CDR
INFANTRY SUPPLY STATION

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(GROUP 9)

1. Why this project matters
2. Design Requirements
3. Design Challenges
   & Objective
4. Proposed Design
5. Schedule & Milestones
6. Components
   1. Budget
   2. Suppliers
7. Questions & Feedbacks

WHY THIS PROJECT MATTERS

- DJI RoboMasters Competition 2018
  - Annual Robotic Competition for Engineering Students hosted in China

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- DJI RoboMasters Competition 2018
  - Annual Robotic Competition for Engineering Students hosted in China

- To Win Against CalTech RoboMasters Student Group

DESIGN REQUIREMENTS

End User: 2 Infantry Robots, Docked Bellow

Max Size: 1m*1m*1m

Specs of Bullets:

2.6 g (±5%),

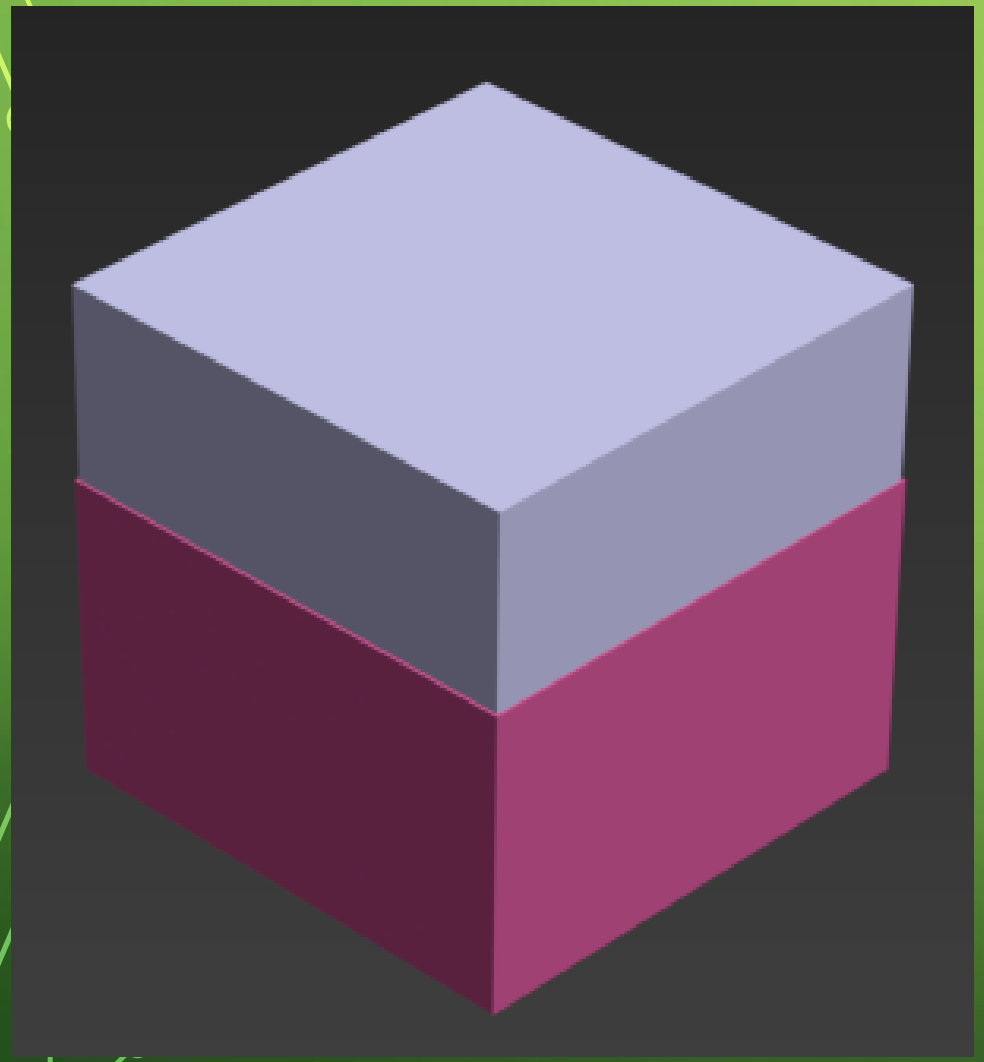
Plastic,

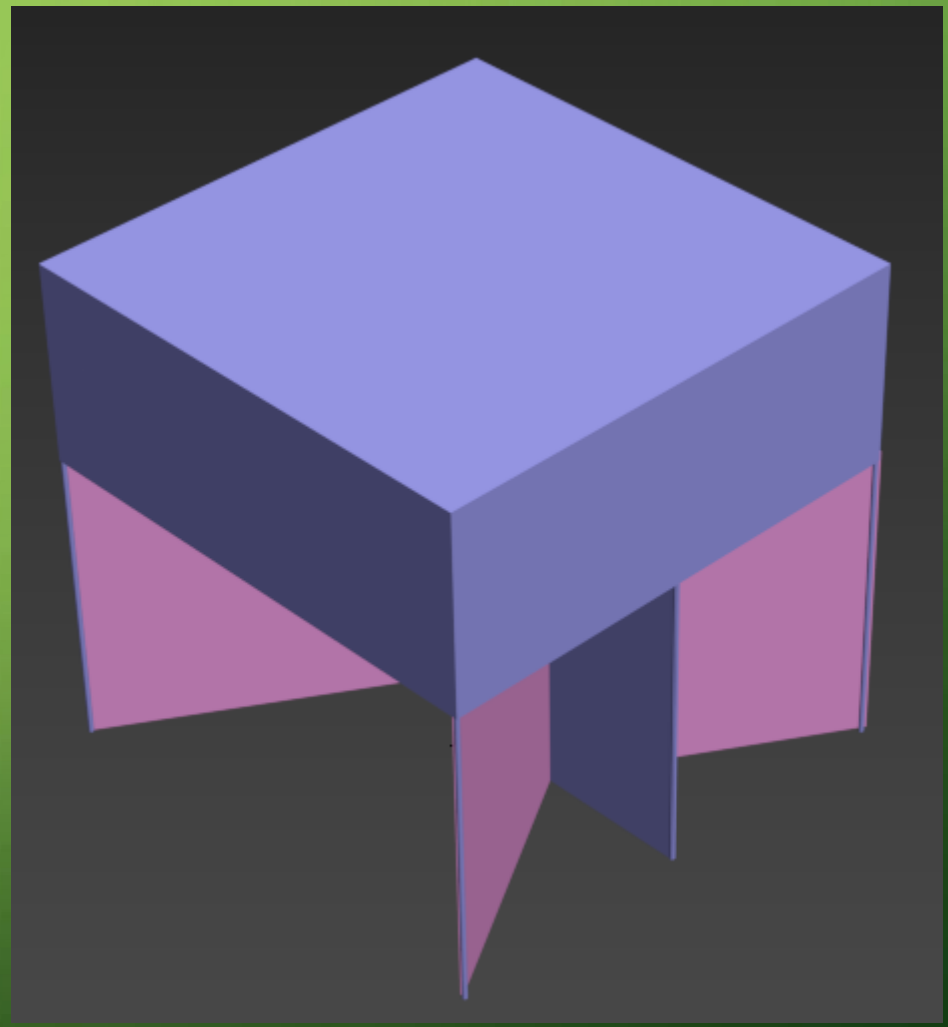
17 mm (-3% to 0%) in diameter

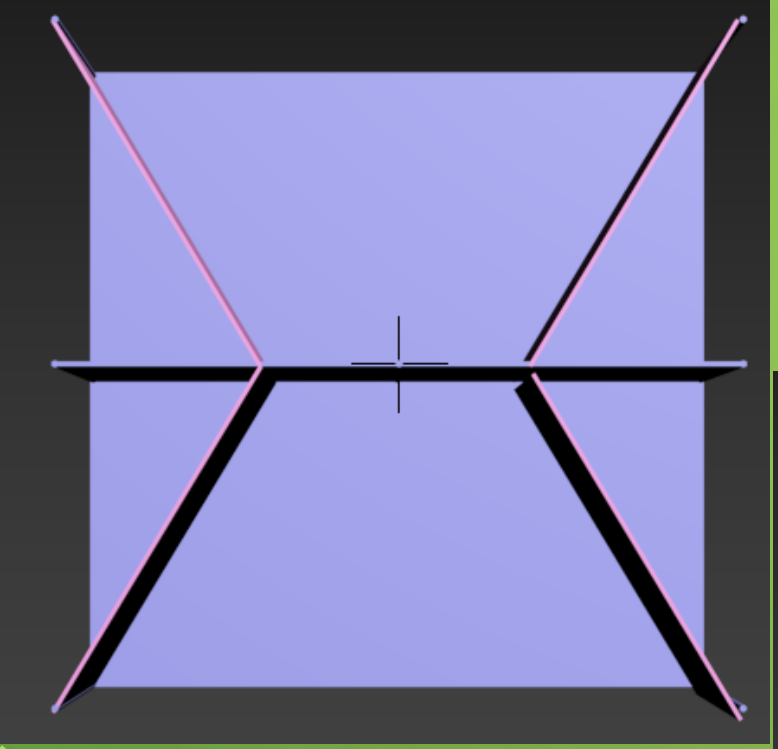
Should be able to store ~400 bullets

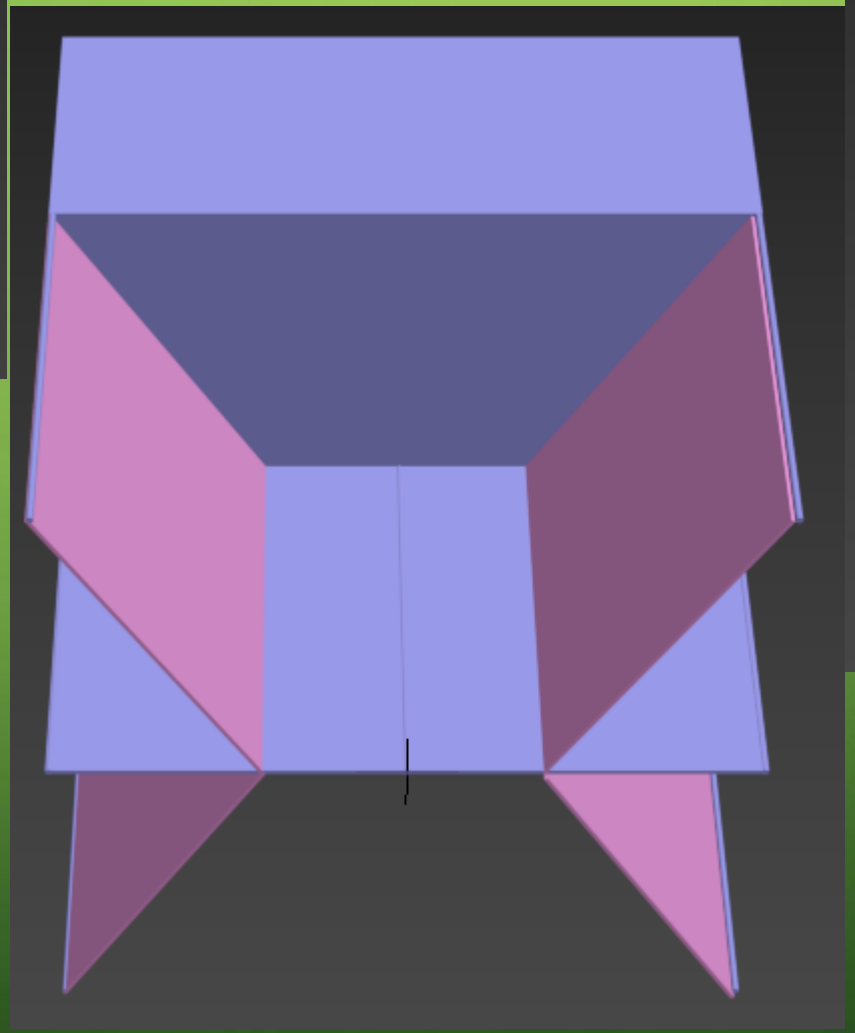
OBJECTIVE

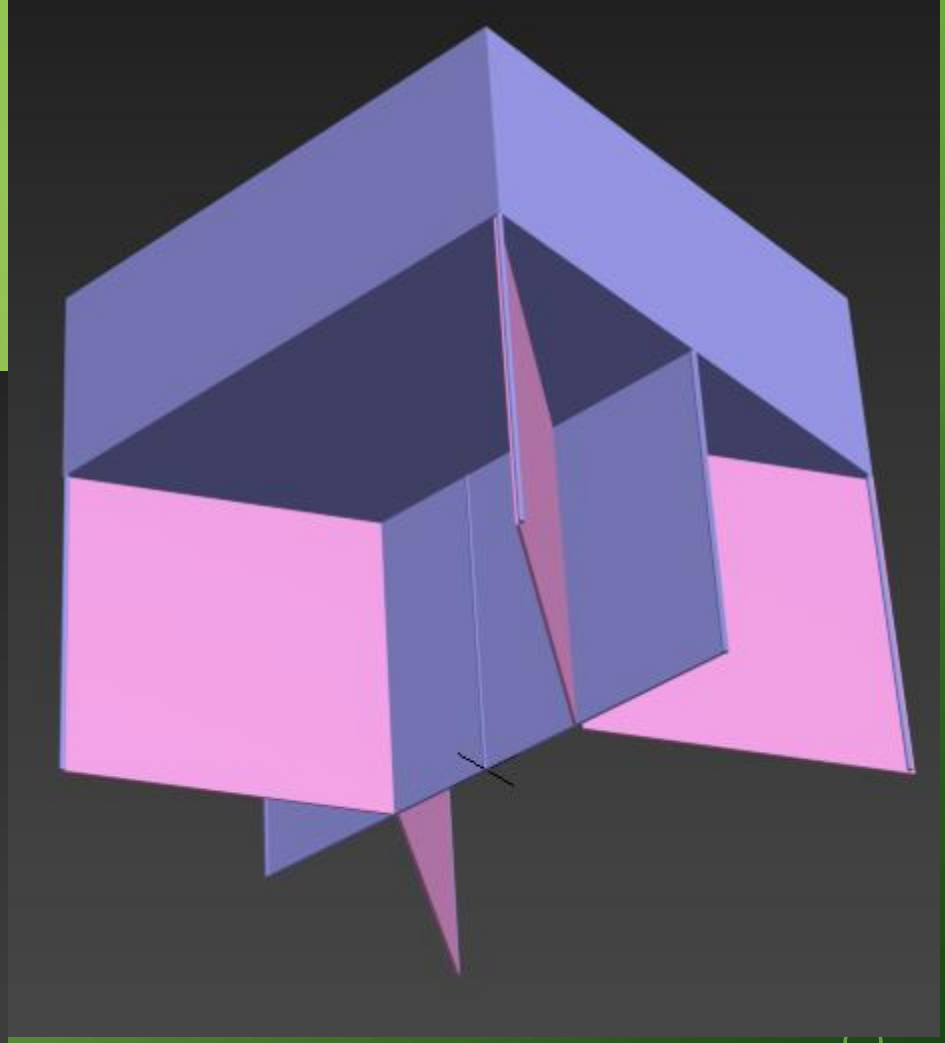
- Be fully automatic
- Minimize the filling time
- Follow restrictions of the competition
- Prevent any jamming of bullets in the station

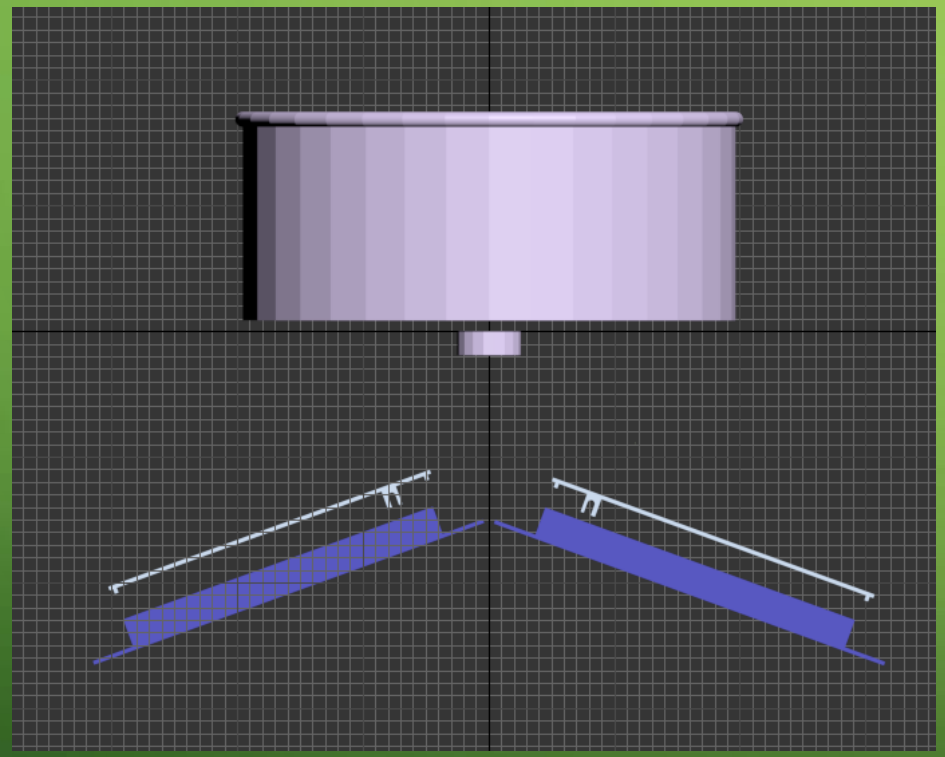


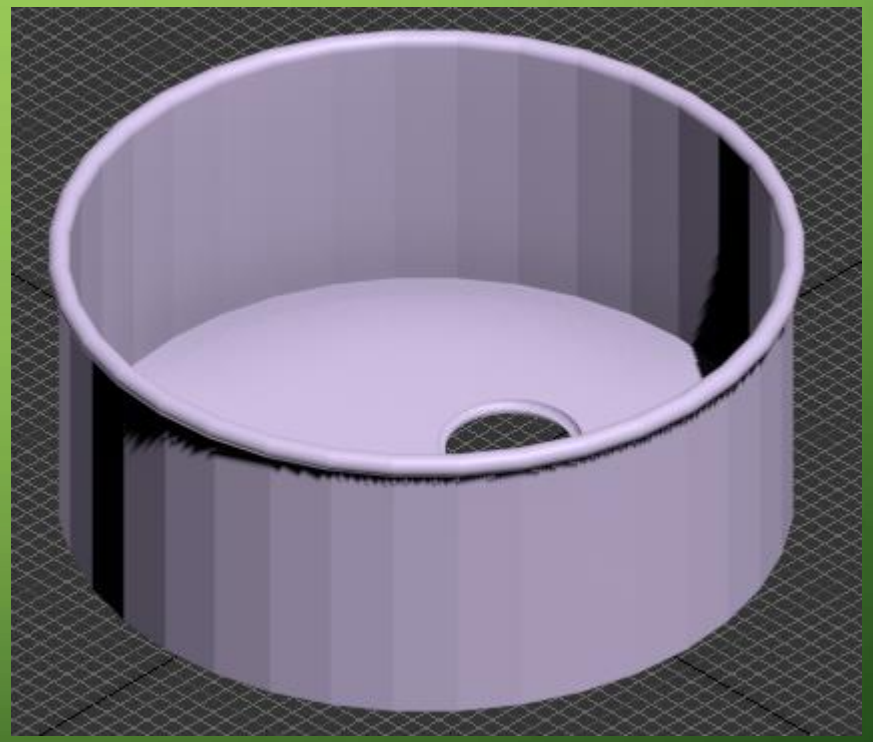


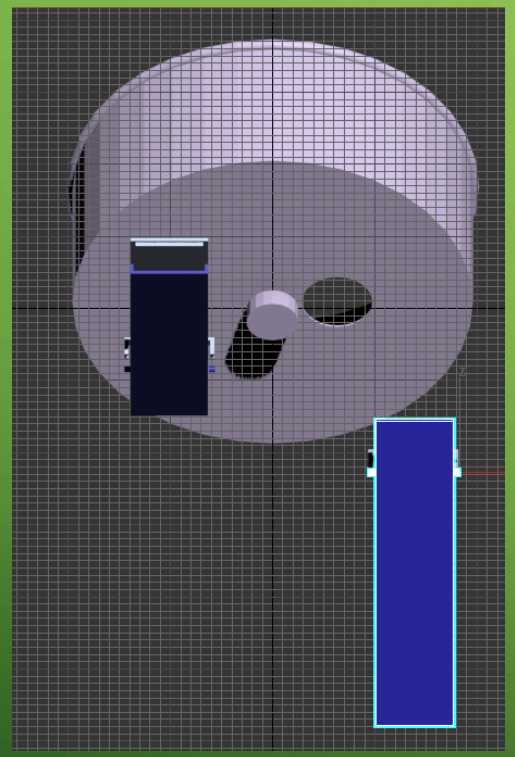


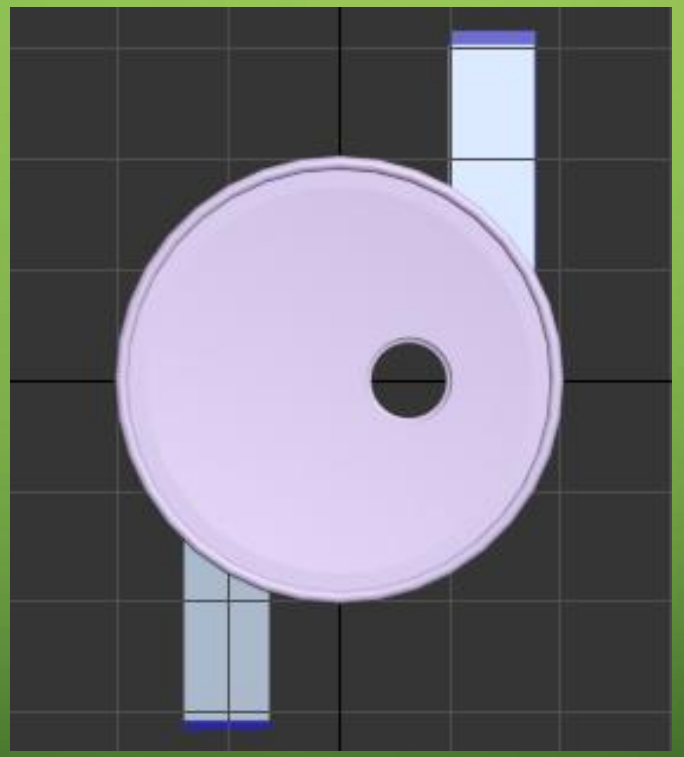


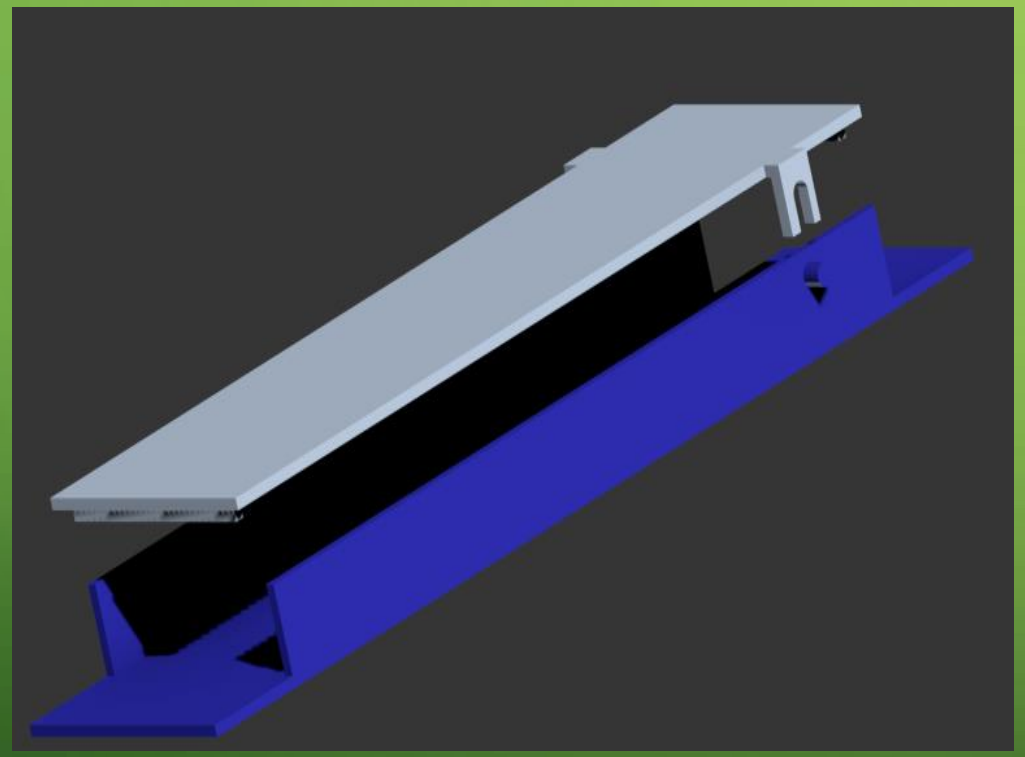


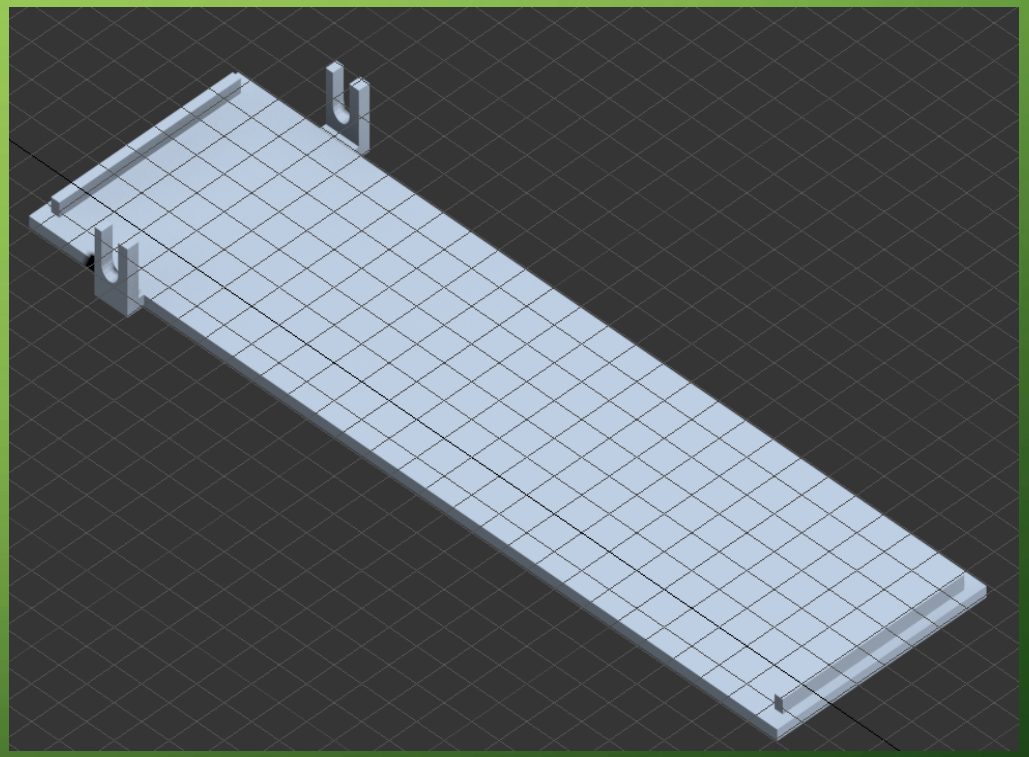


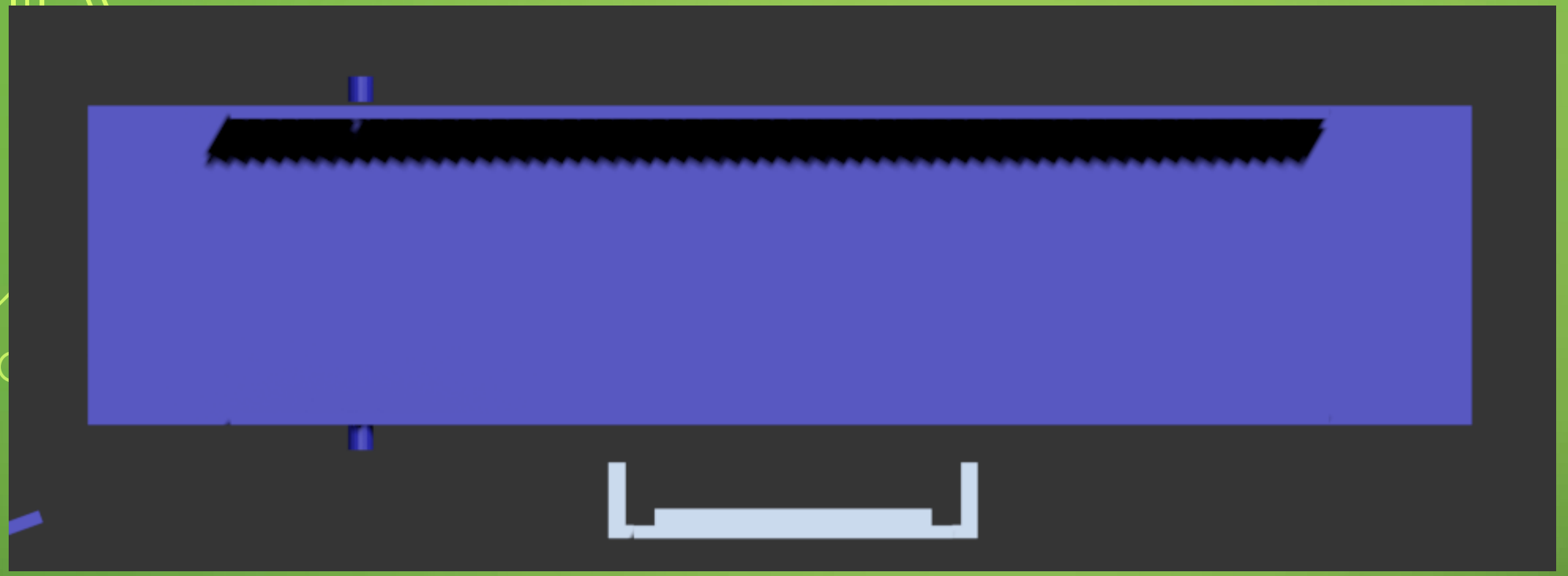


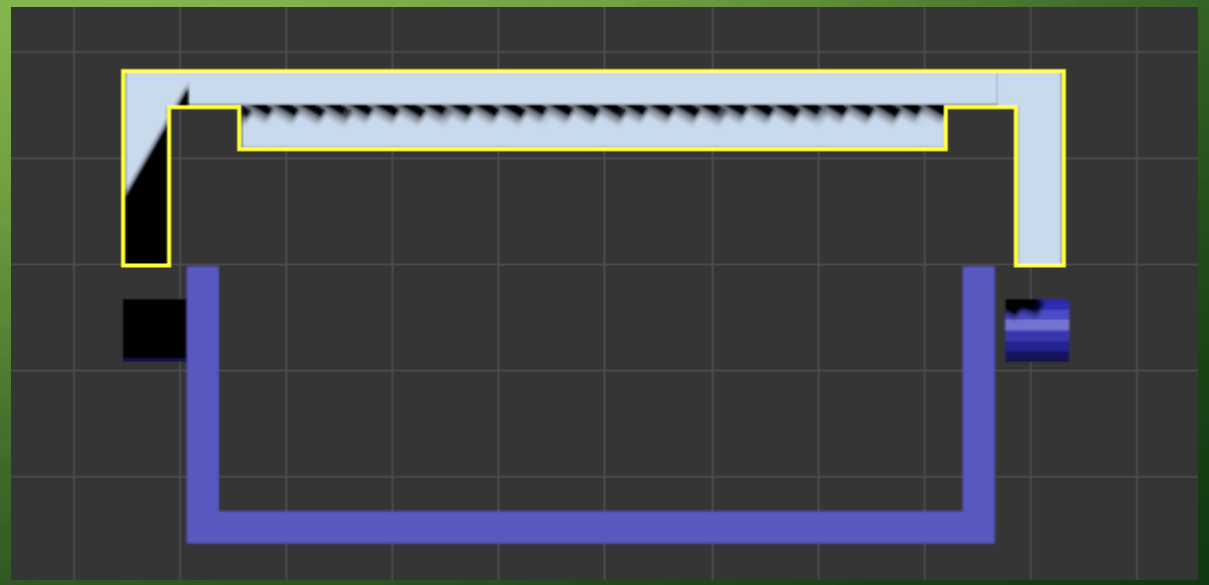




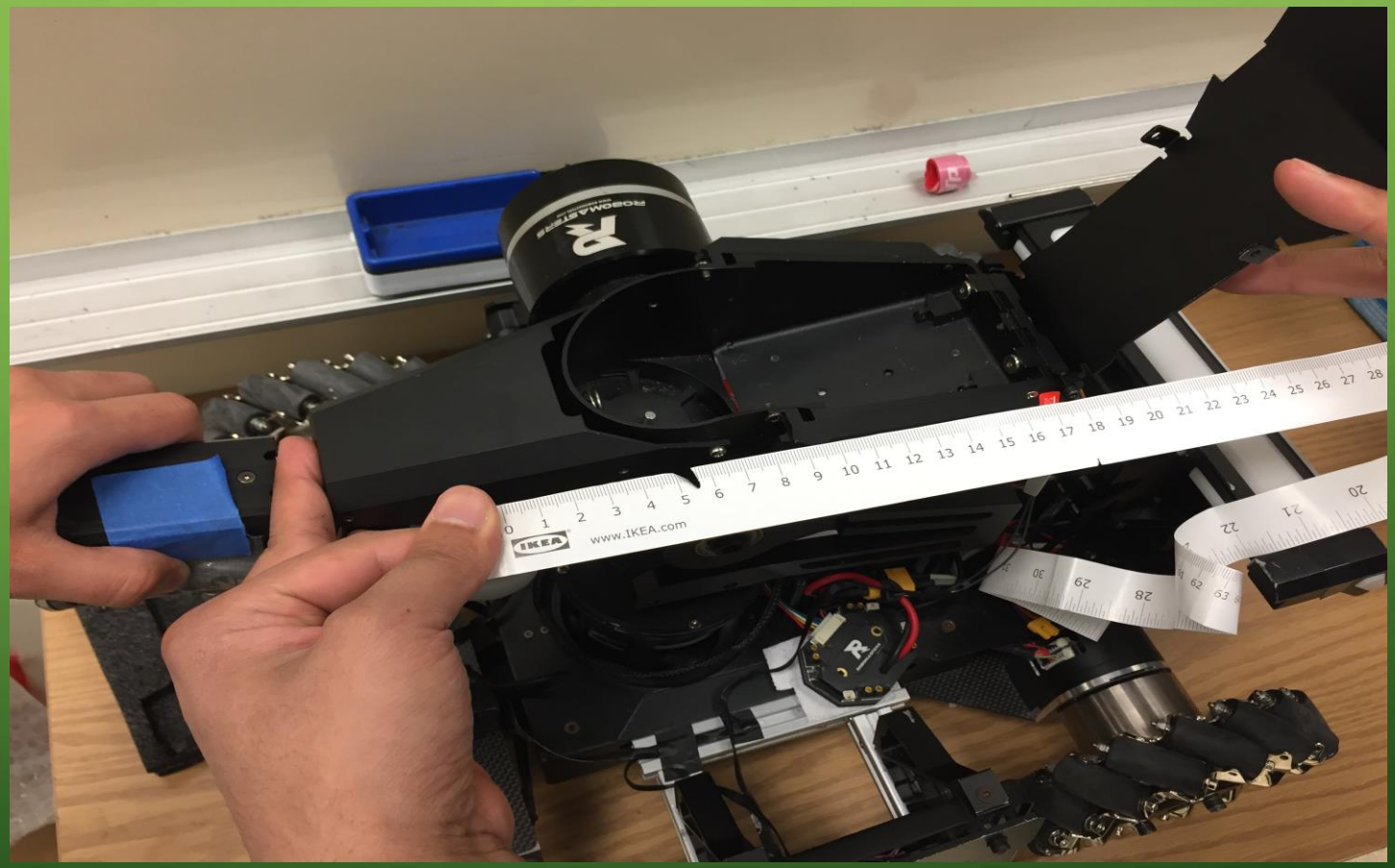








END USER: INFANTRY ROBOT



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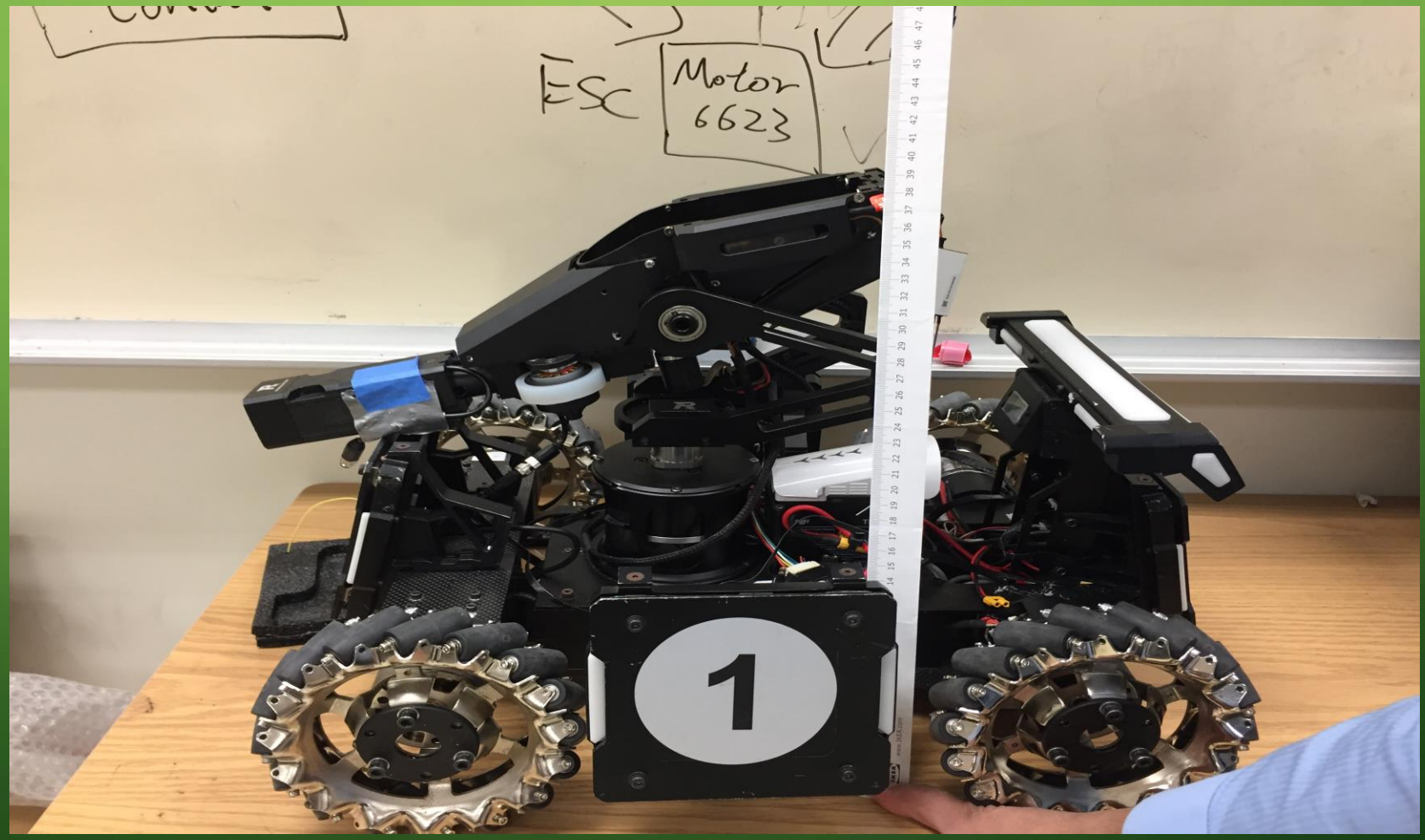


BULLET HOLDING UNIT

INFANTRY ROBOT

MILESTONES AND TIMELINE OF THE PROJECT

Month-Year	Oct - 17	Nov - 17	Dec - 17	Jan – 18	Feb - 18	March - 18	April – 18
Activities	Obtained the specification & Requirements Completed the specification sheet Completed the overall 1st mechanical design Consulted with the mechanical workshop	Did experiment of many mechanical designs regarding for the bullet distribution system Revised the mechanical design Finished the electrical schematic Completed some measurements	Complete all component selection and budget calculation Complete the CDR for the project	Conduct more experiments to test for the mechanical components and electrical components	Finish the electrical assembly and the prototype of the electrical components	Finish the assembly and all testing for the mechanical components	Finish the overall project on time and within budget

COMPONENTS FOR SUPPLY STATION

- 12V motors: 12V 100RPM high torque DC Motor

  MCU: Arduino Uno Rev3

  Motor Driver: Pololu Simple High-Power Motor Controller 18v15

  Detect Sensor: QSD122A4R0-ND & QED123-ND

  Power source: NIMH Battery 12.0V 2300MAH

BUDGET

Components and Different Sources of Cost	Price in Canadian Currency
Arduino Uno Rev3	$45.72
BATTERY PACK NIMH 12.0V 2300MAH	$55.00
Pololu Simple High-Power Motor Controller 18v15	$106.24
2*12V 100RPM Brushed DC Motor	$49.95
4* QSD122A4R0-ND	$7.68
4*QED123-ND	$1.16
Estimate cost of all the materials and labors	$130
Total cost	$395.75

SUPPLIERS

Components	Sources
Arduino Uno Rev3	https://www.digikey.com/product-detail/en/arduino/A000066/1050-1024-ND/2784006
BATTERY PACK NIMH 12.0V 2300MAH	https://www.digikey.com/product-detail/en/energizer-battery-company/NH15VPF2X5/N703-F025-ND/1040731
Pololu Simple High-Power Motor Controller 18v15	https://www.pololu.com/product/1376
12V 100RPM 583 oz-in Brushed DC Motor	http://www.robotshop.com/ca/en/12v-100rpm-583-oz-in-brushed-dc-motor.html
QSD-122-ND	https://www.digikey.com/product-detail/en/on-semiconductor/QSD122/QSD122-ND
QED123-ND	https://www.digikey.com/product-detail/en/on-semiconductor/QED123/QED123-ND/187398
Material Costs and Labour Cost	UAlberta Electrical Engineering Department
Steel and Aluminium Material	McMaster-Carr Company

BLOCK DIAGRAM

Infantry robot block infrared light

↓ PWM signal (Low)

Arduino UNO R3(ATmega 328)

↓ PWM signal (High = 5.0V)

Pololu High-Power Motor Driver 18V15

↓ OUTA=high, OUTB=low, PWM=high

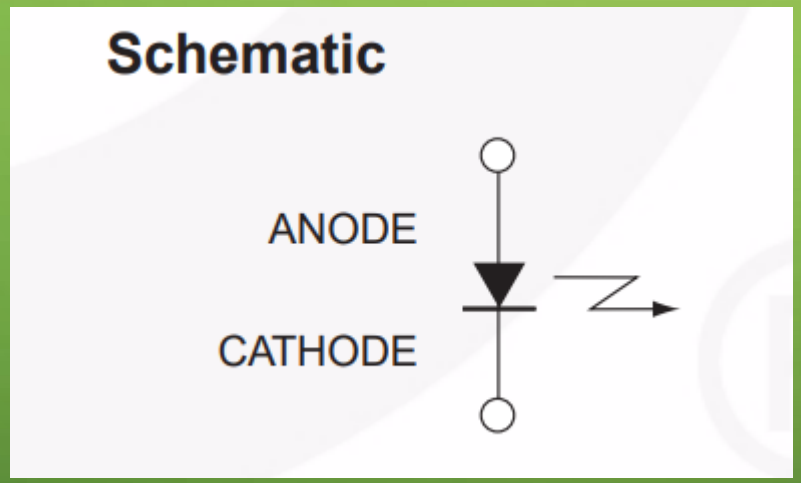
Pololu Motor rotate

PHOTO INTERRUPTER

- Transmission-type photo sensor
  - A light emitting elements
  - A light receiving elements
  - Acting as an optical switch
- Infantry Robots Detector
  - Signal triggers after infantry robots block infrared light
  - Bullets will release from the second stage
- Components:
  - QED123--- Plastic Infrared Light Emitting Diode
  - QSD122--- Plastic Silicon Infrared Phototransistor

PHOTO INTERRUPTER

- QED123 : (Emitter)



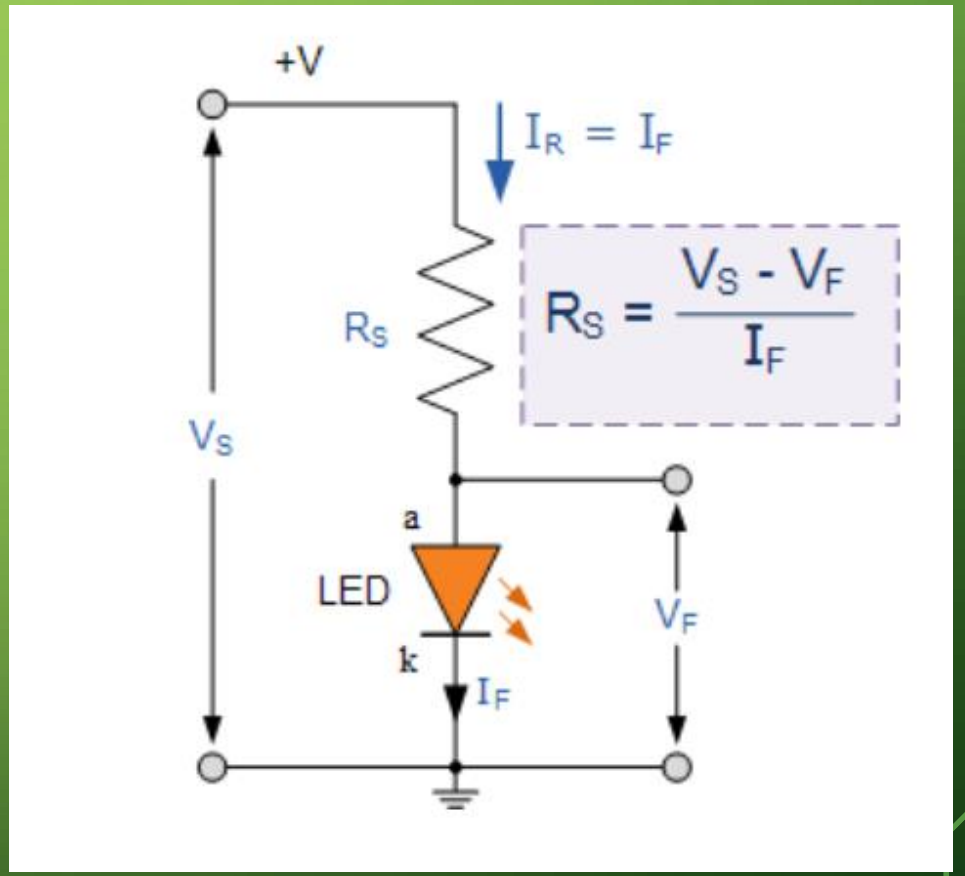
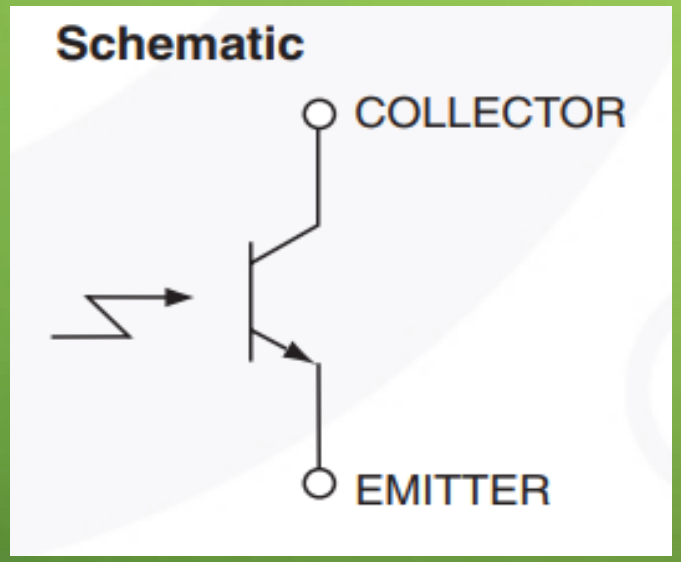


PHOTO INTERRUPTER

- QSD122: (Detector)

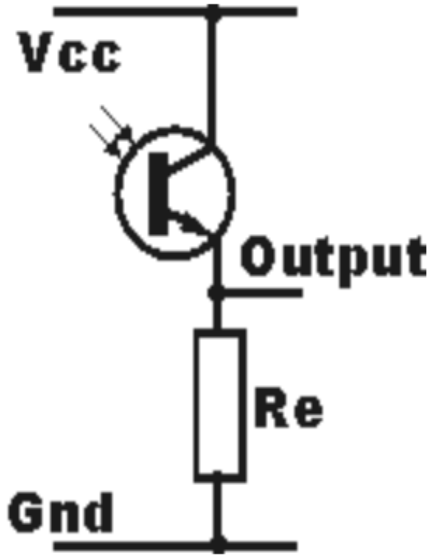


- The base is left disconnected
- Light is used to enable the current flow through the phototransistor.

PHOTO INTERRUPTER

- Phototransistor Circuit:

2. Common Collector phototransistor circuit:



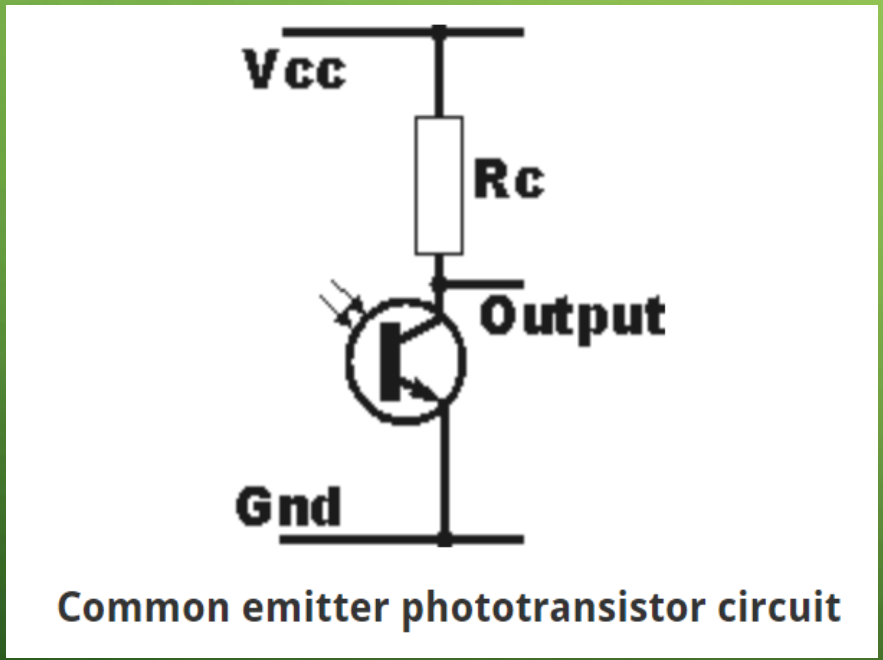
Common collector / emitter follower phototransistor circuit

- The output that moves from the low- state to a high-state when light is detected.
- Rc = Vcc-Vce / Ic

PHOTO INTERRUPTER

- Phototransistor Circuit:

1. Common Emitter phototransistor circuit:



Common emitter phototransistor circuit

- The output moves from a high-voltage state to a low-voltage state when light is detected.
- Rc = Vcc-Vce / Ic

CALCULATIONS USED IN THE DESIGN REGARDING FOR THE MOTOR AND THE MOTOR DRIVER

- Torque $= F \times d(perpendicular) = \int F \times dx$

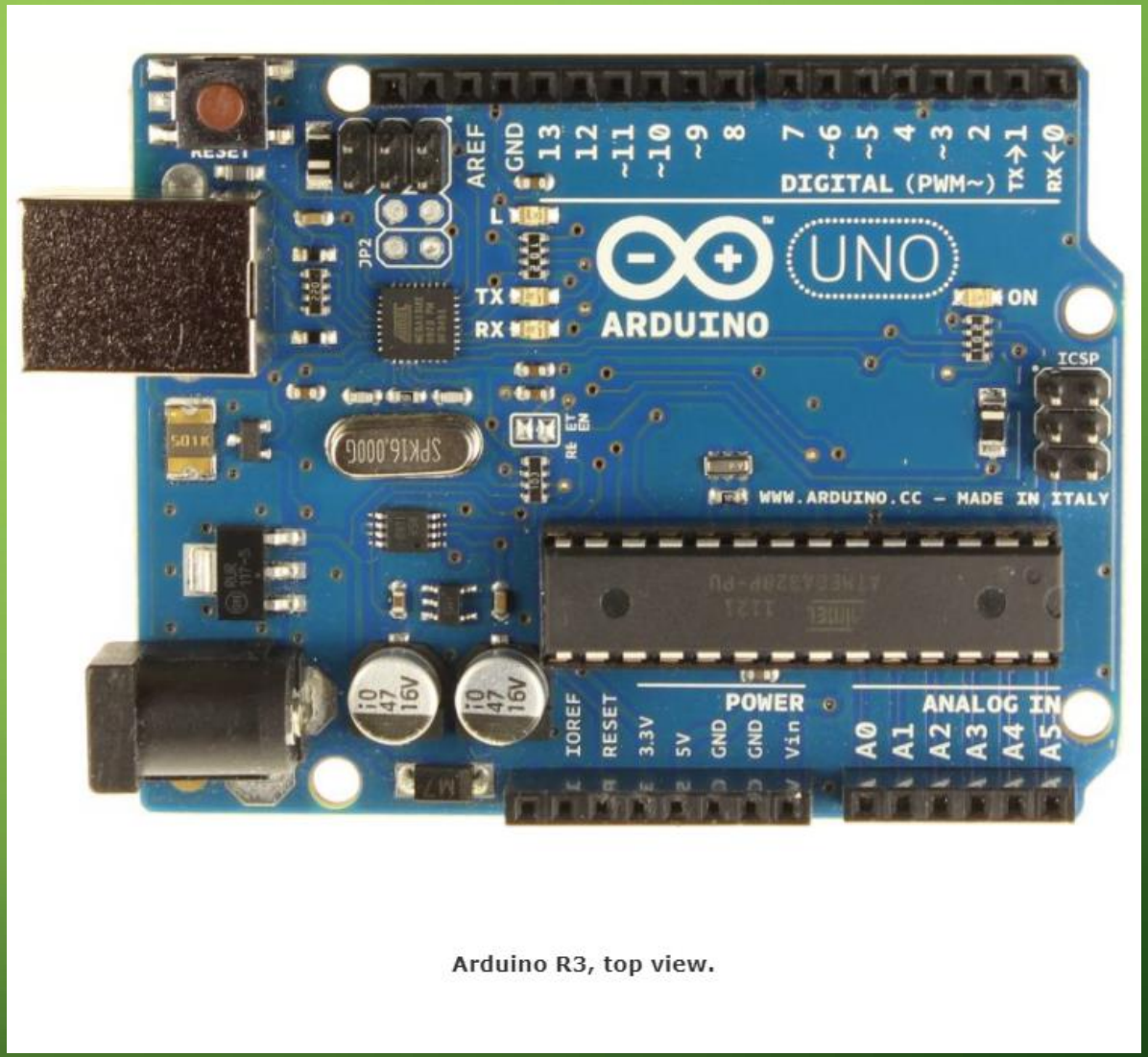
- Material: Plastic(PLA) = 1.430g/cm^3, Force = Force of gravity, Theta(θ) = $\frac{\pi}{4}$, and $\sum r$ = (30cm – 4cm)
- Use approximation by linear extension: $\tau = m \times g \times \theta \times \sum r$
- τ = 94.53mNm

THE MICROCONTROLLER BOARD SELECTED

Arduino Uno R3, using ATmega328P AVR microcontroller

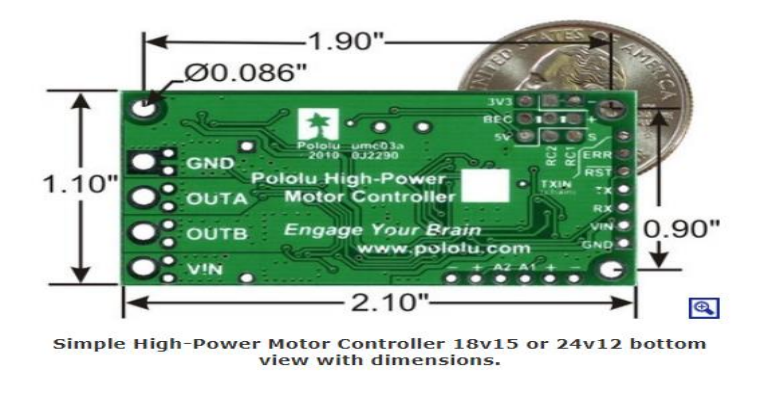
20 digital input/output pins(6 can be used as PWM outputs and 6 can be used as analog inputs)

Extensive support community and easy to work with embedded electronics



Arduino R3, top view.

MOTOR DRIVER: POLOLU SIMPLE HIGH-POWER MOTOR CONTROLLER 18V15



Simple High-Power Motor Controller 18v15 or 24v12 bottom view with dimensions.

- Simple bidirectional control of one DC brush motor
- 5.5V to 30V operating supply voltage range
- Enough to deliver a continuous 15A without a heat sink
- Included axial capacitor that is installed directly on the board in the pins labelled ‘+’ and ‘-’ as shown

THE SELECTED MOTOR (DC 12V)

Supply DC 12V

100 RPM Brushed DC Motor

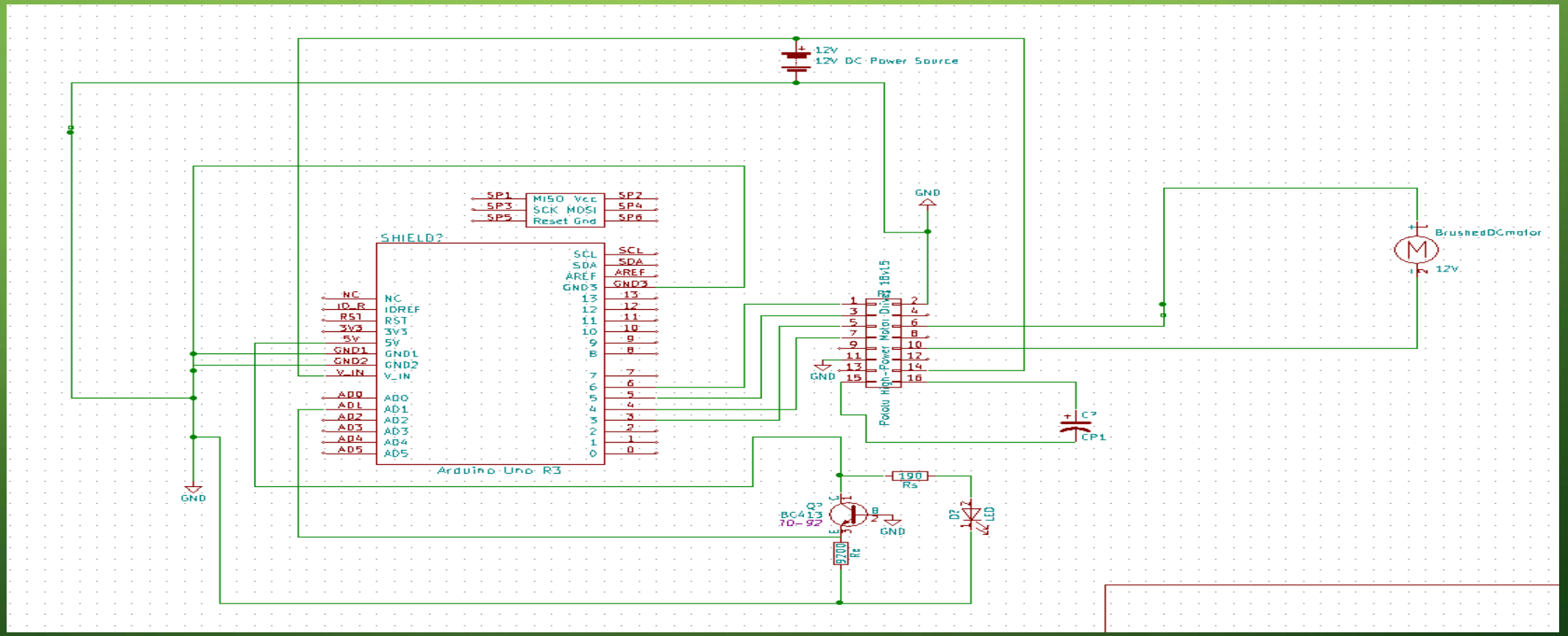
DC 12V Motor Specification Sheet	
Rated voltage:	12 V
Gear reduction ratio:	50:1
D output shaft diameter:	6 mm
No-load speed:	100 RPM @ 12 v
No-load current:	0.17 A
Rated speed:	93 RPM @ 12 v
Current rating:	0.68 A
Rated torque:	7 kg.cm
Stall torque:	42 kg.cm (4.118793Nm)
Stall current:	2.19 A
Power:	5 w
Weight:	210 g

TABLES OF THE PINS FOR THE ELECTRICAL COMPONENTS IN THE SCHEMATIC DESIGN

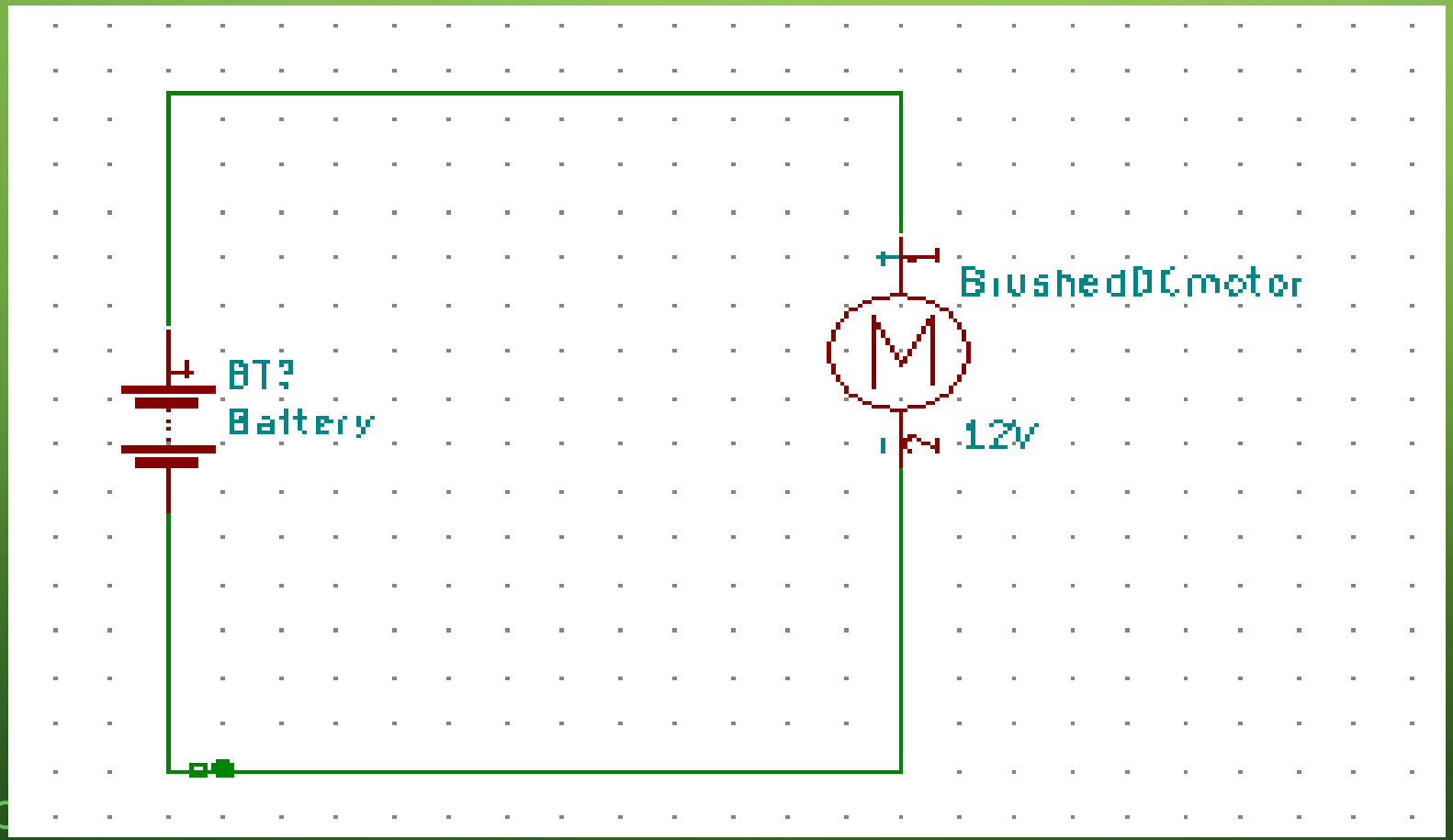
Pololu High Power Motor Driver 18v15	The Corresponding Pin Names
Pin 1	ERR
Pin 2	GND
Pin 3	$\overline{RST}$
Pin 5	TX
Pin 6	OUTA
Pin 7	RX
Pin 10	OUTB
Pin 11	GND
Pin 14	Vin
Pin 15	Pin Labeled +
Pin 16	Pin Labeled -

Arduino Uno R3 Microcontroller Board Pin Name	Values of the Pin Names
AD1	Analog Input 1
3	TX, the sender of the serial communication
4	RX, the receiver of the serial communication
5	$\overline{RST}$ connected to the Motor Driver
6	ERR connected to the Motor Driver

THE ELECTRICAL SCHEMATIC OF THE DETECTION SYSTEM AND THE DISTRIBUTION SYSTEM



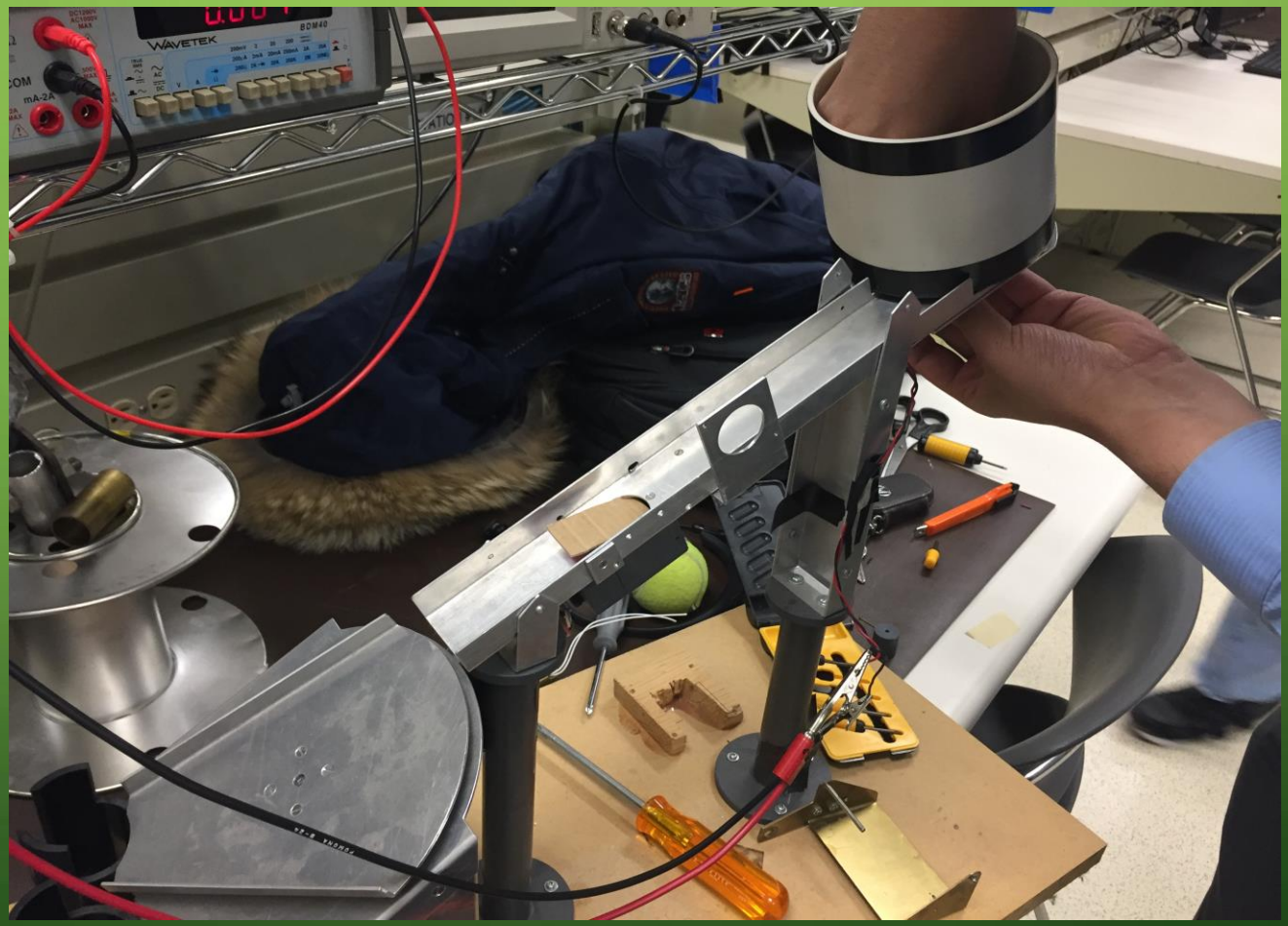
THE ELECTRICAL SCHEMATIC OF THE SPINNER



Modification, if needed:

Current Limiting Resistor can be added in series with the motor

INFANTRY ROBOT



INFANTRY ROBOT

QUESTIONS & FEEDBACKS

REFERENCES FOR THE MICROCONTROLLER BOARD, MOTOR DRIVER, AND THE MOTOR SECTION

- "Pololu Simple High-Power Motor Controller 18v15(Fully Assembled)." Internet: https://www.pololu.com/product/1376, Pololu, 2017
- "Pololu - 1.2. 18v15 and 24v12 Included Hardware." Internet: https://www.pololu.com/docs/0J44/1.2, Pololu, 2017
- "Pololu - 6.7.1. Arduino Examples." Internet: https://www.pololu.com/docs/0J44/6.7.1, Pololu, 2017
- "Pololu Simple High-Power Motor Controller 18v15." Internet: https://www.pololu.com/product/1377, Pololu, 2017
- "Pololu - 4.2. Connecting a Serial Device." Internet: https://www.pololu.com/docs/0J44/4.2, Pololu, 2017
- "Pololu - Arduino Uno R3." Internet: https://www.pololu.com/product/2191/specs, Pololu, 2017
- "Arduino USB Board (Uno R3) : Solarbotics." Internet: https://solarbotics.com/product/50450/?cid=1&gclid=EAIaIQobChMIprCeuJ_d1wIVxF9-Ch0q0gxAEAYYAiABEgL2r_D_BwE, Pololu, 2017
- "Interfacing DC Motor with 8051 Microcontroller using L293D." Internet: http://www.electronicshub.org/interfacing-dc-motor-8051-microcontroller/, Pololu, 2017
- Authors: Russell C. Hibbeler, "Engineering Mechanics: Dynamics, 14th Edition". Location: Toronto, Ca: Pearson, Mar 21, 2015
- "Metal DC Geared Motor - 12V 100RPM 42kg.cm Datasheets", *Media.digikey.com*, 2008. [Online]. Available: https://media.digikey.com/pdf/Data%20Sheets/DFRobot%20PDFs/FIT0492-B_Web.pdf. [Accessed: 27- Nov- 2017].
- "PRODUCT DATASHEET", *Data.energizer.com*, 2017. [Online]. Available: http://data.energizer.com/pdfs/nh15-2300.pdf. [Accessed: 27- Nov- 2017].
- "Arduino Uno Rev3", *Wecl.com.hk*, 2017. [Online]. Available: https://www.arduino.cc/en/uploads/Main/Arduino_Uno_Rev3-schematic.pdf. [Accessed: 27- Nov- 2017].

REFERENCE FOR THE PHOTO INTERRUPTOR

Website title: Hades.mech.northwestern.edu

URL: http://hades.mech.northwestern.edu/images/f/fb/QED123.pdf

Website title: Mouser.com

URL: http://www.mouser.com/ds/2/149/QSD124-191888.pdf