HARDWARE DESIGN DOCUMENT

Project: ECSE 211 Final Design Project – Team 6
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[30/10/2017] Frederic Cyr: added all the information for section 6.0 (Chosen Mechanical Design)

1.0 - TABLE OF CONTENTS

2.0 - MOTORS

The large NXT motors are older than the EV3 ones, but other than a difference in attachment points, they are identical.

The main difference between the large and medium motors is power and precision. The large motors are more powerful, but less accurate, while the medium motor is less powerful, but more precise. The large motors will be used for jobs like driving the robot around, while the medium motor will be used for jobs like moving a sensor back and forth. All motors connect to ports A through D on the top of the brick.

3.0 - BRICK

The brick has four ports for motors (A through D) and four ports for sensors (1 through 4).

4.0 - SENSORS

The gyroscopic sensor allows you to measure the angle and angular velocity of the robot. It is not used often, but may be useful for this year's project. All sensors connect to the ports labelled 1 through 4 on the bottom of the brick.

The light (colour) sensor can determine the colour of an object, the intensity of the light reflected by an object, or the ambient light level. To detect the black lines on the game floor, the intensity of reflected light will be used. Determining the colour of an object will be useful for identifying the opponent's flag during the competition.

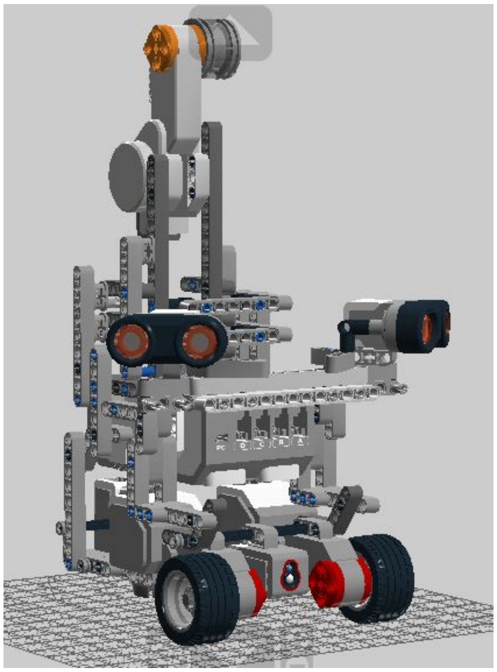
The ultrasonic sensor is used to measure distance by sending ultrasonic waves and measuring how long it takes the wave to echo back. Its main use is in detecting obstacles the robot needs to avoid.

5.0 - ALTERNATIVE HARDWARE DESIGNS

5.1 - Option 1

- Set two ultrasonic sensors at 45 degrees in front of the robot.
- Set one light sensor in front of the robot, between the two ultrasonic sensors, facing straight ahead.
- Set the other light sensor as close as possible to the floor on the back of the robot, pointing downward for localization.
- Set the EV3 brick horizontally (important for the balance point).
- Set the wheels slightly larger than the width of the EV3 brick, with two motors.

PROs	CONs
Can detect a good range of distances since the two ultrasonic sensors are both oriented at a 45 degree angle.	No remaining ports for gyro sensor.
Only three motors, the weight is well-distributed.	Might fail to detect an obstacle at 180 degrees
The two light sensors are set pretty low.	The two ultrasonic sensors might be set too high and give incorrect readings. All the sensors are fixed.



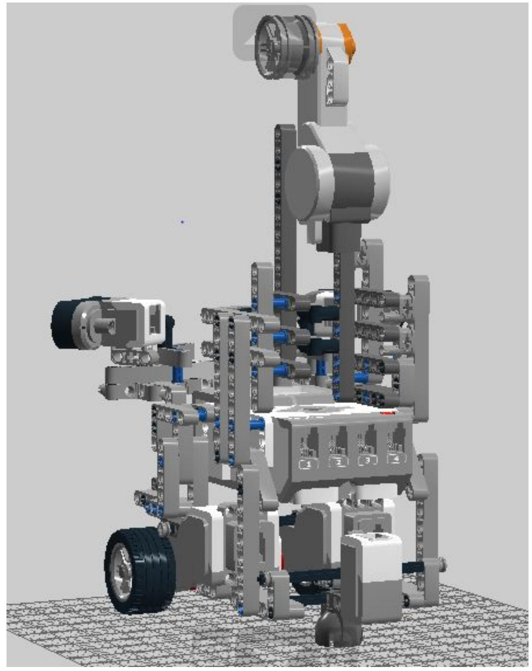
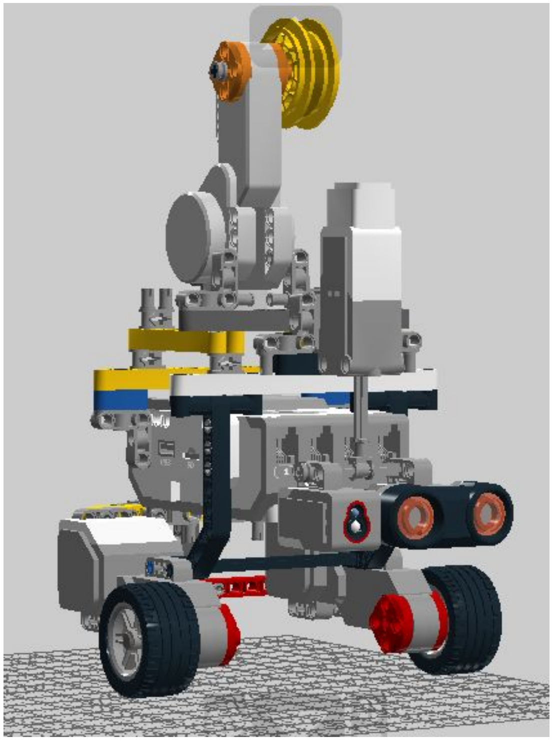


Figure 5.1.1 Option #1 - Front view   Figure 5.1.2 Option #1 - Rear view

5.2 - Option 2

- Set one ultrasonic sensor and one light sensors that are pivoting together in front of the robot. Use one medium motor.
- Set one fixed light sensor as close as possible to the floor on the back of the robot, pointing downward for localization.
- Set the EV3 block horizontally toward the front of the robot to avoid wheel slippage. As a result, we will need to add more weight toward the back for equilibrium. Thus, this robot will be heavier than the others.

PROs	CONs
The smallest robot, lower chance to hit obstacles during navigation or localization.	Height is too low.
The lightest robot, less supporting pressure on both motors.	Supporting arm needs revision .
Light and US sensors attached together, more efficient in detecting obstacles and targets.	



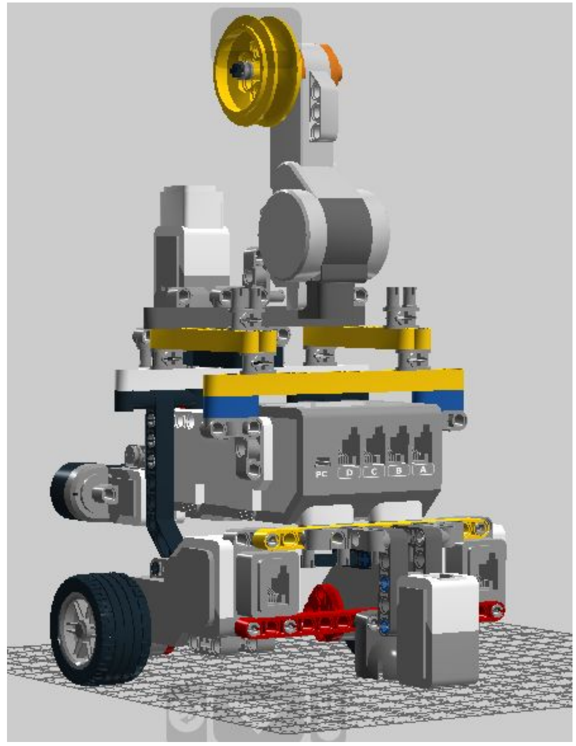


Figure 5.2.1 Option #2 - Front view

Figure 5.2.1 Option #2 - Rear view

5.3 - Option 3

- Set only one ultrasonic sensor in front of the robot that is pivoting. We will have to use one medium motor.
- Set one fixed light sensor in front of the robot that is facing straight ahead.
- Set one light sensor as close as possible to the floor on the back of the robot, pointing downward for localization.

PROs	CONs
Both the ultrasonic and light sensors positioned in front are low enough.	The stability of the arm should be revised.
The ultrasonic sensor can be moved.	The light sensor is not attached to the ultrasonic sensor, so it can't pivot and is less efficient for detecting the object's color.
Simple design, leaves one spare port for the gyro sensor if necessary.	

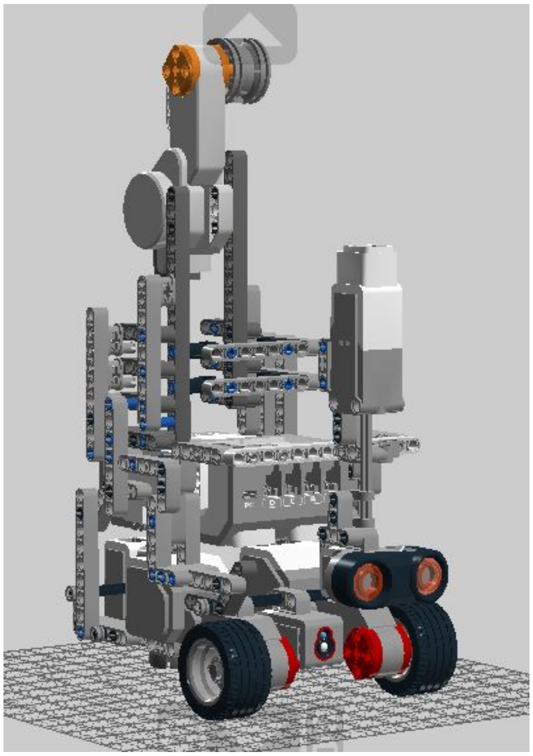


Figure 5.3.1 Option #3 - Front view

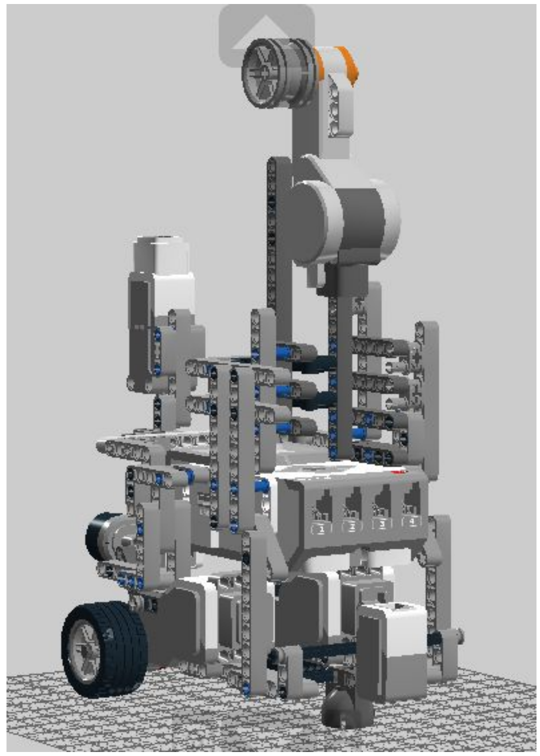


Figure 5.3.2 Option #3 - Rear view

6.0 - CHOSEN MECHANICAL DESIGN

6.1 - Features

With the goal of building the robot in the most efficient and simplest way, we designed a robot capable of localizing its position everywhere on the 8x8 tile, avoiding and searching for obstacles and objects, and detecting the colours of blocks. Here are the physical characteristics of the chosen mechanical design:

- The wheels are placed 15.2 cm apart. This gives the robot stability and the ability to execute tight turns.
- A colour sensor is added in front of each wheel, pointing downward. The sensors are equidistant from the centre of the robot, simplifying the math required for localization.
- An ultrasonic sensor and a colour sensor are mounted to a medium motor. Both sensors are mounted low enough to detect any obstacles, and they can pivot at a 45^o angle either side of centre, allowing the use of P-Controller and Bang-Bang Controller. The ultrasonic sensor is used to search for blocks and to avoid any obstacles placed on the grid, while the light sensor is used to detect the colours of blocks.
- The EV3 brick is positioned such that the wheels are weighed-down enough to avoid slippage. The brick is also placed such that it centres the balance point of the robot, crucial for crossing the zip line and navigating with precision.
- The robot is designed such that the battery can be accessed easily without damaging any components. This makes testing easier and allows for battery changes during the final competition.

- The pulley, placed on the right side of the robot, is tall enough to mount the zipline. The height of the zipline is 23.5 cm, and the pulley clears this height by approximately 2cm.
- The large NXT motor that powers the pulley wheel is also crucial in defining the robot's centre of gravity. The motor is positioned such that, when hanging from the zip line, the centre of gravity is at a point just beneath the EV3 brick's screen.
- To keep the design simple, as few supporting beams as possible are used. However, the stability of the robot is not compromised.

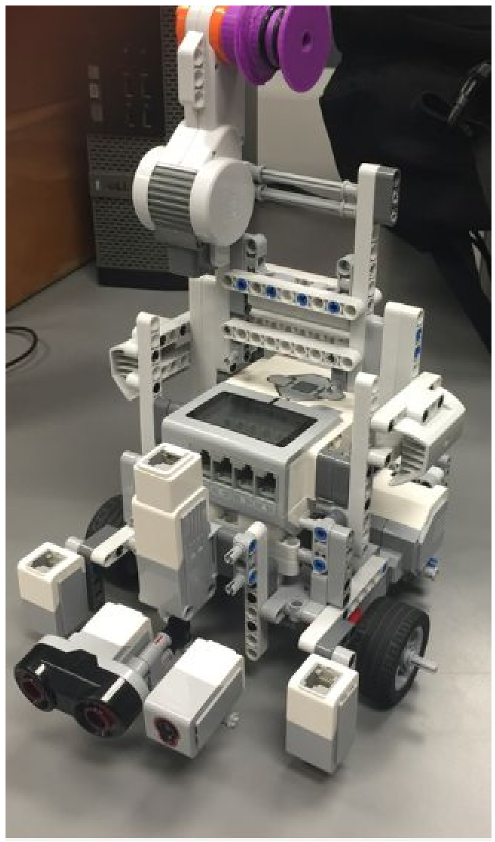


Figure 6.1.1 Physical representation of the chosen design

__Dimensions:__
Distance between the wheels: 15.2 cm
Height: 28.5 cm
Width: 19.8 cm
Depth: 21.2 cm

6.2 - Drawings

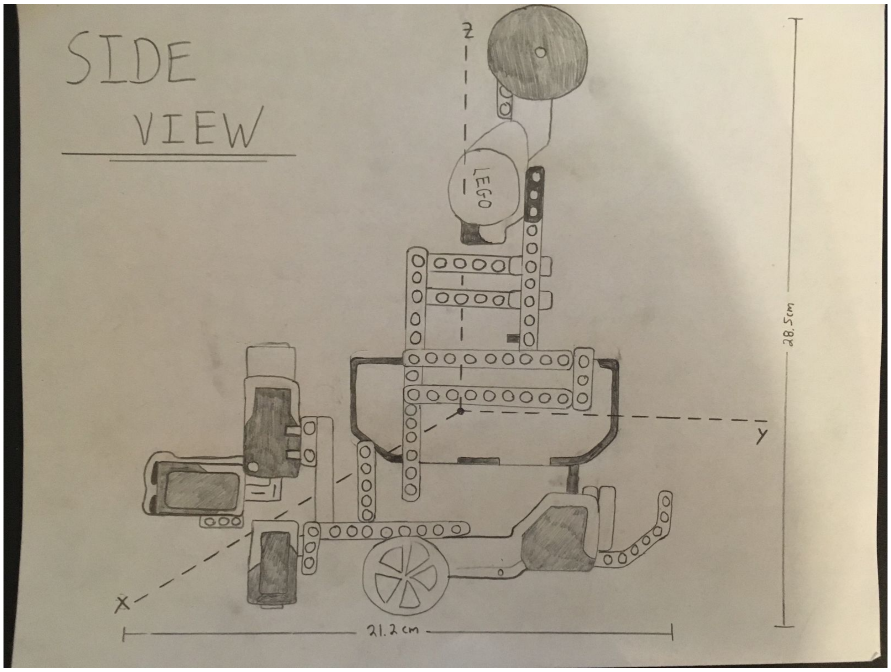


Figure 6.2.1 Sketch of the side view

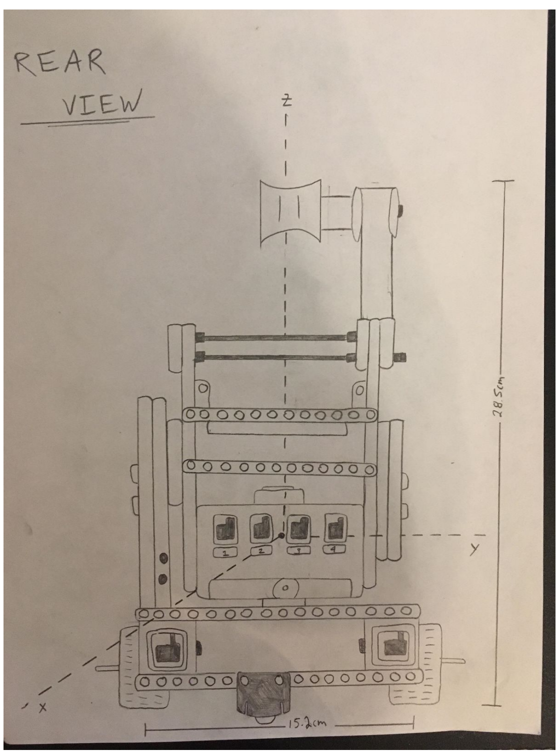


Figure 6.2.2 Sketch of the rear view

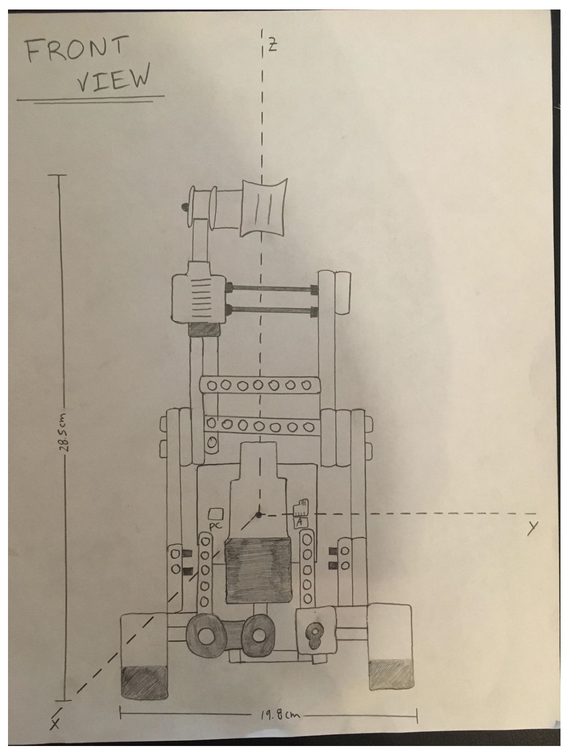


Figure 6.2.3 Sketch of the front view

6.3 - Balance point

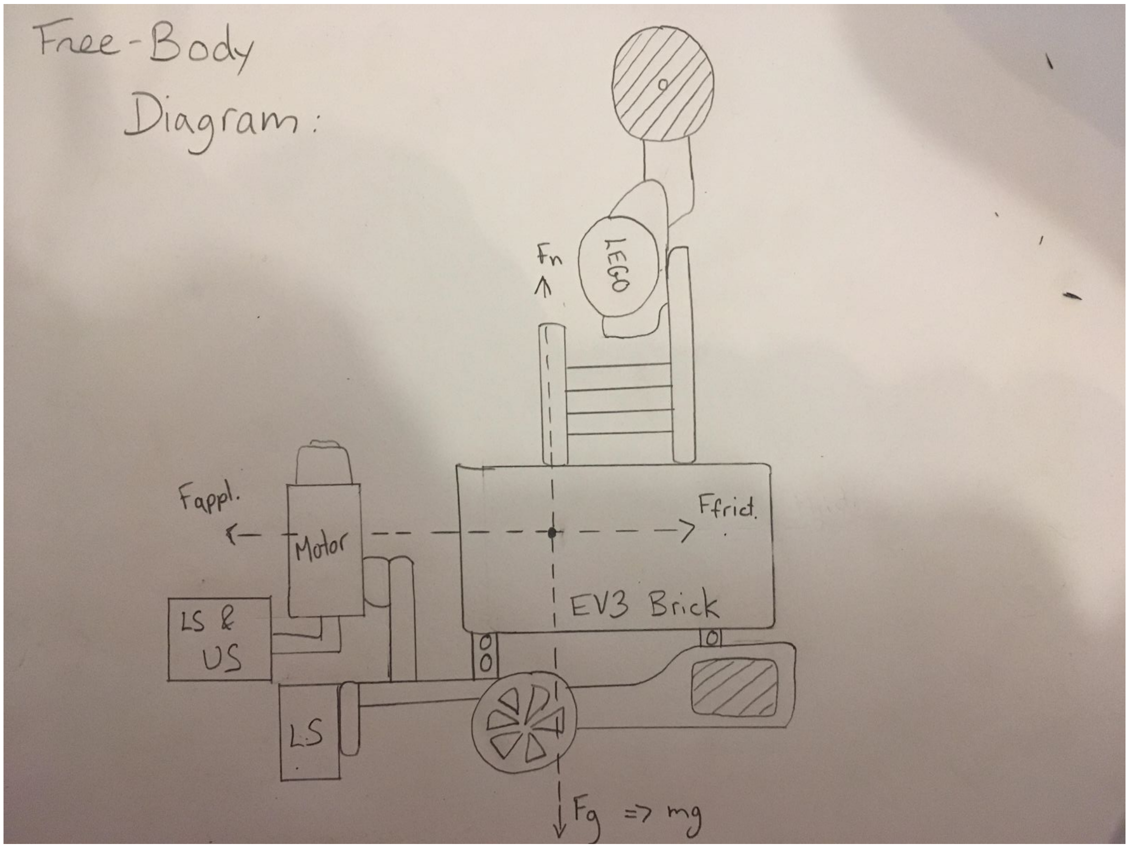


Figure 6.3.1 Simple representation of the free-body diagram

Throughout the building process, the centre of gravity was checked with experimentation. Testing the balance point on the zip line pointed us toward the approximate position of the centre of gravity. Some of our initial designs were unbalanced because the robot had more weight over the front, causing the robot to lean. To correct this problem, we moved the brick backward, but placed the NXT motor and pulley above the centre of the brick. As seen in Figure 6.3.1, the centre of gravity is at the lowest part of the brick's screen.

6.4 Pros and Cons

PROs	CONs
Both the ultrasonic and light sensors positioned in front are low enough.	No remaining ports for gyro sensor.
The ultrasonic and colour sensors can be moved.	The stability of the pivoting sensors should be revised.

Good accessibility to the battery.	
The width of the wheels make the robot stable but can also execute tight turns.	

6.5 - Evolution of design

The robot built for Laboratory #5 was a good representation of the final design, since the zip line was involved during the experiment. An additional light sensor was added in front of the robot in order to detect the colours of objects. After some experiments, we observed that a larger wheel axle will make the robot more stable, but too large will result in more complex turns. The position of EV3 brick was changed a few times to balance the amount of weight over the wheels with the centre of gravity. The most difficult task was to fix the NXT motor and pulley to the brick while maintaining the centre of gravity and balance point. The current mechanical design will be sent to the software team for initial testing, and revisions will be made if necessary.