VEX SuperQuest 2019!

Get to know your neighbor. You will be introducing your neighbors to the rest of the class.

1) Name
2) School or Affiliation
3) Robotics program(s)
4) One thing you would like to get from this workshop.
5) Something else about the person. Hobbies, places travelled, summer plans,

Introductions

Vision for the Course

Schedule for the Year

Grading

Setup Engineering Notebooks

This Session’s Schedule

- Introductions
- Student Expectations
- Lab Rules
- Course Overview
- Get to know this year’s challenge
- Go through

Student Expectations

- Have fun
  - Students design, build, program robots to competed in the VEX Robotics Competitions.
- Sportsmanship
  - **Atmosphere where it is OK to make mistakes, ask questions, encourage others, take chances, and make mistakes**.
- Hustle
  - All Teams incorporate the Scrum Framework for developing robots.
  - All students are actively engaged in training activities and their team's robot.
  - Students complete training challenges
  - Teams create ***quality engineering notebooks***
  - Teams maximize their time to meet the goals
  - Students take advantage of open lab times.
  - **Students willing to do what it takes to keep the team successful**.

To be successful in this course:

- Stay focused and productive in the classroom
- Excellent attendance
- Let your projects, daily work, quizzes and tests display your **best effort**
- Feel free to talk with me about your projects, questions, etc.

(Students) Grading for Robotics Projects

Everyone needs to have a journal!
Once teams are determined, if you are updating the 'Team' journal you do not need a separate individual journal.

- <u>To get a 'B' in the class complete the following</u>
  - Engineering Notebooks (10 points / week)
    - Tasks, activities, pictures, reflections for the week.
    - Add Value/Participation Documentation
  - Activities (5 – 50 points each)
  - Tournament setup (10 points each)
  - Tournament cleanup (10 points each)
  - Tournaments (20 points for each required event)
- <u>To get an 'A' in class you will need to complete one of the following 'Above and Beyond' activities **every six weeks**.</u>
  - Outreach
  - Help at October In-service
  - Help at Concessions/Fund raising activity.
  - Help with new VEX Team(s) outside of West High.
  - Help FIRST LEGO League/ VEXiQ team(s)
- Time spent outside of class on robot, Three hours per 6 weeks.
- Submit a quality VEX 'Online Challenge' entry.
- WORK MUST BE DOCUMENTED IN YOUR ENGINEERING NOTEBOOK.
- … If you have a proposal, check with Smith.

(Students) Grading Scale

- ‘A’ 90%+
- ‘B’ 80 – 89 %
- ‘C’ 70 – 79%
- ‘D’ 60 – 69 %
- ‘F’ Below 60%

Smith’s Performance Goals

- Participants have a model that can be used to run a competitive robotics team.
- Participants build a robot and incorporate best practices
- All can write an autonomous program that can use sensors
  - Training challenges
- All write a ‘driver controlled’ program
- All participate in programming activities
  - Movement Challenges
  - Driving Challenges
  - Programming Skills Challenges
  - Driving Skills Challenges
- All participate in a mini class tournament

(students) Team Goal Attainment

- Six + Vex Robotics Teams
  - Attain funding (Need $$ for this year to compete at State)
    - **Concessions help (Can sign up now to get on the list)**
    - **Hosting VEX Tournaments**
    - Letter writing and visiting campaign
    - Pursue student contacts.
  - Build quality robots with quality team members
    - Incorporate the Scrum Framework
    - Do the little things
    - Be creative in prototyping/testing when parts are not available
    - Encourage others
    - Improve another’s idea if the team so decides
    - Do your team role with excellence!!

VEX Events 2019-2020 (To date)

- 10/12 VEX Idea Factory (Host) Not required, does earn above and beyond for first 6 weeks.
- 11/9 **Tournament at West (Host – All compete, including setup and teardown)**
- 11/23 North Marion
- 1/11 Sandy
- 12/14 Central Oregon (Bend)
- 1/18 North Marion
- **1/24 Tournament at West (Host – All help)**
- **1/25 Tournament at West (Host – All Compete)**
- 2/1 Klammath Falls Community College
- 2/8 Willamette
- 2/21 Vale
- 2/29 Marcola
- **3/14-3/15 State All compete**
- TBD SkillsUSA Student Leadership Conference (Mobile Robotics/ Urban Search and Rescue)
- 4/22-4/25/2020 VEX World Championship, Louisville, KY.

(Students) Autonomous Score Achievement

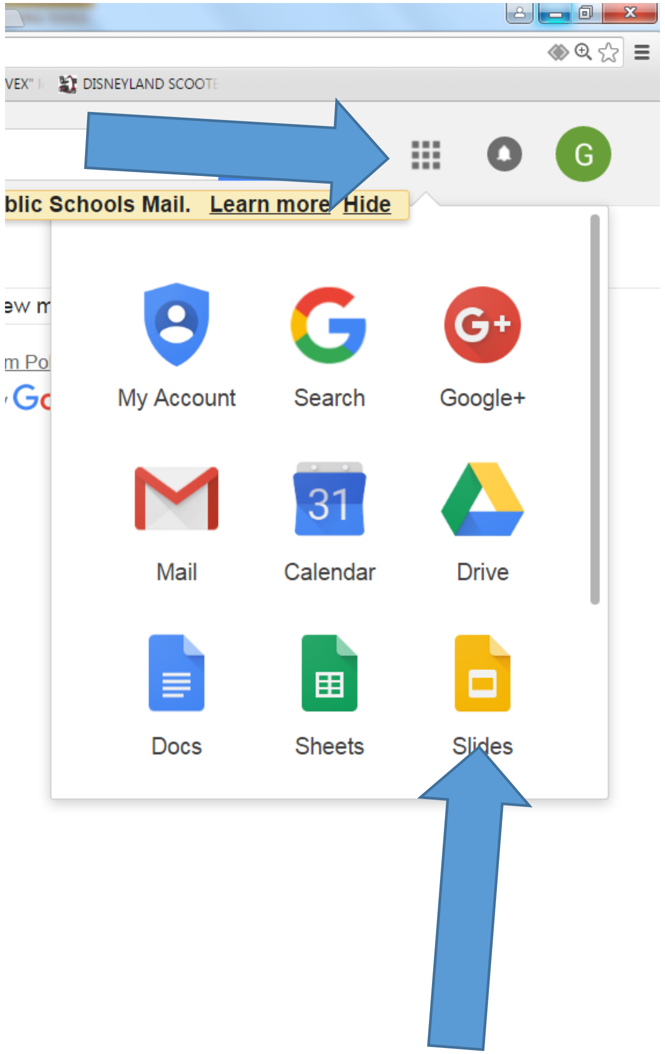
- Autonomous score
  - Incorporate **training** in programming in RobotC
    - Some for all
    - More for programmers
  - Have **running drive trains** for the programmers by the 3rd week of class
    - VEX Squarebot or Clawbot for rookie teams
  - <u>**Always**</u> have a running test bed for programmers and drivers!!!
  - Create in-house challenges based on this year's challenge.

(Students) To be Captain

- Incorporating **Scrum** (an Agile Product Development strategy) into the engineering design cycle this season to help create quality products more rapidly.
- Maintain an excellent Engineering Journal.
  - Document the journey
  - Update at least twice a week: Monday's and Fridays with pictures and descriptions
- Have teams create **a rigorous method for evaluating their design that can also be used for scouting** other teams.
- Practice, practice, practice
- Plan for anything
- Take advantage of open lab times.
- **Always** have a running test bed for programmers and drivers!!!

Today: Superquest Folks also

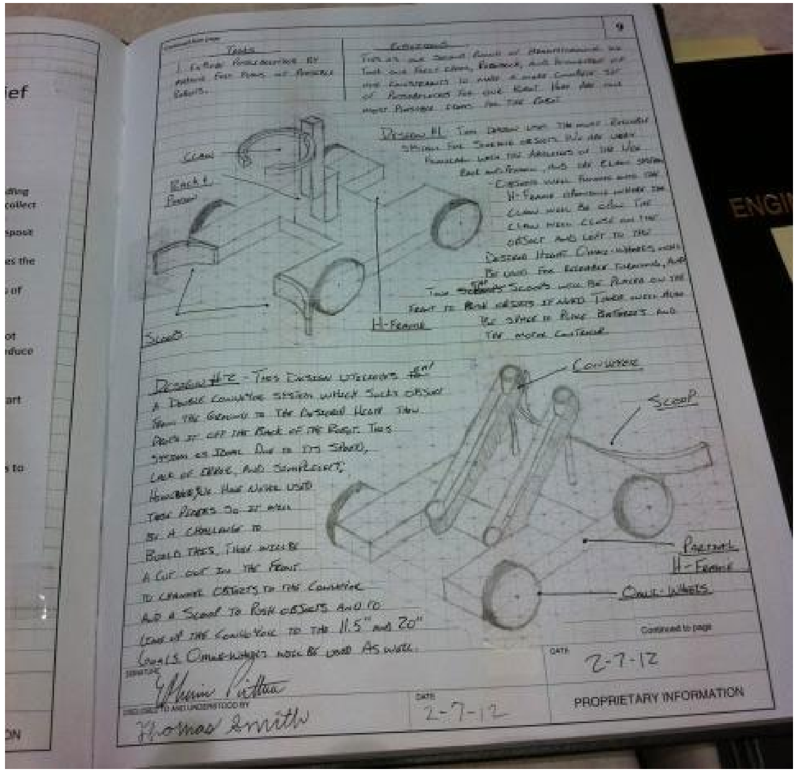
- Create a **gmail** account if you do not have one.
- Create a Google 'Slides' document for your engineering notebook.
  - Log in (create if needed) to your gmail account
- Name it 'YourNameSuperQuestSalemWorkshop2019'
- Share it with
- **'SmithTitanRobotics@gmail.com' and Birkel_Judson@salkeiz.k12.or.us**



- When teams are finalized you will need to share it with your teammates as well.

Individual Engineering Notebook

- Page 1:Introduction
    1) School or Affiliation
    2) Robotics program(s)
    3) Things you would like to get from this workshop.
- Page 2
    - Table of Contents
- Page 3 (Students. I use this to help pick teams at school)
    - The time commitment you are willing to put into your team.
    - Are you taking this class one, or both semesters
    - Skill Set: Classes, abilities, skills that you bring to the robotics team.
    - Roles you would like to take: Builder, programmer, captain, driver, research, promotions, fund raising, product owner, Scrum master…
- Page 4 (Students)
    - Describe a 'Dream Team'. **Focus on skill sets, not names.** I will talk individually with you about people you are interested in having on your team. No guarantees, but it will help me in finalizing the teams.



Hyperlink to Engineering notebook above.

Video for This Years Challenge

Getting to Know the Game

- Jigsaw
- Each person will be assigned pages from the Game manual to become the expert. (What is important, key ideas, you will be able to teach this section to others) (10 minutes)
- Have a written summary of main ideas.
- Expert Groups meet and each person will share on what they see as being important to share with the class. Discuss and agreed to key ideas (10 minutes)
- Expert Groups prepare presentation (15 minutes)
- The expert groups will present their material to the class. All members part of presentation.

- Expert Team Roles
- Time Keeper (Born in earliest part of the year)
- Scribe: Record important information in PowerPoint or Slides (Second earliest)
- Scrum Master: (Born in the latest part of the year)
  - Make sure everyone gets an opportunity to share
  - Run the meeting
  - Assign roles if no volunteers
- Encourager. (Second latest)

Sections: The Game Section of the Game Manual The Game Manual is on the class Website

A. Pages 3-7
B. Pages 8-12
C. Pages 13-17
D. Pages 18-22
E. Pages 23-27
F. Pages 28-32

Line up by Day of the Month you were born.

Getting to Know the Game

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B. Pages 8-12
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Break into teams of 2

- Judson
- Share/combine your engineering notebooks with each other
- Rename the shared notebook to ***bothOfYourNamesSuperquestWorkshop2019***
- From now on you just need to update the team engineering notebook.

Design Process: Challenge	Describes the challenge at the beginning of the notebook with words and pictures and states the teams' goals toward accomplishing that challenge.

Engineering Notebook Page Title: ***The Challenge***

- Research and describe the Challenge for this season
  - As a team. Document in team engineering notebook.
- Resources
  - http://smithcsrobot.weebly.com/superquest2019.html
  - Be prepared to share your description of the challenge, and your goals toward completing the challenge with another group.

Defend your Position

- Group 1 Share : Group 2 listens
  - Group 2 ask clarifying questions
- Group 2 shares: Group 1 listens
  - Group 1 asks clarifying questions
- Both groups return and refine their Positions as needed.

Engineering Notebook Rubric

Engineering Notebook: The notebook...	
Criteria	**Expert (3 points)**
Design Process: Challenge	Describes the challenge at the beginning of the notebook with words and pictures and states the teams' goals toward accomplishing that challenge.
Design Process: Brainstorming	Generates an extensive list of possible approaches to the challenge with labeled diagrams.
Design Process: Select Approach	Explains why the selected approach was chosen and why the other alternatives were not chosen.
Design Process: Build & Program	Records the building and programming process in such detail that someone outside the team could recreate the robot by following the steps in the notebook.
Test & Redesign	Describes in great detail the process of troubleshooting, testing, and redesigning through all iterations (cycles) of the process.
Usefulness	Is such a detailed account of the team's design process that the reader could recreate the project's history. It is a useful engineering tool. It contains evidence that team made decisions about design process based on previous entries. The team can explain why the notebook is organized the way it is.
Resources	Shows the team's efficient use of time with an overall project timeline. The team uses checkpoints to help them know how well they are staying on schedule and readjusts their schedule as needed. The notebook illustrates the good use of human resources by assigning members roles based on their strengths.
Teamwork	Provides evidence that all team members were consistently involved in the process, that individual team members were self-directed enough to finish what needed to be done, and that all team members consistently shared ideas and respectfully considered each other's input.

Engineering Notebook: Specifications and Constraints

- **Engineering Journal Page: 'Specifications' What your robot can do/be**
  - Stable: Will not tip over if placed on a 45-degree angle
  - High Traction: Will not slip when pushed with 8 lb. force
  - …
- **Engineering Journal Page: 'Constraints' What your robot can't do/be**
  - Must fit into an 18"x18"x18"
  - May not use more than 8 motors, or 6 with pneumatics
- **As a team develop at least 8 specifications and 8 constraints for your robot.**
- **Use your team strategies to guide the specifications and constraints that you see as important to your design.**
- **Record these in your team journals.**

VEX V5 Overview

A little History

2000
IFI FRC Robot Controller

2003
IFI EDU-bot

2006
PIC Microcontroller

2010
Cortex Microcontroller

V5 Robot Brain

- 4.25” (480x272 pixels) (480x240 programmable) full color touch-screen
- Dashboard provides real-time diagnostics
- 21 smart ports: Motors, Smart Sensors, Radio, or Tether in any port.
- Eight 3-wire ports for using past sensors: Digital or Analog sensors.
- Built in programs
- microSD Card Expansion. FAT32 up to 16 GB
- Automatic Wire Check
- Automatic device firmware check
- 128 Mbytes Ram
- 32 Mbytes Flash
- Wireless: VEXnet 3 and Bluetooth 4.2

V5 Wireless Controller

- LCD Screen for real-time information
- Start and stop programs from the controller
- Programmable haptic (force) feedback.
- Competition practice mode – synch up with other robots and run practice matches.
- Built in VEXnet 3.0 and Bluetooth
- Integrated rechargeable battery

V5 Robot Battery

- Lithium-Ion 1000mAh
- 12.8 Volts
- Built-in indicator lights
- recharges in about an hour
- 100% power at low voltage (51% for 7.2V)
- Lifespan +/- 2000 full charges (500 for 7.2 V)
- 256 Wats (58 W for 7.2 V)
- 20 Amps max (8 Amps on 7.2 V)
- Separate connections for charging the battery and connecting to the robot. Makes it easier to charge the battery while it is on the robot.

V5 Robot Radio

- VEXnet 3.0 supports 500 simultaneous robot channels.
- Capable of wirelessly connecting to Bluetooth (4.0 and higher) enabled devices
- LED indicator for linked, scanning and active modes.
  - Solid Red:
    - No radio communication
  - Flashing Red:
    - Active connection between V5 Brain and V5 Controller
    - The V5 Controller is not plugged into the field control system OR the brain is not running a user program
  - Flashing Green
    - An active connection between the V5 brain and the V5 Controller
    - The V5 Controller is plugged into a Field Control System
    - The V5 is running a user program
- In the future you can download programs wirelessly

V5 Smart Motors

- Built in encoders!
- Comes with Green 200 RPM gear cartridge. (18:1)
- Cartridges with Red 36:1 (100 RPM) and Blue 6:1 (600 RPM) available
- Can use standard and high strength shafts
- Twice as powerful as the Cortex 393 Motors
- Can see the color of the cartridges from outside the motor. No need to guess on the speed setting for the motor.

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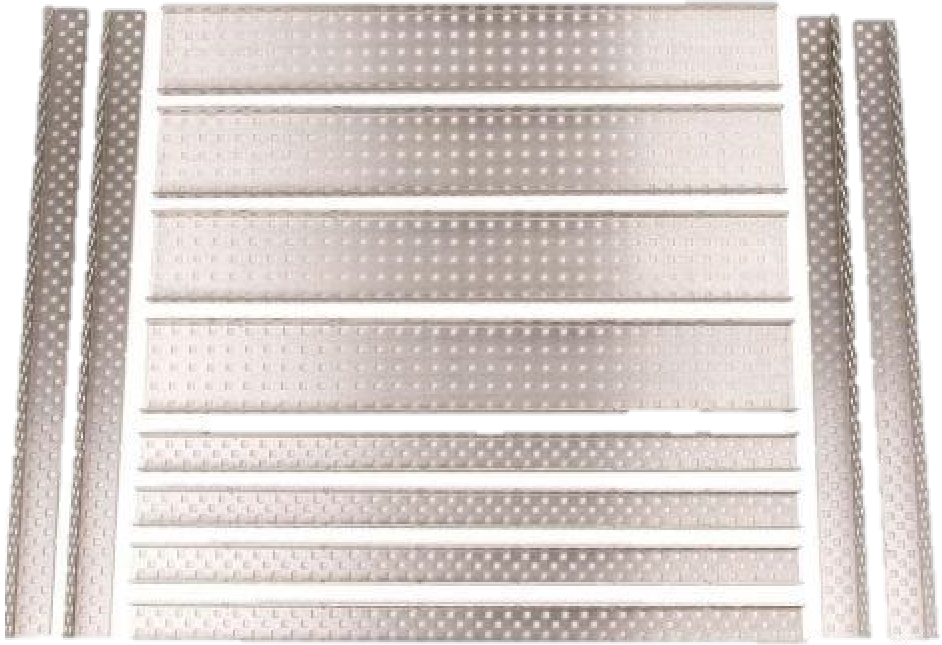
VEX – Structure

VEX Structure



- The VEX structural pieces all contain square holes (0.182” sq) on a standardized 0.5” grid.
- The smaller diamond holes are there to help users cut pieces using tin snips or fine toothed hacksaws without leaving sharp corners.
- Steel and Aluminum

Screws

- Hex Drive (8-32) and Star Drive (T15)
  - ¼” to 2” Lengths
  - Locking Screws: Like normal screws but harder to remove (First 10-12 times)
  - Shoulder Screws (0.20” Long Shoulder)
  - ½” Plastic Thumb Screws
- 6-32 Screws for Cortex Motors and Servos
  - Use 5/64” Hex Key
  - ¼” and ½”
  - ½” Locking

Screws

- 8-32 x 0.125” Setscrew for Shaft Collars

- Couplers: 0.500” and 1.000”
  - Used for connecting Standoffs

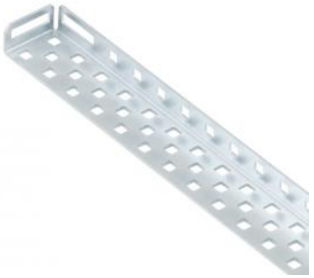
Nuts

- 8-32 Thread
- Keps: Good for prototype/Buildinig
- Nylock: Do not slip as easily as Keps
- Hex: Hex nut retainer pieces (later)

Bars, ‘C’-Channels, Angles, Rails

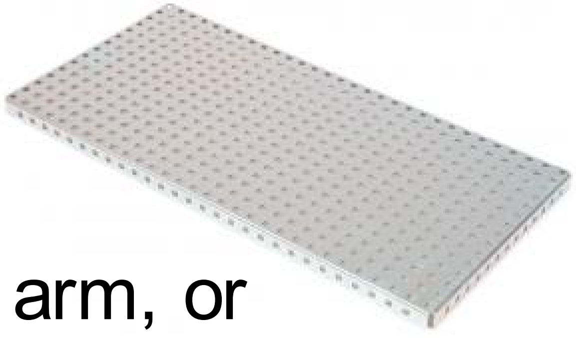
- Bars (1x25)
  - Can be bent, but will never again be straight
- C-Channel
  - 1x2x1x35, 1x3x1x35, 1x5x1x25, 1x5x1x35
  - Added strength and twist resistance
- Angles
  - 2x2x25, 2x2x35, 3x3x35
  - Used for framing, good strength in two axis
- Chassis Rails
  - 2x1x25, 2x1x35
  - Tab at the end allows more connection options.



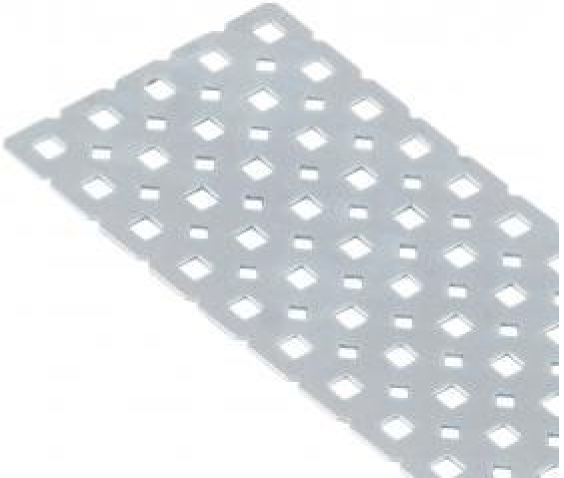



Structure: Plates and Base Plates

- Base Plate
  - 15 x 30
  - Create a large stationary robotic arm, or interlock them to build larger manufacturing type systems.

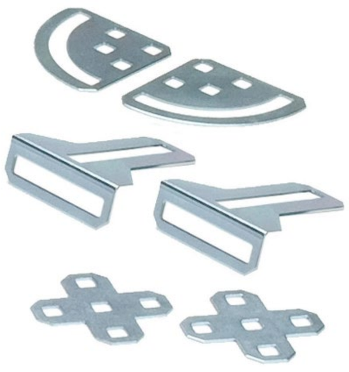


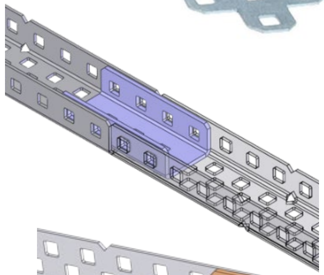
- Plates
  - 15x5 , 25 x 5

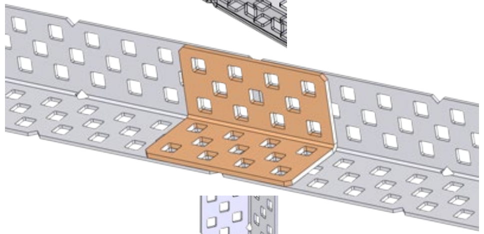


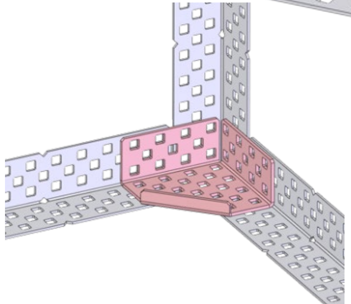
Structure: Gussets

- 45 Degree
- 90 Degree
- Gusset Pack:
  - Pivot Gusset: Connect parts and angles 0 – 90 Degrees
  - Plus Gusset: Strengthen flat joints
  - Angle Gusset: Strengthen ‘T’ Joints
- C-Channel Coupler: Connect two 1x2x1 ‘C’ Channels
- Angle Coupler: Connect two 2x2 Angles
- Angle Corner



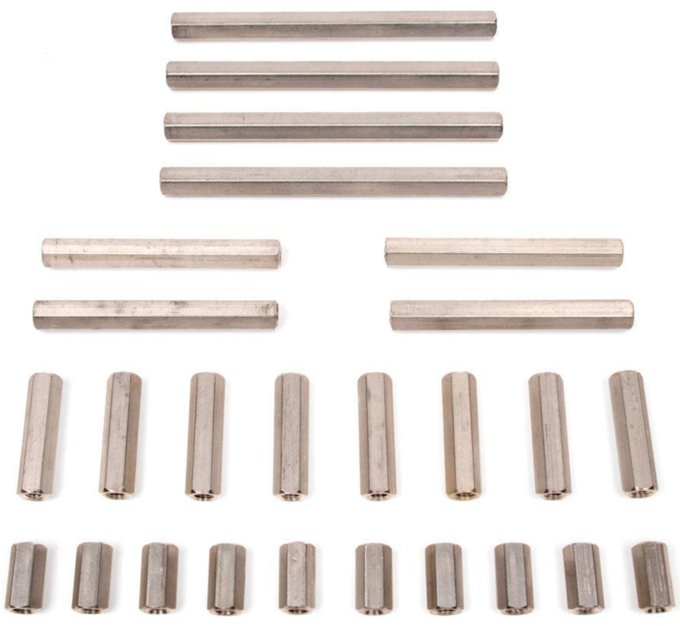






Structure: Standoffs (8-32)

- 0.25” – 6.00”
- Tapped on both ends to fit 8-32 Screws
- Add spacing



Structure: Other

- Latex Tubing: Elastic
- Rubber Bands (#32 or #64)
- Zip Ties (4” and 11”)
- Anti-Slip Math (Thin, Thick)




Hex Nut Retainers (new)

- 1-Post Hex Nut Retainer w/ Bearing Flat.
  - Use for axle going through beam.
- 4-Post Hex Nut Retainer.
  - Used to connect plate to plate with one screw.
- 1-Posts Hex Nut Retainer
  - Used to connect beams/plates

Motion: Wheels

- 2.75” Wheels: Seldom used in competition
- 2.75” Omni Wheel: Omni Direction Wheels slide sideways with almost no friction (no skidding during turns).
- 3.25” Traction Wheel: Best grip on form tile surface of all VEX Wheels. Use these wheels with either standard Drive Shafts or High Strength Shafts
- 3.25 “ Omni Wheel: Very good grip on form tile surface of all VEX Wheels. Standard or High Strength drive shafts.
- 4” Omni Wheel: Same benefits of other Omni’s. Larger diameter therefor faster. Does not support High Strength Drive Shafts.

Motion: Wheels

- 4” Mecanum Wheel: Strafe, Orientation/balance important
- 5” Wheels: Good traction on foam
- 6” Wheel Legs: Go over obstacles

Motion: Gears

- Standard Gear Sizes
  - 12, 36, 60, 84
- Rack Gear Size
  - 19
- Advanced Gear
  - Worm Gears
  - Bevel Gear
  - Differential

Motion: Gears

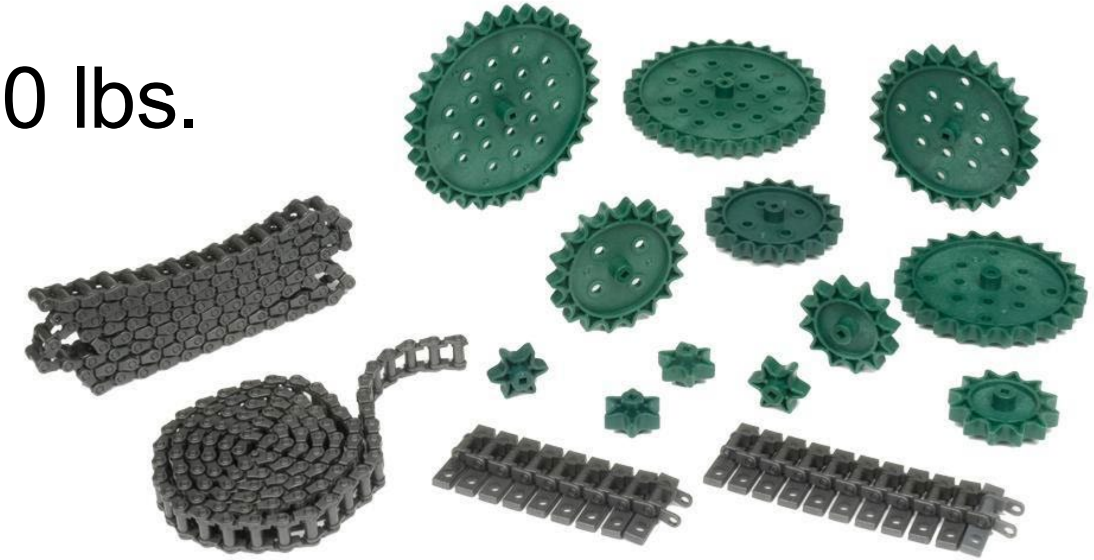
- High Strength Gears: Double Thickness
  - Steel: 12
  - Plastic: 36 , 60. 84
  - Inserts
    - Square for regular shaft
    - Free Spinning on regular shaft
    - Square High Strength Shaft.

Motion: Sprockets and Chain

- Regular Strength
- Sizes:
  - 10, 15, 24, 40, 48 teeth
- Each chain is a master link
- Weak

Motion: High Strength Sprocket and Chain

- Sizes:
  - 6, 12, 18, 24, 30 teeth
- Sprockets also fit VEX Treads
- Support up to 50 lbs.



Motion: Treads

- Tracks, conveyor
- Upgrade kit

Motion: Pneumatics

- Compressed air stored in cylinder
- Single and double acting
- Expensive

Motion: Linear Slides

- Rack and Pinion
- Expanding sections
- Scissor lift base

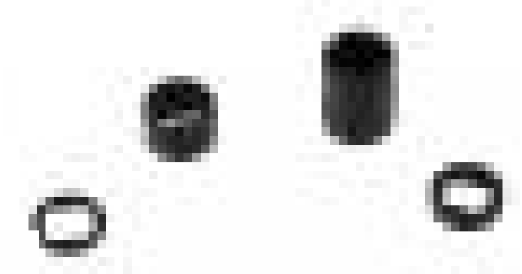
Motion: Shafts

- 1/8” Shafts: Attach to motors, wheels, gears, sprockets, …
  - 2”, 3” and 12”
- Shaft Collars: Attach to shafts. Securing and spacing. Regular, clamping and rubber
- Shaft Coupler: Connects two shafts.
- Delrin Bearing Flat: Used when shaft goes through structure.
- Drive Shaft Bar Lock: Helps structure move with shaft.
- Washers: Spacing and reducing friction.
- Bearing Block
- Lock Plate

Motion: High Strength Shafts and Hardware

- ¼” Shaft
- Sizes
  - 2, 3, 4 and 12” Lengths
- High Strength Shaft Bearing Block
- High Strength Shaft Spacers
- High Strength Shaft Collars.






Motion: Claw

Attach a motor to grab items.

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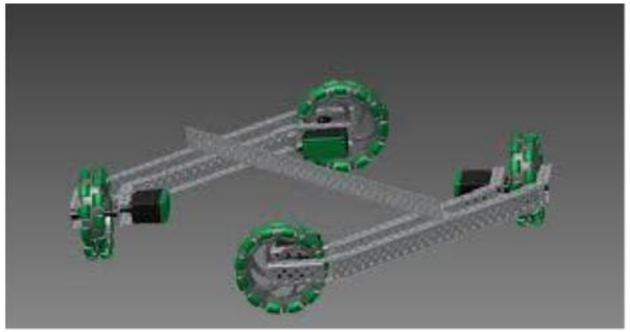
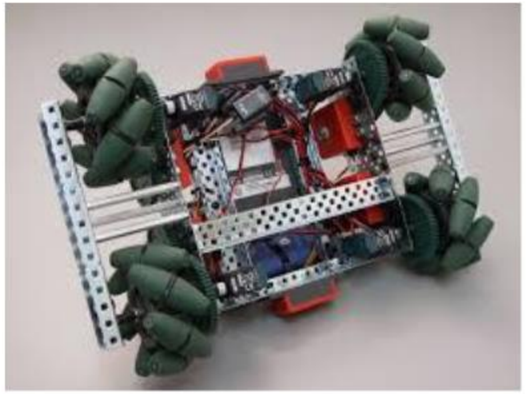
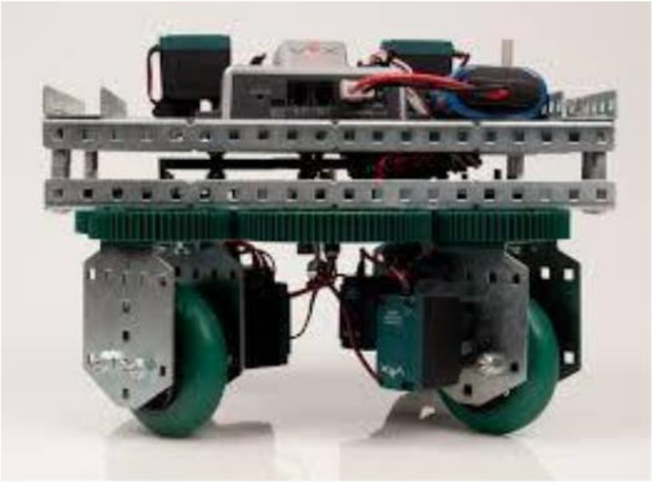
VEX – Drive Train Comparisons

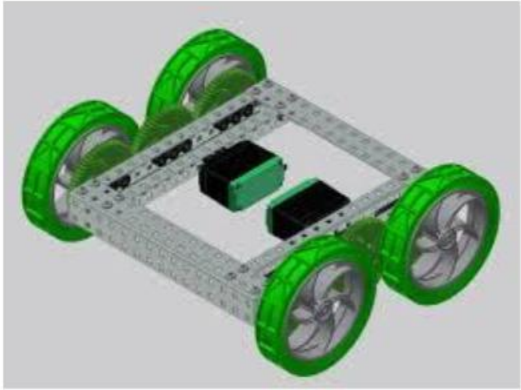
Drive Trains



- Design Hints
- Compare different designs
- Look at examples from Worlds

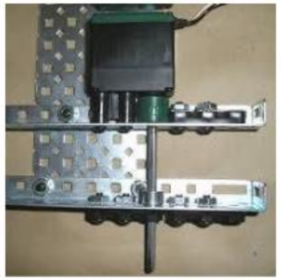






Tips for Drive Systems

- Always support drive shafts on two points (gears, sprockets, track drive sprockets, wheels).
- Always use Delrin bearings flats when placing a drive shaft through a metal structure.



- Always have a shaft collar orientated so as to hold the drive shaft into the motor.
- Check that **no gear**s, sprockets, drive chains, or wheels are **rubbing** against a surface that will cause additional friction to drive system. This can be tested by spinning the drive system without the motor attached.

More Tips/Thoughts

- It is a good practice **to test the mo**tors before attaching them to the drive system.
- Try to orientate **motor screws for easy access** because they have a tendency to loosen up after use.
- **Make sure that screws go into motor.** The V5 motor threading is a point of failure if the screw just barely gets into the motor.
- When using 6 or 8 wheel drive systems it is advantageous to have **the center wheels lower or a slightly larger** size than the end wheels

More Drive Train Tips/Thoughts

- Large wheels are **faster** (all else equal) and provide **less torque**
- Smaller wheels accelerate quicker but have a slower top speed.
- Smaller wheels can be placed closer to the corners

Example: Skid Turn: Two Wheel Drive

2 wheel drive - This type of drive has only two wheels driven each wheel , driven by at least one motor A K A 2 wheel tank .(. . .)

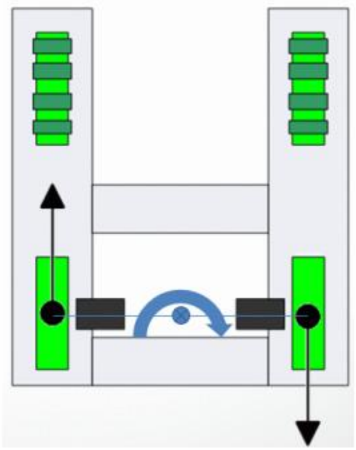
Pros-

- simple to build
- very flexible
- Not easy to push from side if traditional wheels are used

Cons –

- more difficult to control than other options
- the non driven wheels take weight off of the drive wheels -
- limited power in the drivetrain

Summary: Good for starters



Skid Turn: 4-6 Wheel Drive

Pros : Relatively Simple: Common at Worlds

• relatively simple to build

• can utilize multiple motors

• used by many strong teams

• Not easy to push from side if traditional wheels are used

Cons:

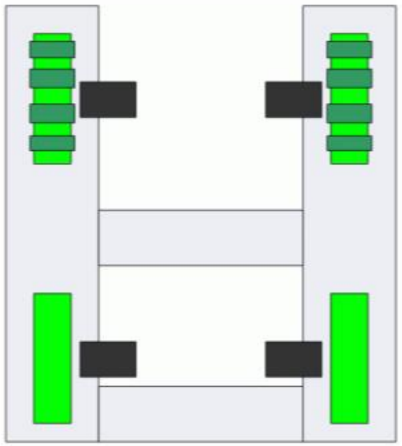
• if gears are used the distance between drive shafts are determined by the gears used

• multiple motors draw more current and use up motor ports on controller

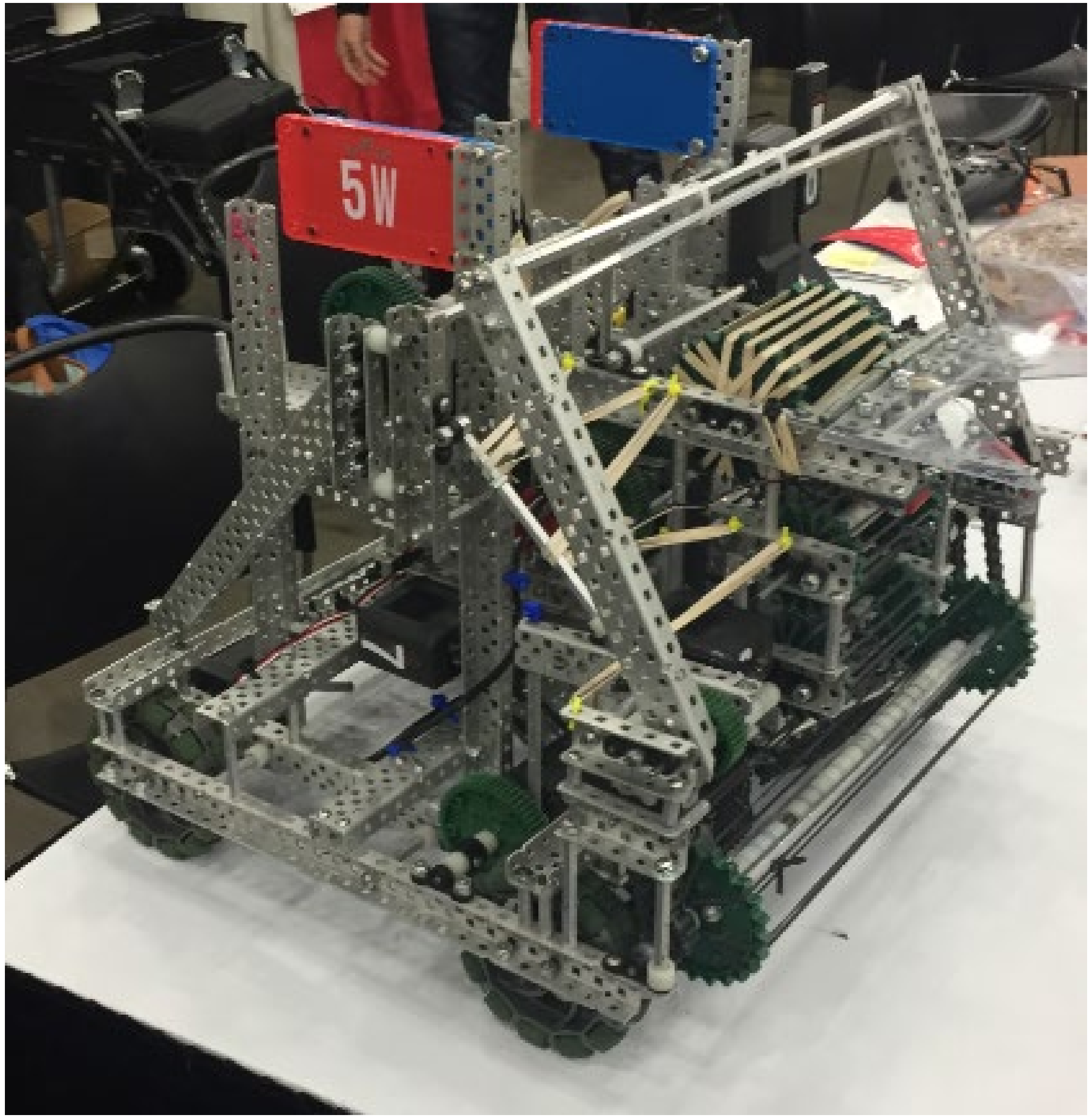
• Can be more difficult to repair and more components to fail

• all the drive wheels need to be close to the same size or they will fight with one another

Summary: Strong, relatively simple

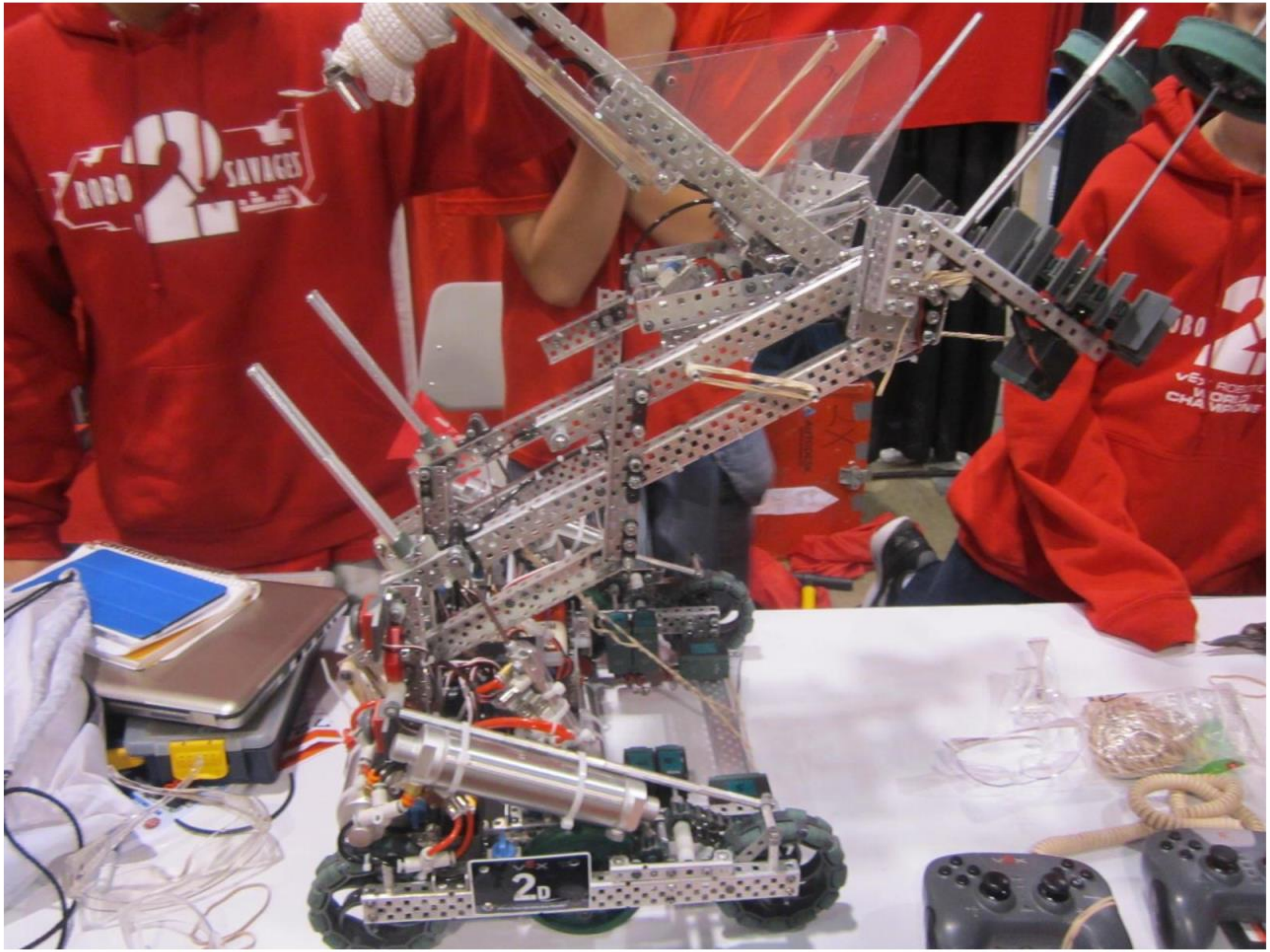


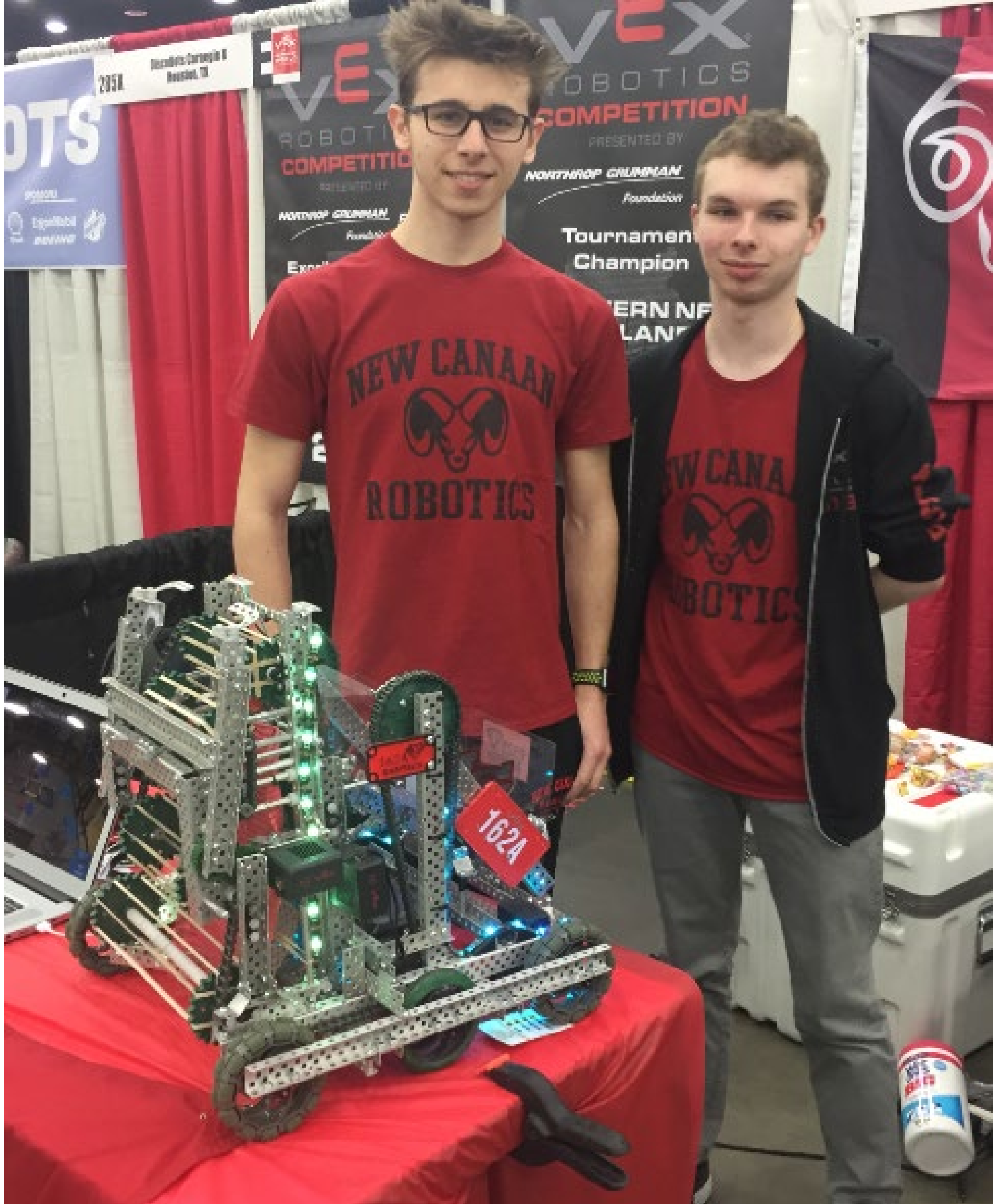
Skid Turn Sample



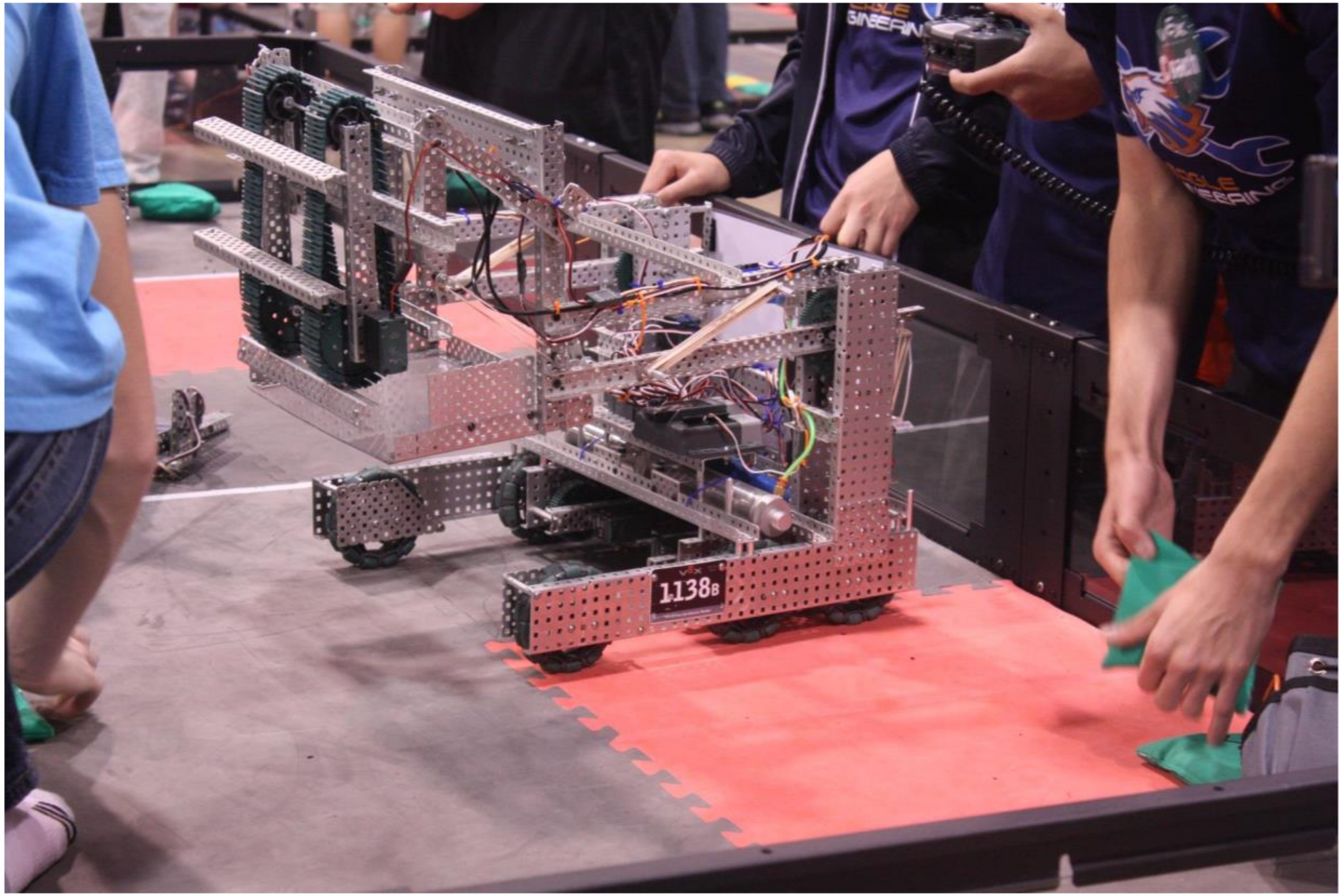
4 Omnis


Tournament
Champion
MAINE
STATE
CHAMPIONSHIP
2019
56 J
BILLY B
☆FOR GDC☆
BILL-DING KNOWLEDGE
56 J

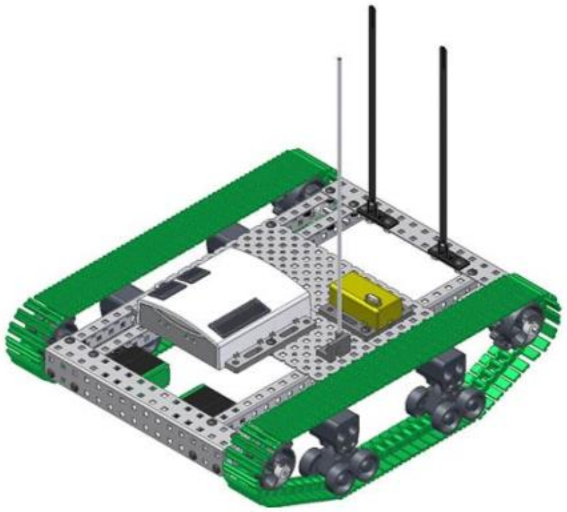

ROBO
2
SAVAGES
2D


VEX ROBOTICS
COMPETITION
PRESENTED BY
NORTHROP GRUMMAN
Foundation
Tournament
Champion
NEW CANAAN
ROBOTICS
NEW CANAAN
ROBOTICS

Back Wheels Powered, Omnis



Track System



Pros

· pivot point is at the center of the drive system

· can use only 2 drive motors or multiple motors

· extra traction treads are available (**P/N:** 276-2214)

· able to climb over field obstacles

Cons

· Slick: the standard track lacks traction on some surfaces

· Slow: the distance traveled per rotation is limited by the size of the drive sprocket (note some teams have used the larger high strength chain sprockets, **P/N:** 276-2252 as drive sprockets to over come this limitation.)

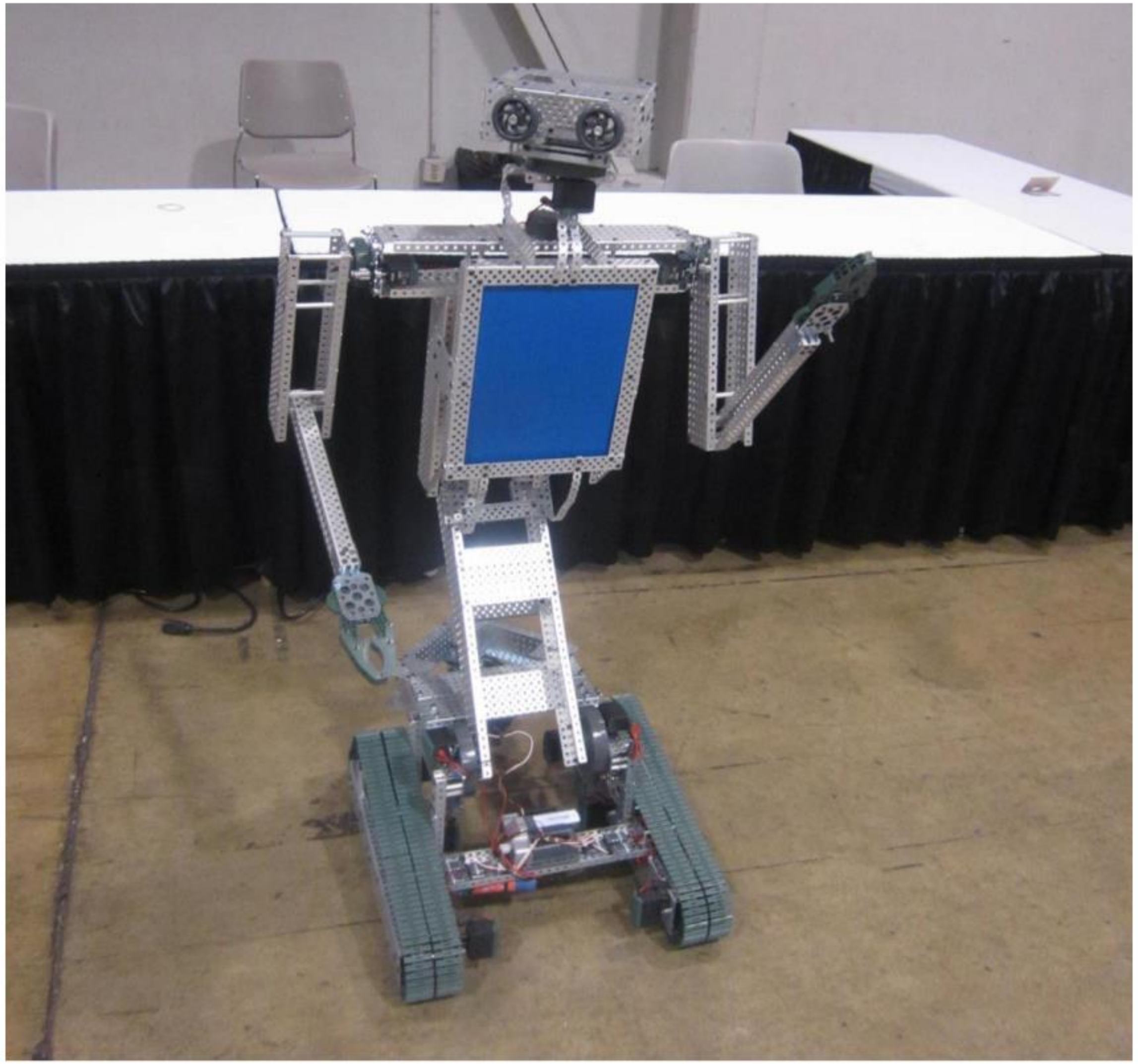
· can slip when pushed from the side.

Summary: Looks cool and can climb, but vulnereable

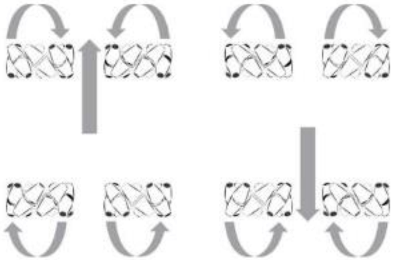
Tracks to helping climbing

LEGO Tank Gun

Mascot



Holonomic: Robots that can go sideways



Pros

· can move in 2 different planes (front to back and sided to side), plus pivot

· very hard to trap in a corner

· very effective for lining up with game pieces

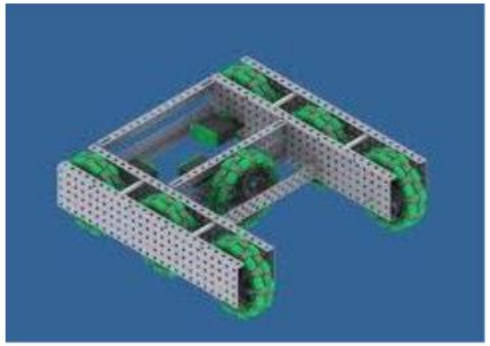
Cons

· requires a motor for each drive wheel

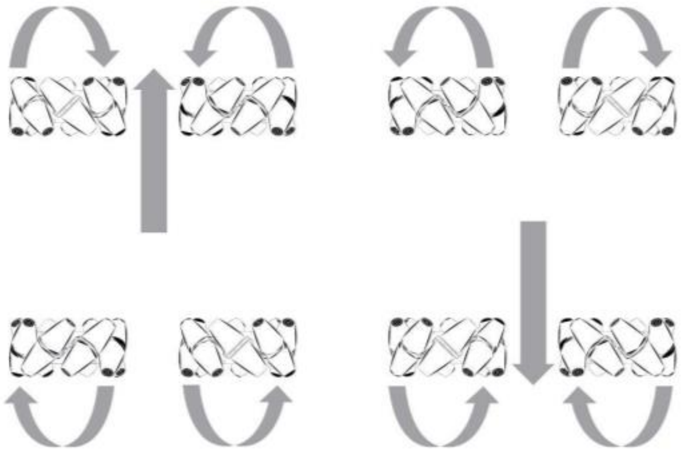
· need driver training

· multiple motors draw more current and use up motor ports on controller

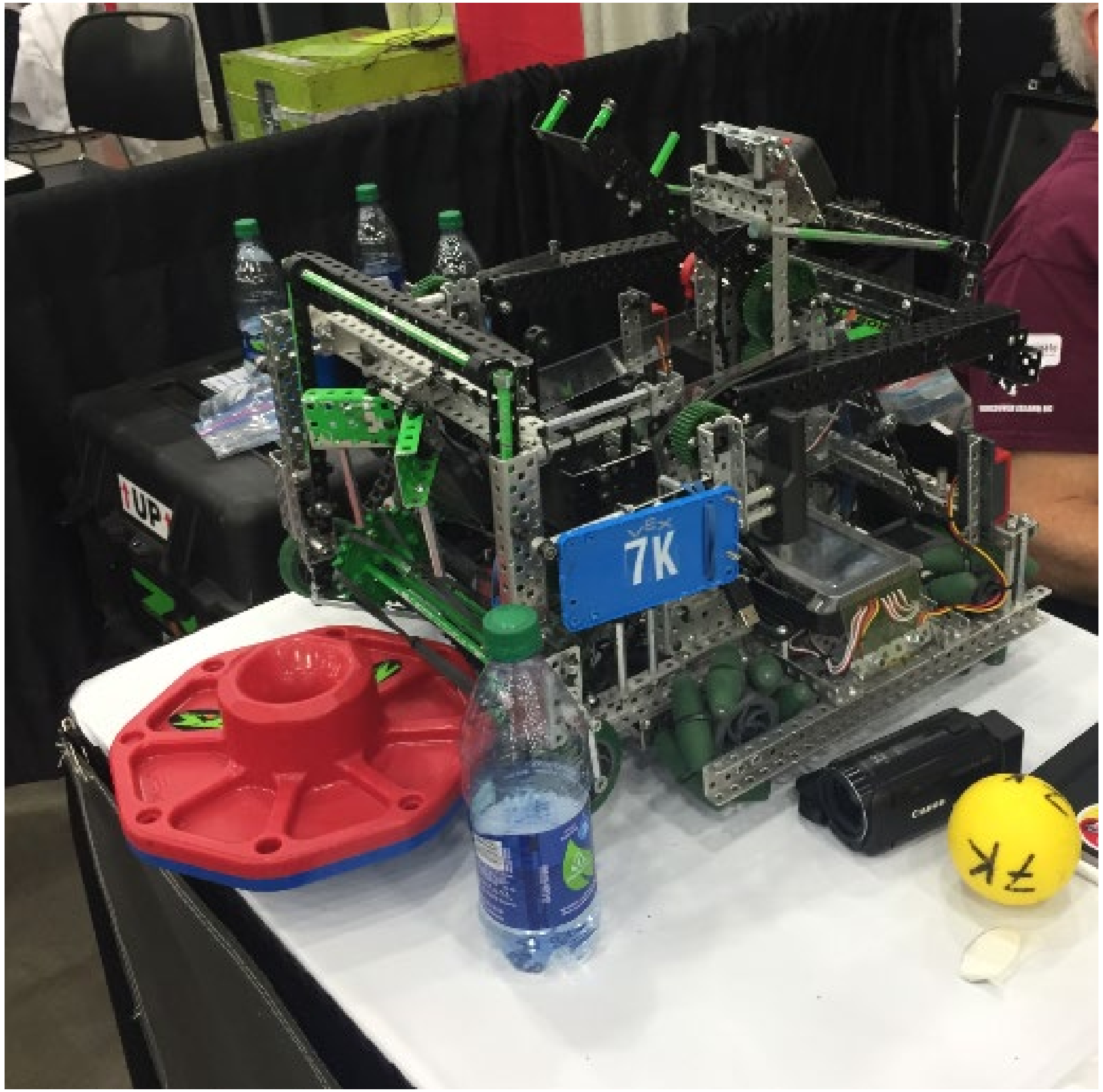
· does not climb field obstacles well



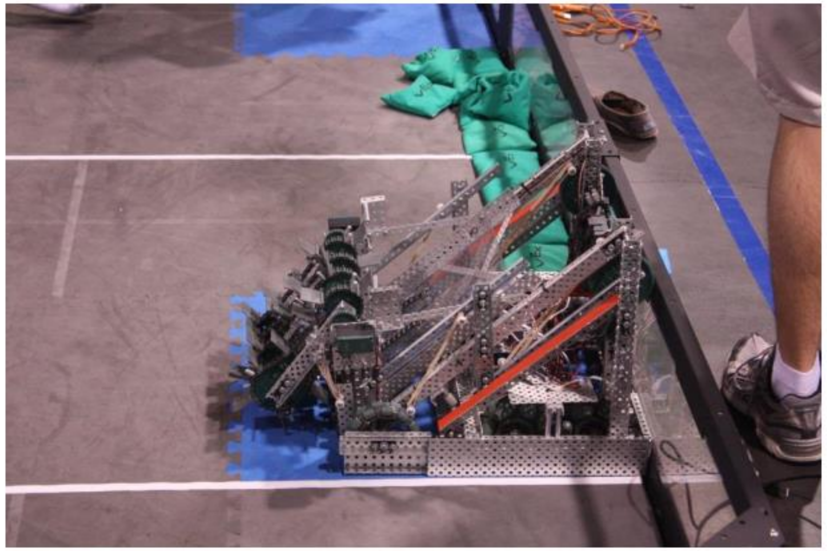
Mecanum

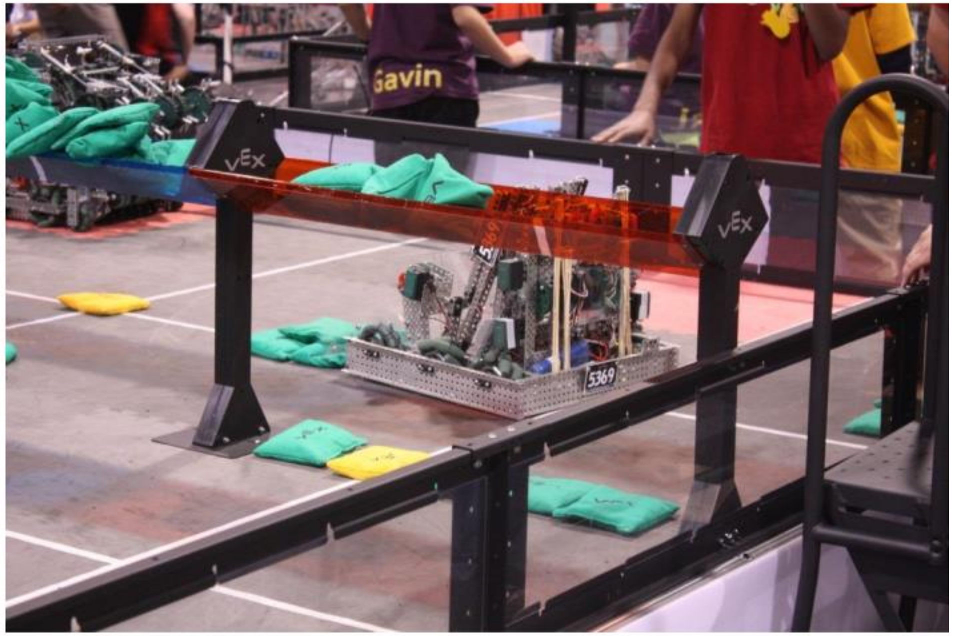


Mecanum: US Create Open Champ 2019

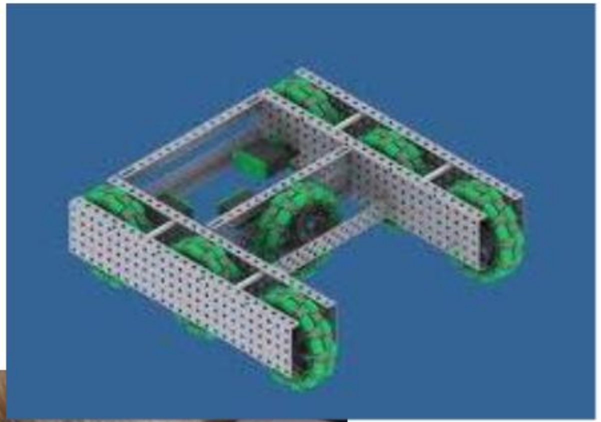


Mecanums in back, Omni in Front

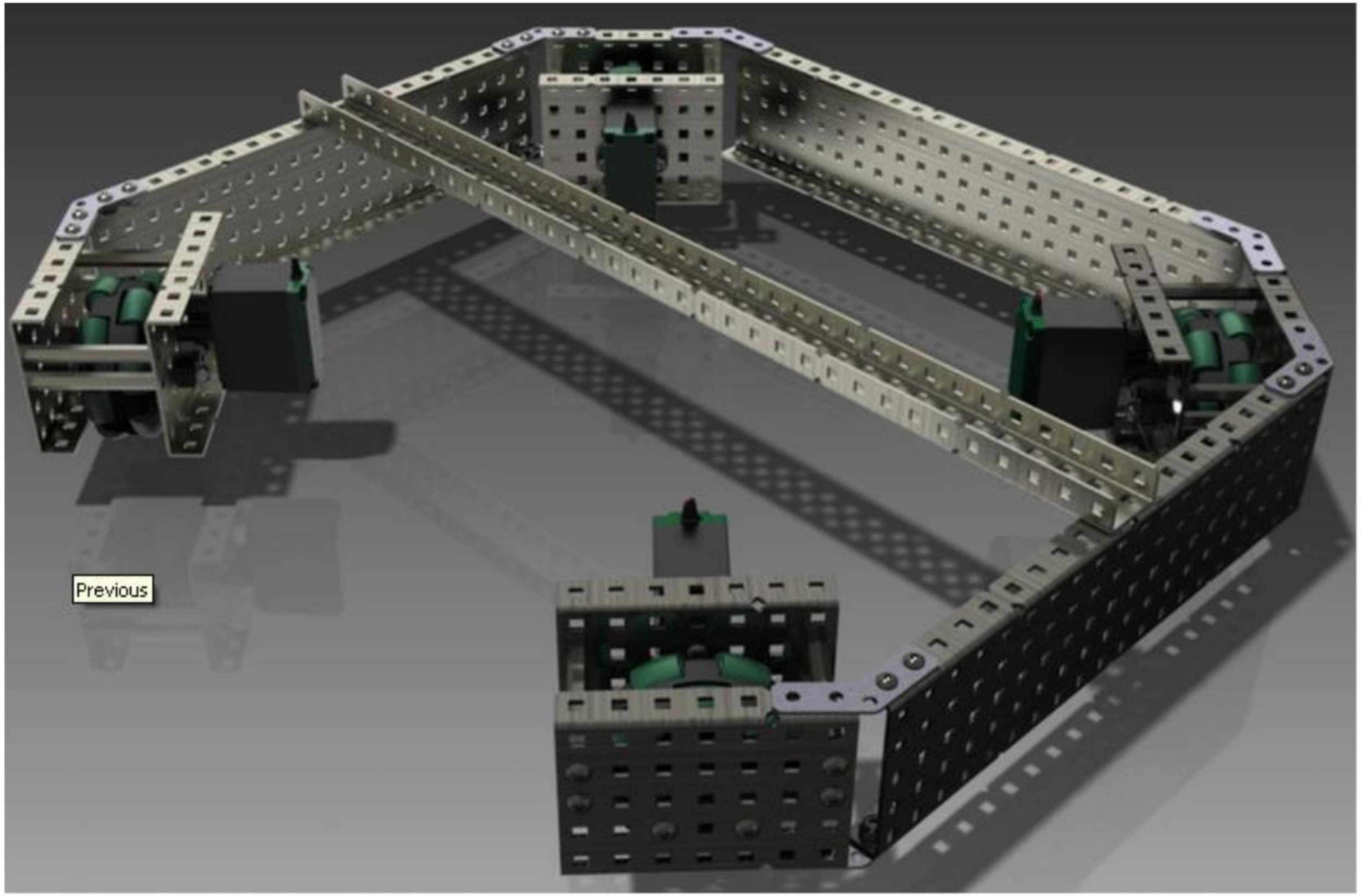




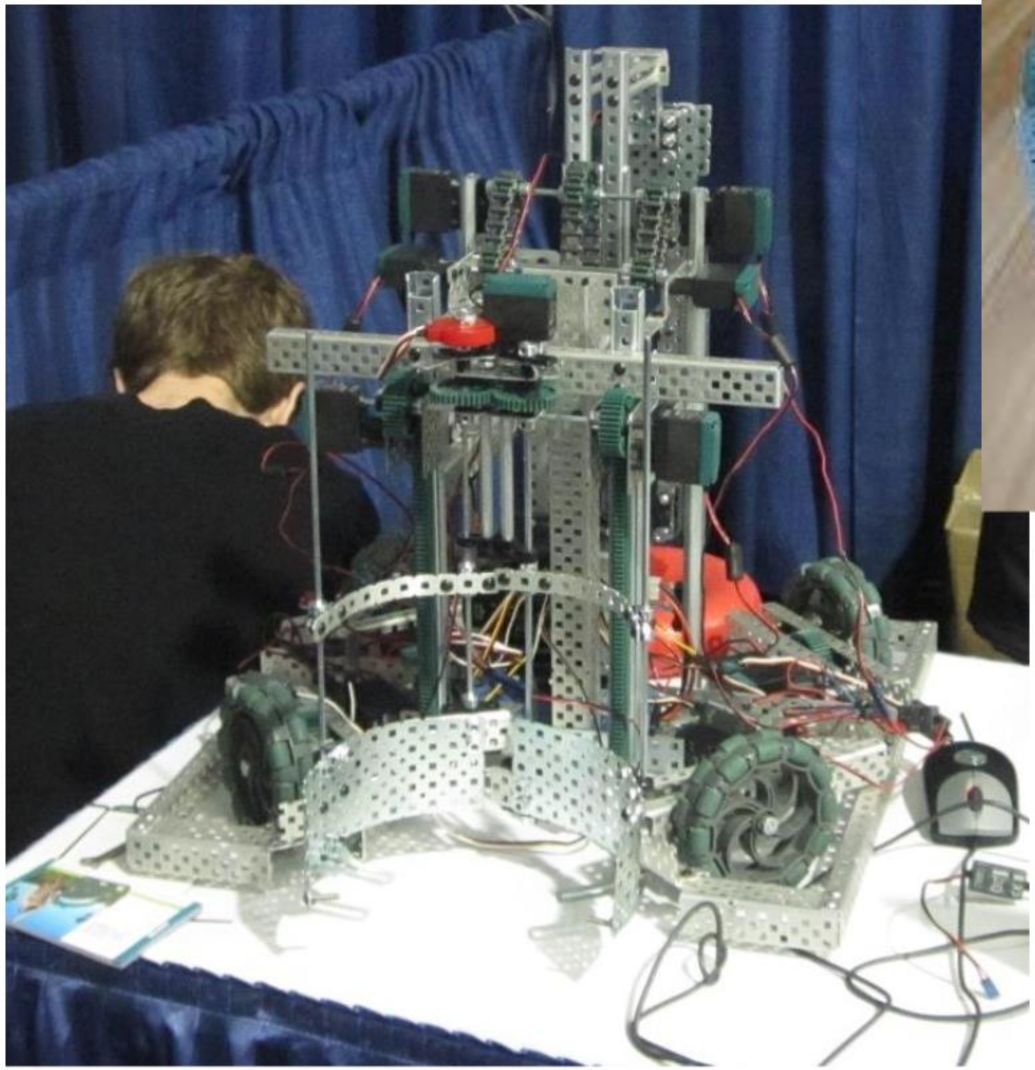
H-Drive



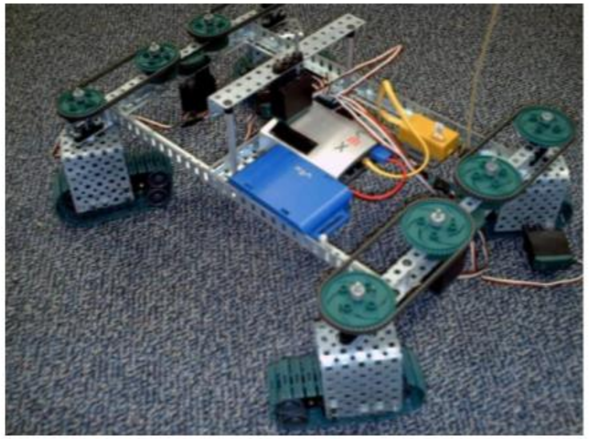
4-Omni, X-Drive



4-Omni



Swerve Wheels



Pros

· agile!

· can climb field obstacles

Cons:

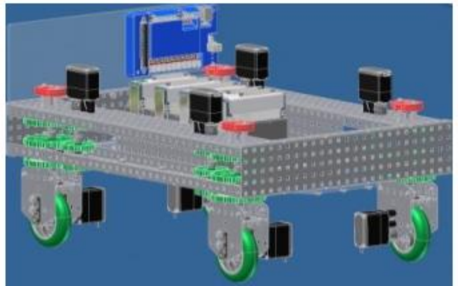
· requires a motor for each wheel and motors to activate the swerve action

· complex

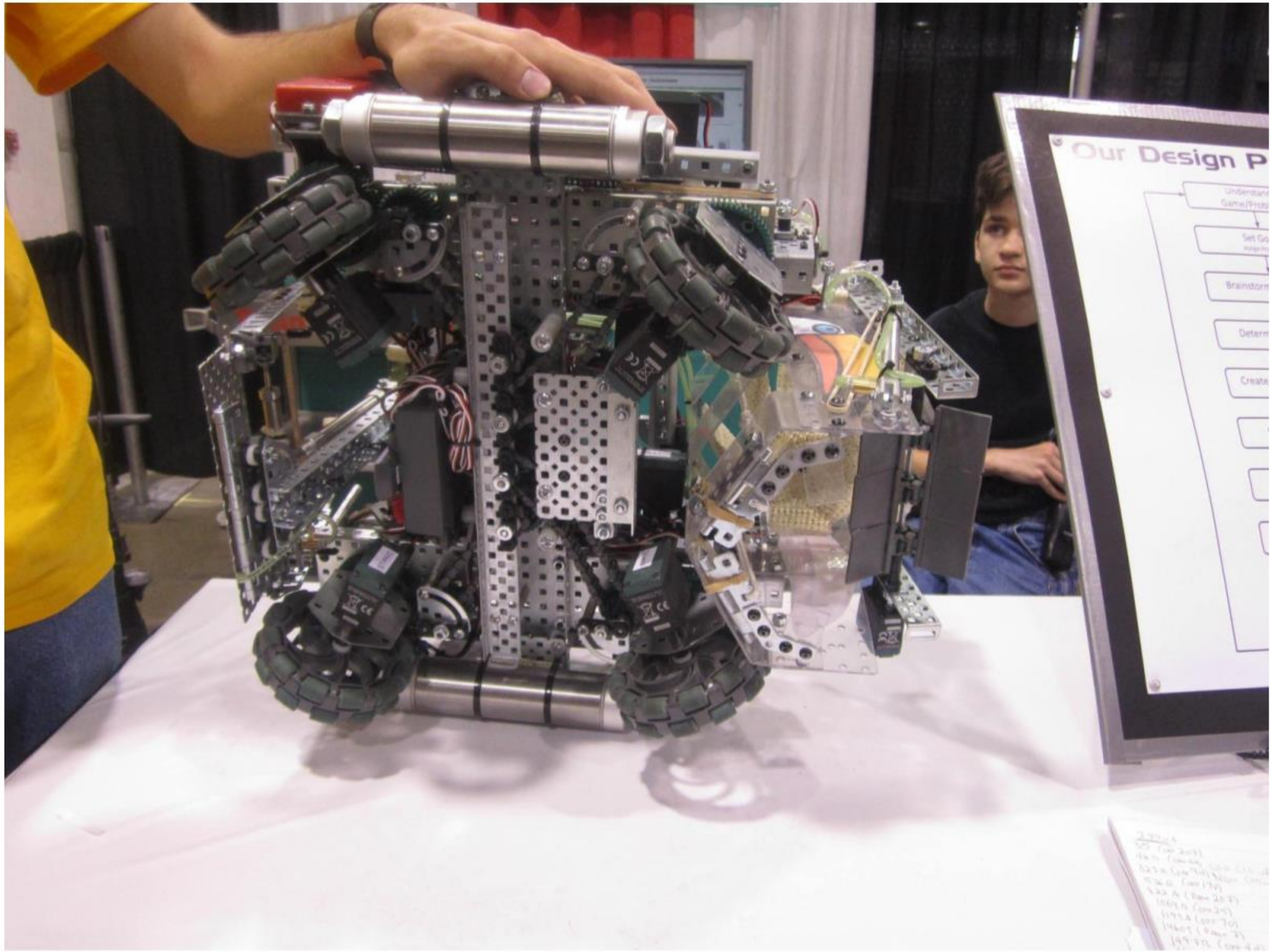
· multiple motors draw more current and use up motor ports on controller

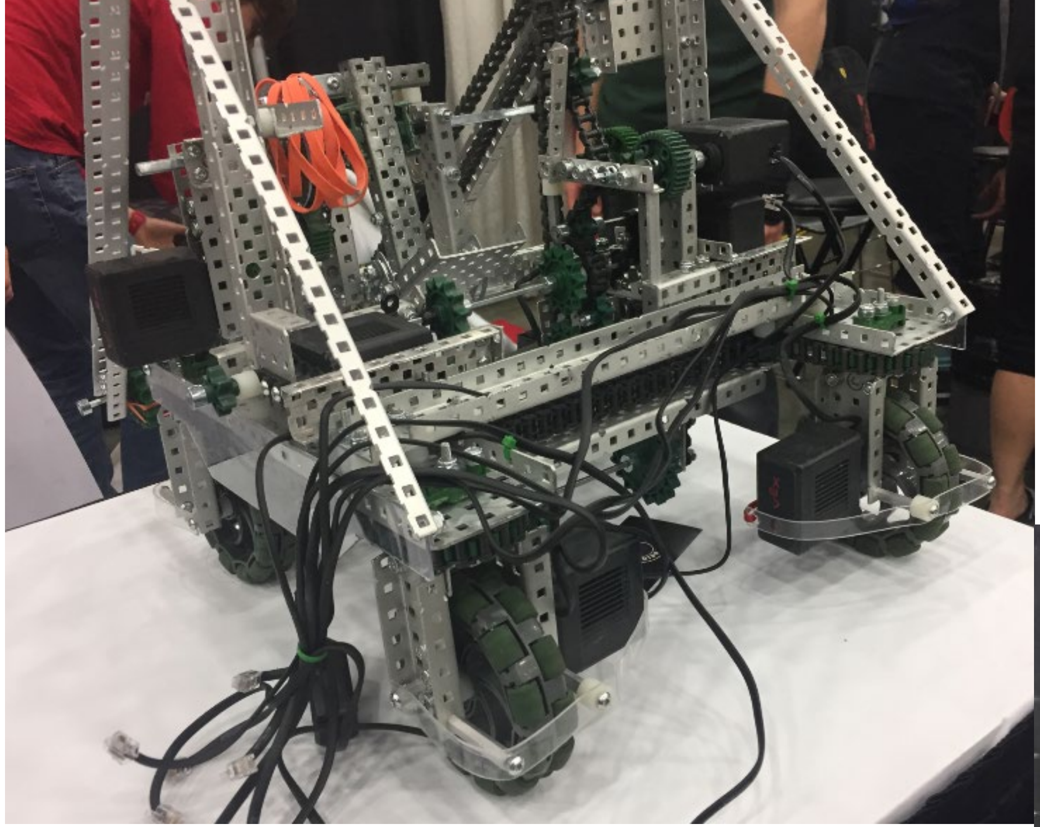
· most designs have a higher center of gravity

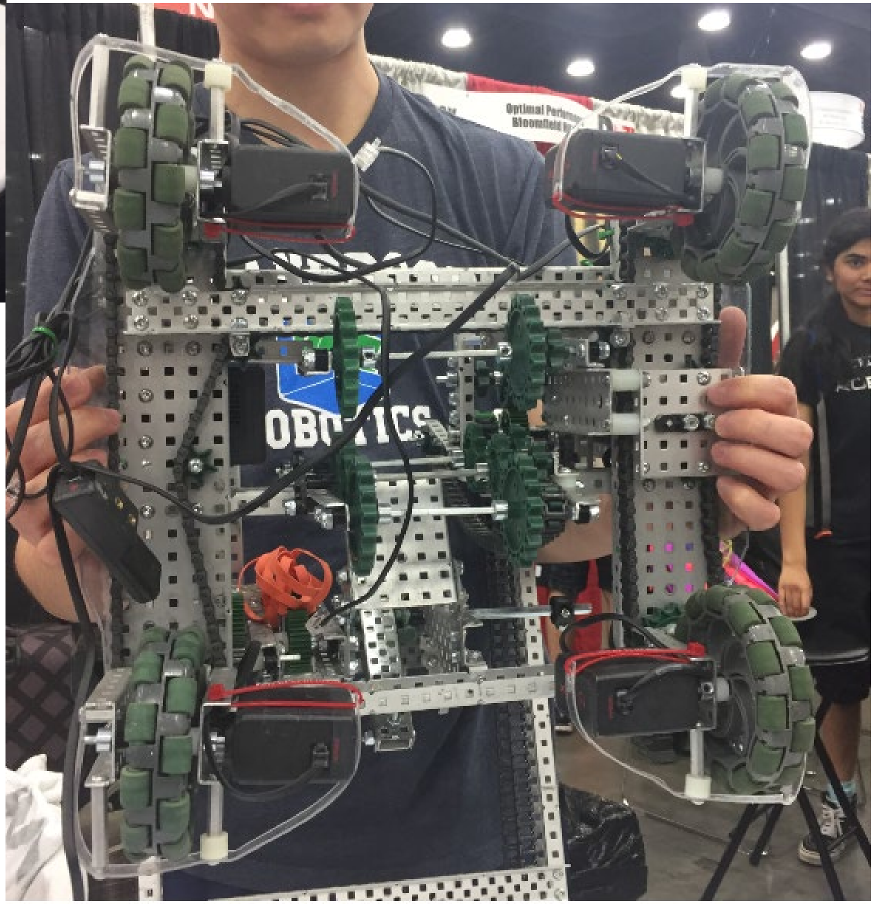
Summary: Very agile, very complex and requires extra parts. Make sure to give yourself time and resources if you are to implement this option.



Swervebot





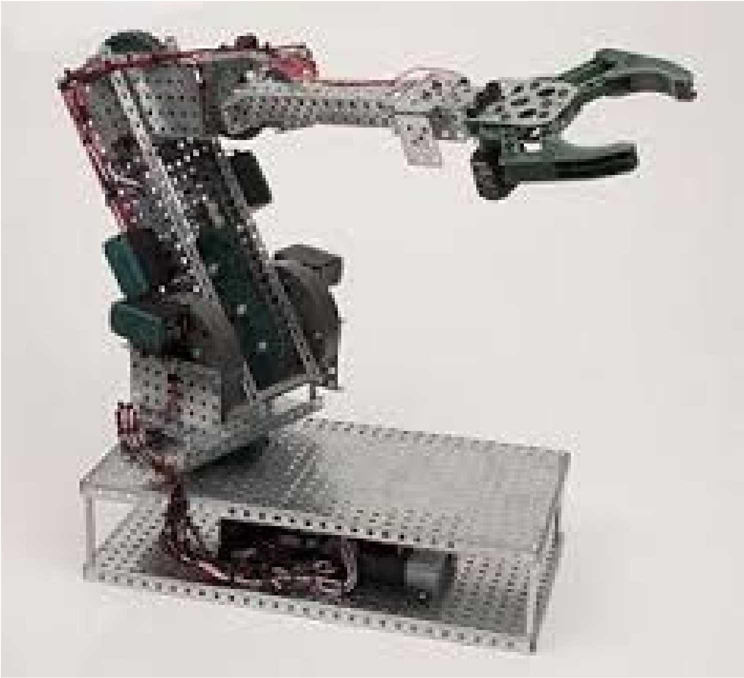


SuperQuest Salem

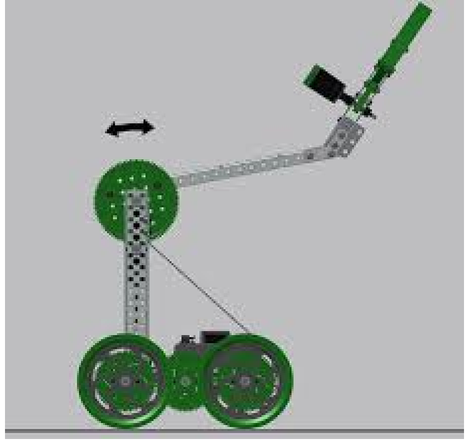
Arms – Best Practices

VEX Arm Designs

- Single
- 4-Bar
- 6-Bar
- 8-Bar
- Linear Slide
- Scissor
- Double Reverse 4-Bar

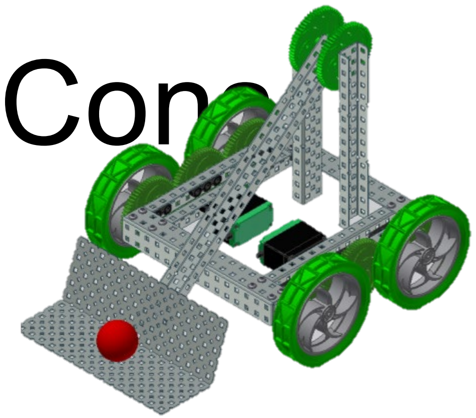


Single Arms



- **Arms** – These manipulators consist of a pivot point and at least 1 motor.
- Arms can be single and supported on each side by a tower
- Arms are levers, the closer the pivot point is to the end of the arm, the longer the arm, and larger the load the more torque is required to lift it.
- Torque is usually the most difficult thing to overcome when designing an arm.

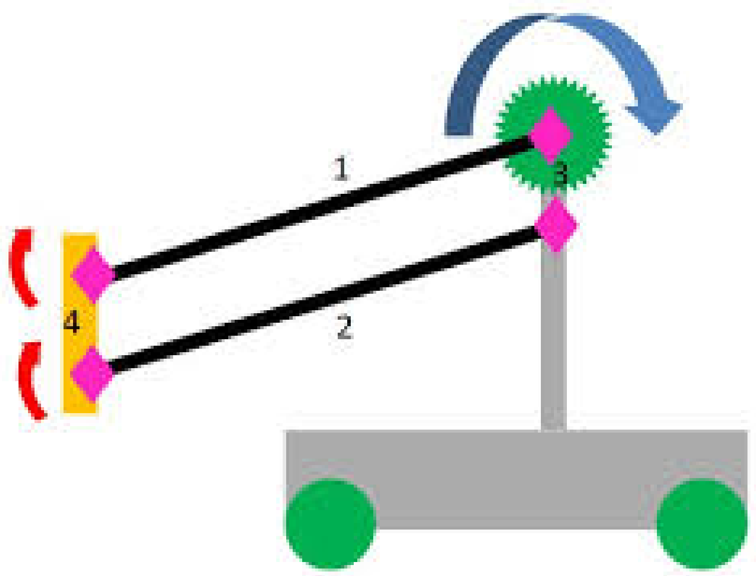
Simple Arm Pros and Cons

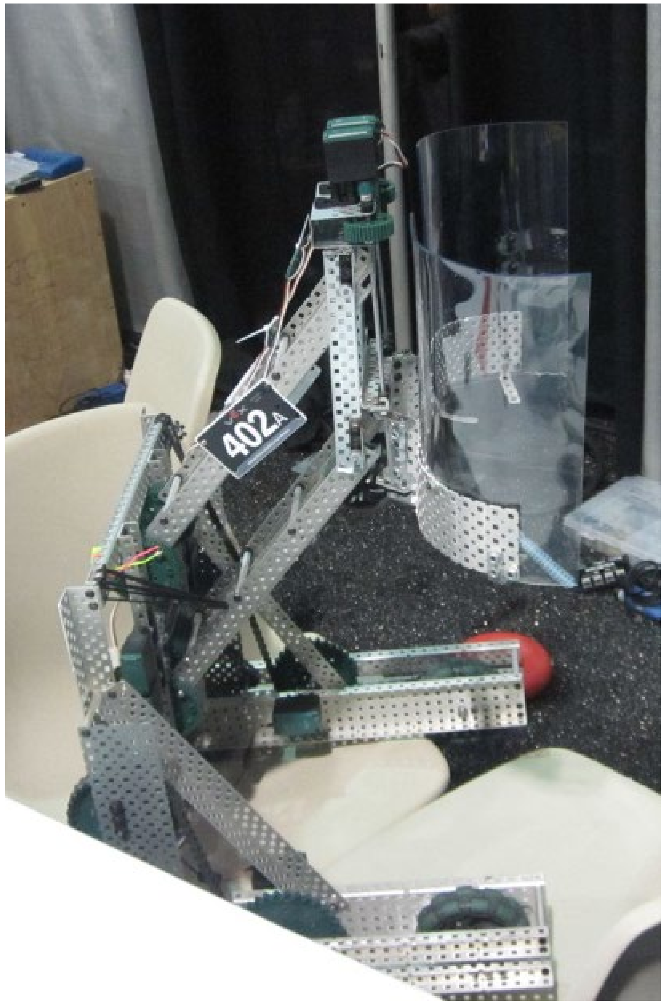


- ***<u>Advantages –</u>***
- Lifts an object from the field surface.
- Relatively easy to design and construct.
- Can be designed to pivot from one side of the robot, over the top to the other sided of the robot.
- ***<u>Disadvantages –</u>***
- Easy to create a design with a high to very high torque situation which can lead to broken drive shafts, stripped gears, broken drive chains, stripped lock plates, etc.
- Back dive when not powered
- Creates a higher center of gravity when lifted.
- The object being picked up maintains its orientation with the arm as it arcs up and may not be aligned with the final manipulation goal.
- ***<u>Summary: A great first arm that can be enhanced with gatherers.</u>***

Four-Bar Linkage

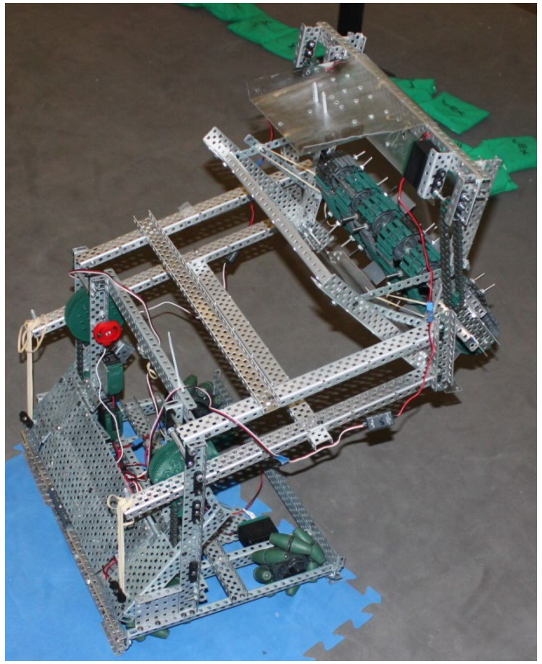
- Usually the four structures consist of a tower, two arms, and a hand.
- Creates a parallelogram
- The closer the linkages are to one another the less they can pivot.

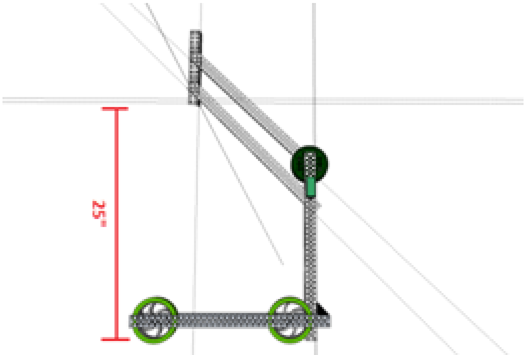




Four-Bar Linkages Pros and Cons

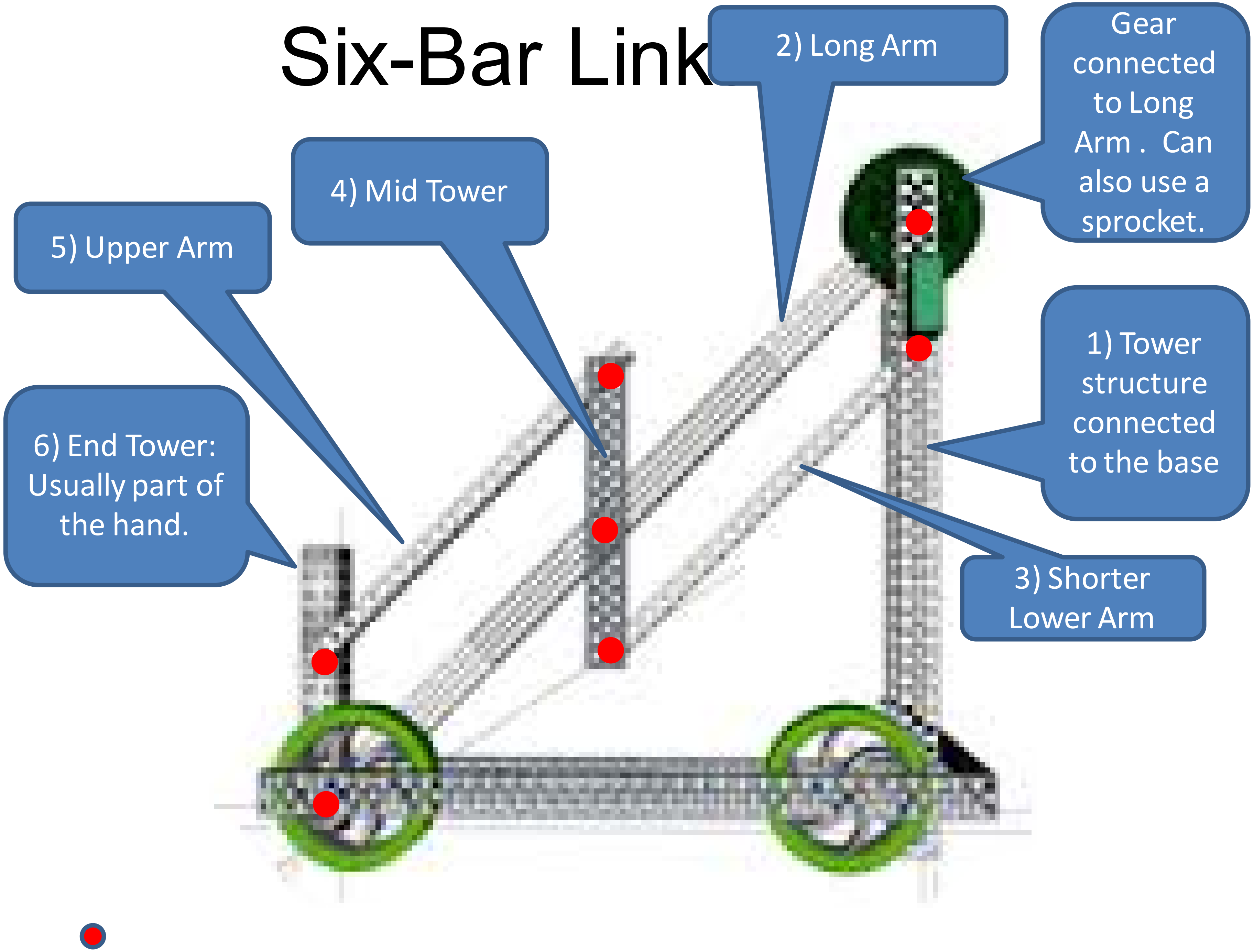
- ***Advantages –***
- The orientation of an object can be changed in respect to the arm as it is pivoted up.
- Elastic forces can be added between the linkages to reduce the amount of force the activator needs to apply.
- ***Disadvantages –***
- Easy to create a design with a high to very high torque situation
- Back dive when not powered
- Can not rotate from one side of the robot over to the other side.
- Creates a higher center of gravity when lifted
- **Summary: A good option that keeps the orientation of the hand, but limited by how high you can reach.**





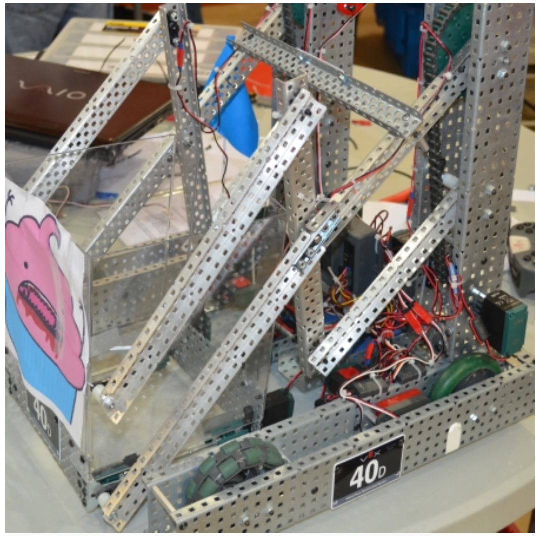
Four bar in raised state

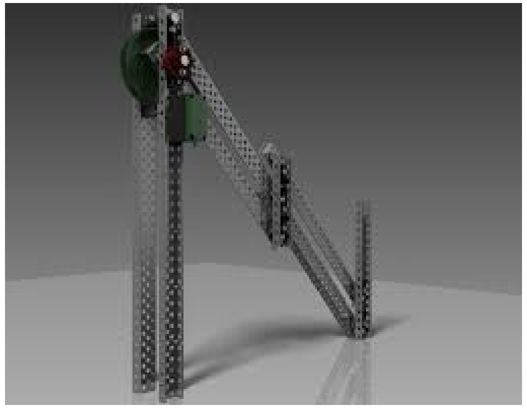
Six-Bar Link


2) Long Arm
Gear connected to Long Arm . Can also use a sprocket.
4) Mid Tower
5) Upper Arm
1) Tower structure connected to the base
6) End Tower: Usually part of the hand.
3) Shorter Lower Arm

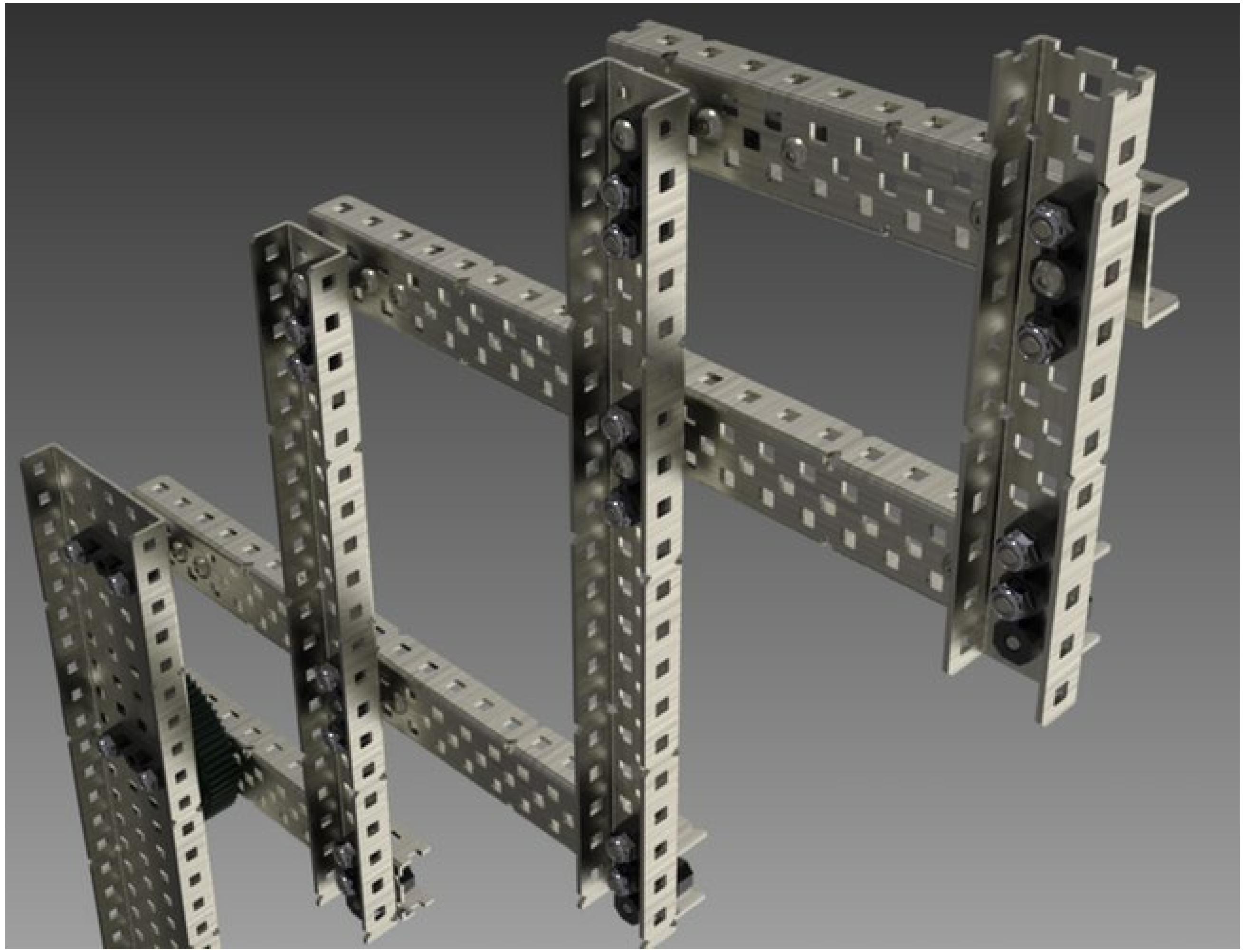
Six-Bar Linkages Pros and Cons

- ***Advantages –***
- The orientation of an object can be changed in respect to the arm as it is pivoted up.
- Elastic forces can be added between the linkages to reduce the amount of force the activator needs to apply.
- ***Disadvantages –***
- Easy to create a design with a high to very high torque situation
- Back dive.
- The amount of pivot is limited by the distance between the arms. Can not rotate from one side of the robot over to the other side.
- Creates a changing and higher center of gravity when lifted
- **Summary: A four-bar linkage on steriods. You can lift higher, but it is a bit more complex to build**

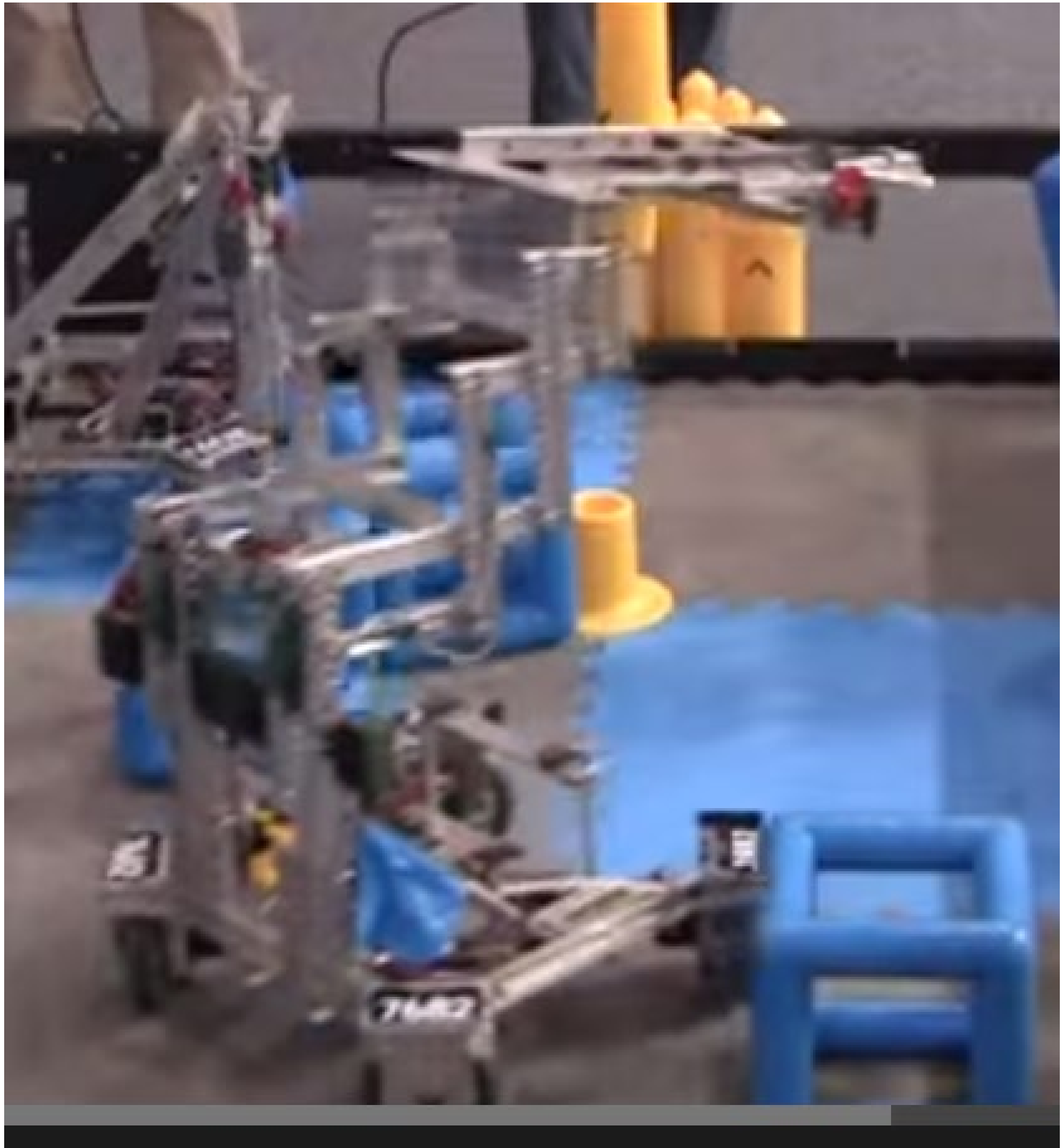




8-Bar Linkage … A Six-Bar Linkage on Steroids

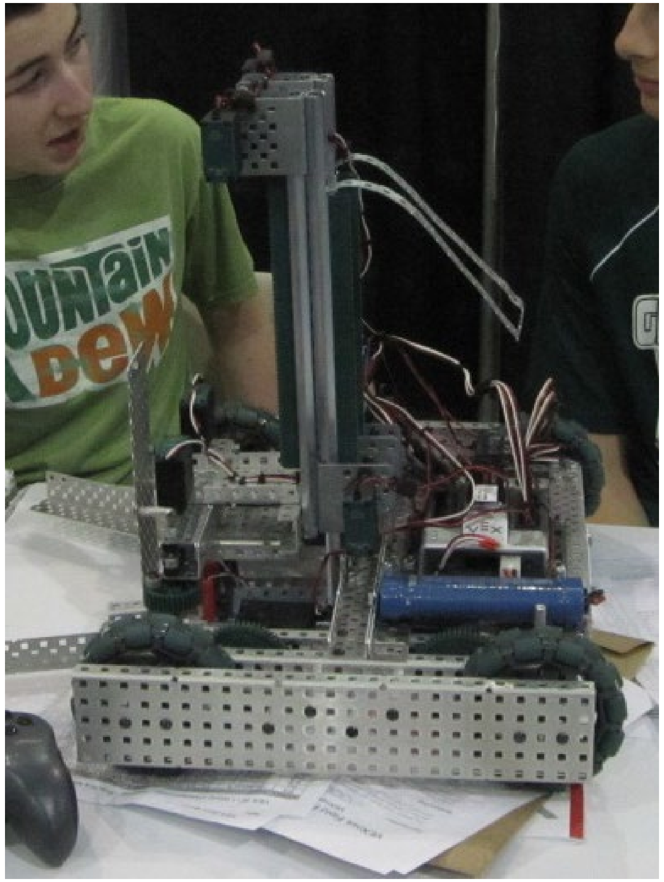


8-Bar Sample



Linear Slide

- **Linear slides** – The VEX design system provides two types of linear slides in the linear motion kit .
  - The linear motion kit provides inside and outside Delrin slide trucks which can slide up and down the linear slide track.
  - The old linear slides are two metal slide members (an outside and an inside) which slide over one another. Both make excellent linear lifts.
- You can use a motor with rack and pinion, or chain or rope to move the slide.



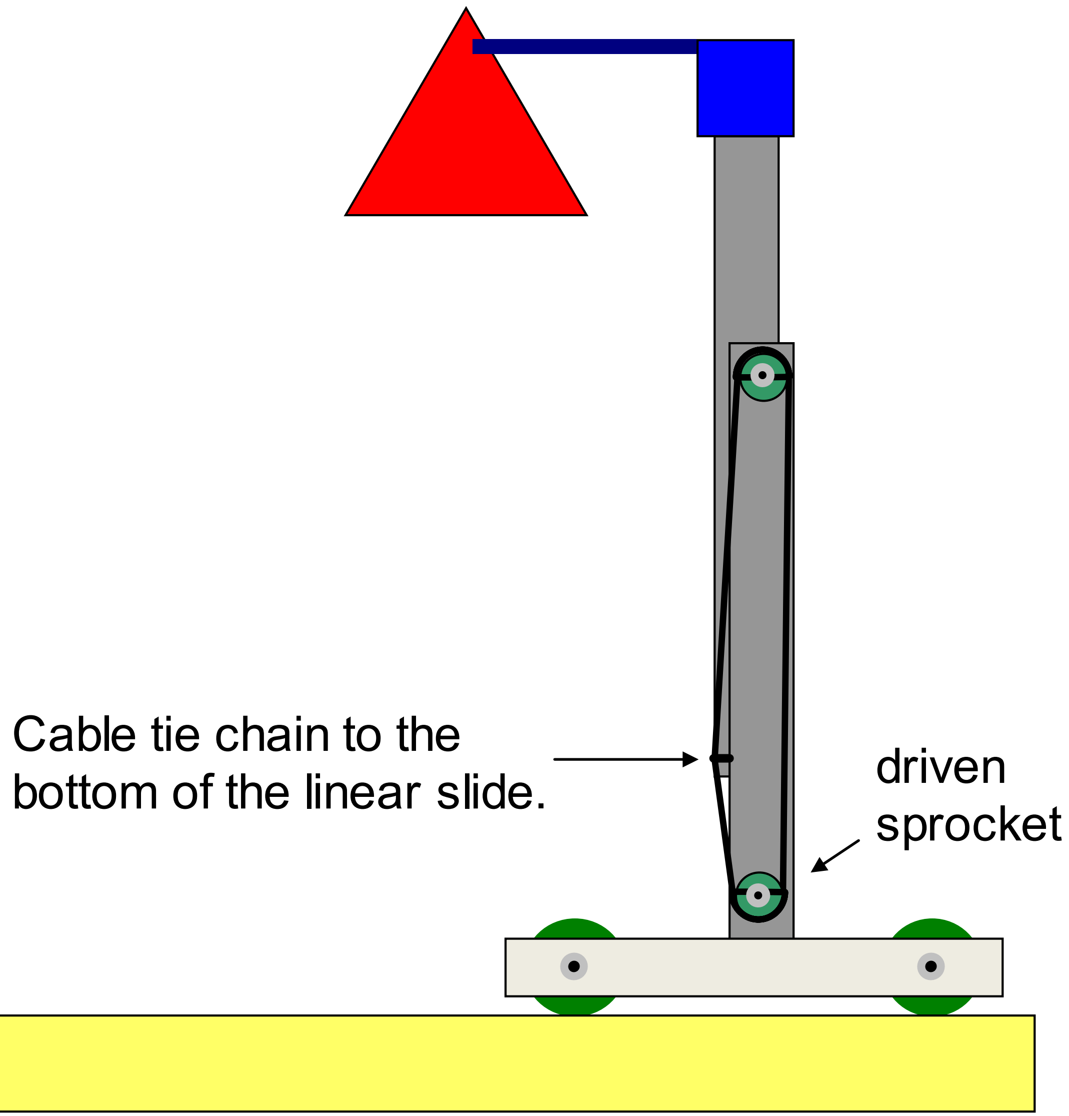
Linear Slide Extension Lifts

Single Stage Chain Lift

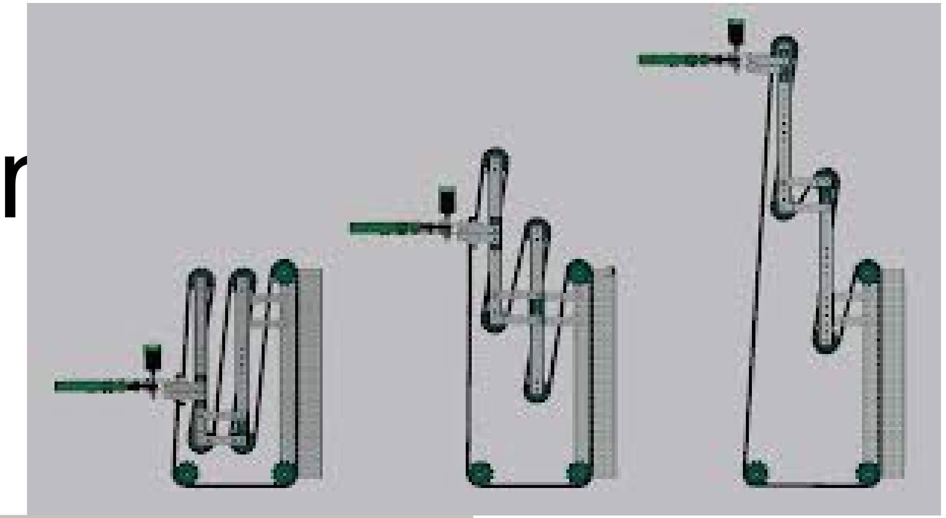
The motor rotates the chain.

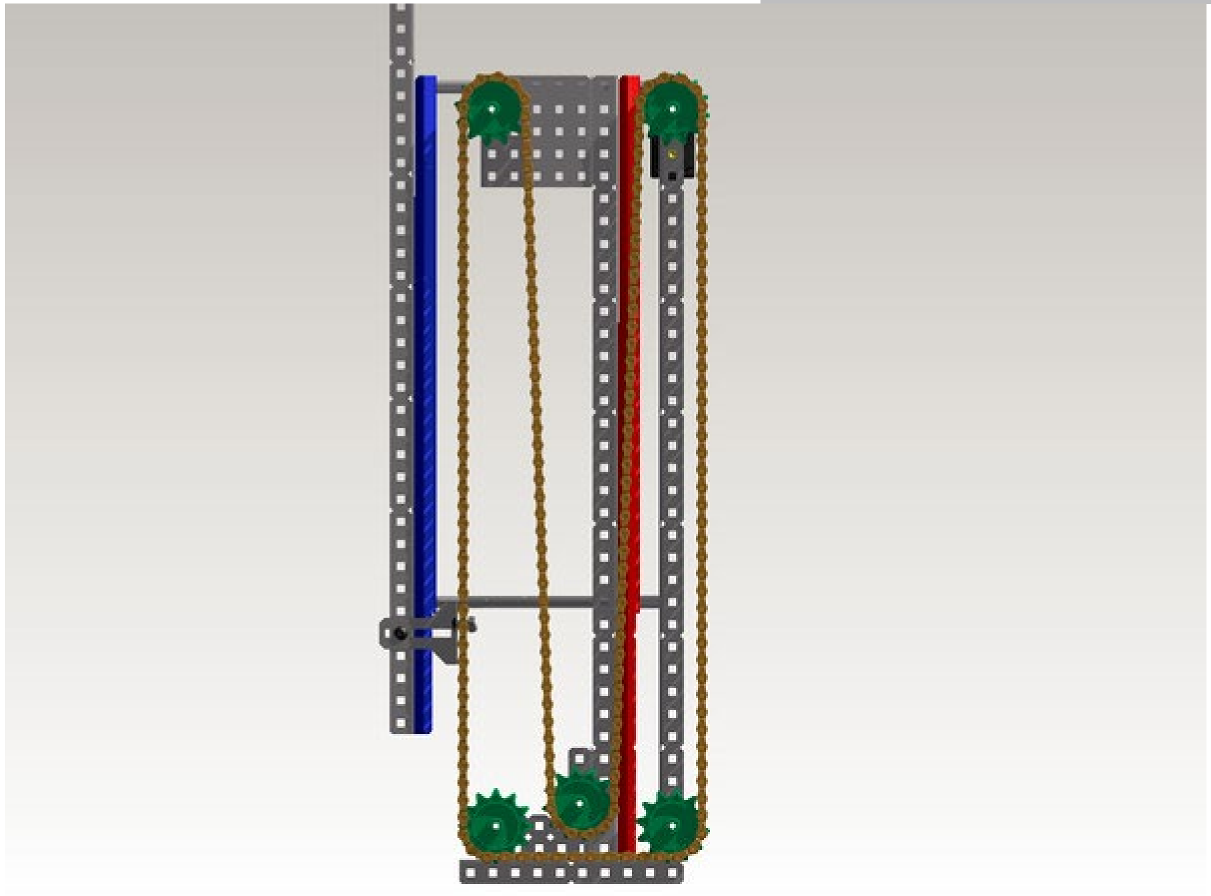
The linear slide is attached to the chain.

The linear slide is pulled up and down by the chain.



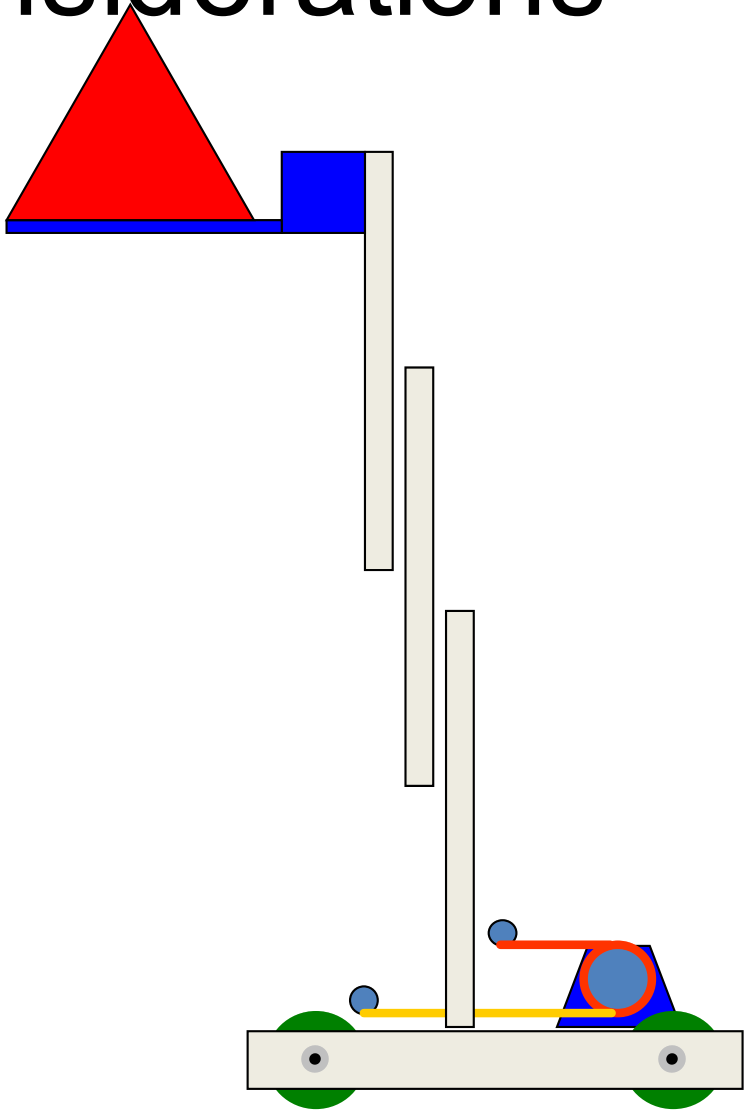
Ani





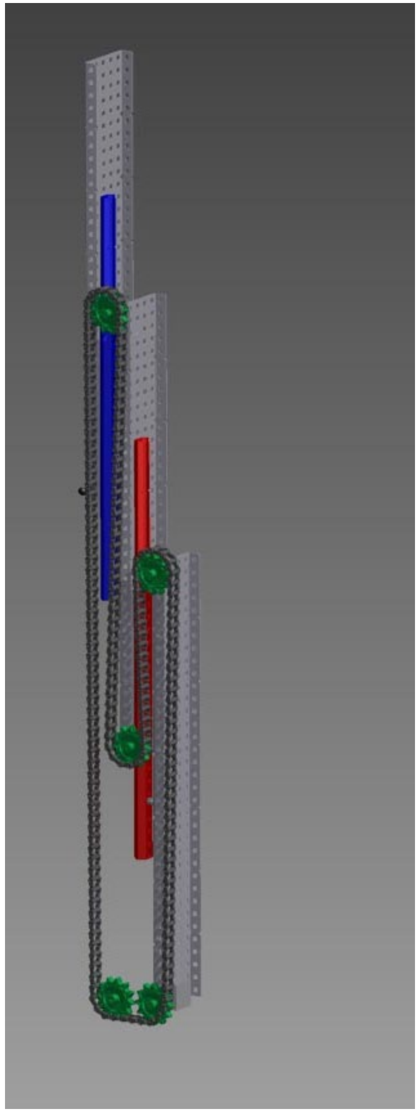
Extension Lift Considerations

- Best if powered up AND down
  - If not, make sure to add a device to take up the slack if it jams
- Segments need to move freely
- Need to be able to adjust chain/cable lengths.
- Minimize slop/ free-play
- Maximize segment overlap
  - 20% minimum
  - more for bottom, less for top
- Stiffness is as important as strength
- Minimize weight, especially at the top



Linear Slide Pros and Cons

- ***Advantages –***
- Very effective linear lift from floor surface.
- Linear motion kit has very little sliding friction.
- Takes up little volume on the robot.
- You can add ‘stages’ to increase the distance the slide can travel.
- ***Disadvantages –***
- The gear teeth on plastic racks can strip.
- Creates a higher center of gravity when lifted
- Difficult to build and keep friction down.
- **Summary: Can be tricky to limit the friction, but gives the advantage of lifting straight up and taking up little room.**



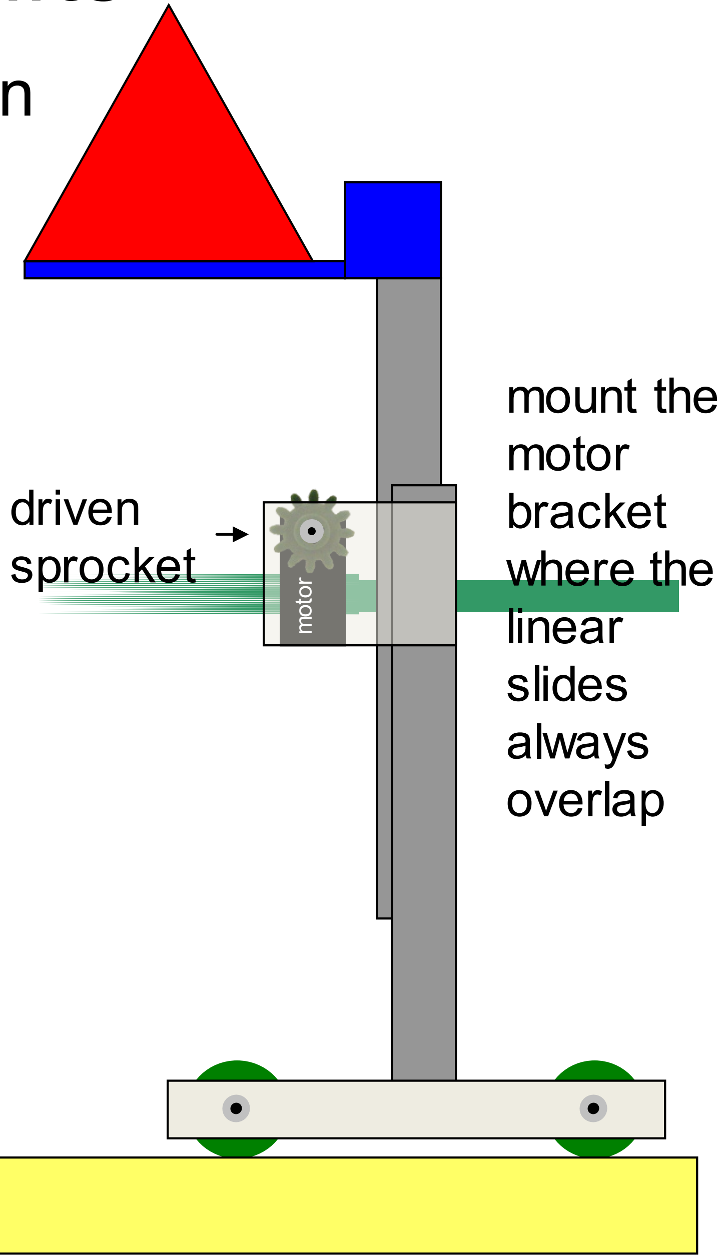
Extension Lifts

Rack & Pinion

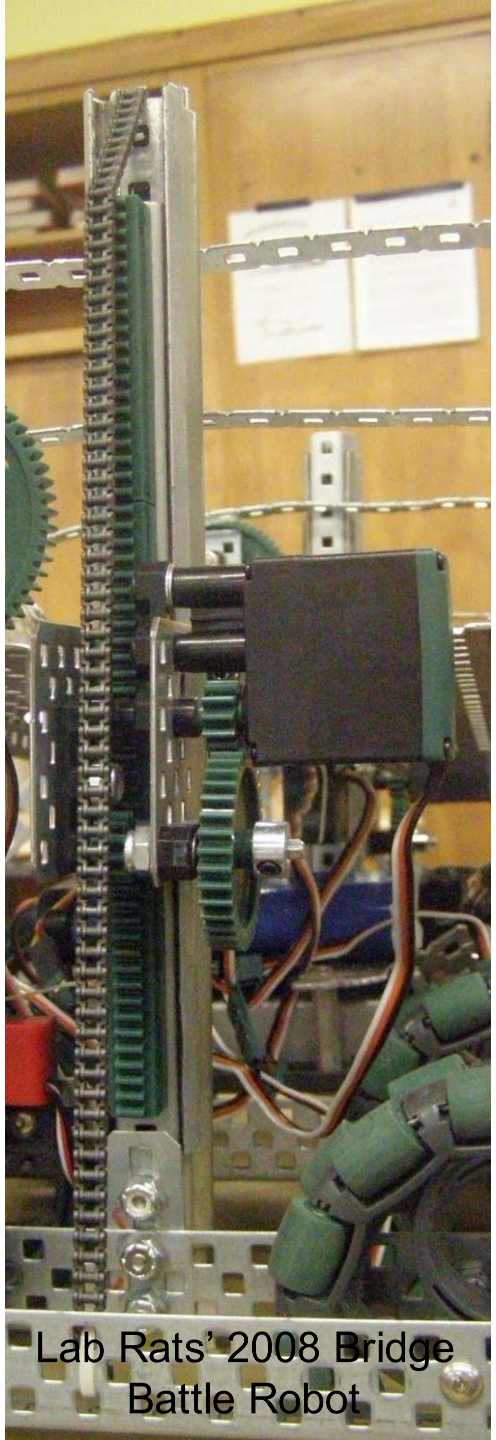
The rack is attached to one linear slide.

The pinion (driven gear) is attached to the other slide

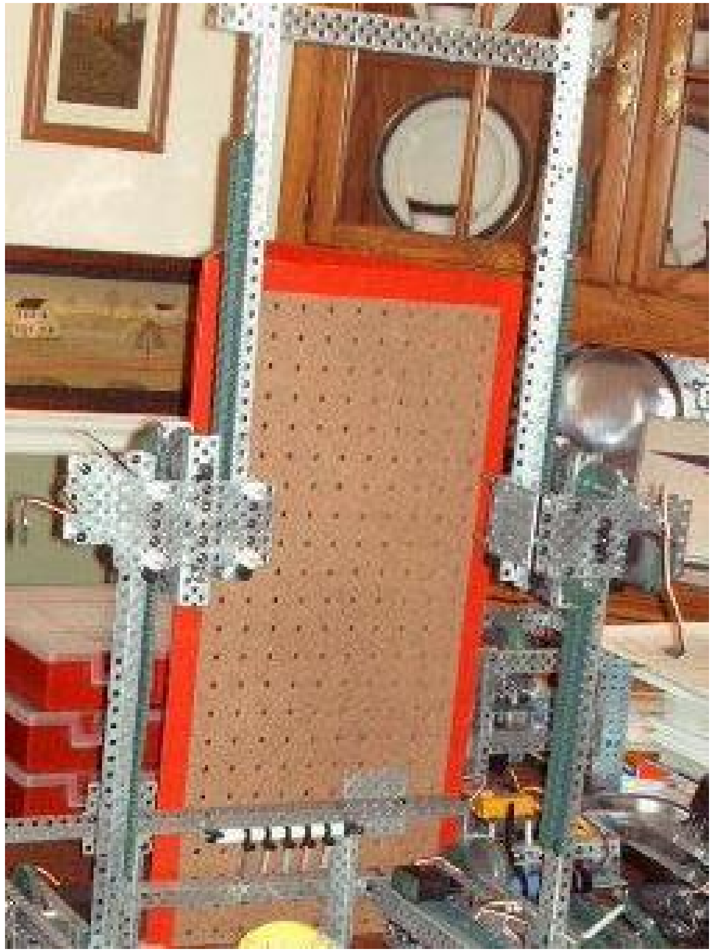
The driven gear must be mounted where the linear slides always overlap.



Rack & Pinion Lift



Lab Rats' 2008 Bridge Battle Robot

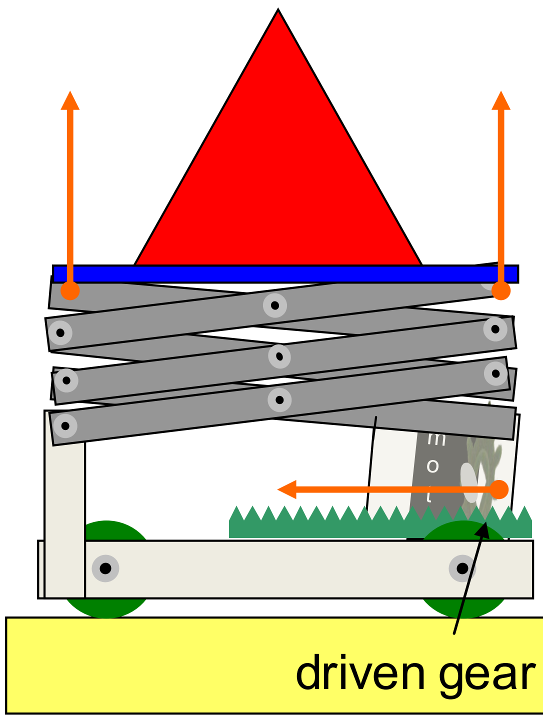


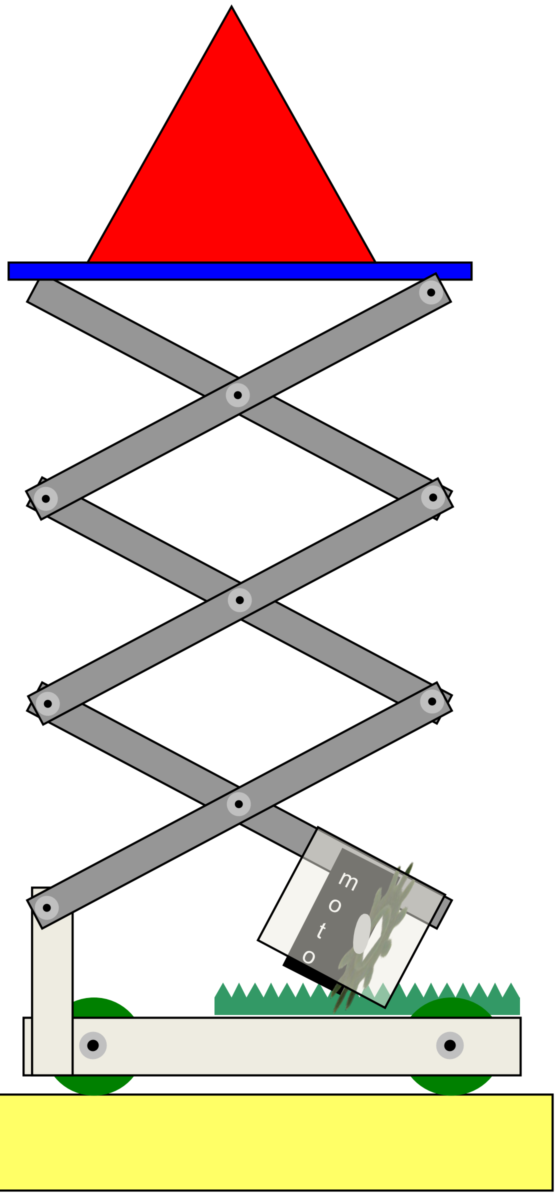
posted on www.vexforum.com
by 1885.blake

Scissor Lifts

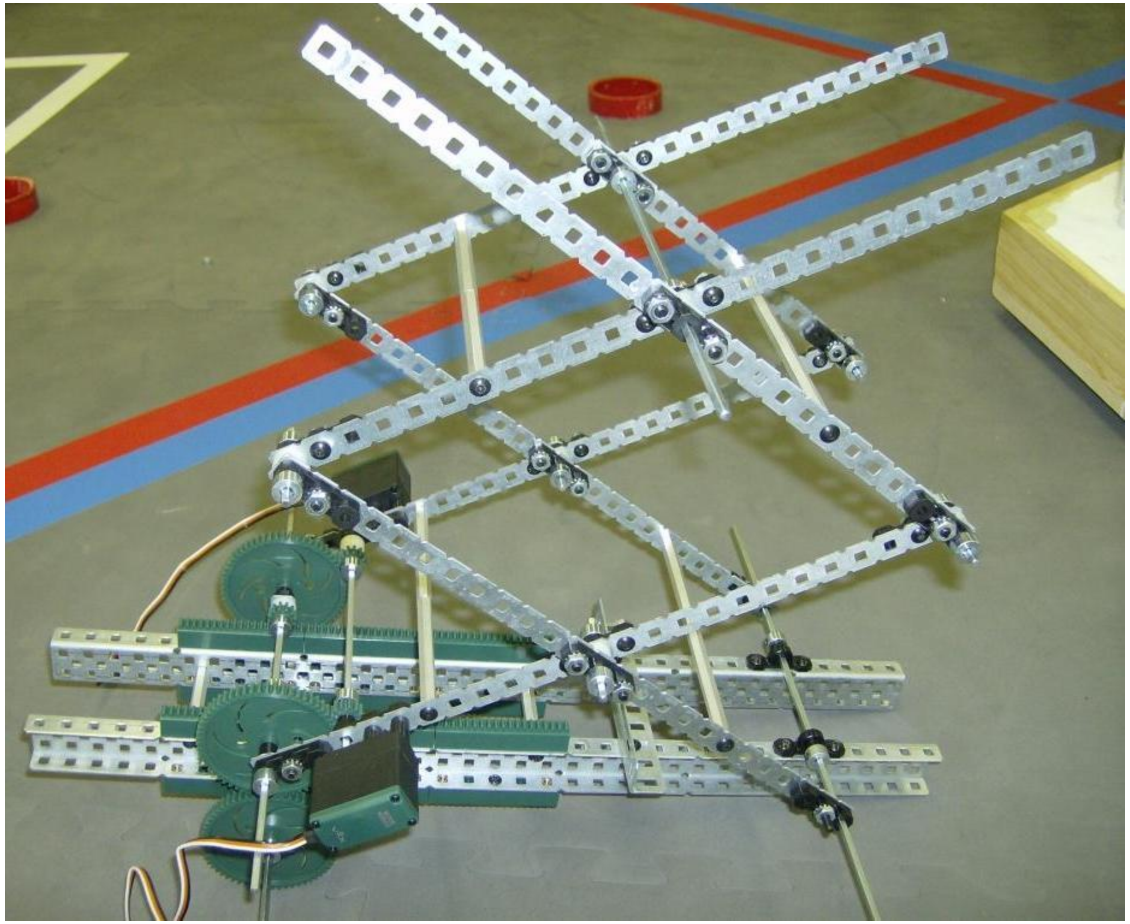
When the bottom of the scissors is pulled together it extends upwards.

In this example a rack and pinion pulls the bottom of the scissors together.





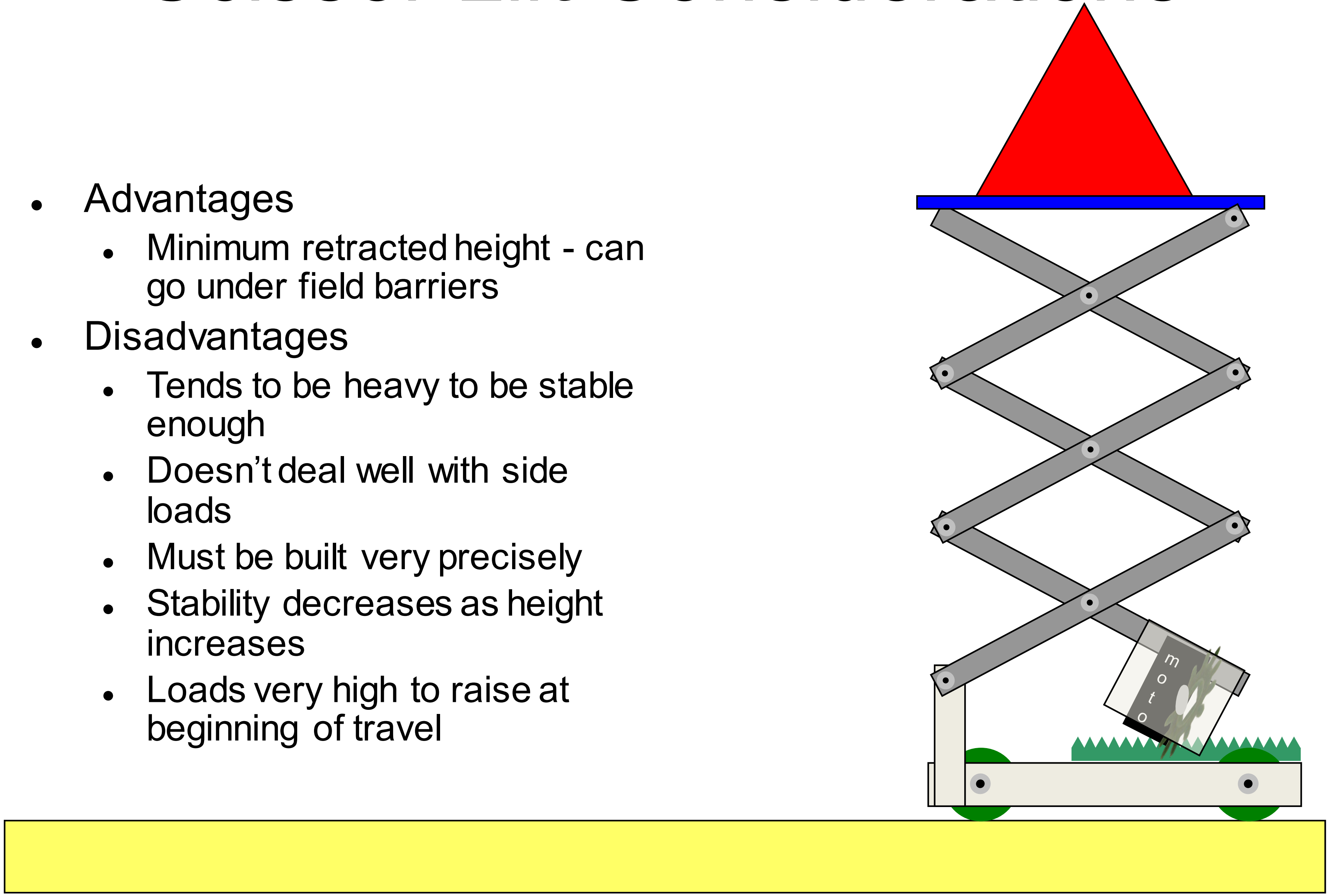
Scissors Lift



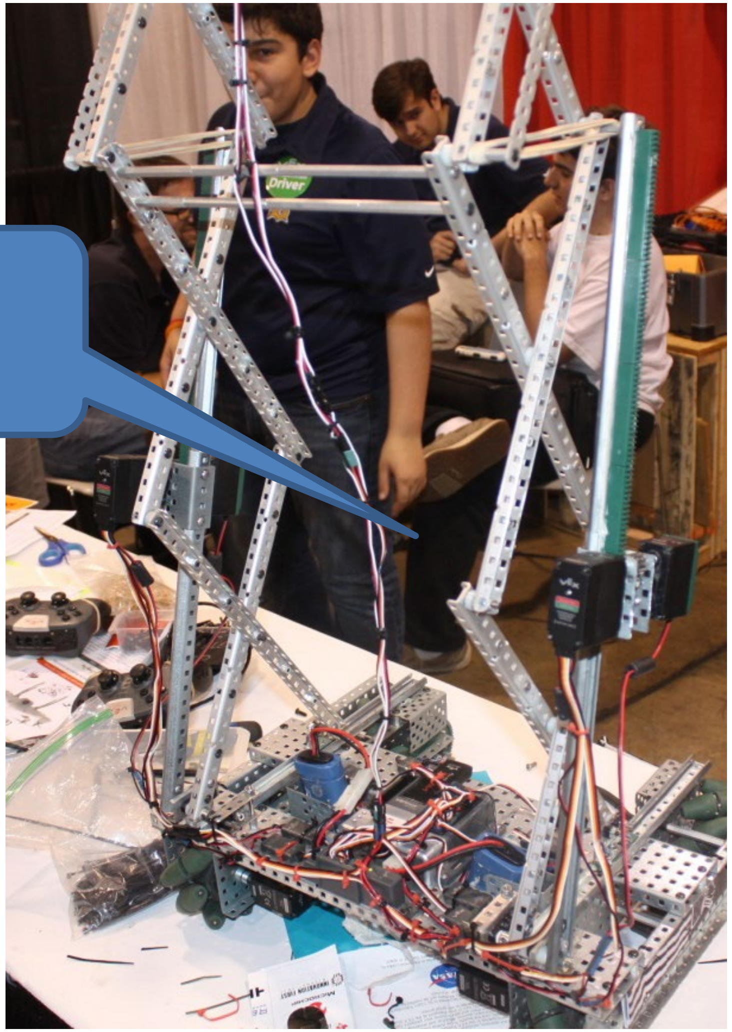
posted on www.vexforum.com
by corpralchee from FVC Team 38

Scissor Lift Considerations

- Advantages
  - Minimum retracted height - can go under field barriers
- Disadvantages
  - Tends to be heavy to be stable enough
  - Doesn't deal well with side loads
  - Must be built very precisely
  - Stability decreases as height increases
  - Loads very high to raise at beginning of travel

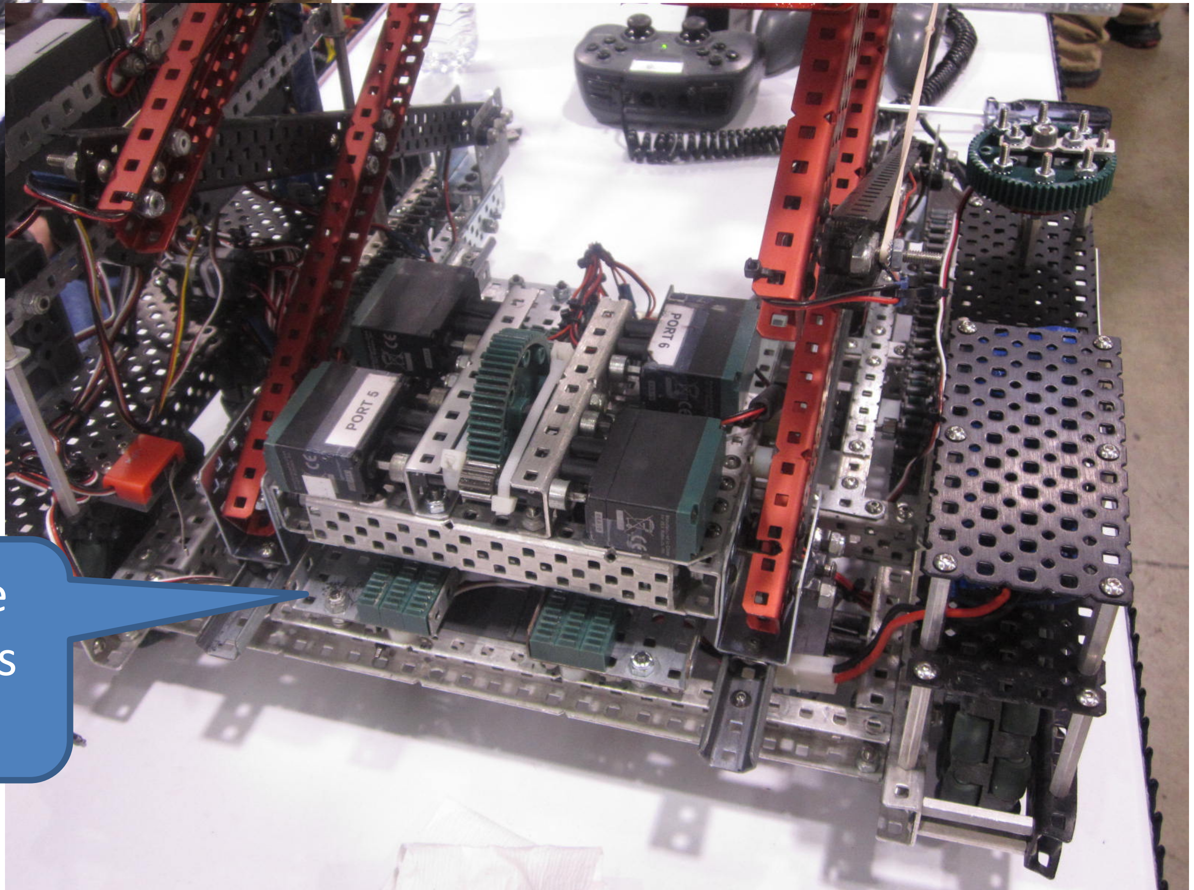


Scissor Lift Example



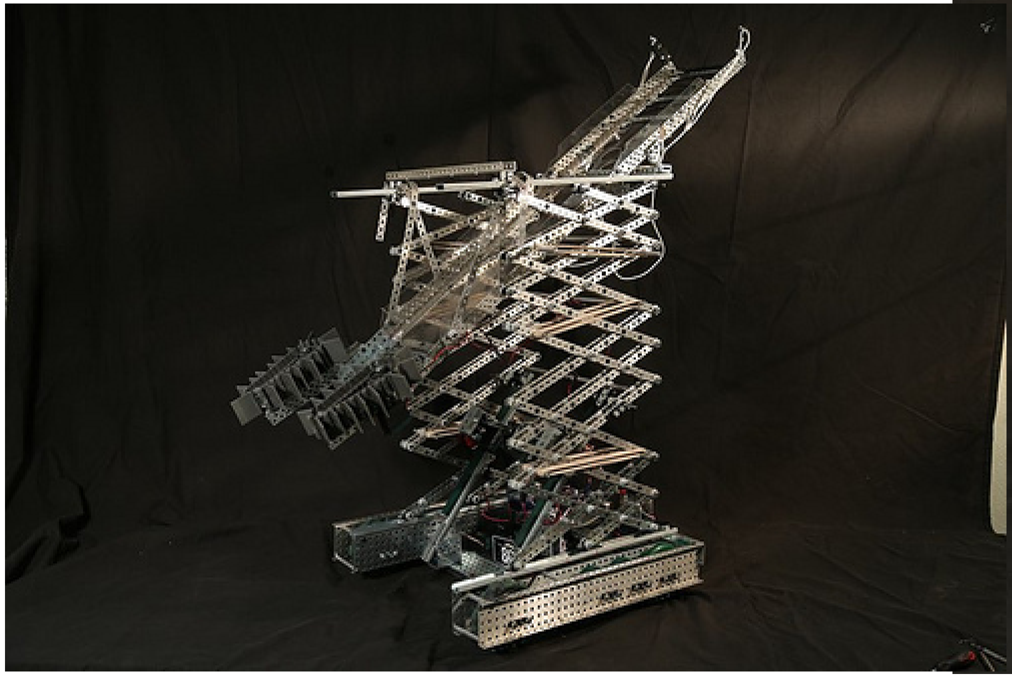
Rack and Pinion for lifting

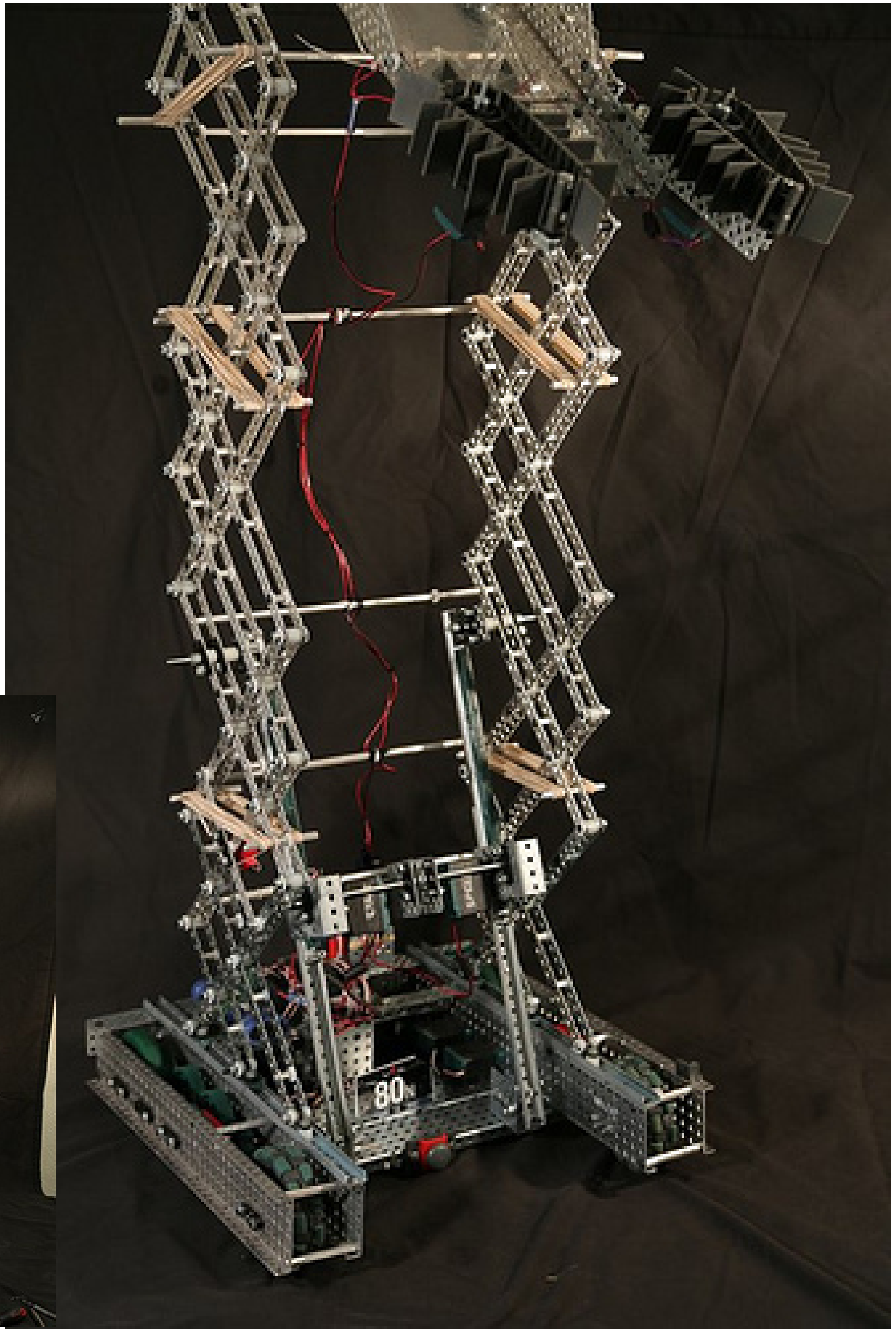
Scissor Lift Example



Motors move the base which moves the arms.

Scissor Lift

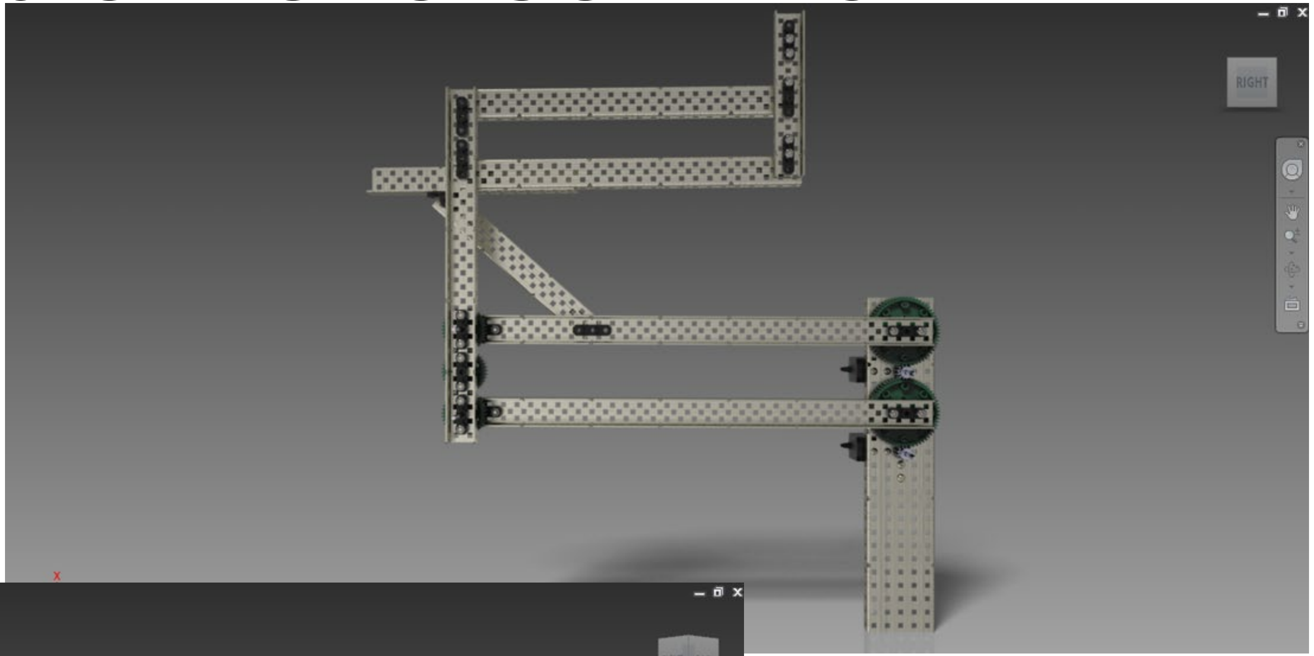


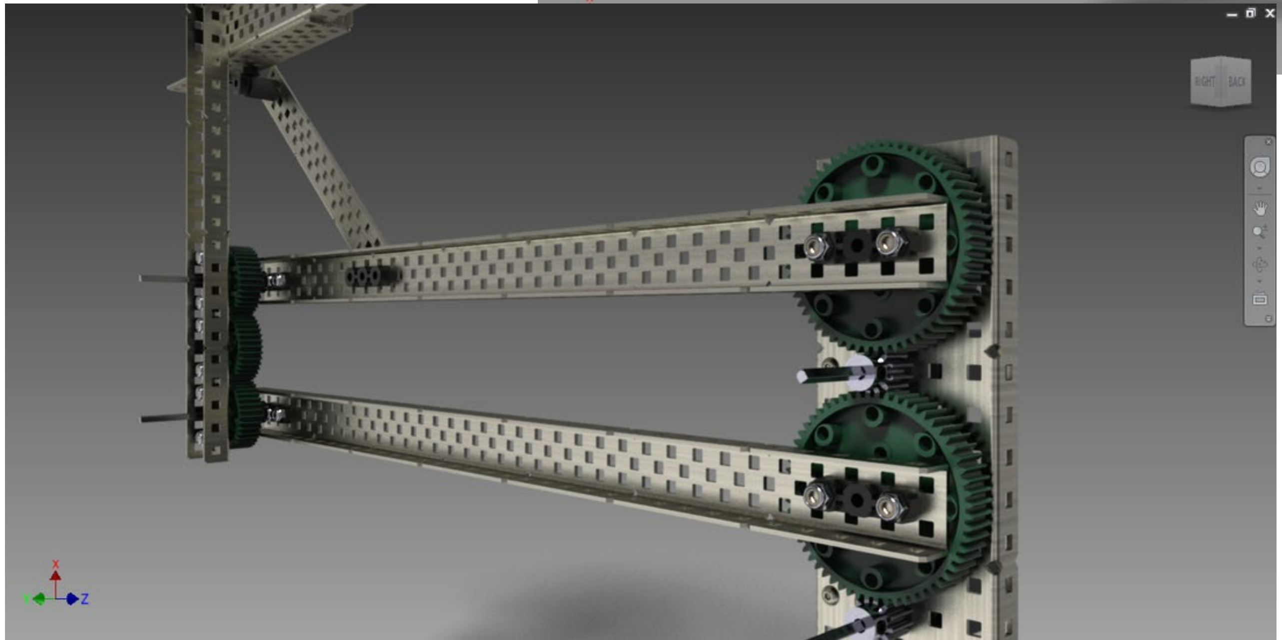


Scissor Lift Pros and Cons

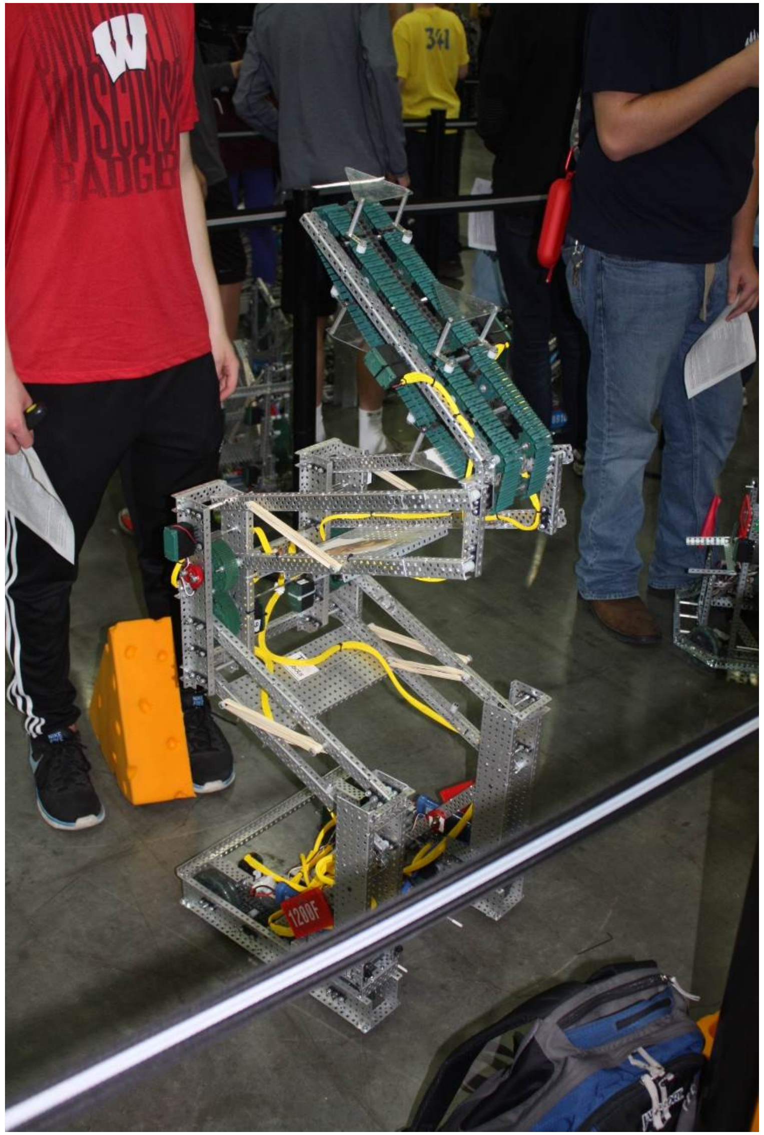
- ***Advantages –***
- Can expand a great distance for very little linear motion.
- Can be expanded horizontally as well as vertically.
- Elastic forces can be used to expand the lift.
- ***Disadvantages –***
- Complex
- The further apart the legs and the lower the center hinge point, the more force is required to lift the structure.
- Scissor lift systems must be well designed or they will bind. Scissor lifts take up a great deal of volume on a robot.
- Creates a higher center of gravity when lifted.
- ***Summary: The Great Tormentor! Great on paper, can be difficult to implement with multiple stages.***

Double Reverse 4-Bar





Double Reverse 4-Bar



Engineering Notebook Page: 'Brainstorming'

- **The goal is to generate as many ideas as possible to help you develop the best product as early as possible**

Brainstorming Rules

- **Every person** and every idea has **equal worth**
- **Every** (school appropriate) idea is a good idea!
- Encourage **wild and exaggerated** ideas
- Go for **quantity** at this stage, not quality
- **Build** on ideas put forward by others

Time for the Storm: 9 minutes

- Team Roles
  - Recorder (Into the team Engineering Journal)
  - Encourager
  - Thought provoker(s) (Idea generators)
- Rotate roles every 3 minutes
- **Brainstorm and record ideas for your robot I'll tell you when to rotate rolls**

Selecting your Design Direction

- The team will be using a Decision Matrix to help in determining your direction.
- Record this in your team journal and copy into your individual journal

Prioritize: What is the best idea?

- Weigh the advantages and disadvantages of each alternative?
- Set up alternatives in a matrix for analysis (See next slide.)
- Mark the grid (Can use other scales)
  1. + = 1: Better. (Above Average)
  2. 0 = 0: No appreciable difference. (Average)
  3. - = -1: Worse. (Below Average)

Engineering Journal: 'Decision Matrix'
Google Sheets: Copy and paste into notebook.

Put your most important Specifications and/or constraints. (At least 4)

Specifications / Constraints	Economical	Feasible	Practical	Reliable	Size	Performance	Total
Alternatives							
Tracts							
Dune Buggy							
2 Legs							
Propeller							
Rack and Pinion+Diff.							
Helicopter							
Hoover Craft							
6-wheel:Banana Split							

Rate (+, 0, -) each alternative for each specification/constraint in the grid.

Total the score for each alternative in the totals column.

Place your brainstorm and researched ideas along the first column. Can leave off the 'off-the-wall' suggestions.

Weighted Decision Matrix Option

How the alternative rates x Importance of specification = score in g

Specifications	Economical	Feasible	Practical	Reliable	Size	Performance	Total
Weighted Importance of specification/ constraint (1 to 5)	1	4	5	[illegible]	[illegible]	[illegible]	
Alternatives							
Trackbot with Scissor	5x1=5	5	[illegible]	4x5=	3x2	3x5=15	86
Omni-bot with 6-bar	4x1=4	4x4=1	=16	15	=10	3x5=15	76
Rack and Pinion + Differential	3x1=3	1x4=4	3x4=12	3x5= 15	3x2 =6	3x5=15	55
6 wheel: Banana Split	4x1=4	3x5=15	5x5=25	5*5= 25	4x2 =8	5x5=	102

Specifications and Constraints

Weights based on the importance of the specification/constraint.

Score = Weight x Rating of alternative

Alternatives

Totals

Engineering Journal Page 'Initial Design Direction'

- Use the rating from the Decision Matrix to help you select the design.
- You do not have to select the design that rated highest in the Decision Matrix.
  - Sometimes a robot that is OK at everything but good at nothing comes out high in the ranking
- Your team has the final say in your design direction, but you should be able to justify it.
- **Record your design choice and why in your engineering journal.**
- **Include Sketch/Picture/idea to help guide building.**

Time to Build your first prototype

- Your team can use your initial design direction
- You can also use the instructions to build a Clawbot.
- The kits checked out have some additional parts