Joon Choi

12/14/22

https://www.instructables.com/Autonomous-Sumo-Battle-Bot-with-Pneumatic-Flipper-/

https://www.instructables.com/Unskinny-Bot-3-lb-Horizontal-Spinner-Combat-Bot/

**https://wiki.robojackets.org/3lb_Beginner%27s_Guide**

**http://runamok.tech/AskAaron/spinner_FAQ.html**

**http://runamok.tech/AskAaron/estimating_spinup.html**

**https://www.youtube.com/watch?v=oc8dGPGdgr8**

**https://www.youtube.com/watch?v=uyU25DdONjo**

**Example Bot (links to motors)**

**Buy stuff**

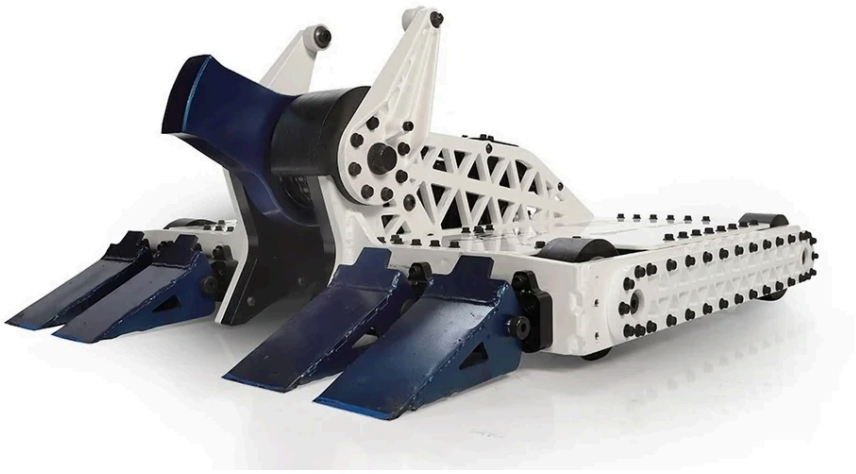
**Weight**

**Resources:**

- **Battlebots 101 (intro)**
- **Notes**
- **Onshape**
- **http://robotbattles.com/howto.htm**
- **https://repeat-robotics.com/handbook/**

Strategy:

- Vertical spinner attacks opponent



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Design Requirement:

- Armor: Has to withstand attack from 3lb bot
- Spin with enough force to rip open metal armor.
    - Angular velocity:
    - Kinetic energy:
- Low wedge in front to prevent flipping
- Move at around 3 m/sec and be able to control each side separately to turn

- Metal casing over wheels
- 4 wheel drive; can go forward and reverse

Joon Choi

12/21/22

Angular Velocity (rad/sec) - ω: 2π x Frequency (Hz)

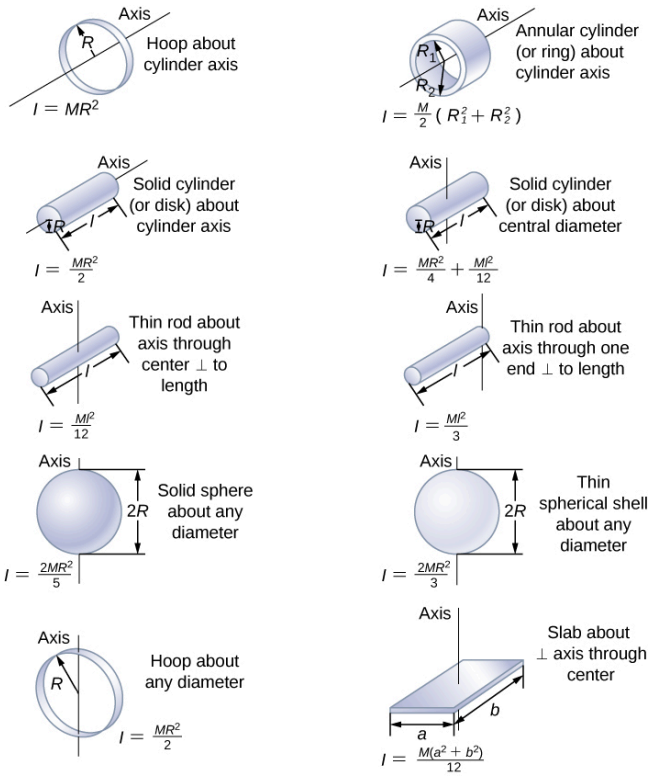
Moment Inertia (kg*$m^2$):

- Bar: (m(length$^2$ + width$^2$))/12
- Disk: ½ Mass (kg) x Radius$^2$ (m)

Rotational KE (Joules): ½ $MV^2$ = ½ $M(\omega R)^2$ = ½ $MR^2\omega^2$ = ½ Inertia x $\omega^2$

Example: A steel bar 300 mm in length, 75 mm wide, and 23mm thick has a mass of 4 kg spinning at 2000 RPM

- R = .15m
- ~33.333 Rev./sec
- ω = 2π x 33.333 = 209.44 rad./sec
- I = (4( $0.3^2$ x $0.075^2$) / 12 = 0.031875 kg * $m^2$
- Rotational KE = ½ x 0.031875 x $209.44^2$ = **699.08 Joules**




Weight Limit: 3 lb, 1360.78g

https://www.youtube.com/watch?v=-iRpQBnvNT8

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You want kinetic energy high enough to do a lot of damage
You want angular velocity to be slow enough relative to your drive speed to let you hit enough of the enemy robot.

1/5/23

- Find the ideal reach/Rotational KE of spinner
- 10 concepts for the mechanisms for spinner, drive, and armor
    - Drive concepts
        - 4-wheel drive (provides more stability and pushing traction and limits gyro forces acting upon the bot)
        - 2-wheel drive (simpler to build but less control, pushing power, and grip)
        - Direct drive (no gears or belts involved, for when load doesn't have impact forces, motor is directly in load, lacks strength and robustness )

1/12/23

- Armor/Weapon Materials
    - AR500 Steel: Extremely durable and hard, resistant to wear and tear, 6-7 times stronger than mild steel (wears well for armor)
        - Density (7.85 $g/cm^3$)
    - Ultra-high molecular weight polyethylene: abrasion resistant tough material and low friction
        - Can be used as an outer layer of armor
        - Density (0.97 $g/cm^3$)
    - 6061-T6 Aluminum: Hard and less dense than steel
    - Titanium: Strong, low density, but expensive

Joon Choi

1/19/23

Parts List:

Weapon:

- Aluminum Bar
    - Dimensions: 2x5x0.25
- Timing Pulley + Timing Belt
- Brushless DC Motors
- Bushings, Bearings

Drive-train:

- 2 Gear Motors
- 4 Wheels
- 4 Axles
- Timing Pulley + Timing Belt

Chassis:

- Polyethylene Armor
- 3 ESCs
- Battery pack

Control System:

- Controller and Receiver
- Power Switch (button to turn weapon on/off)

Miscellaneous:

- Screws
- Motor Mounts

Joon Choi

1/24/23

- Spinner tip speed (how fast the outer tip is moving) of 370 ft/sec (113 m/s). That's the speed limit that the Battlebots competition puts on weapon speeds (see section 8g of https://battlebots.com/wp-content/uploads/2022/09/BattleBots-Design-Rules.2022.0.pdf), so I think that should be enough to do some serious damage, and might be overkill. And NHRL has no speed limit that I'm aware of, so presumably it's legal for us to spin up that fast.
- Spinner kinetic energy of at least 82 joules, although you should probably go higher? This comes from the Ask Aaron recommendation of 60J/kg of a robot's weight class: http://runamok.tech/AskAaron/spinner_FAQ.html
- Bite depth of at least 1 cm. I have no source to back this up, I just thought that 1 cm seemed reasonable.

- Armor: Steel, not aluminum
- Copy exposed wheel - 

Joon Choi

2/2/23

Scaled down spinner:

- Bar length from 5 → 2.5 in
- Bar width from 2 → 1 in
- Bar thick 0.5 → 0.25 in

Chassis Material:

- High Density Polyethylene (HDPE):
    - Density: 940 kg/$m^3$
- Aluminum:
    - Density: 2710 kg/$m^3$
    - Melting point: 660 C

2/9/23

Spinner Motor

https://palmbeachbots.com/products/fingertech-3lb-beater-bar-electronics

- Motor (diam: 1.10 in, len: 1.49 in)
- Mount (thickness: 0.39 in)

- Motor Diameter: 28mm (1.10in)
- Motor Length: 38mm

Joon Choi

Use this mechanism for spinner

http://runamok.tech/AskAaron/spinner_FAQ.html (Ctrl + f: “torque estimate”)

2/16/23

2 in. wheels

Wheels

Motor

Gearbox

Radius: 1 in. Diameter: 2 in.

Thickness: 0.8 in

RPM needed to travel 5m/sec: 2150 rpm (1.75 in. diameter), 1881rpm (2 in. diameter)

2778 RPM with parts

2 3/8 in. wheels

Wheels

Motors

Gearbox

13890 RPM at 7.2v, 3.6a

Target 1583 RPM, 2778RPM

Buy: 2 ⅞ in. Wheels

- 2 ⅞ at 1000 rpm (no load) → 12.54 ft/sec = 3.82 meters/sec

15T Timing Pulley (diam: 14.32 mm, C: 44.99 mm)
30T Timing Pulley (diam: 28.65 mm, C: 90.01 mm)

2/20/23

To-Do:

- Battery cover (Ctrl + f on the 3-lb bot example website)
- Power Switch
- Pulley system for weapon

For future reference: Pulley calculator

2x 7.4V Battery (2.72*1.46*0.77 inch (L*W*H))

Joon Choi

3/16/23

To-Do:

- CAD:
    - Power button - Joon
    - Motor mounts (3-D print them like in this video) - Joon
    - Battery pack - Aden
    - Cover - Sam
    - Drive Motor -
    - Wall Hole for wheels - Joon
    - Bearing (5905K22) for spinner
        - ⅜” shaft diam,  9/16” total diam, ½” wide,
- 60 joules per kg → 81.6 joules

4/27/23

Screws: Screws

Sam: CAD Motor Holders, Wedge, Make holes to screw wall into bottom piece

Joon: Finalize spinner, Make spinner mount, Move spinner to left side of bot

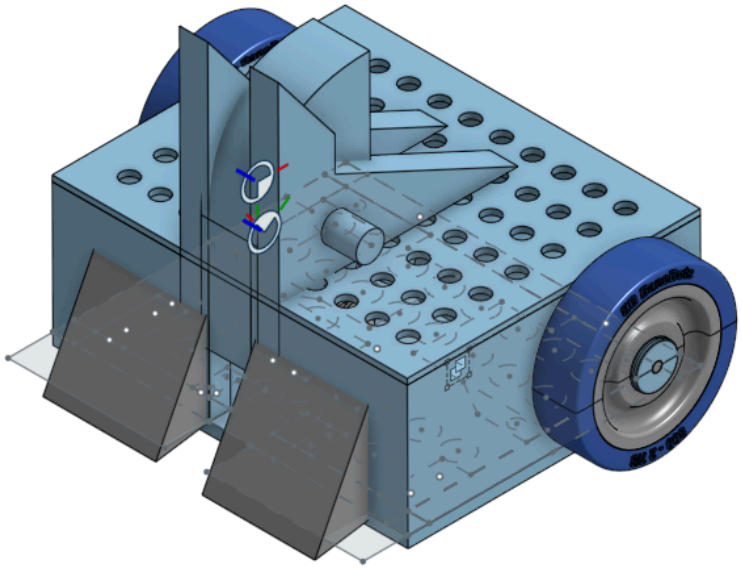
- Spinner: 4 in x 2 in x 1 in
    - Aluminum: Use a less dense metal; allows for bigger spinner (more bite depth) for the same weight → more rotational KE

5/18/23

- Sam: Made motor holders
- Joon:
    - Finished mating the timing pulley to timing belt (now it rotates right)
    - Put together spinner/axle, spinner holder, drive motors, walls, bottom piece
    - Calculated distance between the centers of the two timing pulleys and the angle
        - Len: 6.245 in, Angle: 75.14 degrees

Joon Choi

- “Completed” the assembly (needs some work):

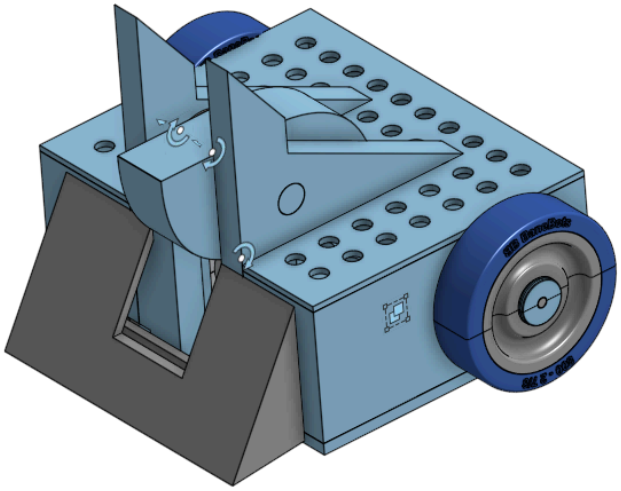


- To-Do:

5/25/23:

- Attached spinner to pulley
- shifted spinner mounts to the right
- Made wedges one piece

Joon Choi



6/8/23

8/2/23

- To-Do:
    - Add screws, ESC/Battery
    - Make illustrations to send
    - Weapon lock/power switch

11/7/23

Parts List and Weight

How to wire bot

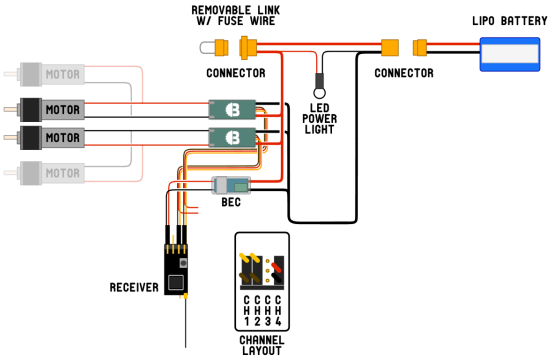
**Complete wiring guide/Better one** (watch starting at ~29 mi

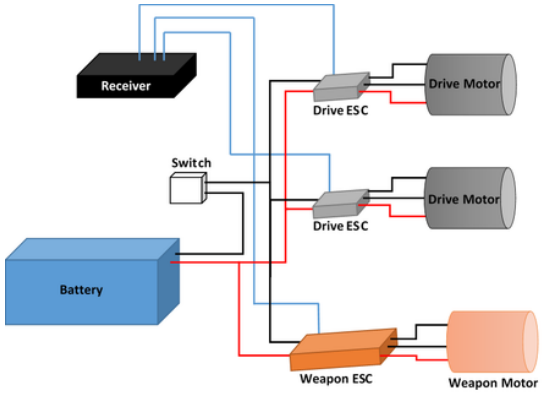
Steps

- Put electric tape on ends of motors
- Solder two esc wires onto drive motors
- Plug two escs into receiver
- Plug battery into switch

- Website

Joon Choi

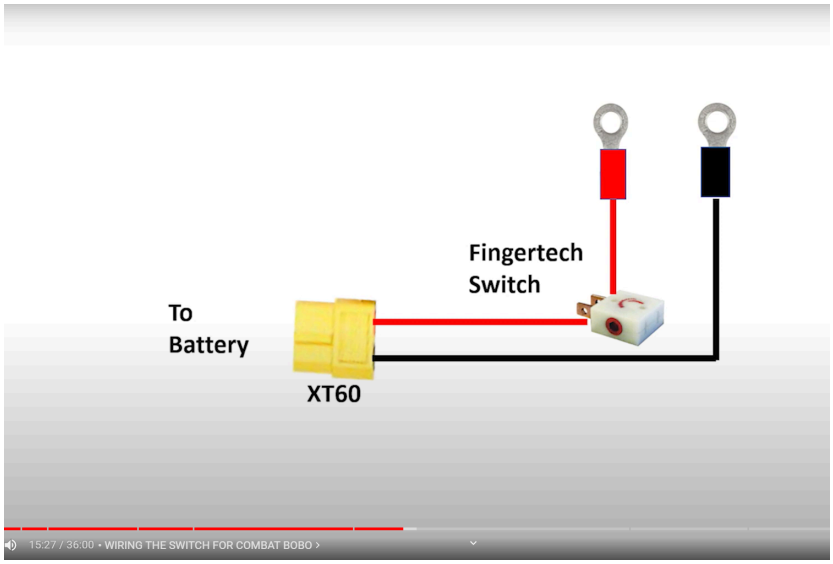


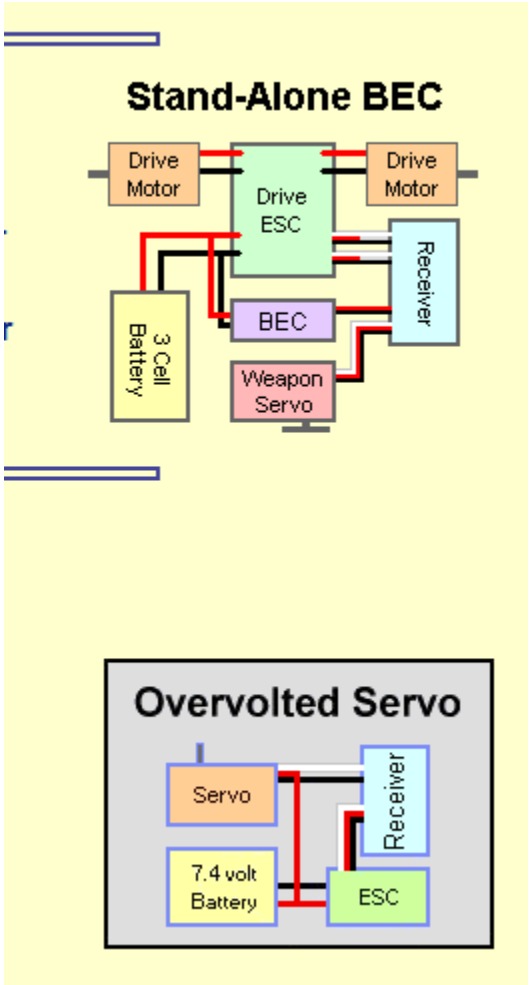




3lb

Circuit

Joon Choi

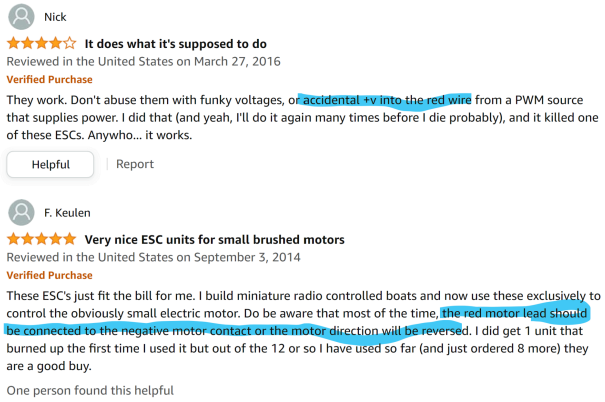



http://runamok.tech/AskAaron/lifter_FAQ.html

Joon Choi

Beware for drive motor esc:



Nick

**It does what it's supposed to do**

Reviewed in the United States on March 27, 2016

Verified Purchase

They work. Don't abuse them with funky voltages, or accidental +v into the red wire from a PWM source that supplies power. I did that (and yeah, I'll do it again many times before I die probably), and it killed one of these ESCs. Anywho... it works.

Helpful | Report

F. Keulen

**Very nice ESC units for small brushed motors**

Reviewed in the United States on September 3, 2014

Verified Purchase

These ESC's just fit the bill for me. I build miniature radio controlled boats and now use these exclusively to control the obviously small electric motor. Do be aware that most of the time, the red motor lead should be connected to the negative motor contact or the motor direction will be reversed. I did get 1 unit that burned up the first time I used it but out of the 12 or so I have used so far (and just ordered 8 more) they are a good buy.

One person found this helpful

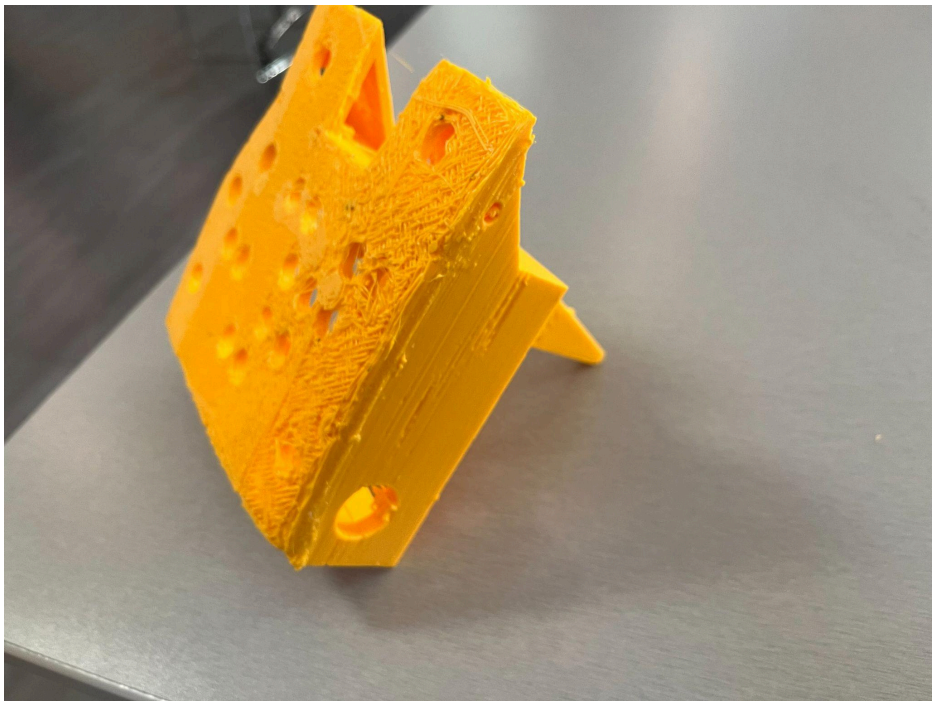
11/8/23 ToDo

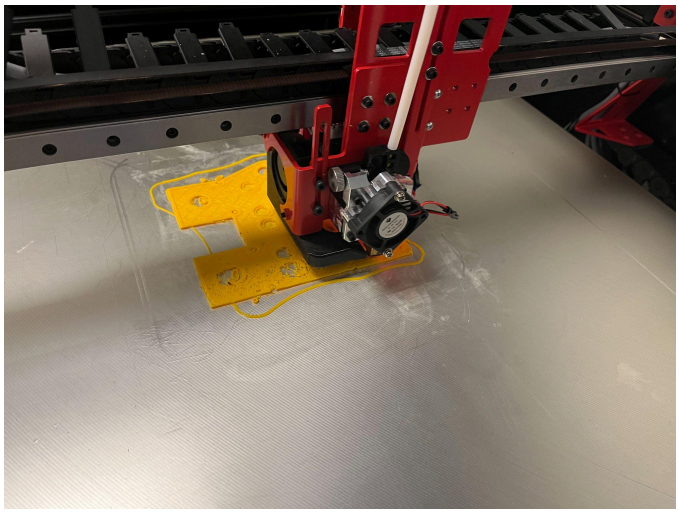
- Bot's total weight currently is ~3.28 lbs
    - Thinner walls, lower them if possible
    - Cut out empty space surrounding weapon motor
    - Make sure to decrease to ~2.9 lbs to account for screw mass
- 3D Print out pieces and assemble
- Buy weapon clamp
- Watch : Spinner bot vid

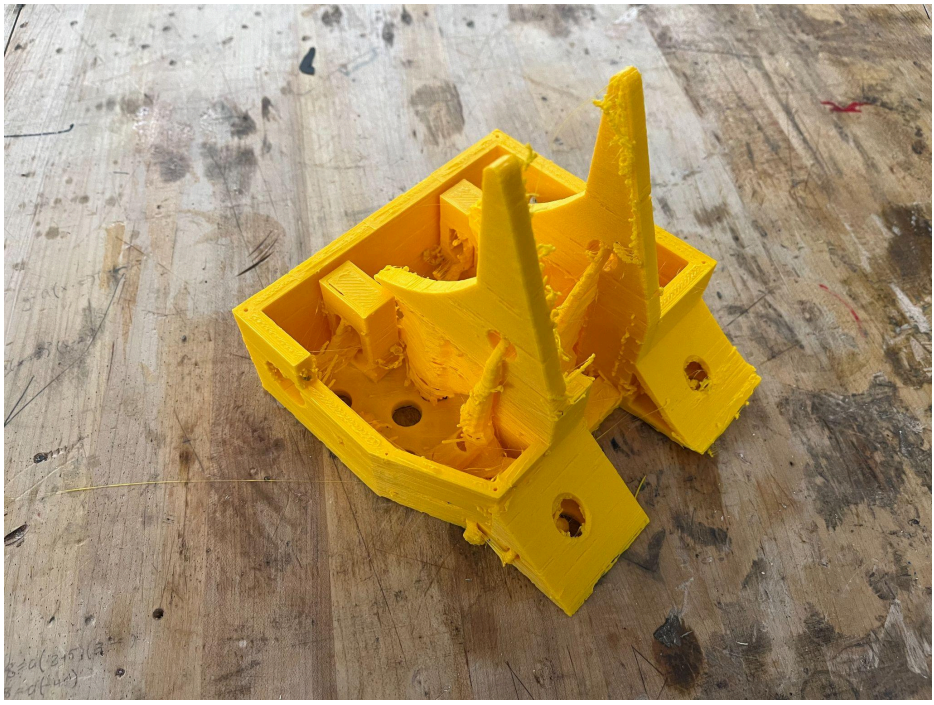
12/19/23

- 3D printed bot last week
- ToDo: Fix screw hole on the bottom piece, buy parts before break, add switch, BUILD!

Joon Choi







12/23/23:

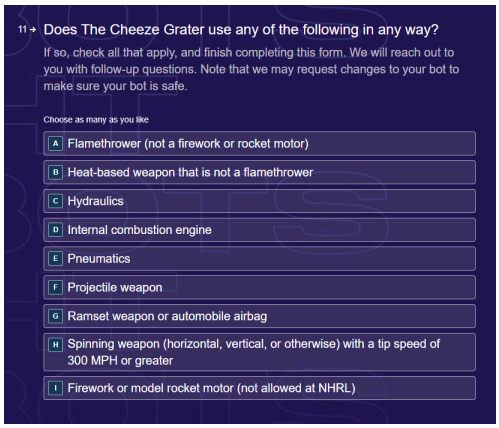
- Bought all internal parts
- How to calibrate ESC
- Add switch

Joon Choi

Registration:

Team Name: WHS Combat Robotics

Battlebot Name: Cheeze Grater

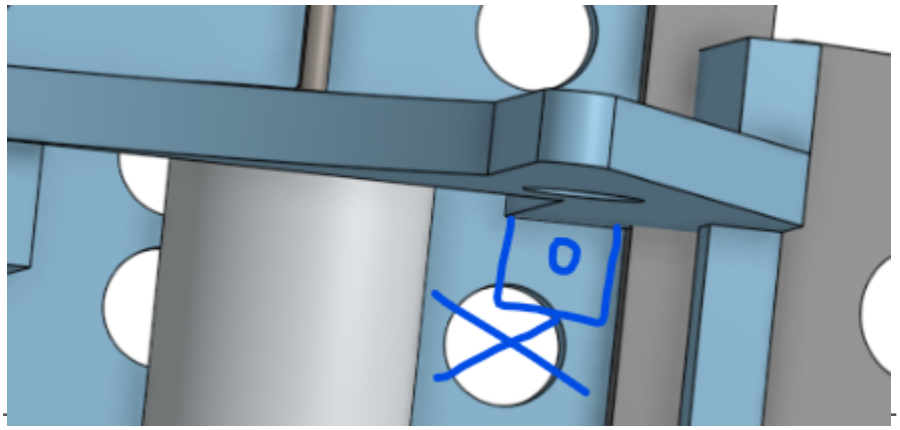



Questions:

- What makes your bot interesting and different?
    - Our bot is perforated to not only decrease weight but also mimic the appearance of cheese. Additionally, our bot is unique because it has two wheels, which is uncommon in combat robotics. We also use a puzzle-like mechanism to prevent fix the cover onto the walls; it prevents the cover from sliding both laterally and vertically.
- How does it work?
    - There are 2 drive motors in the back and 1 motor in the front that attaches to a vertical spinner's axle with a pulley system (the axle goes through needle bearings fitted onto mounts on either side); each motor is individually controlled by an ESC. A low wedge allows the bot to get under the opponent and make impact with the spinner. We use epoxy on the underside of the wedge so that it will not get stuck in crevices.
- Why did you build it? (reached char limit)
    - As a huge fan of Battlebots since elementary school, it was my dream to participate in a combat robotics competition. After building a badminton shuttle launcher in my robotics class in freshman year, I was overjoyed, yet felt that something was missing: that something was action. Thus, I joined our high

school's Battlebots club to fulfill my dreams of becoming a true robot warrior. I also wanted to learn CAD and motor control with wireless transmission which would be helpful for future builds.

1/14/24:

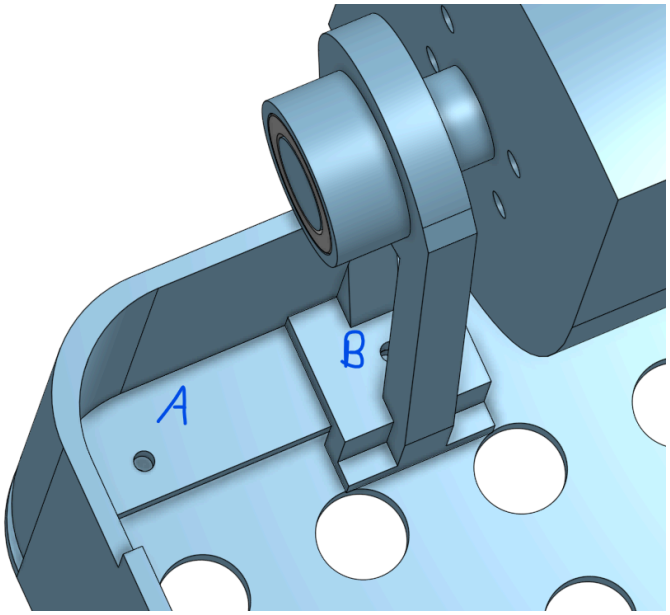
- Added 1 mm tolerance to drive motor hole and spinner axle mounts (increased diam of hole by 1 mm; for the drive motor mount on the bottom piece, I increased height by 1 mm and width by 1 mm)
- To Do:
  - [x] 
    - [x] ~~Add rectangle to bottom of spinner mounts and a screw hole; get rid of circle below it (same for other spinner mount)~~
  - [x] ~~Revert top piece back to original flat design after checking weight of all the internal parts~~
  - [ ] Update drawings after adding screw holes to spinner mount (and add new dimensions) as well as spinner
  - [x] ~~Make spinner mounts thicker~~
  - [ ] Add **W**[**ashers**] in between spinner and mounts and grease them so that they can spin easily
  - [ ] Charge battery
    - [ ] Stop charging before cells are at 4.2V (never leave unattended)
    - [ ] Absolutely make sure charger is on LiPo mode
  - [ ] Find **sharp-end screws** in fabric. Lab

Joon Choi

- [ ] Return screws/drive esc's, buy new drive esc, buy **Battery connector** (scroll all the way to see types of connectors), buy **Bearing** for spinner
    - [ ] Drive ESC wire info - CH2 (Throttle) CH1 (Steering); the remaining wires are probably to connect to other motors (unnecessary)
- [ ] Draw personalized circuit diagram (INCLUDE **SWITCH**)

- Epiphanies:

Joon Choi

- ☐ Found that screws were blunt tipped & esc's max voltage was 5V → return
- ☐ **Order of assembly** (so that no part gets stuck): Attach side to bottom, put everything inside, top to sides, spinner mount + wedge to bottom (at same time)
    - ☐ Screw pulley onto spinner
        - Put in bearings, axle, spinner into spinner mounts before screwing them in
    - ☐ Put motor shaft through square face of wheel hub (this allows the screws to hold shaft in place - otherwise shaft is too short)
    - ☐ 

        - For screw hole A, screw in from the top and have the nut on the bottom (the diameter of a M3 - 3mm outer thread diam - nut is 6mm which will go past the edge of the flap). For Screw hole B, screw in from the bottom and have the nut on top of the spinner mount.

1/17/23:

Calculations for gears:

Original gears: 29

Num teeth per inner radius = 29/(0.516*2pi) = 8.945 teeth/in

Gear circumference: 0.9595*2pi = 6.029in

8.945*6.029 = 53.93 teeth ~ 54 teeth

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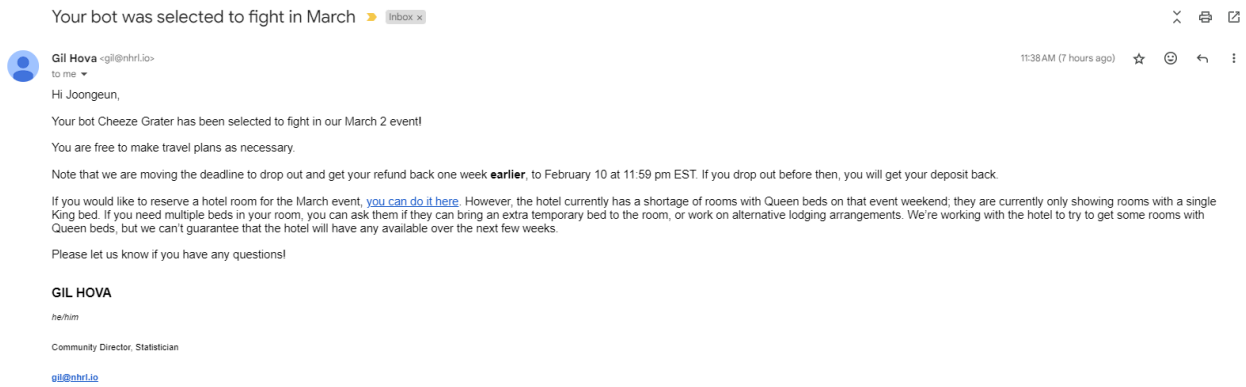


Your bot was selected to fight in March Inbox ×

**Gil Hova** <gil@nhrl.io> 11:38 AM (7 hours ago)
to me

Hi Joongeun,

Your bot Cheeze Grater has been selected to fight in our March 2 event!

You are free to make travel plans as necessary.

Note that we are moving the deadline to drop out and get your refund back one week **earlier**, to February 10 at 11:59 pm EST. If you drop out before then, you will get your deposit back.

If you would like to reserve a hotel room for the March event, you can do it here. However, the hotel currently has a shortage of rooms with Queen beds on that event weekend; they are currently only showing rooms with a single King bed. If you need multiple beds in your room, you can ask them if they can bring an extra temporary bed to the room, or work on alternative lodging arrangements. We're working with the hotel to try to get some rooms with Queen beds, but we can't guarantee that the hotel will have any available over the next few weeks.

Please let us know if you have any questions!

**GIL HOVA**

*he/him*

Community Director, Statistician

gil@nhrl.io

Notes:

- 
- ToDo:
    - Finish gear then make gear drawing; update all other drawings
    - Finish final assembly of chassis and send link to manufacturer

1/31/24:

- Met with Mr. Carl Pasciuto at Custom Machine Inc
- Notes

2/9/24:

- Spinner rad 0.9595→0.9
- Horizontal distance from spinner motor to spinner: 1.5775318in
- #Gears
    - Num teeth per outer teeth radius = 30/(0.58*2pi) = 8.2322 teeth/in
    - Gear circumference: 0.9*2pi = 5.655in
    - 8.2322*5.655 = 46.553 teeth ~ 47 teeth
    - 6.029*8.2322 = 50 teeth
    - 0.9595
    - 2pi*(0.9595+0.045)*8.2322 = 51.96
- NEEDED: 2pi(0.8775 + 0.045)*8.2322 = 47.72 teeth ~ 48 teeth

2/10/24:

Joon Choi

- Recalced spinner motor location 1.0786 in
- New #teeth
    - Belt 3mm/teeth
    - Gear 2(0.9)pi in to mm = 143.633616 mm
    - 143.633616 mm / 3 = 47.878 teeth ~ 48 teeth
- 3mm Screws

2/13/24:

- Lower spinner mounts, center of spinner is 1.299in above center of spinner motor
- Gear radius → 0.84294in
- #Teeth
    - Gear circumference 134.53 mm
    - 134.53 mm / 3 = 44.84 teeth ~ 45 teeth

2/14/24:

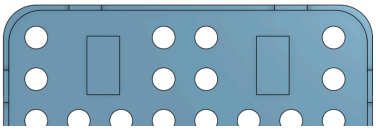
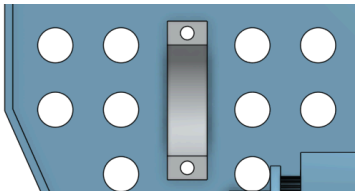
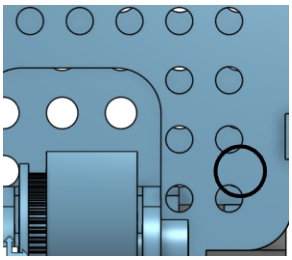
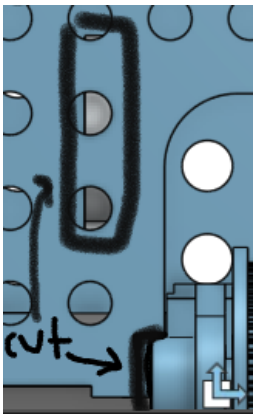
- Weight reduction ideas: Slanted back, lowered top cover to drive motor mount height, cut off rectangles on the cover where drive motor mounts are present (fit the mounts through the cover like a puzzle)
- Joon: Fix the top cover (screw ledge on the front)
- Sam: Fix gear drawings

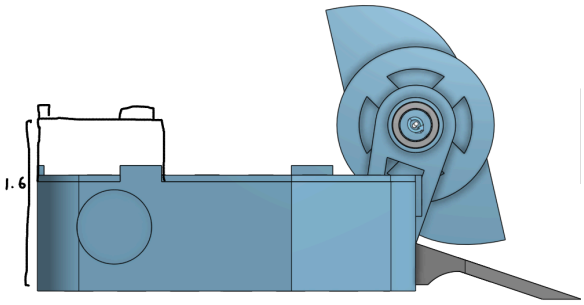
3/16/24:

- Previous: lxwxh = 3.269x5.152x1.850
    - Space between spinner mount & wall: 1.250
    - Len of drive motor mount: 1.025
- Now: lxwxh = 3.790x5.487x1.250

Joon Choi

ToDo:

-  - remove space between drive motor mount & back
-  - add one more hole in center of weapon motor mount
-  - add hole of diam. 0.75 for power switch to go through
- 

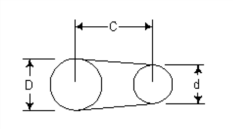
- cut so that the cover will fit through
- 

- raise back so that height is 1.6

3/17/24:

- Try smaller gear because belt is too short

Joon Choi

- Calculations
    - 8.017in belt, one gear pitch diameter 0.596in, other gear currently estimated (0.798+0.157)*2 in = 1.91in
    - Use belt length 7.804 instead of 8.017 to compensate for calculator error
    - Vertical distance 1.4025, horizontal target distance 1.6
    - Target center distance is sqrt(1.4025^2+1.6^2)=2.128in
    - [Belt Length and Center Distance Calculator (pic-design.com)](Belt Length and Center Distance Calculator (pic-design.com))
    - 


      **D = Pitch Diameter Large Pulley**
      **d = Pitch Diameter Small Pulley**
      **C = Center Distance**
      **L = Belt Pitch Length**

      Center Distance Known

      | | | |
      |---|---|---|
      | Large Pulley D | 1.91 | |
      | Small Pulley d | 0.596 | |
      | Center Distance C | 1.816 | |
      | Belt Length | 7.804 | in |

      Belt Length Known

      | | | |
      |---|---|---|
      | Large Pulley D | 1.59 | |
      | Small Pulley d | 0.596 | |
      | Belt Length L | 7.804 | |
      | Center Distance | 2.128 | in |

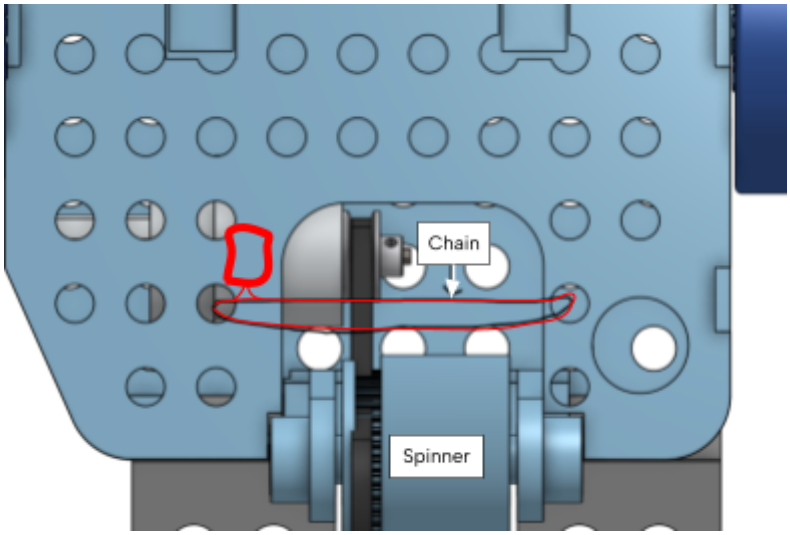
    - 1.59 in = 4.039cm = 40.39mm
    - | # Teeth | Pitch Diameter (for calculating centers) | Outside Tooth Diameter | Weight |
      |---|---|---|---|
      | 9T | 8.59mm (.338") | 7.89mm (.313") | 1.4g (0.05oz) |
      | 15T | 14.32mm (.564") | 13.56mm (.534") | 3.3g (0.11oz) |
      | 16T | 15.28mm (.602") | 14.52mm (.572") | 4.0g (0.13oz) |
      | 18T | 17.19mm (.677") | 16.43mm (.647") | 5.3g (0.18oz) |
      | 22T | 21.01mm (.827") | 20.25mm (.797") | 7.8g (0.28oz) |
      | 26T | 24.83mm (.977") | 24.07mm (.947") | 10.5g (0.38oz) |
      | 30T | 28.65mm (1.128") | 27.89mm (1.098") | 13.5g (0.48oz) |
      | 34T | 32.47mm (1.278") | 31.71mm (1.248") | 16.3g (0.55oz) |
      | 38T | 36.29mm (1.429") | 35.53mm (1.399") | 21.0g (0.73oz) |
      | 42T | 40.11mm (1.579") | 39.34mm (1.549") | 26.3g (0.90oz) |
    - Pitch diameter/teeth relationship is linear, about 0.955mm/T
    - T/0.955mm * 40.39mm = 42.29T
    - Matching to the table, we get ~42T
    - Trace Palmbeach gear in Onshape for smaller gear

3/28/24:

- Meeting Notes with Mr. Pasciuto

4/1/24:

Joon Choi

- Finished soldering drive-train - front/back motion works but moving joystick to the right moves bot to the left and vice versa
- Todo:
    - Joon: Fix drive train turning
    - Sam:
        - Calculate tip speed using max voltage, motor kv, reduction, and weapon size (Check askaron site for calculator)
            - Motor spins at X rpm
            - Tip speed in mph = X(pi)(3.119)(60)(16/38)/(63360)
            - 16000rpm → 62.5mph
        - Respond to email with the question below after calculations (might need to ask about our tip speed)
    - ~~Figure out how to clamp weapon~~
- Questions to include in reply to the safety team:
    - Will this work: 

- chain with padlock looped through two holes on the cover (which is made of aluminum)

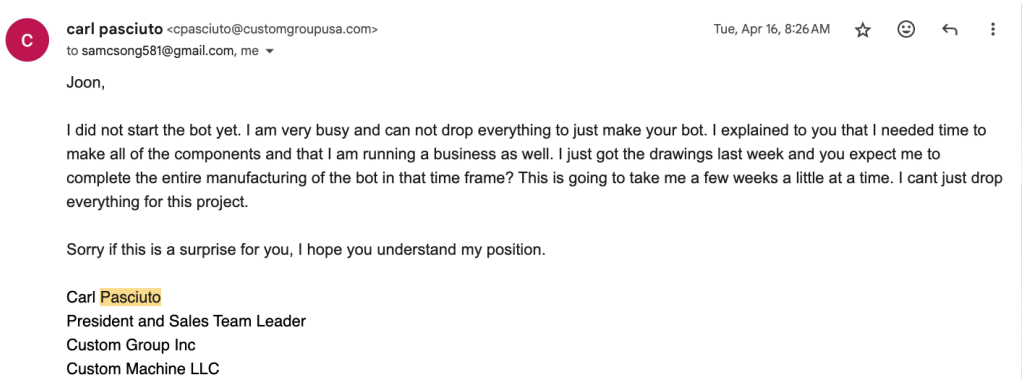
8/27/24

Future chassis material: ultra-high molecular weight polyethylene (3x less dense than aluminum)

Joon Choi

Notes from Manufacturing:

- Next time, double check that CAD file and drawings match up – the spinner was scaled up in drawing
- Don't have sharp corners that need to be cut out – 0.5in radius semi-circles are ok
- Motors didn't fit exactly in the mounts → next time, don't use measurement on website and measure dimensions with a caliper (precise tool) before CADing
- Make sure to give enough time for manufacturer to build and troubleshoot errors –



**carl pasciuto** <cpasciuto@customgroupusa.com> Tue, Apr 16, 8:26 AM

to samcsong581@gmail.com, me

Joon,

I did not start the bot yet. I am very busy and can not drop everything to just make your bot. I explained to you that I needed time to make all of the components and that I am running a business as well. I just got the drawings last week and you expect me to complete the entire manufacturing of the bot in that time frame? This is going to take me a few weeks a little at a time. I cant just drop everything for this project.

Sorry if this is a surprise for you, I hope you understand my position.

Carl Pasciuto
President and Sales Team Leader
Custom Group Inc
Custom Machine LLC

- The best mechanical engineers have an understanding of CNC machines and can make cheaper and easier-to-build designs

9/4/24:

Wiring: Right drive motor → Ch 2, Left drive motor → Ch 1

9/14/24:

Lessons from NHRL Competition:

- Fixed controls not working by using only 1 bidirectional esc to control both drive motors rather than using 2 (1 per motor).
- Buy spare parts in advance (especially for points of weakness such as a rubber pulley), especially if the chassis is expensive, you don't wanna have to forfeit because of a lack of parts
    - The pulley broke in the second round and there was no spares, and superglue didn't work, so we lost

- Another point of weakness was the weapon mount – since it was screwed in with one screw but is the point receiving direct impact, we should either have made it more secure or brought spares (the screws kept unscrewing after each match)
- Low center of mass: Beater bar bots with low heights were easily able to flip our “tall” chassis
    - On the flip side, our vertical spinner was able to easily flip over the horizontal spinner bot
- Use TPU (flexible like rubber so it doesn’t break upon impact) – can print from normal 3D printer!