Robot Selection Guide

High Level Steps

Basic Selection (p. 2)

1) Determine required number of axes, payload, and reach
2) Filter robots using applications on manufacturers' websites

Advance Payload Analysis (p. 3)

1) Calculate total mass, moment of inertia, wrist torque, and center of gravity
2) Compare to capacities in robot manuals

Advanced Reach Analysis (p. 5)

In Onshape for single robot:

1) Put robot in layout
2) Mate wrist to reach points
3) Verify reach

Overview

This document covers basic rules of thumb for how to select a robot for a job, as well as instructions for advanced mechanical analysis of payload and positional reach. The basic rules of thumb can be used to narrow the candidate field for an initial spec, before cell layout and end-of-arm tool are fully known. As design parameters solidify, the advanced analysis is essential to ensure that the robot can both handle the required load and also reach everything in the cell. A robot's payload capacity decreases as distance of load from the flange increases (depends on size of load and EOAT), and the robot's reach is affected by the EOAT, riser height, and track length (if applicable).

Robot selector applications *from manufacturer's websites are at the following links:*

- ABB: https://new.abb.com/products/robotics/industrial-robots/robot-selector
- Fanuc: https://www.fanuc.eu/dk/en/robots/robot-filter-page
- KUKA: https://www.kuka.com/en-us/products/robotics-systems/industrial-robots
- Motoman/Yaskawa: https://www.motoman.com/industrial-robots
- Universal Robots: https://www.universal-robots.com/products/
- Epson: https://epson.com/For-Work/Robots/c/w8?q=

Documentation/CAD libraries *for robots:*

- ABB: http://cdn.robotstudio.com/documentation/17.2/en/index.html
- Fanuc: Must call 888-FANUC-US with robot F-number.
- KUKA: https://www.kuka.com/xpert
- Motoman/Yaskawa: https://www.motoman.com/manuals/download-page
- Universal Robots: https://www.universal-robots.com/download/?query=cad
- Epson: https://epson.com/For-Work/Robots/c/w8?q=

Basic Selection

Industrial robotic arms are identified by three characteristics: axes, payload, and reach. Some general rules of thumb for selection are:

- Axes: 6 is most flexible, 4 is possible if the required articulation is limited.
- Payload: 3 * max(product weight, EOAT weight)
- Reach: 0.5 m + (distance to farthest point robot must touch)

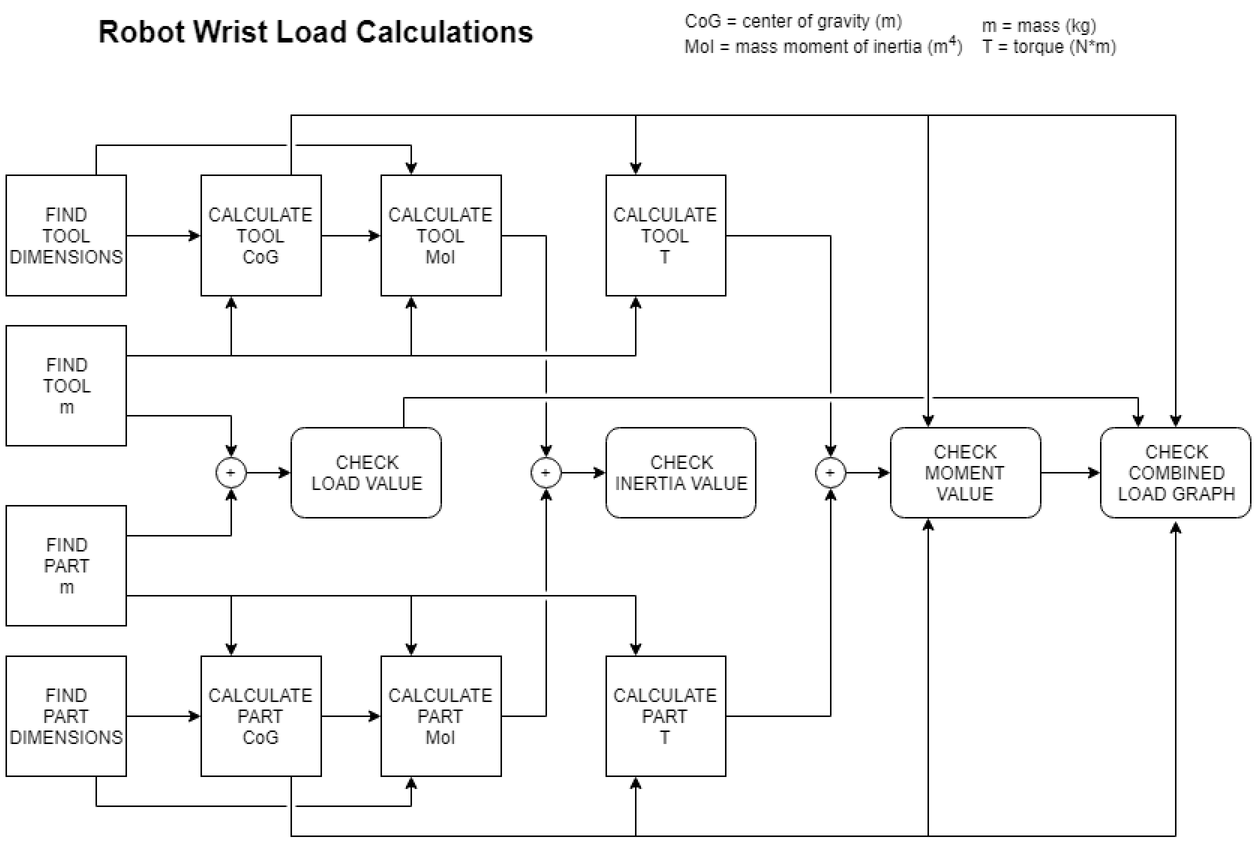
After determining the required axes, payload, and reach, find existing robots using the robot selector tools at the manufacturers' websites:

- ABB: https://new.abb.com/products/robotics/industrial-robots/robot-selector
- Fanuc: https://www.fanuc.eu/dk/en/robots/robot-filter-page
- KUKA: https://www.kuka.com/en-us/products/robotics-systems/industrial-robots
- Motoman/Yaskawa: https://www.motoman.com/industrial-robots

It is better to slightly overspec than underspec a robot. If the robot is too small and weak, it will fail in the application. However, drastically oversizing a robot for a cell will limit its articulation in the given space. This means that the robot might not be able to reach parts in all required orientations or might be too large to fit its wrist and last knuckle into the bin.

Advanced Payload Analysis

The payload for which a robot is rated is given at the wrist. A robot's load capacity decreases as distance of load from the wrist increases, due to the increased moment on the wrist. So for a long EOAT or load, the robot will not be able to lift as much. For this reason, it is important to verify that the (1) load, (2) moment of inertia, (3) torque, and (4) combined load for the application are all in the robot's acceptable range. To calculate these values, follow the procedure shown in the wrist load calculations flowchart below.



Variables:

m: mass (kg) of object, found by weighing object or calculating based on volume and density

$$m = \rho V \qquad m_{net} = \sum m_i$$

CoG: center of gravity distance (m), found by measurement from robot wrist to object centroid

$$CoG_{net} = \frac{\sum CoG_i m_i}{\sum m_i}$$

MoI: area moment of inertia (m[4]), depends on shape. Use the Parallel Axis Theorem to scale the centroidal MOI_o based on its *CoG* and 2D area*, A*

https://sbainvent.com/strength-of-materials/area-moment-of-inertia/

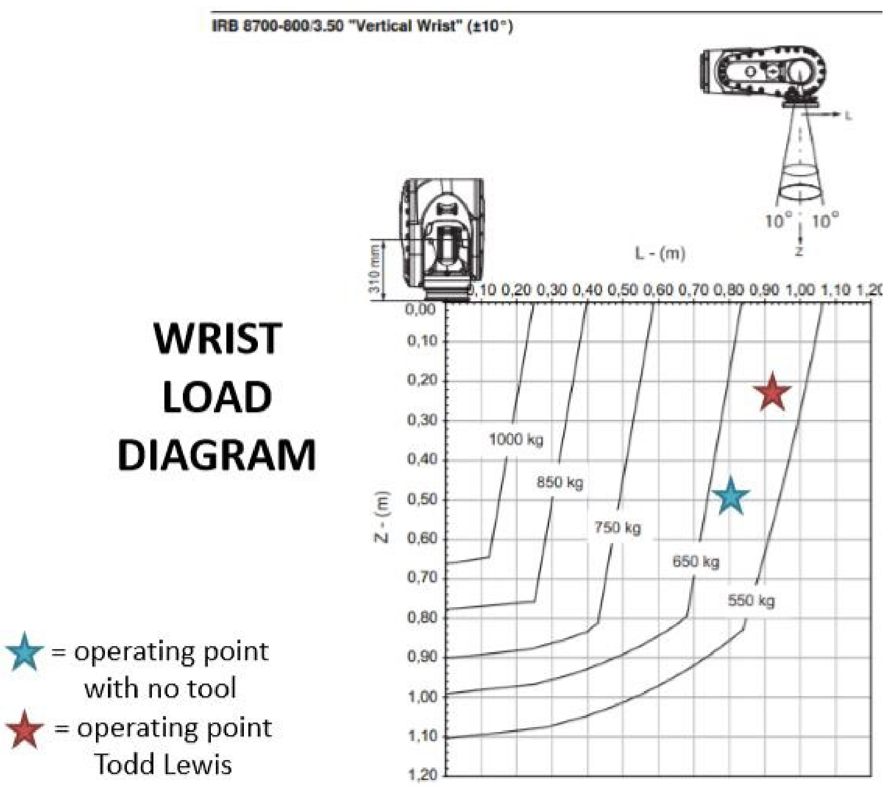
point mass: $MoI_o = r^4$ rectangle: $MoI_o = \frac{1}{12}bh^3$ circle: $MoI_o = \frac{1}{4}\pi r^4$

PAT: $MoI = MoI_o + A(CoG)^2$

T: torque (N*m), the cross product of distance and force

$$\vec{T} = \overrightarrow{(CoG)} \times \overrightarrow{(mg)} \qquad \overrightarrow{T_{net}} = \sum \vec{T}_i$$

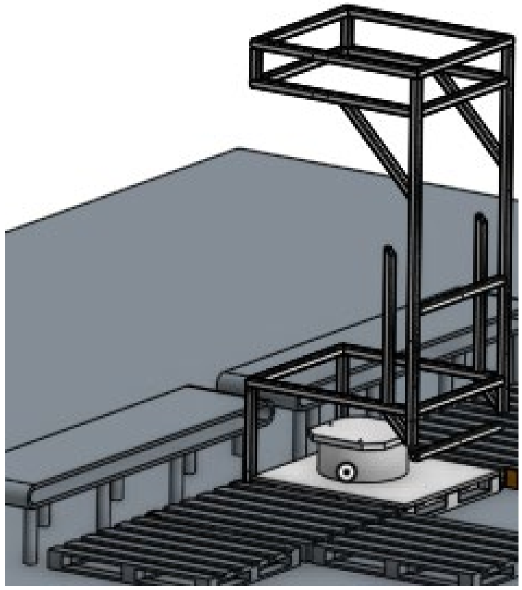
After calculating the net mass, net moment of inertia, and net wrist torque, compare these values to the acceptable ones for each robot model, found in its datasheet or manual. If the values are acceptable, use the net mass and net center of gravity to check the operating point on the combined load graph. See example below.



Advanced Reach Analysis

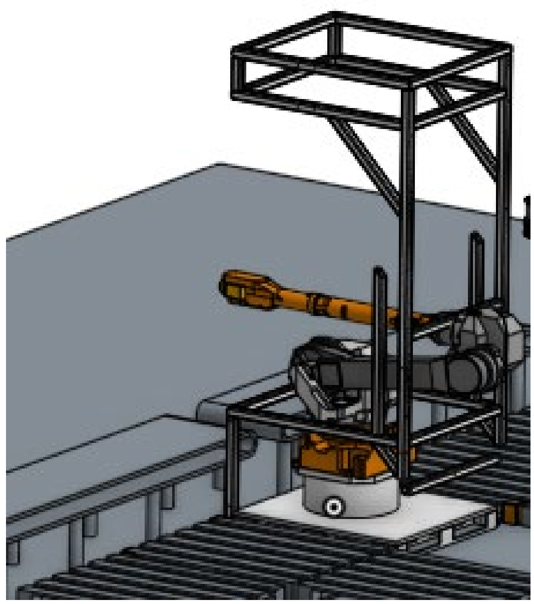
Advanced positional reach analysis is essential to ensure that the robot can reach everything in the cell. This reach is affected by the EOAT, riser height, and track length (if applicable).

1) In Onshape, open the document with the cell layout. If one does not exist, create it.

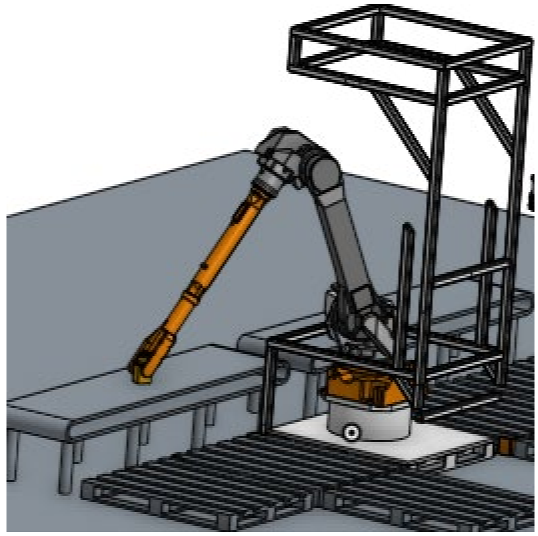


2) Import the desired robot) into the layout. If the robot model to check does not exist in Onshape, build the model using the "Robot Modeling" document on D2L.

3) Fasten mate the robot to its riser or other proper location in the layout (typically world origin).



4) Fasten mate the robot’s wrist to reach points in the layout. Be sure to check at least closest point, farthest point, and pick and place locations.



5) If the robot can reach all points easily, it is probably acceptable. If it is too tight, either revise the layout or reject that model and look for a different robot.