Chassis Design

AJLONTECH

M.S Syed Ajmal

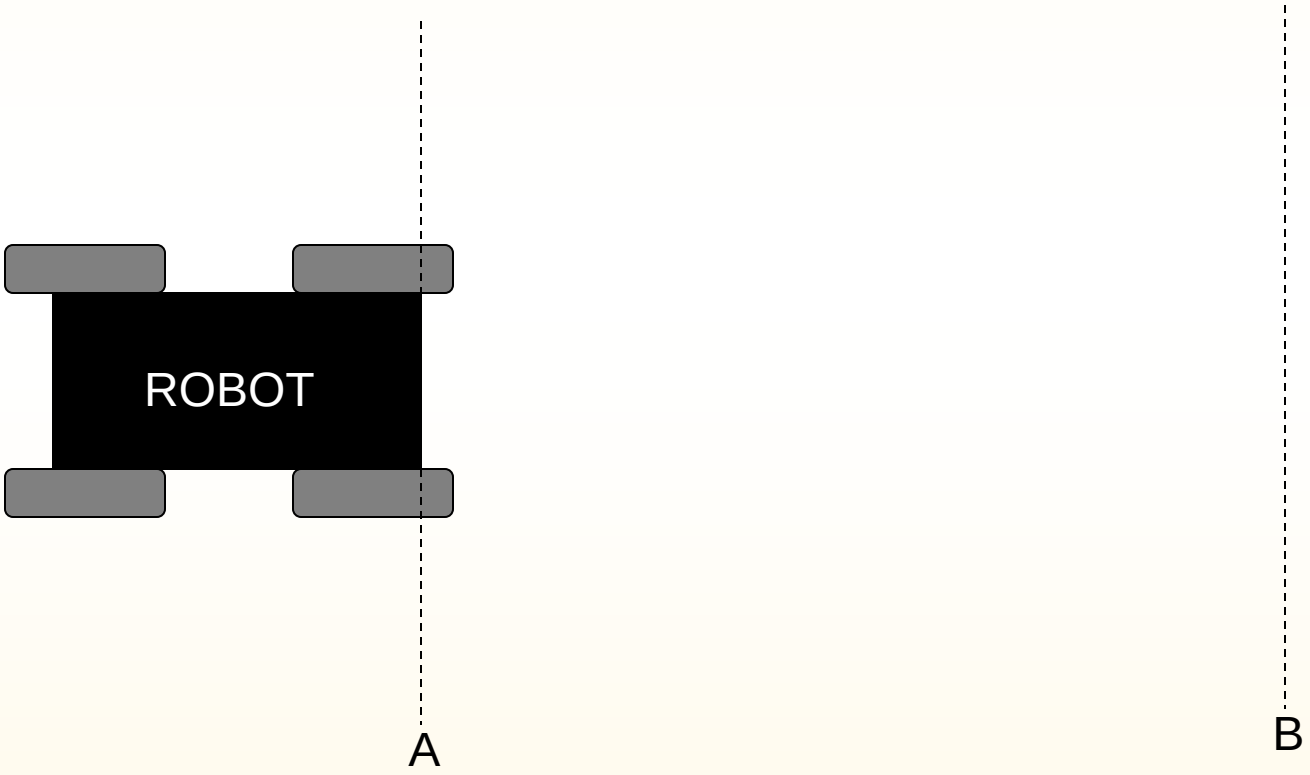
Outline

- Basic Robot Design Theory
- Building a Chassis
- Building a Driveline
- What's in the KOP?
- Moving from VEX to FRC
- Final Advice
- Questions?

Basic Robot Design Theory

Basic Robot Design Theory

Skid (Tank) Steering



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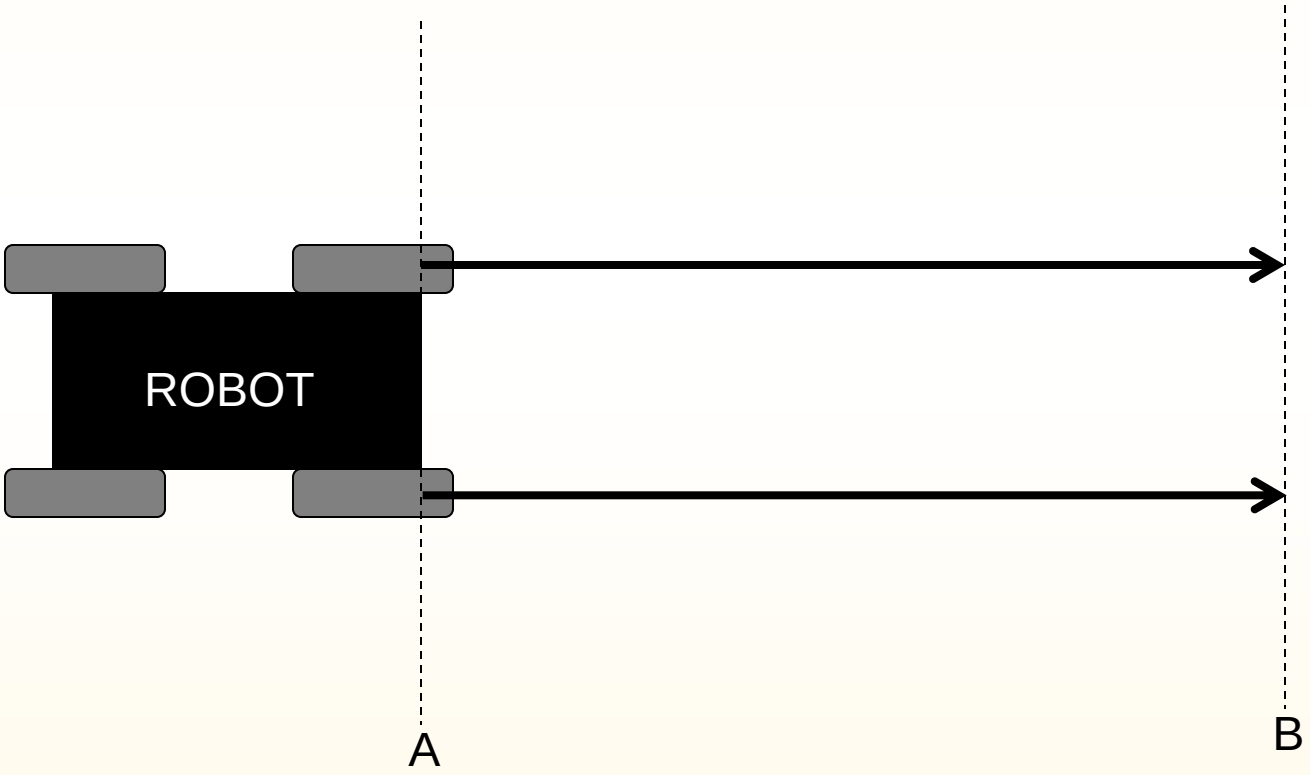

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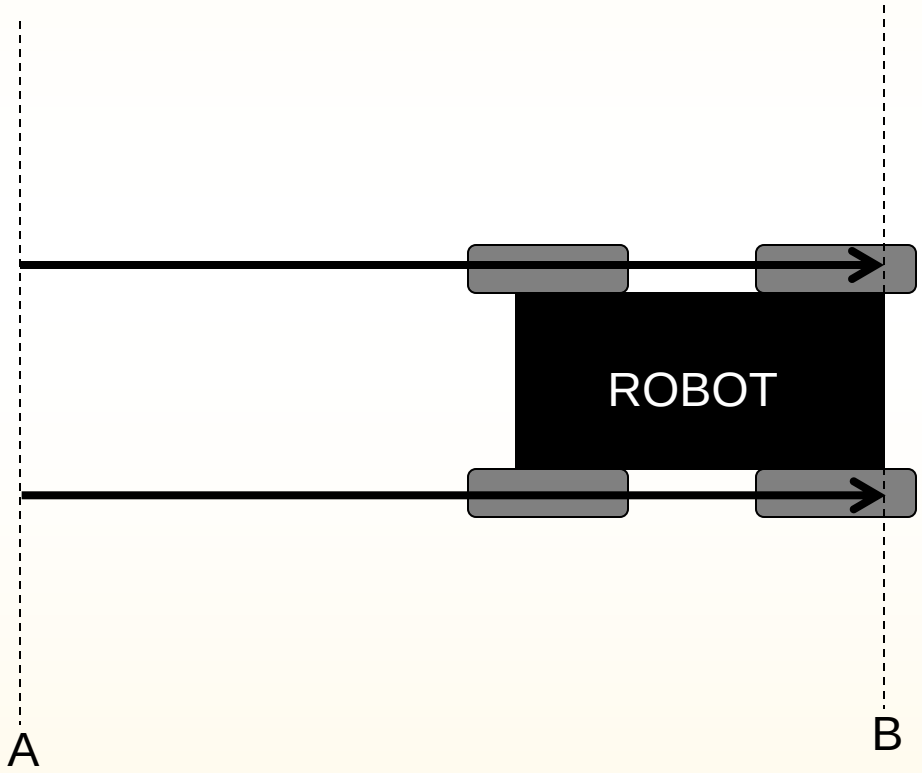

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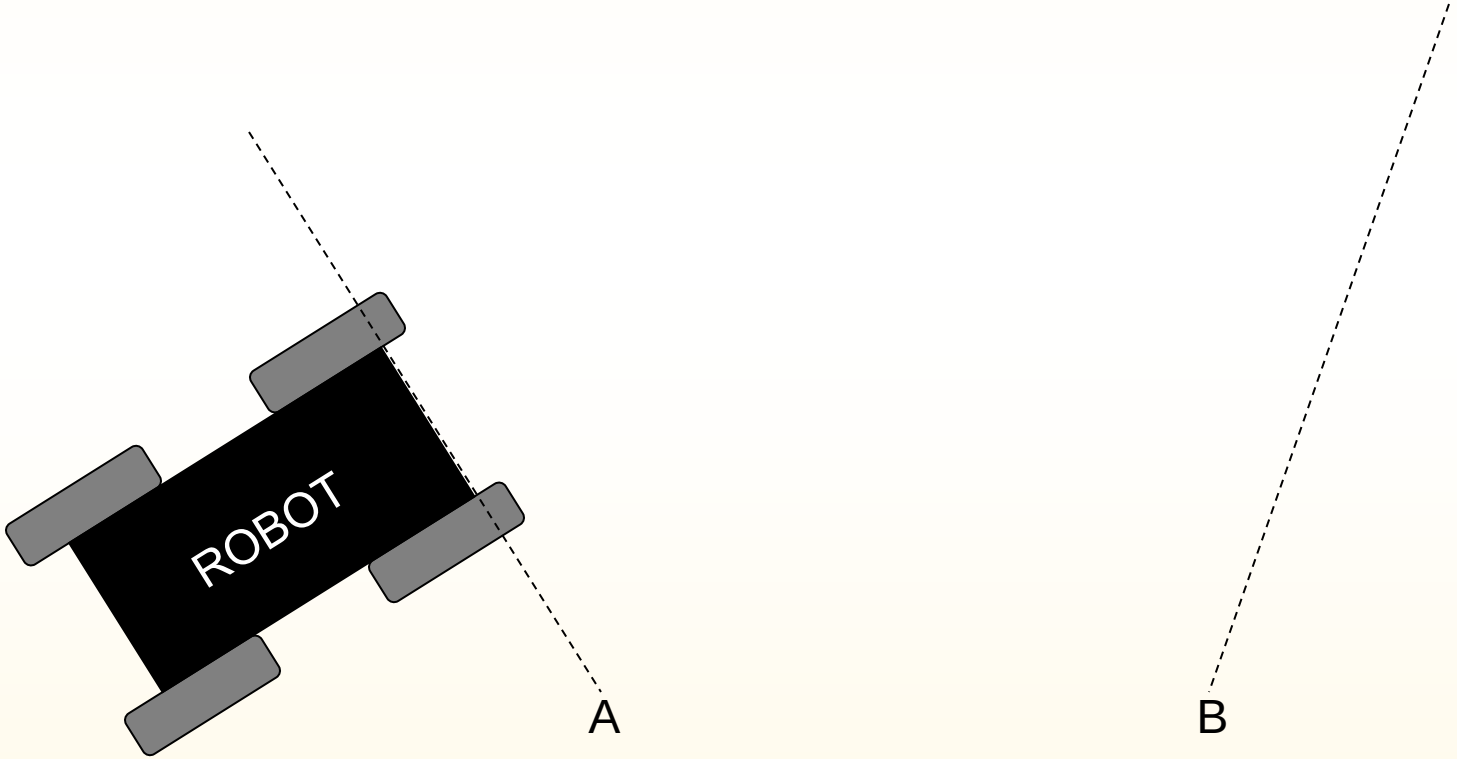

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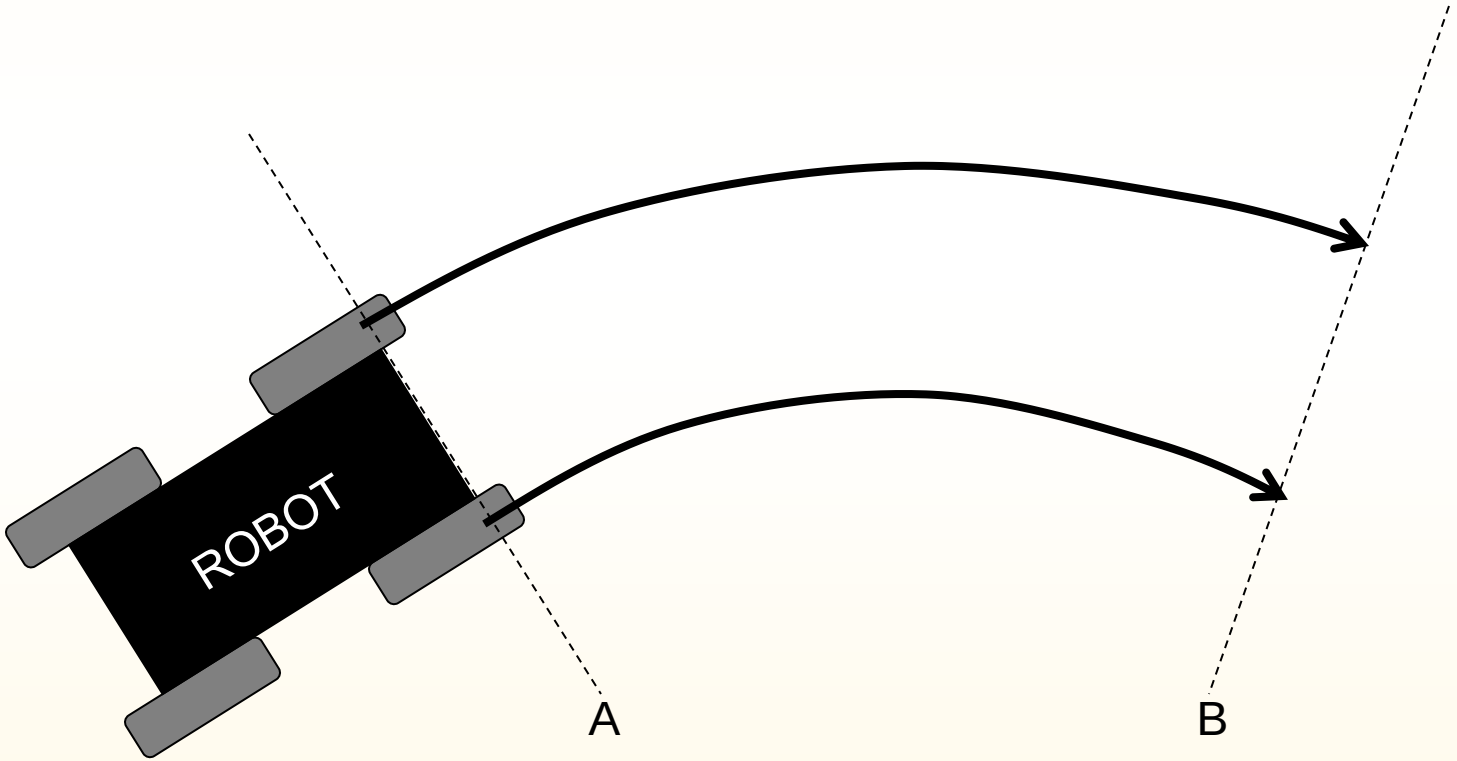

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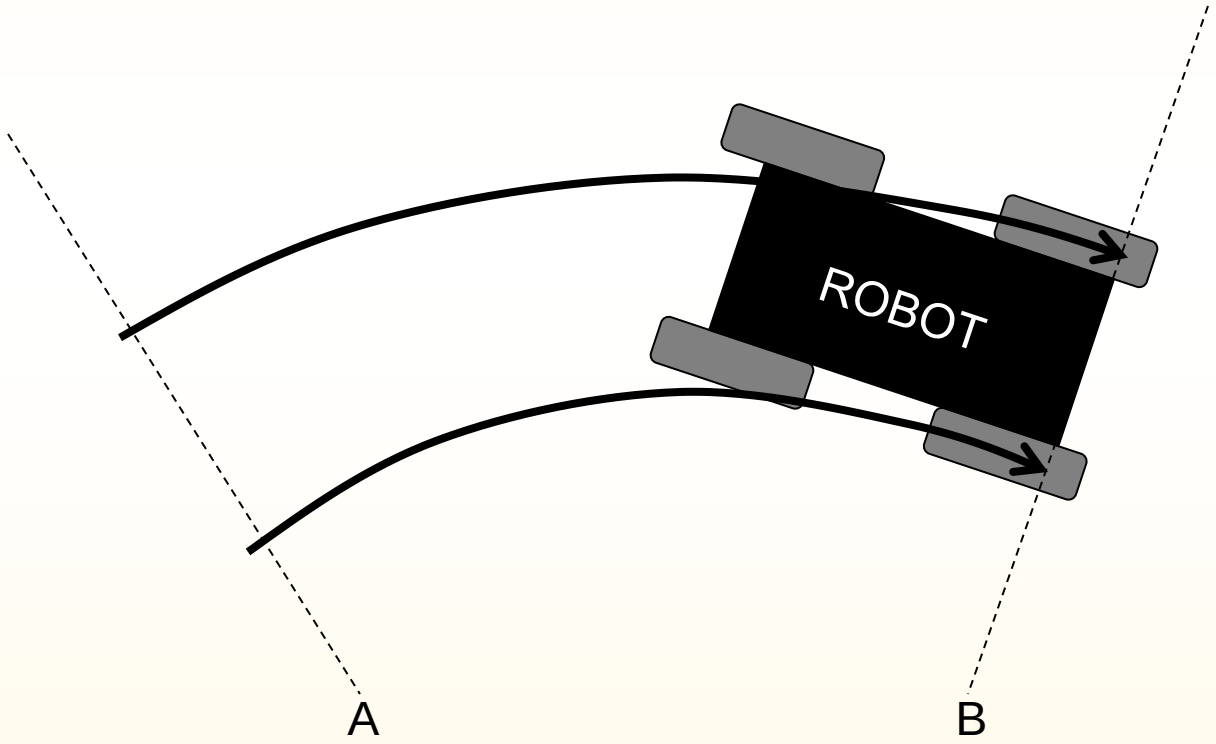


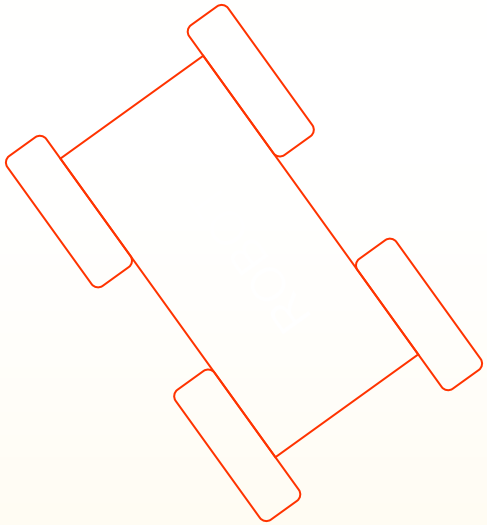
Basic Robot Design Theory

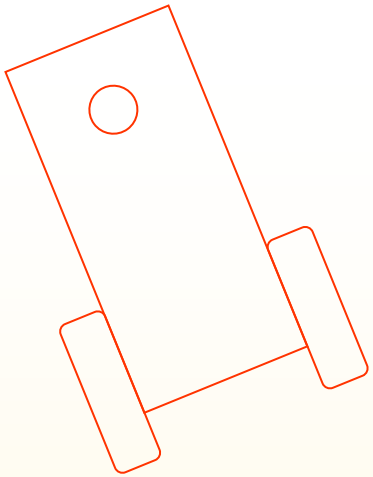
Steering Suggestions

- Skid steering is easy
- Single-joystick controls are great for new drivers
- Two-joystick controls gives drivers more control

Basic Robot Design Theory

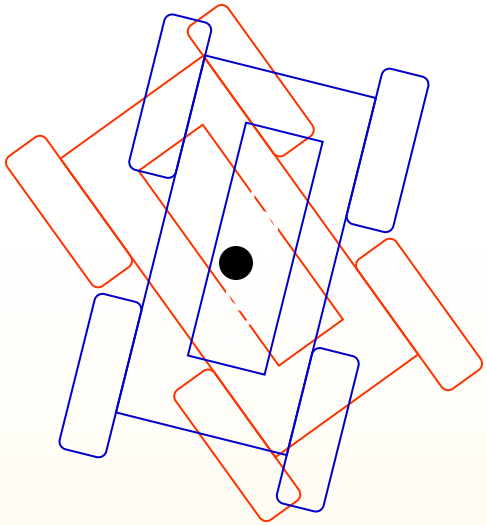
4 Wheels vs. 2 Wheels

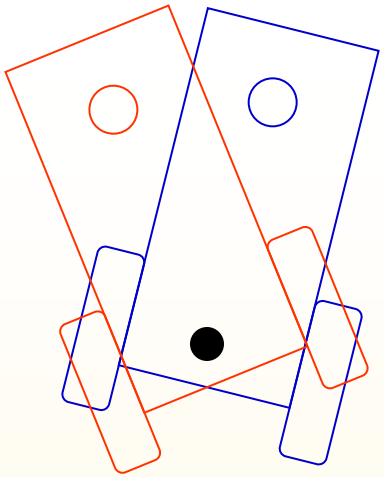




Basic Robot Design Theory

4 Wheels vs. 2 Wheels





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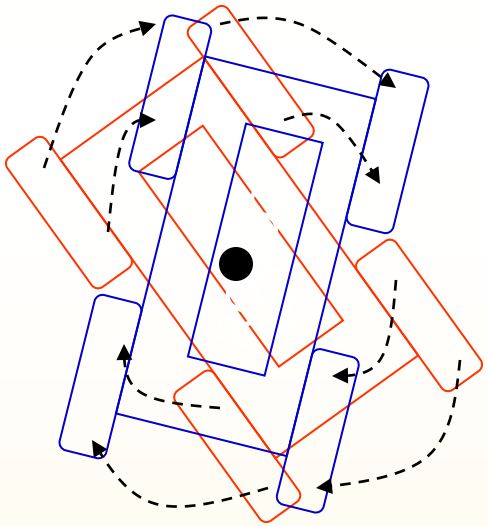
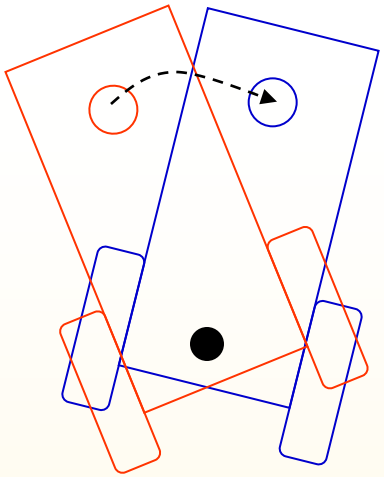
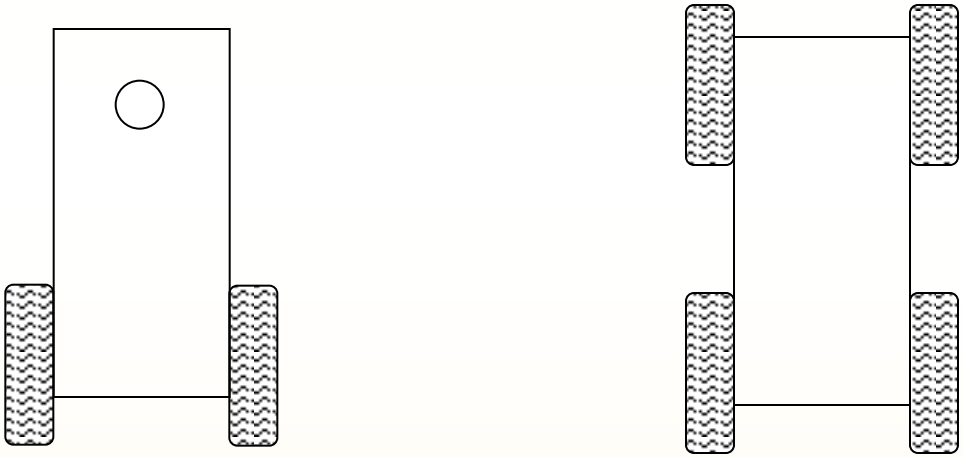




Basic Robot Design Theory

Slicks vs. Grips



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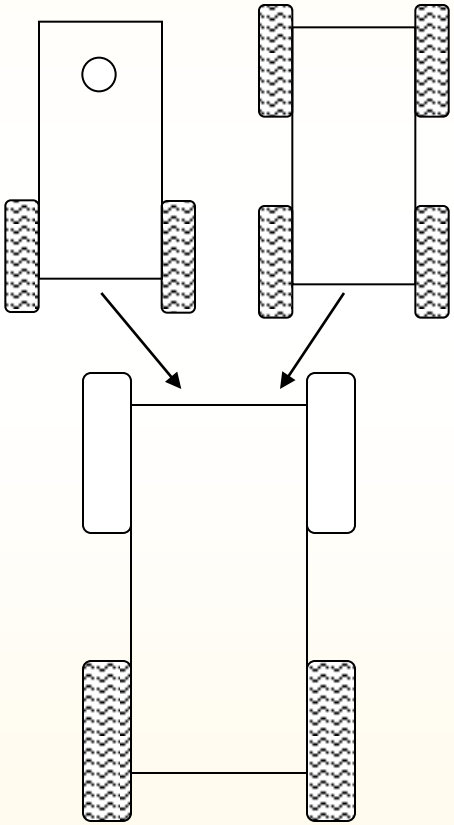

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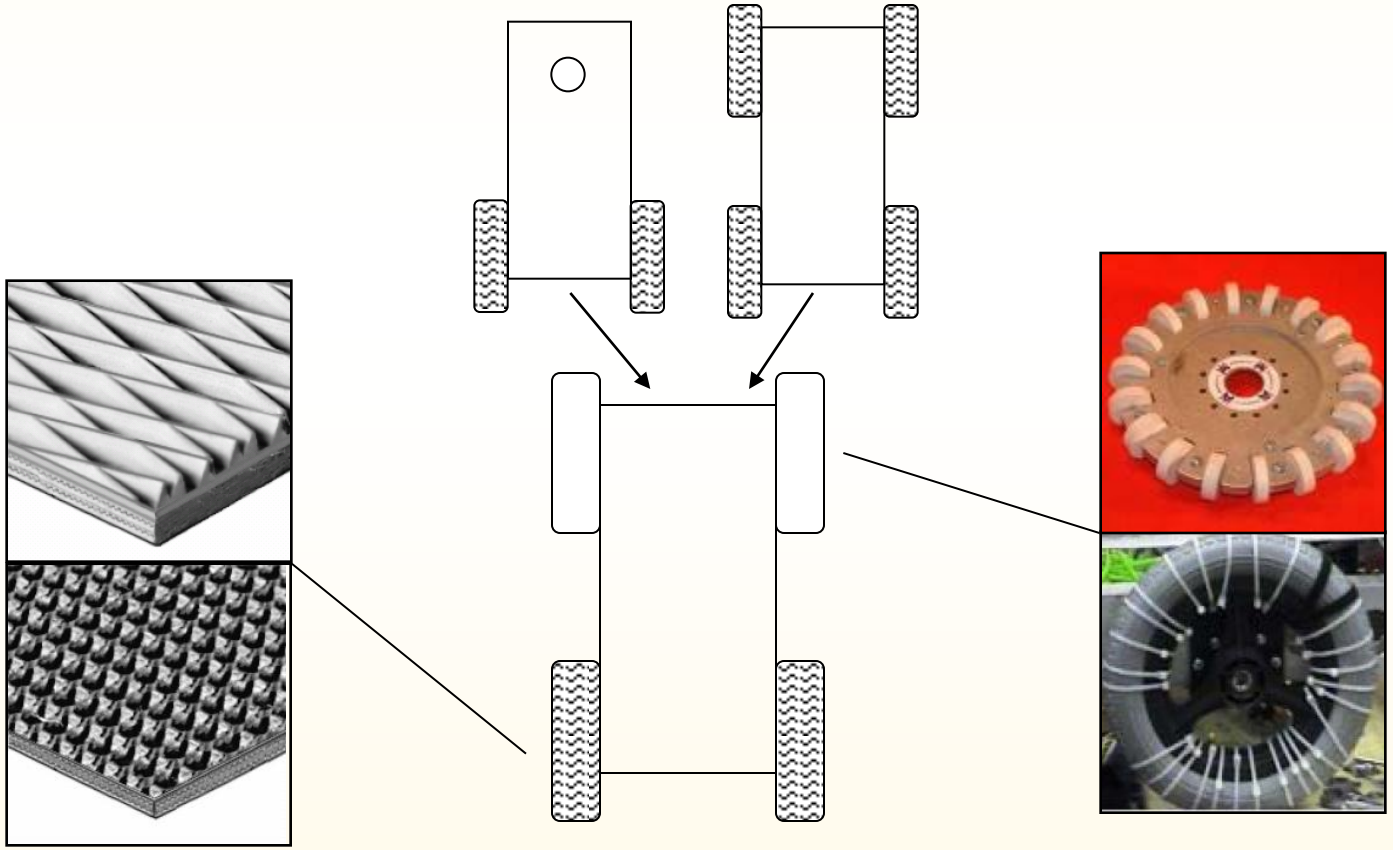


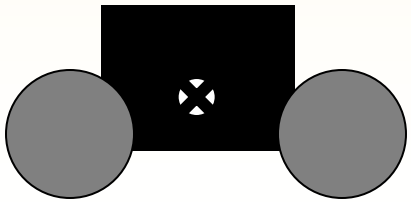
Basic Robot Design Theory

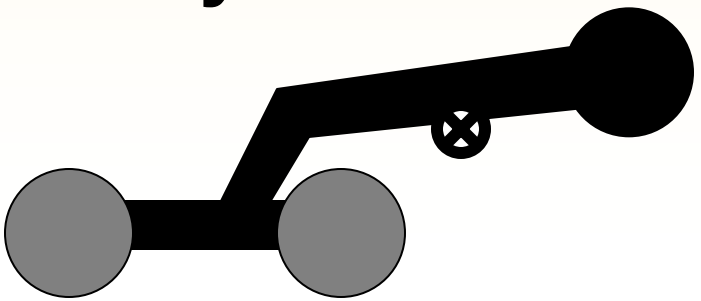
Wheel Suggestions

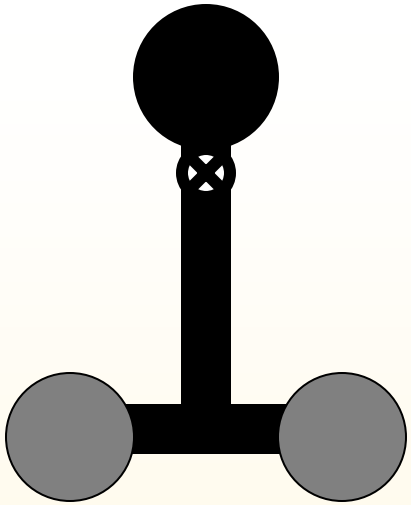
- It doesn't matter how many wheels you have, as long as they all are driven
- If you plan to turn, you should only have two "grippy" tires
  - Incline Conveyor Belt (wedge-top, rough-top)
  - Pneumatic Tires
  - Soft Rubber Tires
- Remaining wheels should be slick
  - Hard rubber or plastic
  - Omni-wheel/Wonder-wheel
  - Zip ties (in case of emergency only!)

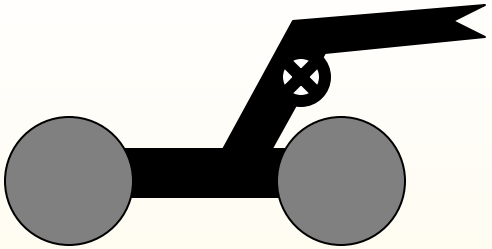
Basic Robot Design Theory

Center of Gravity









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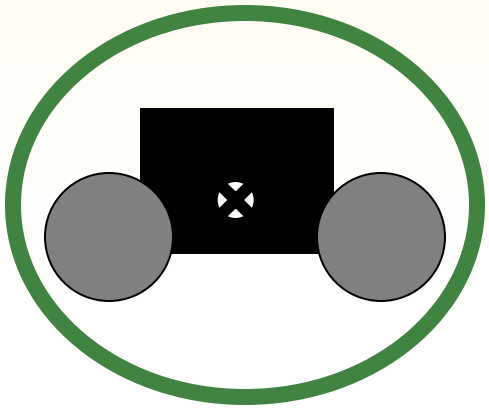

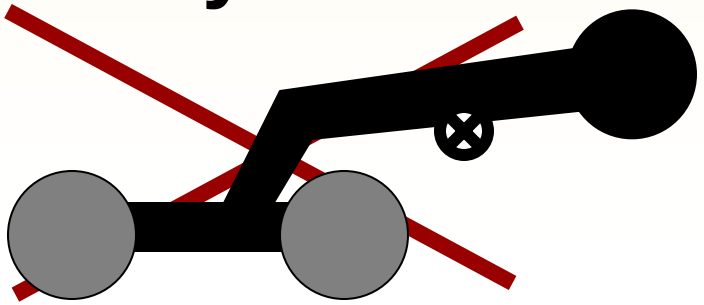

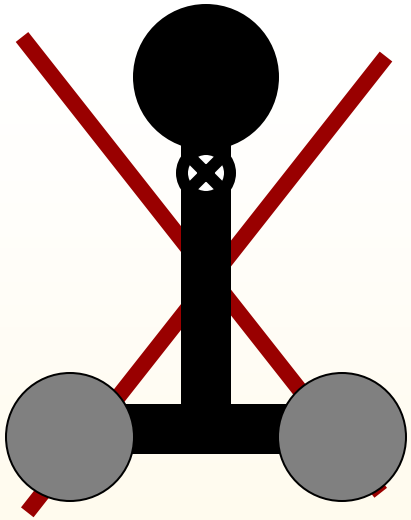

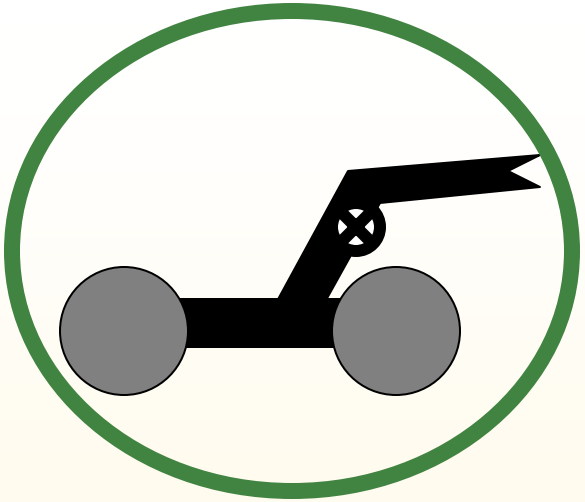

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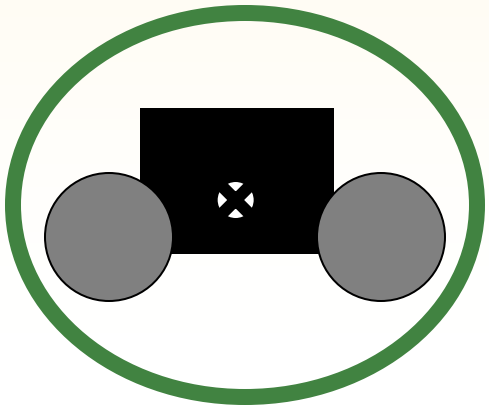

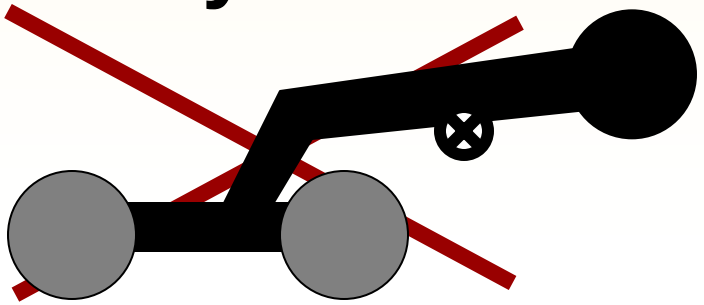

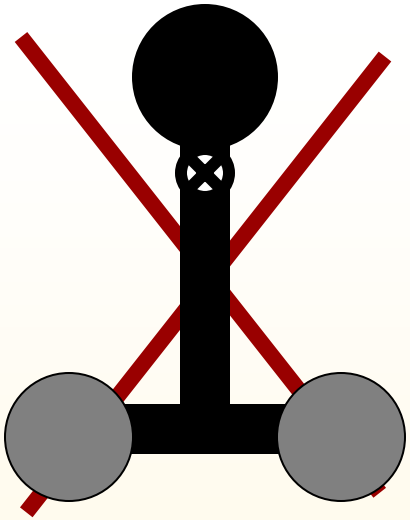

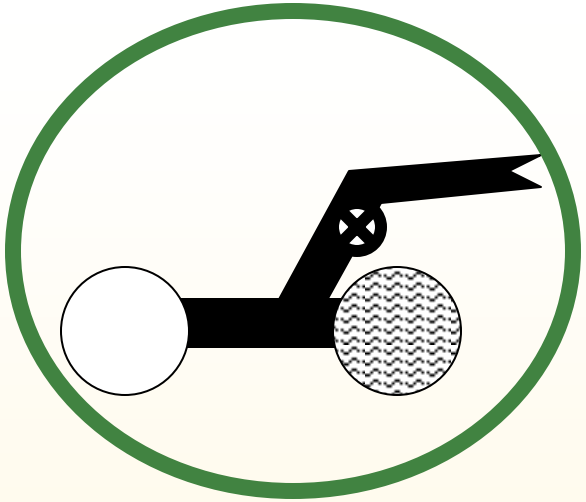

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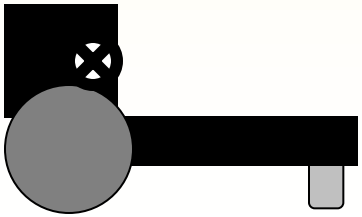

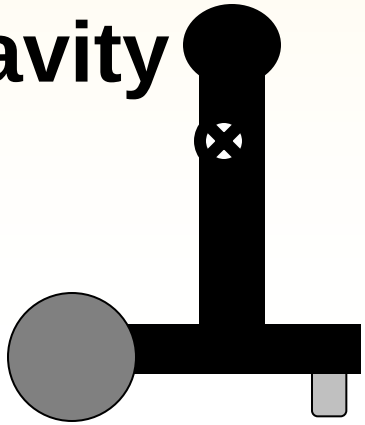

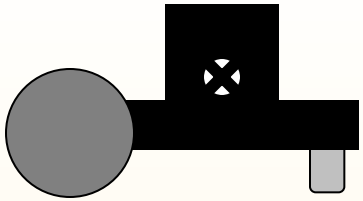

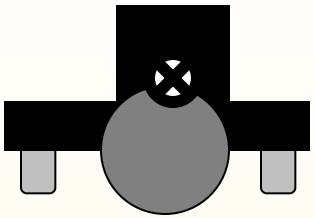

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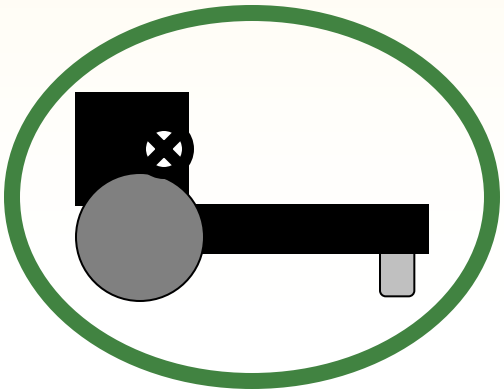

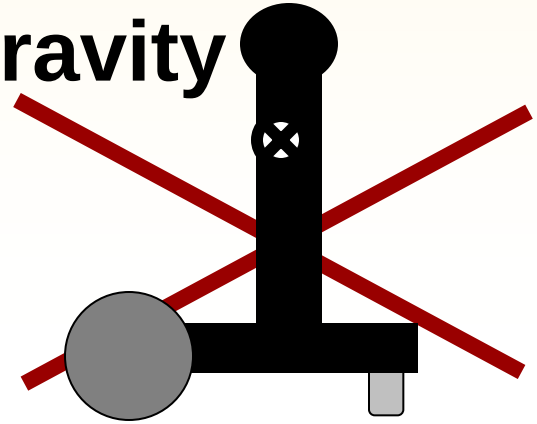

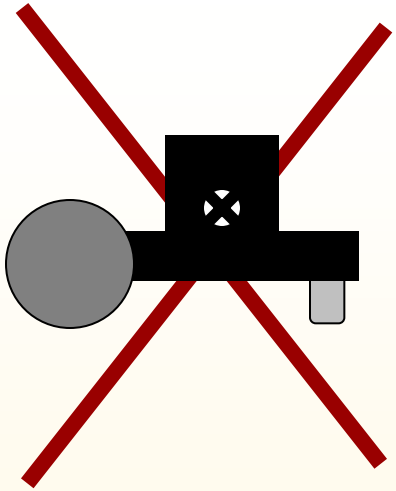

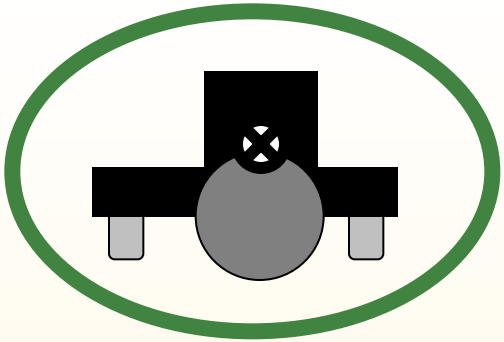

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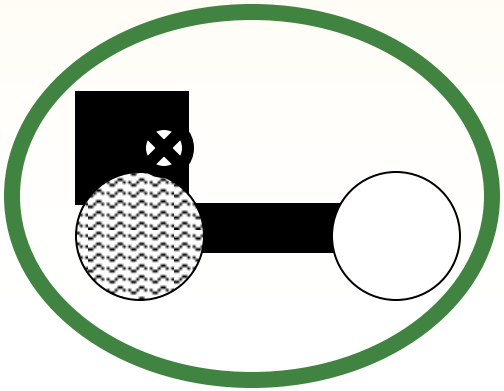
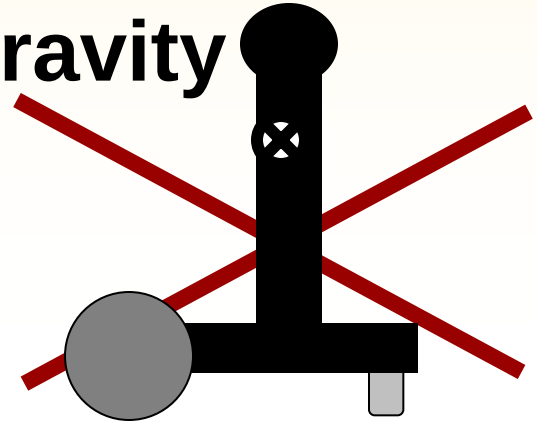
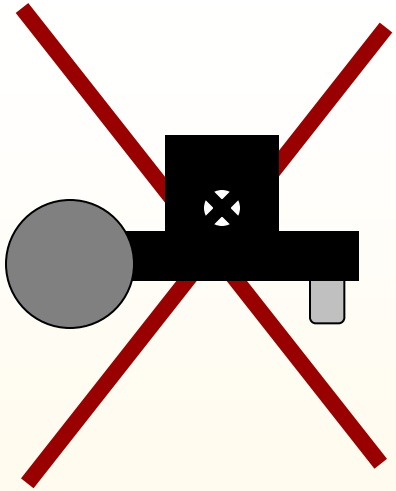
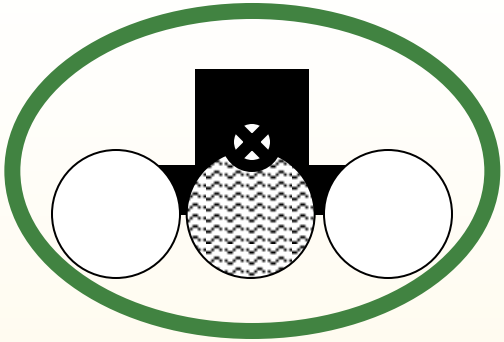








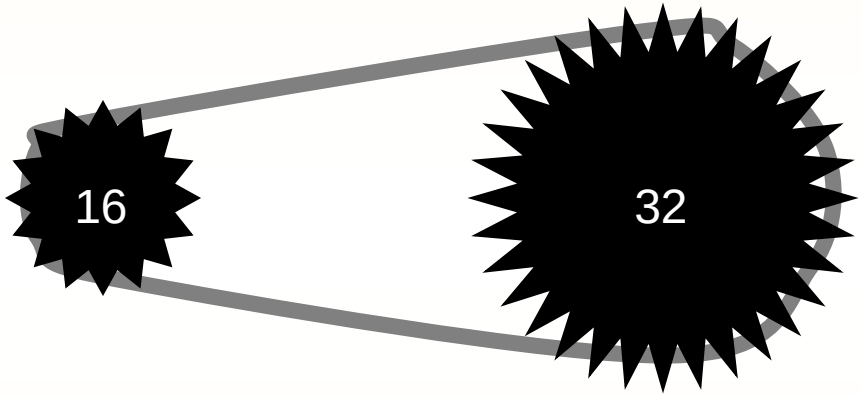
Basic Robot Design Theory

Weight Distribution Suggestions

- Your center of gravity must be between your wheels
- Your center of gravity must be between your wheels even when your robot is at an angle
- The wheels closest to your center of gravity should be grippy

Basic Robot Design Theory

Chain Theory



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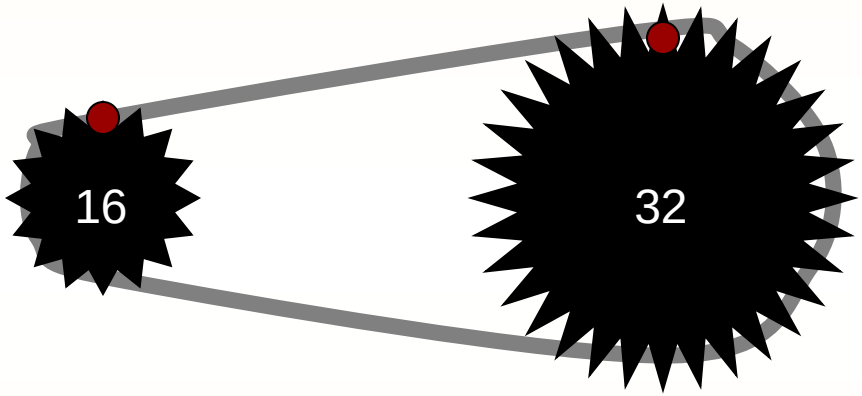

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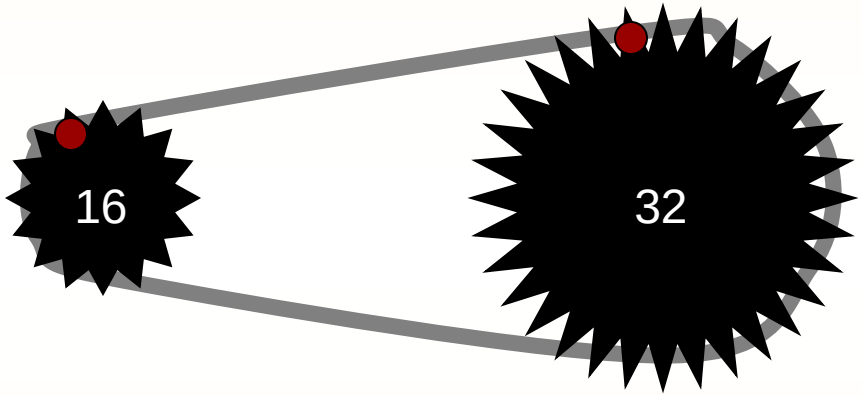

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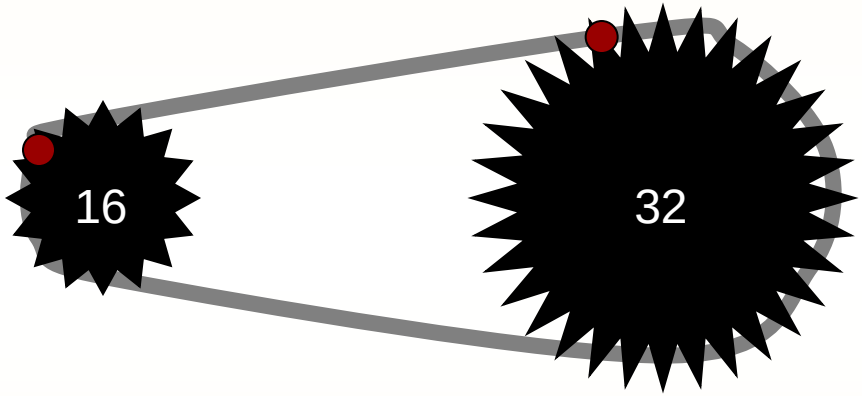

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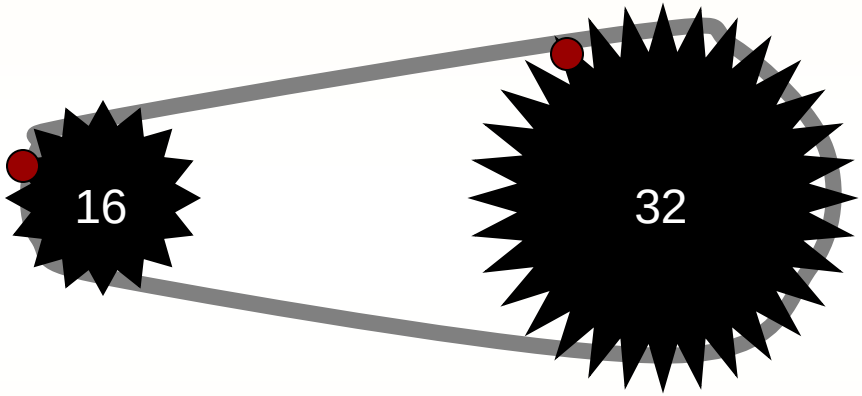

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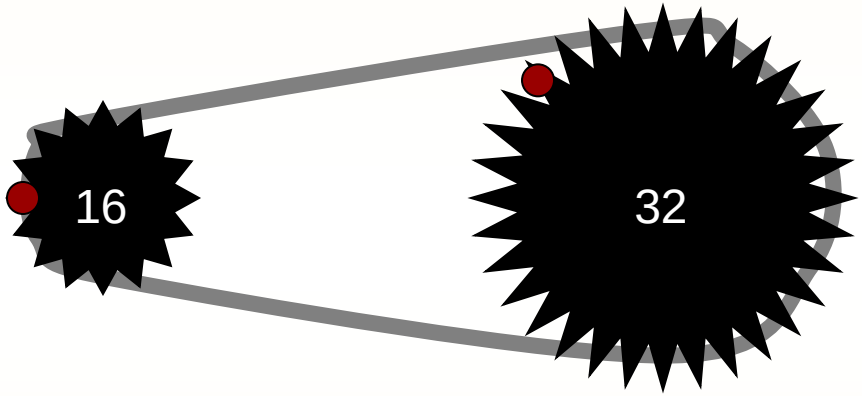

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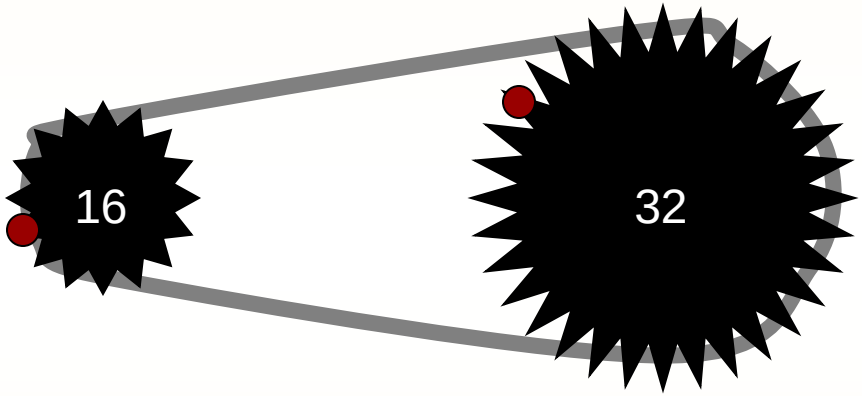

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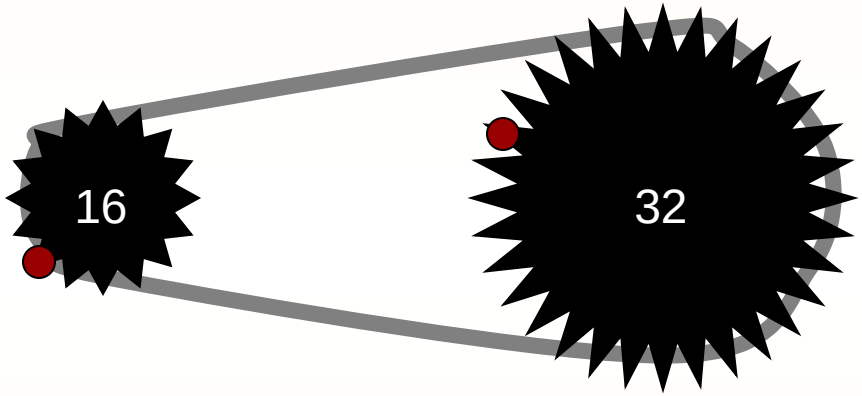

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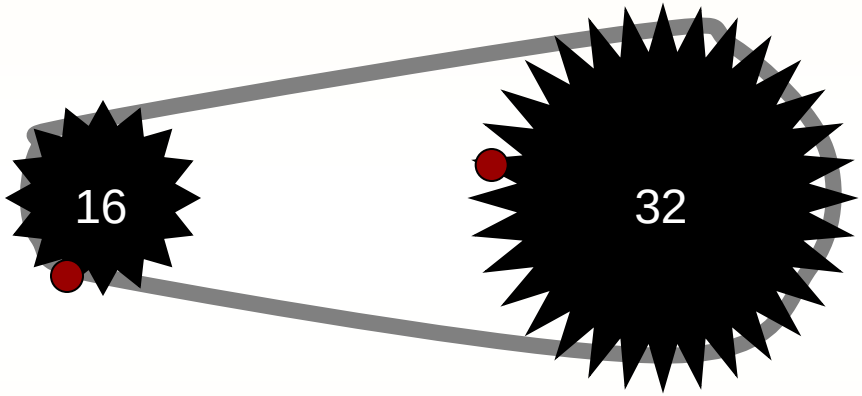

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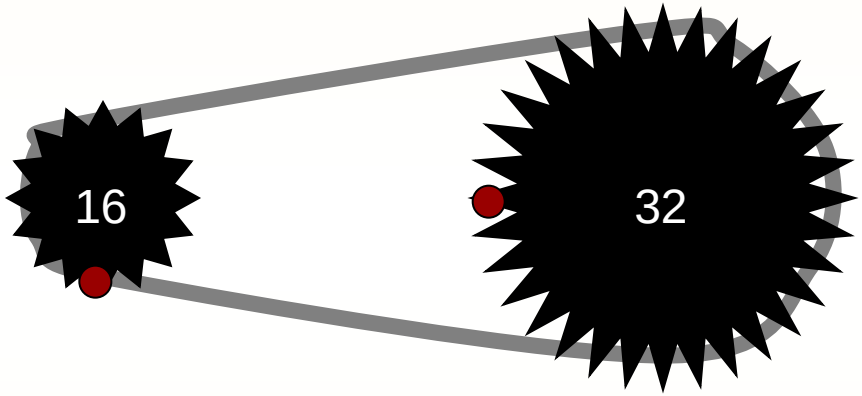

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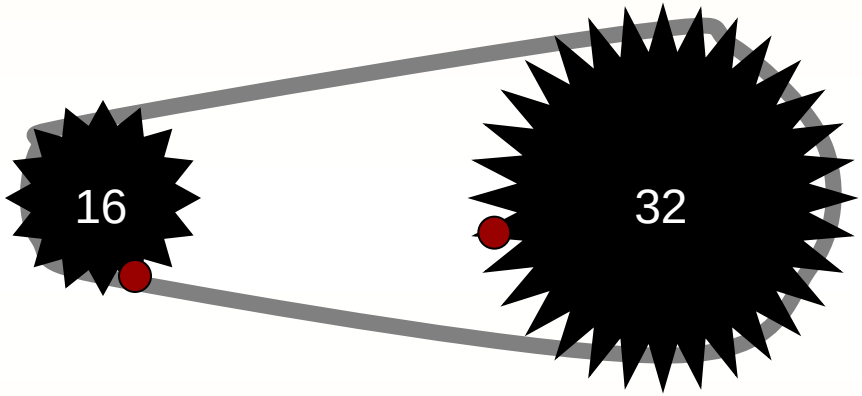

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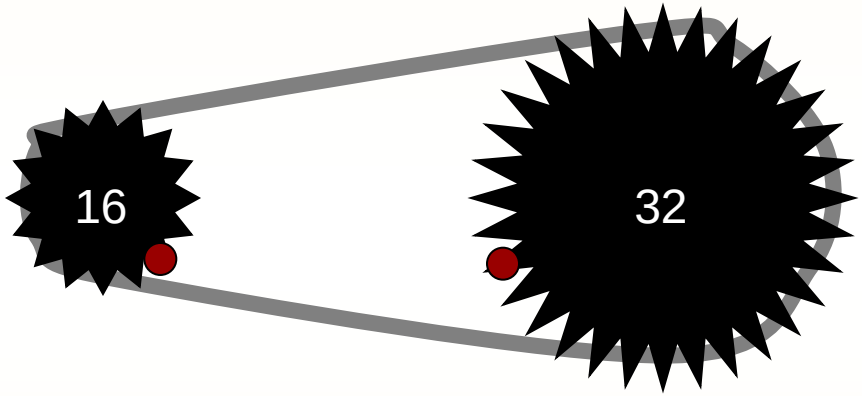

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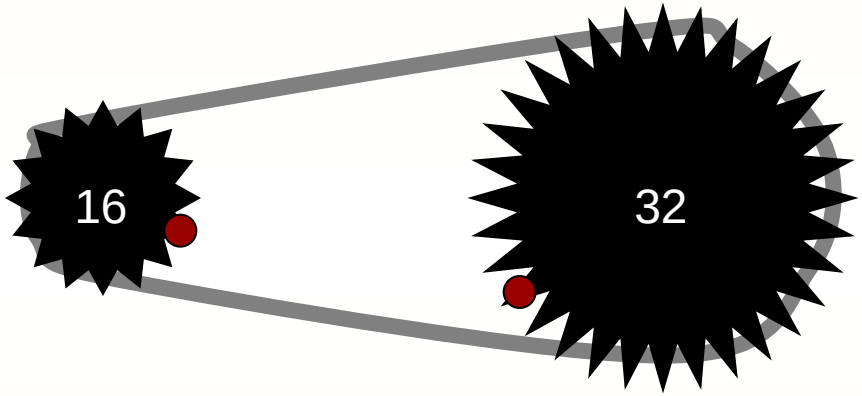

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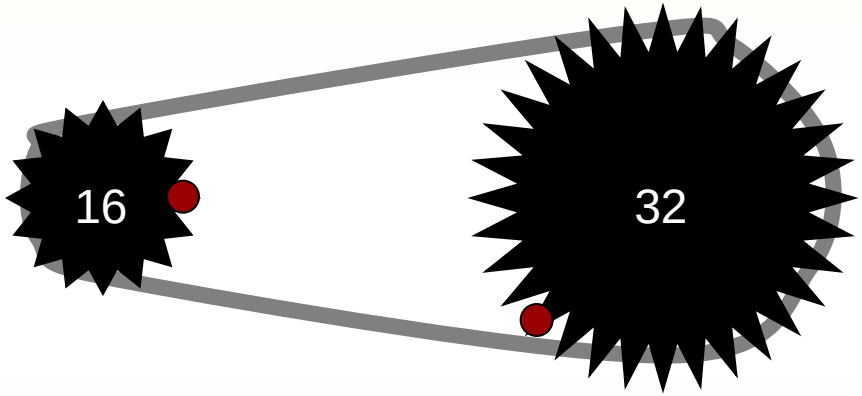

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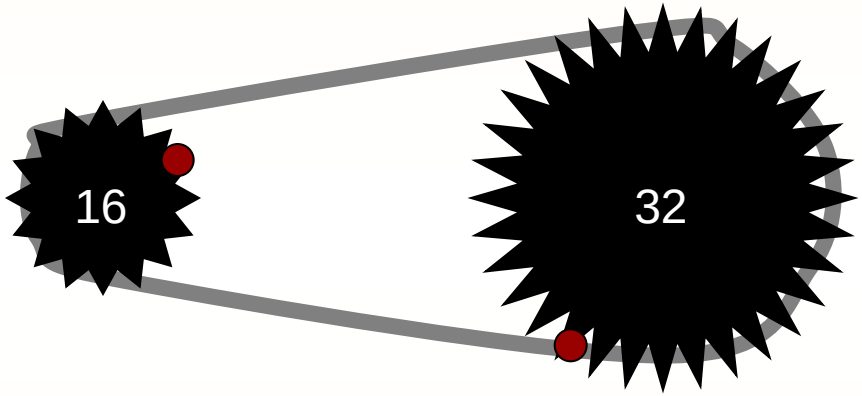

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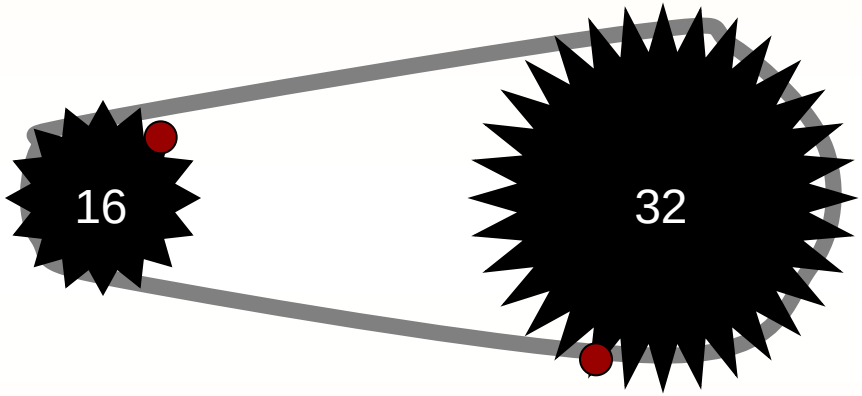

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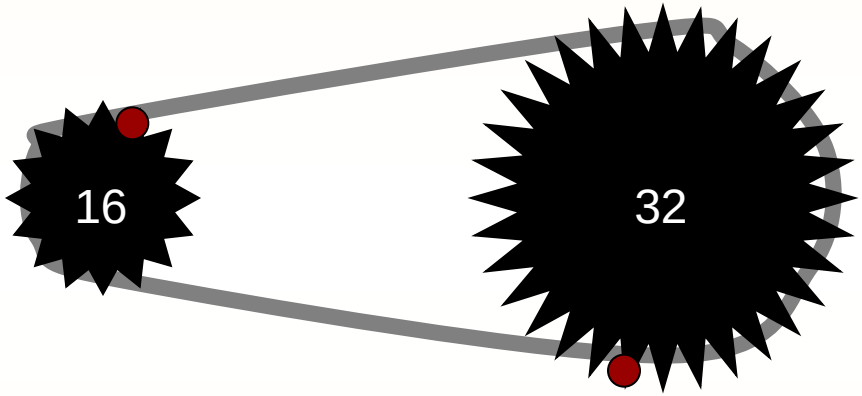

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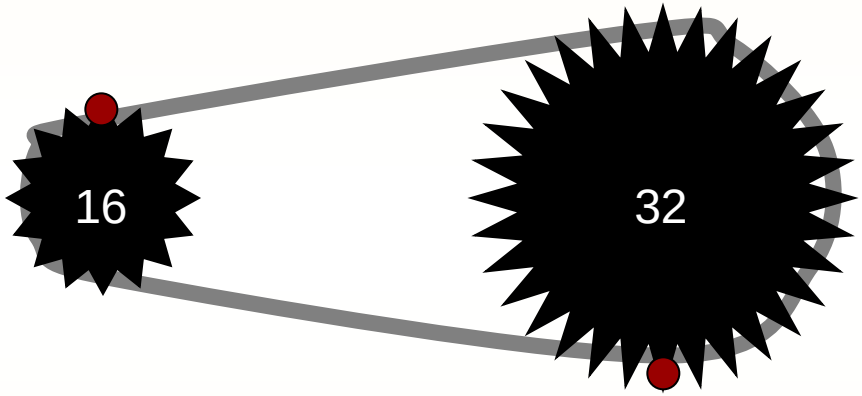


Basic Robot Design Theory

Chain Theory

$$rpm_{output} = rpm_{input} * ?$$

$$torque_{output} = torque_{input} * ?$$

Basic Robot Design Theory

Chain Theory

$$rpm_{output} = rpm_{input} * \frac{teeth_{input}}{teeth_{output}}$$

$$torque_{output} = torque_{input} * ?$$

Basic Robot Design Theory

Chain Theory

$$rpm_{output} = rpm_{input} * \frac{teeth_{input}}{teeth_{output}}$$

$$torque_{output} = torque_{input} * \frac{teeth_{output}}{teeth_{input}}$$

Basic Robot Design Theory

Robot Speed

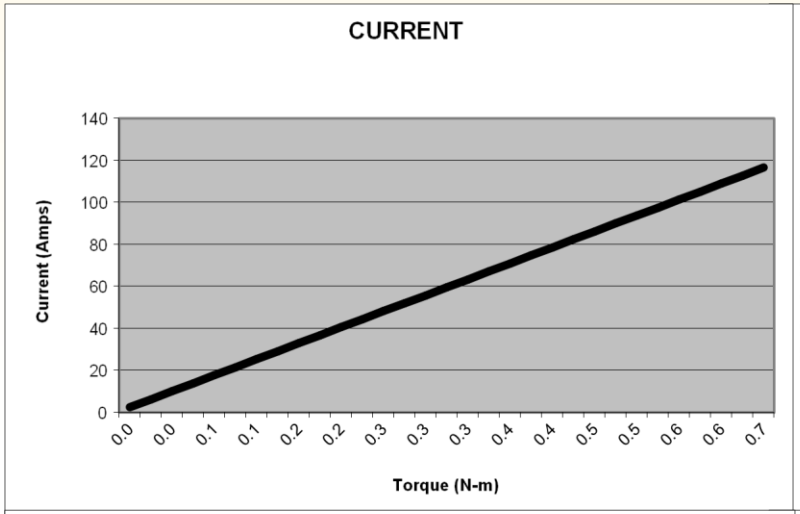
$$speed_{robot} = ?$$

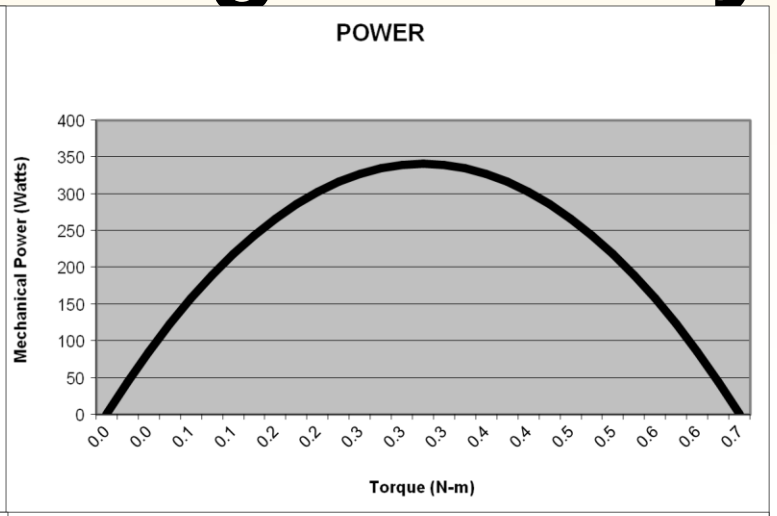
Basic Robot Design Theory

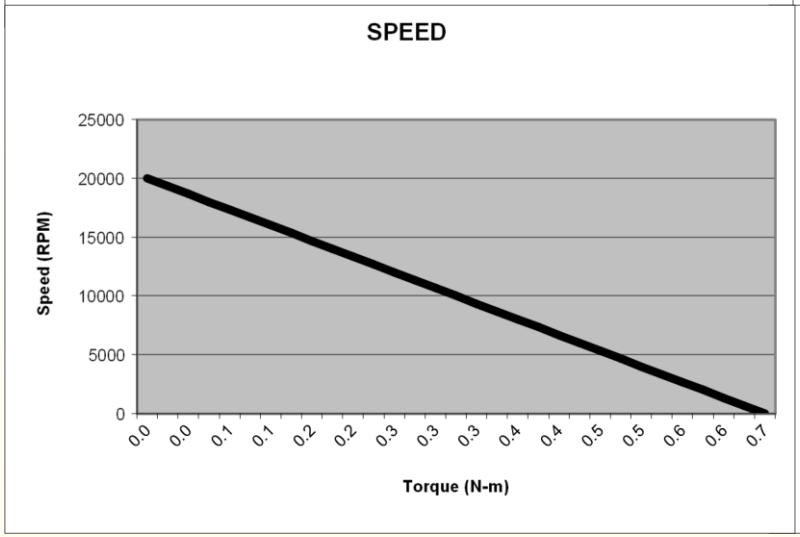
Robot Speed

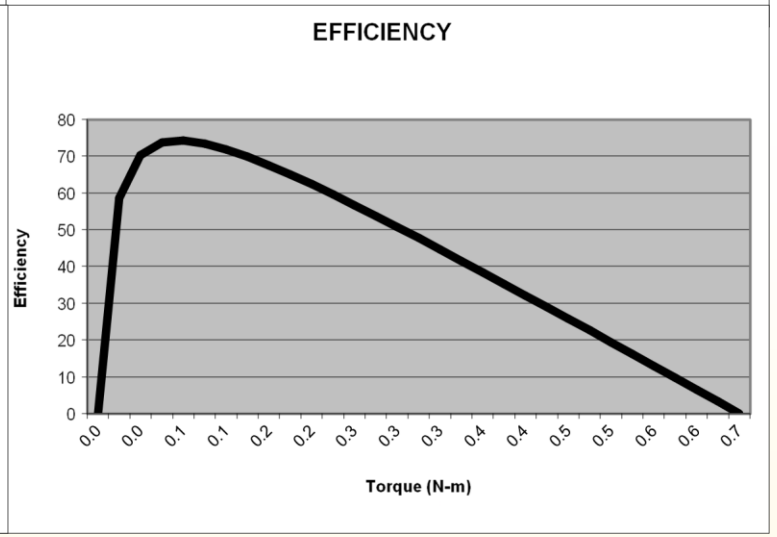
$$speed_{robot} = \frac{rpm_{wheel}}{60} * Diameter_{wheel} * \pi$$

Basic Robot Design Theory









Basic Robot Design Theory

Motor Performance Data

Speed (RPMs)	Torque (oz. in.)	Current (Amps)	Power Out (Watts)	Efficiency	Heat (Watts)
170	0.00	0.1	0.0	0%	1
159	4.68	0.3	0.5	26%	2
147	9.35	0.4	1.0	34%	2
136	14.03	0.5	1.4	36%	2
125	18.71	0.6	1.7	36%	3
113	23.38	0.7	2.0	34%	4
102	28.06	0.8	2.1	32%	4
91	32.73	0.9	2.2	29%	5
79	37.41	1.0	2.2	26%	6
68	42.09	1.1	2.1	23%	7
57	46.76	1.2	2.0	19%	8

Basic Robot Design Theory

Robot Speed

What size wheel should I use if I want my robot's maximum speed to be 3 feet per second?

Basic Robot Design Theory

Robot Speed

What size wheel should I use if I want my robot's maximum speed to be 3 feet per second?

$$3 = \frac{\sim 120}{60} * Diameter_{wheel} * \sim 3$$

Basic Robot Design Theory

Robot Speed

What size wheel should I use if I want my robot's maximum speed to be 3 feet per second?

$$Diameter_{wheel} \approx \frac{1}{2} \quad (6 \text{ inches})$$

Basic Robot Design Theory

Robot Speed

If the 6” wheels are the largest I can fit onto my robot, how would I make my robot’s maximum speed 6 feet per second?

Basic Robot Design Theory

Robot Speed

If the 6” wheels are the largest in the kit, how would I make my robot’s maximum speed 6 feet per second (without damaging the motor or making custom wheels)?

Put a sprocket on the motor that is half the size of the sprocket on the wheel.

Basic Robot Design Theory

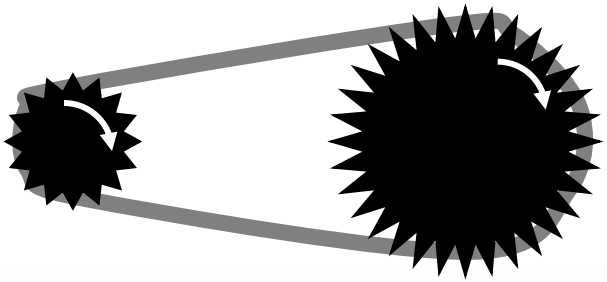
Sprockets vs. Gears

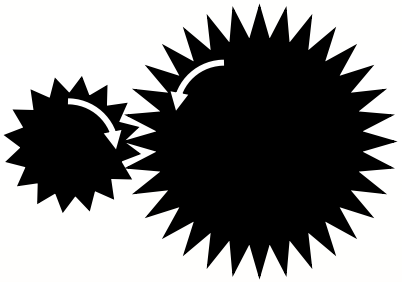
Sprocket

Gears

Basic Robot Design Theory

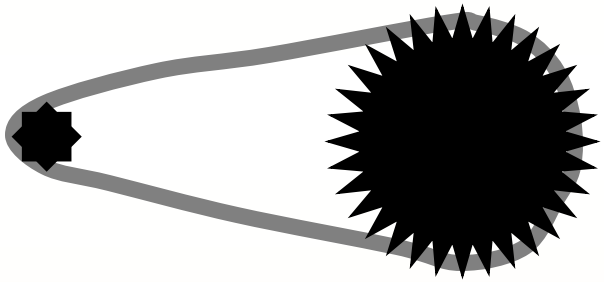
Sprockets vs. Gears





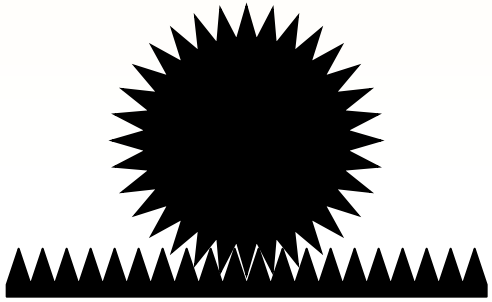
Basic Robot Design Theory

Sprockets vs. Gears



Maximum ratio 8:1

9–72 teeth



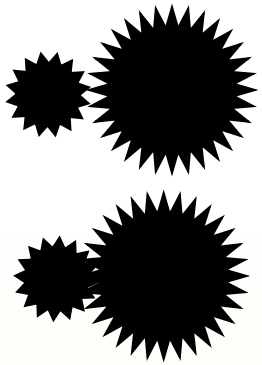
Infinite Ratio Possible

13 – ∞ teeth (<18 not recommended)

Basic Robot Design Theory

Sprockets vs. Gears

Face Alignment Critical



Spacing Critical

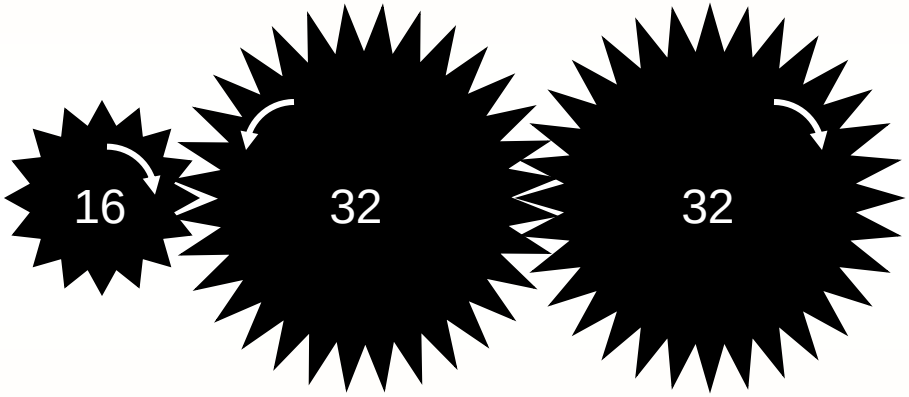
Basic Robot Design Theory

Gear and Sprocket Recommendations

- Sprockets are used with chains, gears mesh with each other
- Sprockets and gears are NOT interchangeable
- Sprocket and chain systems are easier to build than gear systems
- Gear systems can be smaller and lighter than chains and sprockets

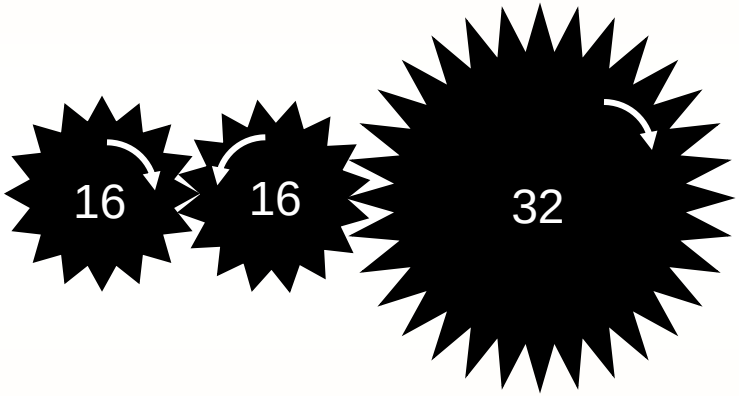
Basic Robot Design Theory

Idler Gears



Basic Robot Design Theory

Idler Gears



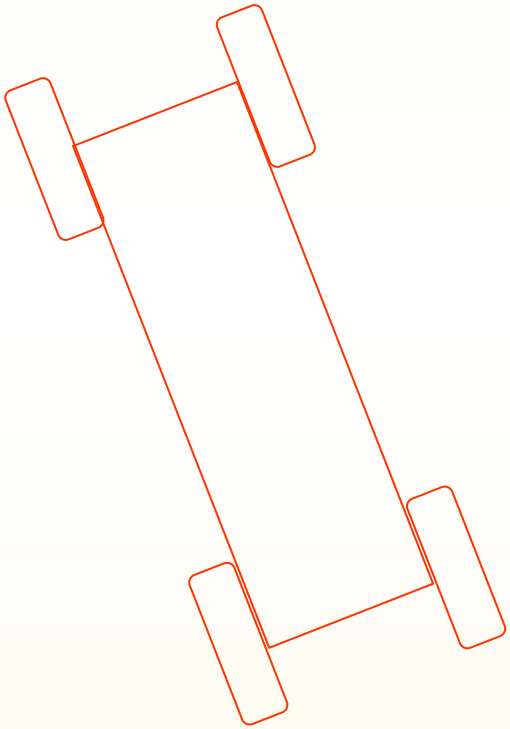
Basic Robot Design Theory

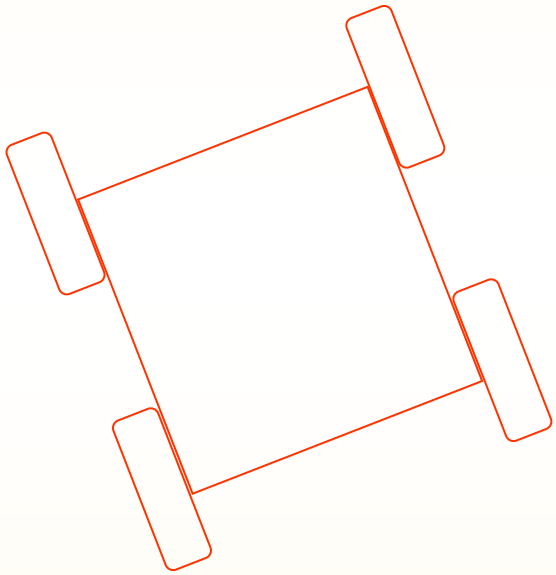
Further Gear and Sprocket Recommendations

- Idler gears change direction of motion, but don’t change gear ratio
- Properly designed gear or chain and sprocket systems are ~97% efficient at each gear/sprocket, so idlers don’t effect much if you don’t go overboard

Basic Robot Design Theory

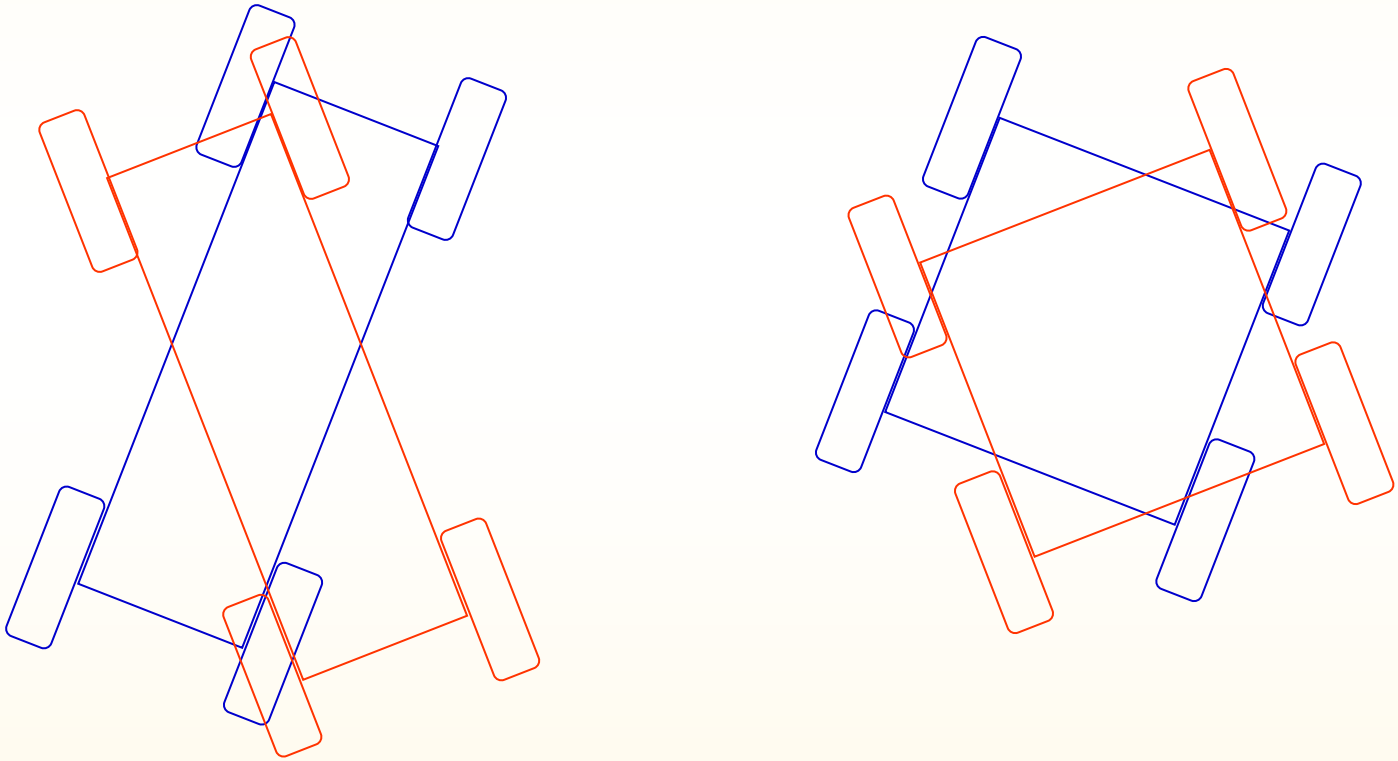
Wheelbase



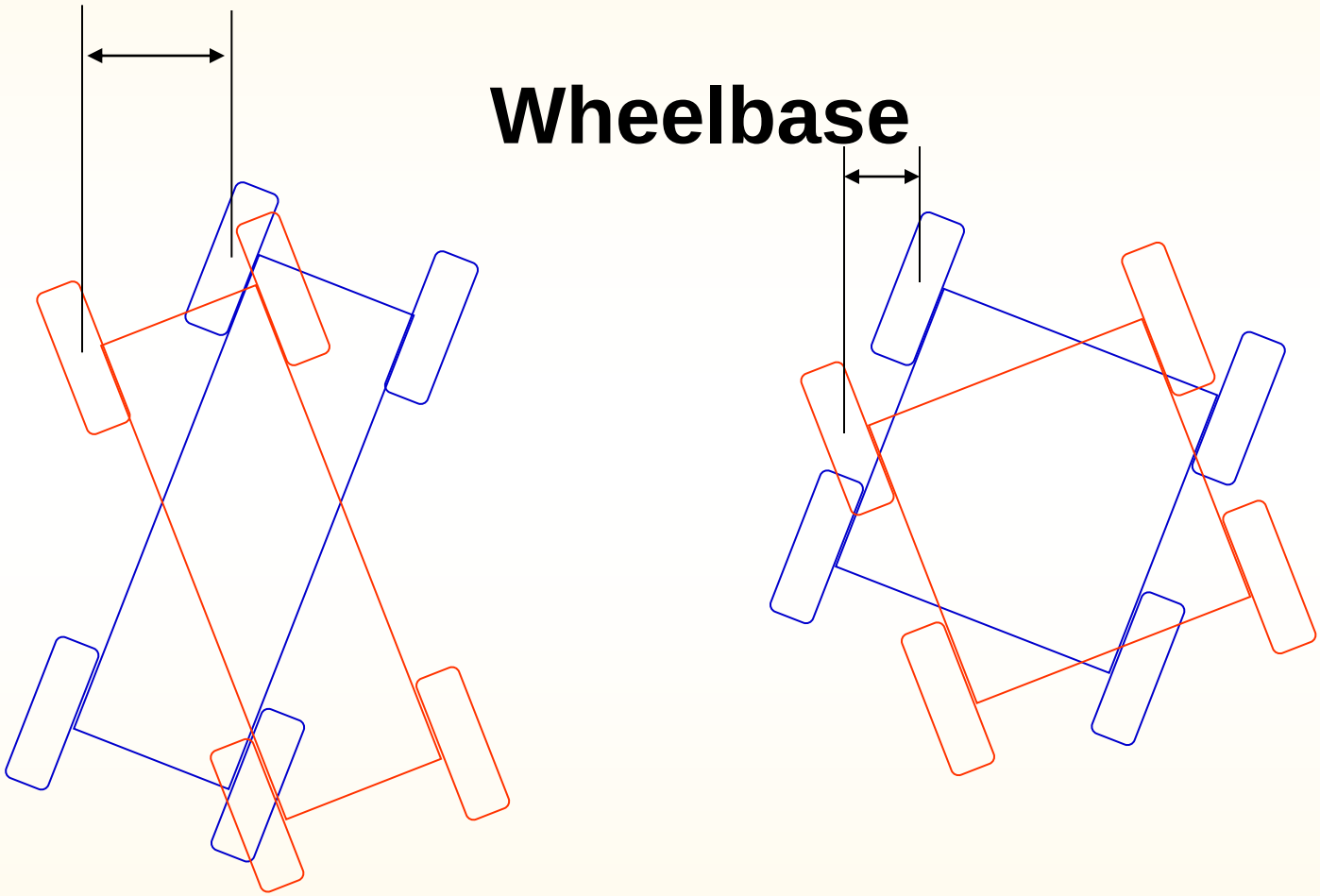


Basic Robot Design Theory

Wheelbase

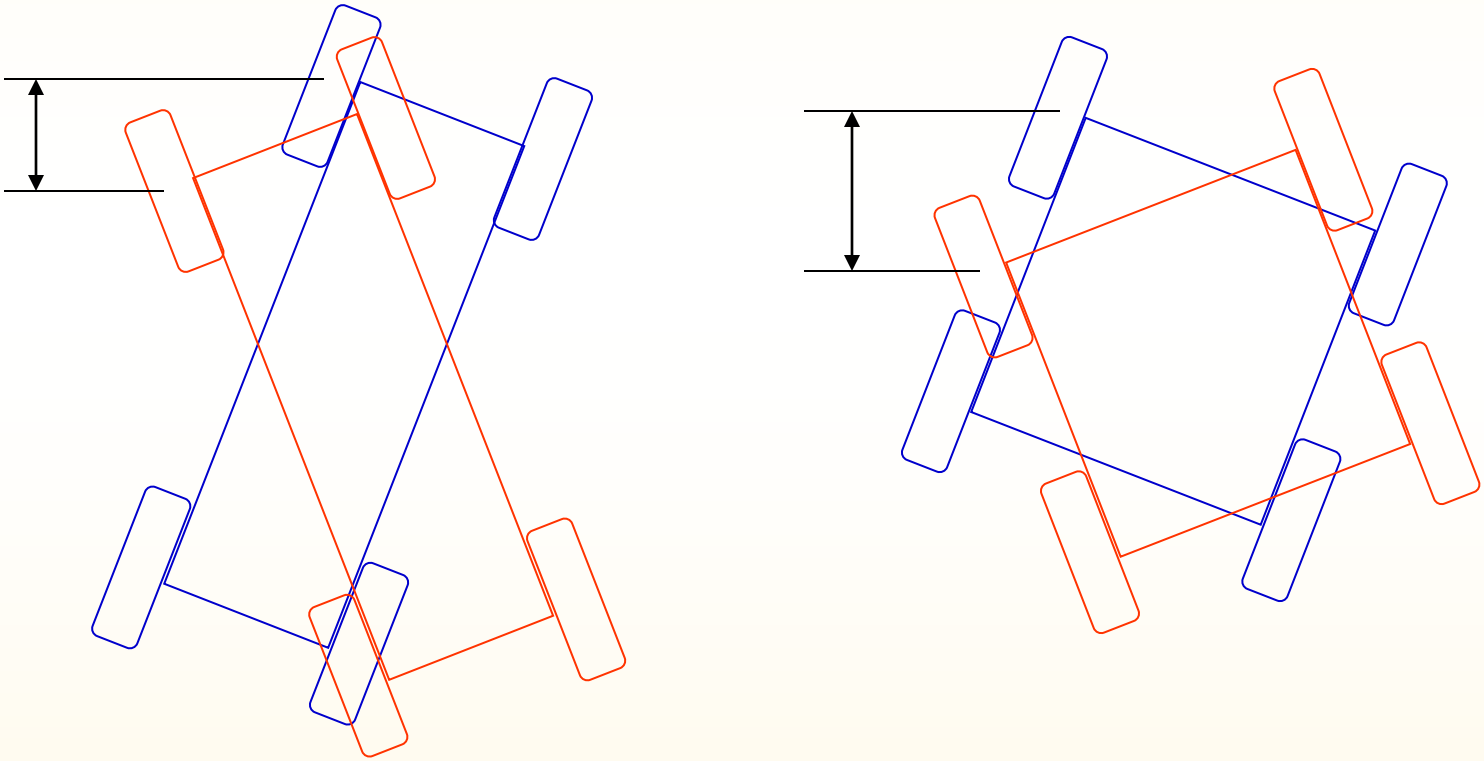


Basic Robot Design Theory



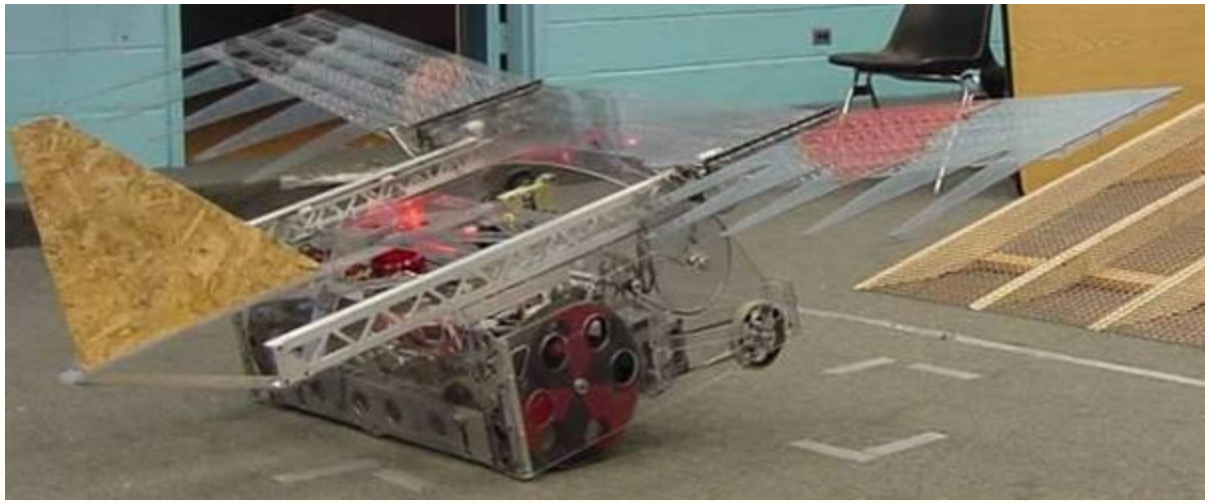
Basic Robot Design Theory

Wheelbase



Basic Robot Design Theory

Wheelbase



Basic Robot Design Theory

Wheelbase Recommendations

- Short and wide robots turn easily and have lots of control, but will tend to not drive straight
- Long and narrow robots will not turn easily and will have poor turning control, but will tend to drive very straight
- Depending on the task, you should balance the two

Building a Chassis

Building a Chassis

Design Tradeoffs

- Stable vs. Maneuverable
- Accessible vs. Compact
- Strong & Rigid vs. Light
- Manufacturabile & Affordable vs. Everything

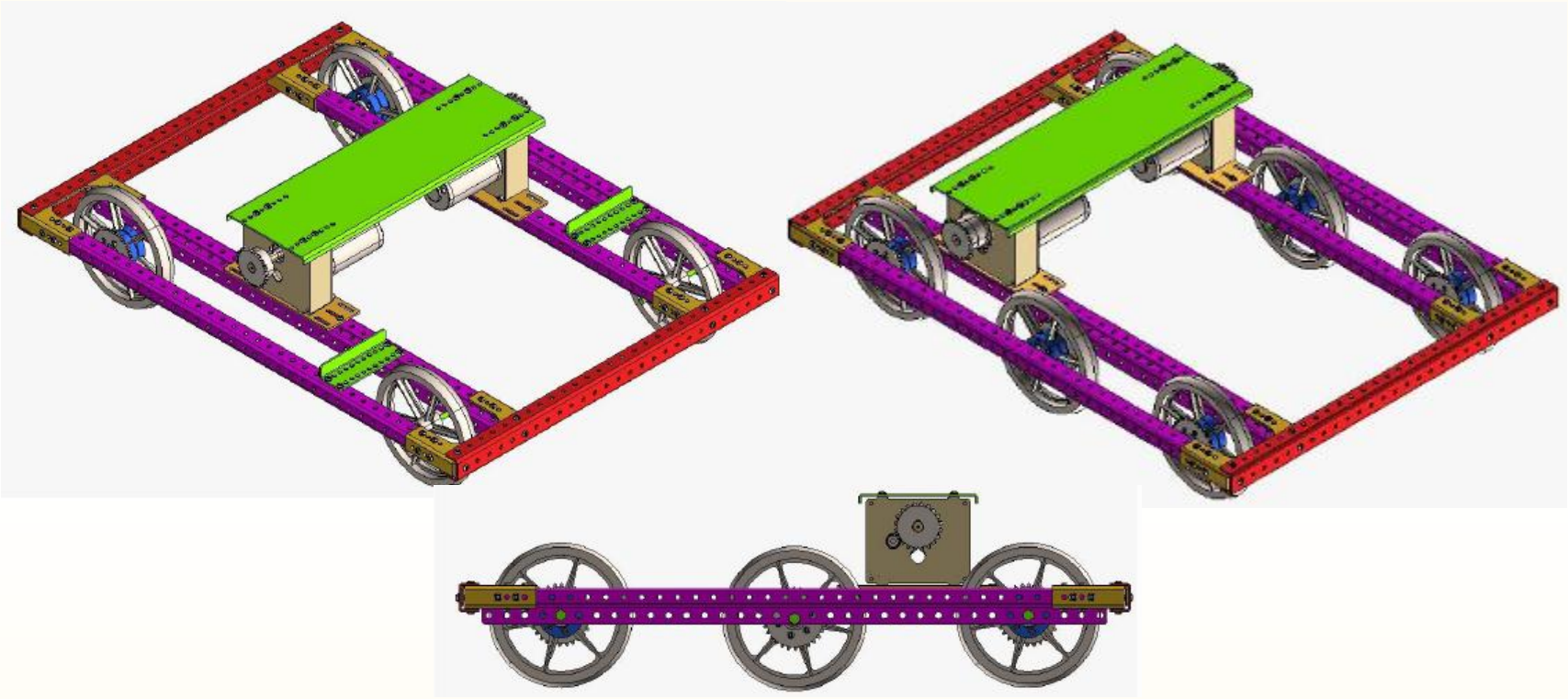
Building a Chassis

Design Tradeoffs

- Stable vs. Maneuverable
- Accessible vs. Compact
- Strong & Rigid vs. Light
- Manufacturabile & Affordable vs. Everything

Building a Chassis

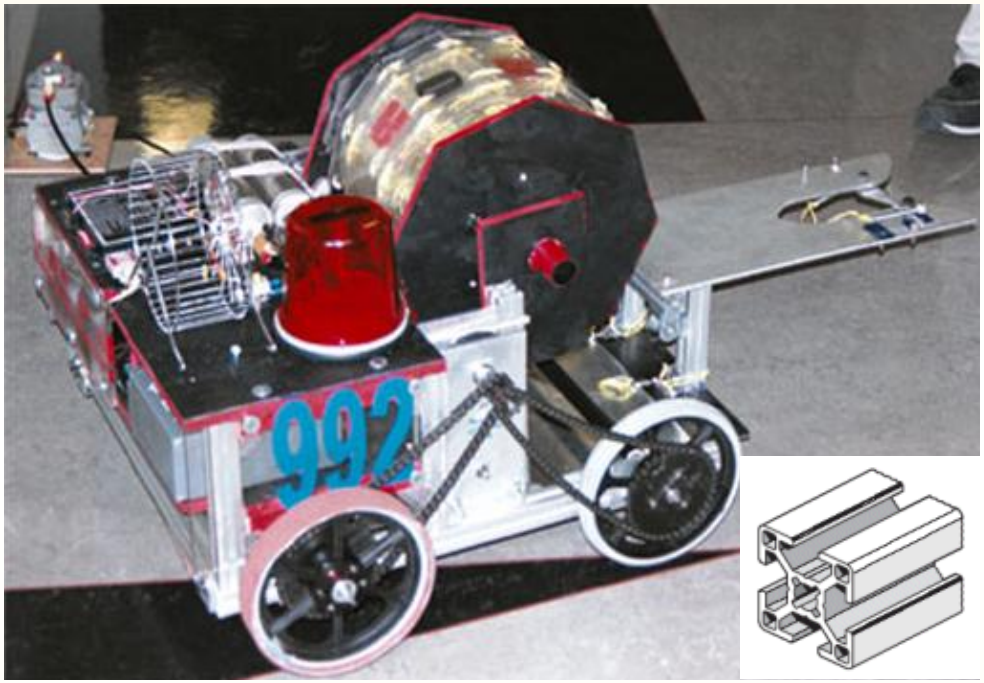
Kit Chassis



- **Advantages: lightweight, quick to build, uses standard parts**
- **Disadvantages: may not fit your design, requires added structure (that will most likely be put on anyway)**

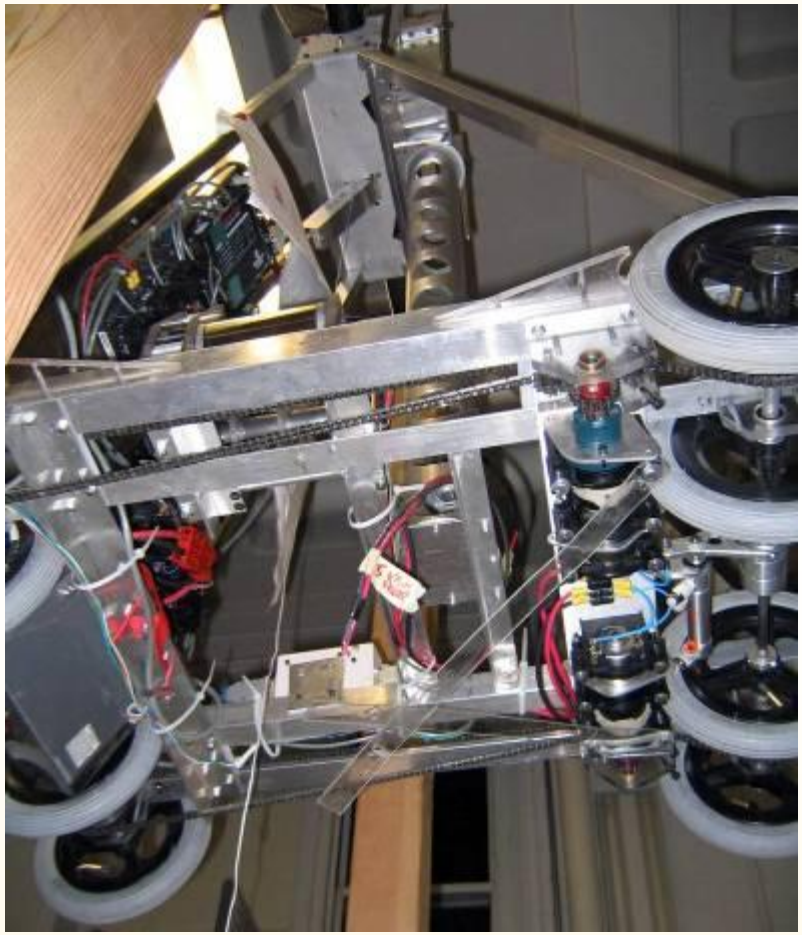
Building a Chassis

T-Slot Extrusion (80/20)



- **Advantages: quick to build, standard parts, easy to create tension and to add fastening points**
- **Disadvantages: heavy, expensive**

Building a Chassis
Aluminum Tube and Plate



- **Advantages: lightweight, strength, fits your design**
- **Disadvantages: takes time, requires skill, non standard parts**

Building a Chassis

Miscellaneous

- **Advantages: fits your design, unique**
- **Disadvantages: takes much time, requires skill, non standard parts**

Building a Chassis

Materials

- Aluminum Extrusion
  - 1/16” – 1/8”: usable but will dent and bend
  - T-slot: use 1” sized profiles or higher
- Aluminum Plate, Bar, and Angle
  - 3/16” – ¼” used often
- Plastic Sheet
  - Spans structures, provides bracing
  - Polycarbonate (LEXAN, etc.) NOT Acrylic (Plexiglas, etc.)
- Wood
  - Lightweight and easy to use
  - Will splinter and fail but can be fixed
- Steel Tube and Angle
  - Strong, but heavy, 1/16” wall thickness is plenty strong
- Misc
  - Extruded fiberglass, PVC tubing, etc. Use your imagination!

Building a Driveline

Building a Driveline

Design Tradeoffs

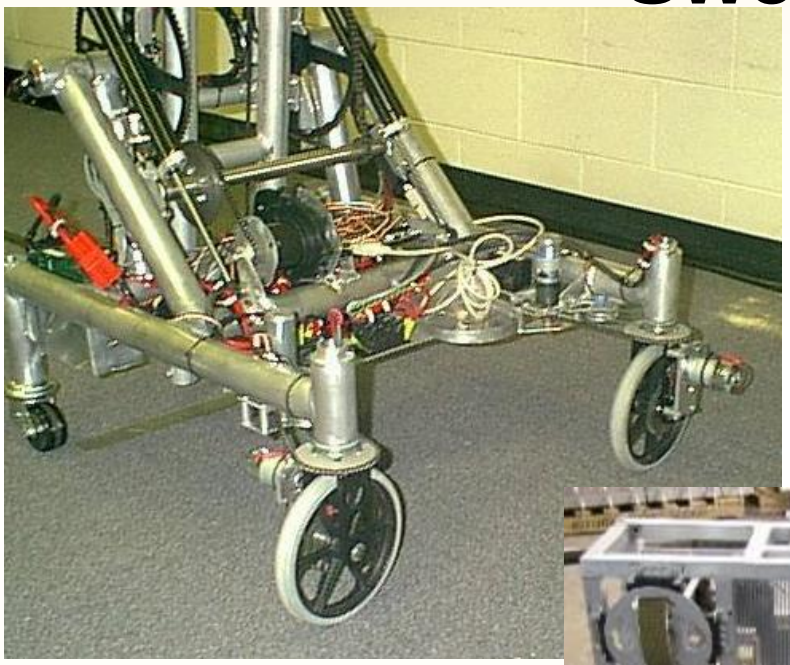
- Speed vs. Power
- Traction vs. Maneuverability

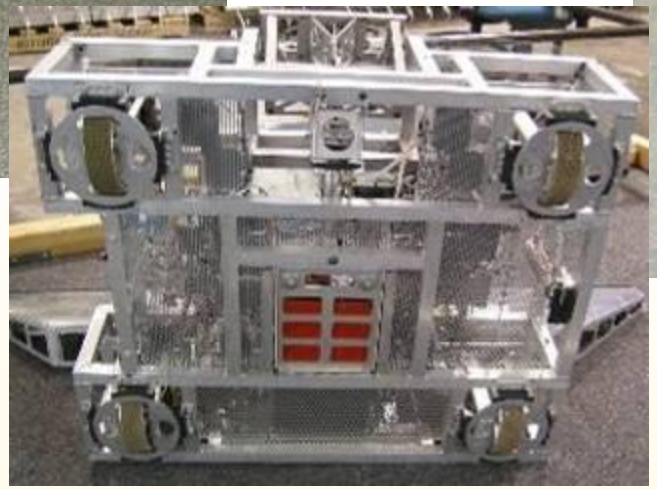
Building a Driveline

6-Wheel Drive

Building a Driveline

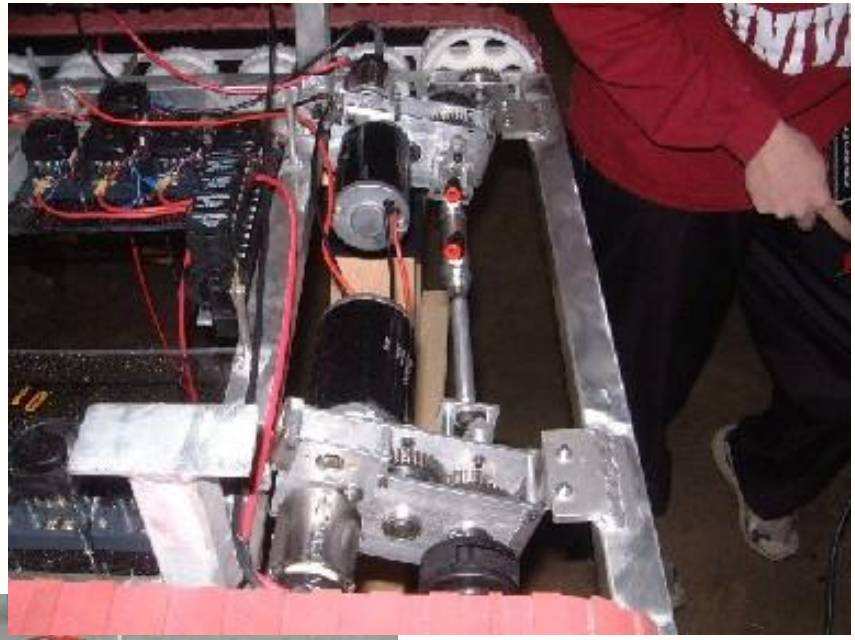
Swerve Drive

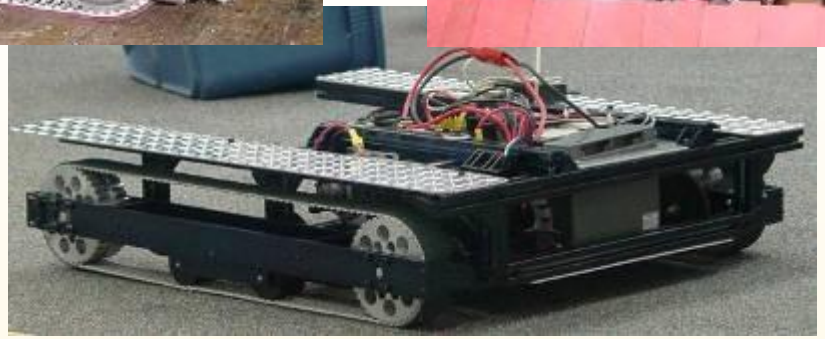




Building a Driveline

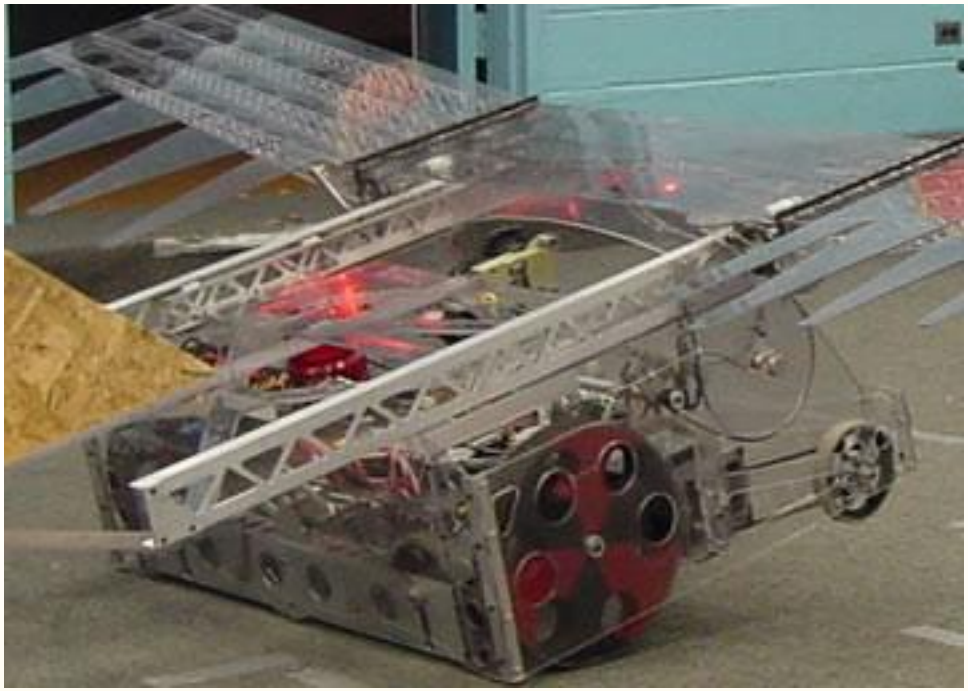
Treads





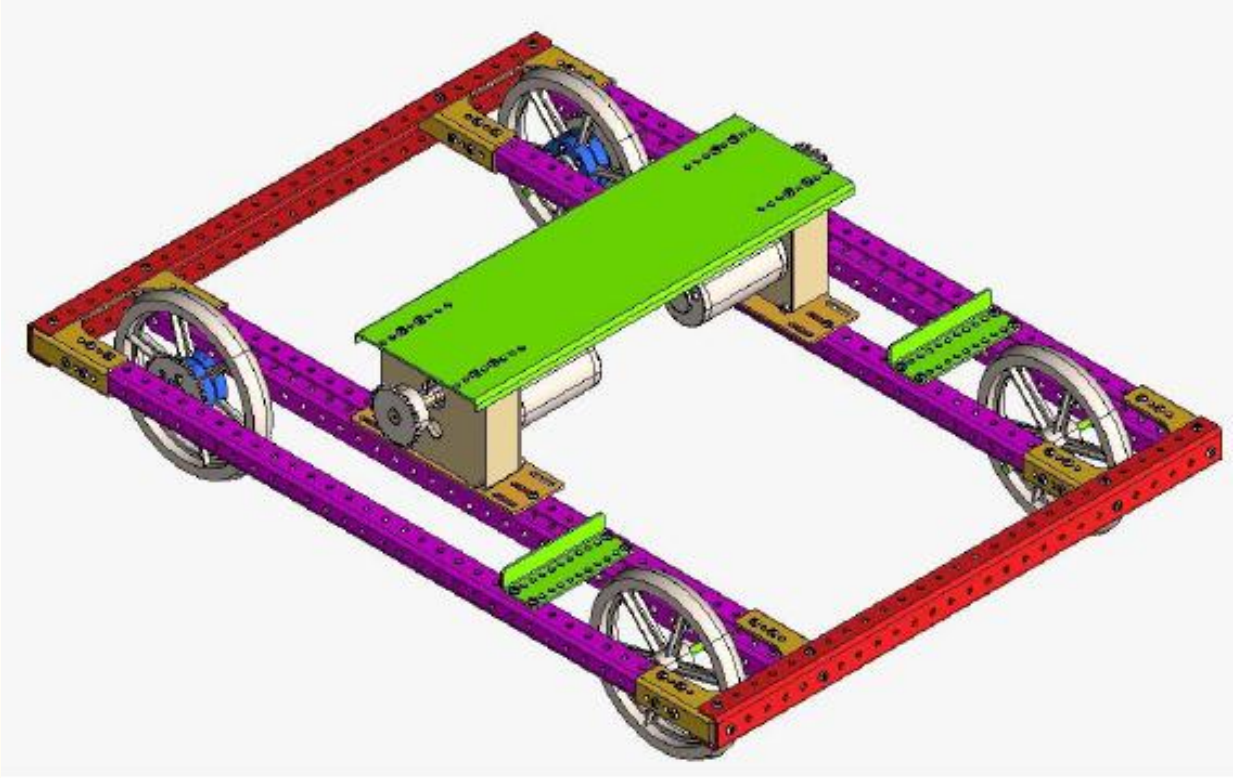
Building a Driveline

Other Wheel Configurations



Building a Driveline

Standard 4-wheel Tank Drive



Building a Driveline

Wheel Sources

- Kit of Parts Skyway wheels (more available at FIRST team discount from 800-332-3357)

- Colson Casters (available from many places, including http://www.robotmarketplace.com/)

- FIRST Specific wheels (high traction wheels, omniwheels, etc)
  - http://andymark.biz/
  - http://ifirobotics.com/

- Make your own (can be made from aluminum, wood, HDPE, lexan, etc.)

Building a Driveline

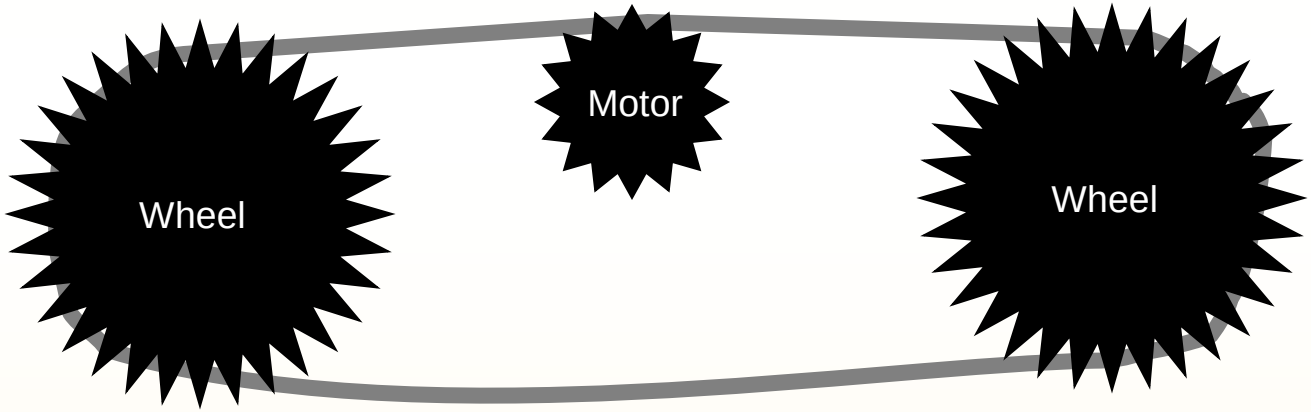
Driveline Recommendations

• There are many types of drivelines, choose the one that best fits your specific game strategy.

• A well driven, reliable, “vanilla” driveline will beat a complex and unreliable driveline in competition.

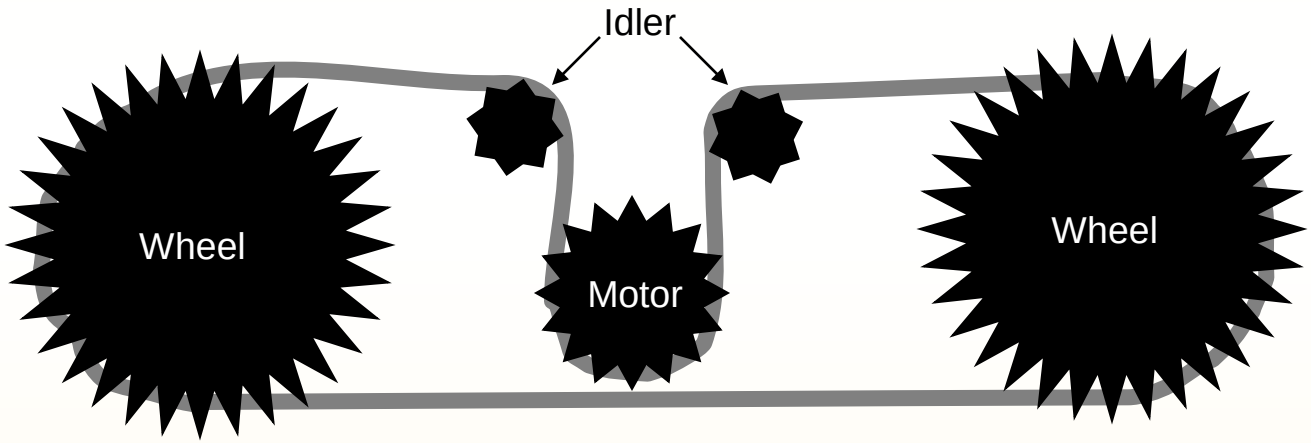
Building a Driveline

Chain Wrap



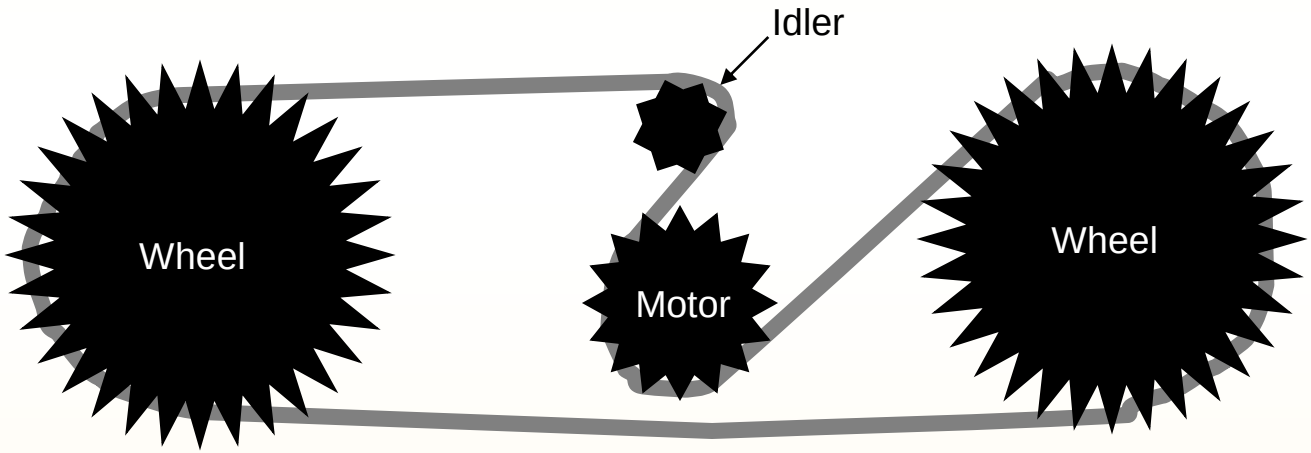
Building a Driveline

Chain Wrap



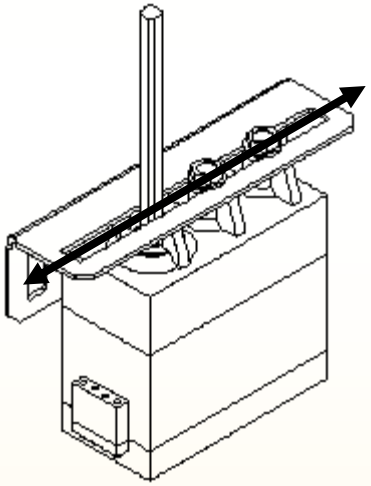
Building a Driveline

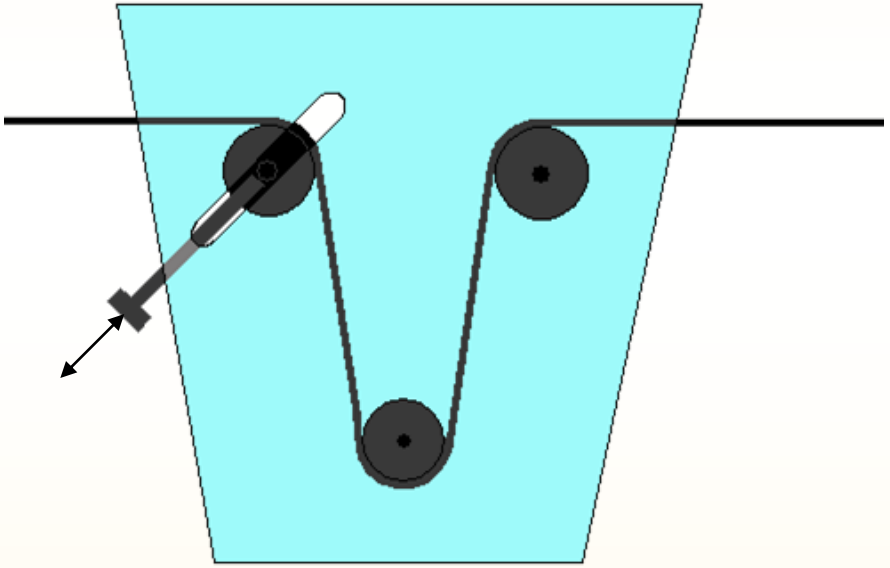
Chain Wrap



Building a Driveline

Chain Tension





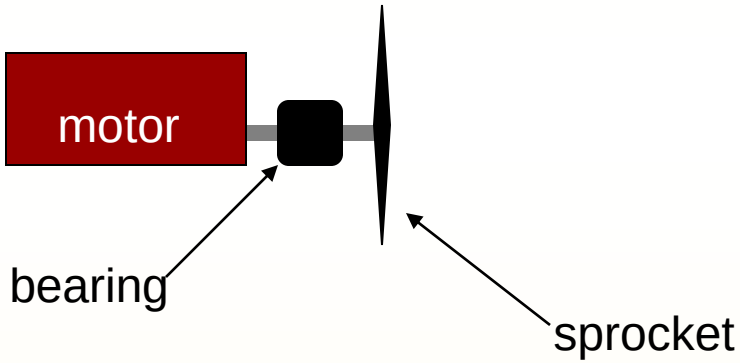
Building a Driveline

Further Gear and Sprocket Recommendations

- All sprockets must have >120º of chain wrap (180º is better)
- Chains “stretch” as they wear, have a way to adjust tension

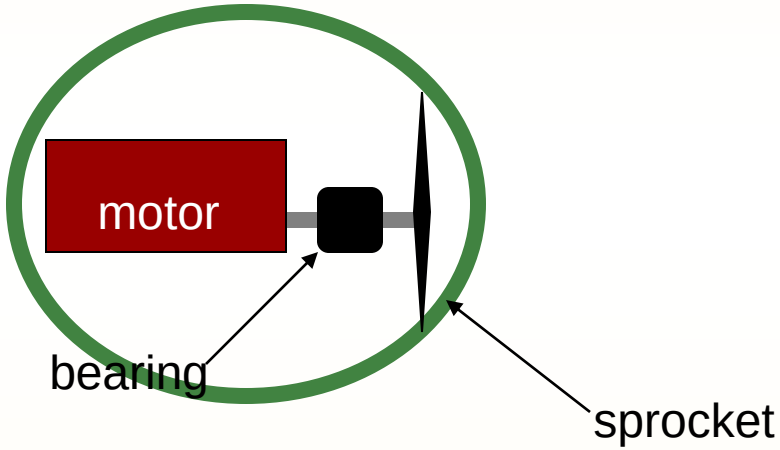
Building a Driveline

Supporting Shafts



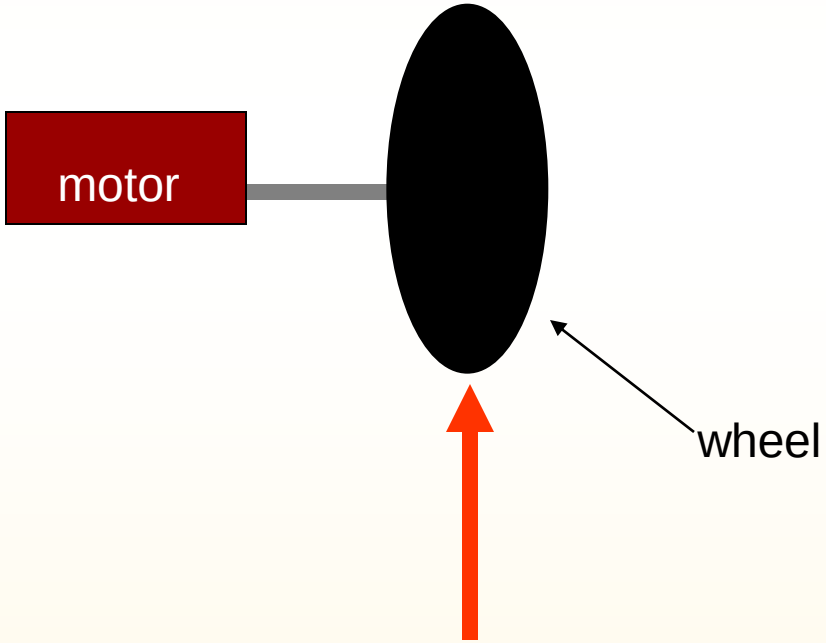
Building a Driveline

Supporting Shafts



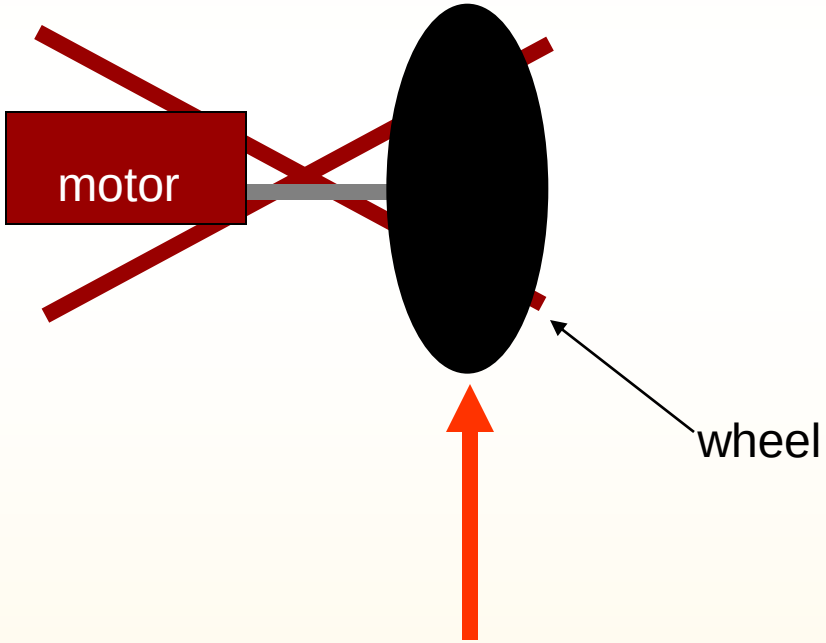
Building a Driveline

Supporting Shafts



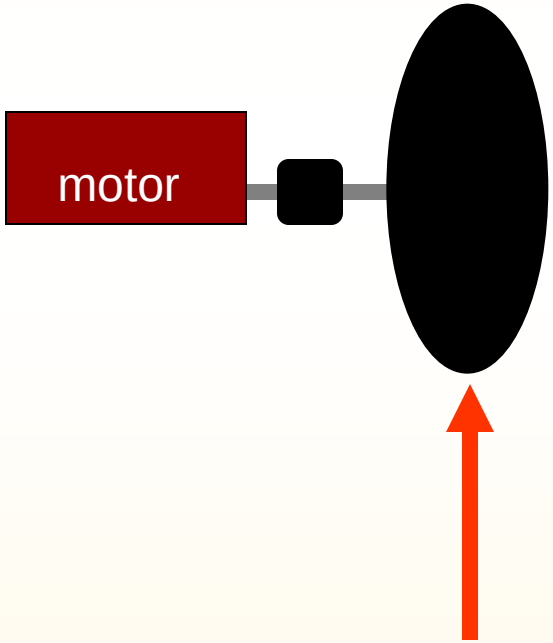
Building a Driveline

Supporting Shafts



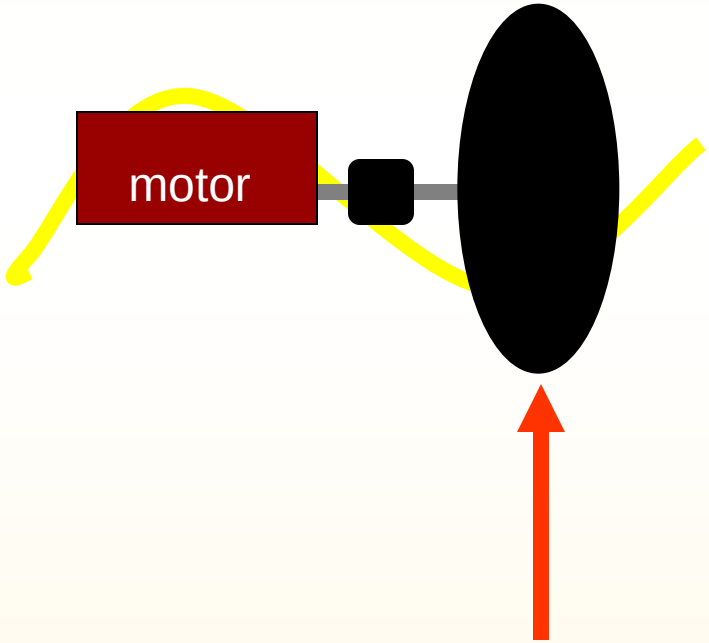
Building a Driveline

Supporting Shafts



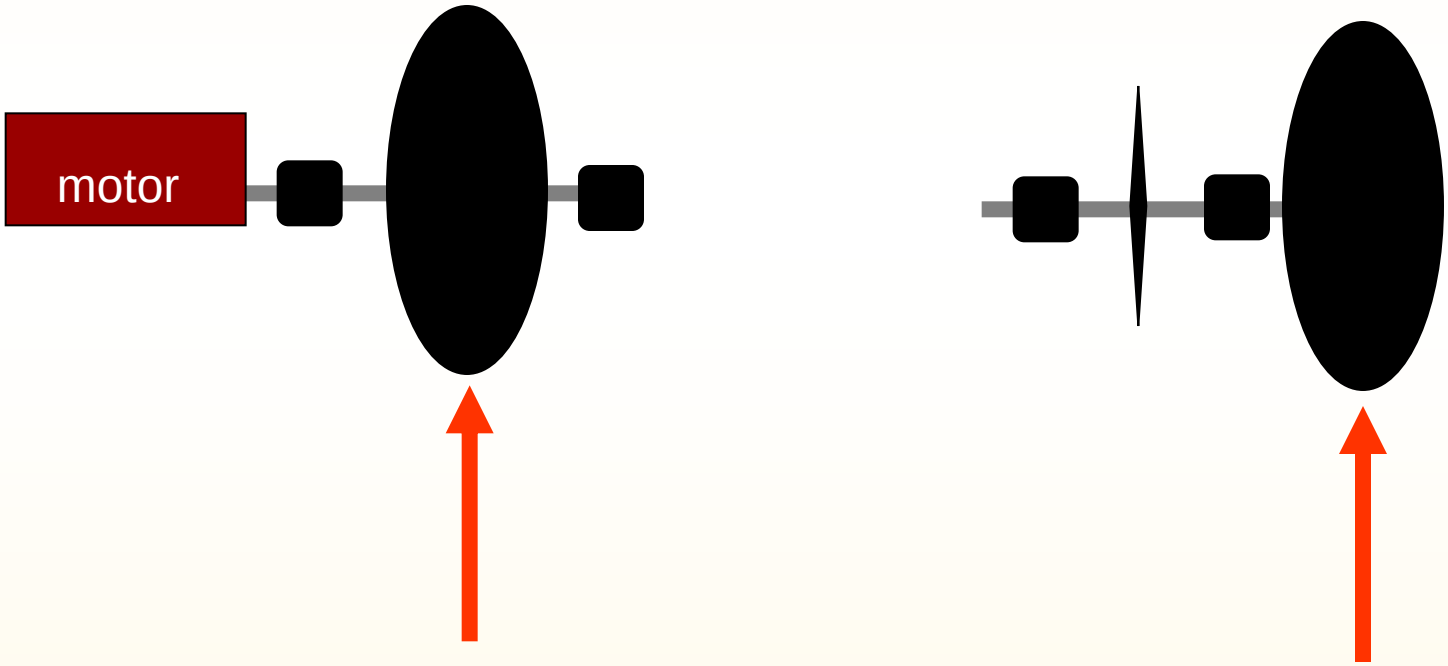
Building a Driveline

Supporting Shafts



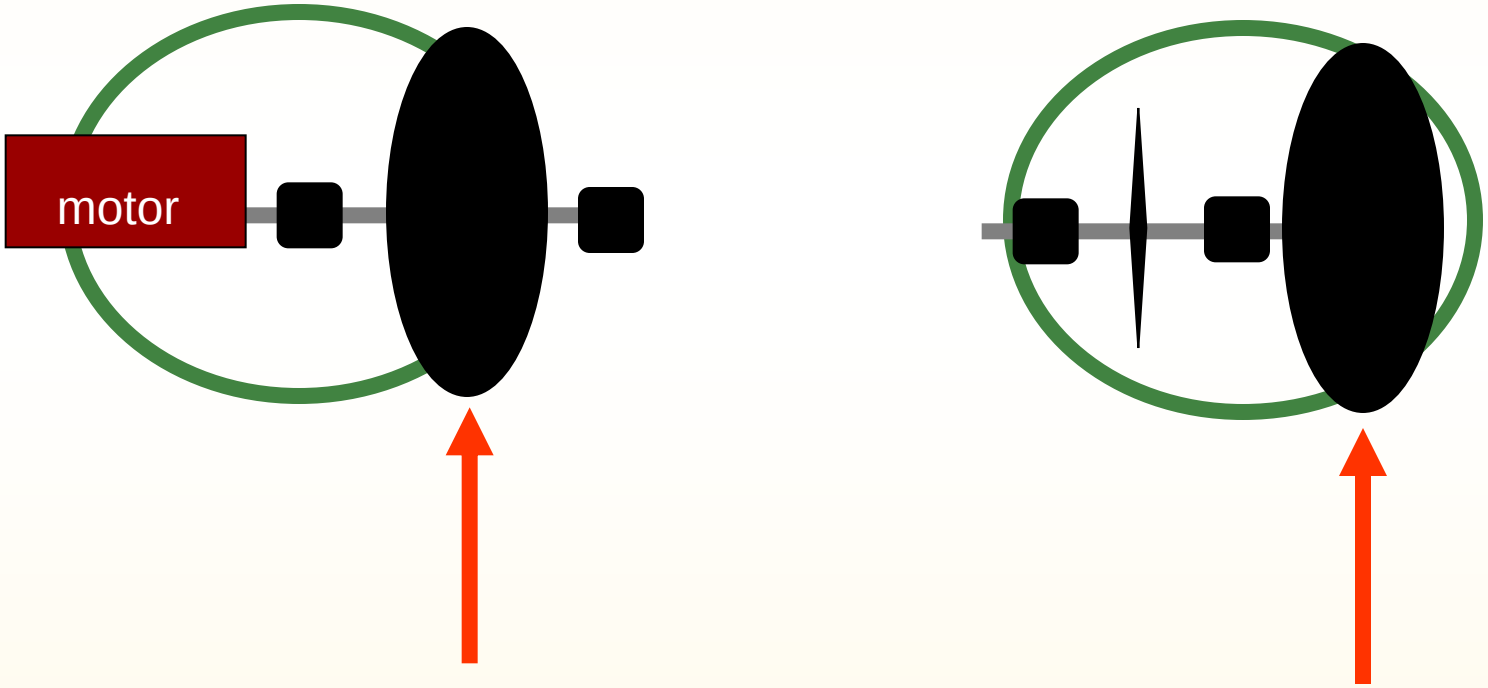
Building a Driveline

Supporting Shafts



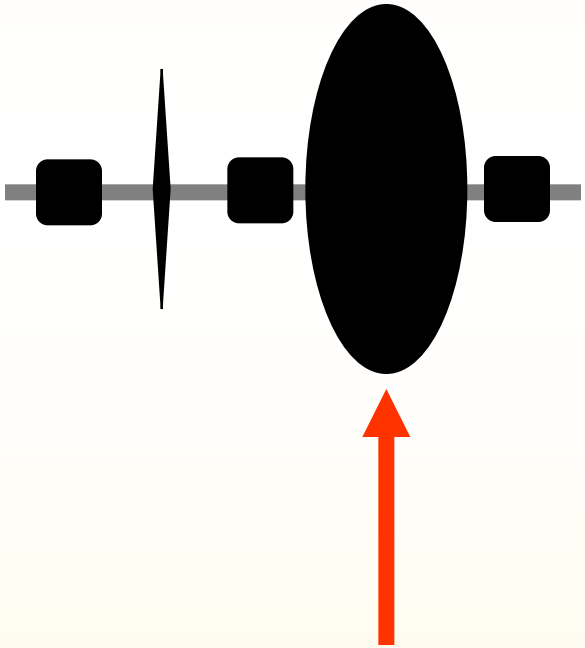
Building a Driveline

Supporting Shafts



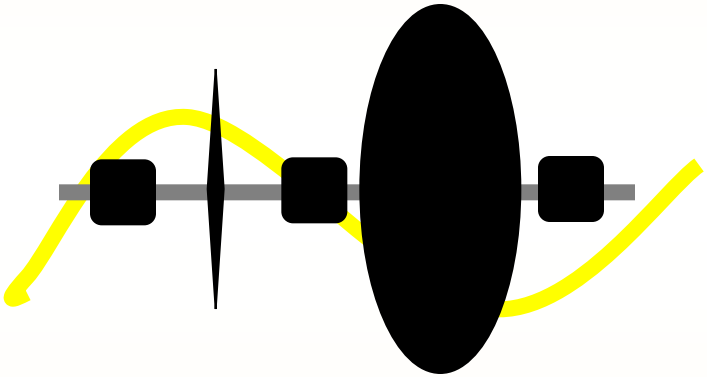
Building a Driveline

Supporting Shafts



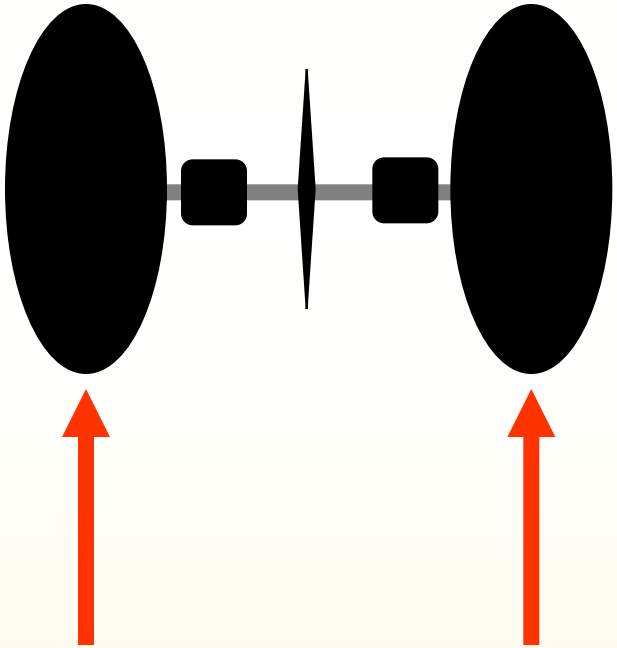
Building a Driveline

Supporting Shafts



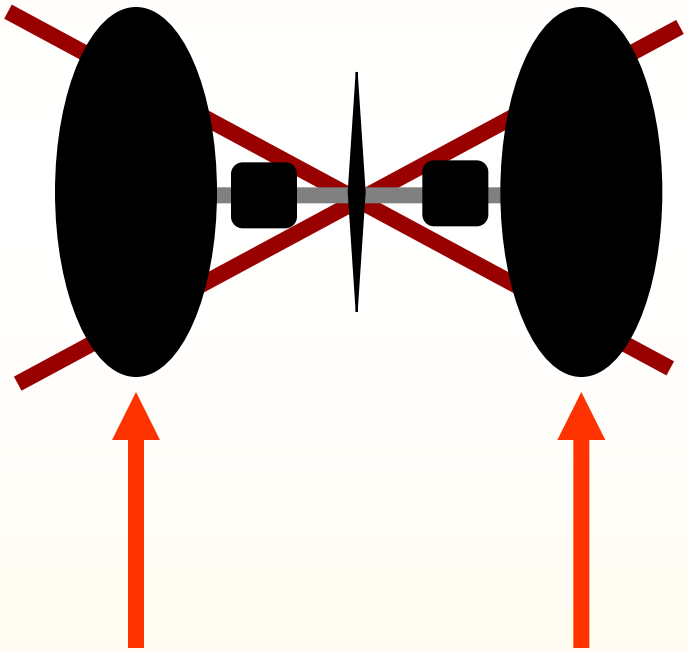
Building a Driveline

Supporting Shafts



Building a Driveline

Supporting Shafts



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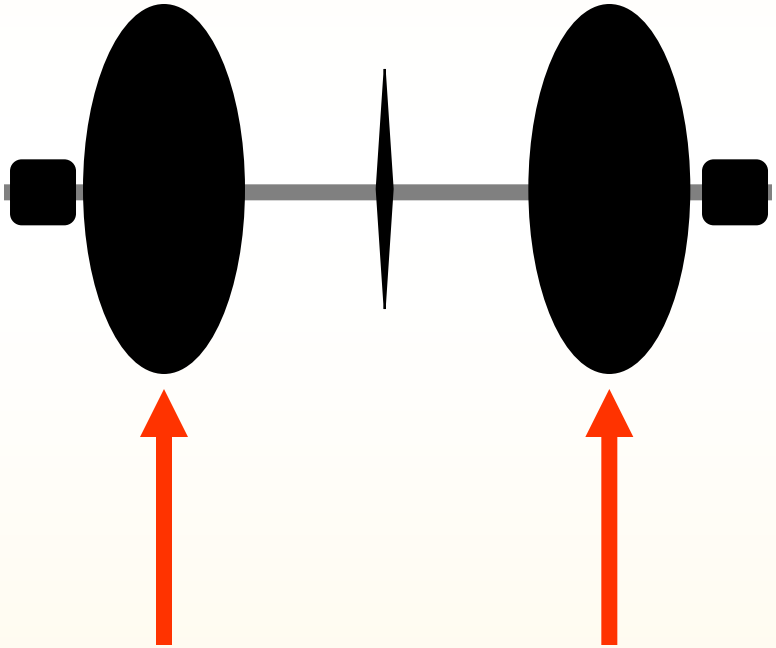
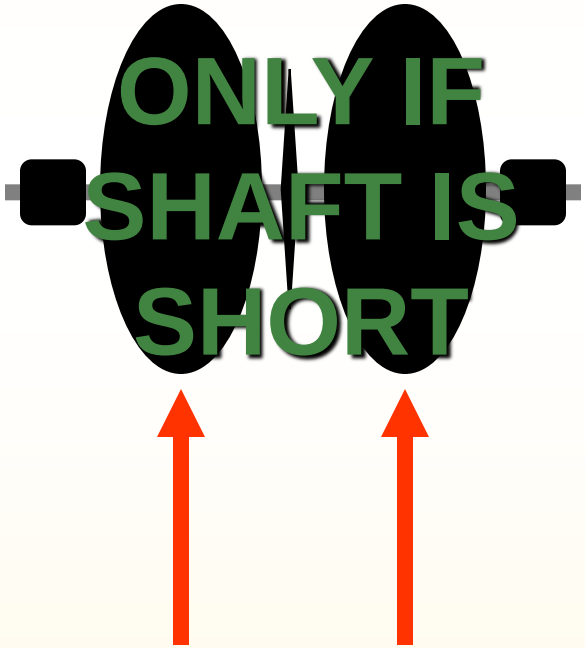
Supporting Shafts



Building a Driveline

Supporting Shafts



Building a Driveline

Shaft Support Recommendations

• Never side-load your motors – they're not designed for it. Always have at least one bearing on the output, and try to have two whenever possible.

• If your shaft is supporting weight, support *it* in two places.

• Try to avoid supporting a shaft in three or more places – a misalignment will lead to a loss of power.

What's in the KOP?

What's been in the KOP?

What's in the KOP?

Motors

CIM Motor

Van-Door Motor

Window Motor

Fisher-Price Motor

Globe Motor

What's in the KOP

Motors

Manufacturer	Model #	Name	Number in kit	Stall Torque (Nm)	Max Efficiency	Max Power (W)
Globe	409A587	Gearmotor - 18 AWG	2	22.6	55%	47
Denso	D-001	Window Motor	2	10.6	25%	23
Fisher-Price	FP9003 or FP9012		2	0.4	70%	172
CIM	FR801-001	Big CIM	2	2.4	65%	337
CIM	FR801-005	Little CIM	2	4.0	75%	267

What's in the KOP

KitBot Chassis

- Metal parts
- Skyway wheels
- #35 Chain and Sprockets
- CIM Motor Transmission and mount

Moving from VEX to FRC

Moving from VEX to FRC

VEX

- **Set screws are used to attach things to shafts**

FRC

- **Set screws inhale audibly. Use a slot and key, brazing/welding, shear pin, or other secure system, or use an axle instead of a shaft.**

Moving from VEX to FRC

VEX

- Casters and two-wheel drive systems work well

FRC

- Casters aren't such a great idea. They can prevent the robot from going over obstacles, and reduce traction on driven wheels.
- All wheels on the ground should be driven

Moving from VEX to FRC

VEX

- **Broken parts are usually easy to fix.**

FRC

- ***If properly designed*, broken parts are easy to fix. Make sure that electronics, shafts, motors, gears, chains, and any other likely to break parts are accessible.**

Moving from VEX to FRC

VEX

- **Robots can’t do much damage.**

FRC

- **An out of control FRC robot can be very dangerous to itself and bystanders. Always take proper precautions when building and testing.**

Moving from VEX to FRC

VEX

- Friction bearings are used on shafts

FRC

- In most cases, ball bearings should be used on all shafts. Each shaft should be supported in exactly two places.

Moving from VEX to FRC

VEX

- **Everything is designed to fit together**

FRC

- **Very few parts will fit together without modification. You will have to be creative when interfacing your motors, wheels, and other mechanical parts.**

Final Advice

Final Advice

- KISS – Keep It Simple Silly
  - Don’t over-engineer
  - Think “outside the box”
  - Don’t try to do all the objectives
  - Do a few things well rather than a lot of things poorly
- Keep the weight limit in mind
  - Adding weight is much easier than removing it

Final Advice

- **Break your design *before* competition**
  - **If you know what will break, fix it or make extras (or plan to make them)**
- **Practice, Practice, Practice**
  - **Get something driving as soon as possible**
  - **Driver practice is just as important as mechanical design**

THANK YOU