

## Robotics Alliance Project Design Guide Set #3

### 1. Brushed and Brushless Motors

- a. A brushed motor uses wound wire coils, the armature, acting as a two-pole electromagnet. A brushless motor, however, uses a permanent magnet as its external rotor. In addition, it uses three stages of driving coils and a dedicated sensor that tracks rotor position.
- b. <https://www.automate.org/blogs/brushed-dc-motors-vs-brushless-dc-motors#:~:text=A%20brushed%20DC%20motor%20uses,as%20a%20two%2Dpole%20electromagnet.&text=A%20brushless%20motor%2C%20by%20contrast,se nsor%20that%20tracks%20rotor%20position.>

### 2. Motor Specs

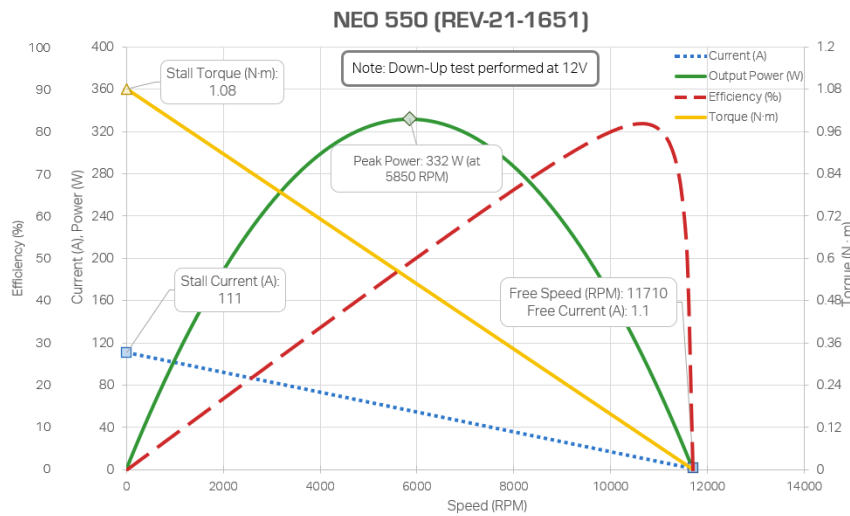
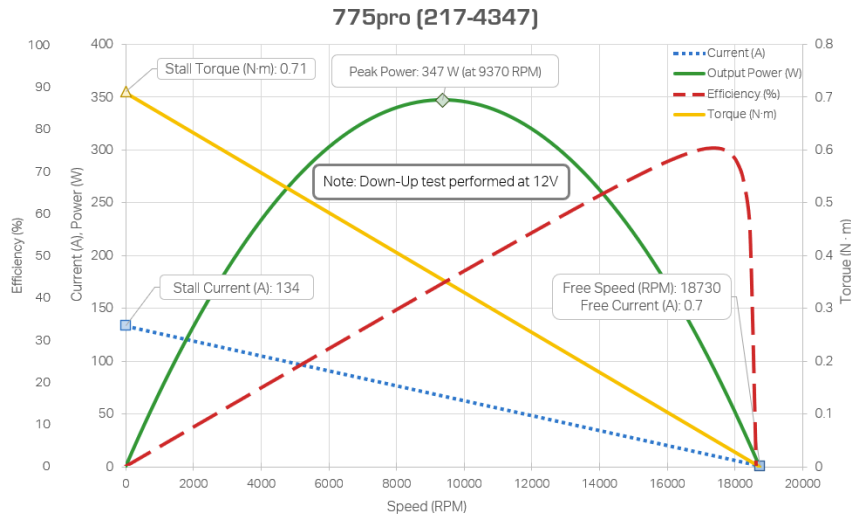
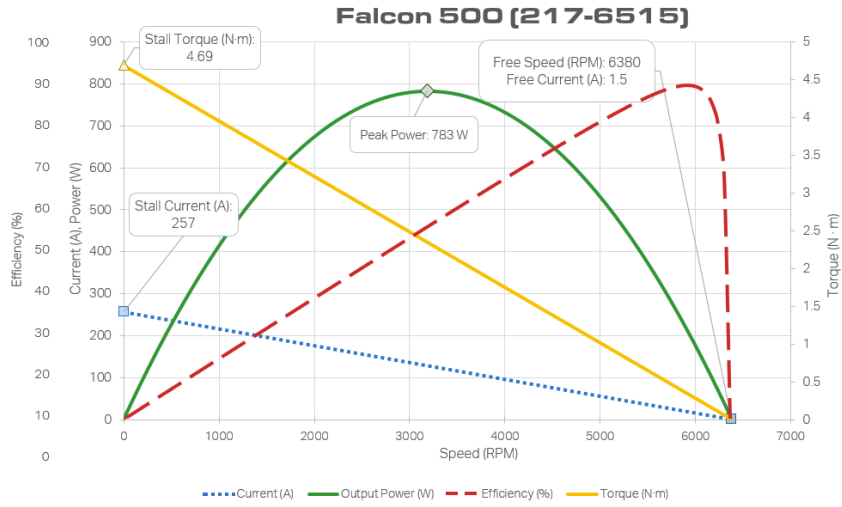
- a. Speed (rpm)
- b. Torque (in-lbs)
- c. Peak Power (W)

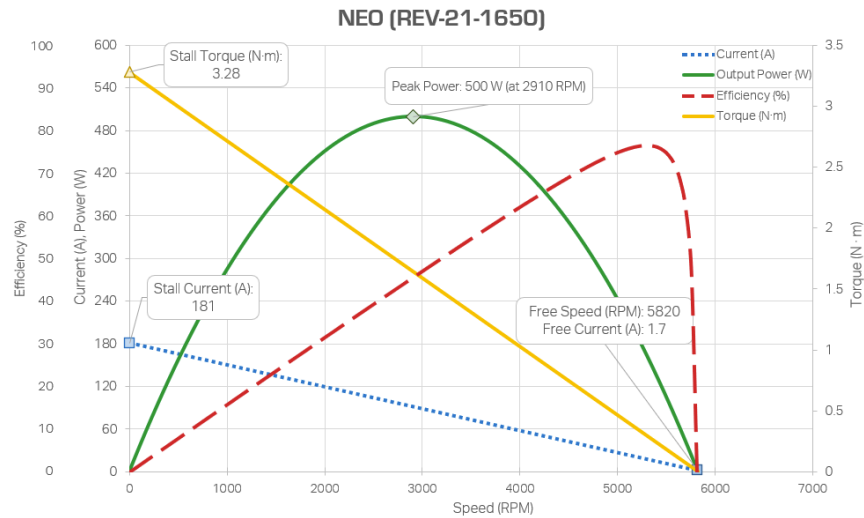
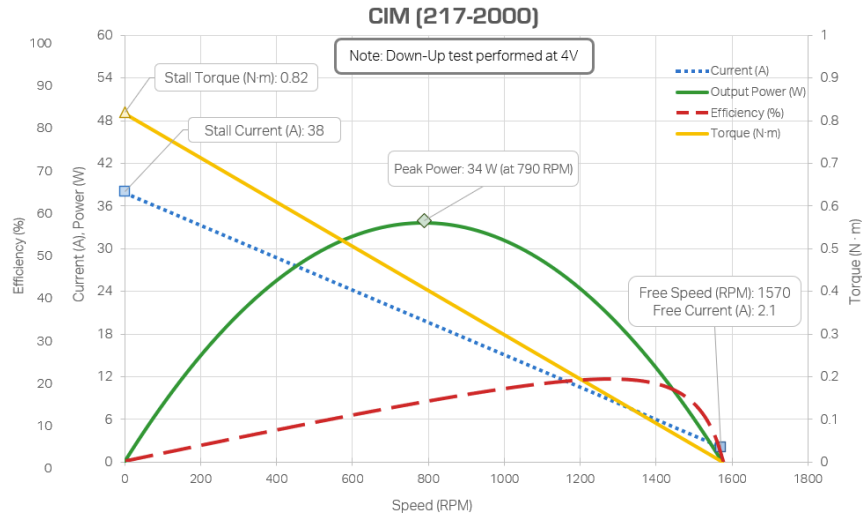
### 3. Motors for Mechanisms

- a. Best motors for intakes
  - i. BAG
  - ii. 775 Pro
- b. Best motors for Drivetrains
  - i. Mini-CIM
  - ii. CIM
  - iii. 775 Pro (with caution)
- c. Intake motors are generally smaller and have higher rpms while drivetrains are larger, have higher torque, and run at lower rpms.

### 4. Motor Curves

- a. Motor curves display a tradeoff between torque and speed. It shows the relationship and balance between torque and speed relating to speed, current, efficiency, and power





## 5. Torque and Speed

- a. As speed increases, torque decreases. The torque output of a motor is the amount of rotational force that the motor develops.

## 6. Torque, Power, and Speed

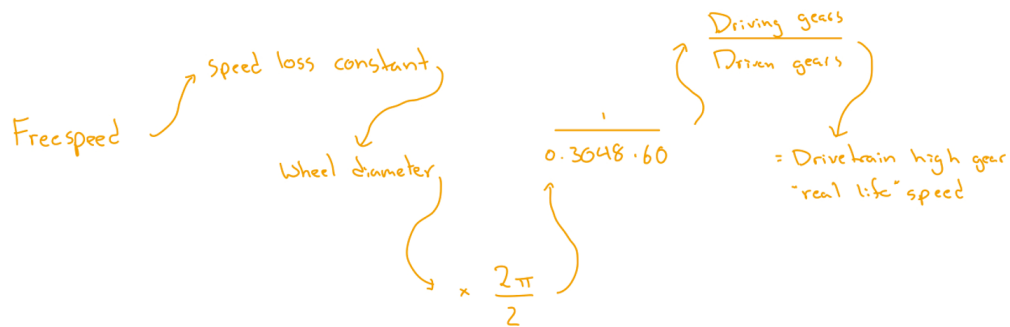
- a. When you double the number of motors in a mechanism, torque and power increase and speed stays the same

## 7. Reduction

- a. Reduction can be achieved by using different gear ratios and thus changing torque and speed. Reduction is reducing the number of gears in a mechanism.

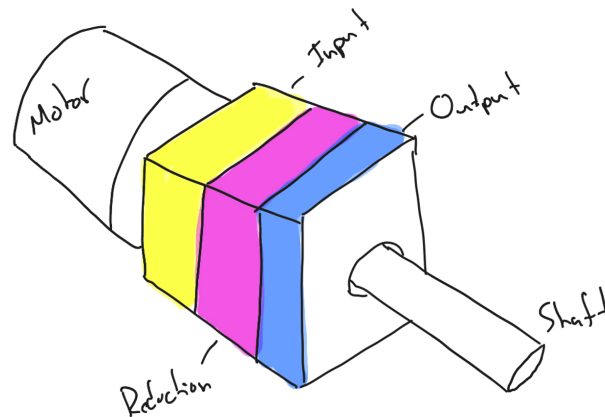
## 8. Free Speed and Output Speed

$$\text{Freespeed} \cdot \text{speed loss constant} \cdot \frac{\text{wheel diameter (cm)} \cdot 2\pi}{2 \cdot 0.3048 \cdot 60} \cdot \frac{\text{Driving gear}_1}{\text{Driven gear}_1} \cdot \frac{\text{Driving gear}_2}{\text{Driven gear}_2} \cdot \frac{\text{Driving gear}_3}{\text{Driven gear}_3} \cdot \frac{\text{high speed driving gear}}{\text{high speed driven gear}} = \text{Drivetrain high gear "real life" speed}$$



## 9. VersaPlanetary

- a. The VersaPlanetary is a battle-tested modular planetary gearbox system designed specifically for use in the FIRST® Robotics market. ... This system allows you to change motors without the need to buy a special pinion and press it on.



## 10. Reduction Stages

- a. The highest reduction stage should be on the motor so that you can then reduce it using a chain, belt, pulley, gear, or other torque transfer methods.

## 11. Versa vs Ultra vs AM Sport

- a. Versa is the most popular gearbox. It can be reduced all the way to 10:1 but that is the weakest gearset. Ultra is smaller but doesn't offer the same number of ratios as the Versa. The Ultra should be used in lower load applications. The AndyMark

sport gearbox is a heavier, beefier planetary gearbox option. It provides an external 4:1 stage.

## 12. Servo Motor

- a. Servos are small motors that can only rotate a set number of degrees. They are mainly used for small actuations not requiring much torque.

13. –

## 14. Bearings

- a. Bearings support rotating shafts. There are radial bearings, thrust bearings, linear bearings, one-way bearings, and even bushings. All of which are for different uses.

## 15. Bushings

- a. Bushings have higher friction than bearings but can handle higher loads.






## 16. Live and Dead Axles

- a. A live axle is where torque is transmitted through the shaft, whereas a dead axle is where the shaft itself does not rotate, but something on it does.

## 17. Torque Transfer Shafts

**Question 17: Torque Transfer Shafts**

• Fill in the table of torque transfer shaft profiles below.

Type	Sketch of Profile	Common Sizes	Vendor	Description/Use Cases
Hex Shaft		1/2", 3/8"	Vex Pro	live axle
Thunderhex		1/2", 3/8"	Vex Pro	rounded corners to fit in bearings
Round Keyed		1/2"	McMaster	Rarely Used
D Profile		6mm	McMaster	
Square		1/4"	McMaster	Patenting, high strength

## 18. Gears 101

- a. A gear is a rotating wheel with teeth.
- b. DP means diametral pitch or the ratio of the number of teeth per inch of the gears pitch diameter.
- c. Pressure angle is the angle between the direction the teeth exert a force on each other and the line joining the center of the two gears.

## 19. Gear Comparisons

- Spur gears is a normal gear used on parallel shafts. Sector gears are not full circles and are used for mechanisms that do not rotate 360 degrees. Bevel gears are conical shaped gears. Worm gears are used to get very high reductions. Rack gears are a liner bar with teeth that allows for linear motion. There are also planetary gear sets which allow very large gear reduction in a very compact space.

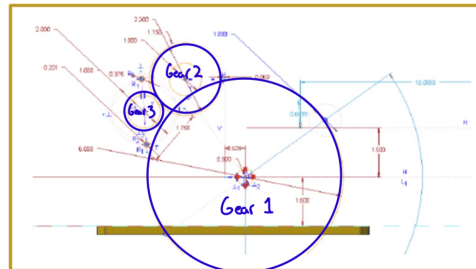
## 20. Designing with Gears

- Center-to-Center Distance =  $N_1 + N_2 / 2P$ . The N's are the number of teeth on each gear.
- Pitch Diameter is the diameter at which a gear interacts with other gears.
- Pitch Diameter = #Teeth/Diametrical Pitch

## 21. 2D Sketch with Gears

### Question 21: 2D Sketch with Gears

- Label where the gears are located in the annotated sketch excerpt from the manual below. Annotate your sketch so an outsider can understand what is going on.



## 22. Chain 101

- #25 is lighter while #35 is capable of transferring higher loads.
- Master link is a chain link that allows you to connect two ends of chain without a tool.
- Half links allow you to create a chain with and add number of links.

## 23. Designing with Chain and Sprocket

- When designing chain and sprocket mechanisms, you must calculate the center-to-center distance.
- Adding a little but of length to your center-to-center distance can make the chain run smoother.

#### 24. Belt and Pulley

- a. Belts and pulleys are usually used to transmit lighter loads. Belts are also much wider to handle the strain.

#### 25. HTD vs GT2

- a. HTD belts are for higher loads than GT2 belts although both have rounded teeth.

#### 26. Belt and Pulley Design

- a. Belts also have to have the correct center to center distance. You also have to test what belt length will work best for your mechanism.

#### 27. Belt Calc's

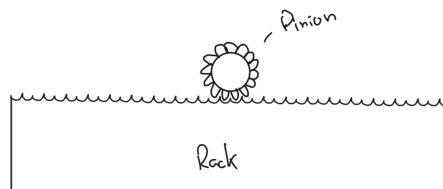
- a. 108
- b. 300

#### 28. Polycord

- a. Poly cord is a type of cut-to-length tubing used to transmit light loads. It is less efficient than timing belts, gears, or chain.

#### 29. Racks and Pinions

- a. A rack and pinion consists of a pinion gear that meshes with a rack to create linear motion from rotation.



#### 30. Elevators

- a. Elevators are typically driven with belts, chain, or cable.