

Step by Step: Sizing a Robot with MotoSize Using Inventor

Introduction:

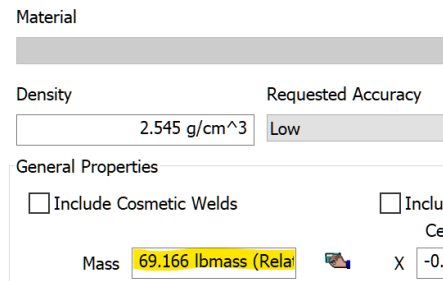
It is always important to have the correct mass data for your End-Of-Arm Tool (EOAT) for sizing the correct robot model and using that tool data in the robot's controller.

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.

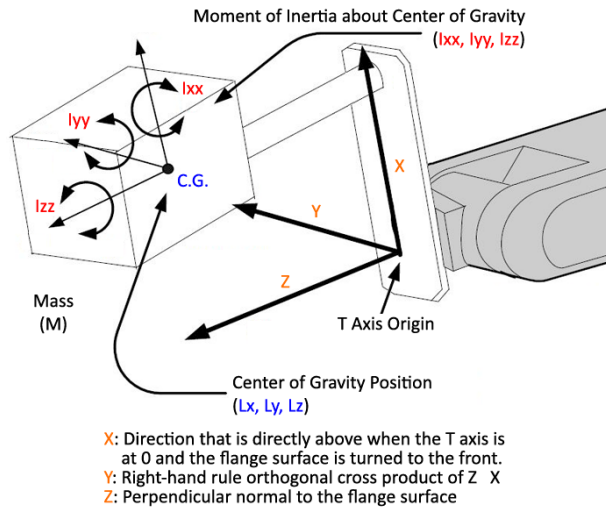
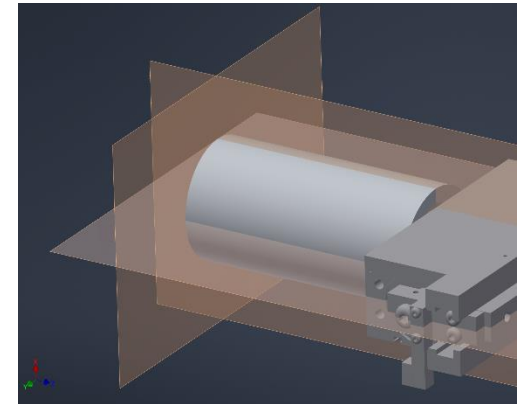


Figure 1: Reference for Proper Alignment

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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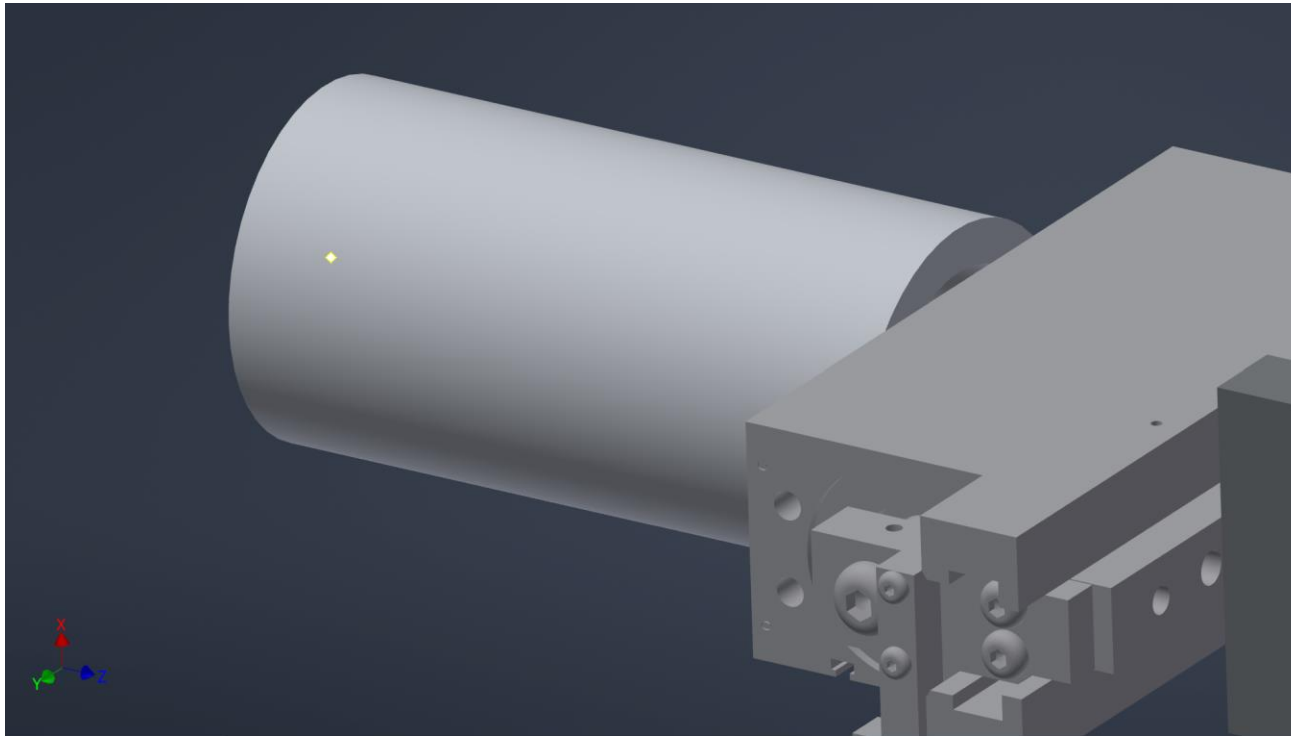


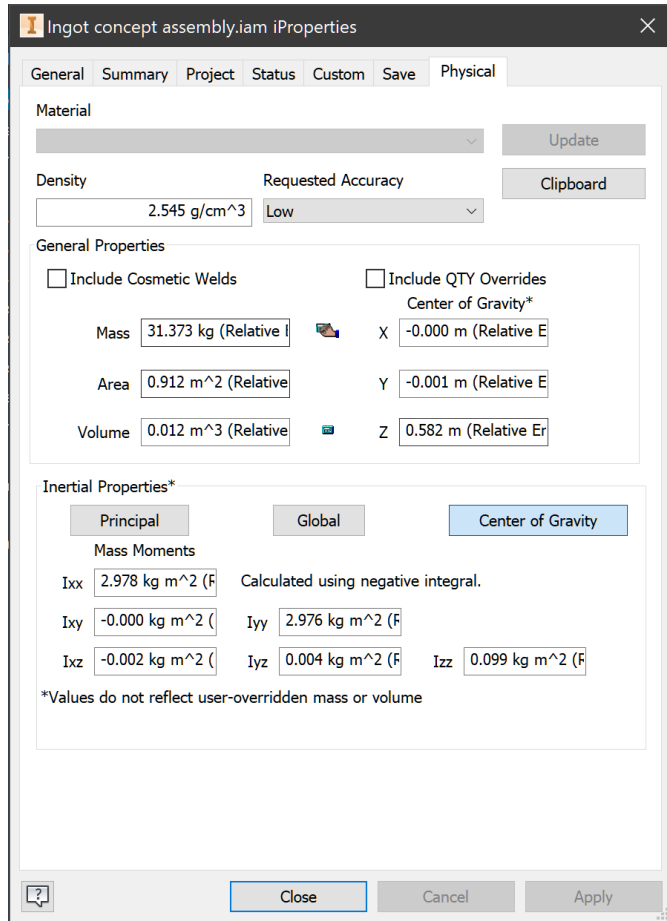
Figure 2: The highlighted point is the origin, Z is normal (away) from the robot flange, and X points away from the robot

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STEP 3: Configure and Output the Mass Data

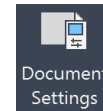
After the models and origin have been configured, the next step is the mass properties output.

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



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.

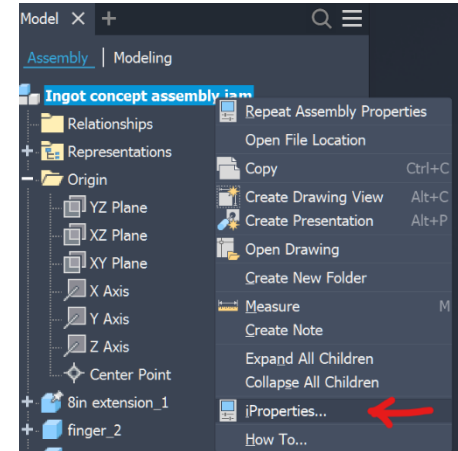


Figure 3: Mass Properties

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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**

Robot Selection Filters
Controller Type: YRC1000 Application Specific Robot: Handling Number of Axes: 4
Select Robot: Show Only Active Robots
PL190
PL320
PL500

Mechanical Description of End of Arm Load
Tooling Reference Diagram
Mass: 0 kg
Mass Center from Flange: Lx: 0 m Ly: 0 m Lz: 0 m
Moment of Inertia: Ixx: 0 kg-m² Iyy: 0 kg-m² Izz: 0 kg-m²
Product of Inertia: Ixy: 0 kg-m² Ixz: 0 kg-m² Iyz: 0 kg-m²

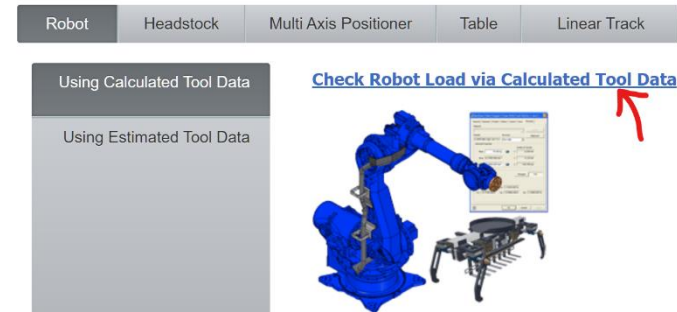
Peripheral Equipment
Location A: Mass: 0 kg CG Offset: 0 mm
Location B: Mass: 0 kg CG Offset: 0 mm
Location C: Mass: 0 kg CG Offset: 0 mm

EQUIPMENT MOUNTING LOCATIONS
SHOWN WITH "T" AXIS MOTOR REMOVED FOR CLARITY

2. Select Inventor

Solid Edge SolidWorks
PTC Creo Inventor

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



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

Select Inventor file:

Choose File Inventor Kg Meter mass data.txt

Go To Configuration Page

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

Robot Selection Filters

Controller Type: YRC1000 Application Specific Robots: Handling Number of Axes: 4 Show Only Active Robots:

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	lxx:	6.42772 kg-m ²	lxy:	0.04516 kg-m ²
Ly:	0.00102 m	lyy:	7.47228 kg-m ²	lxz:	0.01369 kg-m ²
Lz:	0.24713 m	lzz:	8.88955 kg-m ²	lyz:	0.04463 kg-m ²

Peripheral Equipment

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

EQUIPMENT MOUNTING LOCATIONS
SHOWN WITH "T" AXIS MOTOR REMOVED FOR CLARITY

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.

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STEP 5: Review the Results

If a 4-axis arm was selected

Create New Robot Report

Save Robot Input Data

View Existing Robot Report

% Color Key

- < 75%
- 75 - 89.9%
- 90 - 99.9%
- 100% and >

Evaluation Results

Robot: Robot Part #:

Application: Assembly Part #:

of Axes:

	Rated Max	Application	% Max
Payload			
Mass:	<input type="text" value="190"/>	<input type="text" value="114.287"/> kg	60.2 %
Moment			
Moment Arm Rating			
Moment of Inertia			
T-Axis:	<input type="text" value="90.0"/>	<input type="text" value="8.89"/> kg-m ²	9.9 %
B-Axis:	<input type="text"/>	<input type="text"/> kg-m ²	<input type="text"/> %
R-Axis:	<input type="text"/>	<input type="text"/> kg-m ²	<input type="text"/> %
Peripheral Equipment			
Loc A:	<input type="text" value="190"/>	<input type="text" value="0.0"/> kg	60.2 %
	<input type="text"/>	<input type="text"/> kgf-m	<input type="text"/> %
Loc B:	<input type="text"/>	<input type="text"/> kg	<input type="text"/> %
	<input type="text"/>	<input type="text"/> kgf-m	<input type="text"/> %
Loc C:	<input type="text"/>	<input type="text"/> kg	<input type="text"/> %

This payload includes wrist load

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.

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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.

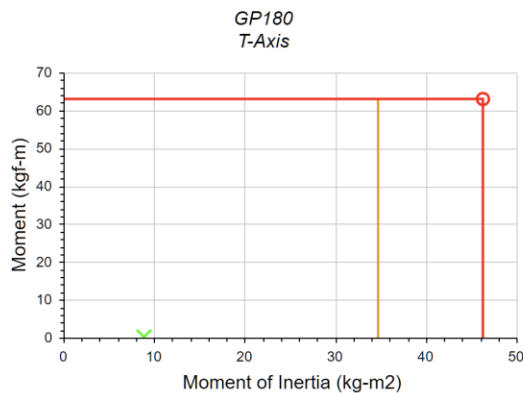
Damage to the robot starts when any value hits 100%

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.

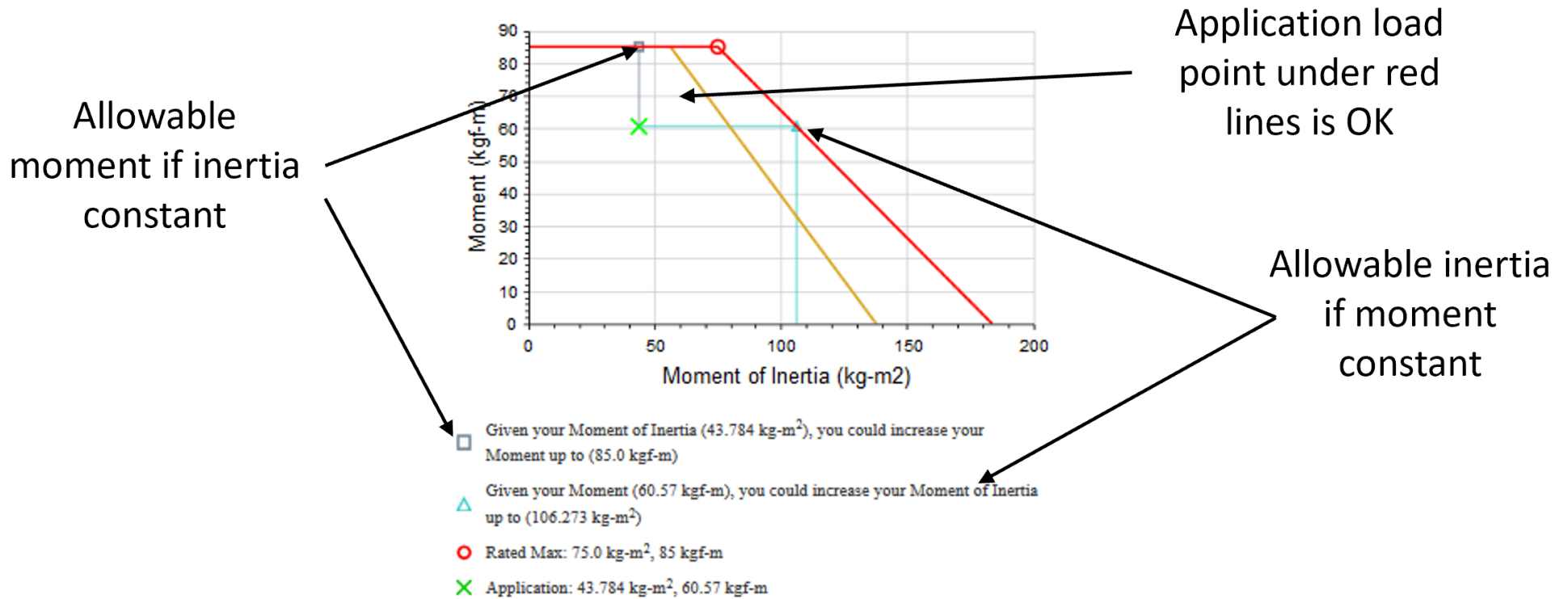
Let's dive into the results of a 6-axis robot:

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.



Rated Max: 46.3 kg-m², 63 kgf-m

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At the bottom of the results are the Input values.

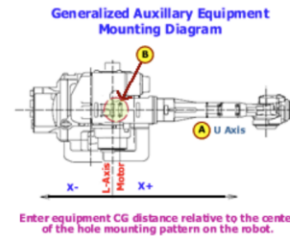
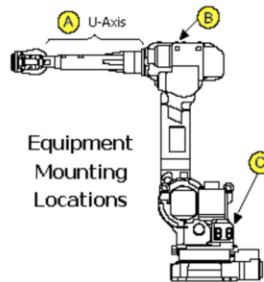
Input Parameters

Mechanical Description of End of Arm Load

Mass: <input type="text" value="114.2874"/> kg		
Mass Center from Flange	Moment of Inertia	Product of Inertia
Lx: <input type="text" value="0.00125"/> m	lxx: <input type="text" value="6.42772"/> kg-m ²	lxy: <input type="text" value="0.04516"/> kg-m ²
Ly: <input type="text" value="0.00102"/> m	lyy: <input type="text" value="7.47228"/> kg-m ²	lxz: <input type="text" value="0.01369"/> kg-m ²
Lz: <input type="text" value="0.24713"/> m	lzz: <input type="text" value="8.88955"/> kg-m ²	lyz: <input type="text" value="0.04463"/> kg-m ²

Peripheral Equipment

Location A	Location B	Location C
Mass: <input type="text" value="0"/> kg	Mass: <input type="text" value="0"/> kg	Mass: <input type="text" value="0"/> kg
CG Offset: <input type="text" value="0"/> mm	CG Offset: <input type="text" value="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.

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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**

The screenshot shows the 'Evaluation Results' form. On the left, there are three buttons: 'Create New Robot Report', 'Save Robot Input Data', and 'View Existing Robot Report'. Below these is a '% Color Key' with two boxes: a green box for '< 75%' and a yellow box for '75 - 89.9%'. The main form has the following fields: 'Robot: GPI80', 'Robot Part #: 1', 'Application: General, Handling', 'Assembly Part #: 1', and '# of Axes: 6'. Below these is a table with columns 'Rated Max', 'Application', and '% Max'. Under the 'Payload' section, there is a row for 'Mass' with values 180, 114.287 kg, and 63.5%. Under the 'Moment' section, there are rows for 'T-Axis' (63, 0.184 kgf-m, 0.3%) and 'R-Axis' (102, 52.050 kgf-m, 52.0%).

	Rated Max	Application	% Max
Payload			
Mass:	180	114.287 kg	63.5 %
Moment			
T-Axis:	63	0.184 kgf-m	0.3 %
R-Axis:	102	52.050 kgf-m	52.0 %

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

The screenshot shows the 'Summary Report' form. A note at the top states: '* These fields must be completed before viewing the report.' The form has the following fields: 'Customer: *', 'Installation:', 'Engineer:', 'Tool ID:', 'Robot ID:', 'Serial Number:', 'Date: 03/19/2022 * (mm/dd/yyyy)', 'Comment:', and 'Tooling Image: Choose File No file chosen'. At the bottom, there is a 'View Report' button.

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**

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

Printer Friendly Page

Summary Report
This report will NOT be saved until the report is downloaded by clicking the "Save Report" button below.

Report Details

Customer: Installation:

Engineer: Tool ID:

Robot ID: Serial Number:

Date:

Comment:

% Color Key	
< 75%	
75 - 89.9%	
90 - 99.9%	
100% and >	

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

If the colors in the report do not print correctly, ensure that background color and image printing is enabled in your browser.
Click the "Hide" button before printing this page.

MotoSize Robot Summary Report

Report Details

Customer: Installation:

Engineer: Tool ID:

Robot ID: Serial Number:

Date:

Comment:

Version: Robot model data (3/11/2021 5:09:12 PM); Website calculations (2022-02-8)

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

% Color Key

< 75%	
75 - 89.9%	
90 - 99.9%	
100% and >	

Evaluation Results

Robot: Robot Part #:

Application: Assembly Part #:

of Axes:

	Rated Max	Application	% Max
Download			
Mass:	<input type="text" value="180"/>	<input type="text" value="114,287"/> kg	 63.5%
Moment:			
T-Axis:	<input type="text" value="63"/>	<input type="text" value="0,184"/> kgf-m	 63%
B-Axis:	<input type="text" value="107"/>	<input type="text" value="0,1400"/> kgf-m	 63%