TEAM 5587 - TITAN ROBOTICS

ENGINEERING NOTEBOOK

2020 Infinite Recharge

TABLE OF CONTENTS

STRATEGY

Overall

- We decided we wanted to focus on scoring more raw points that going for the ranking points, going for a win instead of simply getting the climbing or shield generator ranking point
- Since the trench is protected area, we discussed the possibility of creating a robot short enough to cycle through it
- We also decided to use pneumatic wheels to more easily navigate the boundaries in the center of the field

Power Port

- Upper power port scores at least twice the points of the lower, with the possibility for additional points with the inner port
- Scoring power cells in the power port is necessary for advancing through the stages for the shield generator, opening up the possibility for ranking points

Control Panel

- The control panel requires massive amounts of power cells to be scored before becoming useful
- Since we decided to solely focus on raw points, a mechanism to spin the control panel was not on our priority list
- However, due to the simplicity of such a mechanism, we decided to leave room in our design for its addition later

Shield Generator

- Since the endgame of Infinite Recharge is where the majority of the points are, we decided to prioritize a climber
- Since a ranking point could be achieved with two climbing robots that were level, we opted for a mechanism that would be mounted on top of the climber that would be able to shift our position and become level

BUILD LOG

1.4: Kickoff

Strategic Analysis

- Kickoff was largely spent discussing the strategies available to us as well as the strategies we thought other teams may use
- We split into groups and made lists of the priorities we had for strategy, settling on prioritizing a climber and shooter to score the most points possible

Week 1: 1.5-1.11

Build

1.8

- Prototyped climber and shooter
    - For the climber, tested a constant force spring mechanism to shoot the roller all the way up to the bar and began testing a stealth wheel roller for the top bar
    - Began testing a double horizontal flywheel shooter and a fixed-angle hooded shooter
- Began creating field elements
- Worked on drivetrain CAD

1.9

- Tested omni wheels with the roller
- Tested a double horizontal flywheel shooter and single wheel shooter
    - Decided that the single wheel shooter would not be able to shoot to the target distance
- Started a climber prototype based on a drawer slide and constant force springs
- Decided which belts and pulleys to use with the drivetrain
- Discussed attaching shooter to an arm mounted to the drivetrain for increased precision and compactness

1.10

- Worked on climber prototype (drawer slide) CAD
- Worked on double wheel shooter, prototyping compression, type of wheels, and we attached the prototype to motors to test how far it would shoot
- Prototyped an omni/belt intake that pulls balls to the center with belts above an omni roller
    - Uses a roller of omnis to pull balls above bumpers, at which point they are moved to the center by the timing belts, and pushed into the robot by a wheel above that is belted to the omnis
    - Tested with timing belts, which worked well
    - Powered by 2 drills

        - We will make the shaft that the axle is mounted on the proper length, increase the size of the wheel that pushes balls into the robot, and test with stealth wheels in place of omni wheels.
- Discussed an intake deployment mechanism
    - Intake mechanism is spring-loaded forward by gas pistons and a retaining arm is made which hooks onto the intake such that when the intake is run, the retainer is rolled off and allows the intake to spring forward.
- Tested a prototype for the tank (indexer) that consisted of parallel timing belts
    - Found that timing belts moved the balls well
    - Found that a single powered timing belt paired with a free-spinning timing belt would allow the balls to roll against the free-spinning belt until they touch, at which point they cause the belt to rotate as well (acts as a single belt roller until the balls touch, at which point it is more similar to a double belt roller).
- Made a prototype slip clutch with the router by routing a sprocket with custom holes that allow bolts to clamp around the outside of a hex hub, failure torque is increased by tightening the bolts.
- Made a prototype of the scooter. The scooter was attached to a hook to try hooking on to a pole. The hook was made out of 3 pieces of 80/20 connected by L and T brackets. The scooter was made out of a double 80/20 and a single 80/20 to form a triangle. Later on, this was tested by attaching the 10 pounds to the hook.

1.11

- Tested belt-centering intake
    - Ball slipped under belt in testing due to the looseness of the belt mounting
    - Started CAD on the next version of the intake
    - Brainstormed actuation methods, settled on gas pistons pushing the intake out, with a hook that gets attached to the arm when it is in the vertical position so that when the arm is let down, the hook releases and causes the intake to spring out.
- Finished drivetrain CAD
    - 6 pneumatic wheels with a ¼” drop center
    - Back-mounted gearboxes to free up space for the arm and to keep the center of mass as close to the climber as possible
    - Lifting eye bolts to make picking up the robot easier
- Began prototyping arm

Electrical

1.8

-

1.9

-

1.10

-

1.11

- Worked on a CAD for an electrical board prototype

Programming

1.8

-

1.9

- New members read WPILib documentation
- Started concept Arduino program for Driver Station

1.10

- Finished concept Arduino program for Driver Station

1.11

- Presentation on changes to WPILib

Week 2: 1.12-1.18

Final Schedule:

Build

1.14

- Making First Drive Rail
    - Both gearboxes were easily assembled
    - Belts were very tight assembling, won't need idlers
    - Bearings didn't quite fit, increased hole diameter by .01 before routing next rail
- Arm
    - Routed arcs out of wood for prototyping
- Intake prototype V2
    - Routed most of the intake
    - Started assembly

1.15

- Intake prototype V2
    - Assembled new prototype
    - The prototype took in and centered balls very quickly
    - Considering using PVC pipe coated in truck bed liner in the future (or another coating to increase grip on balls) to cut down on the weight of the roller
- Arm
    - Assembled one arc with the chain and chain guards, can be attached to the arm prototype in the next meeting
- Drivetrain
    - Assembled one drive rail complete with belt and gearbox
    - Cut stock for bumper mounts and the front/back
    - Started to route drivetrain brackets
    - Considered switching the flanges on the hex bearings to be on the outside of the drive rail
        - Decided to see if it was ok when completed first -- it might need to be changed
- Shooter
    - Replaced compliance wheels with Colson Wheels
    - Attached Neos with an external reduction of 2.33:1
- Scooter
    - Finalized roller design to allow us to balance on the shield generator
    - CAD is close to being complete
- Elevator
    - Printed caps for square tube as a part of a potential nested square tube design, found a .019" inner tolerance and .008" outer tolerance to be the most effective

1.16

- Intake prototype V2
    - Tested and found that balls would push the center belts to the side, causing the derailment of the belts (bad)
    - V2 is also very heavy
- Intake prototype V3
    - Consists of 5 full-length rollers made of hex shaft that will pull the balls over the bumper and into the robot, at which point they will be centered
    - This design will not have the problem of intaking too many balls because the balls will constantly be in contact with the rollers, even when in the robot.
    - This will allow the intake that leaves the frame to be lighter and more robust
- Shooter
    - Replaced shaft collars with blue stealth wheels to add space between the main shooter wheels (4” colsons)
    - Tested and found that the balls often hit within an area of around 2ft
    - Found slight dropoff between shots, far less than what was seen with 775 pros
- Drivetrain
    - Routed side rail and some brackets
- Arm
    - Assembled other chain arc and guards. mounted both arc assemblies to the prototype. Removed motors and axle used to drive from bottom pivot in the initial design. Installed sprockets at the midpoint of the arm.

1.17

- Intake Prototype V3
    - Assembled intake to the point that the first 3 rollers spin, found that with hex shaft, the balls crept slowly up the bumpers
    - Put 2” stealth/compression wheels to test with larger diameter
    - Wheels on the intake significantly increased the speed
    - Plan to try with only 3 rollers instead of the full 5
- Shooter
    - Built supports for the shooter so it doesn’t shake as much
    - Started PID
- Drivetrain
    - Routed more drivetrain pieces
        - Drive rail, cross beams, brackets
    - Began prepping driverail for belts + gearbox
    - Deburred and cleaned brackets and driverail

1.18

- Drivetrain
    - Assembled second driverail
    - Riveted crossbeams, front/back rails
        - Missing 2 crossbeam brackets for the bottom
    - Assembled and put on wheels
        - Need to change hex shaft for middle and front wheels

- Robot CAD almost complete; arm with rails, shooter, and drivetrain in one assembly

Electrical

1.14

- Finished basic drivetrain electrical board
- Prototyped a board layout and considered how to most effectively connect the CAN bus

Week 3: 1.19-1.25

Goals

1. Finish arm CAD (1/21)
2. **Prototype intake dropdown: (1/21)**
3. Route and assembly arm (Thursday)
4. Arm arcs (Friday)
5. Intake and full assembly (Saturday) - Stay late?

Build

1.20

- Drivetrain assembly completed
- Arm CAD mostly finished: had to shorten arm to fit in frame perimeter and under the trench
    - Still need to check dimensions and possibly make arm shorter
    - Still need to design:
        1. Indexer stop before flywheel or just use the flywheels
        2. Motor mount for moving arm
        3. Belt system (entire bottom belt run and top of the top)
- Using flywheel to stop the balls from entering the shooter.
- Intake doesn't fit inside frame perimeter:
    - Double jointed arm to lower intake
- Climber design not started: either put on arm or in front of robot
- Design with vertical flywheel to use the spin to get more distance, rather than having it turn the ball. Wait until programming tests.
- CADed nested elevator

1.21

- Arm now fits nicely inside frame perimeter
- Fixed messed up arm dimensions on brackets for the arm
- Brainstormed linear slides mounted to arm driven up and down by a spool connected like a cascading elevator (to be used to place hook on bar for climb [linear slide elevator: LSE])
- Started CADing parts needed for climber/elevator prototypes
    - Sliders (two sizes), carriages for both sizes

1.22

- Started routing brackets for the arm
- Redesigned intake to be a little smaller so it fits within frame perimeter
- Developed second design for the climber
    - Telescoping square tube mounted to drivetrain with constant force springs pulling it up and a winch to pull the robot up
- Continued CADing parts for LSE
- CADed nested elevator

1.23

- 3D printed a cap for LSE and used cable and v-wheels to test

1.24

- Began to review final cad and change hole sizes to be more accurate
- Cut square tube to length for the arm/tank
- CADed the inserts to hold the spring and cord for the LSE
- CADed nested elevator

1.25

- Routed the first arc and several brackets/square tube for the arm and shooter
- Prototyped surgical tubing insert with barbs to more easily connect tubing
- Worked on LSE
    - 3D printed the previously CADed parts
    - Decided to use steel cable for winch and nylon fishing cord for elevator stages
    - Began assembly and testing of linear slide elevator with one big slider attached to robot and two lighter stages
- CADed nested elevator

Electrical

1.20

- Test electrical board mounted on drivetrain; drivetrain runs smoothly.
- Need to design final electrical board and add battery mount
- Cad for the belly pan is complete, need to see where the components would be best placed

1.23

- Thought about potential PCB redesign to fit more CAN devices on the bus
- Cleaned up belly pan CAD

Week 4: 1.26-2.1

Build

1.27

- Routed Arm Brackets
- Added idler to the drivetrain belt from gearbox to center wheel

1.28

- Decided to use 3 light stages instead of one big one and two light ones for Linear Slide Elevator
- Brainstormed ideas to keep the stages of the elevator together, we decided on 3D printing inserts for the linear slide that included spacers to hold the linear slides at a specific distance from each other
- CADed nested elevator

1.29

- Drivetrain belt was stripped after a brief driver practice
- The inserts for the linear slides were tested, but further proved to create too much space in between the linear slides
- New inserts were 3D printed to allow for enough space for the linear spring to fit onto the inserts
- Began assembly of the arm top and bottom frame

1.30

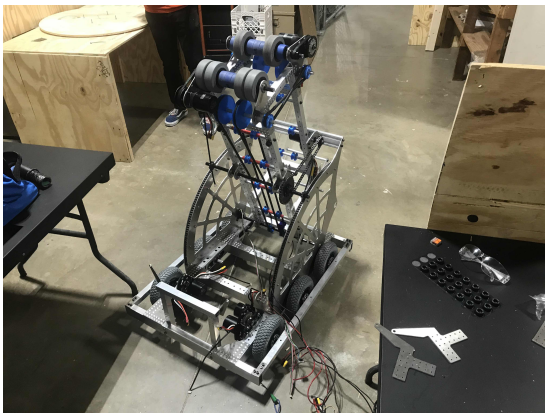
- Arm/tank was partially assembled
- The new inserts were ground down to allow for the space between the stages to be at appropriate height
- Ideas were brainstormed for a hook mechanism to attach to the shield generator
- Found out why the belt got stripped
    - Idler caused the belt to be pushed into one of the bolts that attached the arc, causing the bolt to rip up the belt

1.31

- Arm/tank was almost fully assembled
- Assembled first arc with chain
- Finished routing the arc
- Decided to switch to NEOs on the drivetrain because Falcons were ripping the belts of the drivetrain due to instantaneous acceleration
- Shaved down Colsons for shooter so that they would fit between the brackets

2.1

- Assembled second arc with chain
- Arm/tank attached to robot
- Replaced drivetrain belt in under 30 minutes
- Replaced drivetrain Falcons with NEOs
- Put belts onto shooter (bracket fits belts well)



Electrical

1.27

1.28

1.29

1.30

General Design

Week 5: 2.2-2.8

Build

2.4

2.5

- Fixed clicking noise in the drivetrain

2.6

- Routed sides of intake out of ⅛” lexan

2.7

- Intake hex shaft was lathed
- Began to assemble intake pieces for truck bed liner
- Assembled sides of intake

2.8

- Intake was fully assembled, pvc coated with truck bed liner
- Started to manufacture nested square tube version of climber

Electrical

2.4

- Attached belly pan
- Built battery mount

2.5

2.6

2.7

2.8

- Built encoder brackets but scrapped design and opted for the encoder to be mounted on the drive wheels

Week 6: 2.9-2.15

Build

2.10

- Continued with the assembly of the nested elevator, refined tolerances for caps and sliders to ensure a good fit

2.11

- Printed and tested plastic pieces for sliders to go in LSE (finally worked)
- Assembled LSE with new springs, didn't lift 3 stages but lifted 2 with ease
- Continued with nested elevator assembly, decided to split bottom sliders into two pieces for ease of assembly

2.12

- CADed and printed new bracket that was able to hold the string for the LSE

2.13

- Fixed LSE CAD and CADed a bracket to hold all the stages together, printed brackets too

2.14

- Tested LSE with new brackets, didn't work so we exchanged the cascade idea for another spring attaching the 2nd and 3rd stages and it worked *beautifully*
- Routed hook for LSE
- 8" pneumatic wheels impeded turning so 9" SmoothGrip wheels added in place
- Made measurements for bumpers
- Cut boards out of plywood for bumpers

2.15

- Continued with construction for nested elevator, routed remaining brackets and 2" square tube
- Internal drivetrain belts were destroyed and external chain was added as a fix
- Cut lengths of wood for bumpers

Electrical

Week 7: 2.16-2.22

Build

2.17

- External drivetrain chain not tensioned properly, so chain was skipping
- CADed a sprocket to go on the drivetrain to tension the chain
- Discussed winch ideas for climber
    - Deciding between webbing and rope
    - Using a pre-made winch with a ratchet
    - Using a toughbox mini with a falcon 500 and custom spool and ratchet
    - Adding a hardstop closer to 70 degrees to mount the winch to the upper hardstop for the arm
    - Running rope or webbing through pulleys on the hook and attaching to the lower hardstop to center the robot
- Added on 2” stage for nested elevator, cap needs to be reprinted to fix friction issues
- Made a list of broken mechanical items that need to be fixed
- Attached angle iron to wood for bumpers

2.18

- What happened on tuesday?
- Attached angle iron to wood for bumpers

2.19

- Routed sprockets to tension drivetrain chain
- Cut and drilled brackets to go on bumpers

2.20

- Decided on linear slide elevator for climber
- Winch/rigging ideas?
- Attached brackets to bumpers

2.21

- Attached sprockets to tension drivetrain chain, routed custom spacer and washer to keep the sprocket on the bolt
- Tensioned intake so that it sat level
- Continued work on bumpers, made an initial test bumper to test intake
- Climber and winch CAD continued
- CAD for Pit layouts was finalized
- Made a list of what build has to do on and off the robot and assigned them to people
- Put silicone on pulleys for extra grip
- Attached brackets to bumpers

2.22

- Hook cad finished, routed second version of the hook with mechanism to release when on the bar
- Moved intake springs back to make sure the intake stays inside frame perimeter when inside

- Experimented with using linear springs to hold the tensioner between the arm and intake up
- Discussed how to climb, thought about running strap from front to back of arm and lifting from the front and back hardstops
- After having issues with surgical tubing snapping, decided to route paracord inside the tubing to increase strength while retaining the grip of tubing
- Began redesign of robot cart
- Recut, redrilled, and reattached middle brackets to bumpers
- Covered bumpers with noodles

Electrical

2.22

- NEO motor on the arm was not running correctly, with a current spike once per rotation. Factory resetting sparkMAX motor controller fixed this issue
- Wired and installed the color sensor

Week 8: 2.23-2.29

Build

2.25

- **Owen knows, ask him**
- Filed bumpers to fit better
- Measured lengths of fabric to cover the bumpers

2.26

- Printed and designed parts for climber
    - Bracket to mount versaplanetary with Falcon 500 with 30:1 gearing
    - Slider to run strap through a hole in the arc
- Decided to run strap from one arc to another at the center of gravity, route around back hardstop for arm to avoid getting in the way
- The hook will be on one side with a pulley, so it can center itself along the robot to balance when it's released from the elevator
- Ironed on numbers to the bumper fabric

2.27

- The black bracket on the top of the second level of the climb broke after being accidentally dropped; a new one based on the design of the first level black bracket is being 3D printed for tomorrow
- Assembled the carabiner hook with bolted churros in between the hooks
- Attached a spring onto a plug at the top of the climb and bolted it into the slider box to pull the hook, but found that all the leftover springs that fit were unable to lift both sides of the hook
- Added hex shaft collars around the robot to make sure shaft wasn't falling out

2.28

- Brackets for winch and new hardstop were routed
- Decided to switch to Neo with 30:1 instead of Falcon 500 for the climber
- Decided to use nested square tube elevator instead of linear slide
- Designed clip to keep elevator in place
- Replaced sliders in nested elevator to make it smoother
- Attached winch to top of arm
- Added hardstop on winch for arm
- Added steel cable outrigging to secure the arc with turnbuckles

2.29

- Made new hook for use with climber
- Issues with drivetrain tensioners slipping off the chain, designed lexan chain guides
- Replaced bearings on drivetrain
- Routed hooks to keep intake inside frame perimeter
- Added paracord tensioners to keep intake level
- Attached neo with 30:1 versaplanetary to winch

Electrical

2.28

- Cable management
    - Bolt taped down motor controllers
    - Made sure connections to CAN bus were good
- Added frosted lexan to cover up wires next to the PDP
- Swapped out bolts for thumb screws to access the RoboRIO more easily

2.29

- Discovered problem with the neo internal encoder, neo was not completing full rotations
    - Decided to remake the breakout board and move the SparkMAX closer to the motor to decrease resistance

Week 9: 3.1 - 3.7

Build

3.2

- Attached hooks to keep intake inside frame perimeter for start of match
- Attached climber pulleys to side of arc at center of gravity
- Assembled climber hook with bearings and churros
- Ran ¾” strap through pulleys, hook, and winch
- Tested elevator mount, and decided to have the elevator at an angle to avoid collision with winch motor

3.3

- Tested climber with neo on 25% power
- Drilled and attached bars for elevator to release hook
- Moved climber pulleys up to compensate for future added weight
- Redesigned elevator mount to be at an angle
- Added ratchet to hold winch after the robot was disabled
- Attached winch neo to hardstop use hose clamps to ensure that the bracket would not bend if the winch was driven against the ratchet.

3.4

- Put spacers and green wheels on intake to help with getting balls in more easily
- Printed elevator mount
- Secured bumper mounts
- Attached lexan chain guides to the drivetrain tensioners

3.5

- Mounted elevator
- Routed elevator spool divider
- Attached elevator spool divider
- Fixed drivetrain tensioners so that the bolts weren’t scraping the arcs

3.6

- Ran fishing line to elevator with vee wheel
- Added spool to make the fishing line spool in twice as fast as strap, since the strap is reeled in at two points and the elevator is only pulled down at one, which led to the hook not being able to detach

3.7

- Added license plate
- Added pins made from ¼-20 bolts to keep strap out of the way of the arm when not climbing
- Added Thunderhex across the bottom of the intake to attach a belt to, making a smoother transition between the intake and conveyor belt
- Added a larger spool for elevator fishing line, allowing the elevator to spool down faster than the strap reels in and adjusted the slack so that the winch will unwind and wind properly

- Retied multiple conveyor belts with the “Surgeon’s reef knot” and put heat shrink over the knot to manage excess

Electrical

3.2

- Arm neo was fixed without any electrical modifications

3.3

- Added SparkMAX for the climber

3.5

- Fixed color sensor
- Attached limelight with new mount
- Added limit switch to the top of the arm

3.6

- Added limit switch to the bottom of the arm

3.7

- Fixed wiring for limit switch

Week 10: 3.8 - 3.15

Build

3.10

- Cut and attached surgical tube skin to elastic belts
    - Only had enough surgical tubing for the top belts, though this may be sufficient
- Weighed robot, robot weight is approx 108lbs

Electrical