Team Just ‘Cuz Robotics
Drive System Design Guide

Drive Calculation Spreadsheet: https://bit.ly/JustCuzDriveCalc

For the calculator you need to know the # of wheels, # of motors, wheel diameter, and motor specs

Main parameters that determine the needed motor/gearing

1. Weight class (how much weight can be dedicated to drive?)
2. Drive Strategy - control, wedge, or other?
    a. *Speed* is actually a lower priority for a control bot than a vertical spinner - spinners need to achieve good bite and escape from a bad position
    b. Pushing power/low end *torque* are critical for control bots, especially w/o wedges
    c. Generally a wedge, lifter, grabber, or other control bot will want more drive *power* than a spinner
3. Determining how much drive power is needed is a function of the desired speed and torque for your chosen wheels
4. According to Ask Aaron’s drivetrain guidelines, you will want at least 1.5-2X the torque required to spin the robot wheels to prevent stalling/overloading the motor while pushing an opponent into or against a wall.
    a. Note: **More torque with a reasonable top speed >> stupid fast top speed**
    b. Having the ability to go 100mph if you only have room to accelerate to 20mph means leaving lots of torque on the table
    c. Combat arenas are small - **acceleration and pushing power** is often far more important than speed, and both **are only related to torque and traction**

Transferring Power to Wheels - Mechanics and Reductions

1. Direct drive - often risky and fragile, but very simple; no external gearing
    a. Supporting the other end of the axle is recommended - easy to destroy the motor with impacts
    b. Basically just don't even think about it with an ungeared motor unless you have a very special circumstance (ultra low kV brushless yolodrive???)
2. Belt/chain drive - Simplest/easiest way to run 4WD off 2 motors, no tensioning needed if done properly
    a. Generally easy to attach pulleys to a motor shaft
    b. Typically can get no more than 3:1 per stage
    c. Timing belts or chains are often best for 12lb and up as they won't slip, but round belts work great for smaller bots with lower torque
    d. I managed to use O rings in place of welding my own PU belts in Draconid given sufficient stretch/tension, but this can be difficult to size properly
    e. Note: all plain rubber belts lose significant tension over time
    f. 3D printing pulleys for belts works extremely well

3. Planetary Gearboxes - Pricey but compact and robust
    a. Not good with impact loads, but often beefy output shafts that easily handle shear loads (best to support the axle if you can though)
    b. Handle a ton of torque and very compact for the high ratios
    c. Extremely expensive to get many P60s or Versas, expect $50-90 per drive side in a 12lb+ bot
    d. Often needs an adapter to use brushless, but usually someone has done it before
    e. Can drive a central pulley and belt to 4WD, or drive one wheel directly and belt to second for extra redundancy (see #5)
4. Gears
    a. Metal gears are expensive but 3D printing is a great option (see Draconid)
    b. Less impact tolerant than belts, but can be designed/made to spec
    c. Pretty compact, but very restrictive on center-center
    d. Unlike with pulleys/chains, it's not always possible to change ratios without changing center-center
    e. 3D printed herringbone gears have a larger root area, stronger tooth profile
    f. Need 3 gears per side to reverse direction for 2 motor 4WD
    g. Some guesswork can be involved in determining the width and pitch/module needed
5. Combinations of the above!
    a. No harm in combining two different approaches, as long as you're careful
    b. Can get the best of both worlds by combining gears with belts/chains - high reduction with shock isolation
    c. It can be much cheaper to replace a shaft and pulley than a two stage gearbox
6. Where to Buy Mechanical Components
    a. You can buy Chain Sprockets, Gears, Pulleys, wheels and more at Andymark, Vex, ServoCity, McMaster, and more!
    b. P60/P80/P61 gearboxes are at Banebots, and Versaplanetary is Vex.
    c. Wheels are available from tons of hobby stores, Amazon, Fingertech, Robotshop, several of the above vendors, etc.
        i. Also take a look on Ebay, Banggood, or other Chinese retailers but YMMV
    d. Brushless motors are available on Amazon, Hobbyking, Banggood, and any drone/RC hobby store

Wheels, wheels, wheels!

1. Softer rubber is more grippy but less durable
2. Foam tires are able to take direct hits without trashing your bot unlike rubber (see: D2 kit wheels, Fingertech wheels, lite flights)
3. Custom silicone cast tires are soft and grippy and often the best performing, but require a lot of experimentation, which means a lot of $$$ and time
4. Be sure to think about how to actually transmit torque to the wheels
    a. Live shaft turning with the wheel
        i. Set screws on flats (Fingertech hubs)
        ii. Keyed hubs (Banebots and similar, common for larger bots)
        iii. D or Hex shaft/bore, or spline (also Banebots, VEX stuff, Servocity hubs)
    b. Dead shaft - axle doesn't spin
        i. Bolt through to pulley/gear (Conduit)
        ii. Custom 3D printed things (Draconid)
        iii.

Sources:
Team Tentacle torque Calculator: http://runamok.tech/squid/newtorquecalc.htm
AskAaron Drivetrain Gear Ratios Article: http://runamok.tech/AskAaron/optimum.html
Brushless motor torque estimation article