



To find the CG, we first measure the XYZ coordinates of each component with respect to an arbitrary point on the robot. In this case we will set the reference as the top-center of the LIDAR as shown above. This point will be our Origin.

Assumptions made:

1. All screws, nuts, bolts and washers and wiring's CG are not accounted for as it is assumed to have no impact on the overall CG
2. Parts symmetrical about the origin are assumed to have CG within the axis Z of the origin.
3. Counterweights are also not included here in order to show the robot's true CG

Table 1: Bill of Materials

Calculated to 3 decimal places.

S/n.	Component	Weigh ht (kg)	Component's CG from Origin		
			X(m)	Y(m)	Z(m)
Level 1					
1.1	Waffle Plate lvl 1	0.080	0.000	0.000	-0.240
1.2	Left Dynamixel Motor	0.056	-0.053	0.03	-0.210
1.3	Right Dynamixel Motor	0.056	0.053	0.03	-0.210
1.4	Left Wheel + Tire	0.035	-0.080	0.035	-0.215
1.5	Right Wheel + Tire	0.035	0.080	0.035	-0.215
1.6	Battery	0.139	-0.005	0.030	-0.210
Level 2					
2.1	Waffle Plate lvl 2	0.080	0.000	0.000	-0.200
2.2	OpenCR	0.064	0.000	0.000	-0.170
2.3	Plate_Support_M3x45mm	0.006	0.068	0.040	-0.170
2.4	Plate_Support_M3x45mm	0.006	-0.068	-0.050	-0.170
2.5	Plate_Support_M3x45mm	0.006	-0.015	-0.058	-0.170
2.6	Plate_Support_M3x45mm	0.006	-0.015	-0.085	-0.170
Level 3					
3.1	Waffle Plate lvl 3	0.080	0.000	0.000	-0.150
3.2	Raspberry Pi	0.047	0.005	-0.025	-0.12
3.3	USB2LDS	0.002	0.000	0.000	-0.145
3.4	Right DC Motor	0.025	0.053	0.120	-0.050
3.5	Left DC Motor	0.025	-0.053	0.120	-0.050
3.6	Right Flywheel	0.009	0.045	0.120	-0.050

3.7	Left Flywheel	0.009	-0.045	0.120	-0.050
3.8	Launch Tube	0.137	0.000	0.120	-0.100
3.9	PVC Elbow Connector	0.097	0.000	0.150	-0.050
3.10	Ball Feeder (Funnel)	0.004	0.000	0.150	-0.040
3.11	Plate_Support_M3x45mm	0.006	0.068	-0.01	-0.135
3.12	Plate_Support_M3x45mm	0.006	-0.068	-0.01	-0.135
3.13	Plate_Support_M3x45mm	0.006	0.025	0.068	-0.135
3.14	Plate_Support_M3x45mm	0.006	-0.025	0.068	-0.135
3.15	Plate_Support_M3x45mm	0.006	0.068	0.025	-0.135
3.16	Plate_Support_M3x45mm	0.006	-0.068	0.025	-0.135
3.17	35mm FM Hex Standoff (1st Layer after Plate Support)	0.005	0.068	-0.010	-0.090
3.18	35mm FM Hex Standoff (1st Layer after Plate Support)	0.005	-0.068	-0.010	-0.090
3.19	35mm FM Hex Standoff (1st Layer after Plate Support)	0.005	0.025	0.068	-0.090
3.20	35mm FM Hex Standoff (1st Layer after Plate Support)	0.005	-0.025	0.068	-0.090
3.21	35mm FM Hex Standoff (1st Layer after Plate Support)	0.005	0.068	0.025	-0.090
3.22	35mm FM Hex Standoff (1st Layer after Plate Support)	0.005	-0.068	0.025	-0.090
3.23	35mm FM Hex Standoff (2nd Layer after Plate Support)	0.005	0.068	-0.010	-0.055
3.24	35mm FM Hex Standoff (2nd Layer after Plate Support)	0.005	-0.068	-0.010	-0.055
3.25	35mm FM Hex Standoff (2nd Layer after Plate Support)	0.005	0.025	0.068	-0.055
3.26	35mm FM Hex Standoff (2nd Layer after Plate Support)	0.005	-0.025	0.068	-0.055

3.27	35mm FM Hex Standoff (2nd Layer after Plate Support)	0.005	0.068	0.025	-0.055
3.28	35mm FM Hex Standoff (2nd Layer after Plate Support)	0.005	-0.068	0.025	-0.055
Level 4					
4.1	Waffle Plate lvl 4	0.080	0.000	0.000	-0.005
4.2	LIDAR	0.128	0.000	0.000	-0.003

Table 2: Moment of Components

Calculated to 3 significant figures.

Components	Xm(kgm)	Ym(kgm)	Zm(kgm)
Level 1			
Waffle Plate lvl 1	0.000	0.000	-0.0192
Left Dynamixel Motor	-0.00297	0.00168	-0.0118
Right Dynamixel Motor	0.00297	0.00168	-0.0118
Left Wheel + Tire	-0.00216	0.000945	-0.00581
Right Wheel + Tire	0.00216	0.000945	-0.00581
Battery	-0.000695	0.00417	-0.0292
Level 2			
Waffle Plate lvl 2	0.000	0.000	-0.0160
OpenCR	0.000	0.000	-0.0109
Plate_Support_M3x45mm	0.000435	0.000256	-0.00109
Plate_Support_M3x45mm	-0.000435	-0.000320	-0.00109
Plate_Support_M3x45mm	-0.0000960	-0.000371	-0.00109
Plate_Support_M3x45mm	-0.0000960	-0.000544	-0.00109
Level 3			
Waffle Plate lvl 3	0.000	0.000	-0.0120
Raspberry Pi	0.000235	-0.00118	-0.00564
USB2LDS	0.000	0.000	-0.000290
Right DC Motor	0.00133	0.00300	-0.00125
Left DC Motor	-0.00133	0.00300	-0.00125
Right Flywheel	0.000405	0.00108	-0.000450
Left Flywheel	-0.000405	0.00108	-0.000450

Launch Tube	0.000	0.0164	-0.0137
PVC Elbow Connector	0.000	0.0146	-0.00486
Ball Feeder (Funnel)	0.000	0.000540	-0.000144
Plate_Support_M3x45mm	0.000435	-0.0000640	-0.000864
Plate_Support_M3x45mm	-0.000435	-0.0000640	-0.000864
Plate_Support_M3x45mm	0.000160	0.000435	-0.000864
Plate_Support_M3x45mm	-0.000160	0.000435	-0.000864
Plate_Support_M3x45mm	0.000435	0.000160	-0.000864
Plate_Support_M3x45mm	-0.000435	0.000160	-0.000864
35mm FM Hex Standoff (1st Layer after Plate Support)	0.000360	-0.0000530	-0.000477
35mm FM Hex Standoff (1st Layer after Plate Support)	-0.000360	-0.0000530	-0.000477
35mm FM Hex Standoff (1st Layer after Plate Support)	0.000133	0.000360	-0.000477
35mm FM Hex Standoff (1st Layer after Plate Support)	-0.000133	0.000360	-0.000477
35mm FM Hex Standoff (1st Layer after Plate Support)	0.000360	0.000133	-0.000477
35mm FM Hex Standoff (1st Layer after Plate Support)	-0.000360	0.000133	-0.000477
35mm FM Hex Standoff (2nd Layer after Plate Support)	0.000360	-0.0000530	-0.000292
35mm FM Hex Standoff (2nd Layer after Plate Support)	-0.000360	-0.0000530	-0.000292
35mm FM Hex Standoff (2nd Layer after Plate Support)	0.000133	0.000360	-0.000292
35mm FM Hex Standoff (2nd Layer after Plate Support)	-0.000133	0.000360	-0.000292
35mm FM Hex Standoff	0.000360	0.000133	-0.000292

(2nd Layer after Plate Support)			
35mm FM Hex Standoff (2nd Layer after Plate Support)	-0.000360	0.000133	-0.000292
Level 4			
Waffle Plate lvl 4	0.000000	0.000000	-0.00400
LIDAR	0.000000	0.000000	-0.00320
Total:	-0.000652	0.0498	-0.171

The overall CG position can therefore be calculated by summing the individual component moments in each axis and dividing that sum by the sum of mass of all the components.

Sum Xm(kgm)	Sum Ym(kgm)	Sum Zm(kgm)
-0.000652	0.0498	-0.171

Total Mass = 1.297 kg

CG Coordinates:

X-distance(m)	Y-distance(m)	Z-distance(m)
-0.000503	0.0384	-0.132