Component Type	Mass (kg)	Length [m]	Notes	Required Rated Torque [Nm]	Spec'd Motors	Rated Torque Cos	t N	Mass [Kg]	
Joint 1	1.42	0		26.14123746	Robstride 04	40	280	1.42	
Link 1	0.2019843687	0.0762						4.161	
Joint 2	1.42		Sum Mass of components below for Torque	36.78683086	Robstride 04	40	280	1.42	
Link 2	0.4039687374	0.2024						4.476	
Joint 3	0.88	0		15.19523786	Robstride 03	20	250	0.88	
Link 3	0.3366406145	0.127							
Joint 4	0.88		Sum Mass of	19.53629652	Robstride 03	20	250	0.88	
Link 4	0.5386249832	0.2532						2	
Joint 5	0.88		Matching to Joint 3 spec	15.19523786	Robstride 03	20	250	0.88	
Link 5	0.2		End Effector						
Point mass	5		Payload mass dictates torque requirements						
		0.735		Numbers increase from Proxima	al to Distal	Cost per Arm:	1310		
						Total Upper Body	2620		
			com whist affector						
			T Carloss						
"Showler		laure ne	er lower for						
(Trunk) clavical (upper	s read								
(1.510.)									
27) 23))		· 2 5	6 7 20				4	Assumptions	
	0-100 A							Mass of links are based on tube	diameter
								loint masses based on Stompy	
/									
		1_4	(16)						
L, L,			- /						
2	,								
	04.	Units	Notes	APPROACH: SUM ALL Momen	ts together				
Joint 4 Torque Calculation (Shoulder)									
			Notes		_				
Mass: Link 5 and Link 4	0.7386249832	Kilograms	110103	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4	0.7386249832 0.3294	Kilograms Meter			static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5	0.7386249832 0.3294 0.1647	Kilograms Meter Meter	Assume Cylindrical Tube uniform geometry	Assume links prior to joint 4 is a	static fixed point				
Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam	0.7386249832 0.3294 0.1647 7.245911085	Kilograms Meter Meter N	Assume Cylindrical Tube uniform geometry	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload	0.7386249832 0.3294 0.1647 7.245911085 49.05	Kilograms Meter Meter N N		Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294	Kilograms Meter Meter N N Meter	Assume Cylindrical Tube uniform geometry Treated as point mass	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328	Kilograms Meter Meter N N Meter N Meter	Assume Cylindrical Tube uniform geometry	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4)	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532	Kilograms Meter Meter N N Meter N Meter N Meter N Meter	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5)	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N Meter N Meter	Assume Cylindrical Tube uniform geometry Treated as point mass	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N Meter Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N Meter Nm Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N Meter Nm Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass	Assume links prior to joint 4 is a	static fixed point				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.1570 2.18582496 19.53629652	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N Meter N M M M M M M M M M M M M M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 5 Moment on Joint 5 Moment on Joint 4: (Sum of Moments)	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652	Kilograms Meter Meter N N N Meter N Meter N Meter N Meter Nm Nm Nm Nm Nm Nm Nm Nm Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance	Assume links prior to joint 4 is a	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment: Joint 4 (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335	Kilograms Meter Meter N N N Meter N Meter N Meter N Meter N Mm Nm Nm Nm Nm Nm Nm Nm Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Joint 5 Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652	Kilograms Meter Meter N N N Meter N Meter N Meter N Meter N Mm Nm Nm Nm Nm Nm Nm Nm Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment: Joint 4 (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N M Meter N M N M N M N M M M M M M M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Joint 5 Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N M Meter N M N M N M N M M M M M M M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N M M M M M M M M M M M M M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883	Kilograms Meter Meter N N N Meter N Meter Nm Nm Nm Nm Vm Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Weight of Beam Weight of Payload	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883 49.05	Kilograms Meter Meter N N N Meter N Meter N Meter N Mm Nm Nm Nm Mm V Mn Mm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.5112888 49.05 0.4564	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N M M M M M M M M M M M M M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight of Joint 5 Length: Joint 2 to Payload Weight of Joint 5 Length: Joint 2 to Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328	Kilograms Meter Meter N N Meter N Meter N Meter N M Meter N M N N N N N N N N N N N N N M N M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight of Joint 5 Length: Joint 5 Length: Joint 5 Lo Joint 5 Length: Joint 5 Length: Joint 5 Length: Joint 10 Joint 5 Length: Joint 10 Joint 5 Length: Joint 10 Joint 5 Weight: Joint 10 Joint 5 Weight: Joint 10 Joint 5 Weight: Joint 10	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328 0.5826	Kilograms Meter Meter N N N Meter N Meter Nm	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight of Joint 5 Length: Joint 2 to Joint 5 Weight: Joint 2 to Joint 5 Weight: Joint 2 to Joint 5 Length: Joint 2 to Joint 5 Length: Joint 2 to Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 1.193401556 16.15707 2.18582496 19.53629652 Oty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328	Kilograms Meter Meter N N N Meter N Meter N Meter N Mm Nm Nm Nm Nm Nm Nm Nm Nm Meter N Meter Meter Meter Meter Meter Meter Meter Meter N N Meter	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight of Joint 5 Length: Joint 2 to Joint 5 Weight: Joint 2 to Joint 5 Weight: Joint 4 Length: Joint 2 to Joint 5 Length: Joint 2 to Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 10 Joint 4 Weight: Joint 10 Joint 10 Joint 10 Joint 2 to Joint 4 Weight: Joint 2 to Joint 4	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.5112888 49.05 0.4564 8.6328 0.5826 8.6328 0.3294 8.6328	Kilograms Meter Meter N N Meter N Meter N Meter N Mm Nm Nm Nm Nm Nm Mm Meter Meter Meter Meter Meter Meter N	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight of Joint 5 Length: Joint 2 to Joint 5 Weight: Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 2 to Joint 3	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Oty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328 0.5826 8.6328 0.3294 8.6328	Kilograms Meter Meter N N Meter N Meter N Meter N Meter N M M M N M N M N M N M N M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight Joint 2 to Joint 5 Weight: Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 2 to Joint 3 Moment: Beam (Link 5,4,3,2)	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328 0.5826 8.6328 0.3294 8.6328 0.3294 4.78001854	Kilograms Meter Meter N N Meter N Meter N Meter N M Meter N M N N N N N N N N N N M N M N M M N M M N M M N M N M N M N M N M N M M N M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 (link 4) Moment: Joint 4 (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Payload Length: Joint 2 to Payload Weight of Joint 5 Weight: Joint 2 to Joint 5 Weight: Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 3 Length: Joint 3 Length: Joint 3 Moment: Beam (Link 5,4,3,2) Moment: Beam (Link 5,4,3,2) Moment: Beam (Link 5,4,3,2) Moment: Beam (Link 5,4,3,2)	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 1.193401556 16.15707 2.18582496 19.53629652 Oty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328 0.3294 8.6328 0.3294 4.78001854 22.38642	Kilograms Meter Meter N N N Meter N Meter N Mm Nm Nm Nm Nm Nm Nm Nm Nm Meter Meter N Meter Meter N Meter N N Met	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 (link 4) Moment: Joint 5 (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight: Joint 5 Length: Joint 4 Length: Joint 2 to Joint 5 Weight: Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 2 to Joint 3 Moment: Beam (Link 5,4,3,2) Moment: Payload Moment: Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2523 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328 0.5826 0.3294 8.6328 0.02024 4.78001854 22.38642 5.02946928	Kilograms Meter Meter N N N Meter N Meter N Meter N Mm Nm Nm Mm Whits Kg Meter Meter N Meter N Meter N Meter N M Meter N M M M M M M M M M M M M M M M M M M	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 Moment on Joint 4: (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight: Joint 2 to Joint 5 Length: Joint 2 to Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 3 Length: Joint 3 Length: Joint 2 to Joint 3 Moment: Payload Moment: Payload Moment: Joint 5 Moment: Payload Moment: Joint 5 Moment: Joint 10 Moment: Joint 3 Moment: Joint 5 Moment: Joint 4	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2532 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.5112883 49.05 0.4564 8.6328 0.3294 8.6328 0.3294 14.78001854 0.2234 4.78001854	Kilograms Meter Meter N N Meter N Meter N Meter N Mm Nm Nm Nm M Meter Meter Meter Meter Meter Meter Meter Meter Meter N Meter Meter N	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				
Mass: Link 5 and Link 4 Length: Link 5 and Link 4 Center of Mass Sum Link 4 and 5 Weight of Beam Weight of Payload Length: Joint 4 to Payload Weight of Joint 5 Length: Joint 4 to Joint 5 (link 4) Moment: Beam (link 4 and 5) Moment: Payload Moment: Joint 5 (link 4) Moment: Joint 5 (Sum of Moments) Joint 2 Torque Calculation (Elbow) Mass: Link 5, 4, 3, 2 Length: Link 5, 4, 3, 2 Center of Mass Sum Links 5,4,3,2 Weight of Beam Weight of Beam Weight of Payload Length: Joint 2 to Payload Weight: Joint 5 Length: Joint 4 Length: Joint 2 to Joint 5 Weight: Joint 4 Length: Joint 2 to Joint 4 Weight: Joint 3 Length: Joint 2 to Joint 3 Moment: Beam (Link 5,4,3,2) Moment: Payload Moment: Joint 5	0.7386249832 0.3294 0.1647 7.245911085 49.05 0.3294 8.6328 0.2523 1.193401556 16.15707 2.18582496 19.53629652 Qty 1.479234335 0.6588 0.3294 14.51128883 49.05 0.4564 8.6328 0.5826 0.3294 8.6328 0.02024 4.78001854 22.38642 5.02946928	Kilograms Meter Meter N N Meter N Meter N Meter N Mm Nm Nm Nm Nm Nm Nm Nm Meter N Meter Meter N Meter Meter N	Assume Cylindrical Tube uniform geometry Treated as point mass Treated as point mass Force * distance Rated Torque Spec	Assume links prior to joint 4 is a Note: Motor Lengths are treated	static fixed point as negligible				

Joint 1 Torque Calculation (Elbow)	Qty	Units	Notes	Note: Motor Lengths are treated as negligible					
Mass: Link 5, 4, 3, 2	1.479234335	Kg		This is effectievly the same torque	as on Joint 2. Assume joint 2 ber	nt 90 degrees applying mome	ent on 1. Mass and mom	nents from joint 2 and	1 negated a
Length: Link 5, 4, 3, 2	0.5588	Meter							
Center of Mass Sum Links 5, 4, 3, 2	0.2794	Meter							
Weight of Beam	14.51128883	N							
Weight of Payload	49.05	N							
Length: Joint 2 to Payload	0.4064	Meter							
Weight of Joint 5	2.3544	N							
Length: Joint 2 to Joint 5	0.4826	Meter							
Weight: Joint 4	2.3544	N							
Length: Joint 2 to Joint 4	0.2794	Meter							
Weight: Joint 3	2.3544	N							
Length: Joint 2 to Joint 3	0.1524	Meter							
Moment: Beam (Link 5,4,3,2)	4.054454098	Nm							
Moment: Payload	19.93392	Nm							
Moment: Joint 5	1.13623344	Nm							
Moment: Joint 4	0.65781936	Nm							
Moment: Joint 3	0.35881056	Nm							
Moment on Joint 2: (Sum of Moments)	26.14123746	Nm	Rated Torque Spec						
Joint 3 Torque Calculation		Units	Notes						
Mass: Link 5 and 4	0.7386249832	Kilograms							
Length: Link 5 and 4	0.2794	Meter							
Center of Mass Sum Links 5 and 4	0.1397	Meter	Assume Cylindrical Tube uniform geometry						
Weight of Beam	7.245911085	N							
Weight of Payload	49.05	N	Treated as point mass						
Length: Joint 4 to Payload	0.2794	Meter							
Weight of Joint 5	2.3544	N	Treated as point mass						
Length: Joint 4 to Joint 5 (link 4)	0.2032	Meter							
Moment: Beam (link 4 and 5)	1.012253779	Nm	Force * distance						
Moment: Payload	13.70457	Nm							
Moment: Joint 5	0.47841408	Nm							
Moment on Joint 4: (Sum of Moments)	15.19523786	Nm	Rated Torque Spec						