(11/17/2019)

Roboting TL;DR

(Too Long; Didn't Robot)

Abridged Edition by Brian Gray
Lead Ment0rer - Team 5256

Wheels

Wheels

Standard Traction Wheels

(AM HiGrip, Vex VersaWheels)

Low-cost, no-frills traction wheel.

Pros:

Preassembled, cheap.

Cons:

Junk when tread worn; Average performance.

AndyMark Hi-Grip Wheel

Vex VersaWheel

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Wheels

Customizable Tread

(AM Performance Wheels, AM Plaction Wheels)

Traction wheel rims for replaceable tread.

Pros:

Custom tread available in various materials/patterns; More consistent performance if maintained; Durability of rims; Potential for top of the line traction.

Cons:

Tread can come loose, resulting in extremely poor traction; Aluminum wheels expensive; Requires regular maintenance; Increased wear on drivetrain with aggressive traction.

Performance wheel with Roughtop Tread installed.

Tread wear after 25 matches

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Wheels

Pneumatic Wheels

(AM 8" Pneumatic Wheel)

Traction wheel designed for power scooters and wheelchairs; Good speed over rough terrain.

Pros:

Aggressive on obstacles; big; some adjustability by varying inflation.

Cons:

Valve stem can cause wobbling; Tires can go flat; Can be too bouncy

8” Pneumatic Wheel with hub assembly

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Wheels

Omni Wheels

(AndyMark/Vex Omni Wheels)

Wheels with casters mounted around its circumference to allow lateral movement.

Pros:

Fully omnidirectional in holonomic drives; Reduces wheel scrub in regular drives.

Cons:

Vulnerable to defense; Poor traction compared to other wheel types.

Vex 6” Omni-Directional Wheel

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Wheels

Mecanum Wheels

(AndyMark/Vex Mecanum Wheels)

Vectored wheels for omnidirectional movement.

Pros:

Full omnidirectional movement at a relatively low-cost.

Cons:

Vulnerable to defense; Inefficient due to low coefficient of friction; Requires 4 gearboxes.

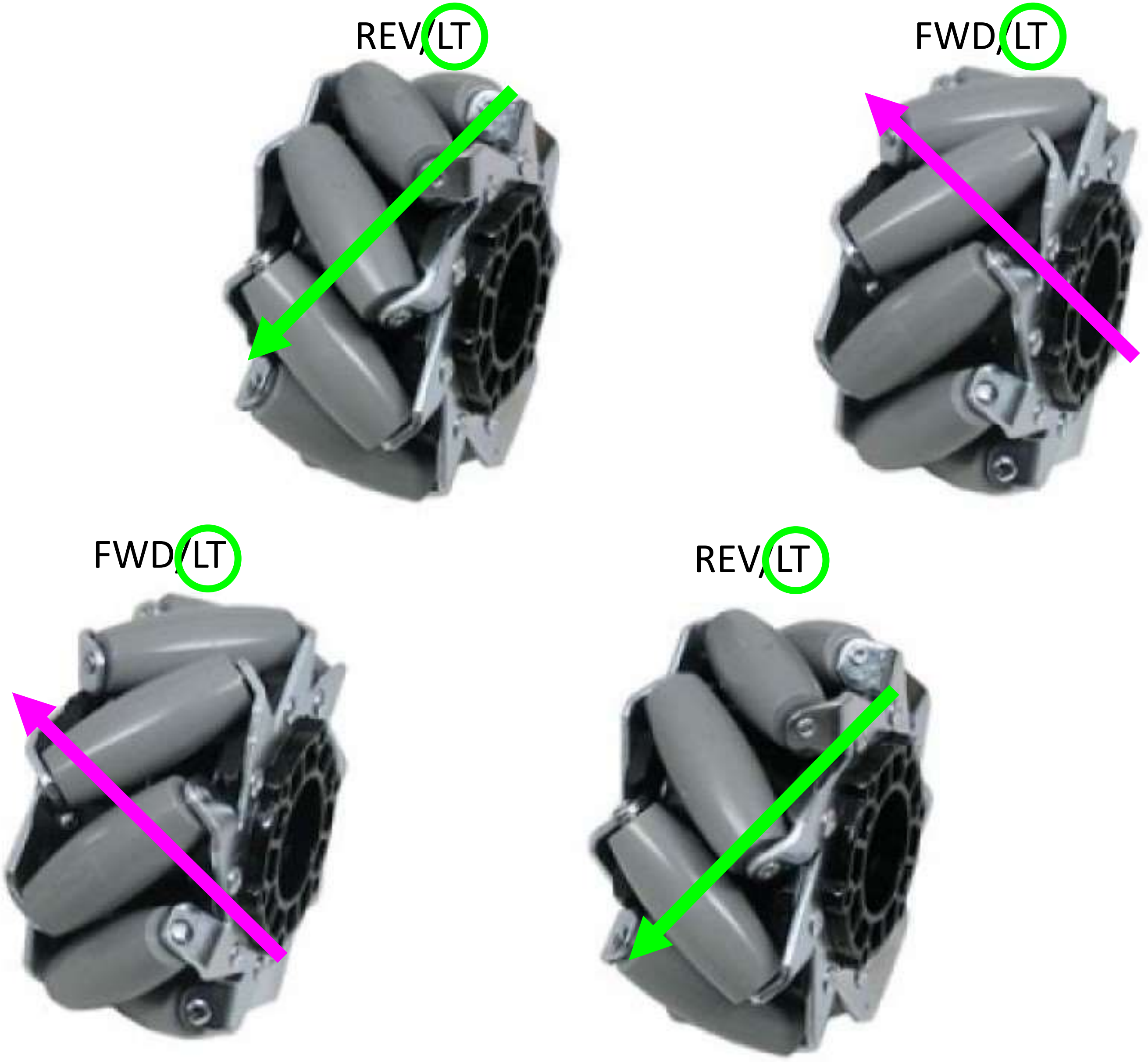
AndyMark 6” SR Mecanum wheel set

Mecanum
Wheel Motion

Think of each wheel as moving in 2 directions at once. Movement is determined by the common direction shared by all 4 wheels. In this case, the robot is moving forward.

Mecanum
Wheel Motion

In this scenario, the front left & right rear wheels are going in reverse, while the others continue forward. Looking at the common direction, we can see the robot will now move left.



Wheels

Compliant Wheels

(AM Compliant Wheels, WCP Flex Wheels)

Used for intakes and other mechanisms designed to pick up or transfer objects.

Pros:

Conforms to accommodate objects of varying size and shape; Designed with different material durometers to match intake/conveyor RPM.

Cons:

Not designed to be used for drive wheels; Loses effectiveness when dirty.

Assorted compliant wheels

Drivetrains

Drivetrains

Six-Wheeled Tank

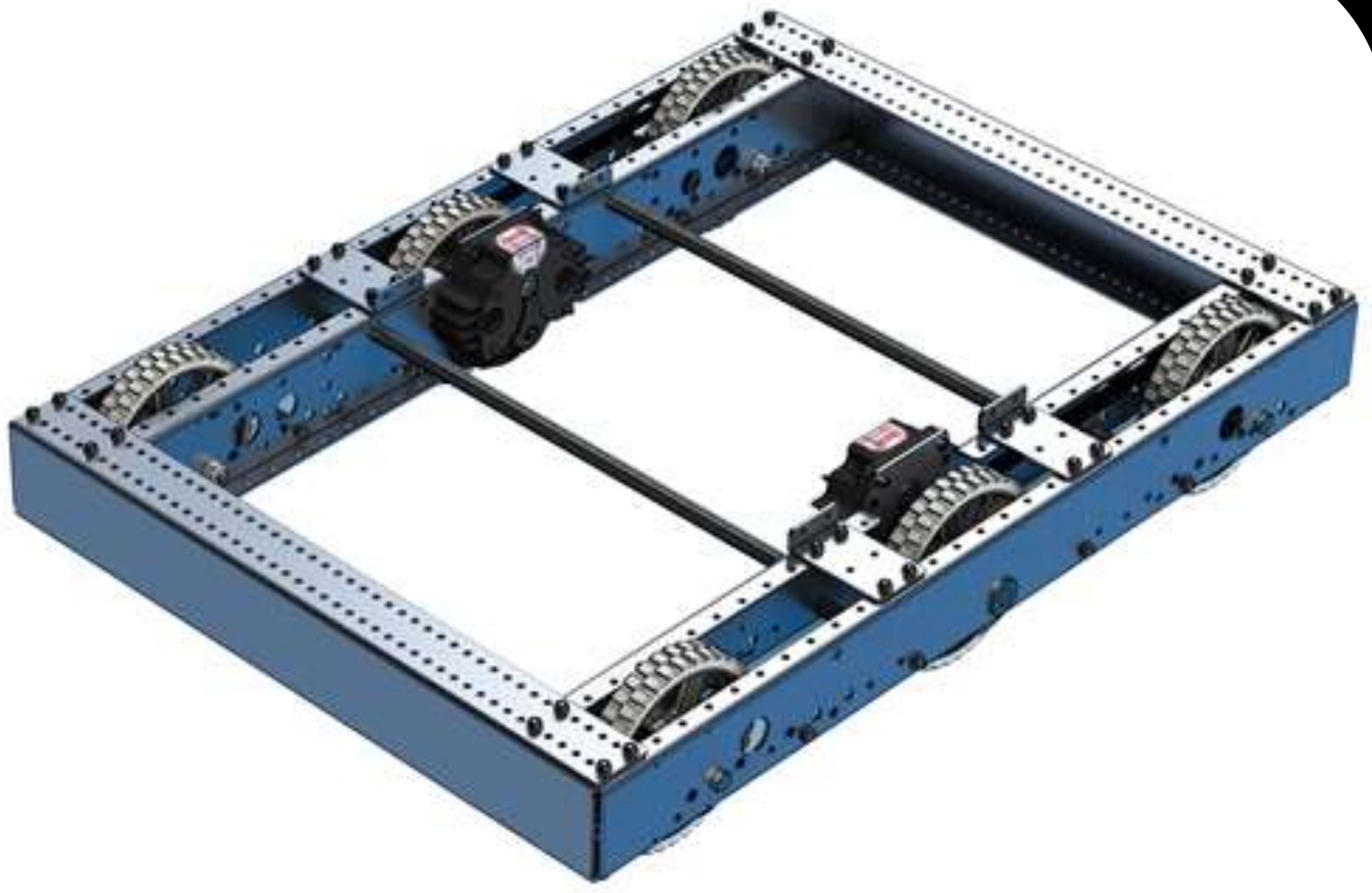
- Left and Right sides driven independently.
- Dropped center wheels, or omni outer wheels.
- Left/Right sides driven independently.
- Most common type of FRC drivetrain.

Pros:

Durable; Simple to design, build and program.
Cheap; Ample support for the KOP chassis kit.

Cons:

Standard means you'll be equally matched frequently (especially if using KOP chassis);
Slight rocking due to dropped center wheels;
Potential wheel scrub problems with long chassis configurations.



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Drivetrains

Eight-Wheeled Tank

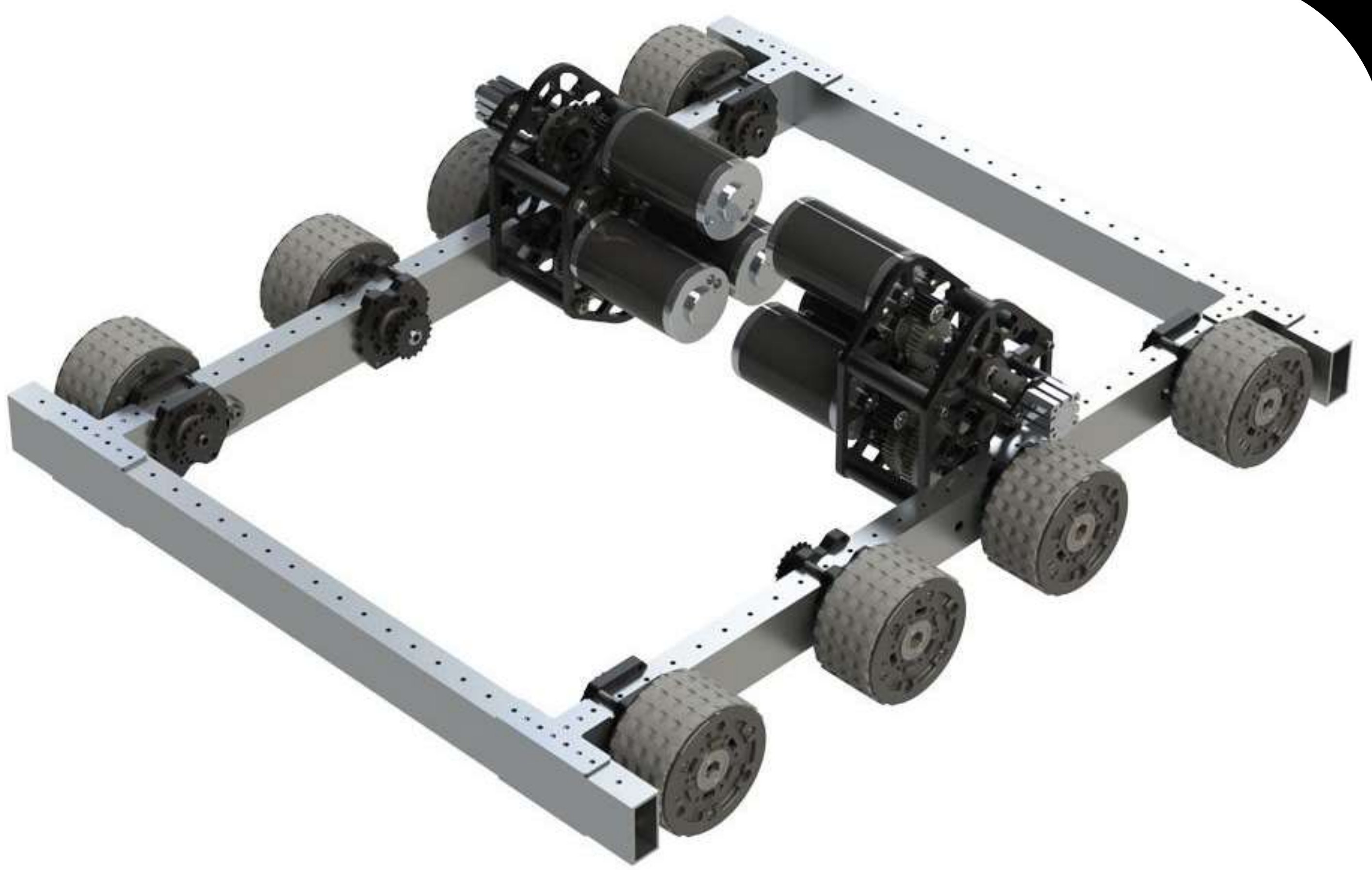
- **Left and Right sides driven independently.**
- **Dropped center wheels (2 per side).**
- **Left/Right sides driven independently.**

Pros:

Durable; Relatively simple to build; More traction, Better at handling ramps and other irregularities than 6-wheel, less likely to high center

Cons:

Custom build or serious modification required; Greater likelihood of wheel scrub problems with long chassis configurations. Mo’ wheels, mo’ problems.



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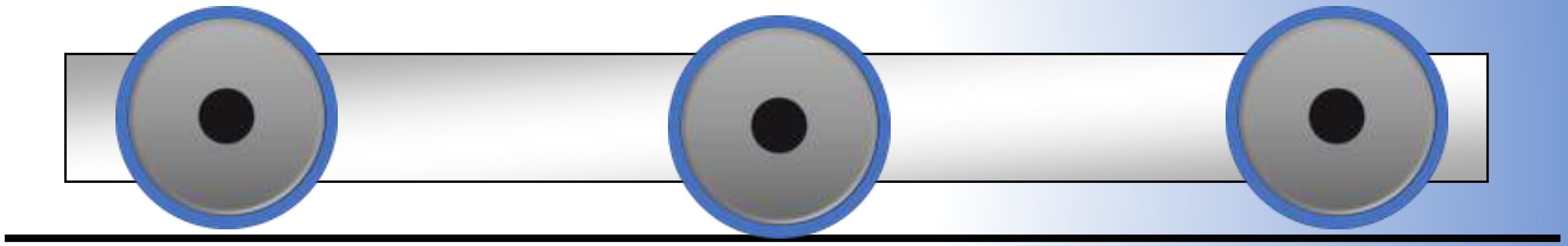
No Scrubs: Dropped Center and Omni Wheels

Wheel scrubbing is unwanted friction condition caused by sideways movement of traction tires, such as in a spin or turn. It's like drifting, but it's not cool when robots do it. Scrubbing creates an additional load on drivetrains, causing them to draw more current. Spikes in current draw can trigger brownout protection, which results in a temporary loss of power to the drivetrain. Because of this, tank drives typically utilize one of the two strategies shown below.

Example 1:

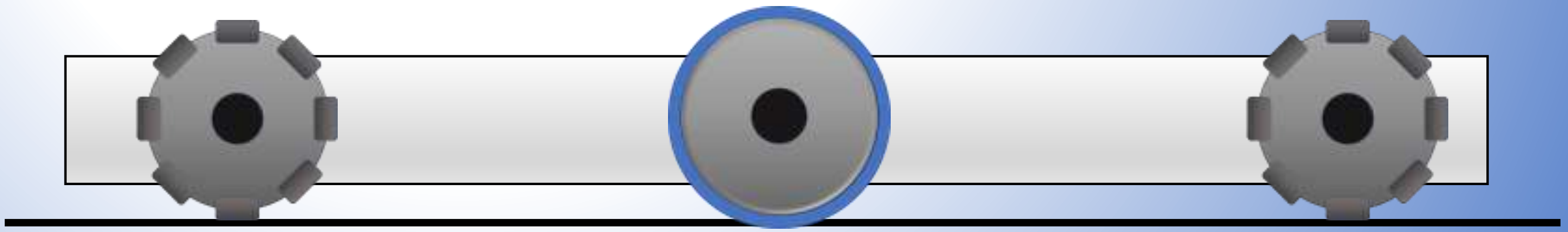
Tank drive shown with six traction wheels with the center slightly lower in relation to the front and back.



Pros: More traction
Cons: Slight rocking; Wheel scrubbing

Example 2:

Tank drive with center traction wheel and outer omni wheels. All wheels are installed on the same plane.



Pros: Low center of gravity
Cons: Less traction

Drivetrains

Mecanum

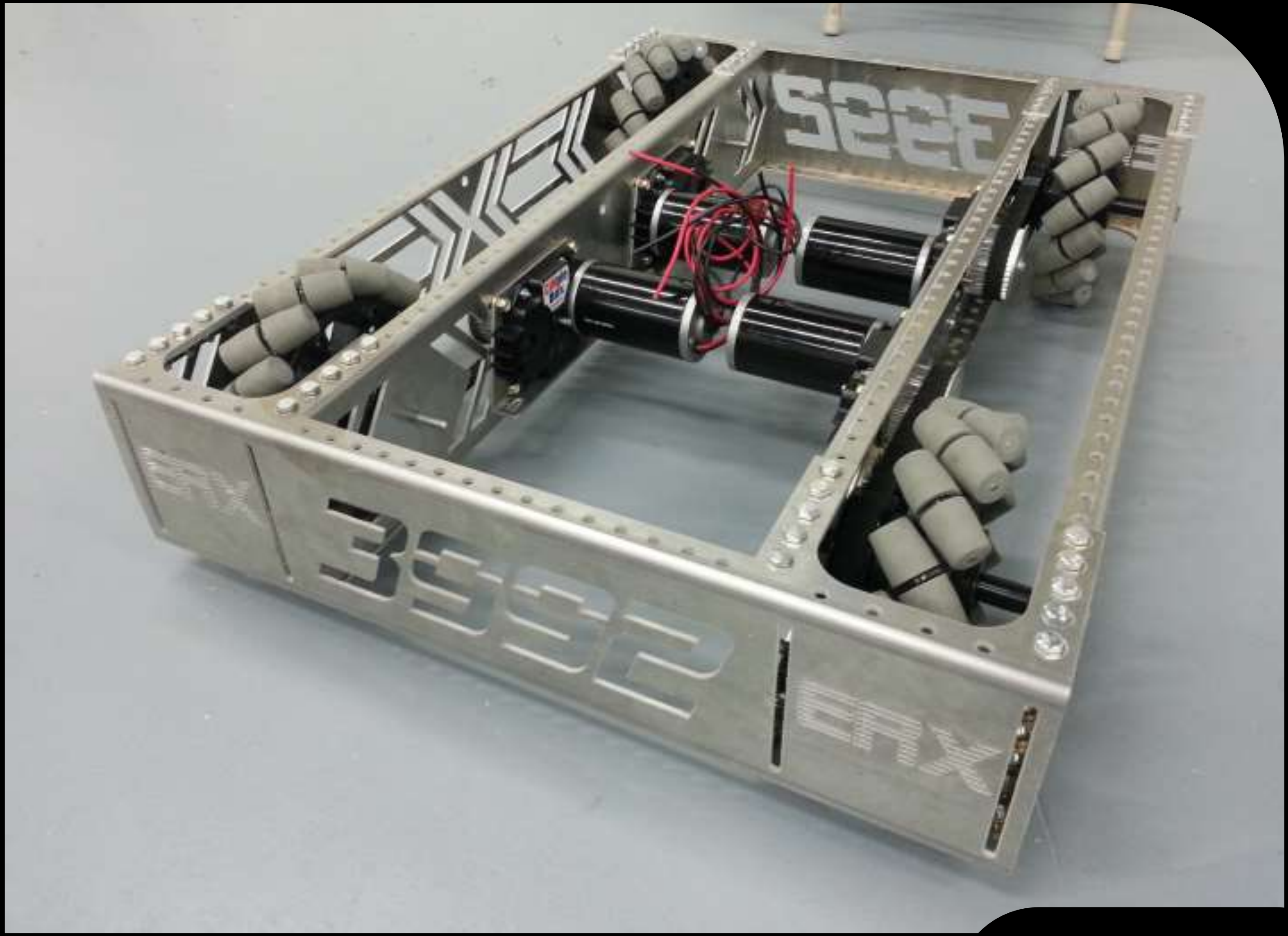
- **Requires 4 independently driven wheels.**
- **Wheels must be installed correctly due to vectored rollers.**
- **Capable of full omnidirectional movement.**

Pros:

Fairly easy to design and build; Good programming support available; Agile.

Cons:

No potential for pushing force. Challenging to learn to drive well. Added expense due to costly wheels and extra gearboxes.



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Drivetrains

X-Drive/Killough

- **4 omni wheels positioned on 45° angles in the corners of the frame (“X” pattern).**
- **Each wheel must be driven independently.**
- **Uses all omnidirectional wheels.**

Pros:
Agile; Good programming support.

Cons:
No potential for high pushing force. Challenging to program and learn to drive well. Requires extra gearboxes.

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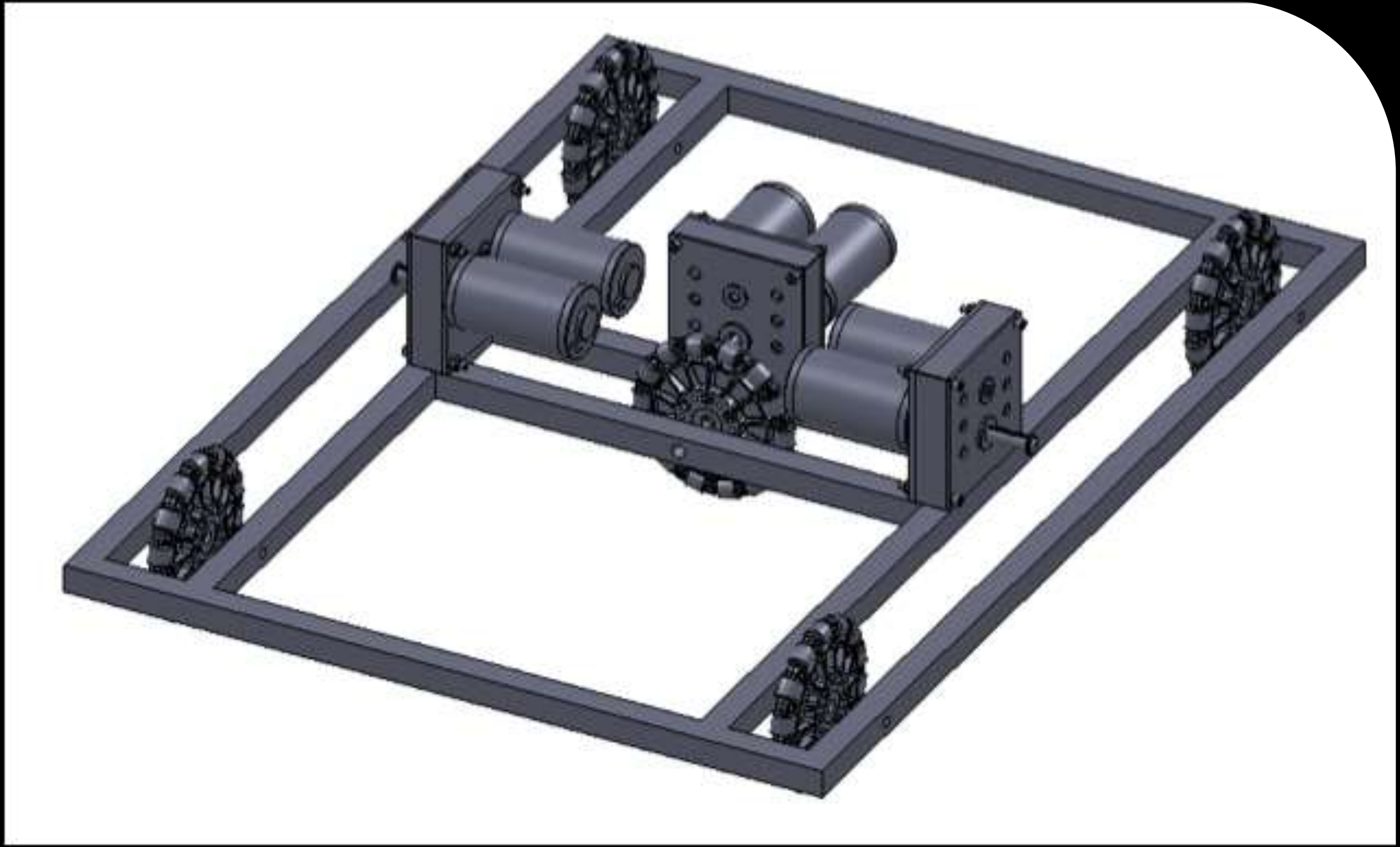
Drivetrains

Slide

- **Similar layout to tank drive, with an extra wheel(s) perpendicular to the rest.**
- **Uses all omnidirectional wheels.**

Pros:
Fairly easy to design and build. Agile.

Cons:
No potential for high pushing force. Extra wheels, motors, and gearbox required to allow robot translate sideways. Middle wheel tends to get caught going over small obstacles or uneven surfaces if not actuated to get out of the way.



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Drivetrains

Swerve/Crab

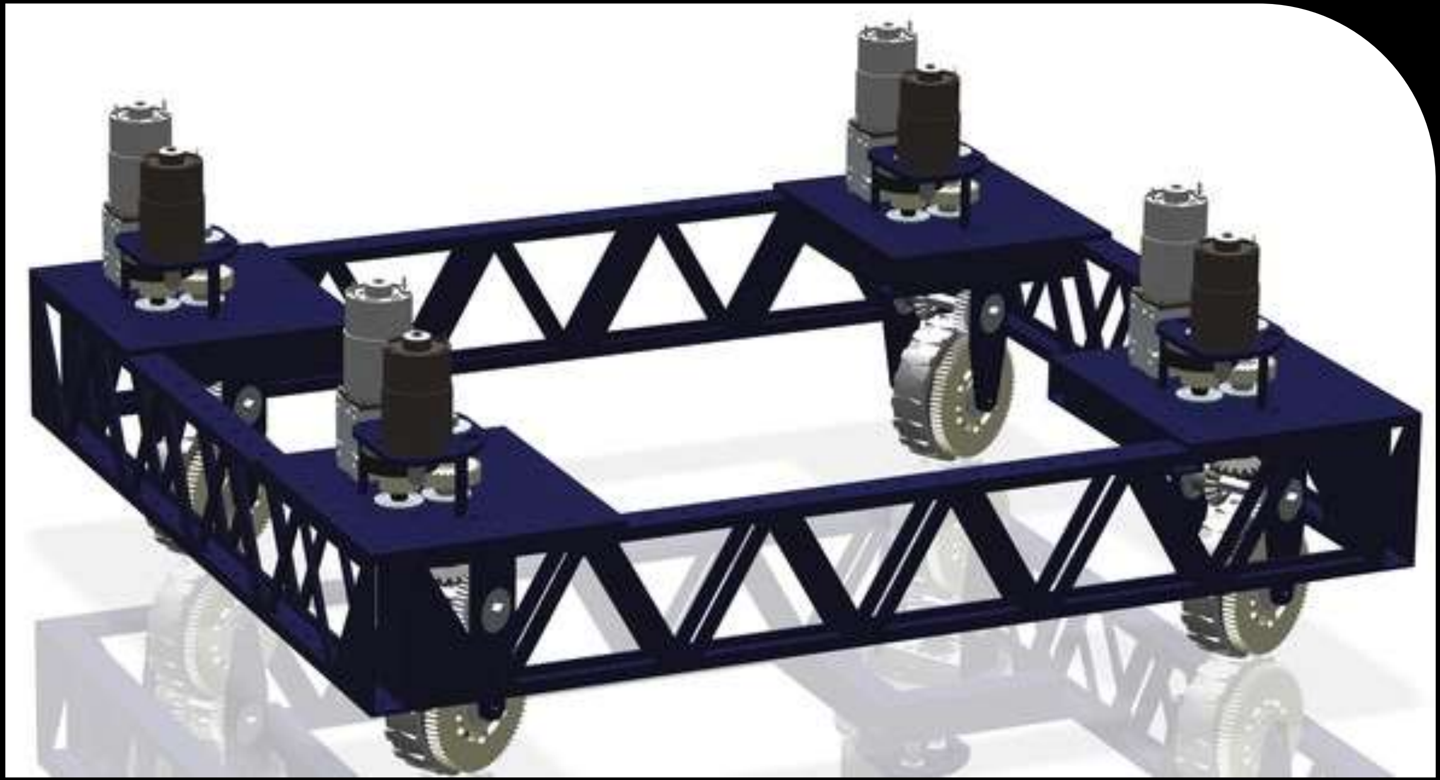
- **Uses 4 independently powered traction wheel modules which rotate on a vertical axis to control direction.**
- **Capable of full omnidirectional movement with a great deal of agility and power.**
- **Crab steers pairs of wheels together; Swerve has more complex independent steering.**

Pros:

High speed and pushing force; Agile.

Cons:

Most complex and expensive drivetrain to design and build, few COTS modules available. Programming is exceedingly difficult. Requires at least 8 motors. More potential failure modes.



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Choosing the Right Drivetrain

For the most part, the standard AndyMark Kit of Parts (KOP) chassis is more than sufficient to complete game objectives. It is easy to assemble, sturdy, and is an overall, tried-and-true performer.

Despite this, a number of teams opt for alternatives. While the reasons vary and may be driven by cost reduction, game strategy, or just the desire to tackle a greater challenge, all teams should make this decision carefully and be sure to weigh all the pros and cons of each option. ***Whichever option you choose, it's important to ensure your team is up to the task and is not building beyond their means in terms of cost, materials, technical proficiency, and time available***

Drivetrain	Complexity	Maneuverability	Pushing Power	Learning Curve
Tank (Skid Steer)	Decreased	Decreased	Increased	Decreased
Holonomic (Omni/Mancanum)	Increased	Increased	Decreased	Increased
Holonomic (Swerve/Crab)	Increased	Increased	Increased	Increased

Section 3

Chassis Fabrication

Chassis

Sheet Metal Kit

(AndyMark AM14U3 KOP Chassis; Vex Drive in a Day Chassis Kit)

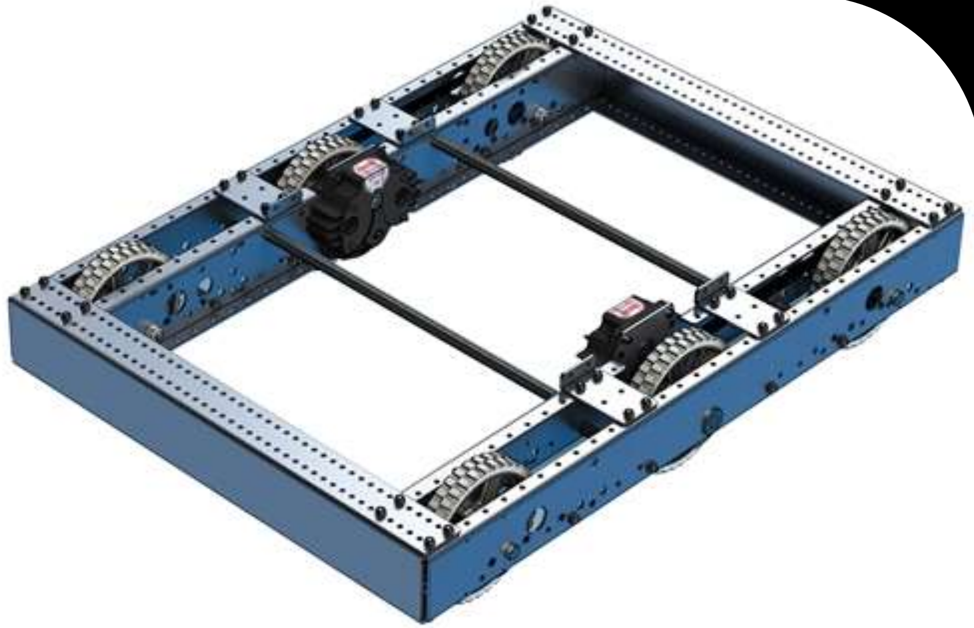
Standard kit of parts (KOP) chassis given out at Kickoff. Good enough for most tasks.

Pros:

Quick, reliable build; Easy belt and wheel spacing; Robust construction; Comes with KOP. Help available.

Cons:

Limited configuration and adjustability possibilities (without custom machining); Can be hard to work on in pits.



2018 AndyMark KOP Chassis

Vex 2014 Drive in a Day Chassis Kit

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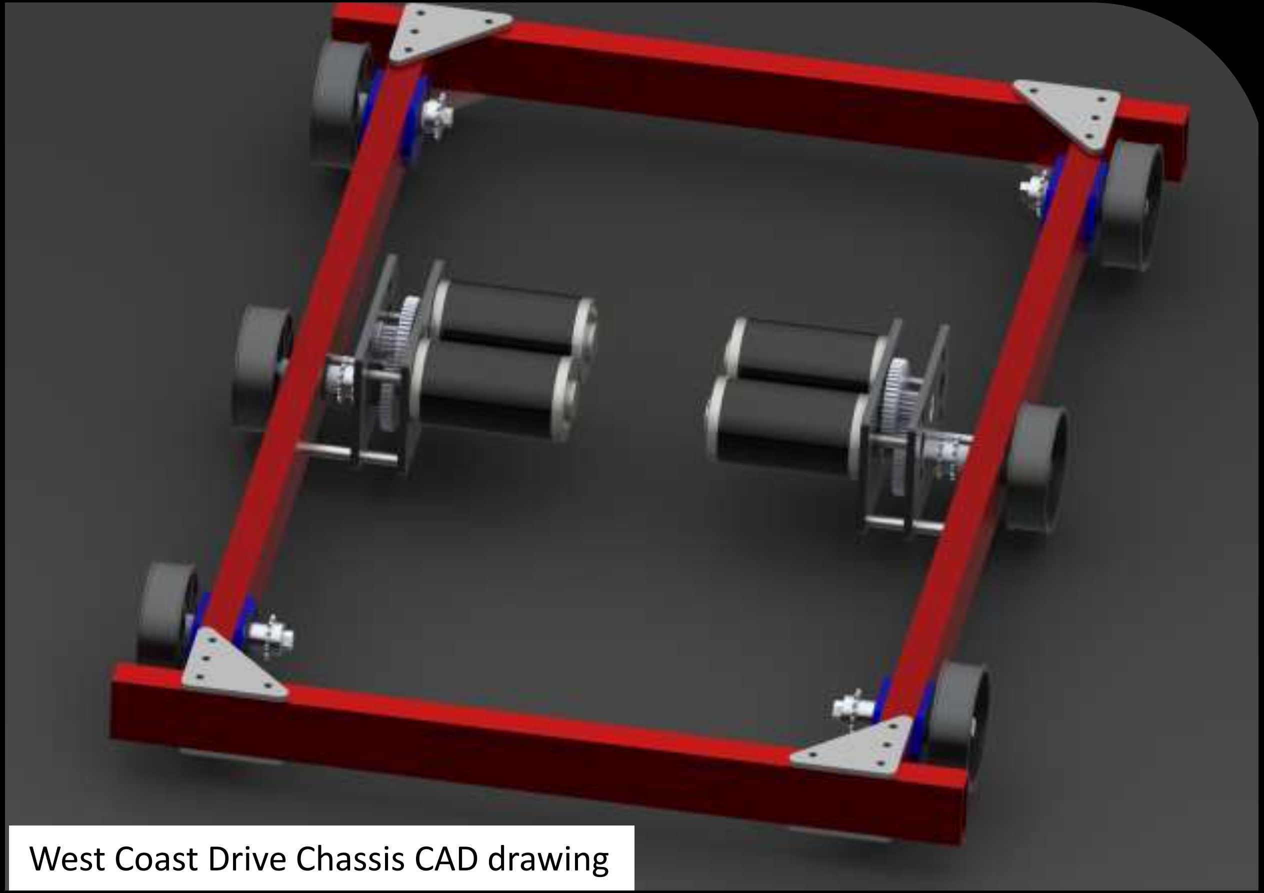
Chassis

Aluminum Tubing
(Vex VersaChassis)

Simplified fabrication using 1x2 aluminum tube stock.

Pros:
Tube stock readily available; Adjustable chain/belt tension; Easy access for pit repairs. Pre-drilled holes if using VersaChassis.

Cons:
Problems if not designed/built correctly; Bearing blocks and gearboxes can come loose over time.



West Coast Drive Chassis CAD drawing

1”x2”x0.125” Tube

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Chassis

T-Slotted Extrusion

(80/20, Bosch Rexroth)

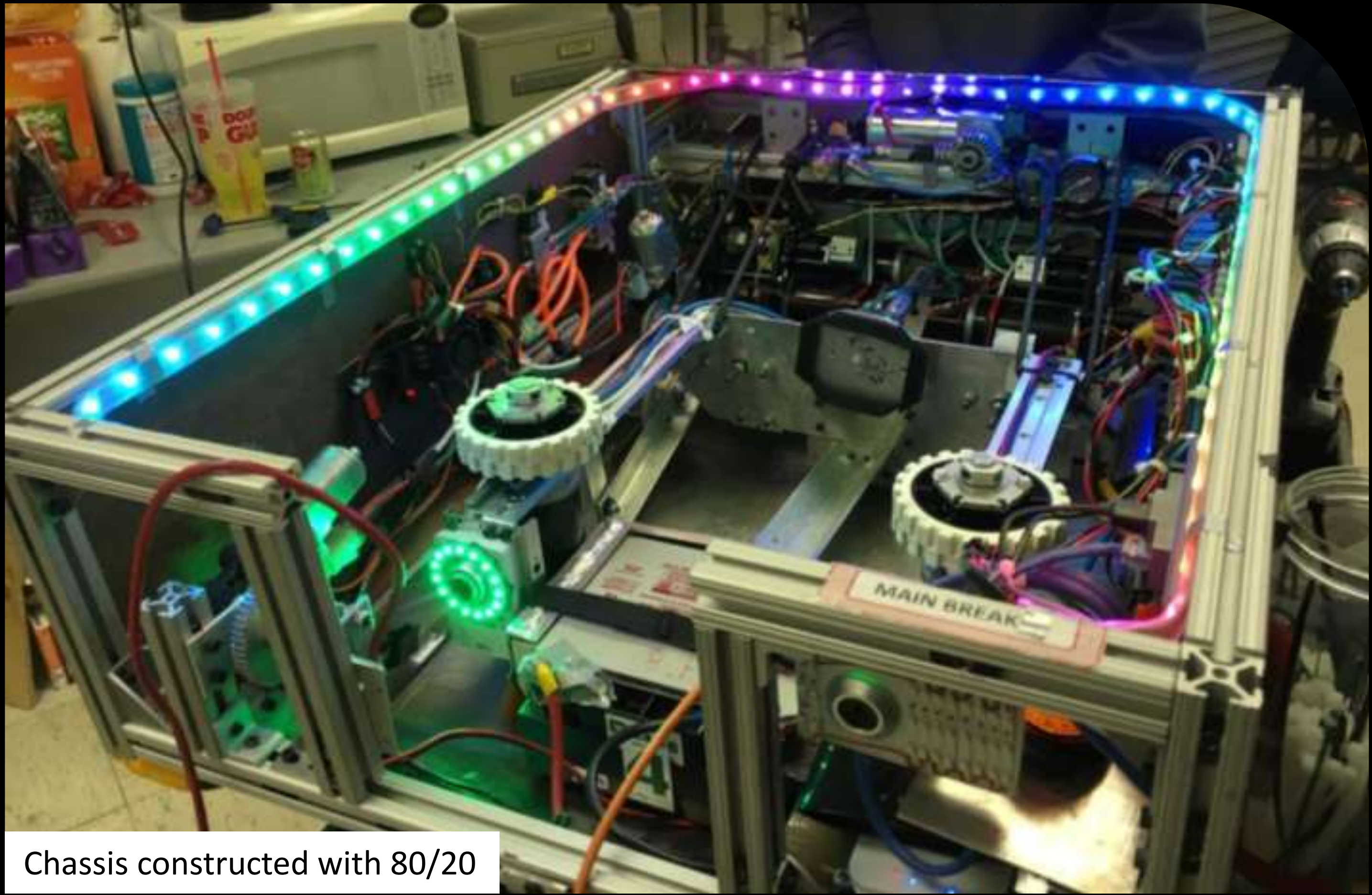
“Erector set for adults” available in various sizes and cross-sectional profiles. Most commonly found in swerve drive chassis.

Pros:

Robust material designed for bolt-together construction; Works well when translating linear motion.

Cons:

Heavy; Fasteners can work loose or break free of channels under heavy loads; Expensive; Not well suited for machining.



Chassis constructed with 80/20

Various sizes and profiles of T-Slot Extrusions

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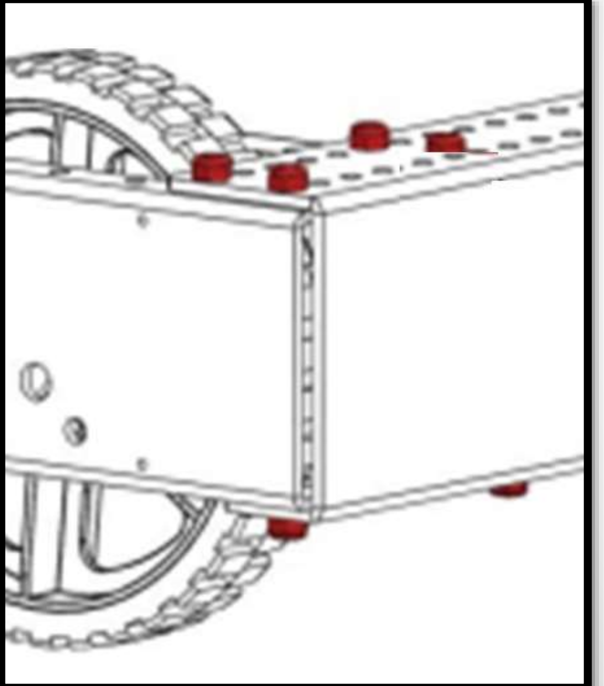
Fabrication Techniques

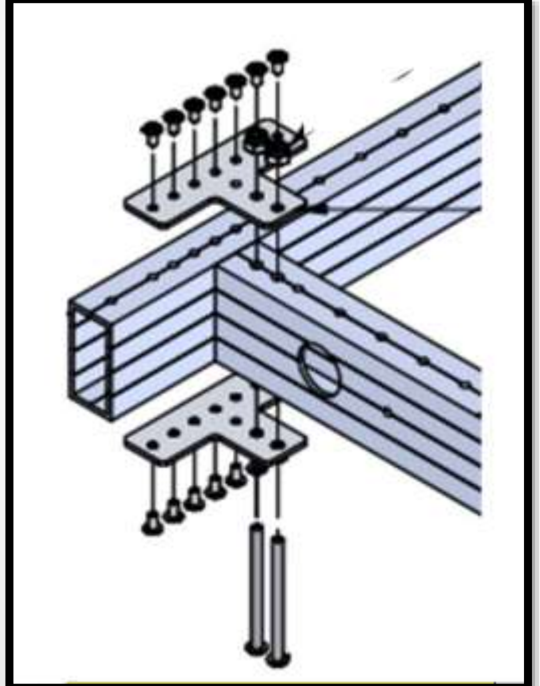
Here are a few of the most common methods of fabricating chassis frames found in FRC.

Nuts and Bolts



Bolt together construction using hex head fasteners and nylock nuts is a common to sheet metal builds

Riveted Gussets



Most tube stock construction uses steel rivets and T-braces as well as bolts.

T-Locks

Specially designed fasteners for aluminum extrusion that drop into channels and tighten with bolts.

Welding

Clean/durable joints when done correctly. Requires special equipment. Typically not repairable at competition.

Aluminum

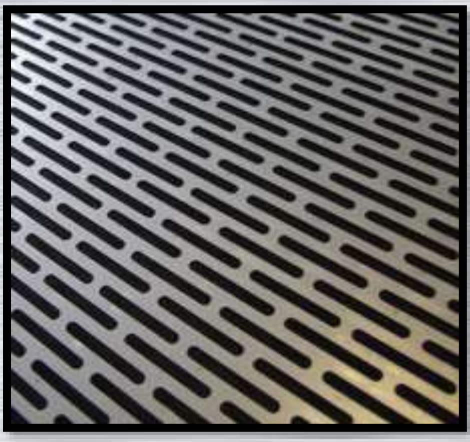
For chassis and structural fabrication

VS

Steel

Fasteners and crucial components









Just like using the right tool for the job, learning where and when to use the appropriate materials is important for a successful robot build.

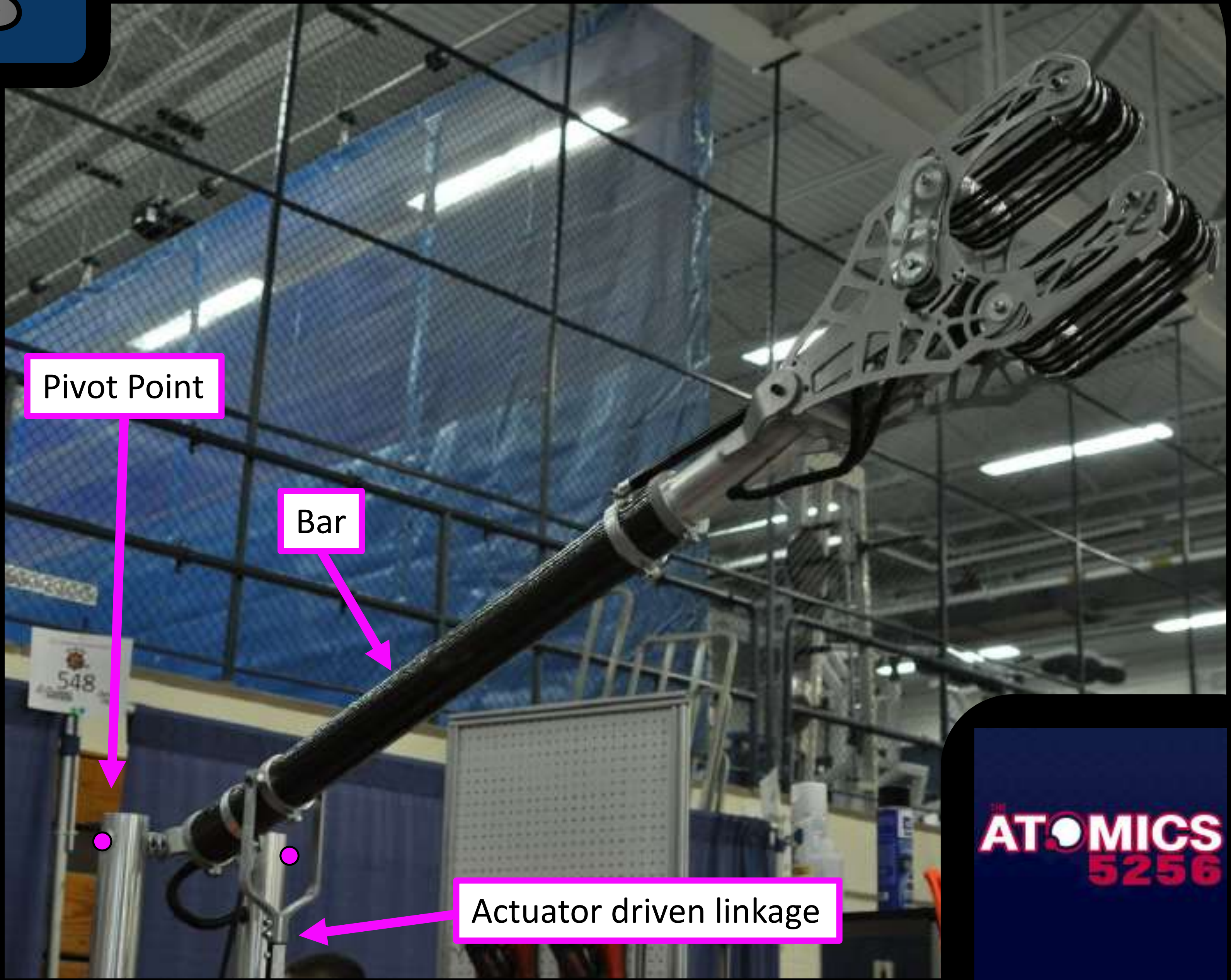
Mechanisms

Mechanisms

Arms

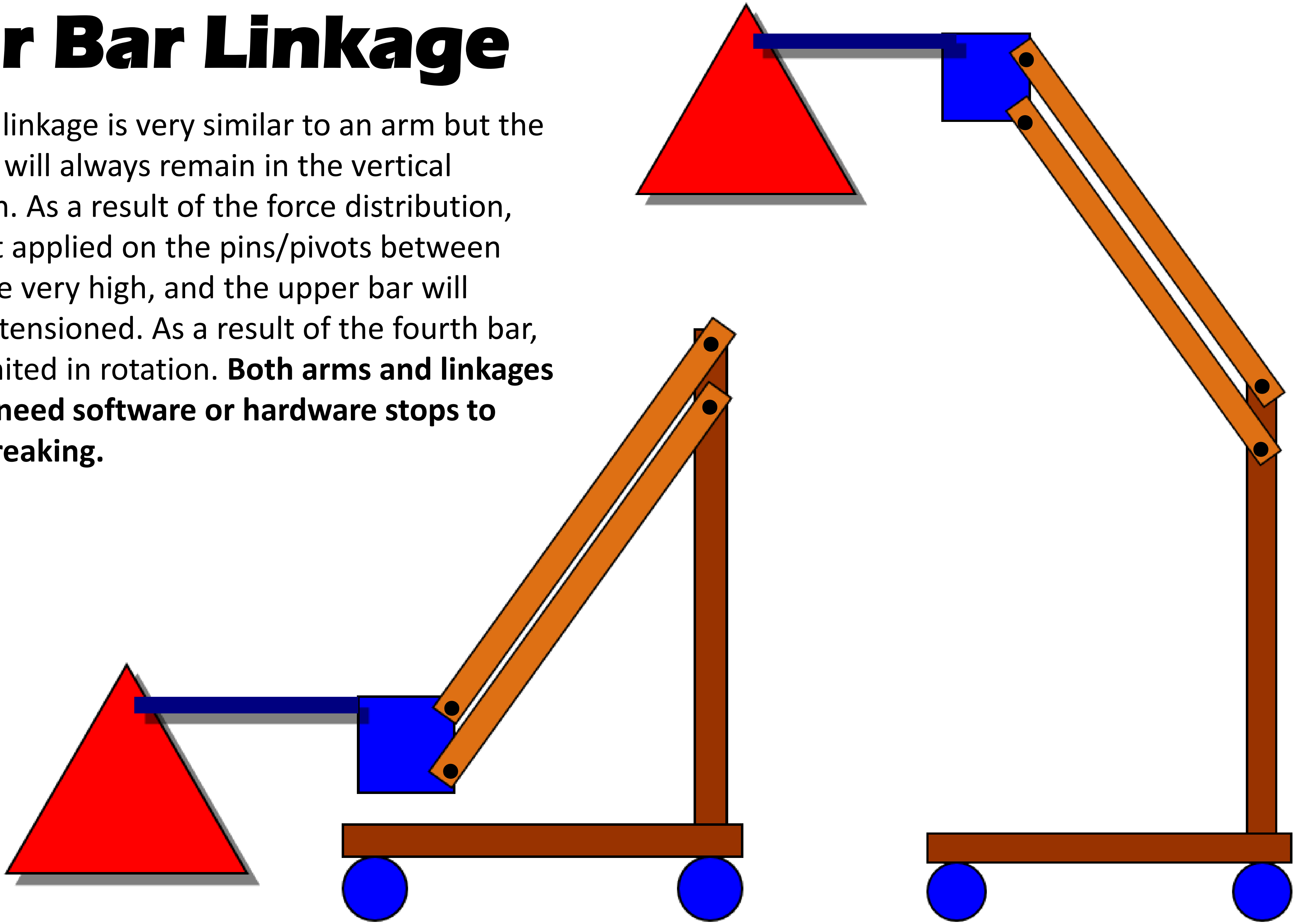
Arms consist of a **pivot point**, a **bar** and an **actuator**. Being powered traditionally by either a motor set or a set of pneumatics, they allow rotation about a given point for the end of an arm. Typically the torque needed is large, and as such, teams need powerful motors and/or pneumatics to move them effectively.

Both arms and linkages will likely need software and/or hardware stops to prevent breaking themselves in the event they overtravel.



Four Bar Linkage

A four bar linkage is very similar to an arm but the fourth bar will always remain in the vertical orientation. As a result of the force distribution, the weight applied on the pins/pivots between bars can be very high, and the upper bar will always be tensioned. As a result of the fourth bar, they're limited in rotation. **Both arms and linkages will likely need software or hardware stops to prevent breaking.**



Real World Example: Arm Forces, Angles & Torque

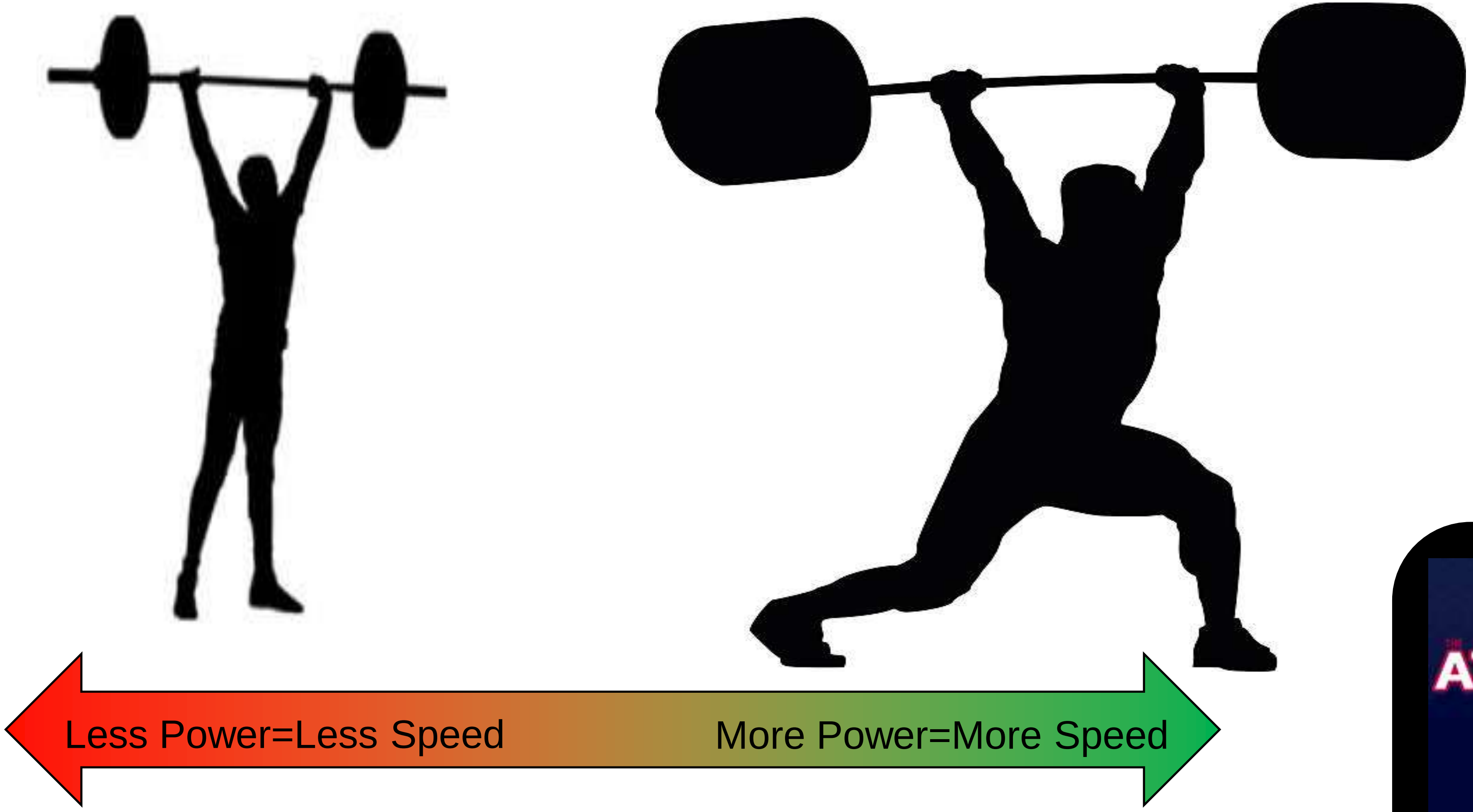
- Same force at different angle will need more or less torque.
- Weight held at arm's length will require more effort due to greater distance.

More Distance Requires More Torque

Less Distance Requires Less Torque

Arm Power Real World Example

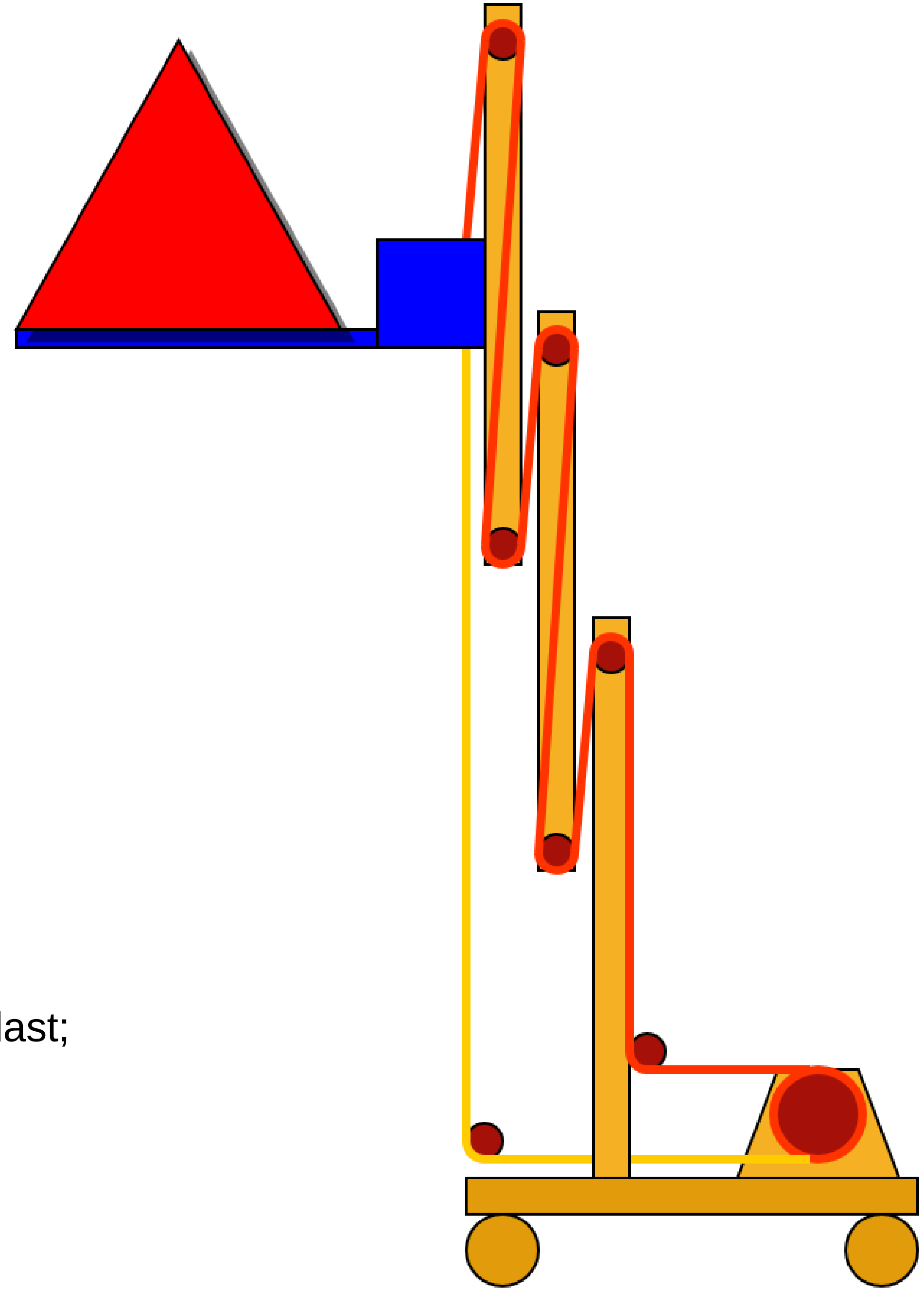
- Same torque with twice the power results in twice the speed when under load
- Stronger is often faster when it comes to handling demanding tasks.



Mechanisms

Continuous Lifts

- **Cable Goes Same Speed for Up and Down**
- **Intermediate Sections sometimes Jam**
- **Low Cable Tension**
- **More complex cable routing**
- **The final stage moves up first and down last**



Pros:
Reduced load on motor; Simple drum design; Lightweight cabling.

Cons:
Slower lift operation; Final stage moves up first and down last; Potential for jamming; Cable routing is more complex.

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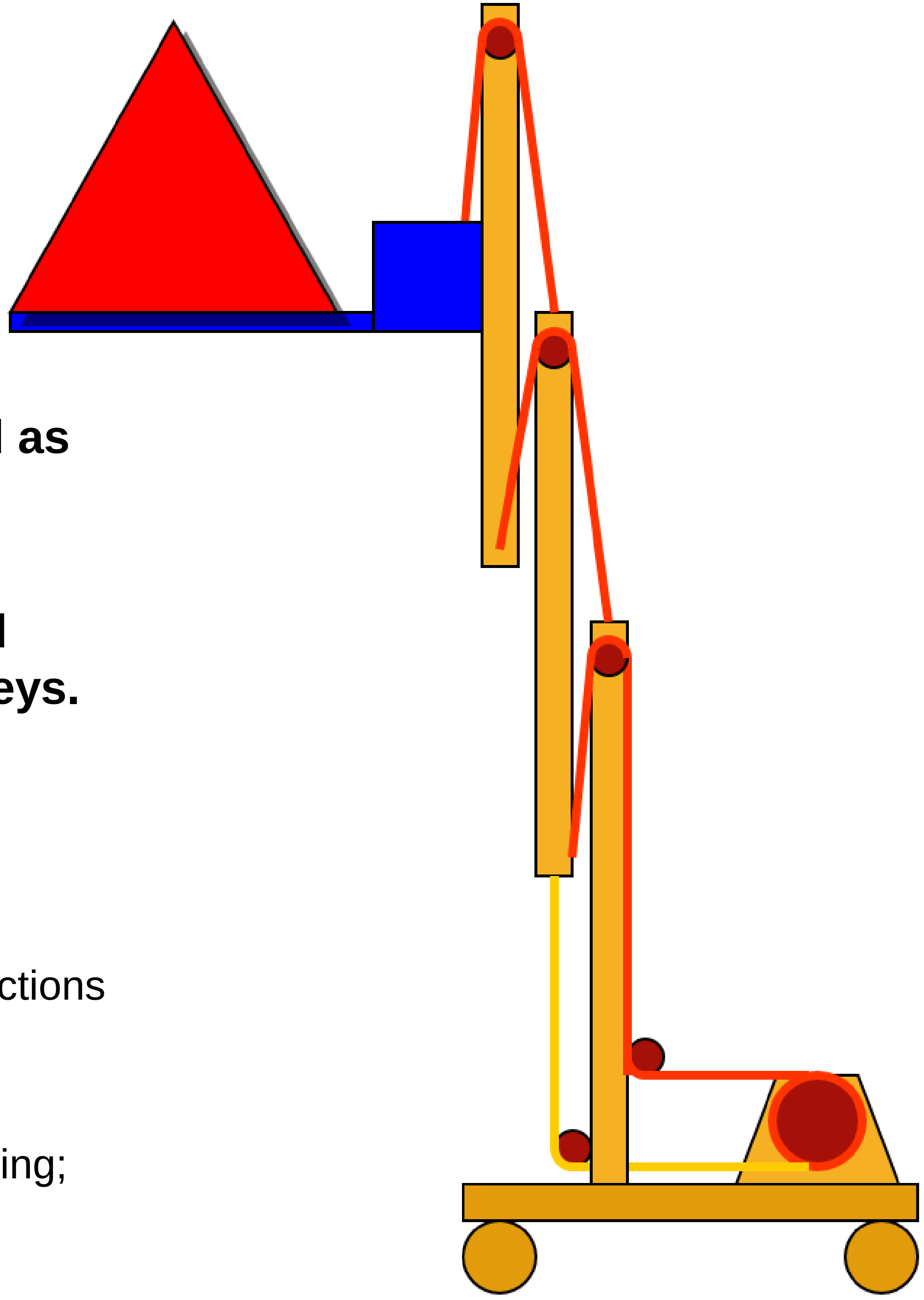
Mechanisms

Cascading Lifts

- **First stage is raised using a pulley and drum system, while subsequent stages are tethered as shown in the drawing at right.**
- **All stages extend simultaneously, resulting in different cable speeds which must be handled with different drum diameters or Multiple Pulleys.**
- **Load placed on the motor is about double the actual weight of the lift.**



Pros:
Faster lift operation; Middle stages less likely to jam; All sections extend simultaneously; Lightweight cabling.

Cons:
Greater load on motor; Increased complexity with drum sizing; Cabling must be maintained regularly.

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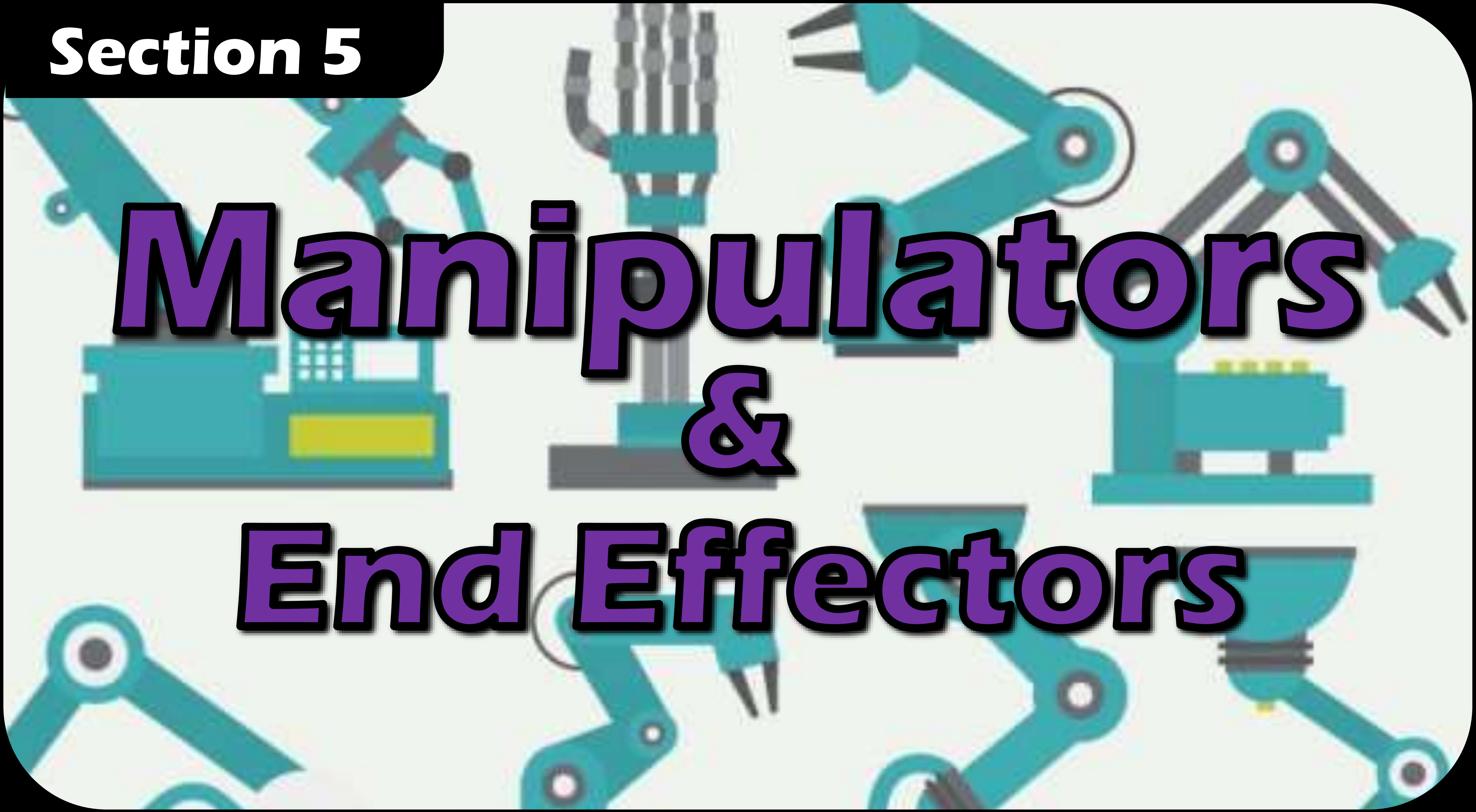
Section 5

Manipulators & End Effectors



Manipulators

Roller Claws

Good manipulators combining rotary motion and the grabbing properties of claws. With articulation, are incredibly effective methods of holding game pieces, and are relatively simple to build.

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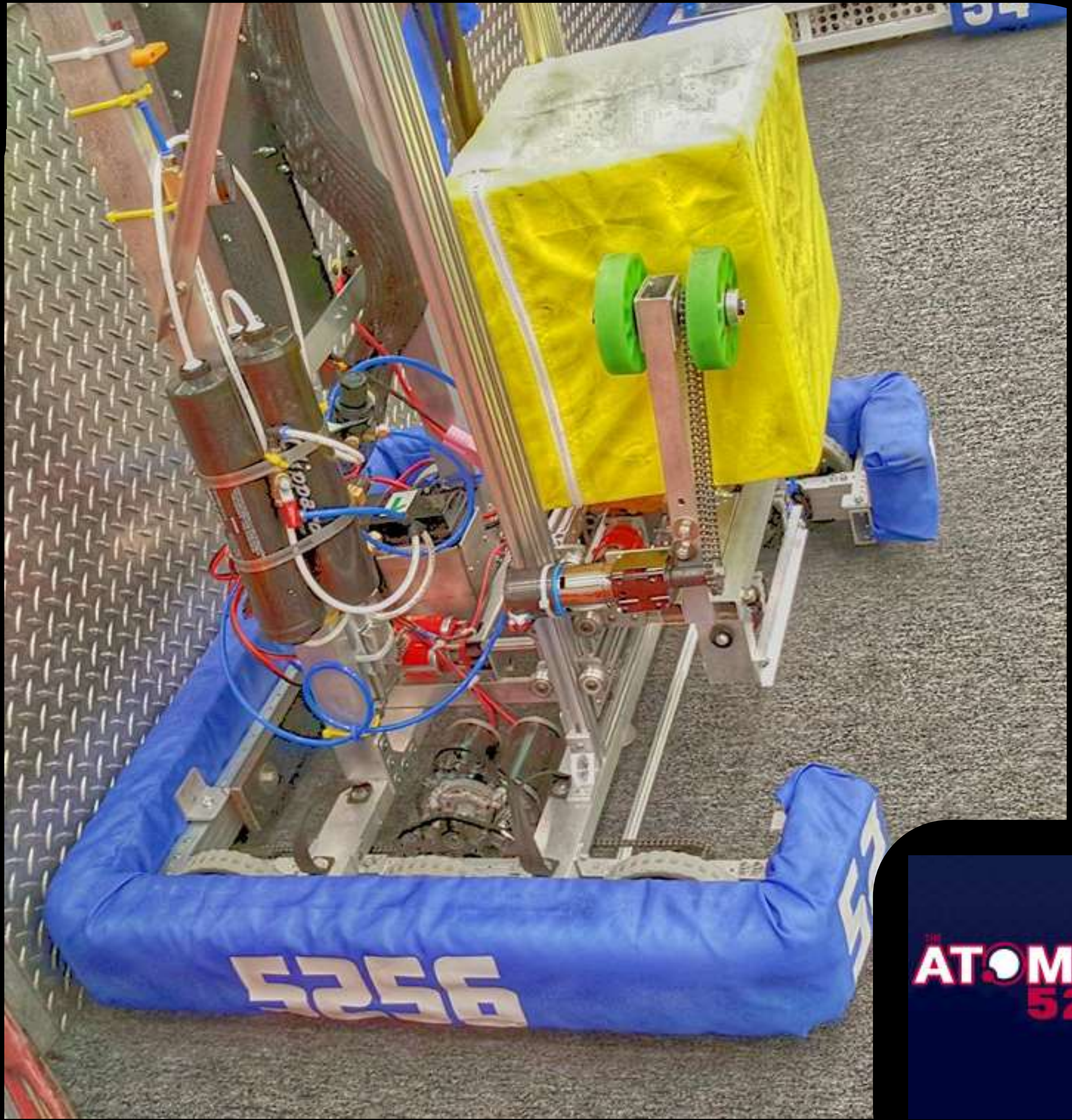
Manipulators

Articulated Roller Claws

Same as roller claws, except articulated in ability to open up jaws of intake. Typically articulated using motors or pneumatics depending on the situation.

Sometimes roller claws are passively articulated, using something like surgical tubing to hold it closed as an item is grabbed.



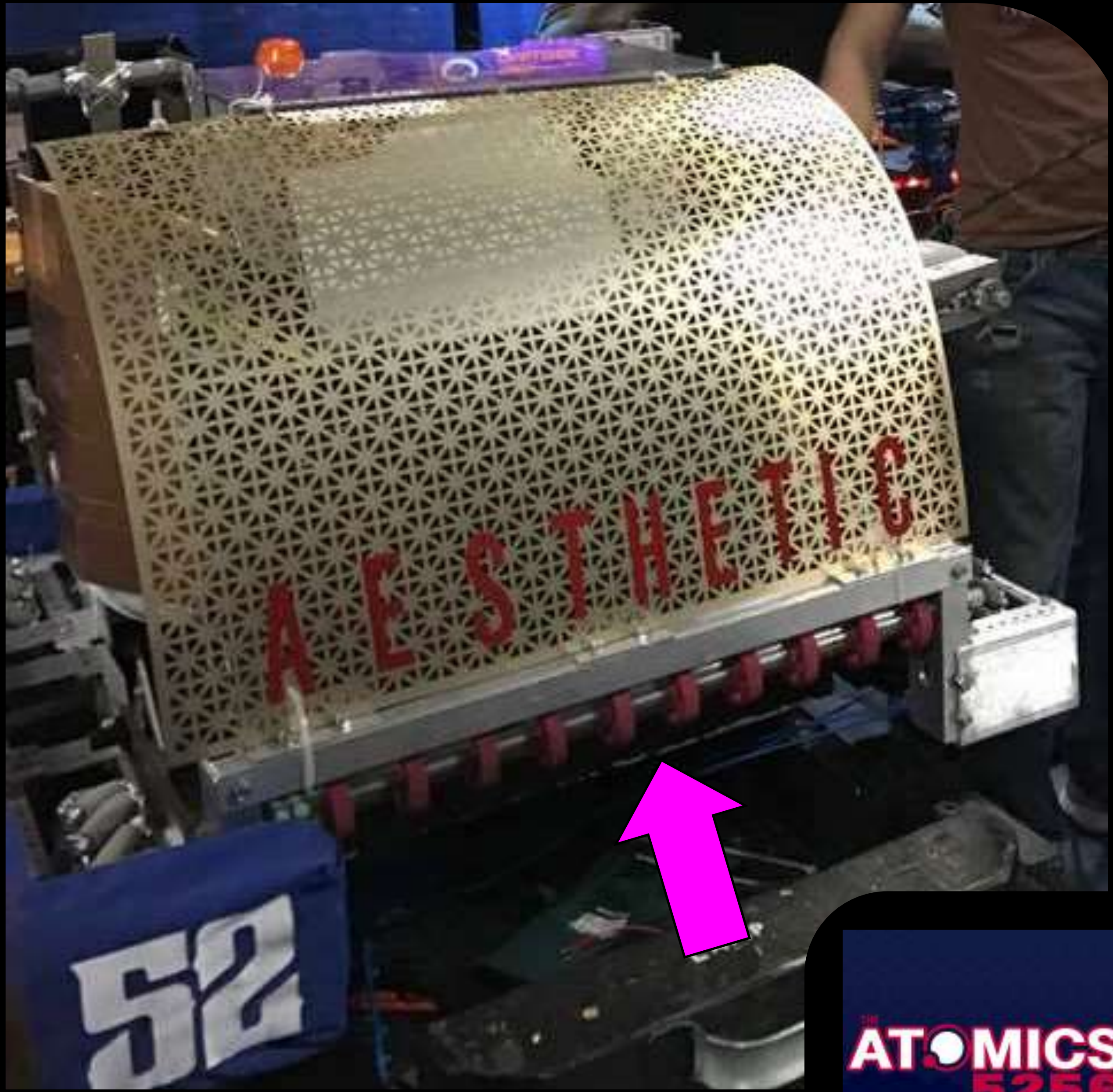
Manipulators

Rollers

Great for intakes, transporting or storing balls or other game pieces. Belts are good for small, single file paths, with roller cord being good for wider paths. More control is better, and as such knowing that gravity based feeds will jam. In addition, the physical properties of game pieces may evolve or degrade over the course of competition (under-inflated tubes, damaged boulders, broken fuel).

Pro Tips:

- **Ball intake rollers should spin at about double the max robot speed.**
- **Material durometer of compliant wheels should be rated for the RPM of the intake.**
- **If using a shooter, it should match or double the intake RPM (your mileage may vary depending on ball types and other factors).**



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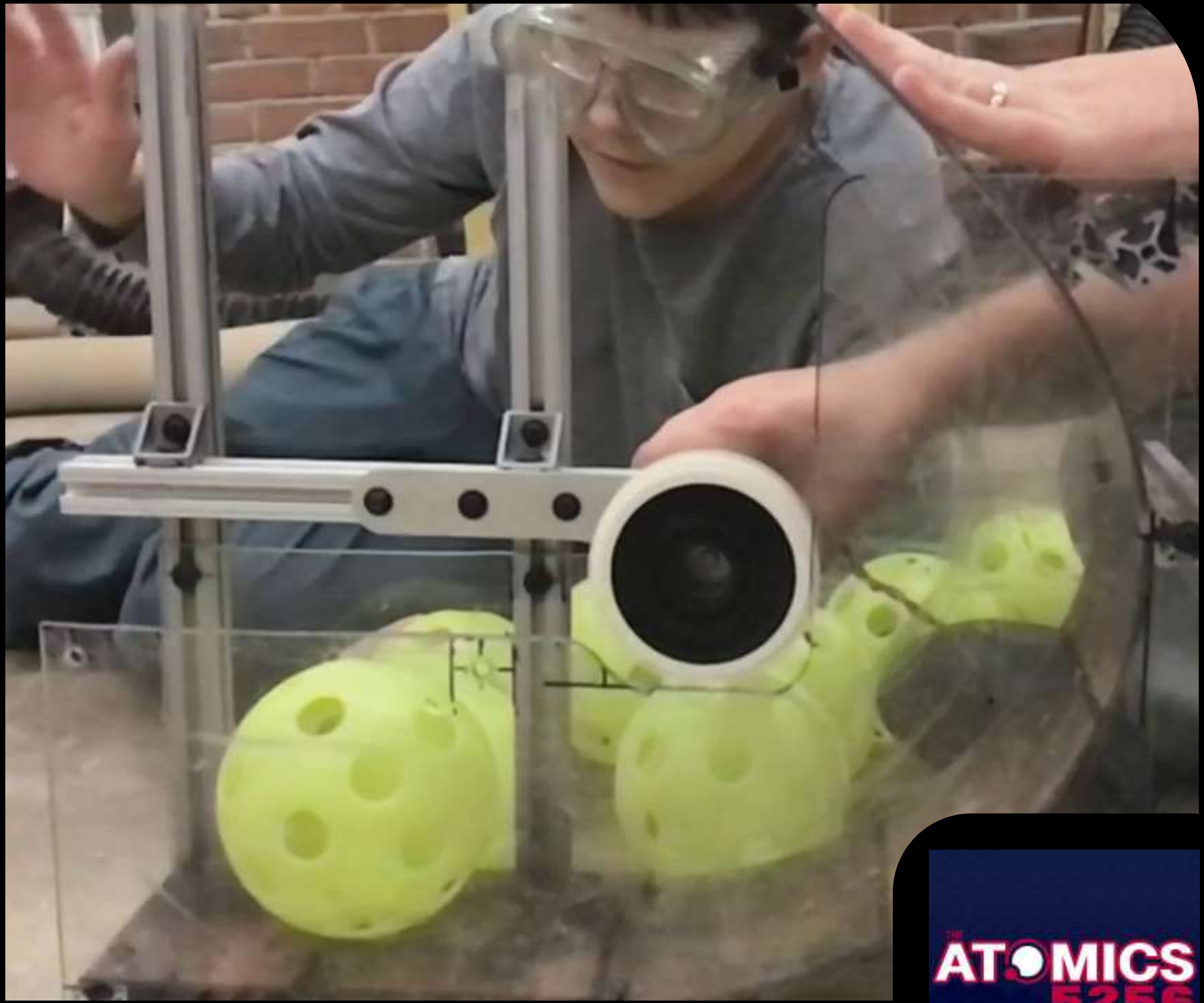
Manipulators

Single Wheel Shooter

- Distance can be varied by changing wheel speed or changing angle of guide rail.
- Spin is constant.
- Wheel needs to be mounted vertically.



Manipulators

Two Wheel Shooter

- Distance is determined by speed of wheels.
- Spin can be varied by relative speed between two wheels.
- Wheels can be mounted vertically or horizontally.

Manipulators

Hoppers

A massive bin of game pieces are a staple of traditional FRC design, especially in the “golden era” where shooter games were common. However, serializing the game objects was a major issue and as such, hopper design circulated around it. Some teams achieve this by copying a “dye hopper” design from paintball guns, but this isn’t always necessary.

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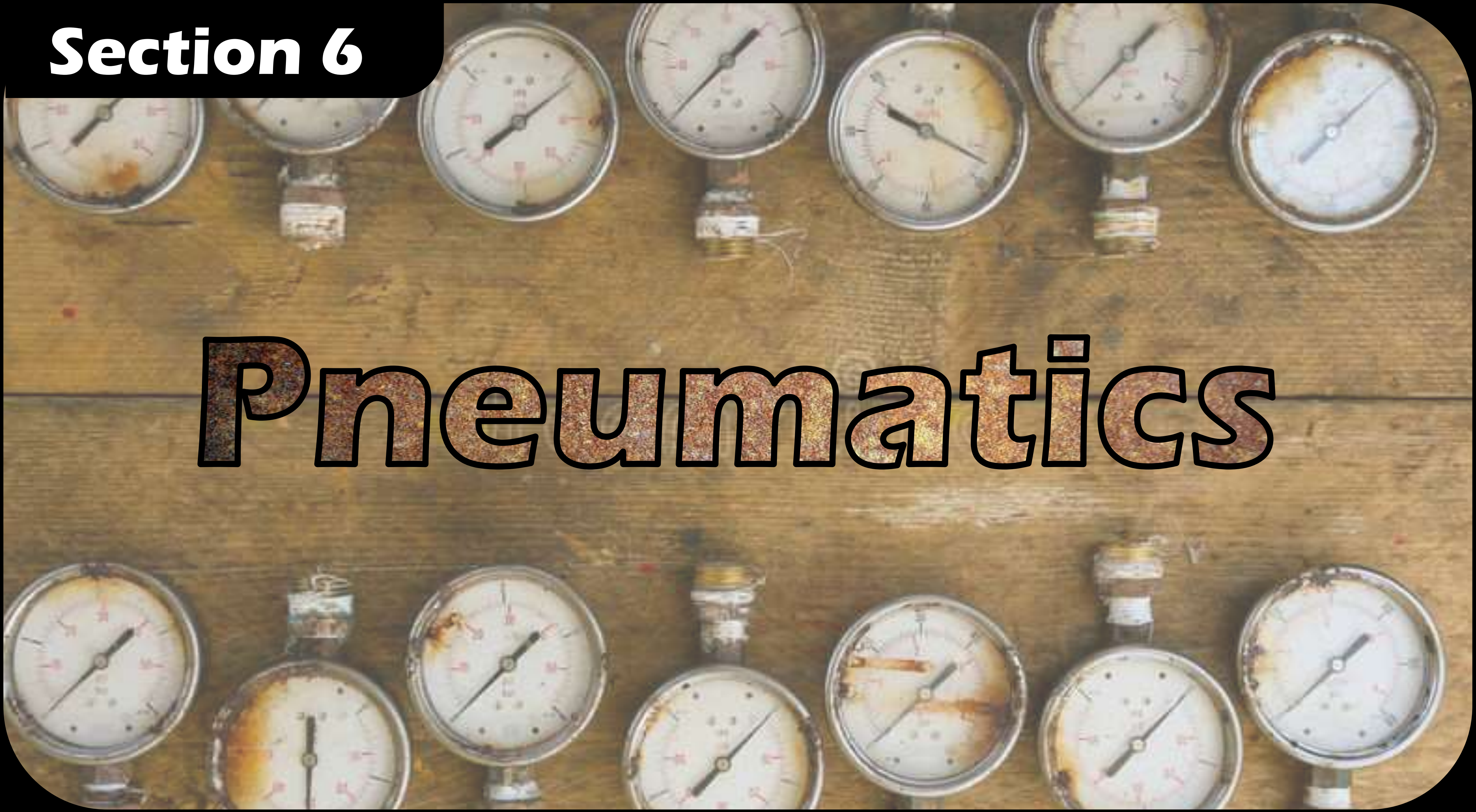
Section 6

Pneumatics

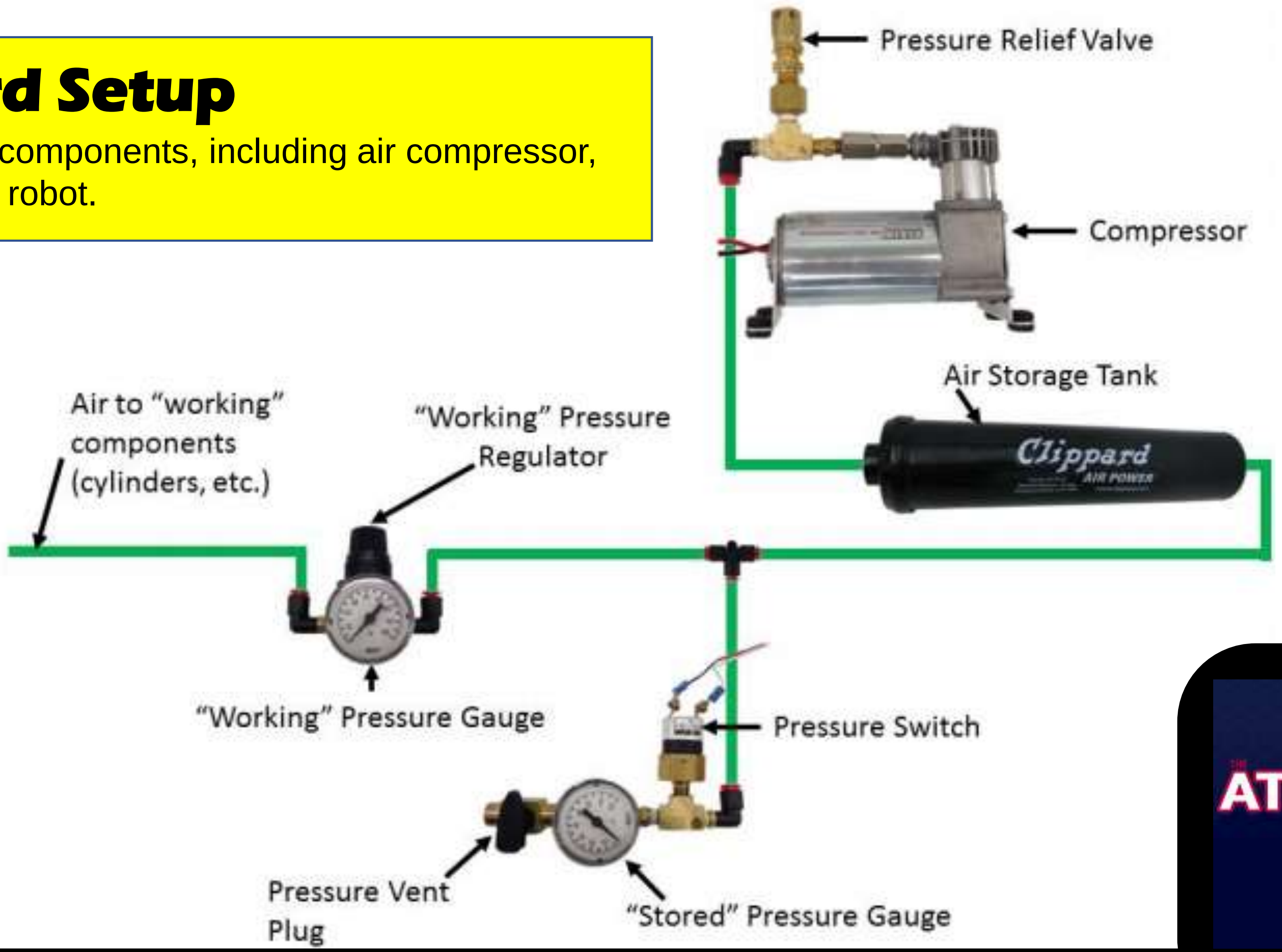


Pneumatics

Component Overview

On-Board Setup

All pneumatics components, including air compressor, are installed on robot.



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Pneumatics

Pros

- Much lighter than motors when several are used.
- Can maintain position at stall without failure.
- Can be used in more compact environments.
- Actuation can be very fast.
- Typically rugged and resistant to impacts.
- Easy to setup and install.
- Superior means of producing linear motion.

Cons

- Heavy "upfront cost" in terms of weight/space.
- Excessive air requirement may lead to a higher compressor drain on battery.
- Compressor Duty Cycle.
- Vibration in system.
- Possible to run out of air depending on system design and usage.
- Overheating with prolonged use.

Making the Most of Pneumatics

Pneumatics can provide a very efficient and robust means of actuation in your robot if used effectively in a way that offsets the weight and bulk of the system, not to mention the additional demands on the battery. Basically, make the most of your pneumatic system—If you got 'em, use 'em.

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Brushed DC Motors

Standard Brushed DC

(CIM, Mini-Cim, Bag, 775 Redline, 775pro)

Most commonly found in drivetrains and mechanisms.

Pros:

Varies by model, but generally robust, simple 2-wire operation, low-cost.

Cons:

Varies by model; Low torque, Weight, Heat issues, Brush wear, Rules require one ESC capable of 100W+ per motor .

775 Redline

CIM Motor

MiniCIM Motor

Bag Motor

Brushed DC Motors

Brushed DC Gearmotors

(Automotive, throttle, AM PG series)

Motors with preinstalled gearboxes for large gear reductions; Many repurposed and included with the KOP.

Pros:

Higher torques; Can wire two motors to one ESC; Some resistant to backdriving.

Cons:

PG series models very heavy, Non-standard output shafts on auto/throttle motors, tend to be very slow.

NeveRest 60

Snowblower Motor

Window Motor

AndyMark PG-71 Gearmotor

Brushless DC Motors

Neo Brushless Motor

A drop-in CIM replacement that's compact and lightweight.

Pros:

Efficient, lightweight, small and powerful.
Integrated hall effect and temperature sensors.

Cons:

Only works with Spark Max motor controllers.

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Brushless DC Motors

Neo 550 Brushless Motor

Out-runner construction in a compact package designed for intakes and other non-drivetrain robot mechanisms .

Pros:

Lightweight; Bottom of case spins and has mounting holes for pulleys and sprockets; Relatively low-cost.

Cons:

Requires expensive Spark Max motor controllers; Untested in FRC.

Brushless DC Motors

Falcon 500

Unparalleled performance and efficiency in a compact feature-loaded package.

Pros:

Integrated Talon motor controller; Best power and efficiency in FRC; Simplified wiring requirements; Replaceable spline output shaft; Air cooling port.

Cons:

Non-standard output shaft; Expensive; Non-replaceable motor; Untested in FRC.

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Section 8

Gears and Gearboxes

Gears: What You Need to Know

This stuff can get really complicated–and there's a lot more to learn–but the following should be the most important takeaways from this section:

- **Tooth Count**
  - The number of teeth on a given gear.
  - Gear ratio is determined by the Tooth Count of one gear compared to another.
- **Diametral Pitch (DP)**
  - The number of teeth of a gear per inch of its pitch diameter.
  - Commonly used for sizing gears. The DP of all gears in a set should match.
- **Bore**
  - The size shaft for which the gear is designed to mount.

If you know the tooth count, DP and bore of a gear, you have the basic information needed for most basic applications in FRC.

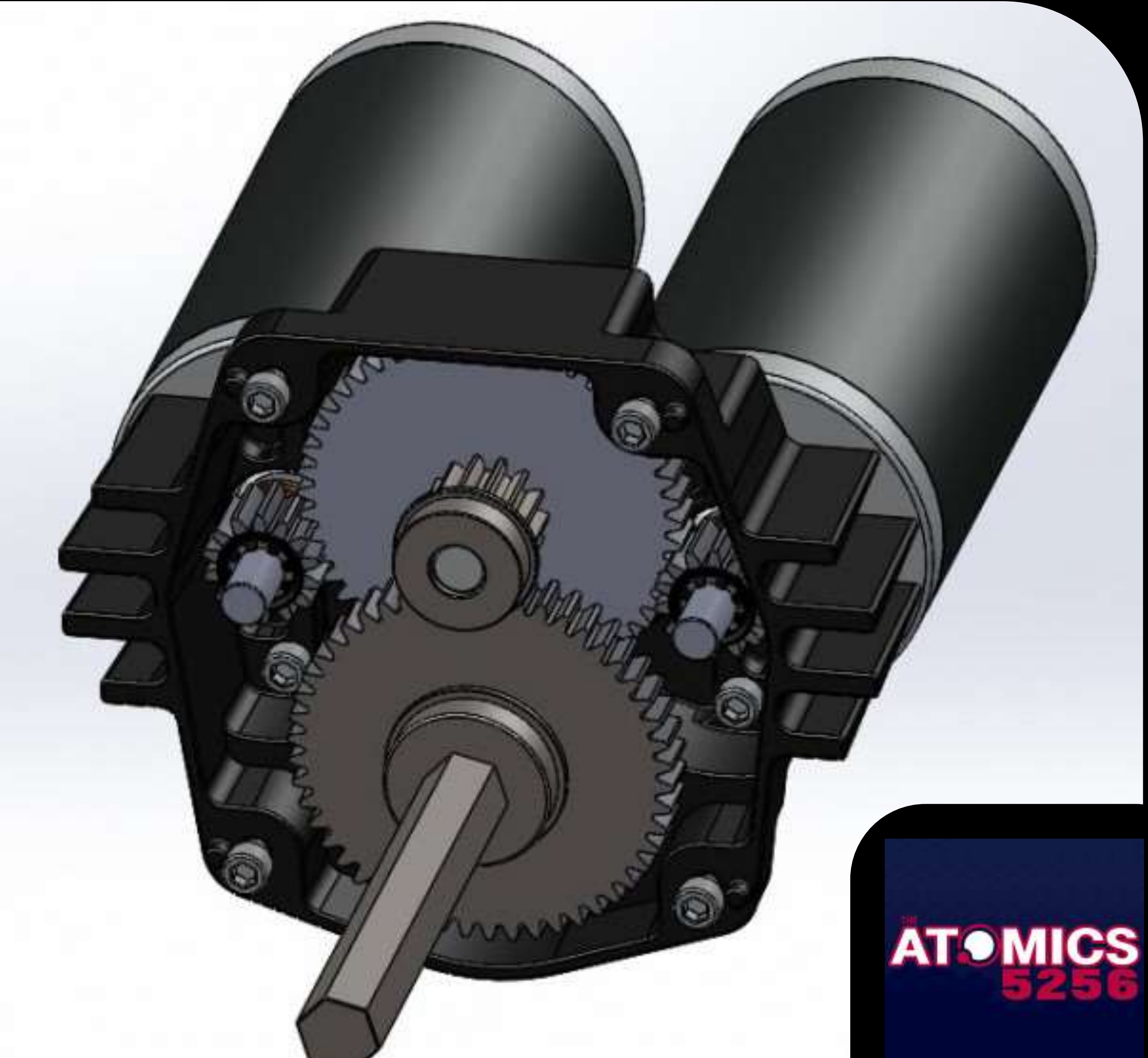
Gearboxes

Single Speed
(AM Toughbox Mini, Vex WCP-SS)

Single speed drivetrains; Least costly and simplest option.

Pros:
Lowest cost option for drivetrains;
Customization of overall gear ratio;
Replaceable parts.

Cons:
Only one overall gear ratio.



AndyMark Toughbox Mini

Gearboxes

Two Speed

(AM Evo Shifter, Vex WCP-DS)

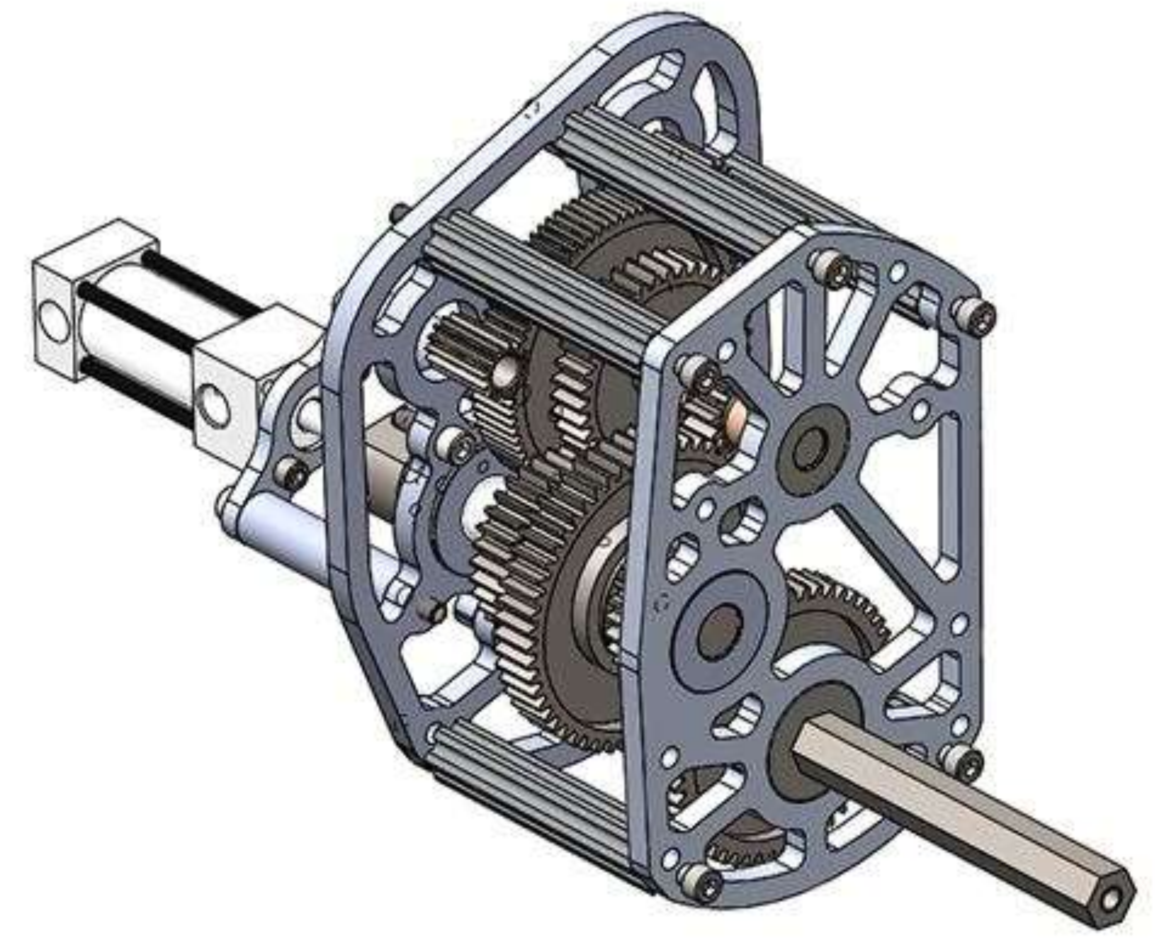
Shifting from fast speeds to lower gear ratios with more torque; PTO models can run mechanisms.

Pros:

Capability to shift to a different overall gear ratio; Customization; Replaceable parts; Some have PTOs.

Cons:

Significant cost; Complexity; Shifters can fail due to wear or pneumatic/mechanical issues.



AndyMark Evo Shifter

Gearboxes

Planetary

(CIM Sport, BaneBots BB220)

Mechanisms requiring a lot of torque for high loads.

Pros:

Powerful, compact, durable; Parts replaceable.

Cons:

Can be bulky/heavy, expensive, not modular.

BaneBots BB200 Planetary Gearbox

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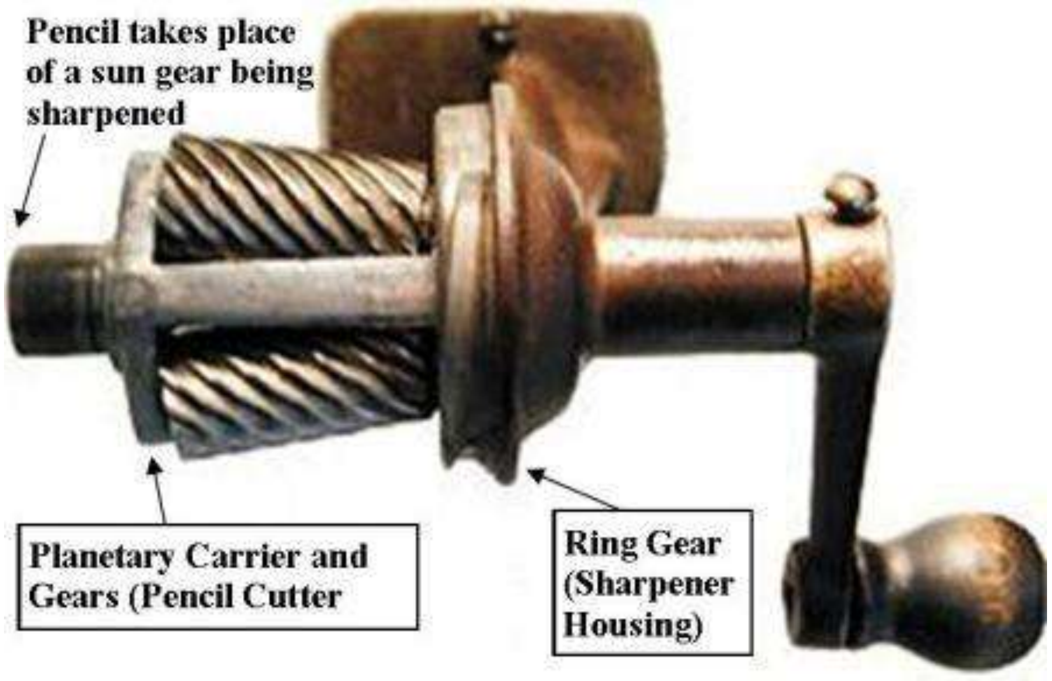
Planetary Gearboxes at work

Real world examples found in the wild

Pencil Sharpener



Cordless Drill Gearbox

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JVN's Mechanical Design Calculator

A spreadsheet designed to simplify the process of designing effective gear trains.

WCP SS Gearbox Drivetrain

http://www.vexrobotics.com/vexpro/motion/gearboxes/wcp-ss.html

	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
Choose Gearbox Motors: 2 CIM	5330	4.82	262	5.4

Wheel Dia. (in)	Wheel Coeff of Friction	Total Robot Weight (lbs)	Weight on Driven Wheels
6	1.1	140	100%

Select VEXpro Gearbox Options:

Choose Motor Pinions:	11-tooth Pinion [50:11]
Choose 2nd Stage Gearing:	2nd Stage Option 5 [60:14]

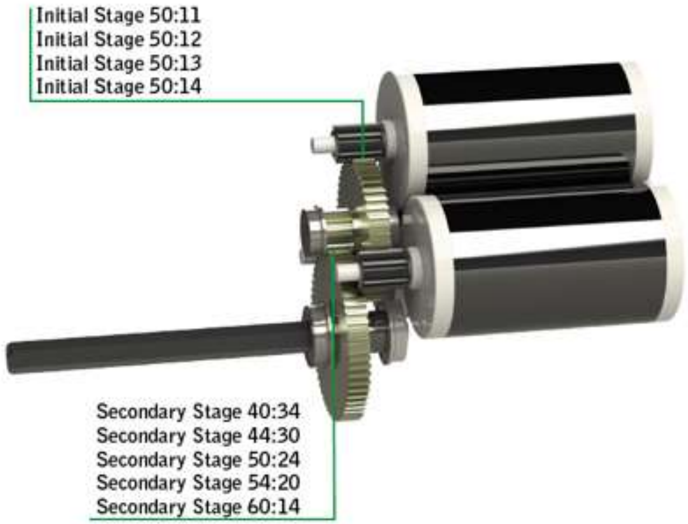
	Driving Gear	Driven Gear
Additional External Reduction:	1	1

Drivetrain Outputs:

Drivetrain Free-Speed	Drivetrain "Real Life" Speed	"Pushing" Current Draw per Gearbox	Overal Ratio
7.16 ft/s	5.80 ft/s	84.65 Amps	19.48 : 1

Chosen Gearing Config:

	Driving Gear	Driven Gear
Initial Gearing Stage:	11	50
2nd Gearbox Stage:	14	60
External Stage:	1	1



1. Enter motor info

2. Enter wheel dia, CoF & weight

3. Select from gearing options

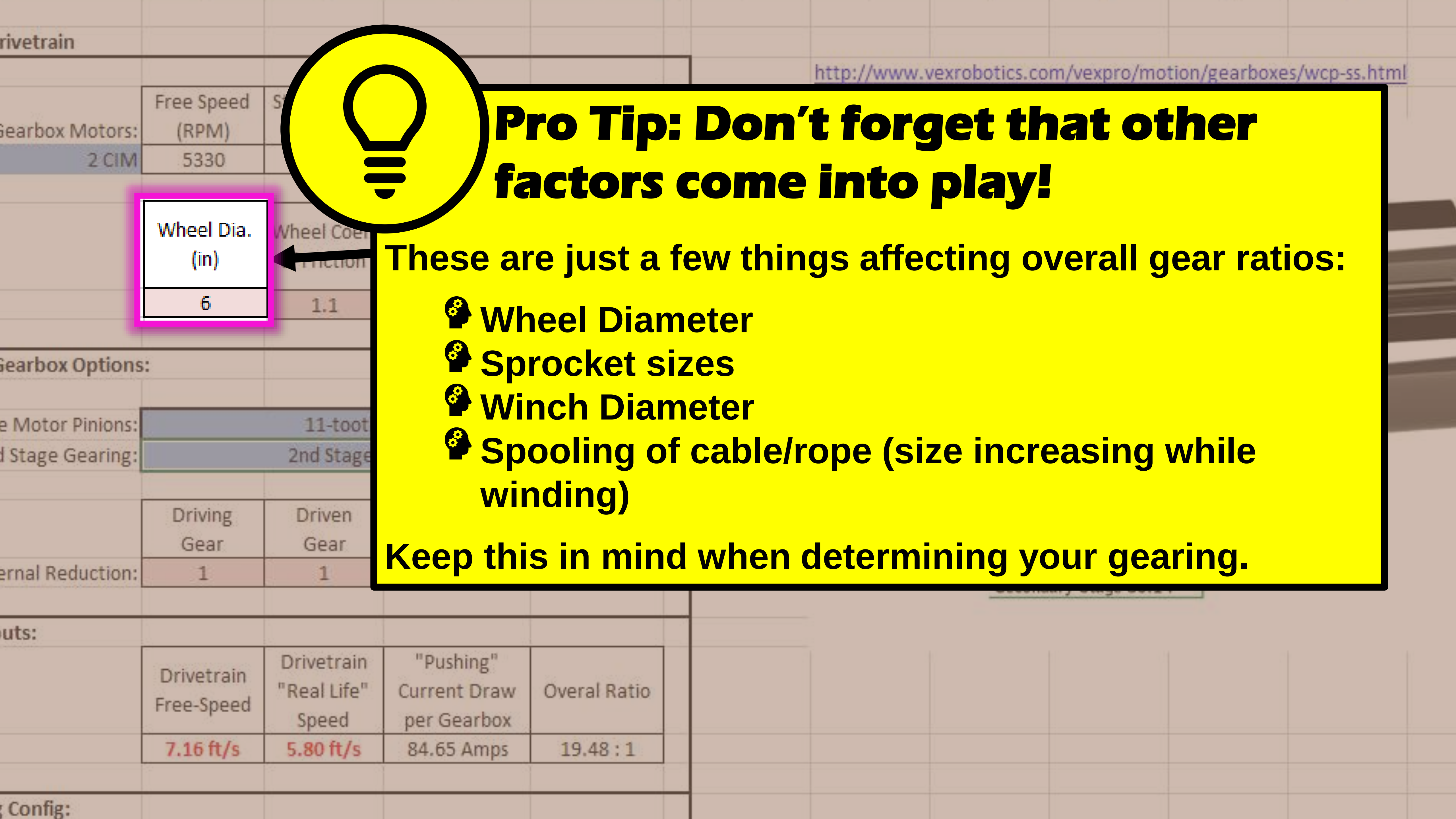
Calculator will determine Free Speed, “Real Life” speed, “Pushing” current draw & overall gear ratio

Pro Tip: Don't forget that other factors come into play!

These are just a few things affecting overall gear ratios:

- Wheel Diameter
- Sprocket sizes
- Winch Diameter
- Spooling of cable/rope (size increasing while winding)

Keep this in mind when determining your gearing.



Section 9

Mechanical Power Transmission

Transmission

Shaft

(Round and Hex Shaft Stock)

Primary means of enabling power transmission for most entries in this section.

- Rotating machine element, usually circular or hexagonal in cross section
- Transmits power from one part to another
- Used for mounting pulleys, gears, sprockets, wheels, etc.

Can you find all 2 shafts in this AM Toughbox Micro?

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Transmission

Sprocket & Roller Chain

Transfer of power in drivetrains and mechanisms

Pros:

Fairly quick and easy, good strength; Ease of design and adjustability.

Cons:

Rollers break in after usage, resulting in “stretching” of chain; Increased weight

Transmission

Synchronous Belt and Pulley

Flexible belt with teeth molded onto its inner surface, designed to run over matching toothed pulleys.

Pros:

Lightweight and reliable with consistent performance (does not “stretch” like chain).

Cons:

Can be difficult to get pulley spacing and tension correct in custom builds; Replacement usually involves disassembly of pulley axles.

Section 10

Control System Overview

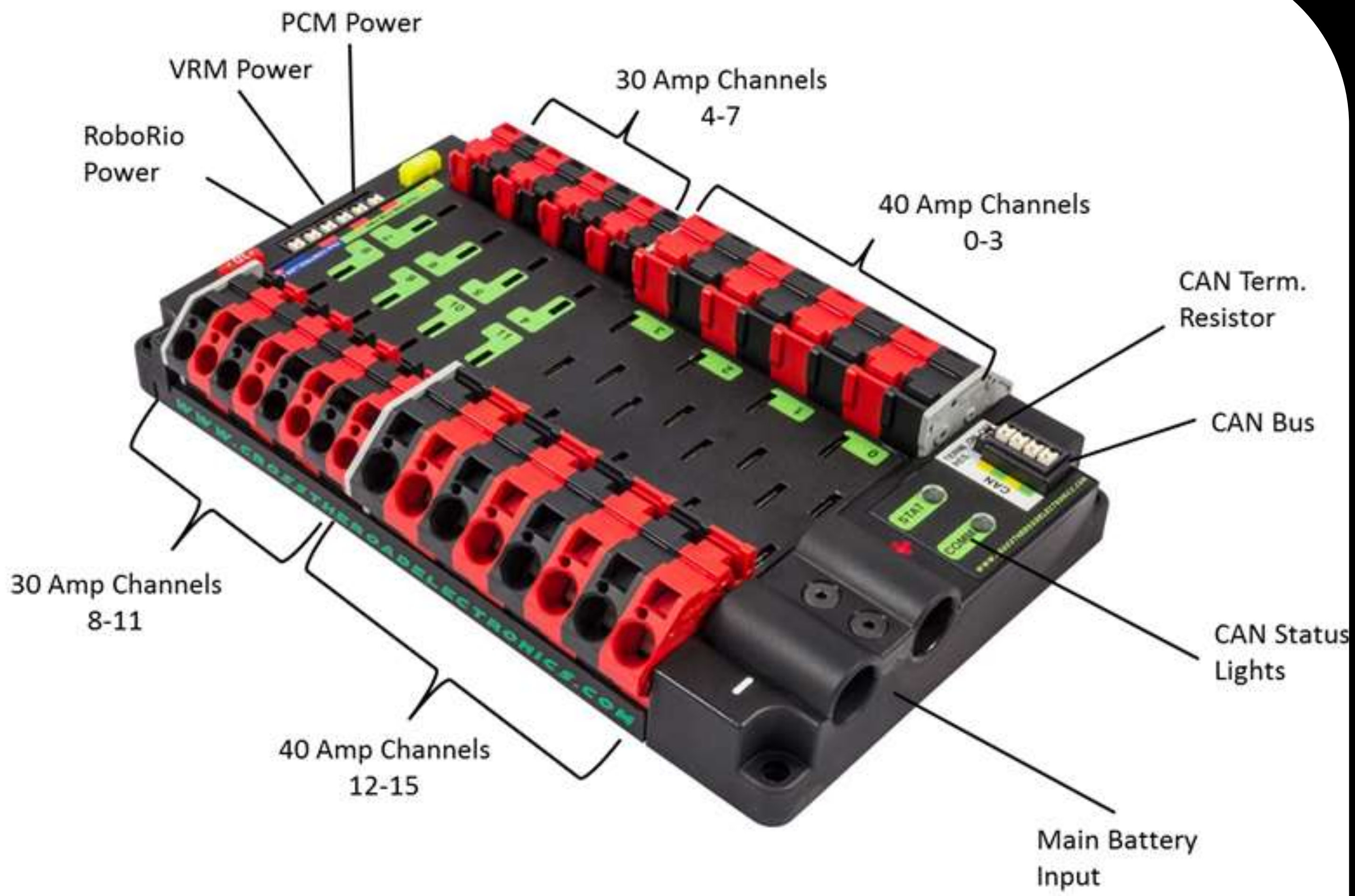
Controls

Power Distribution Panel
(PDP)

- **Distributes power from battery to rest of robot.**

- **Uses breakers to restrict how much power is sent.**
  - 40 and 30 amp channels.
  - Accepts 10, 20, 30 & 40 amp Snap Action Breakers.

- **Generally terminates CAN* bus connections.**



Power Distribution Panel (PDP)

*Controller Area Network

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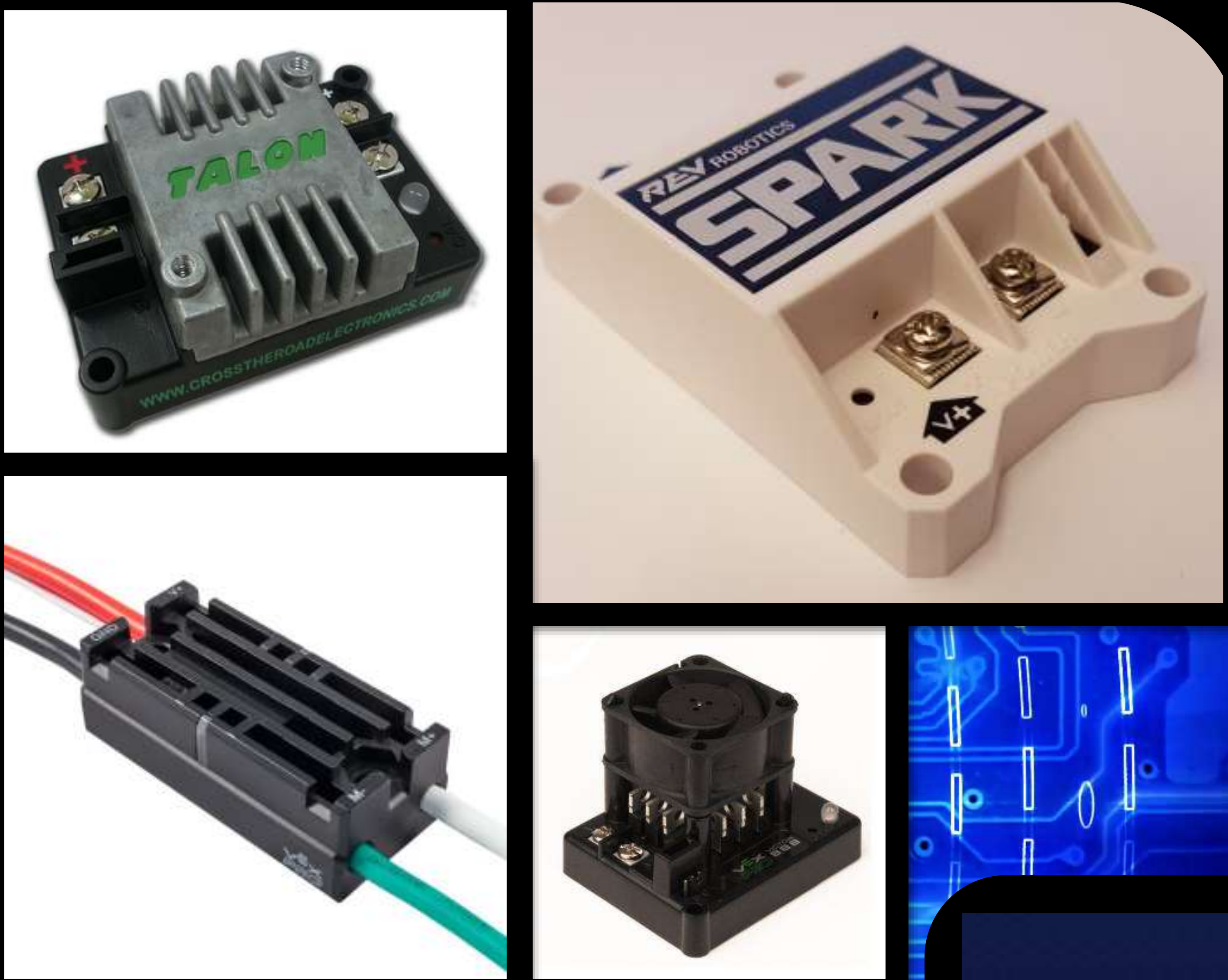
Controls

PWM Motor Controllers

- Receives power from the PDP
- Supplies power to motors.
- Receives control signal via PWM from the RoboRio.
- Controls the speed and direction of the motor it supplies with power.



Clockwise from top-left: CTRE Talon, Rev Spark, Vex Victor 888, and CTRE Victor SP

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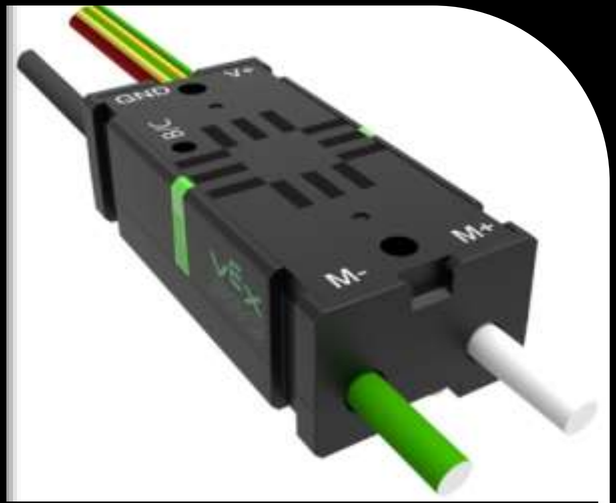
Controls

CAN Motor Controllers

- Receives power from the PDP
- Supplies power to motors.
- Designed to be part of a CAN Bus network, but can receive PWM from the RoboRio as an alternative.
- Can be configured to control or be controlled by other CAN Bus devices.
- Controls the speed and direction of the motor it supplies with power.

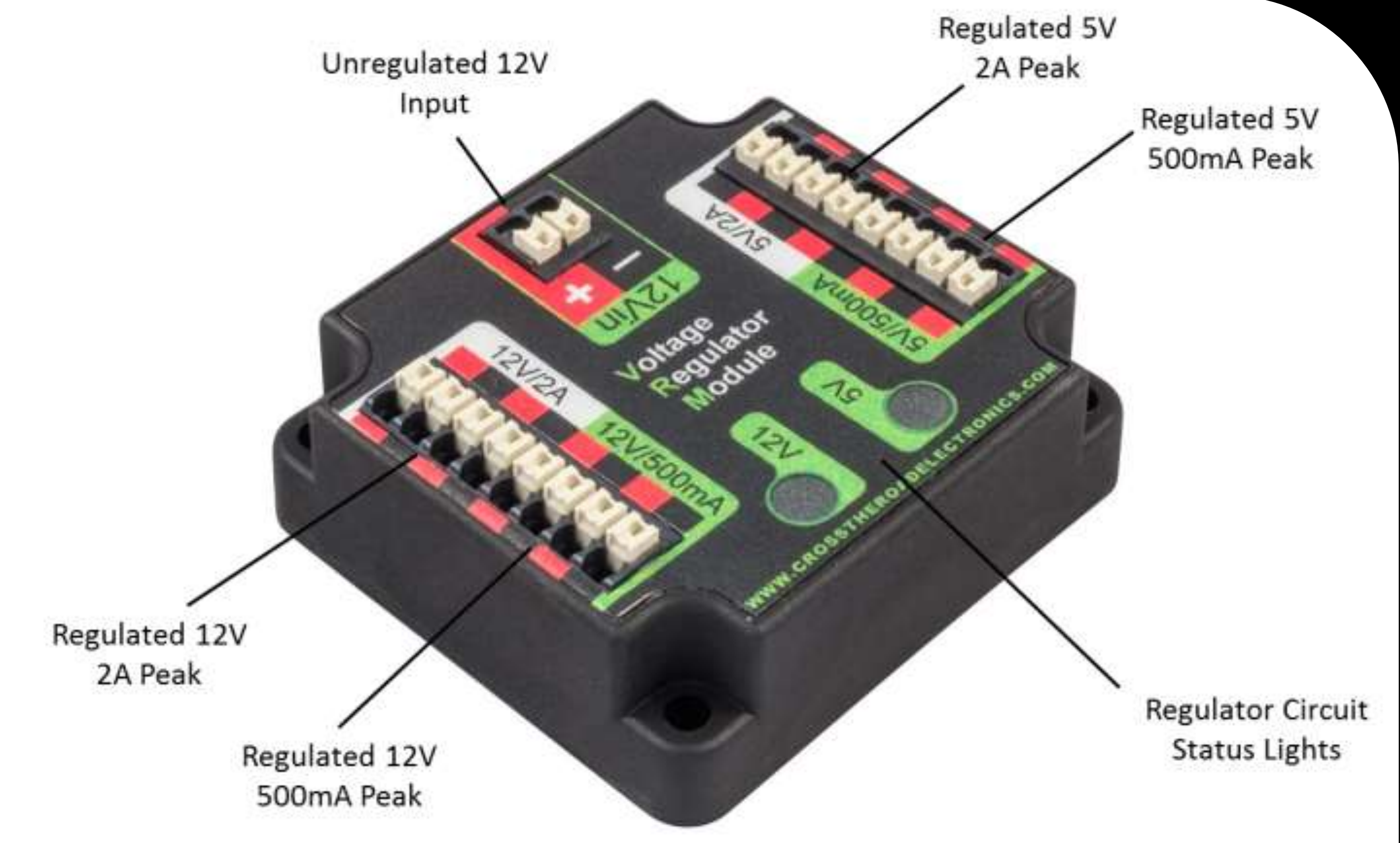


Clockwise from top-left: Rev Spark Mac, CTRE Talon SPX, CTRE Talon SRX, and CTRE Talon FX integrated motor controller..

Controls

Voltage Regulator Module
(VRM)

- **DC to DC converter with both boost and buck voltage regulation.**
    - **Boost Converter:** Steps up voltage while stepping down current.
    - **Buck Converter:** Steps down voltage while stepping up current.
- **Used when components require special protected power.**
    - Router
    - Light Ring
    - Flashlight



Voltage Regulator Module (VRM)

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Controls

Open-Mesh OM5P-AC

(Dual Band 1.17 Gbps Access Point)

- **Onboard WiFi lets us connect to the robot and control it from a nearby computer**
- **Communicates with the RoboRIO over ethernet.**
- **Connects to VRM for power. Can be used with a Power over Ethernet (PoE) injector.**
- **Must be configured at competitions**
  - Needs to be reflashed with updates to work with the Field Management System (FMS)

Open-Mesh OM5P-AC Access Point/Router

Controls

NI roboRIO

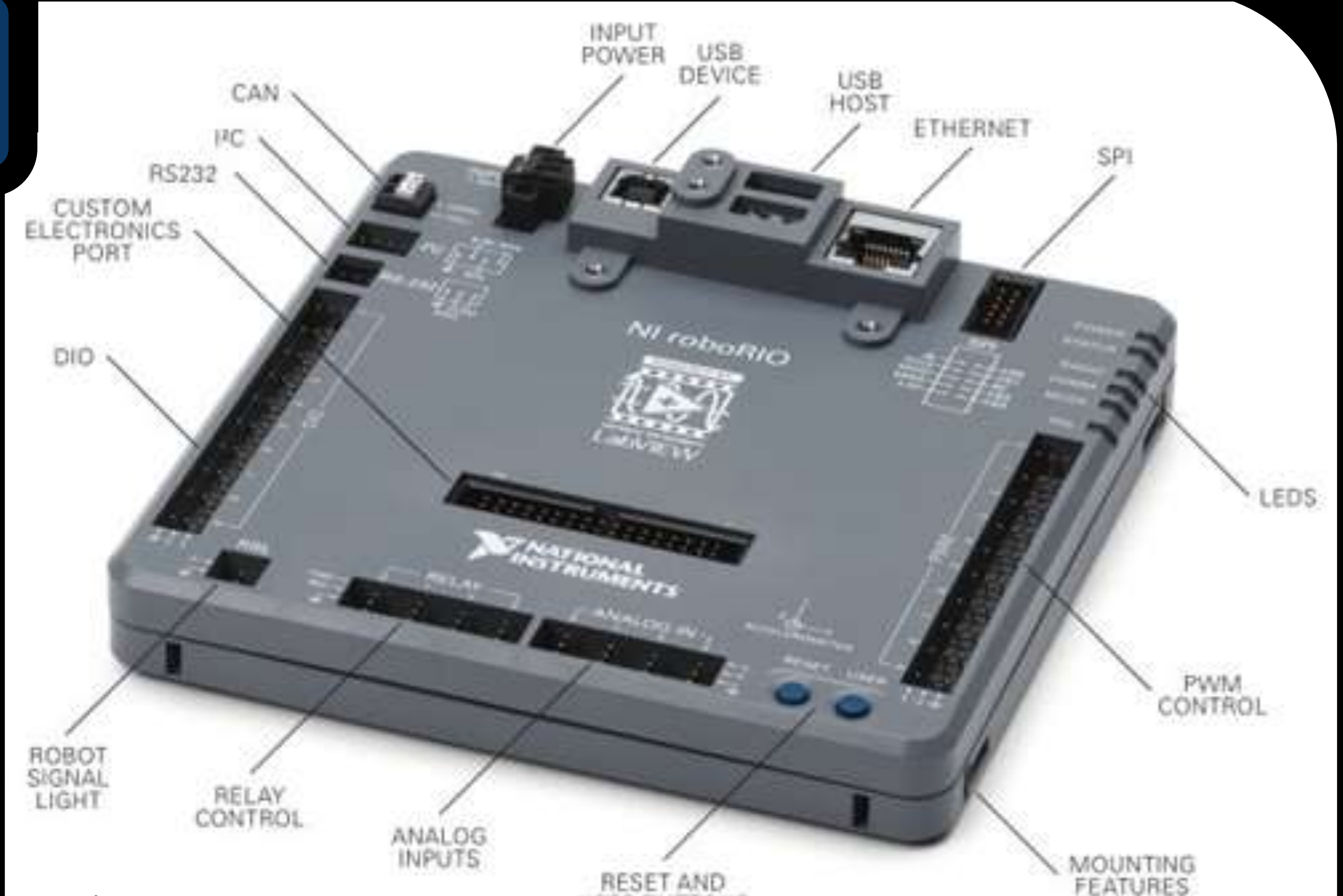
(Advanced Robotics Controller)

- **Brain of the robot**
  - Where code is uploaded and ran.
  - Sends signals to CAN chain and PWM.
  - Has Digital and Analog In ports for sensors.

- **Has port for signal light**
  - Signals when robot has been enabled.

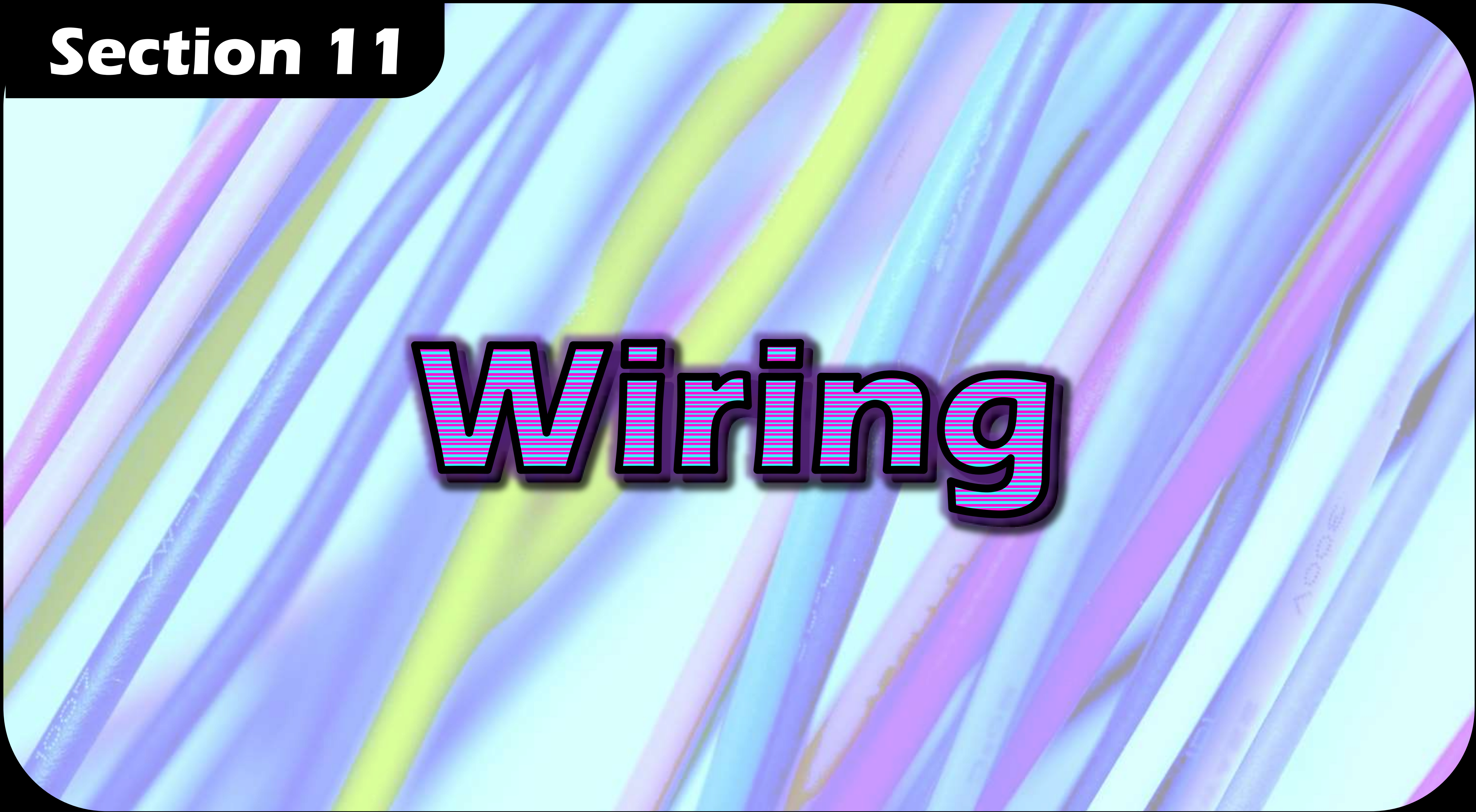
- **Ethernet port to connect to router to allow tethered control of the robot.**

- **USB ports for devices (camera, etc.)**



NI roboRIO

ATOMICS 5256



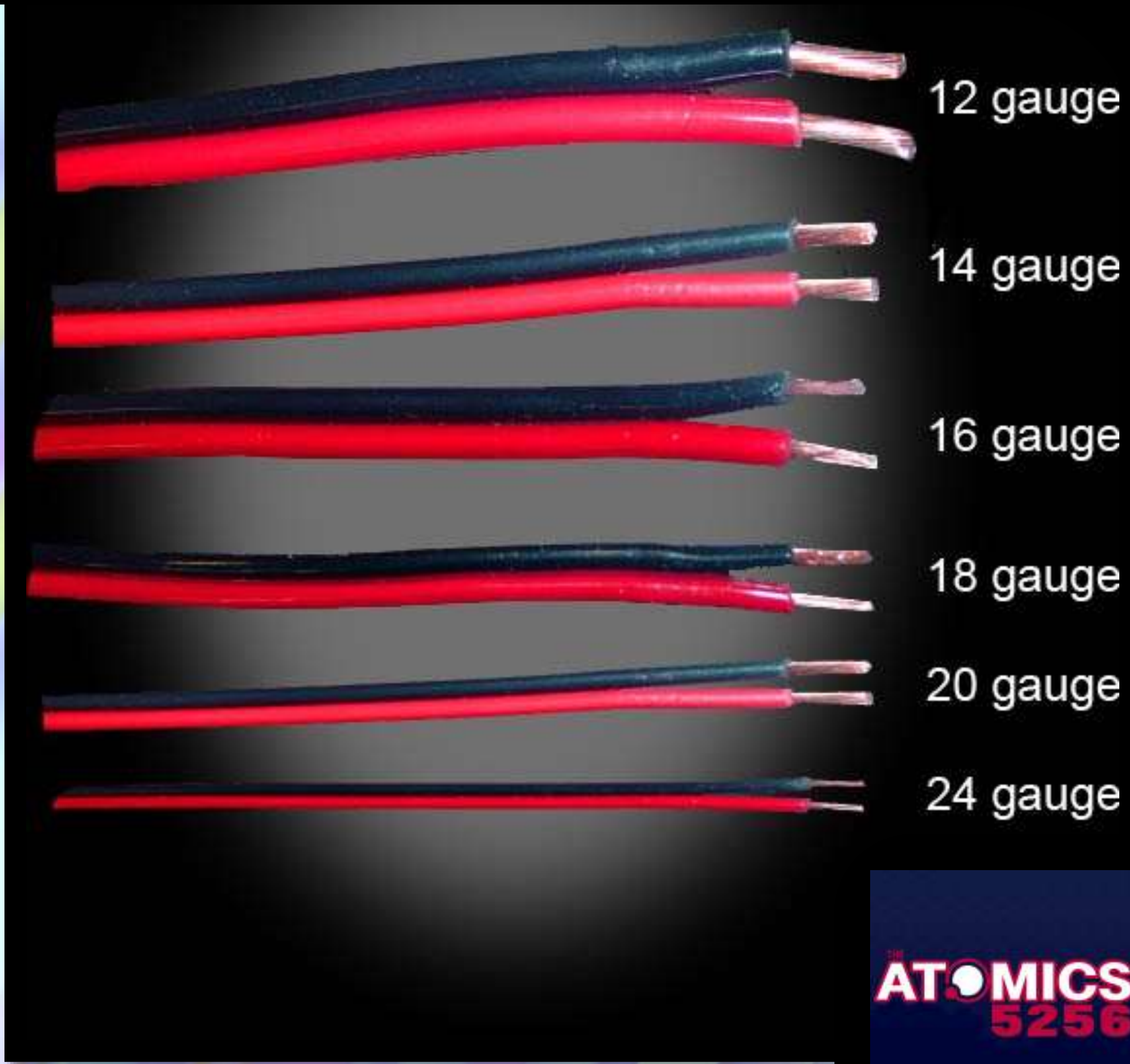
Section 11

Wiring

Wiring

Wire Gauge

- A measurement of wire diameter using the unit American Wire Gauge (AWG).
- Sizes range from 0 to 40, going from largest to smallest.
- FRC sizes run from 4 or 6 AWG for battery cables, all the way up to 22 AWG for CAN wires.
- If a wire is hot to the touch, it may be not be a big enough gauge for the load. Don’t be afraid to go bigger if necessary.

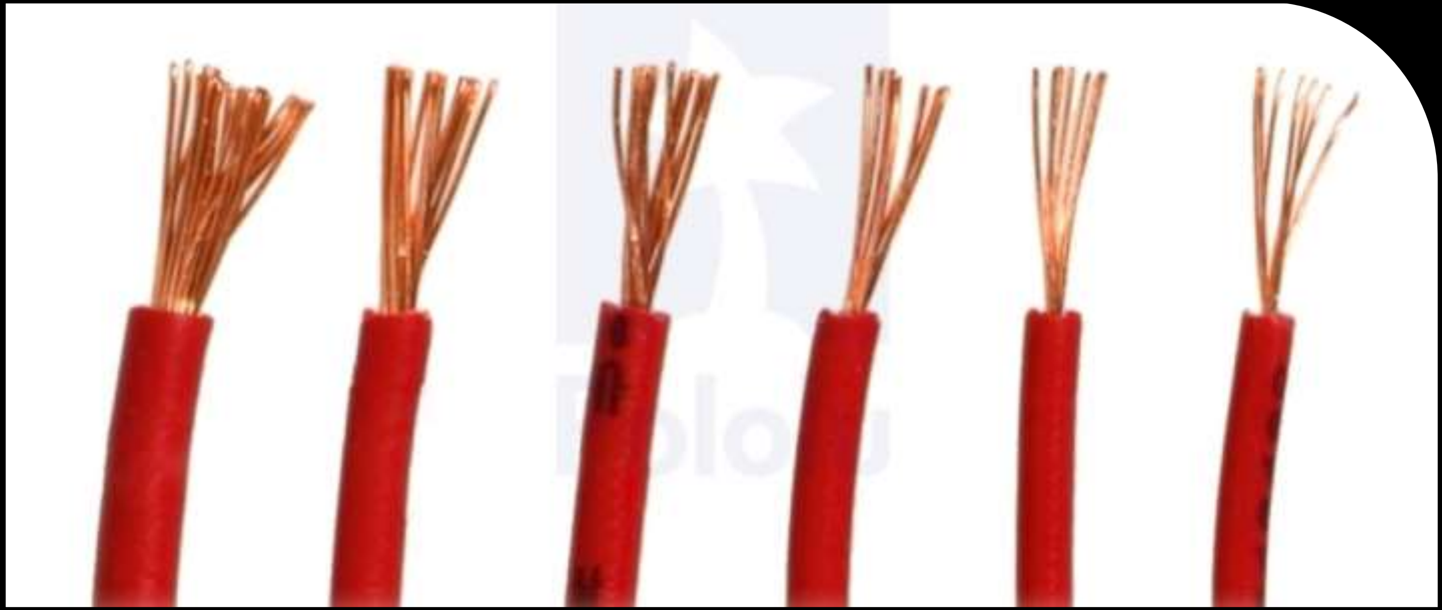


Wiring

Stranded Wire

- **Single Conductor**
- **Composed of many pieces of solid wire all bundled into one group.**
- **Used when the wire needs to move around frequently, such as in a robot arm.**
- **Designated by 3 numbers:**
    - **Overall AWG size, Number of strands, and AWG size of each strand**
    - **For example, a 22 AWG 7/30 stranded wire is a 22 AWG wire made from seven strands of 30 AWG wire.**

Stranded wire is the standard for machine and robot wiring due to it’s flexible nature. It’s made up of several smaller individual strands of wire, instead of one single larger strand, making it much more supple, and thus more durable, than solid wire.



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Wiring

If you remember only one thing from this section…

For prototypes, breadboards, and custom circuits where wires are not subject to flexing.

For all robot component wiring, from the battery cables to the entire control system.

Do Not Wire Your Robot with Solid Wire

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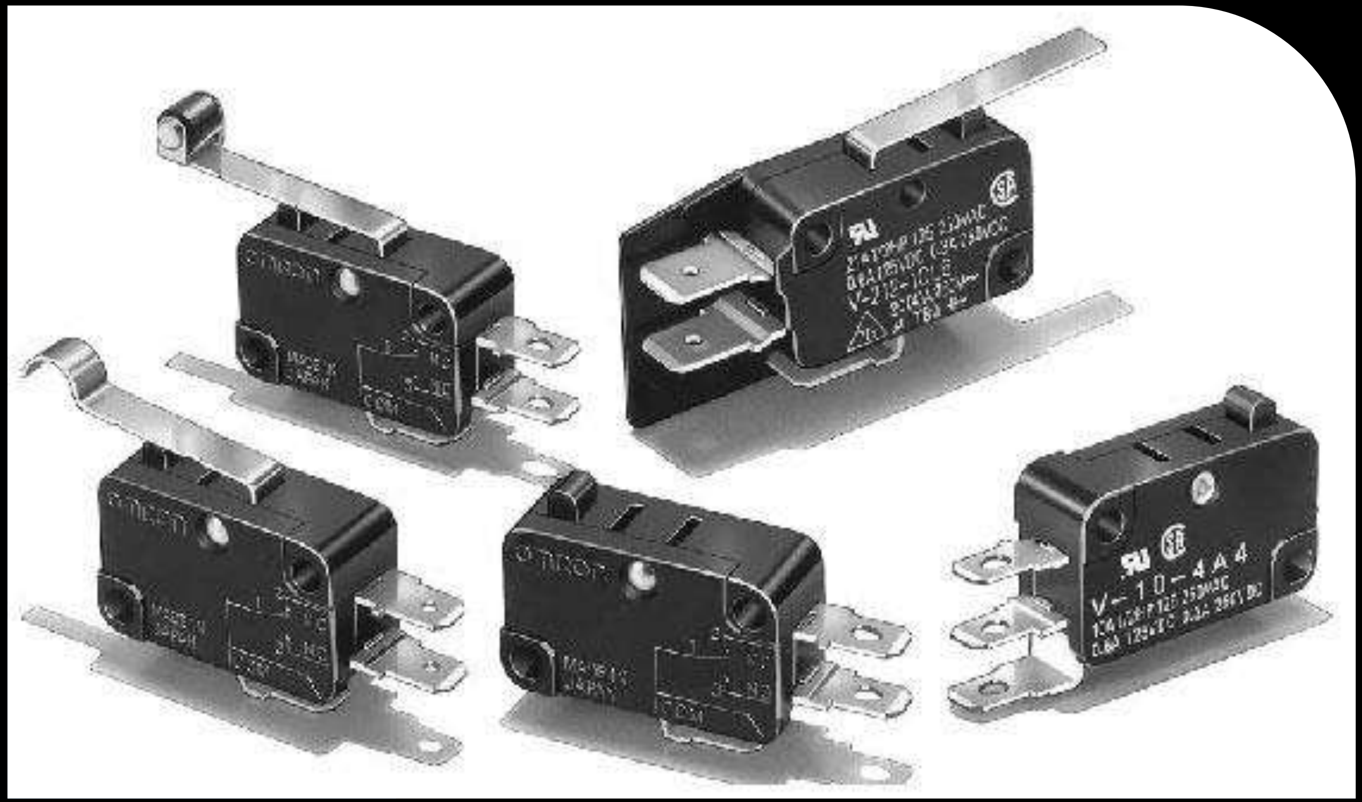
Section 12

Sensors & Inputs

Sensors



Limit Switches

- Probably the easiest of all of the sensors is the limit switch
- Typically implemented as a simple switch attached to actuator that indicates that you've reached some end condition
  - Switch can be Normally Open or Normally Closed depending on your logic in the software.

TL, DR:

Most motors just move things and don't know how far is too far, which tends to break things. By having the moving thing hit a limit switch we can send a signal to tell when to stop the motor from going too far.

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Sensors

Encoders

- Encoders have a number of pulses per revolution
  - Given the diameter of the attach point, you can determine how far the system has moved based on the number of pulses
  - Can also be used as a tachometer
- Make sure you purchase the encoder rated for the speed you're trying to measure

TL, DR:

Imagine putting a piece of red tape on one spoke of a bicycle wheel. Now, spin the wheel and count every time it makes a complete revolution. That's basically what all encoders do.

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Sensors

USB Webcam

- Often used to stream video from the robot back to the drivestation.
  - Can use a fair amount of the allotted bandwidth depending on resolution and framerates.
- Also used for machine vision using software such as OpenCV.
  - Will require additional hardware such as a co-processor and lighting (usually a green LED ring).

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Sensors

COTS Machine Vision Solutions

JeVois Smart Machine Vision Camera

- Combines a video sensor, quad-core CPU, USB video and serial port in a very small and inexpensive open source package.

Limelight

- A plug-and-play smart camera purpose-built for FIRST Robotics Competition
- Designed for teams with no vision experience or expert mentors

Pixy CMUcam5

- Fast vision sensor designed to simplify machine learning (Can be taught to identify specific objects with relative ease)
- Requires a coprocessor (Arduino, Raspberry PI, Beaglebone or similar controller)