control modules available
- Sensors available
- Types of mechanisms we can build
- Types of drives we can build
- Software we can create

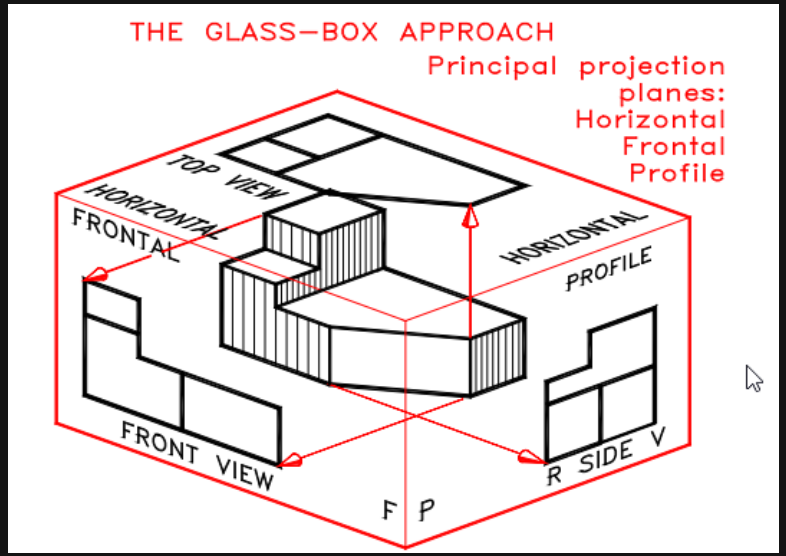


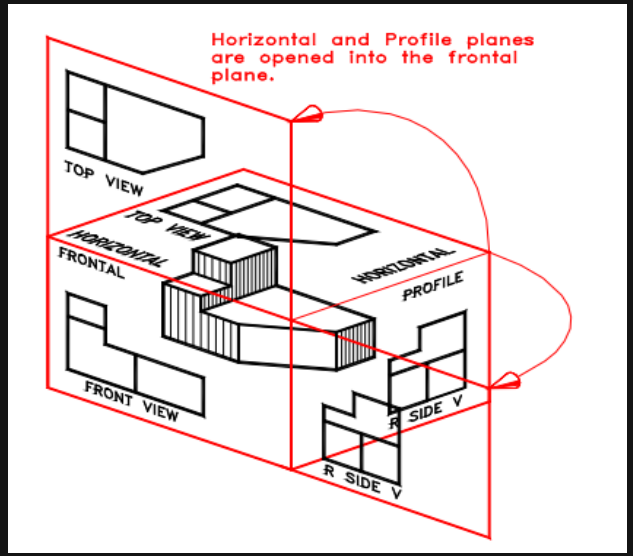
Robot Concept

Engineering is the process of using the tools in hand to solve a problem within the defined constraints

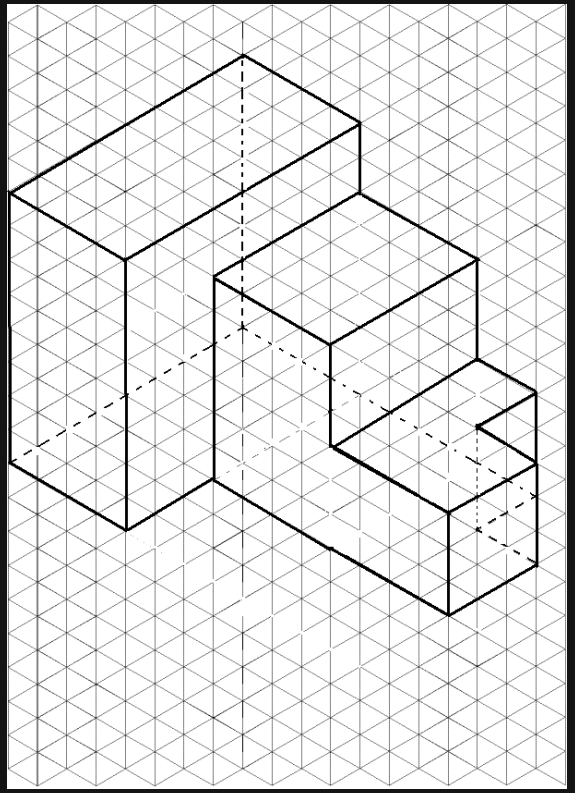
Develop a Concept Sketch

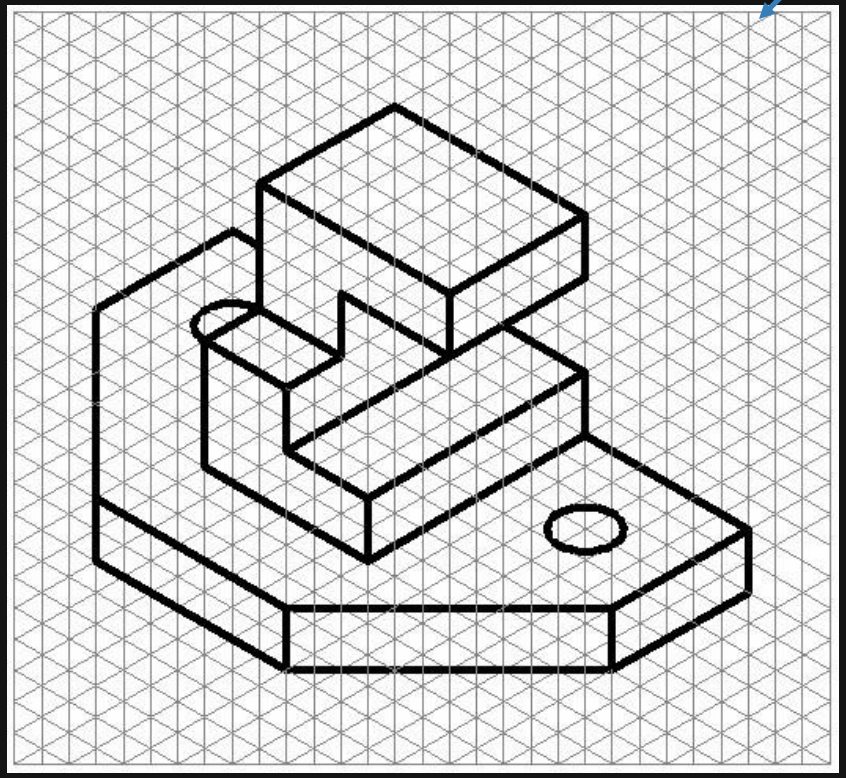
How we view a mechanical object





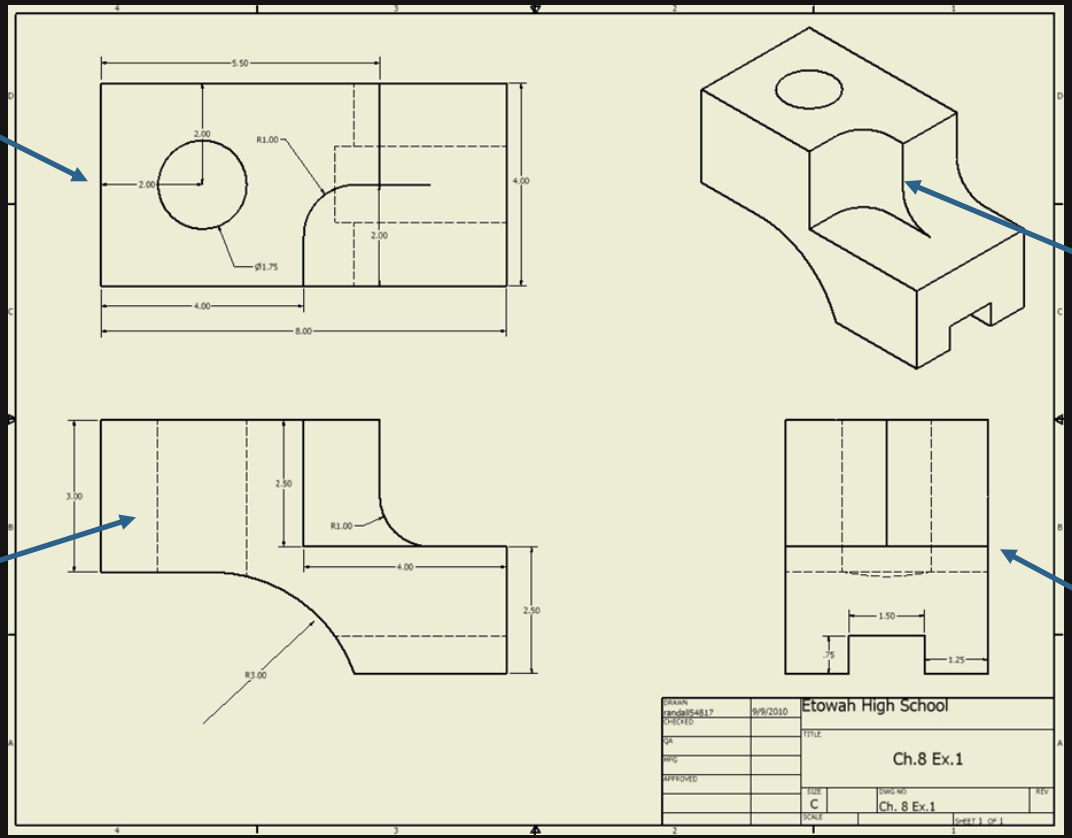
Concept Drawing - Isometric





Part Detail Drawing – Orthographic View

Top View

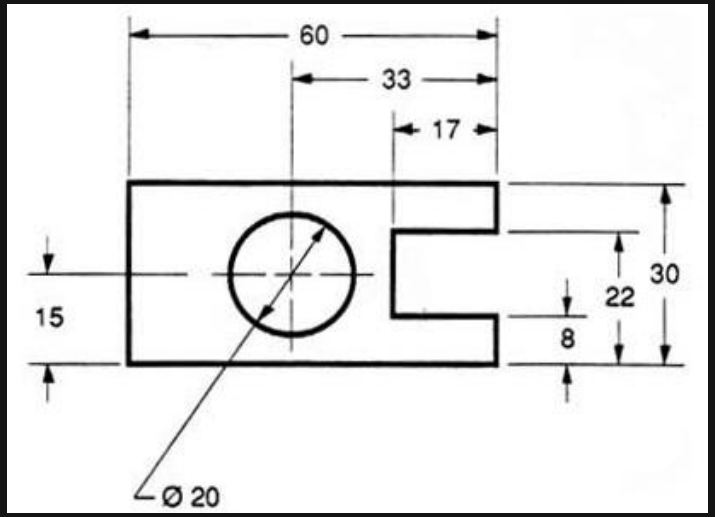


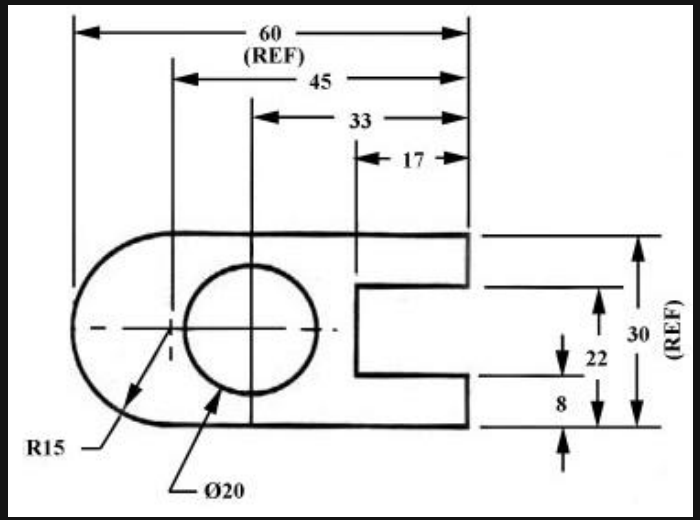
Isometric View

Front View

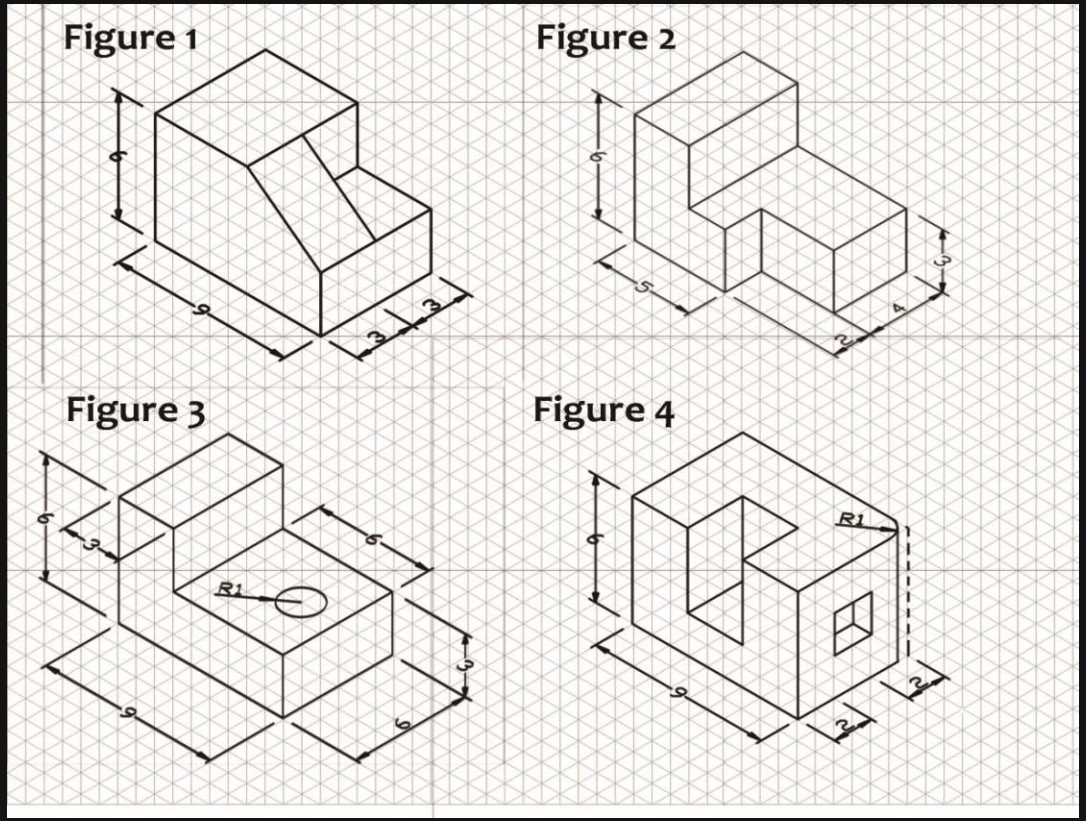
Side View

Part Dimensioning

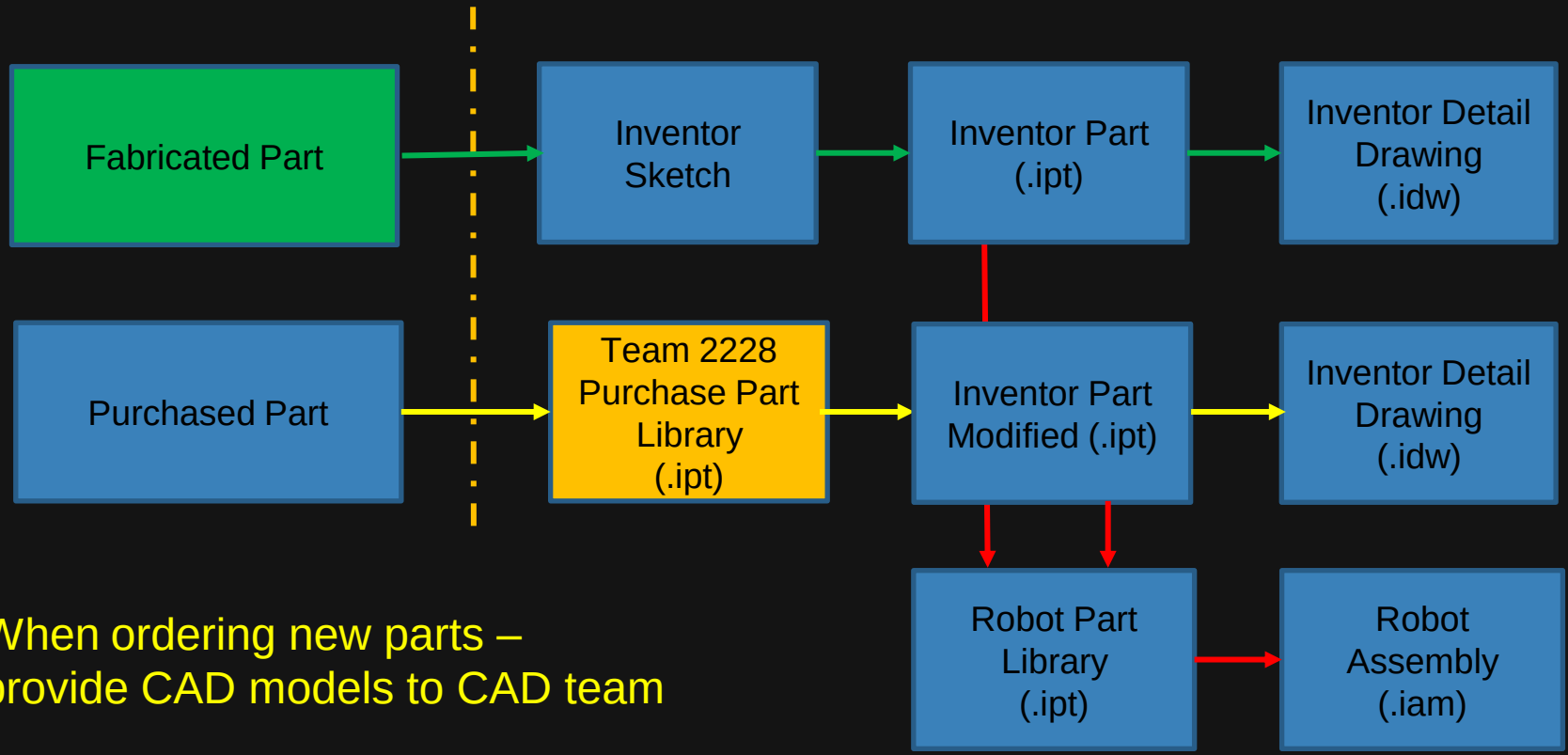




Isometric Drawing Practice



Sketches to CAD



When ordering new parts –
provide CAD models to CAD team

Knowledge Challenge

1. What is convergent thinking?

2. Why do we make a concept sketch?

Engineering SWOT Analysis

Engineering SWOT Analysis (For Robot Concept Development)

Description of Module operation

S-Strengths:

- Does concept meet function requirements
- Is the concept simple?
- Does the concept meet FIRST robot design constraints?
- Is the control concept simple? (Few parts)
- Does the concept have a small weight?
- Is the concept easy to build? To maintain?
- Is there tolerance adjustability in the design?
- Will concept be reliable? -- PERFORMS SAME OPERATION EVERY TIME

W-Weaknesses:

- What parts of the required function are not addressed?
- Do we have learn new technology?
- Does the concept require complex controls?
- Does the concept require a complex mechanical system?
- Did you use gravity as a process control?
- What don't we know about the concept?
- What do we have to prototype? How long will it take?
- What does the prototype have to prove?

O-Opportunities:

- HAVE YOU SEEN A SIMILAR CONCEPT BEFORE?
- Have you done pizza dough thinking?(What ifs)
- Can the concept do several functions?
- Can parts of this concept integrate into another concept
- Think of an opposite concept – For example: (typewriter moved carriage - today's printers move print head)

T-Threats:

- HOW CAN THE CONCEPT FAIL?
- Is the game object always constrained?
- How can you overcome weaknesses?
- How can you overcome concept failures?
- If broken in competition, can we fix it quickly?

Concept: Proof-of-Principle (PoP)

Explores, with minimal construction, to verify an idea or function

Design Steps

1) Develop PoP for ideas or functions you need to understand

2) Define the PoP
   - Define what you want to learn
   - Draw a sketch / Develop BOM
   - Develop a test plan

3) Kit parts, cut wood, assemble (goal - build/test in one day)

4) Evaluate the idea or function

Concept Visualization - Models

To visualize concepts build models:

Materials:

1. Cardboard
2. Foam Core
3. Tape
4. Paper clips
5. Paper fasteners, etc

Elevator to lift fuel out to furnace(2017)

Team 2340 used cloth that wound up to lift fuel up.

Knowledge Challenge

1. What does SWOT mean?
2. Why does the SWOT need a operation description?
3. Why do a proof of principle
4. Why would you make a concept Model?

Concept Development - Stage3

Stage 3: Iteration

- Evaluate the concept (SWOT)
  - ✓ Does it meet the problem needs?
  - ✓ Will it work?
  - ✓ Can you build it?
  - ✓ Does the concept meet the design constraints?

- Iterate the concept
  - ✓ Play with the concept (“WHAT IF” Thinking)
    - ❑ Reverse the concept, ask “what if” questions
    - ❑ Combine other team member ideas, concepts
    - ❑ How do you make it simpler, faster, integrate more functions?

Concept Decision Process

Anyone can develop a concept - students/mentors

1 Concept Documentation:

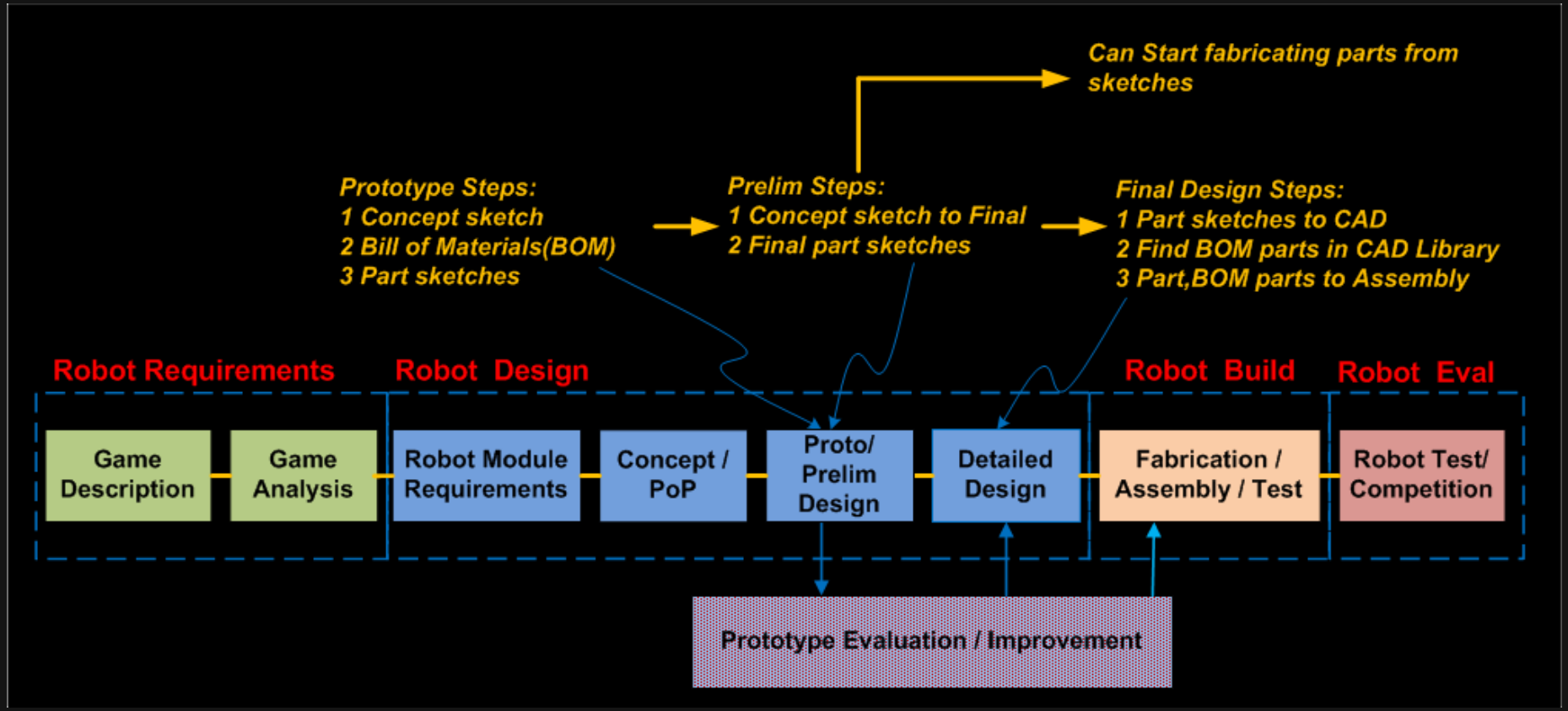
a) Concept picture, SWOT analysis

2 Concept Decision steps: **(Concepts are not VOTED on!!)**

a) Concept consensus approval – move forward

b) Competing concepts: Decision matrix

Prelim Design



Preliminary Design: Prototype

A prototype is a tangible representation of the intended design of the robot

- Do not prototype every concept – You don’t have time
- Select best concept with least amount of issues
- The prototype should be a:
  - Acquisition module
  - Orientation/storage module
  - Action Module

Prototype First Steps:

1. Complete three stages of concept development (Analysis, Synthesis, Iteration)

2. Develop concept sketches and (BOM) Bill of Material

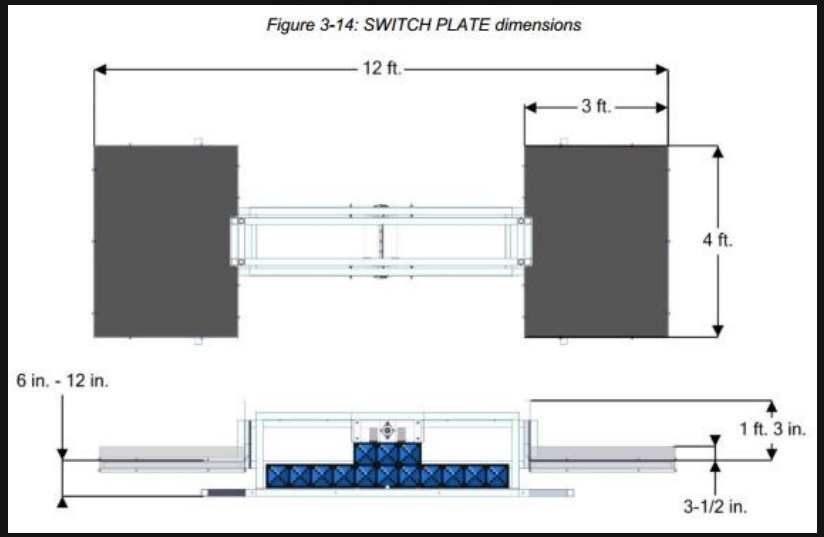
3. Collect material and start construction of prototype

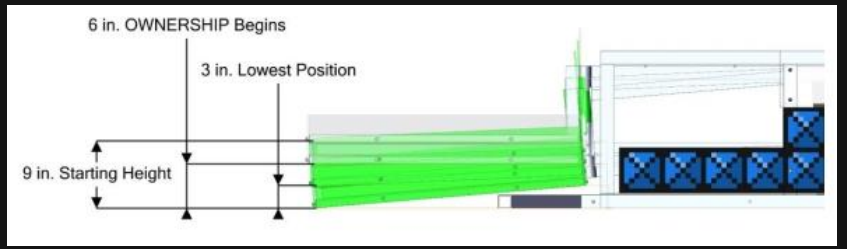
4. CAD prototype from concept sketches and fit module into robot model

Game Field Element Dimensions

The first thing to do is?

For Example:





Proof of Principle / Prototype Material

Tools: hand drill, 1 1/8in hole saw(for bearings), C/Bar clamps

Frame: wood;

Fasteners: screws, hot glue, duct tape, Velcro

Conveyors: polycord

Springs: surgical tubing, small torsion springs(mouse-rat traps)

Mechanism Shaft: collars, hubs, spacers, hex shaft, bearings with flanges, timing belt pulleys, chain sprockets

Motors:

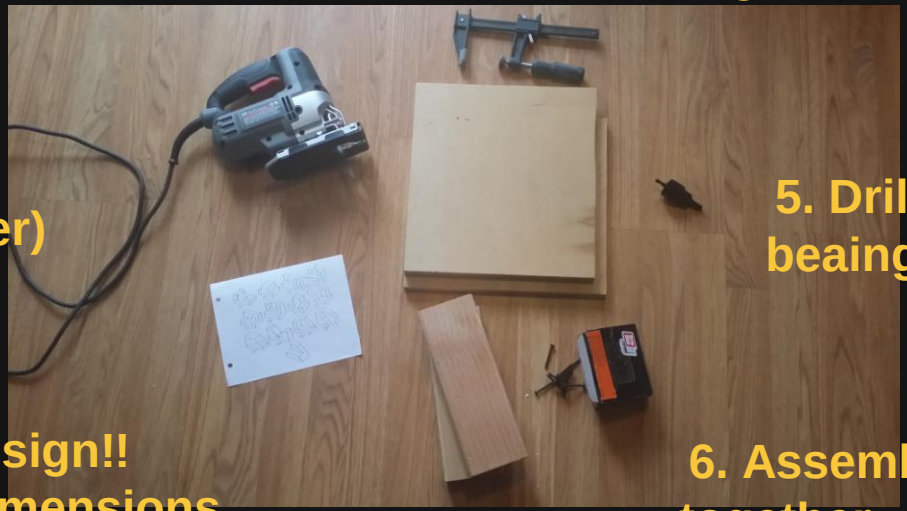
Proof of Principle – hand drill with adapter to 1/2in hex socket, motor test box

Prototype: motor brackets, 8mm – 1/2in shaft coupler

Prototype Frame Design-Fabricate

3. Cut wood frame

4. Clamp wood for shaft bearing holes



2. Kit parts (find them or order)

5. Drill holes for shaft beaings (1 1/8in hole saw)

1. Develop design!!
   a. Dwg, dimensions
   b. Bill Of Materials (shopping list)

6. Assemble and screw frame together

Proof of Principle Examples

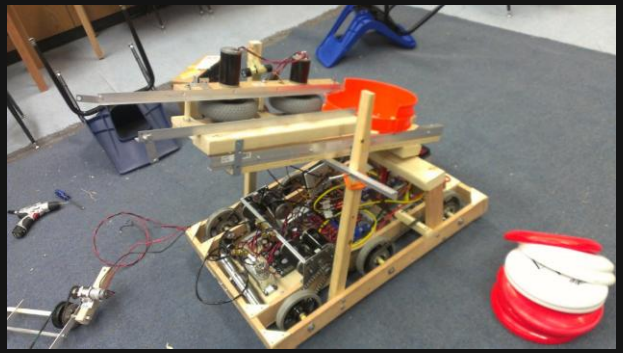
Team 254

Team 254

Prototype Examples

Team 254

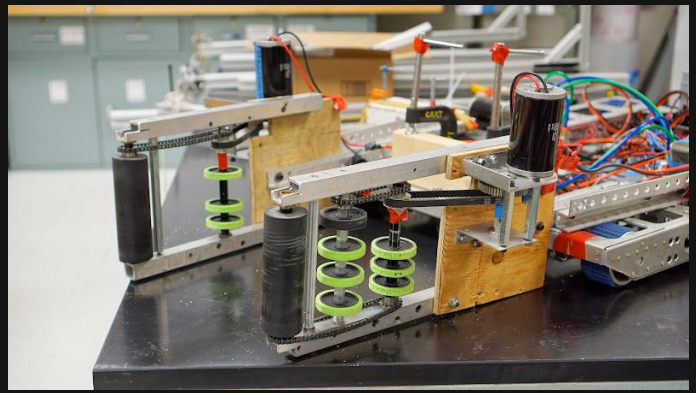
Team 4183



Prototype Examples

Team 971

Team 971



Drive Shaft Components

Collar

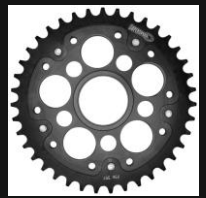
Bearing

Spacer

Hub

Pulleys’

Sprockets



Spacer

Bearing

Collar

Motor

Motor Bracket

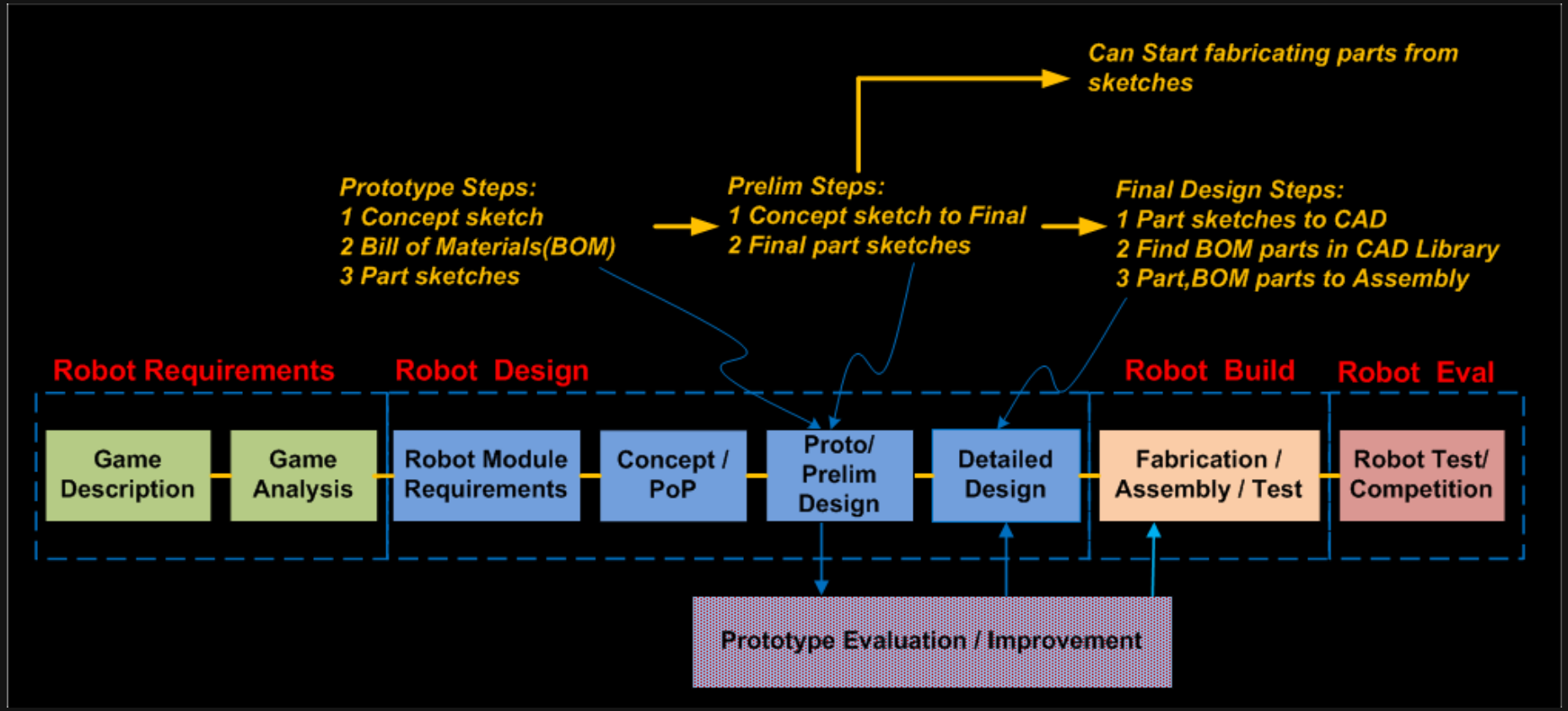
Coupler

Hex shaft

Adapter

Hand Drill

Detailed Design



Robot Weight Estimate Calculation

All weight is in lbs: Tubes/Shafts weight is in lbs/ft

DriveTrain – 30

80/20 1x1-0.4367; 1x2-0.9216
Tube: 1x1x0.1predrilled-0.3966; 1x1x0.04-0.1831; 1x2x0.1-0.66712
Peanut Tube: 1x1x0.05-0.533
C channel: 1x1x1x0.09-0.2676; 1x2x1x0.09-0.3633
Gussets/Motor Mounts: 0.09

Churro Tube: 1/2-0.16
Hex Shaft: 3/8-0.1467; ½-0.2633: ½ Thunder-0.2367
Bearings: 0.058, collars-0.02

Motors: CIM-2.8; Mini CIM-2.16; bag-0.71; 775-0.78; 550-0.5; Window/snowblower-1.11
Controls: 5.5