# ENPH 253 Robot Design Proposal

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## Executive Summary

### Defining the Challenge

The challenge presented to our robot is to rescue six agents from drowning in a tub of water. This will include time dependent alarmed doors, scaling a narrow passage (ascending a narrow ramp), saving the agents from their pedestals which will collapse, and delivering them safely on a zipline.

### Our Solution

Our solution is an all aluminum robot consisting of a rotating arm, a raising platform, and a claw mechanism.

| DESCRIPTION | MEASUREMENT |
| --- | --- |
| Robot Size | Condensed: 1’W x 1’L<br>Extended: 1’W x 1’-6”L |
| Robot Weight | Without Agents: < 3kg<br>With Agents: 3kg |
| Estimated Speed | 0.5 m/second |
| Claw Raising & Lowering Speed w/ Agent | 0.05 m/second |

### Document Content

Our document includes all of the necessary calculations, CAD designs, and tasks needed to create our robot. Specifically, the engineering portion of the document includes:

1. Course measurements and restrictions
2. Torque calculations for the various mechanical components
3. Circuit diagrams and calculations for all of the major circuits used to run the robot and its functions
4. Pseudo-code for the software needed to control the robot

As well, there are numerous sections that cover the organizational structure of the team working on our robot, a general timeline of the progression of design, and the major milestones our team hopes to achieve.

## Preface

### Document Responsibilities

| PERSON | SECTION | RESPONSIBILITIES |
|---|---|---|
| Theophilus Ko | 3.3 Claw | CAD for the Claw |
| | | Weight, Torque, Length Calcs |
| | 5.0 Code | Pseudo Code |
| | | Usable Code |
| | | Logic Diagrams |
| Jessica Chapman | 1.0 Overview and Preface | Challenge Description |
| | 4.0 Circuits | Circuit Layout in Chassis |
| | | Circuit Schematics and Calcs |
| | | TINAH Board Planning |
| | 6.0 Risk | Assessment and Contingency |
| | 7.0 Tasks | Compiled Tasks/Milestones |
| Ryley Simpson | 2.1.1 Complete Design | |
| | 3.1 Chassis | |
| | 3.4 Basket | CAD for Basket/Scissor Lift |
| | | Weight, Torque Calcs |
| Toren Dofher | 2.0 Proposed Design | CAD for Final Design |
| | 3.1 Chassis | CAD for Chassis |
| | | Weight, Torque, Length Calcs |
| | | Wheel Design |
| | 3.2 Arm | CAD for Arm |
| | | Weight, Torque, Length Calcs |

All authors are qualified and expected to perform at a second year Engineering Physics Level.

We would like to acknowledge everyone working in the ENPH 253 Labs including Andre, Jon and Bernhard and the TAs Connor, Connor, and Riley for their mentorship and vital assistance.

This document is confidential information and its creators ask that its contents not be shared outside of the teaching staff of Engineering Physics 253 until the completion of the competition.

This document was created for reference by its creators and teaching staff within Engineering Physics 253 at the University of British Columbia. The circumstances of this document's creation dictated that it be produced within a tight timeframe. It should therefore be noted that all designs and calculations may be subject to change as further testing and iteration is undertaken.

No licensed engineers were involved in the creation of this document. This should not be regarded as an engineering document.

Signed:

Jessica Chapman, Toren Dofher, Theophilus Ko, Ryley Simpson

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## 1.0 Overview and Strategy

### 1.1 - Challenge Constraints

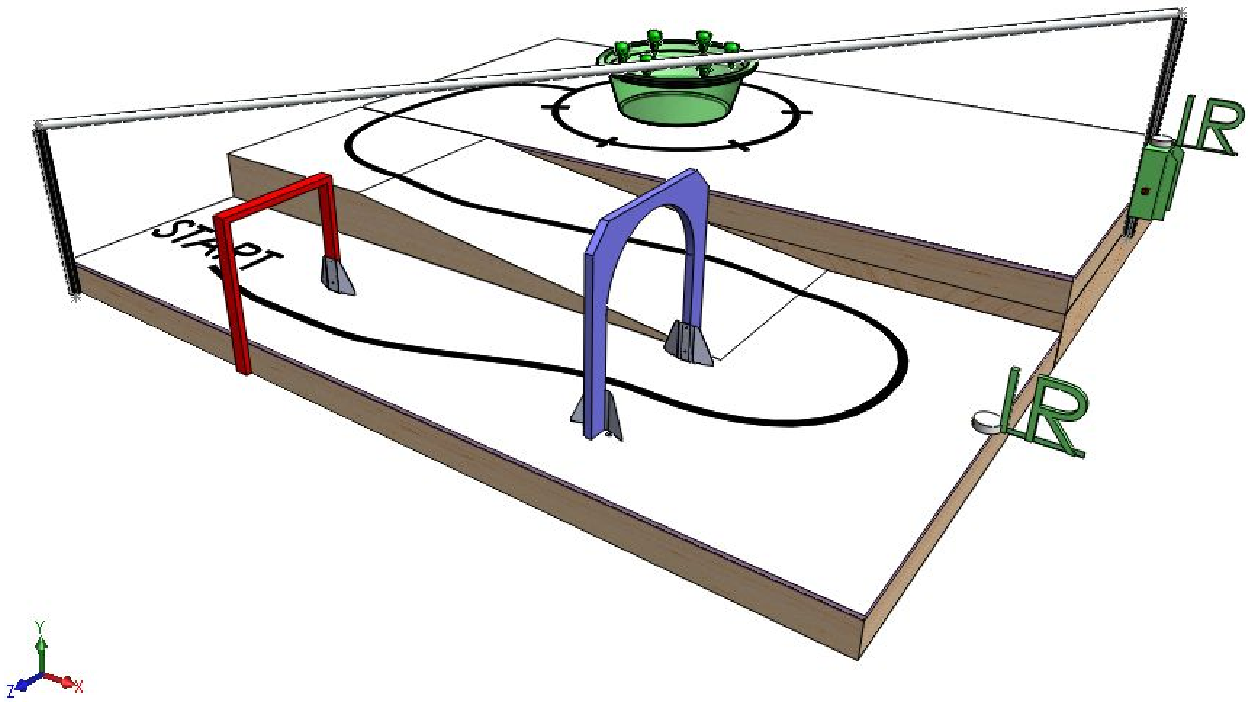


Figure 1.1.1: Challenge Course (photo credit: Jon Nakane and Bernhard Zender)

| **Measurement Constraints**<br>Figure 1.1.2 Course Measurements | | | |
|---|---|---|---|
| ***Type*** | ***Measurement*** | ***in/degree*** | ***cm/rad*** |
| *Zipline* | Height | 20 | 50.80 |
| | Diameter | 1.16 | 2.95 |
| *Ramp* | Angle of Ascent | 7° | 0.0388π |
| | Length | 47 | 119.38 |
| | Width | 24 | 60.96 |
| | Width to Wall (min) | 6 | 15.24 |
| | Width to Edge (min) | 6 | 15.24 |

| | | | |
|---|---|---|---|
| *Entrance Gate* | Height | 12 | 30.48 |
| | Width | 12 | 30.48 |
| *Alarmed Gate* | Height | 18 | 45.72 |
| | Width | 14 | 35.56 |
| *Tub* | Height | 7 | 17.78 |
| | Diameter | 22 | 55.88 |
| | Pedestal Range | 5.03-6.61 | 12.78-16.78 |
| | Water Depth | 5.03-5.82 | 12.78-14.78 |

Additional Constraints

- Time Limit :
  - Maximum of two minutes
  - Agents fall into water starting after 1 minute

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**1.2 - Proposed Solution and Strategy**

We propose a tape following robot with built 4 tape following sensors and two independent functional bodies. The robot will have 7 motors, two of which are used for driving the robot, and the rest which control the heights and angles of the arm and basket.

We will be separating the robot so that the ziplining can be done using an independent body consisting of a basket and hook. We will be using all rotational motion to avoid losses due to conversion to linear motion. Our main strategy is to create a claw that can sense objects very well, regardless of where they are in the bucket.

## 2.0 Proposed Design

Our design combines a basket mechanism, claw mechanism and arm mechanism, all connected by the low chassis. The basket is independent of the scissor lift, using weight distribution and magnets to keep it from tipping, and will be used to put the agents on the zipline. The claw and arm are used to grab the agents from the tub, use rotating motion to extend the length of the arm and to move it around from the tub to over the basket. The robot has two rear motors connected to the wheels and three smooth, front wheels that are only used for balance. Strings connecting claw and arm are not shown.

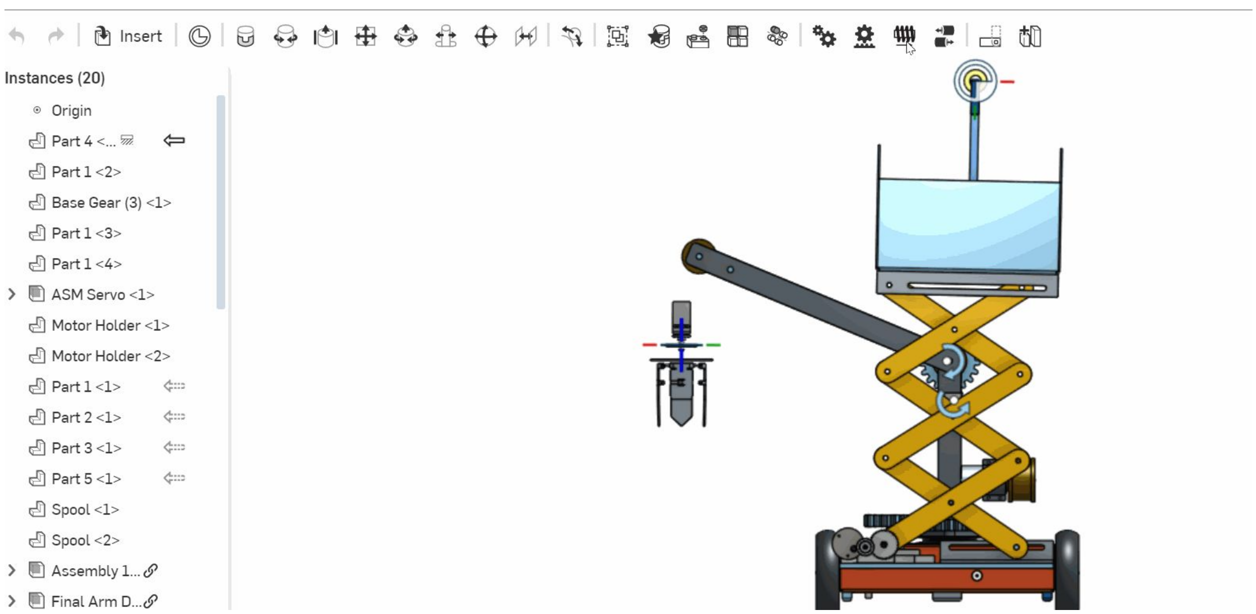


Figure 2.1.1 Complete Design

**Total Mass of Assembly: ~2.5 kg**

**Torque needed for drive motors:**

$$2.5/2 * 0.0381/2 \quad = 0.024 \;\; N\ m$$

**Wheel diameter**: 0.0381 m

**Max speed of robot:** 0.5 m/s

## 3.0 Mechanisms and Drive and Actuator Systems

### 3.1 - Chassis

The chassis has a very simple design that is quite low and wide to keep the robot from tipping over. Inside can be seen the circuit layout (total three circuits). It will have three wheels on the front and two wheels controlled by the motor in the back. Chassis will be made of waterjet cut aluminum.

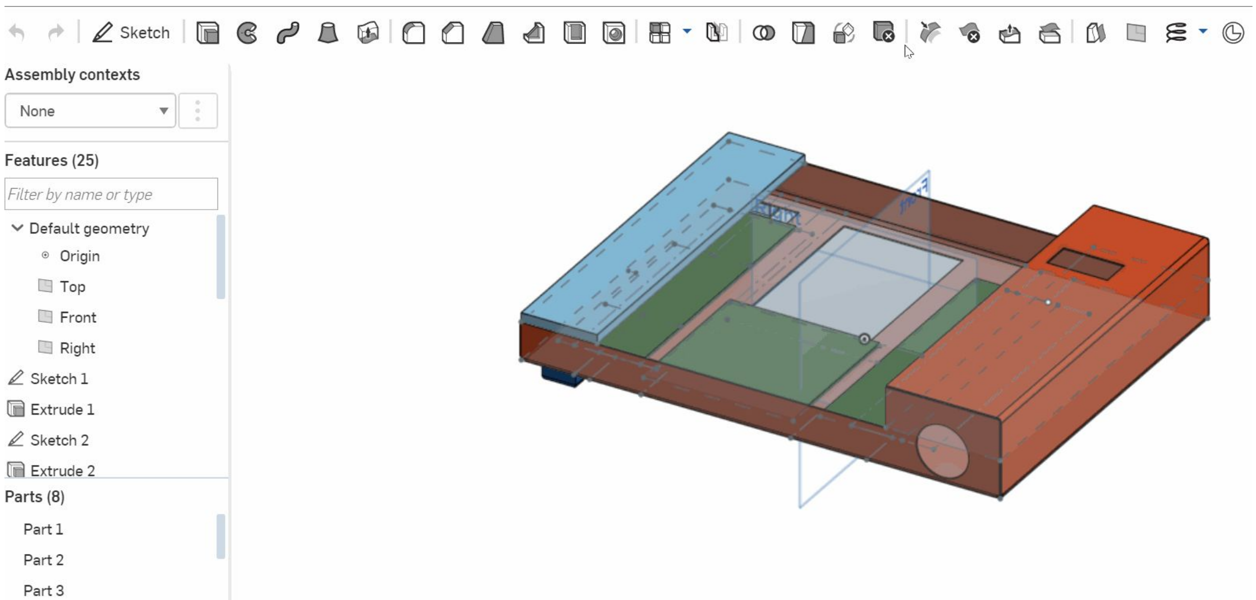


Figure 3.1.1 Chassis Mechanism

**Masses:**

**Main chassis:** 0.383 kg
Wheels: 0.017 kg
TINAH: 0.25 kg
LIPO battery: 0.13 kg
Other circuits: 0.5 kg

## 3.2 - Arm

Our arm works to the motor's strengths by using rotational motion for its primary functionality. The whole arm system rotates about the chassis on a lazy-susan bearing. The arm extension then rotates about the primary trunk, also controlled with a servo motor via a gear system that reduces torque and translates the full 180 degree servo range into an 80 degree range of rotation desired by the arm. The claw will be raised and lowered using a spool connected to a DC Motor. Using simple trigonometry we should be able to use the rotation of the arm and the raising and lowering of the spool in place of linear motion.

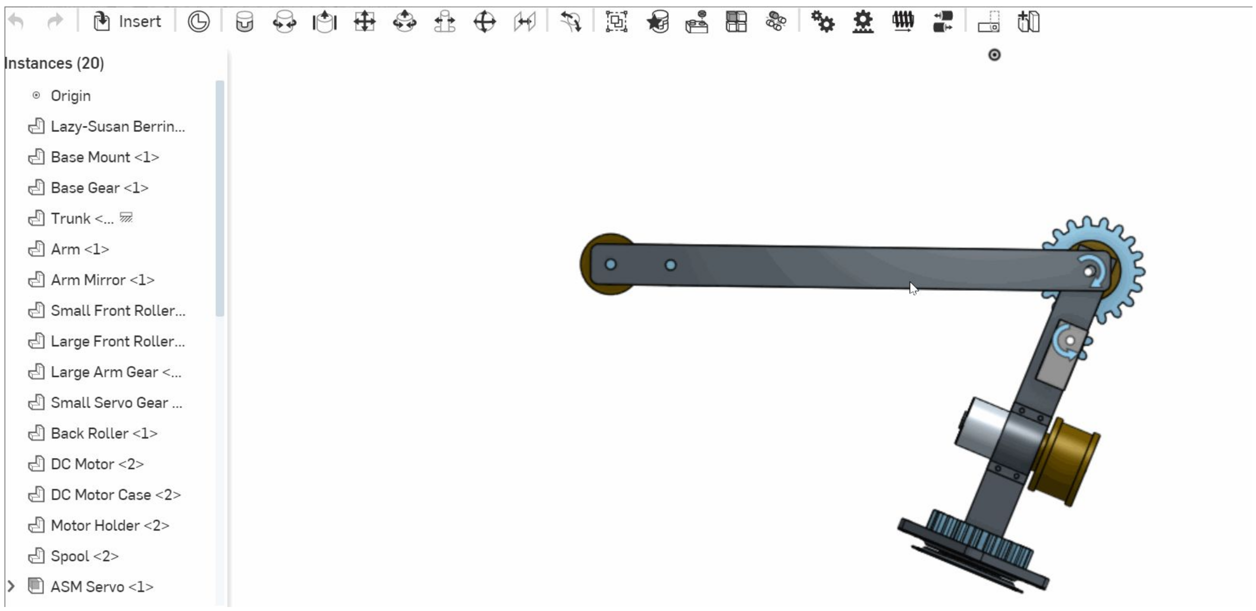


Figure 3.2.1 Arm Mechanism

**Torque in Arm Servo Motor Calculations:**

**Rated Servo Torque:** 0.373 Nm

**Large Gear Diameter:** 64.82 mm
**Small Gear Diameter:** 28.00 mm
**Arm length:** 279.4 mm

**Density Aluminum:** 2700 kg/m^3
**Arm Volume**: $V = A * t = (7235.3mm^2)(\frac{6.35}{2}mm) = 22\,971mm^3$
**Mass of Arm:** $M = V * \rho = (22\,971mm^3 * 2)(2.7 * 10^{-3}g/mm) = 124g$

**Mass of Claw, Animal, Error:** 120g

**Torque in servo**: Torque in arm * Small Gear diameter/ Large Gear diameter

**= 0.289 N.m**

**Torque in arm:** (mass of claw + mass of animal + uncertainty for fasteners)*length of arm*gravity + (mass of arm)*length of arm/2*gravity

**= 0.669 N.m**

0.289 < 0.373
Therefore this should work
If we find that the mass was greater than expected we can lower the gear ratio even more to ensure that less torque is put on the servo motor.

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**Spool Motor Torque Calculations:**

**Spool diameter:** 22.6 mm
**Mass of claw with animal:** 120 g

**Motor Rating:** 0.2 Nm
**Force on string: (**9.81)(0.120) = 1.178 N
**Torque in spool:** force on string * spool radius

**= 0.0133 Nm**

0.0133 < 0.2
Therefore this should work
Use rollers to reduce friction

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**Rotating in the Horizontal Plane Calculations:**

**Mass claw:** 0.04126 kg

**Mass servo:** 0.04 kg
**Mass Agent:** 0.023 kg
**Mass Arm:** 0.062 kg (x2 arms)
**Error:** + 0.01 kg

**Total Length of extending arm:** 0.2089 m
**Center of mass of extending arm:** 0.1045 m

$$\tau = r * F$$
$$\tau = (0.1045)(9.81)(0.062 * 2 + 0.01) + (0.2089)(9.81)(0.04126 + 0.04 + 0.023)$$
$$\tau = 0.35\ Nm$$

## 3.3 - Claw

Our claw design uses four arms and a servo motor. The servo will be attached with two supporting pieces of aluminum (not shown due to visible obstruction of the side features) attached at the holes of the servo to both edges of the claw. There will also be strings attached to each arm of the servo and the claw, which will pull around when the servo rotates to close the arm.

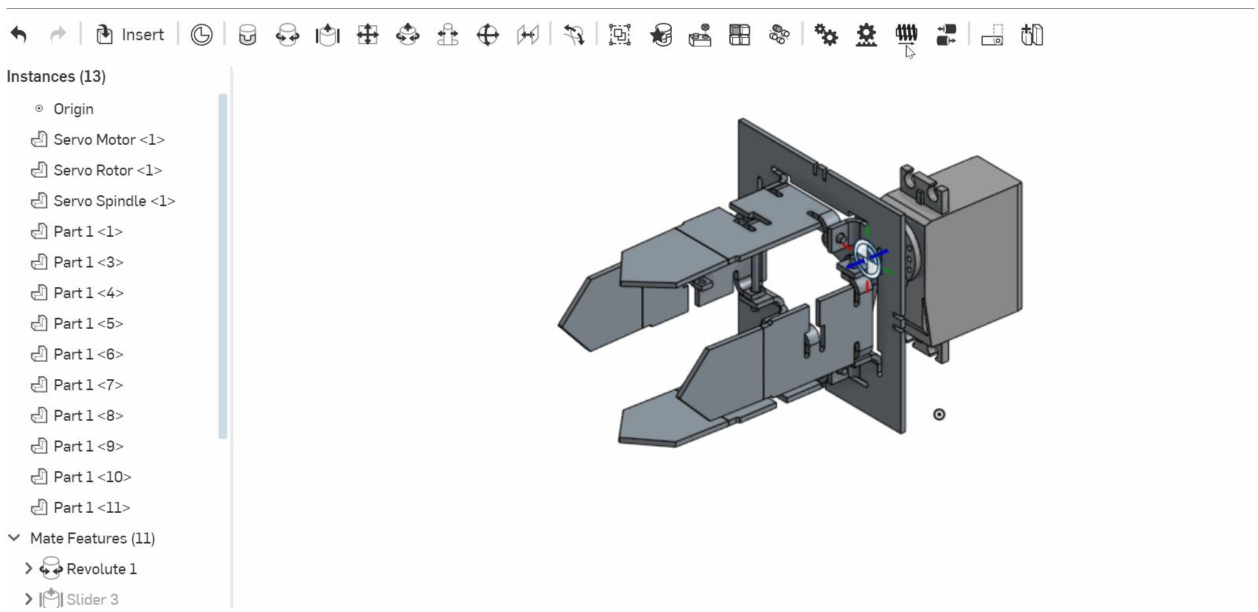


Figure 3.3.1 Claw Mechanism

**Claw Mechanism Calculations:**

**Sheet metal thickness:** 1.6mm

**Density:** $2700\ kg/m^3$

**Frame Volume:**
$(1.6mm)(70mm * 70mm\ -\ 30mm * 30mm\ +\ 4 * 10mm * 30mm)\ =\ 4480m^3$

**Claw Volume:**
$70mm * 23mm * 1.6mm\ *\ 4\ =\ 10304mm^3$

**Holder: Servo to Frame:**
$31mm * 5 * 1.6mm * 2\ \approx 500mm^3$

**Ultrasonic sensor:** $15g$

**Total:** 80g

## 3.4 - Basket

Basket will be 2400 cubic cm with a hook hanging above to slide down the zipline. Hook has a roller on it to reduce friction. Basket will be lifted by a scissor lift driven by a DC motor. The basket will be made of MDF sprayed to waterproof with an aluminum hanger. Scissor lift will be made entirely out of aluminum.

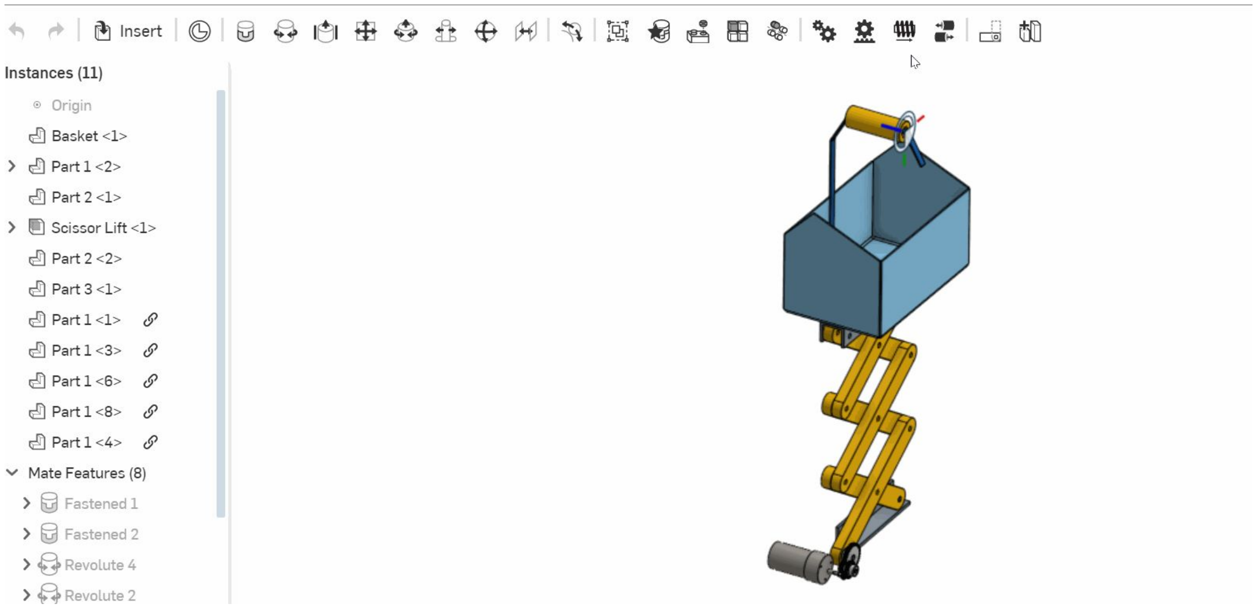

Figure 3.4.1 Basket Mechanism

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**Masses:**

**Animals:** ~0.15 kg
**Basket:** 0.15 kg
**Hook:** 0.09 kg
**Scissor lift arm:** 0.04 kg each
**Motor:** 0.182 kg
**Gear train:** 0.024 kg

**Total:** 0.85 kg

**Calculating Torque:**

Simplified calculations by calculating only top two arms with torque and pin slot on them. If angular velocity is zero, all x-components of forces are zero. Assuming angular acceleration is zero.

$\tau = m_{Load} g/2\ L\ cos\ \theta$

Torque is maxed when cosine term is 1 (angle = 0).

$\tau_{Max} = 0.4\ N\ m$

Giving torque a factor of 5 for operation purposes

$\tau_{Required} = 2\ N\ m$

Max torque of the geared Barber-Colman motor is 0.2 N m so a 10:1 gear train will be used. For size, this will be a 3:1 connected to a 3.3:1.

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## 4.0 Circuits

### 4.1 - TINAH Board Pinouts

| **TINAH BOARD PINOUT CHART**<br>Figure 4.1.1 Pinout Chart | | | |
|---|---|---|---|
| **TYPE** | **PIN** | **CONNECTION** | **PLACEMENT** |
| **KNOBS** | PF6 | | |
| | PF7 | | |
| **PWM** | PB5 | | |
| | PB6 | | |
| | PB7 | | |
| | PE3 | | |
| | PE4 | | |
| | PE5 | | |
| **ANALOG** | PP0 | | |
| | PF1 | Right QRD Sensor | Chassis |
| | PF2 | Left QRD Sensor | Chassis |
| | PF3 | Speed Control Potentiometer | Code |
| | PF4 | P Control Potentiometer | Code |
| | PF5 | I Control Potentiometer | Code |
| | PF6 | D Control Potentiometer | Code |
| | PF7 | Ultrasonic Sensor | Claw |
| **DIGITAL IN** | PC7 | Push Button | Claw |
| | PC6 | Push Button Front | Chassis |

| | | | |
|---|---|---|---|
| | PC5 | Push Button Left | Chassis |
| | PC4 | Push Button Right | Chassis |
| | PC3 | IR Circuit Output | Chassis |
| | PC2 | | |
| | PC1 | Right+ QRD Sensor | Chassis |
| | PC0 | Left+ QRD Sensor | Chassis |
| **DIGITAL OUT** | PD7 | | |
| | PD6 | | |
| | PD5 | | |
| | PD4 | | |
| | PD3 | | |
| | PD2 | | |
| | PD1 | | |
| | PD0 | | |
| **MOTOR SIGNAL** | MOTOR 0 | | |
| | MOTOR 1 | | |
| | MOTOR 2 | | |
| | MOTOR 3 | | |
| | PE3 | Servo 1 Arm | Arm |
| | PB7 | Servo 2 Arm | Arm |
| | PE2 | Servo 1 Claw | Claw |
| **MOTOR OUTPUT** | 0- | L. Wheel Comparator 1 | Chassis |
| | 0+ | L. Wheel Comparator 2 | Chassis |
| | 1- | R. Wheel Comparator 1 | Chassis |
| | 1+ | R. Wheel Comparator 2 | Chassis |
| | 2- | Arm Motor 1 | Arm |

| | | | |
|---|---|---|---|
| | 2+ | Arm Motor 2 | Arm |
| | 3- | Basket Motor 1 | Basket |
| | 3+ | Basket Motor 2 | Basket |

## 4.2 - Wiring and PCBs

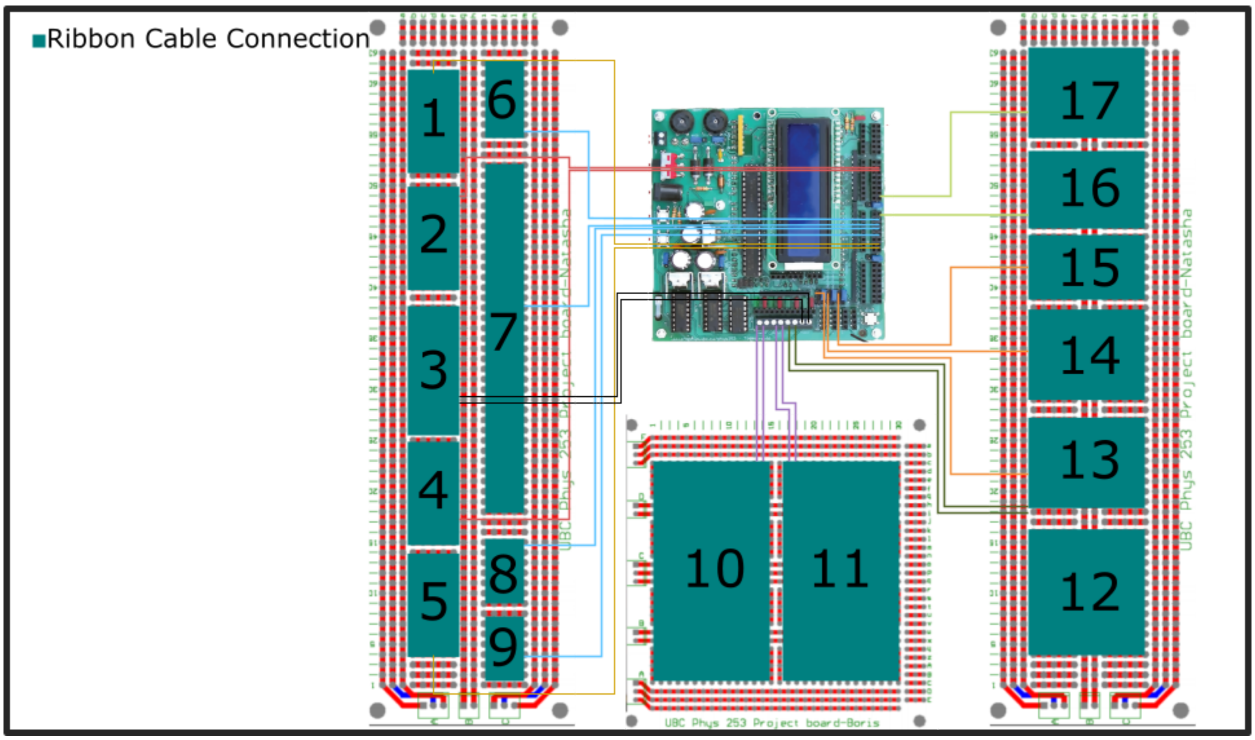


Figure 4.2.1 General Circuit Layout

The above diagram represents the general connections and layout of the boards we have chosen to use. The wire colours correspond to the different ribbon cables used (see below). From left to right it goes board One, Two, Three. The square around represents the inside of the chassis of the robot with the front of the robot to the left of circuit One and the back to the right of circuit Three.

| **PCB BOARDS**<br>Figure 4.2.2 PCB Boards | | | | | |
|---|---|---|---|---|---|
| **NUMBER** | **SIZE** | **ON BOARD** | **CONNECTION** | **WIRE TYPE** | **#** |
| **ONE** | LONG | QRD Right+ Circuit | TINAH PC1 | Ribbon #7 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| | | QRD Right Circuit | TINAH PF1 | Ribbon #2 | 2 |
| | | QRD Left Circuit | TINAH PF2 | Ribbon #2 | 4 |
| | | QRD Left+ Circuit | TINAH PC0 | Ribbon #7 | 5 |
| | | Push Button Circuit R. | TINAH PC4 | Ribbon #3 | 6 |
| | | Push Button Circuit L. | TINAH PC5 | Ribbon #3 | 9 |
| | | Push Button Front | TINAH PC6 | Ribbon #3 | 8 |
| | | IR Circuit | TINAH PC3 | Ribbon #3 | 7 |
| | | Motor 1 Basket | TINAH Motor 3- | Ribbon #8 | 3 |
| | | Motor 1 Basket | TINAH Motor 3+ | Ribbon #8 | 3 |
| **TWO** | SHORT | L. Motor (H-Bridge) | TINAH Motor 0- | Ribbon #1 | 10 |
| | | L. Motor (H-Bridge) | TINAH Motor 0+ | Ribbon #1 | 10 |
| | | R. Motor (H-Bridge) | TINAH Motor 1- | Ribbon #1 | 11 |
| | | R. Motor (H-Bridge) | TINAH Motor 1+ | Ribbon #1 | 11 |
| **THREE** | LONG | Push Button Claw | TINAH PC7 | Ribbon #6 | 16 |
| | | UltraSonic Sensor | TINAH PF7 | Ribbon #6 | 17 |
| | | Servo 1 Arm | TINAH PE3 | Ribbon #4 | 13 |
| | | Servo 2 Arm | TINAH PB7 | Ribbon #4 | 14 |
| | | Motor 1 Arm | TINAH Motor 2- | Ribbon #5 | 12 |
| | | Motor 1 Arm | TINAH Motor 2+ | Ribbon #5 | 12 |
| | | Servo 1 Claw | TINAH PE2 | Ribbon #4 | 15 |

## 4.3 - IR Detection Circuit

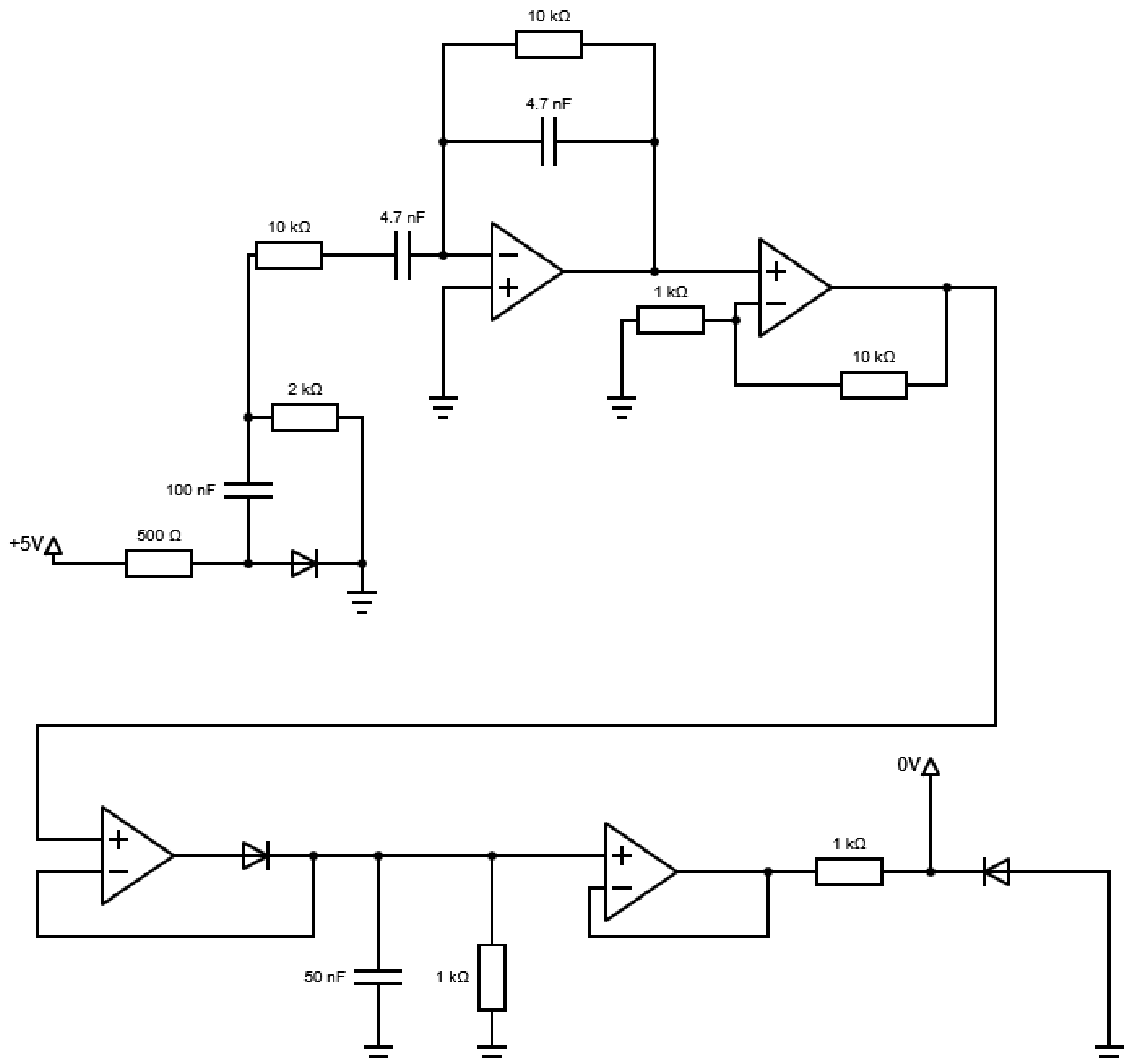


Figure 4.3.1 IR Circuit Schematic

Our IR Circuit consists of five parts:

- DC Block
- Band-Pass Filter
- Inverting Amplifier
- Peak Tracking Circuit
- Overvoltage Protection Circuit

The signal coming from the IR Detector (bottom left) is apart of the DC Block circuit. It will then be filtered, amplified, and go through peak tracking. We have also decided to filter before the amplifying.

#### *4.3.1 Band-Pass Filter*

The Band-Pass Filter allows us to filter out both high and low signals that are not in the desired range. Since the signal from the alarmed door will be 10KHz, we want to choose the values of our capacitors and resistors to be match this.

---

**Calculating R and C Values:**

$$\frac{1}{2\pi RC} = f$$

$$\frac{1}{2\pi(10\,000)(4.7*10^{-9})} = 10\,160\ Hz \approx 10\,000\ Hz$$

---

Therefore we get an R = 10 000Ω and a C = 4.7 nF to give us a frequency reading of around 10 000 Hz.

#### *4.3.2 Inverting Amplifier*

We chose to use an inverting amplifier since our signal will be flipped twice. We wanted an approximate gain of about 10 so that are signal was amplified enough so highs and lows were easily distinguishable, but low enough that noise amplification did not become too much of a problem.

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**Calculating Gain:**

$$Gain = \frac{V\,out}{V\,in} = \frac{R1+R2}{R1}$$

$$Gain = \frac{1+10}{1} = 11$$

---

**IR Circuit Values:**

| | | |
|---|---|---|
| **DC Block** | ***C1*** | 100 nF |
| | ***R1*** | 500 Ω |
| | ***R*** | 2000 Ω |
| **Band-Pass Filter** | ***R1*** | 10 000 Ω |
| | ***C1*** | 4.7 nF |

| | | |
|---|---|---|
| | ***R2*** | 10 000 Ω |
| | ***C2*** | 4.7 nF |
| **Inverting Amplifier** | ***R1*** | 1000 Ω |
| | ***R2*** | 10 000 Ω |
| **Peak Tracker** | ***R1*** | 1000 Ω |
| | ***C1*** | 50 nF |
| **Overvoltage Protection** | ***R1*** | 1000 Ω |

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## 4.4 - H-Bridge and Comparator Circuit

**CIRCUIT SET-UP FOR MOTORS**
Figure 4.4.1 Motor Set-up Table

| MOTOR | PIN NUMBERS | COMPARATORS | H-BRIDGE |
|---|---|---|---|
| **Left Wheel** | 0-, 0+ | 2 | Constructed |
| **Right Wheel** | 1-, 1+ | 2 | Constructed |
| **Arm** | 2-, 2+ | 0 | TINAH |

For our motors, we will be using both an H-Bridge and a Comparator circuit to increase the current going into the motors since the TINAH outputs are limited and do not provide the necessary current for a full sized robot. The circuits are show below. Note that two of the comparator circuits will be used, one for each input into the H-Bridge.

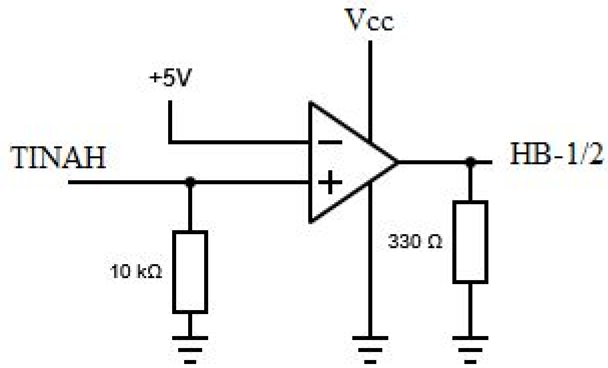


Figure 4.4.2 Comparator Circuit

### *4.4.1 Comparator Circuit*

Using a TL082 Op-Amp, we have designed a digital output interface which is used to convert the signal from the TINAH motor outputs into either ON or OFF when combined with the H-Bridge.

| **Condition** | **Value** |
|---|---|
| V(TINAH) > V(in) | V(out) = +15V-V(Resistor) |
| V(TINAH) < V(in) | V(out) = 0V |

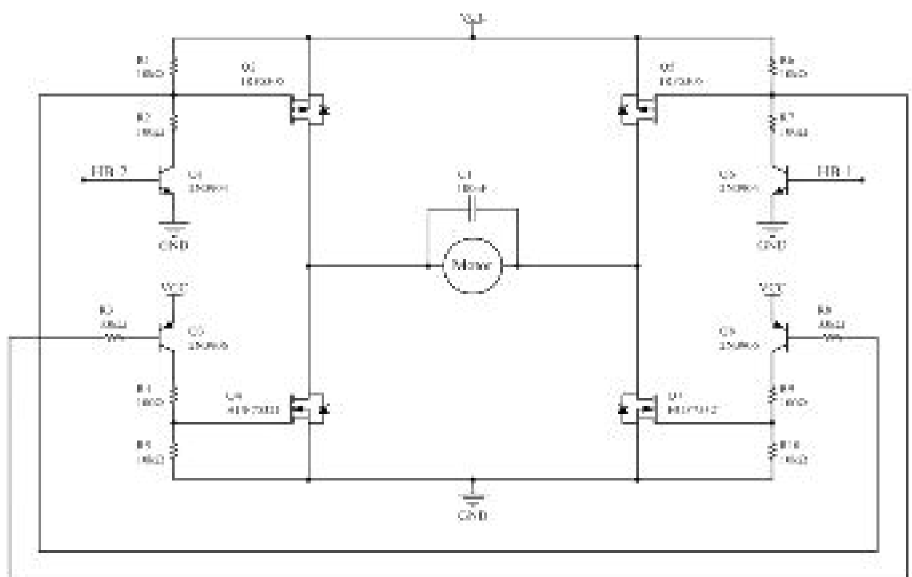


Figure 4.4.3 H-Bridge Circuit (Credit: Jon and Bernhard)

### *4.4.2 H-Bridge Circuit*

We will be using the H-Bridge configuration as seen in the lecture to control both of our wheels in the back. For this configuration, we have chosen Vcc = 15V.

| **MOTOR RESPONSE TABLE**<br>Figure 4.4.4 Motor Response and H-Bridge Input | | |
|---|---|---|
| **Direction** | **Input-1** | **Input-2** |
| Stop | 0 | 0 |
| Forward | 1 | 0 |
| Reverse | 0 | 1 |
| Not Allowed | 1 | 1 |

The H-Bridge works by turning on and off the various MOSFETs and BJTs. When the gate voltage is zero a MOSFET will be off, and when the magnitude of the gate voltage exceeds the magnitude of the source voltage the MOSFET will be off.

These are the four different elements used within the H-Bridge Circuit to turn the two motors on and off.

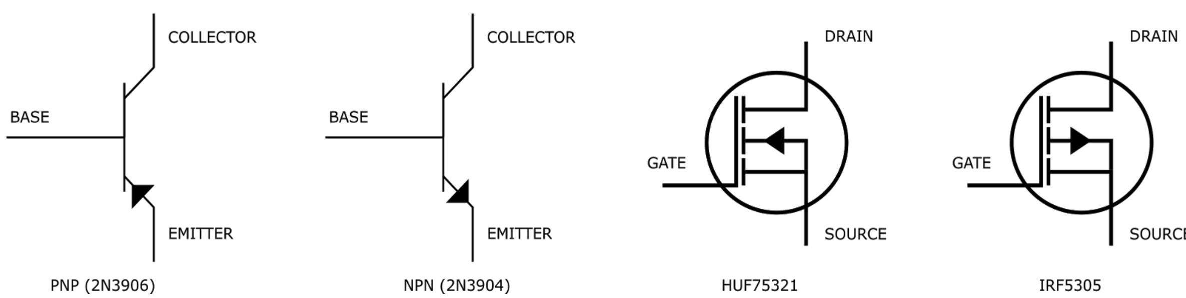


Figure 4.4.5 MOSFETs and BJTs

## 4.5 - QRD Sensors (Tape Following)

We have chosen to use four QRD sensors to do the tape following for our robots. The Right and Left sensors will do the main portion of the following and will be plugged into the Analog inputs. The Right+ and Left+ will be used specifically to detect the dashed lines used to find the position of the agents along the circle, they are currently connected to analog inputs, but may be changed to digital inputs depending on the other circuit needs of our robot by converting the analog signal to a digital one with a comparator.

The sensors will output a high voltage if it is reflecting from the black tape and a low voltage if it is reflecting off of the white paint. If the Right+ and Left+ read 1s while the Right and Left both read 1 then the robot is at a dashed line.

**Voltage Threshold: 200 mV**
**Tape: 800 mV**
**Paint: 50 mV**

**VOLTAGE RESPONSE OF TAPE FOLLOWER**
Figure 4.5.1 Tape Following and Motor Voltage Response

| RIGHT | LEFT | HISTORY | X | R. WHEEL | L. WHEEL |
|---|---|---|---|---|---|
| 1 | 1 | - | 0 | ON | ON |
| 0 | 1 | - | +1 | ON | OFF |
| 1 | 0 | - | -1 | OFF | ON |
| 0 | 0 | LEFT | +5 | ON | OFF |
| 0 | 0 | RIGHT | -5 | OFF | ON |

## 4.6 - Claw Sensing

Our claw will use both an ultrasonic sensor and a pushbutton to sense the objects to pick up. The ultrasonic sensor will read voltages depending on the height level, so we plan to use this height reading for when the agents have already fallen in the water. The pushbutton is used to know when to close the claw and to begin pulling the agents up and out of the bucket.

## 5.0 Code

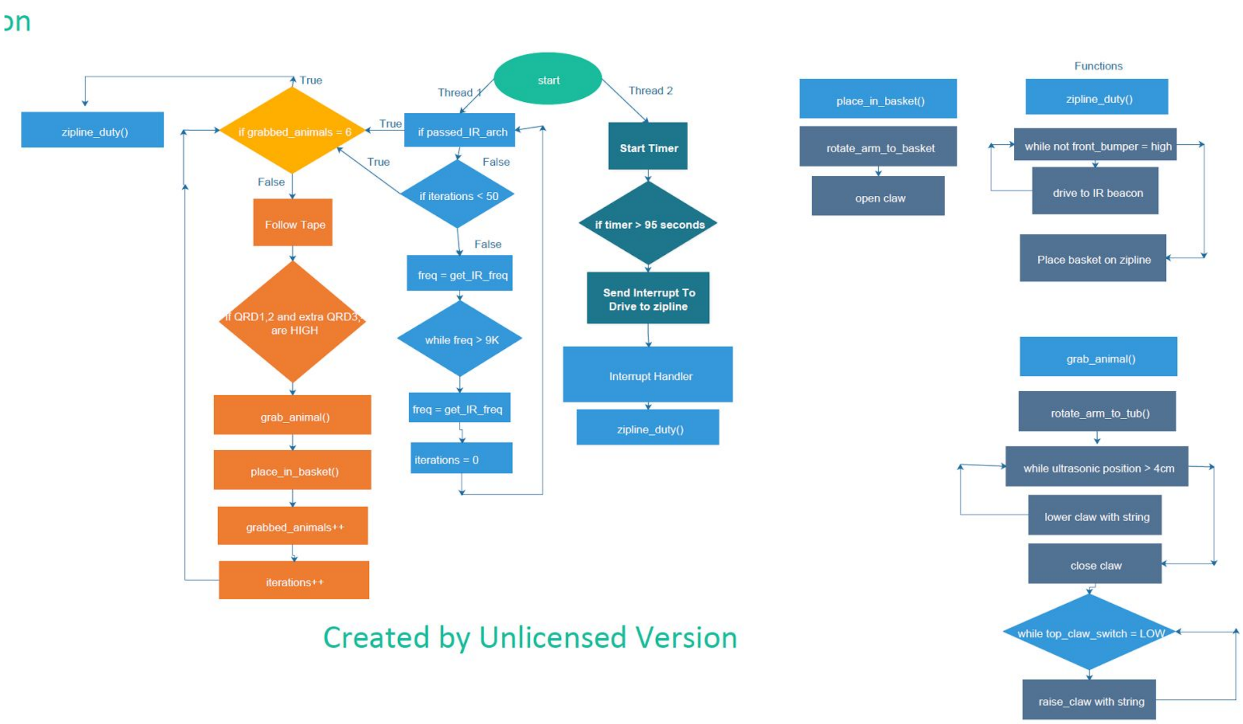


Figure 5.1.1 Logic Diagram

## 6.0 Risk Assessment and Contingency Plan

### 6.1 - Risk Assessment

**Claw**

For our claw, the main risk is the fact that we are planning to use string to hold the claw. We figure this is light and quick and easy to work with, but this means that when we move the claw (especially rotating it in the horizontal plane), there is the possibility of the string getting tangled or caught.

We propose to avoid this as much as possible, to have the string tie up around the arm to avoid it from getting knotted in itself. We will also always pull the claw up to its highest vertical position when rotating the claw.

**Arm**

The arm presents quite an area of risk. Since it is quite tall, there is the possibility of it being top heavy or titling/bending. It also requires three motors which involves more possibility for error in positioning and overall more complications to the circuit.

We have placed our motors on the back of the arm (on the opposite side of where the claw will be) to try to even out the weight. We also originally had planned to do a linear actuator and have now instead switched to rotating arms to reduce the loss of torque in moving from rotational to linear motion.

**Basket**

The basket relies a lot on weight placement and careful raising so as not to drop the agents in it. There is also significant risk in the raising mechanism getting jammed or needing too great of torque to lift the basket with the agents.

To create some security for the animals, we have added lips on the opposite side of the hook (where the basket is most likely to tip). We also will add some weak magnets to keep it from falling off the raising mechanism.

### 6.2 - Contingency Plan

For our contingency plan we have primarily designed alternatives only for the basket, claw, and arm mechanisms.

We have chosen to do a very simple chassis that is just large enough to hold the circuits and the basket on top.

For the claw we propose a three-pronged alternative that is slightly taller in height to avoid getting the electrical components in the water. It will have wide ends to properly grasp the agents in the tank.

For the basket we propose four rotating bars, two sets with the first being attached to the robot chassis and the second connected to the end of the first and also to a platform holding the basket. We will raise the basket to the appropriate height and then using tipping we will slide the basket off of the platform and onto the zipline.

For the arm we propose a linear actuator with chains that pull the claw back and forth. The arm will also rotate in the horizontal plane in a similar manner to our current design, but will be rigidly vertical with a rigid horizontal beam coming off the top.

## 7.0 Tasks and Milestones

### 7.1 - Task List

Task List is ordered in time of completion.

| **TASK LIST AND ASSIGNMENTS**<br>Figure 7.1.1 Task List Table | | | |
|---|---|---|---|
| **MAIN** | **SECONDARY** | **TESTING** | **PERSON** |
| **Chassis** | H-Bridge Circuits | Prototype board and motors | JC |
| | Comparators | Prototype board and Oscilloscope | TK |
| | Layout spacing | Create prototype of chassis | TD |
| | QRD Sensors | Check voltage output paper/tape | RS |
| | Machining | Do stress tests and try motors | TK |
| | Wheels | Try running with large loads | RS |
| | PID Code | Test on now built Chassis/circuits | TD |
| **Arm** | Servo Circuits | Test with loose servos | JC |
| | Motor Circuit | Test with loose motor | RS |
| | Machining | Stress test/confirm functionality | TK |
| | Servo Code | Test on now built arm/circuits | RS |
| | Motor Code | Test on now built arm/circuits | TD |
| **Claw** | Servo Circuit | Test with loose servos | JC |
| | Machining | Stress test/confirm movement | TK |
| | Ultrasonic sensor | Test with various heights in tub | JC |
| | Button Circuit | Test with animals and claw | RS |
| | Claw Code | Test on now built claw/circuits | TK |
| **Basket** | Servo Circuit | Test with loose servos | RS |

| | | | |
|---|---|---|---|
| | Machining | Stress test/confirm movement | JC |
| | Basket Code | Test on now built basket/circuits | TD |
| **Misc.** | Push Buttons | Add to Chassis and test voltages | TK |
| | Design | Add a name | ALL |

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### 7.2 - Milestones

For our team there are four major milestones:

1. Get a chassis that can line follow efficiently with equivalent weight of the arm/claw and a basket with the agents inside.
2. Create an arm that is able to recognize the position of the agents in the tub, pick them up and properly place them in our basket.
3. Attach and have the basket go down the zipline without dropping any of the agents inside of it.
4. Complete all of the robot one week before the competition to allow for five days of testing and optimizing.

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### 7.3 - Responsibilities

**Toren Dofher**

Toren will focus on writing and testing the code as well as overseeing the proper documentation (proper variable names, updates to git, commit statements etc.).

**Jessica Chapman**

Jessica will oversee the organization and planning. She will also act as the "floater" on the team, depending on what needs to be done.

**Ryley Simpson**

Ryley will focus on the mechanical designing and machining due to his prior experience with laser cutters and waterjet cutters. Though everyone will do cutting, Ryley will be our primary team member for this field.

**Theophilus Ko**

Theo will primarily be in charge of circuit design due to his experience with Sailbot on the electrical team. This means that though all of us will work on circuits, Theo will be in charge of overseeing it as a whole. Theo will also be our battery Tsar.

## 8.0 Document Summary

### 8.1 - Document Summary and Sharing of Work

| | |
|---|---|
| Letter of Transmittal | Toren Dofher |
| Executive Summary | Jessica Chapman |
| Preface | Toren Dofher |
| Overview of Basic Strategy | Jessica Chapman |
| Chassis | Toren Dofher and Ryley Simpson |
| Circuits | Jessica Chapman |
| Arm | Toren Dofher |
| Claw | Theophilus Ko |
| Basket | Ryley Simpson |
| Software Code and Algorithms | Theophilus Ko |
| Risk Assessment and Contingency | Jessica Chapman |
| Milestones, Task List, and Responsibility | Jessica Chapman |