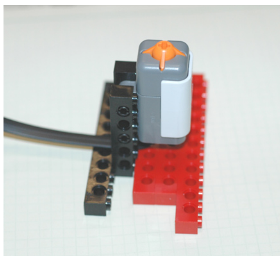
NXT Mindstorms Capability Testing

This exercise is designed to find the design limitations and capabilities of the NXT Mindstorms Lego set. In order to more efficiently design robots, one needs to know what limitations exist to produce the best possible designs and/or where a particular design might not perform well. Furthermore, only sometimes companies will provide specifications for their products or limited information about specifications.

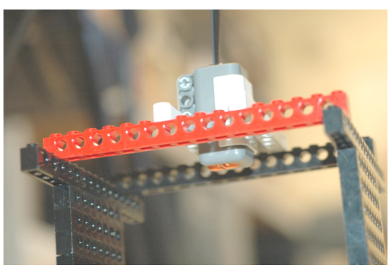
1) Find the capabilities of each sensor. Building an appropriate test stand might be helpful.

Touch sensor: How much force is required to activate this sensor? Use small weights or a force gauge for testing. Do five trials and use the average result. For a robot of given mass *m*, what minimum deacceleration *a* is needed for the sensor to work? Remember that $\boldsymbol{F} = m\boldsymbol{a}$.



Trial Num	Force (N)
1	
2	
3	
4	
5	
AVE	

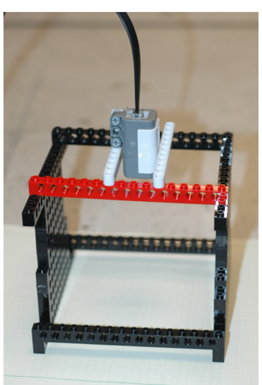
Light sensor: How does the sensor behave for different light frequencies (colors) and intensities? A table is given for a series of experiments. Do one series of tests at a dark location so ambient light does not affect the results and do the tests again with normal lighting (to see to where the sensor is no longer reliable). Suggested distance for placing test colors are 5 mm, 10 mm, 50 mm and 100 mm. Do some research to find how does this device works (it is a silicon photo diode).



Dark Location

Intensity Data Table

Distance	RED	YELLOW	GREEN	BLUE	BLACK	0.7 GREY	0.4 GREY	0.2 GREY
5 mm								
10 mm								
20 mm								
50 mm								
75 mm								
100 mm								

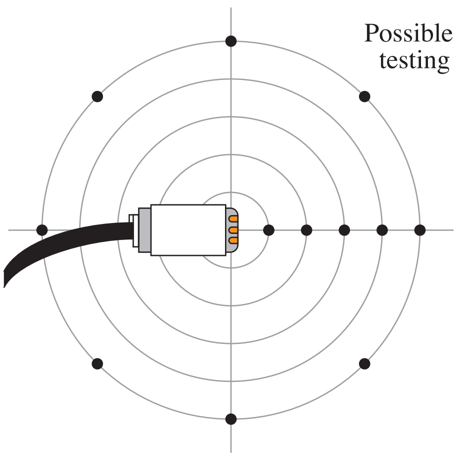


Normal Lighting Location

Intensity Data Table

Distance	RED	YELLOW	GREEN	BLUE	BLACK	0.7 GREY	0.4 GREY	0.2 GREY
5 mm								
10 mm								
20 mm								
50 mm								
75 mm								
100 mm								

Sound sensor: Measure sound at different locations around the sensor at different distances (but at the same height as the sensor). Do this systemically to create an measured intensity graph as a function of distance and angle. Try different frequencies and distances at a quiet location. You could use another NXT programmable brick as a sound source and select the frequencies show below. From the data, determine how doubling loudness changes the sensors readings.



Possible location testing pattern

Distance = 25 cm

ANGLE	INTENSITY
0°	
15°	
30°	
45°	
60°	
75°	
90°	
105°	
120°	
135°	
150°	
165°	
180°	

DISTANCE	INTENSITY
5 cm	
10 cm	
15 cm	
20 cm	
25 cm	
30 cm	
40 cm	
50 cm	
60 cm	
75 cm	
100 cm	
150 cm	
200 cm	

Ultrasonic sensor: How wide of an area (horizontally and vertically) does this sensor use to determine object distances? What kind of surfaces give the best/worst readings? What orientations relative to the ultrasonic sensor give the best results (is placing an object perpendicular to the sensor better than angled orientations)? How far away can the sensor reliably measure an ideal object's distance? What distance from the sensor gives a reading of 40 units?

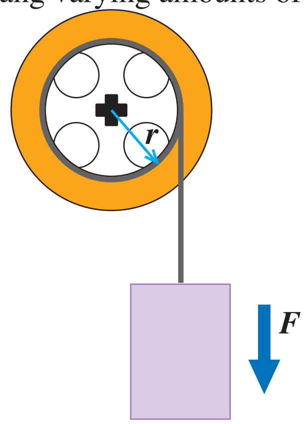
2) Torque test for motor

The NXT servo motors provide mechanical power through rotary motion. The equation that provides a relation to the pulling force from rotary force or torque (also called a moment) around a rotation axis is:

$$\boldsymbol{M} = \boldsymbol{r} \times \boldsymbol{F}$$

with the vectors $\boldsymbol{M}$ (torque/moment), $\boldsymbol{r}$ (radial position vector), and $\boldsymbol{F}$ (force) and the operator × is a vector cross product.

To find the maximum torque $\boldsymbol{M}$ available from a servo motor, one could apply different combinations of $\boldsymbol{r} \times \boldsymbol{F}$ until the motor can just barely turn. This is called a static load test. Practically, fixing $\boldsymbol{r}$ and varying $\boldsymbol{F}$ is usually the easiest way to do a static load test. One simple way is to hang varying amounts of weight as shown below:



Try each of the three motors that comes with a NXT Mindstorms kit. What is the average maximum value of $\boldsymbol{M}$ for the motors?