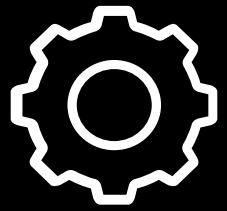


Robot Parts & Mechanisms in Design

FeMaidens Design

http://first.wpi.edu/FRC/frc-mechanical.html

Designing a Drivetrain

Type of drive, which motors, how many and what type of wheels, etc.

Fundamental Terminology

A bit confused as to how a drivetrain works, or wondering how to effectively communicate ideas? Educate yourself!

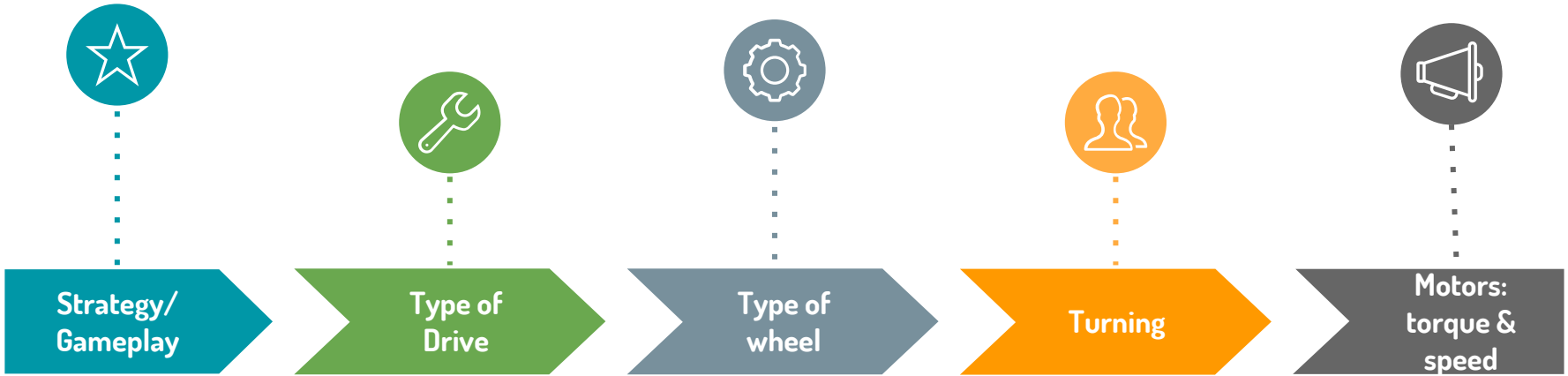
1. Static Friction (prior to moving) & kinetic Friction (during movement in contact)
   Normal Force: force that presses two sliding things together (gravity & mass)
   Traction: friction/grip between a wheel and a surface
2. Drive Wheel: the wheel that the motor is attached to which propels the robot forwards
3. Turning point: the point that the robot turns at
   Turning scrub: the friction that results from wheels dragging sideways when turning (slows speed of bot in certain directions)
4. Zero radius turn: when the robot turns but does not move forward (drop wheels)

Steps to Designing a Drivetrain

http://curriculum.vexrobotics.com/curriculum/drivetrain-desig

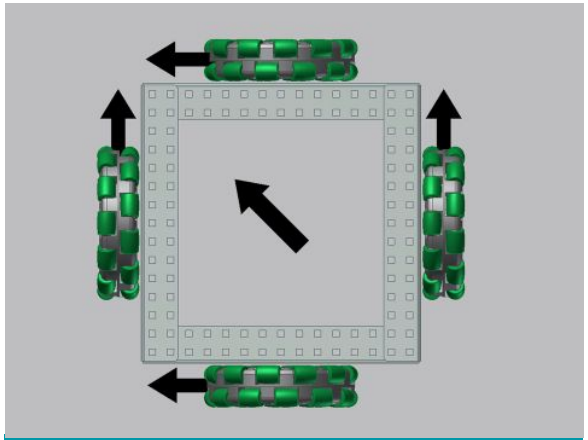
Steps/Parts

https://docs.google.com/presentation/d/1E0-yv54rXZPPUL3jURV1xhxdwqntV1iOxmmEmn3VLmc/edit#slide=id.g253b363315_1_314



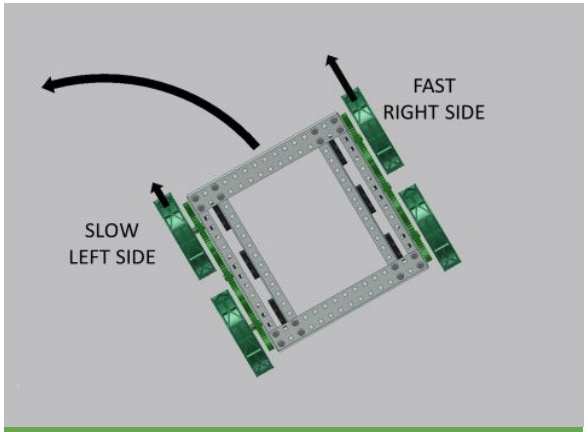
Types of Drive

These are the 3 commonly used types of drive (although the 3rd one kind of isn't)



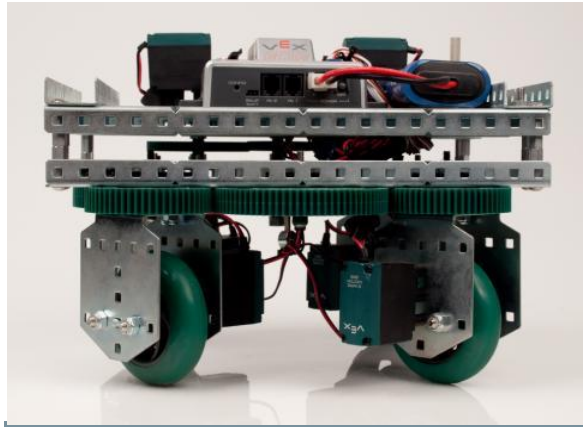
Omni-directional

~ 4 wheels placed in strategic locations
~ Requires four motors



Skid Steer

~ Requires 2 motors
~ All the power in the motors can be directed for acceleration and pushing

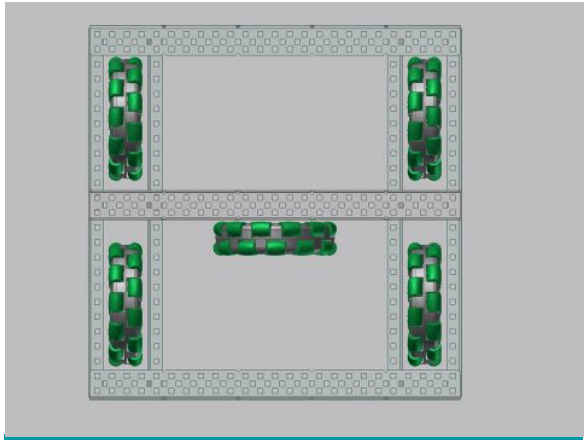


Swerve

~ 2 sets of skid steer are used in 2 different directions
~ Each is controlled separately and only 1 is ever on the ground since they alternate to switch directions

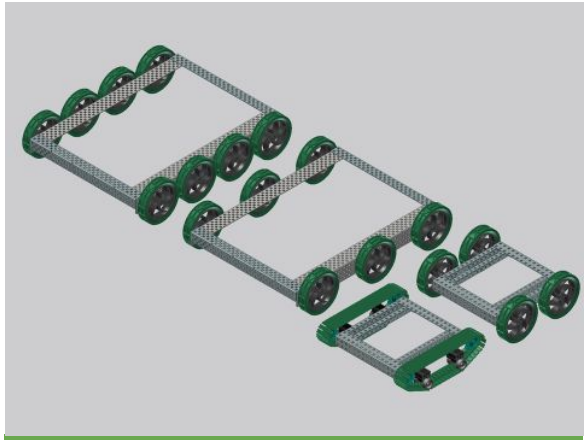
Types of Drive

This slide is one that should make you think about how configuration is key and how it relates to strategy, physics, and the game.



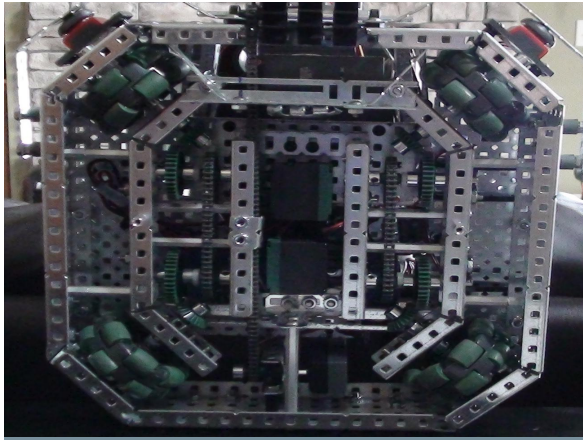
Omni-Directional

This is another configuration for omni-directional driving



Skid Steer

These are several iterations of the skid drivetrain, but they all possess the same functionality



Holonomic (Omni)

~ Uses too much space
~ Wheels can easily be rotated
~ Easily programmed and controlled

Types of Wheels

Depending on the drive, strategy, maneuverability, and game play the type of wheel means a world of difference.

Mecanum Wheels

~ Can move in any direction, although less force/speed is able to be used when moving diagonally
~ Frees up a few extra inches of space on the chassis (for intake for example)

Pneumatic Wheels

~ Compressible
~ Can be used for shooters
~ Extremely high traction & difficult to be pushed around by other bots
~ Usually should be paired with swerve drive in order to be able to turn
~ Usually needs a lot of torque to drive

Omnidirectional Wheels

~ Highly maneuverable for game goals
~ Good at evasion
~ Cons: Can be pushed by other bots easily, and usually can't push other bots, low friction/traction

Types of Wheels

Depending on the drive, strategy, maneuverability, and game play the type of wheel means a world of difference.

Colson Wheels

- Unlike pneumatic wheels they have no treads on the perimeter and don't need them because they are completely rubber
- Extremely hard to push due to high coefficient of friction (greatest traction)

Drivetrain Turning

Complete with all the technicalities that may make or break our driving game!

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Drop Wheels

Complete with all the technicalities that may make or break our driving game!

Drop Wheels

In 4 & 6 wheel drives

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Design: Robo Parts

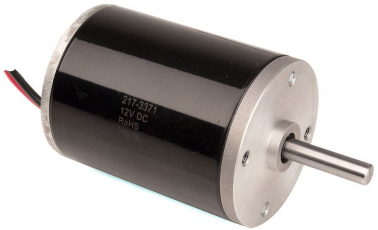
Braces, mounts, bearings, bearing blocks, spacers, washers, bolts, nuts, gearboxes, motors, chain, belt, polycord belt, piston, gussets, lexan, gears (for chain and pulleys), ...

Types of Motors

What type of motor depends on the drive, wheels, how many speeds you want to switch between, torque, etc.

CIM Motors

- Usually only used within the drivetrain and perhaps moving heavy objects



Mini CIM

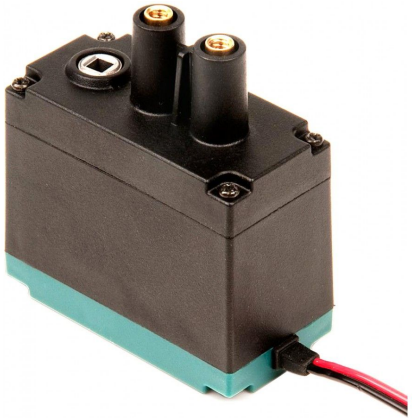
- 2/3 The power of a CIM motor
- Similar mounting → pay attention to bolt diameter specified in the drawing on VEX

775 Pro

- Has the power of a Mini CIM but is smaller and lighter
- Uses: intake, shooter wheels, and conveyors

Types of Motors

What type of motor depends on the drive, wheels, how many speeds you want to switch between, torque, etc.



Servo

- This sensor motor only turns however many degrees you specify

BAG Motor

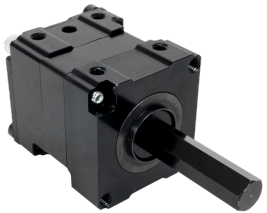
- Similar to the Mini CIM and used for medium-power applications
- -Used in conjunction with versaplanetary gearboxes

~ Uses too much space
~ Wheels can easily be rotated
~ Easily programmed and controlled

Types of Transmissions

What type of transmission (aka Gearbox) depends on the drive, wheels, how many speeds you want to switch between, torque, etc.

Gear ratios!



Versaplanetary

- Used in conjunction with BAG, MiniCIM, RS-550, RS-775, AM-9015, and CIM)
- Used to modulate speed and torque requirements using a range of gear ratios inclusive: 3:1 to 100:1

These are several iterations of the skid drivetrain, but they all possess the same functionality

~ Uses too much space
~ Wheels can easily be rotated
~ Easily programmed and controlled

Pulleys

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Pistons

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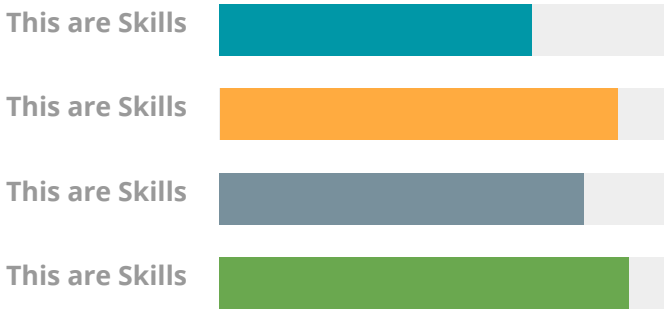
Main Usages



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Wheels

Using the right wheels is essential for a drivetrain

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Two Examples Portfolio

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Our Services

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Design: Sensors

CAM, Ultrasonics, Gyro, Limihttps://www.vexrobotics.com/vexedr/products/accessories/electronicst Switches, Encoders, etc.

CAM

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Ultrasonics

Emits high-frequency sound waves and helps the robot either navigate obstacles or determine the distance away from something during autonomous or scoring goals

Limit Switches

The small metal tab is sensitive and will be able to tell the robot (relates to programming) when the robot's mechanism such as an arm has completed its potential movement

Feature

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Feature

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Electronics Estate

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Design: Calculations

(Gear ratios, chain length, list more...)

Editable Column Chart

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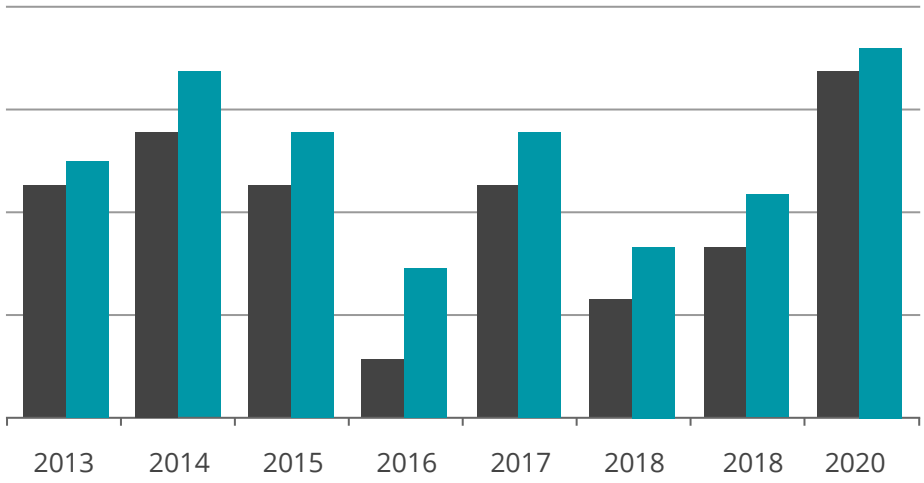

Sample Text

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Data Driven Column Chart

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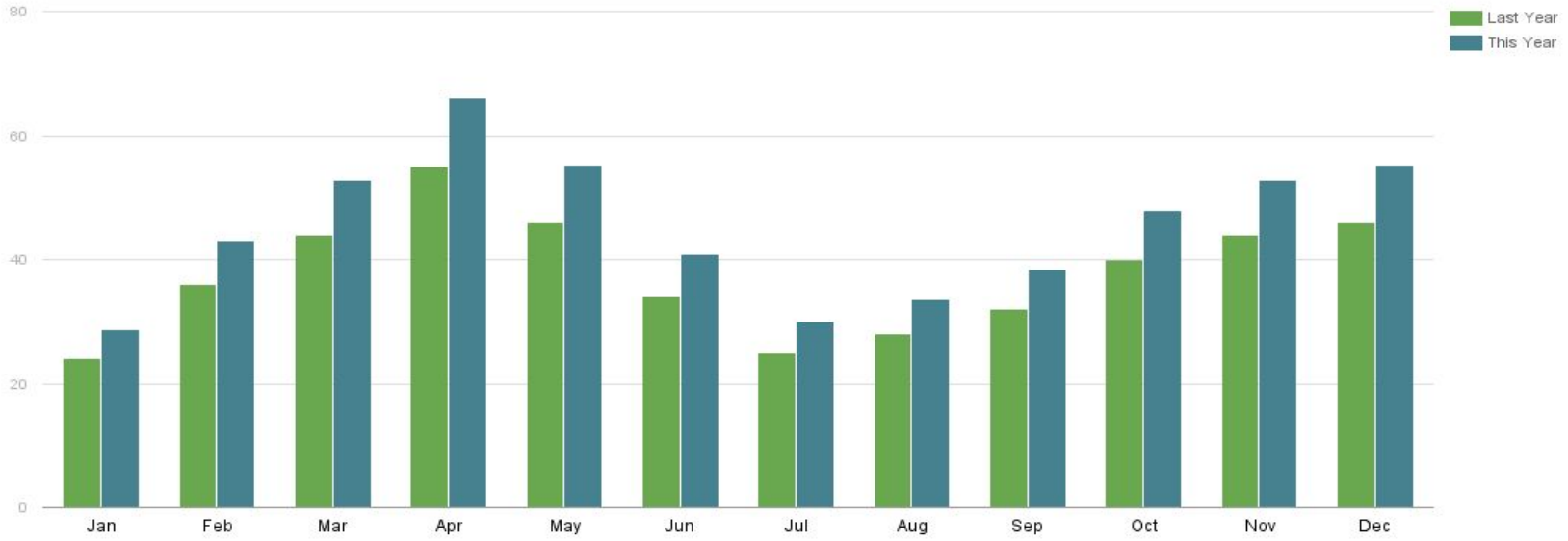

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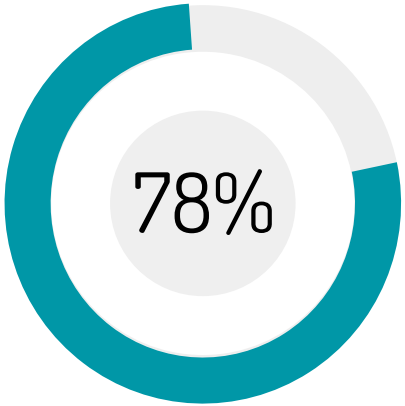

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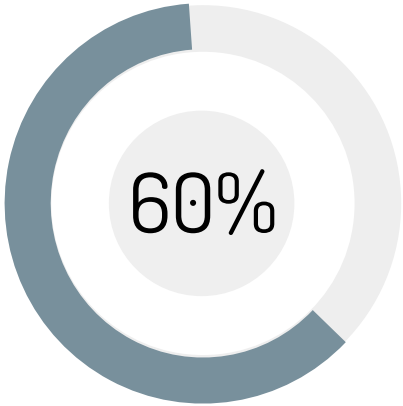

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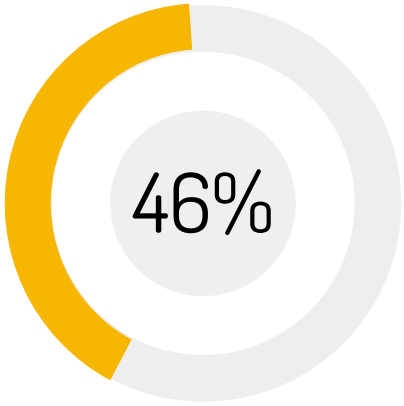

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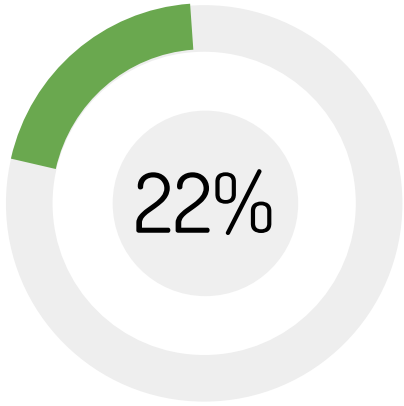

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Data Driven Column Charts

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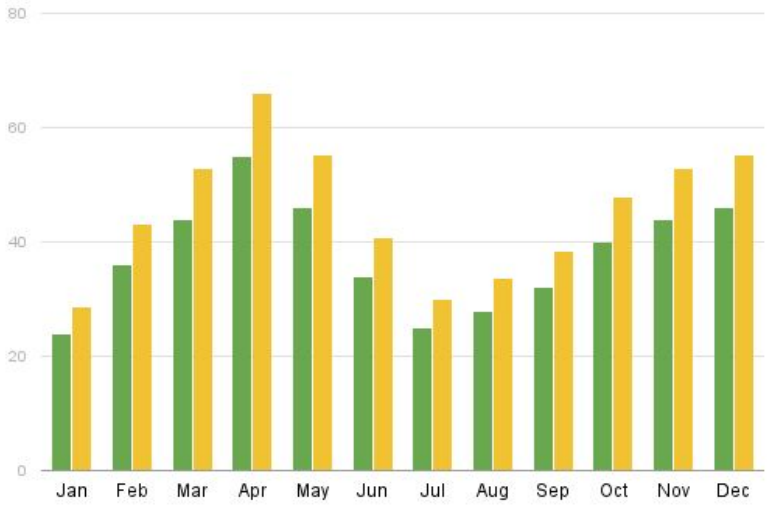

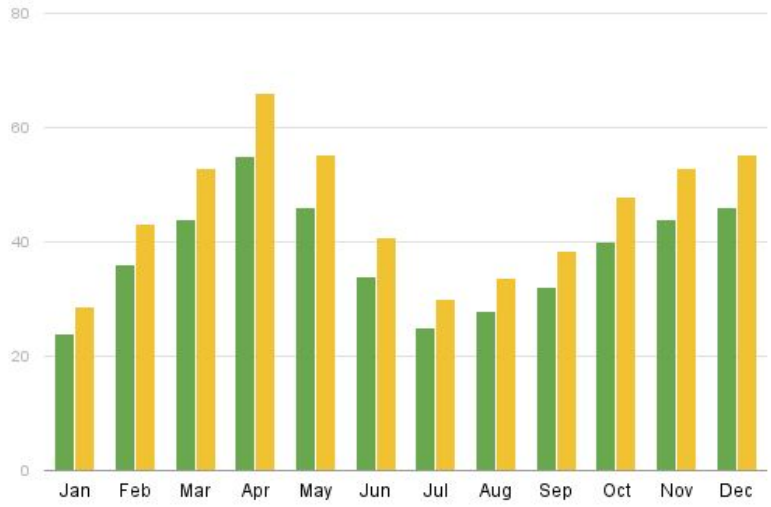

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Motor Stats Chart

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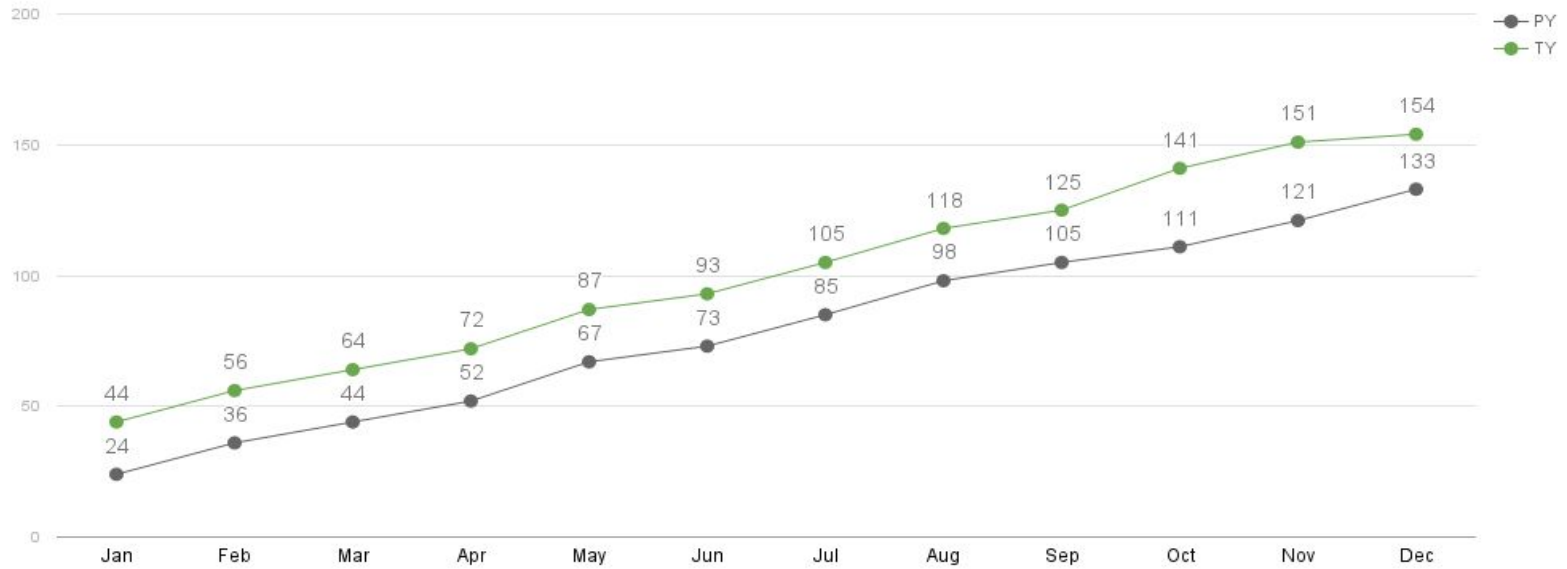

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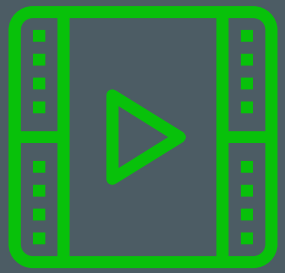

Design: Mechanisms

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manipulators

- Acquiring the game piece and manipulating it.
- http://www.instructables.com/id/Introduction-to-Manipulators/

Climbers

- Acquiring the game piece and manipulating it.

Agitators

- Acquiring the game piece and manipulating it.

- **Rollers/wheels** - One of the most popular and widely used ways to grab or intake a game piece is to use motorized rollers/wheels to absorb pieces.
  - Rollers are simple and easy. They also fix human error in alignment.

- **Claws** - Clamp around a game piece using fingers. Usually used in tangent with an arm. The wrist, where the fingers join the arm, might also be powered.
  - **Pneumatic** - Use the piston to push or retract the fingers. They are easy to make and quick, but have a limited grip force.

  - **Motorized** - They have varied grip force, but they are more complex, heavier, weaker, and slower.

-Tube Specific

- Suction cups - They need a vacuum generator, can’t handle heavy things, and require precise placement.
  - They are best configured in a triangular fashion for a tube

- Ball Specific

- Conveyors - For balls it is harder to figure out how to get the ball to the shooter rather than how to grab it.
  - Ball needs to be compressed for it to move.
  - Guides - Use guides to guide the ball to the shooter.
    - Polycord/Belt - May be hard to change the direction of the ball.
    - Tower - The ball is led through the circular guides by a rotation cylinder in the middle.
    - Balls may get jammed in the conveyor when they rub against each other. Either make the non moving surface super slippery (teflon), use multiple segments (might get heavy and complex), use two segments on either side.

- **Crate Specific**
  - **Rollers** - Fly wheels can be used to intake the crate into the robot's frame or gripper.
  - **Snap** - Metal tabs or hooks can be used to grip onto the sides of the crates.

- **Disc Specific**
  - Discs are usually loaded in the human station, but can also be picked up from floor if wanted.
  - **Rollers + polycord + wedge** - Use a roller to pull the disc into the robot. Then use the polycord to guide the disc over the wedge and into inside of the robot.

SHOOTERS

- **Using wheels to propel a game piece out of your robot.**

- **Pneumatic Wheel** - a pneumatic wheel is usually used to do this because they provide a lot of friction and give.
- Must use guides for the game piece to shoot straight and consistently.
- The game piece can be guided around the wheel but this may take a lot of space.
- Never put shooter at the bottom of the robot, it might get blocked by defending robots.

- **Disc shooter** - A transmission should be used along with the motor to power the wheel, because with just the motor the motor will slow down a little when the disc touches the wheel wasting time. The disc also should touch the bottom of the wheel because the disc will not be propelled out of the robot if it is tangent to the wheel.

- **Ball shooter** - The space between the wheel and the guide or the other wheel must be smaller than the ball in order to squeeze it. You must allow the wheel to be moveable so that the optimal distance can be tested for.

-

HITTERS

- Propelling a game piece out of your robot with a sudden release of energy.

- **Kicking** - Long distances
  - **Winch/pulley** - This what can provide the potential energy. An elastic rope, such as surgical tube, can be rolled up and tightened around the winch using a motor. When the winch releases, the rope loosens and shoots out whatever is attached to the other end.
    - This is a hand wound winch. Instead of the handle, a motor will be attached to roll up the tubing.
  - **Catapult** - It takes a lot longer to shoot and is a quite large contraption. However it is more reliable in that the force is constant. Powered by a winch.
  - **Linear punch** - Can be attached to a winch, so that the rod is projected out and hits the game piece.

- **Punching** - Short distances
  - **Piston** - Good for short distance motion that needs a high amount of power. Requires pneumatics knowledge.
  - **CAM** - It is attached to a motor that spins it around. A mobile object rides along the sides of the cam. The shape causes the potential energy to build up and its release.

ARMS

- Arms allow for manipulating game pieces in the air. A gripper can go on the arms.

Arms are one of the most common manipulators used in FRC. Generally, they are used in conjunction with an end effector to control the gamepiece. The two common types are single and multi-jointed arms. While multi-jointed arms are able to reach farther and can have more control of the orientation of the end effector, they are also much more complex. On the other hand, single jointed arms have the advantage of simplicity.

One common design used for arms is a 4 bar, or parallel, linkage. Such a linkage is shown in the third picture. The main feature of this design is that the end effector is held in a constant orientation.

Tips for arm design:

- Pay attention to weight – can cause the arm to be slow or even fail
- Use light materials such as circular or rectangular tube and sheet metal
- Use sensors such as limit switches and potentiometers to simplify controlling the arm
- Counterbalance the arm with springs, gas shocks, or weight to stabilize it and reduce load on motors

- **Lead screw/piston** - They are strong in short distances but become weak over long distances. They can be used at the pivot closer to the base since they can carry a heavier load.

Winches and Brakes

- **Motors** - It is possible to use motors to pivot. However they can back drive (the load might be so heavy that it when the motor is turned on it goes in the opposite direction than desired) so it best to use them with lighter loads closer to the tip of the arm.
- **4-bar linkages** - They are collapsible and foldable in small spaces. They are super stable in that they don't bounce like other arms, so they are reliable for heavier loads.

  - It is the simplest movable closed chain linkage. It consists of four bodies, called bars or links, connected in a loop by four joints. One joint would be fixed, one powered by a motor, and the other two free to move.

- **Turrets** - Turntables that allow for circular 360 degree motion.
  - Can also be used for aiming a shot.
  - **Lazy Susan Bearings** - Attaching these to a powered gear or sprocket allows for you to pivot the arm at the base in a circular motion. But they cannot handle heavy loads.

LIFTS/ELEVATORS

- They are for moving things to extremely high distances.

- If there are multiple stages, they need to overlap 20% at least and be made out of stiff material for stability.
- **Wide vs Long** - Making your lift wide will save space saver but the robot will be more likely to tip. Long is the way to go.
- **Power up/down** - Powering the lift both ways will keep game piece steady in one y-position. However it may eat a lot of power.
- **Gravity drop** - In powering the lift only to pull the load upwards and let the load fall by gravity, you will not lose a lot of power. Since it is less complex than a fully powered lift, it is less likely to break and make it easier to service if broken.
- **Cascade** - The separate stages of the elevator will go up one at a time. This allows you to make each stage a specific necessary height, removing human error when driving.

- **Continuous** - All the stages move at once in a continuous elevator, so the lift will extend faster. More complex cabling so possible to get tangled.
- **Continuous Internal** - Since the pulldown and pullup cables are the same the going up and down speeds are the same. Very complex cabling.
- **Telescopic** - The elevator extends like a telescope
- **Scissor lift** - The concept of a scissor lift is simple. You connect multiple crossing beams with free pivots. One of the bottom beams is powered to move in and out to move the lift up and down and the other one is fixed. However it's hard to build and it probably won’t work in the end.

MISCELLANEOUS

- **Suspension** - The end of the mechanism can be hooked onto a field element and the robot can pull up.
  - **Winches** - Explained in the Hitting section.
  - **Arms** - Explained in the Gripper section. Not as efficient.
  - **Lifts** - Explained in Lifts section.
- **Dumpers** - Make a bucket to accumulate the game pieces in, then use a piston, spring, or gear to tip the bucket over.

- **Gussets** - Connector pieces that strengthen the joints of the frame. Be mindful that if the joints are stronger than the metal, the gussets may stay intact during impact but the frame may bend or sustain damage.
  - 3647 west coast drive (the black corner pieces are gussets)
  - 80/20 https://www.8020.net/
- **Springs -** Springs can be added at connections so that when the robot is hit, the spring will absorb the energy and the frame will not be damage.
- **Lexan** - Clear plastic that comes in sheets. It is flexible so if the robot is hit, the frame will not sustain much damage.

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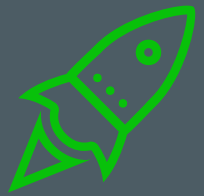

THANK YOU