YASKAWA
PARTNER SUPPORT
Shared Integration Experience

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Step by Step: Sizing a Robot with MotoSize Using Inventor

Introduction:

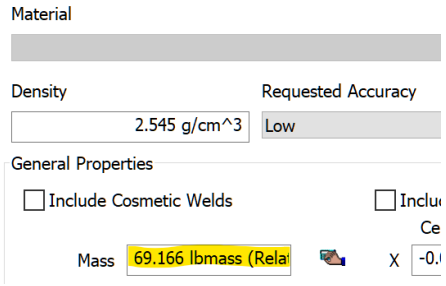
It is always important to have the correct mass data for your End-Of-Arm Tool (EOAT) for sizing the correct robot model and using that tool data in the robot's controller.

Below are step by step instructions to configure Inventor CAD data, export it to MotoSize, and calculate the results.

STEP 1: Check CAD model Integrity

In Inventor, verify the following in the Assembly:

1. All relevant components are represented (anything that will generate enough mass.) This includes fasteners if they are numerous.
2. Verify there are no duplicate components embedded in the assembly.
3. All relevant models are solid bodies; not just surfaces (surfaces have no volume for mass to be calculated).
4. All manufactured models have the correct material applied (steel, aluminum, plastics, rubber, etc.) …giving it mass.
5. All purchased components have either the correct material applied, or the mass is over-ridden with a value provided by the manufacturer.



6. In addition to the tool mass, the mass of the part, being picked, needs to be represented, since it can significantly impact the overall mass properties.
    a. Select the largest, heaviest part that the tool will pick.

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STEP 2: Setup Second Coordinate System

It is critical that the coordinate system is accurately located. It will affect the center of gravity and moments of inertia.
The origin needs to be located at the connection point of the robot flange and the tool.
It is also important how the coordinate system is aligned with the robot flange…see Figure 1.

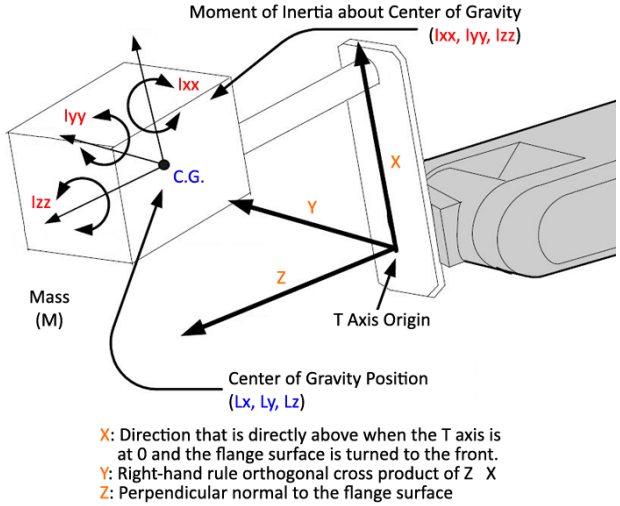
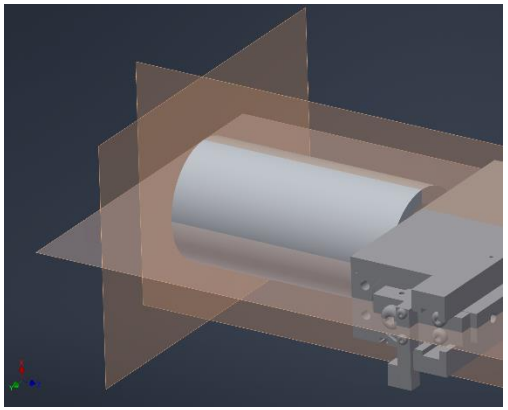


Figure 1: Reference for Proper Alignment

1. In the Inventor, unless the Assembly was prebuilt using Figure 1's coordinate system, create a new top-level assembly and insert the tool and part as a subassembly.
2. Use the constraints to align the sub-assembly to the top-level's origin, using the top-level's work-planes as a reference.



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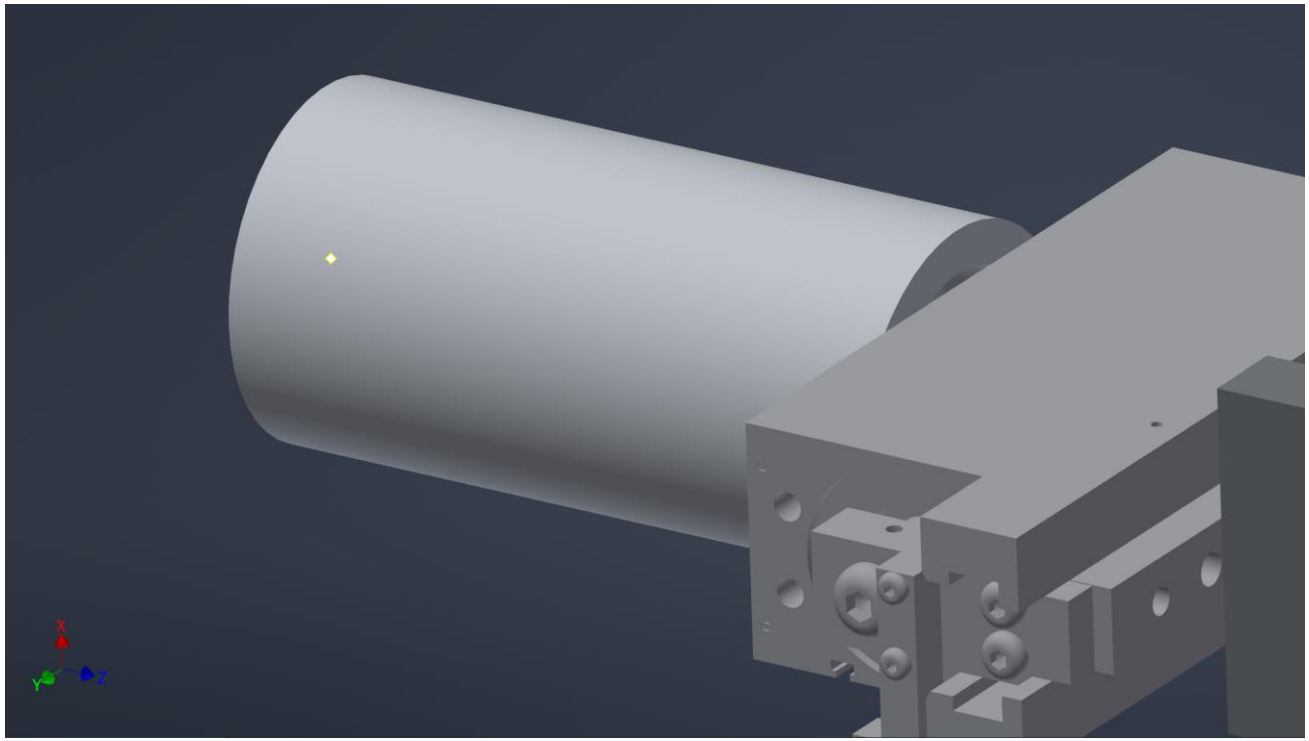


Figure 2: The highlighted point is the origin, Z is normal (away) from the robot flange, and X points away from the robot

STEP 3: Configure and Output the Mass Data

After the models and origin have been configured, the next step is the mass properties output.

It can be found by right clicking the top-level assembly in the model tree and selecting iProperties/Physical**s**

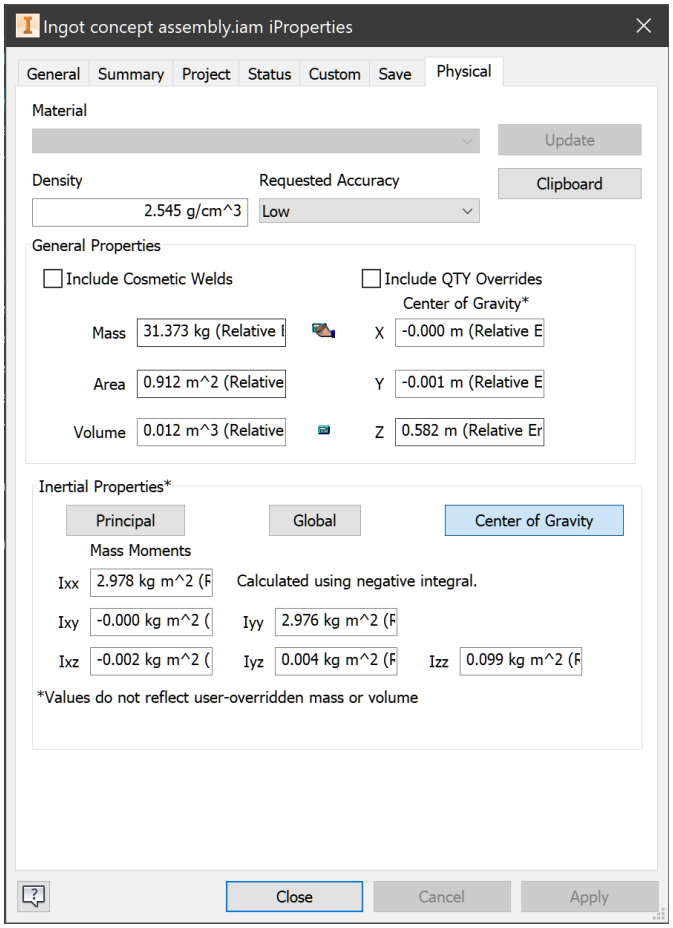
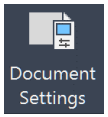


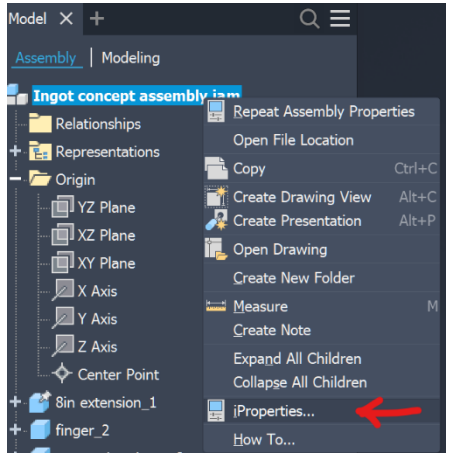
Figure 3: Mass Properties

The sample Mass Properties to the left displays how the results should look.

1. Verify that the units are set to Kilogram and meters, using the **Tool** Tab / **Document Settings**.



2. Select **Units** to change the length and mass options.
3. Use the **CLIPBOARD** button to copy the data to the windows clipboard.
4. Open a new text file (ex: notepad or notepad++) and paste in the data just copied.
5. Save and close the file.
6. WARNING: Do not manually edit the text file. Any change to the syntax will prevent MotoSize from recognizing the data structure.



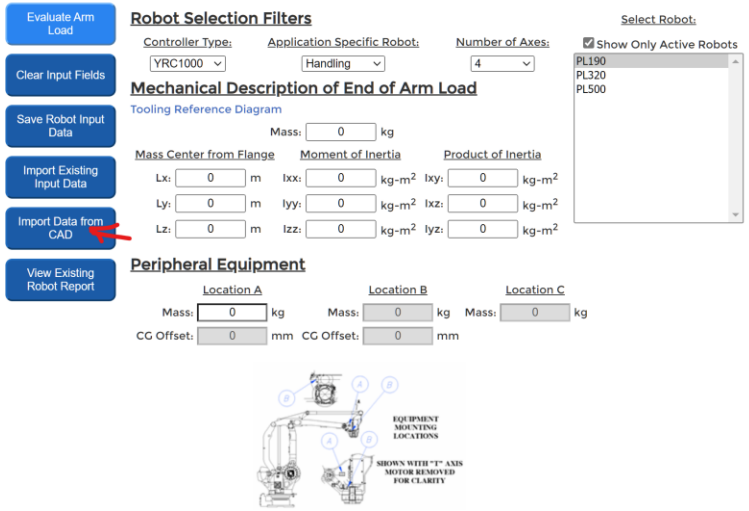
STEP 4: Enter the Data in MotoSize

Login to MotoSize.motoman.com

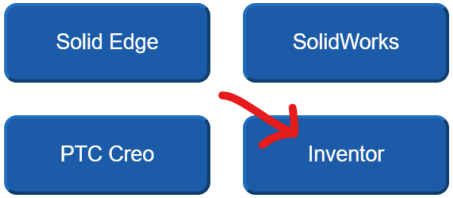
At the main page select the option for **CHECK ROBOT VIA CALCULATED DATA**

At the Data Input Screen:

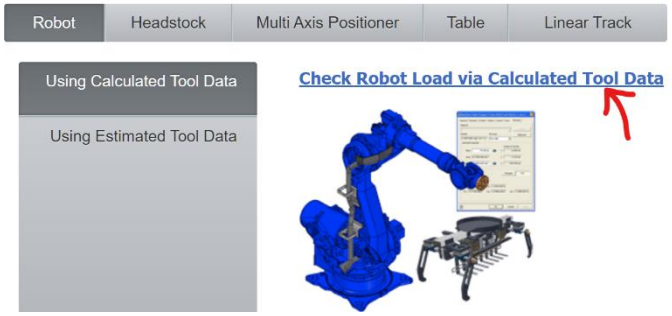
1. Select the button **Import Data From CAD**



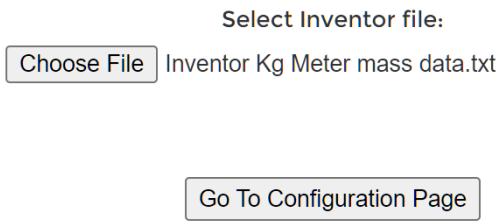
2. Select Inventor



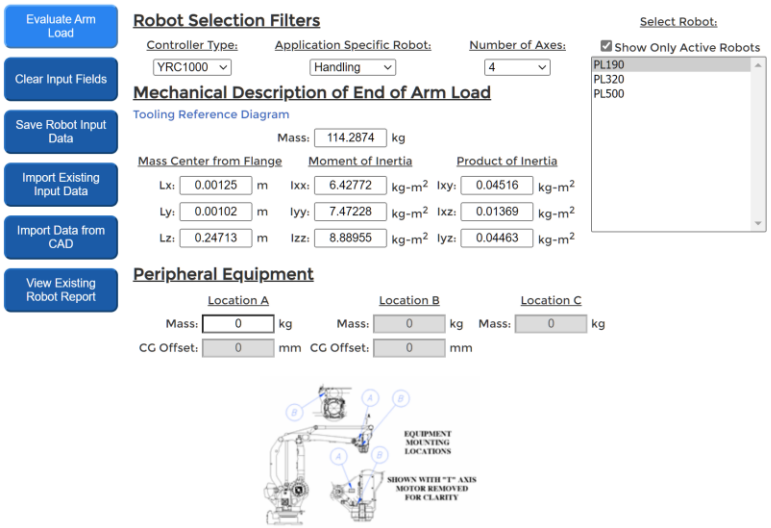
NOTE:
The accuracy of the results directly corresponds to the accuracy of the input data.



3. Browse for the recently created text file and select **Go to Configuration Page**.



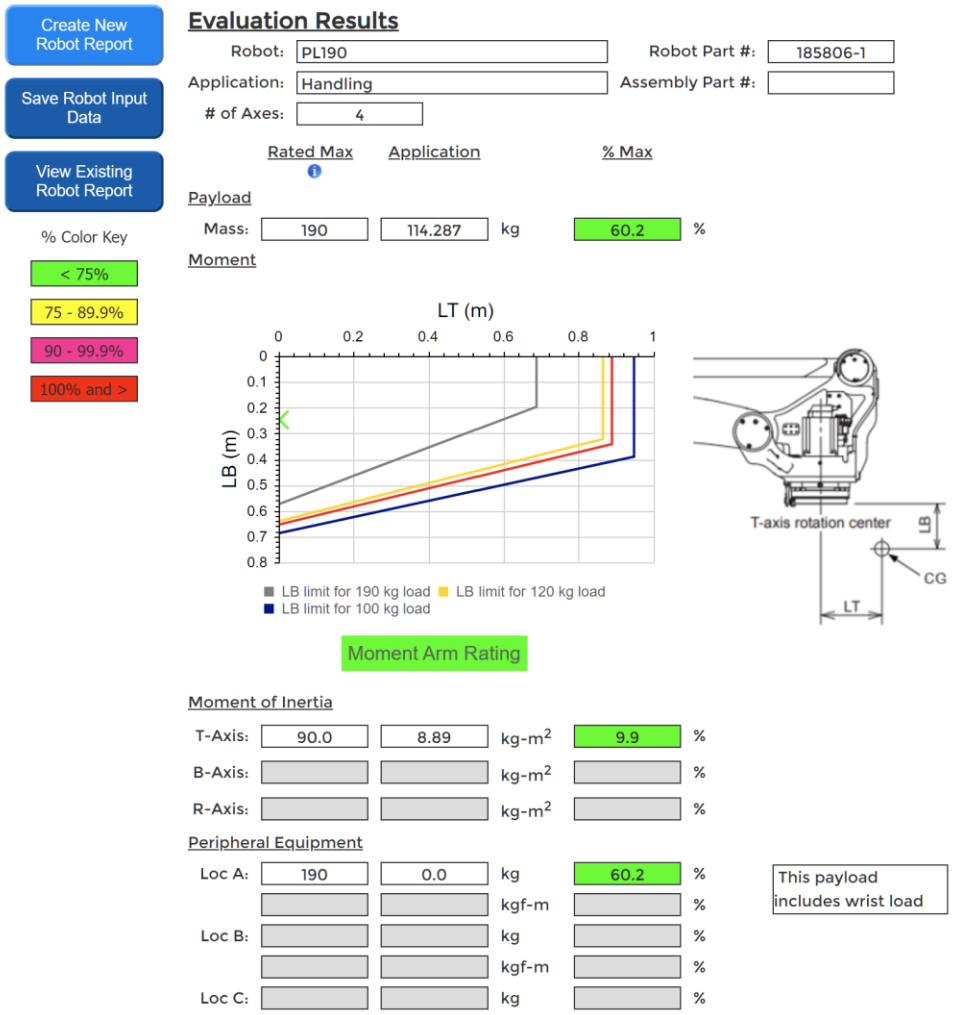
4. Back on the Data Entry Screen the mass, center of mass, and moments of Inertia will be filled in.



5. Selection of the robot model can be assisted by using the Controller, Application, and Axes filters.
6. If any Peripheral equipment will be mounted to the robot, enter the data in the available fields. The drawing at the bottom of the screen can assist.
7. Once all data is filled in, select the Evaluate **Arm Load button**.

STEP 5: Review the Results

If a 4-axis arm was selected



As can be seen, everything is green. This model can safely perform its tasks up to 100% speed.

Damage starts when any value hits 100%

This damage causes wear and tear to each axis gear drive.

If all values are below 100% then the robot will run normally, barring any external forces or external collisions.

Let's dive into the results of a 4-axis robot:

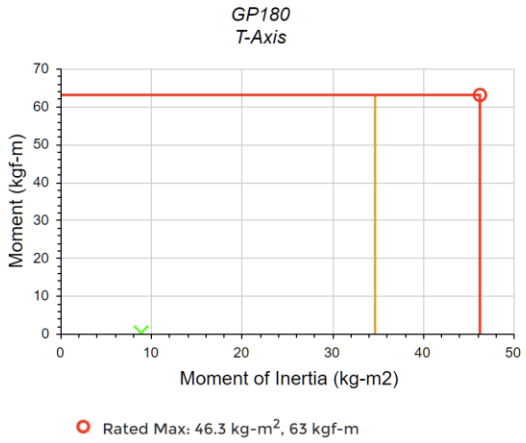
1. The first result is always mass. If over on mass, then either change the robot or change the tool.
2. The Moment Arm Rating displays the EOAT Cg (X) in relation to different curves of load limits. This X is well within the max load limit of 190Kg.
3. The moment of inertia only affects the T-axis for this model, and it is very low. A high value exceeding 100% would be a problem if the program required the T-axis to actively rotate.

If a 6-axis arm was selected

		Rated Max	Application		% Max	
Payload						
	Mass:	180	114.287	kg	63.5	%
Moment						
	T-Axis:	63	0.184	kgf-m	0.3	%
	B-Axis:	102	53.959	kgf-m	52.9	%
	R-Axis:	102	53.959	kgf-m	52.9	%
Moment of Inertia						
	T-Axis:	46.3	8.89	kg-m^2	19.2	%
	B-Axis:	90.0	32.948	kg-m^2	36.6	%
	R-Axis:	90.0	32.948	kg-m^2	36.6	%
Peripheral Equipment						
	Loc A:			kg		%
				kgf-m		%
	Loc B:	30	0.0	kg	0.0	%
		5	0.0	kgf-m	0.0	%
	Loc C:	250	0.0	kg	0.0	%

This payload is separate from wrist load

This payload is separate from wrist load



As can be seen, everything is green. This model can safely perform its tasks up to 100% speed.

Damage to the robot starts when any value hits 100%

This damage causes wear and tear to each axis gear drive.

If all values are below 100% then the robot will run normally, barring any external forces or external collisions applied.

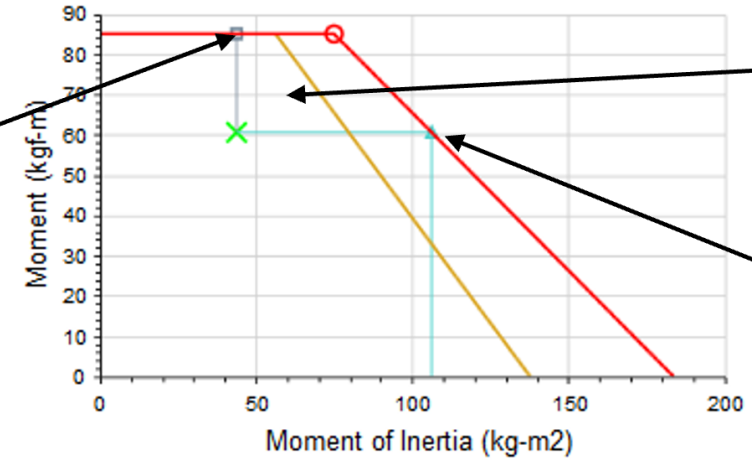
Let's dive into the results of a 6-axis robot:

1. The first result is always mass. If over on mass, then either change the robot or change the tool.
2. Moment Rating displays the percentage of static moment for the R, B, and T axes. If an axis is red and is being used against gravity, then there will be a problem.
3. The moment of inertia also affects the R, B, and T-axes. A high value exceeding 100% would be a problem if the program required any of the upper axes to actively rotate.
4. Below the summary are the Derating charts for the R, B, and T axes. They visually show where each axis lies related to the moment and moment of inertia.

Allowable moment if inertia constant

Application load point under red lines is OK

Allowable inertia if moment constant



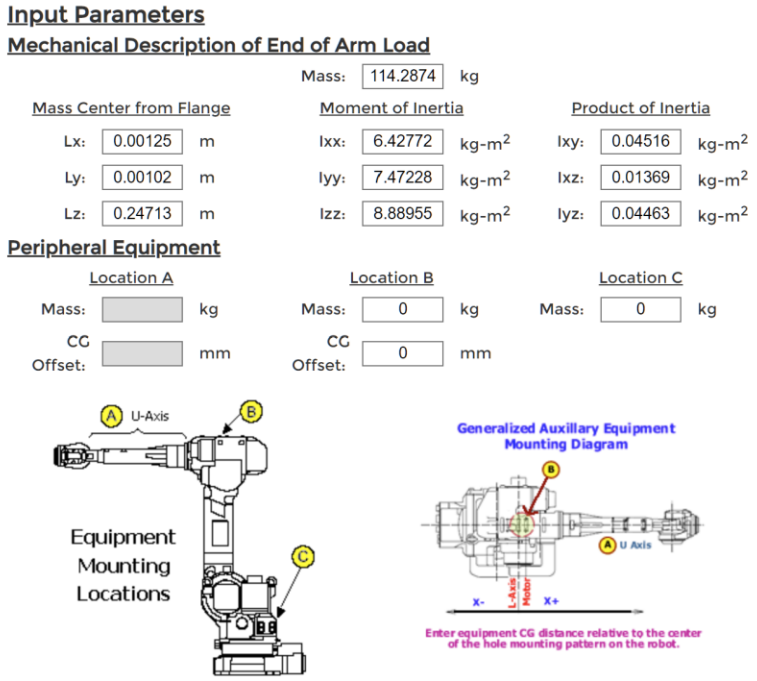
Given your Moment of Inertia (43.784 kg-m^2), you could increase your Moment up to (85.0 kgf-m)

Given your Moment (60.57 kgf-m), you could increase your Moment of Inertia up to (106.273 kg-m^2)

Rated Max: 75.0 kg-m^2, 85 kgf-m

Application: 43.784 kg-m^2, 60.57 kgf-m

At the bottom of the results are the Input values.



Input Parameters

Mechanical Description of End of Arm Load

Mass: 114.2874 kg

Mass Center from Flange			Moment of Inertia			Product of Inertia		
Lx:	0.00125	m	Ixx:	6.42772	kg-m²	Ixy:	0.04516	kg-m²
Ly:	0.00102	m	Iyy:	7.47228	kg-m²	Ixz:	0.01369	kg-m²
Lz:	0.24713	m	Izz:	8.88955	kg-m²	Iyz:	0.04463	kg-m²

Peripheral Equipment

Location A			Location B			Location C		
Mass:		kg	Mass:	0	kg	Mass:	0	kg
CG Offset:		mm	CG Offset:	0	mm			

Assuming the tool is a completed design, these values can be programmed into the actual robot controller's tool data.

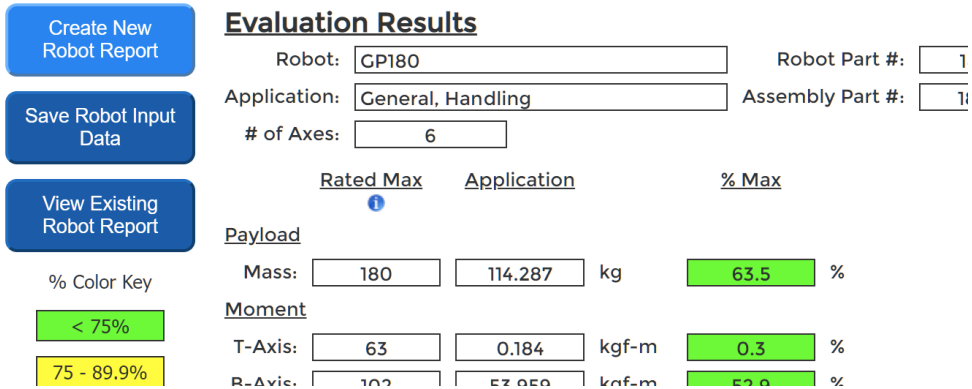
It is more accurate than using hand calculations or letting the controller estimate the tool data.

STEP 6: Saving the Results

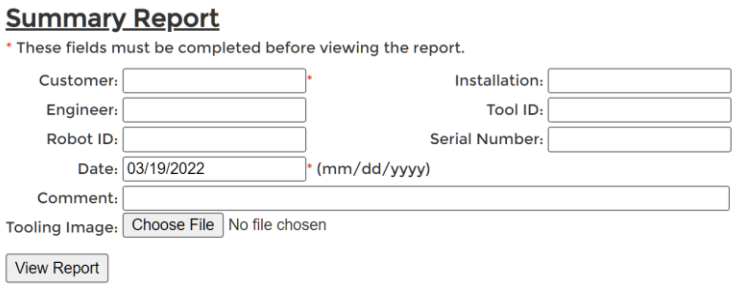
Once satisfied with the results, they can be saved to a PDF, or the results can be saved as an XML file.

Most people, though, prefer the PDF.

1. Select **Create New Robot Report**

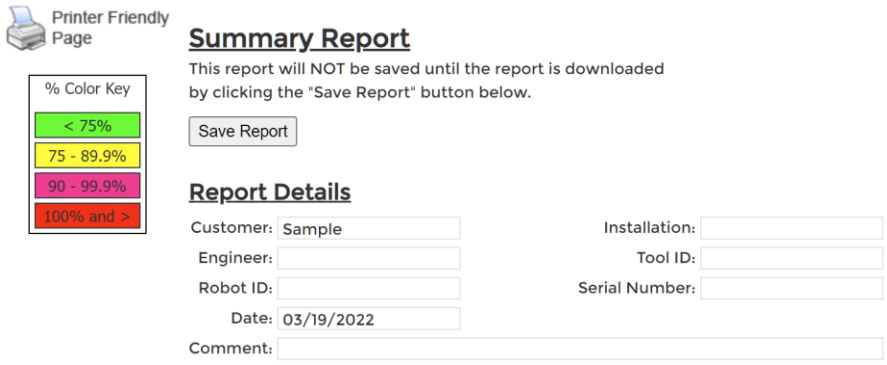


2. Fill in the Customer field and any other optional field desired



3. A useful option is to include an image of the actual tool. Just select the Tooling Image button and choose any image file.
4. When ready, select **View Report**

5. The finished report will appear…just select **Printer Friendly Page**



7. The printer friendly page will display message reminding the user to verify their browser background graphics are checked in the printer settings.
    a. If not, then the color key will be gray only and harder to interpret.

8. Select the **Hide** button to remove the message,
9. Use the browser to print to PDF (built-in to Chrome and Edge browsers)
10. Done