DATE: February 26, 2020
WRITEN BY: Lester Iwata
FROM: Team B2, Ben Bishop, Lester Iwata, and Drew Munechika
RE: Testing, Motor Performance Curve

PURPOSE *(EDITORIAL comment: Always include a purpose statement – the reader wants to know the purpose without looking elsewhere)*

The purpose of this experiment **was to*** determine the performance curve for the Lego NXT motor provided to the team. The data will be used to determine appropriate gear ratio to pull a plow in the *Lulay Sisters* test facility. *(*EDITORIAL comment: note that the testing **has** occurred. Correct tense "…**was to**…")*

GIVENS/ASSUMPTIONS

Battery remained fully charged for all testing.

PROCEDURE

See attached test plan.

DATA

See attached test plan for raw data. Figure 1 shows the motor performance curve.

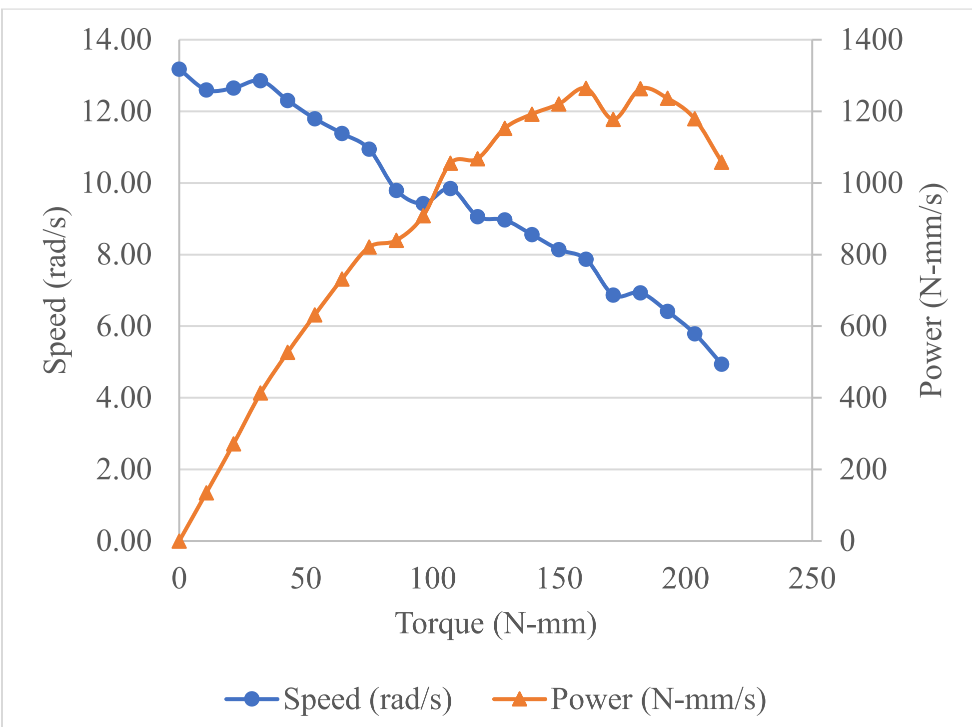

Figure 1 – Generated Performance Curve of Torque versus Rotational Speed and Power

(EDITORIAL comment, something to fix: data such as these should include trendlines – not "connect the dot")

DISCUSSION

As seen in the performance curve, the motor reaches a maximum power with a load of 1500g. After this mark the curve levels off and begins to decrease. Power is torque per time so it was expected that the motor power would begin to decrease at a higher weight. The motor was set to 100% power for the entirety of the experiment so that the absolute maximum motor power can be determined from the performance curve. To ensure that the motor underwent the five rotations as it was programmed to complete, the power was reduced to a lower setting, decreasing the rotational speed and allowing the rotations to be counted. The drop in power seen near the peak of the curve could be due to some procedural errors.

Some possible sources of error are variance in the motor's braking, weights swaying, observational error, and the drum shaft flexing:

- The motor was programmed to complete exactly five rotations, at the end of which a built-in braking system was used. The Lego NXT program gives two options after a movement is performed, brake and coast. The coast setting removes the power from the motor and lets it spin loosely until rest. The brake setting applies built-in brakes to ensure that the motor does not exceed the number of rotations. This leads to a potential source of error because at a faster rotation the brakes may need to be applied earlier in order to slow down the motor.

- The masses used in this experiment came in increments of 100, 200, and 500 grams. This meant that masses had to be strung together in order to reach the higher torque measurements. The longer strands of masses tend to sway which could lead to the motor pulling an inconsistent force depending on the trial.

- The observational error is the error of the person timing the starting and stopping of the motor. This error is due to the reaction time of the person as well as braking system of the motor, creating different stopping points of the weight.

- At greater masses, the shaft that connects to the motor and holds the drum experiences flexing. This could have introduced losses that would slow the time it takes to lift the masses.

CONCLUSION

The test results of the motor performance are reliable for use in further Phase I design work. Peak power is about 1300N-mm/sec at a75N-mm and 7 rad/sec.

DATE: February 24, 2020
WRITEN BY: Lester Iwata
FROM: Team B2, Ben Bishop, Lester Iwata, and Drew Munechika
RE: Testing Plan, Motor Performance Curve

EDITORIAL comment: you do not need to printout another test plan – you can attach the original.

Signatures: {included in hardcopy}

Test Plan: Generate a Performance Curve

PURPOSE: The purpose of this experiment **is to*** determine the performance curve for the Lego NXT motor provided to the team. The data will be used to determine appropriate gear ratio to pull a plow in the *Lulay Sisters* test facility. *(*EDITORIAL comment: note that this is the plan so the test has not yet happened. Correct tense "...**is to**...").*

PLANNED TEST DATE and LOCATION: Feb. 25, 6PM, Test facility outside SH110

PERSONNEL: entire team B2.

TEST PLAN

1. Measure diameter of the drum.
2. Program the NXT motor to perform five rotations at maximum power.
3. Attach the motor to the drum.
4. Attach weight(s) to the drum.
5. Take photographs and record testing (video)
6. Begin motor and record the total time to complete the five rotations. Perform step 5 three times for each weight.
7. Add weights incrementally and repeat steps 4 through 6 until the power curve levels off and decreases

TEST SETUP

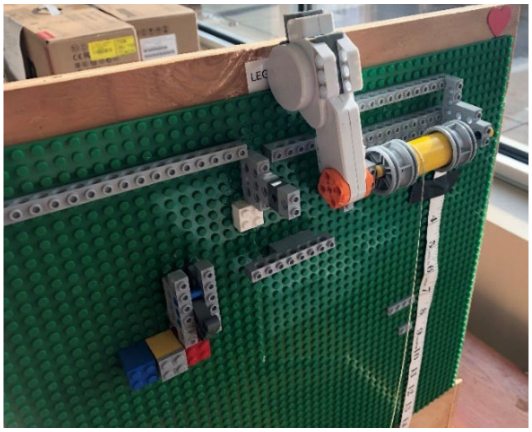

Figure 2 – Lego NXT motor in the test stand. Different masses were attached to the drum via the string.

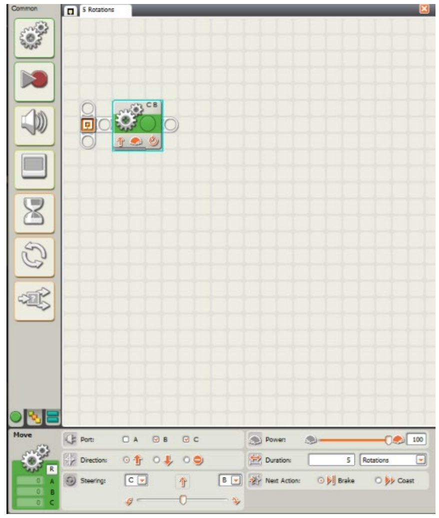

Figure 3 – Lego NXT program. The program causes the motor to rotate 5 times at 100 % power.

CALCULATIONS:
Torque (N-mm) = (radius of drum)*weight; weight = mass*a_g; a_g=9800mm/sec^2
1 rev/sec = 1 (rev/sec)*(2π rad/rev) = 6.28 rad/sec
Power (N-mm/sec) = Torque * angular velocity (rad/sec)

DATA: (blank for the test plan, raw data for the test report)

Table 1: pre-test data (blank for the test plan, raw data for the test report)

Measured Parameter	**Value**
Radius of Drum, R (mm)	10.9 millimeters
Amount of Rotations	5 rotations
Record video for each test	

DATA TABLE (blank for the test plan, raw data for the test report)

	Measured time to complete 5 revolutions			Calculated values			
Mass (g)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Average (s)	Torque (N-mm)	Angular Velocity (rad/s)	Power (N-mm/sec)
0	2.31	2.44	2.4	2.38	0	13.18	0
100	2.61	2.41	2.46	2.49	11	12.60	135
200	2.53	2.5	2.42	2.48	21	12.65	271
300	2.42	2.42	2.49	2.44	32	12.86	413
400	2.48	2.59	2.59	2.55	43	12.30	527
500	2.63	2.72	2.64	2.66	54	11.80	632
600	2.69	2.81	2.78	2.76	64	11.38	732
700	2.81	2.89	2.91	2.87	75	10.95	821
800	3.17	3.22	3.23	3.21	86	9.80	840
900	3.35	3.33	3.32	3.33	96	9.42	909
1000	3.18	3.21	3.18	3.19	107	9.85	1055
1100	3.42	3.49	3.49	3.47	118	9.06	1068
1200	3.48	3.54	3.49	3.50	129	8.97	1153
1300	3.56	3.71	3.74	3.67	139	8.56	1192
1400	3.8	3.9	3.88	3.86	150	8.14	1221
1500	3.95	4.05	3.98	3.99	161	7.87	1264
1600	4.51	4.71	4.5	4.57	171	6.87	1178
1700	4.47	4.48	4.64	4.53	182	6.94	1263
1800	5	4.8	4.9	4.90	193	6.41	1237
1900	5.43	5.45	5.39	5.42	204	5.79	1179
2000	6.19	6.49	6.41	6.36	214	4.94	1058

Test Engineer: Lester Iwata

Test Engineer's signature attesting to the legitimacy of the data:___{signed for hardcopy}_______

Test Date:_______________________