Robotics 1 Lecture 7 End Effectors

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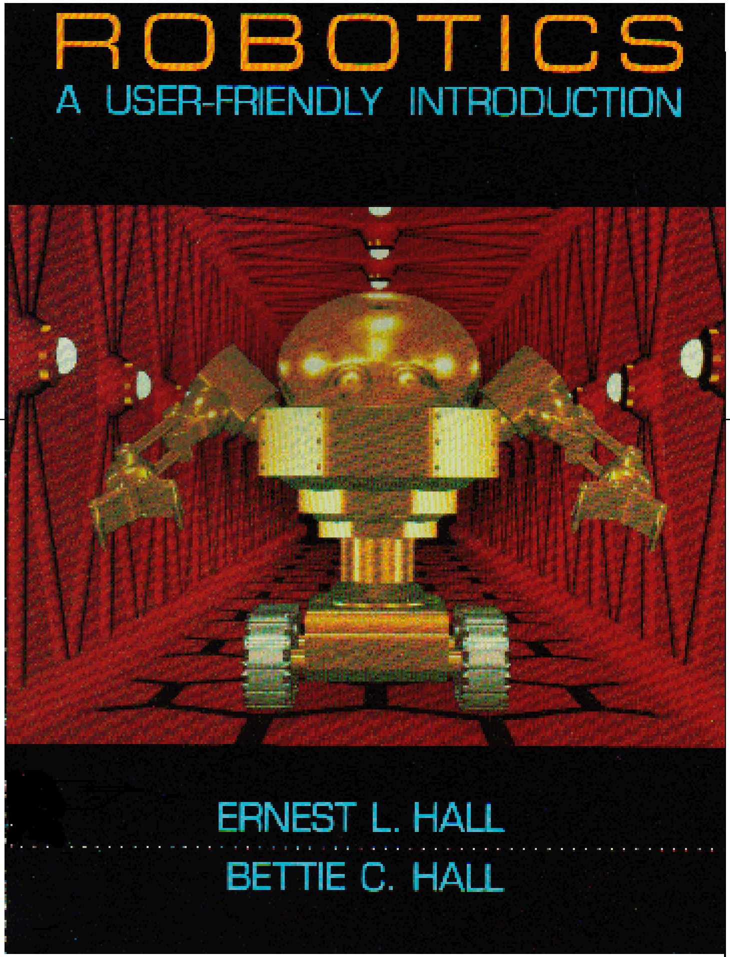
1 author:

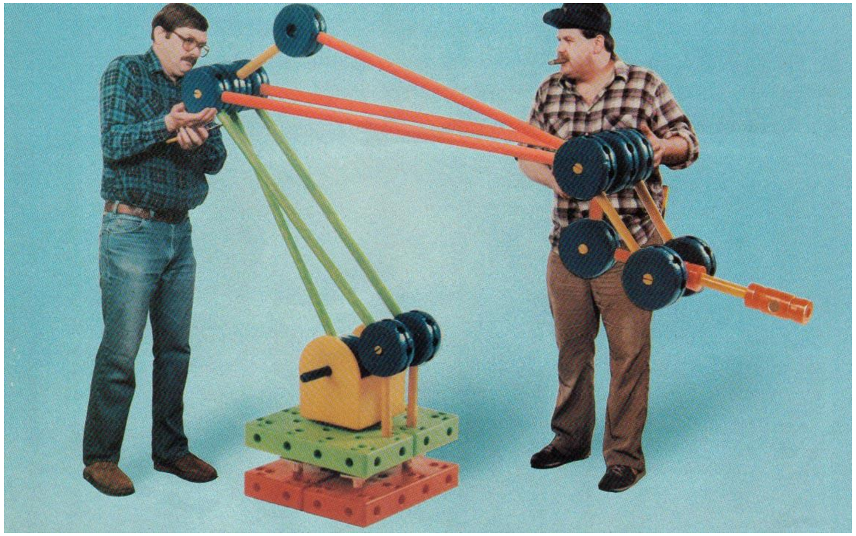
Ernest L. Hall
University of Cincinnati

Robotics


ROBOTICS
A USER-FRIENDLY INTRODUCTION
ERNEST L. HALL
BETTIE C. HALL

Course objective

- To provide a broad understanding of the use of industrial robots
- And an experience in specifying, designing and presenting a new robot application in oral and written formats.



SYLLABUS

TOPIC

1. Realistic and Safe Use of Robots
2. Applications of Industrial Robots Project
3. Economic Justification

Excel Template

4. Robot Implementation
5. Arm Configurations Quiz 1 Take Home
6. Wrist Configurations
7. End Effectors and Tooling
8. Methods of Actuation
9. Non-servo Operation
10. Servo Controlled Robots
11. Cell Control, Hierarchical Design
12. Performance Measures

Sample Report 1 - Welding

Sample Report 2 - Painting

Sample Report 3 - Soldering

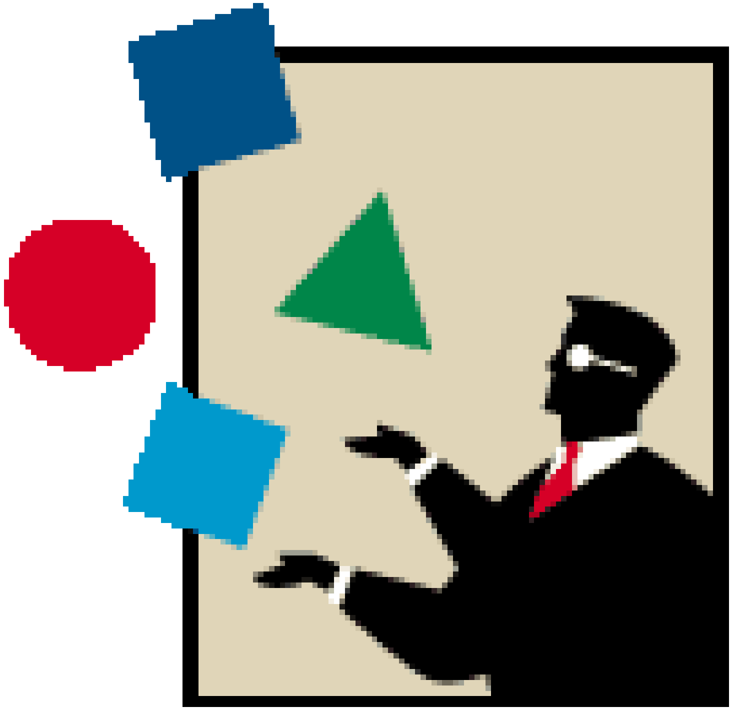
Sample Report 4 - Batch Manufacturing

Sample Report 5 - Machine Loading

13. Joint Control Programming
14. Path Control Programming
15. High Level Languages
16. Simulation and Programming
17. Vision and Sensor Systems
18. Work Cell Interfacing; REPORT DUE
19. Intelligent Robot Cells
20. Flexible Manufacturing
21. FINAL ORAL EXAM

Objective

- Determine the relationship between various robot applications and the end effectors and tooling available on commercial robots or automated guided vehicles.
- Be able to select the appropriate end effector for a robot application.
- Be able to compute the load force and moments.



End Effectors

- End effectors are of two types
- Grippers

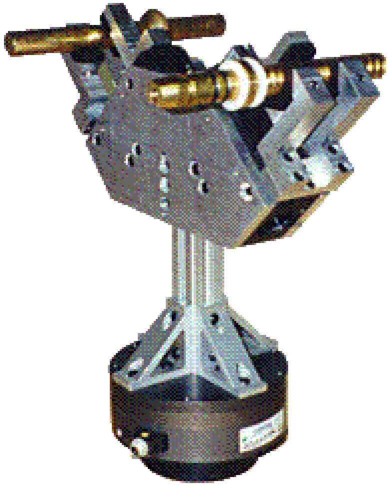
  Two linkage grippers

  Three finger gripper for feeding lathe chuck

  Four linkage grippers for parallel finger movement

  Other
- Process tools

  Thousands of types



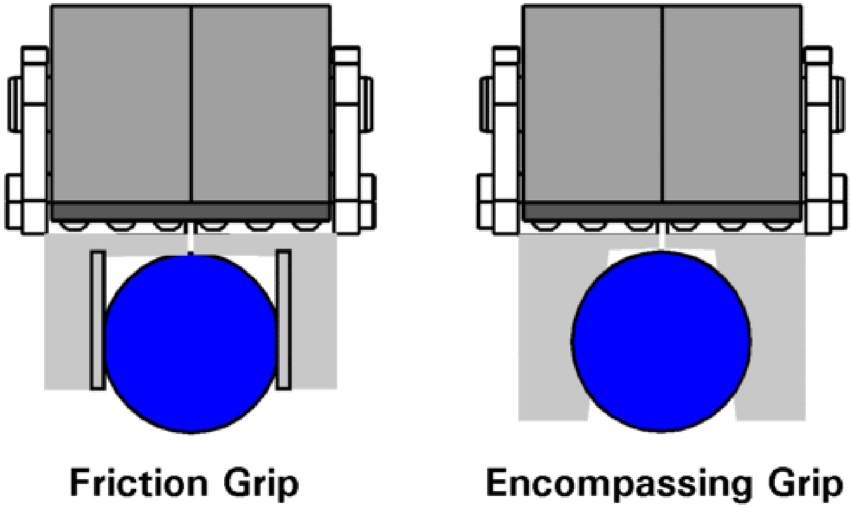
http://www.urcautomation.com/robot-gripper.htm

Other gripper sites

- http://www.intelitek.com/products/robotics/accessories/grippers-effectors/gripper-dc.html
- http://www.urcautomation.com/CNC-Loading.htm
- http://www.starhub.net.sg/~apspl/flyer_schunk7.html
- http://hgighub.lbl.gov/esd/BioinstrGroup/DNAPrep/GantryDesign.html

Gripper Sizing Article by Zajac

- http://www.grippers.com/size.htm



Problem

- An industrial robot is used to lift an 80 pound load vertically using a constraint gripper. The gripper weighs 20 pounds. If it moves with an acceleration of g/2, what minimum payload must be specified for the robot?

$$\sum F = Ma$$

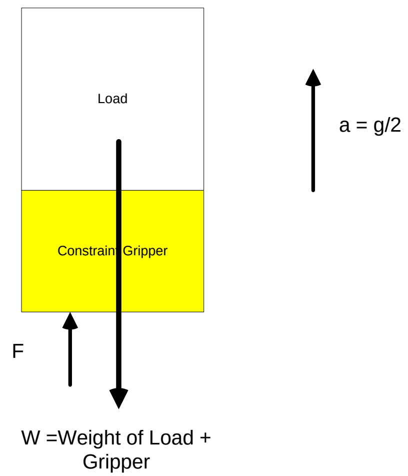
Example – Constraint gripper

Constraint gripper

$F = F_s + F_d$

$F = W + ma$

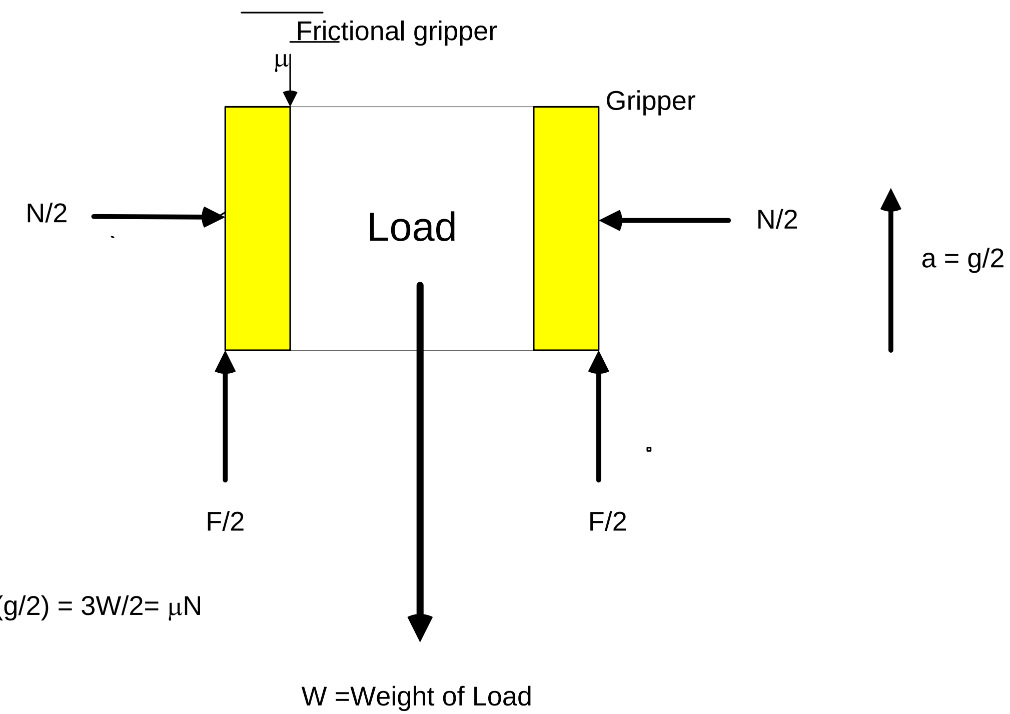
$F = W + (W/g)(g/2) = 3W/2$



Problem

- An industrial robot is used to vertically lift a W=100 pound total load (gripper plus payload) using a frictional type gripper. If the coefficient of friction, m, between the gripper and load is 0.2, and the maximum acceleration is g/2, what normal force, N, must be exerted by the gripper?

Frictional gripper



$F = F_s + F_d$

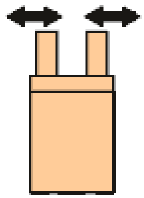
$F = W + ma$

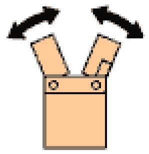
$F = W + (W/g)(g/2) = 3W/2 = \mu N$

$N = 3W/2\mu$

Grippers

- Robot Systems Directory
- http://www.robotsystems.co.uk/Product/Prgrip.html
- Example – PhD





Size a gripper with PhD calculator – Try it!

- http://www.phdinc.com/products/grippers/angular.asp?Productline=Angular%20Grippers#
- Try it! Application Description
  Load (including tooling):100.00 lbDistance to Load Center of Gravity:1.00 inWorking Air Pressure:87.0 psiGripper Type:Imperial, ParallelGripper Contact:Internal (grip on close)Spring Usage:Permit spring assist on gripGrip Factor:400.00

  Note: All applications of this type assume the part is encapsulated and automatically apply a 4:1 safety factor.

  Application Results
  PHD Sizing has found the following grippers which are acceptable for your specified application.

  The lightest valid device is a Series GRT (3 jaw): GRT152
  PHD Sizing identified a total of 18 valid grippers.
  Smallest Valid Devices Series 5300 15380 Unit Weight: 14.0 lbRepeatability: 0.002 in Number of Jaws: 2Jaw Travel: 1.310 in Series GRC GRCx61 Unit Weight: 21.7 lbRepeatability: 0.002 in Number of Jaws: 2Jaw Travel: 3.070 in Series GRT (3 jaw) GRT152 Unit Weight: 2.8 lbRepeatability: 0.002 in Number of Jaws: 3Jaw Travel: 0.787 in Series GRR GRR-12-1-50-200 Unit Weight: 36.6 lbRepeatability: 0.002 in Number of Jaws: 2Jaw Travel: 7.870 in
  ***Note:* Question marks in a part number indicate options which must be specified before a device can be ordered, but which do not affect sizing. Consult the PHD Catalog or your local distributor for further assistance.**
  You can get more information about a particular series by clicking on the series name. PHD also offers several software packages which allow you to size a variety of products and to generate 2D, 3D, and, in some cases, IGES surfaced CAD files in our download area.

Ph D Designer Resources

- http://www.phdinc.com/software/
- Designer's Resource
  PHD has provided a collection of tools to aid engineers and designers in selecting the proper products for their applications and designs. Whether you already have a design and product in mind, or if you are just looking for ideas, this CD-ROM is for you. Sizing Software
  PHD's sizing software provides accurate sizing of most PHD products. You can input the application data and the software will aid in finding a product that will meet your needs. This saves you time calculating properly sized units.
- CAD
  The CAD Configurator provides accurate PHD model number selection including option compatibility and travel increments. It creates a 2D and/or 3D DXF or IGES CAD file drawing of the exact model number selected. **The CAD Configurator now generates drawings to support Solid Models.** Software Support
  PHD offers online support forms to answer any questions you might have. Forms are available for all software issues from reporting bugs to feedback forms. Other online help is also available here. Desktop Enhancements
  PHD desktop enhancements help brighten up your desktop. This is where screensavers and desktop wallpaper can be found.

End of Arm Tooling

- EOA Systems, Inc. http://www.eoa.com/
- End Effector Calculator
- INTRODUCTION
-
- EOA Home Page Calculator Calculator Definitions Conversion Factors
- Thank you for your interest in the EOA Product line. This web end effector calculator is provided for your convenience. EOA's End Effector moment and inertia 'End Effector Calculator' allows you to determine approximately the moment and inertia that your robot will experience. You enter pertinent information about your End Effector and robot. The moment, payload, and inertia acting on the robot are then instantly calculated.
-
- Every attempt has been made to determine accurate acceleration, moment and inertia calculations. Actual values may vary depending upon the final robot motions made, differences between the calculator End Effector model and your End Effector, and the actual capabilities of the robot you use. **These rough calculations should be used only to size products and not for final design considerations**.
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- All units must be entered in inches, and pounds.
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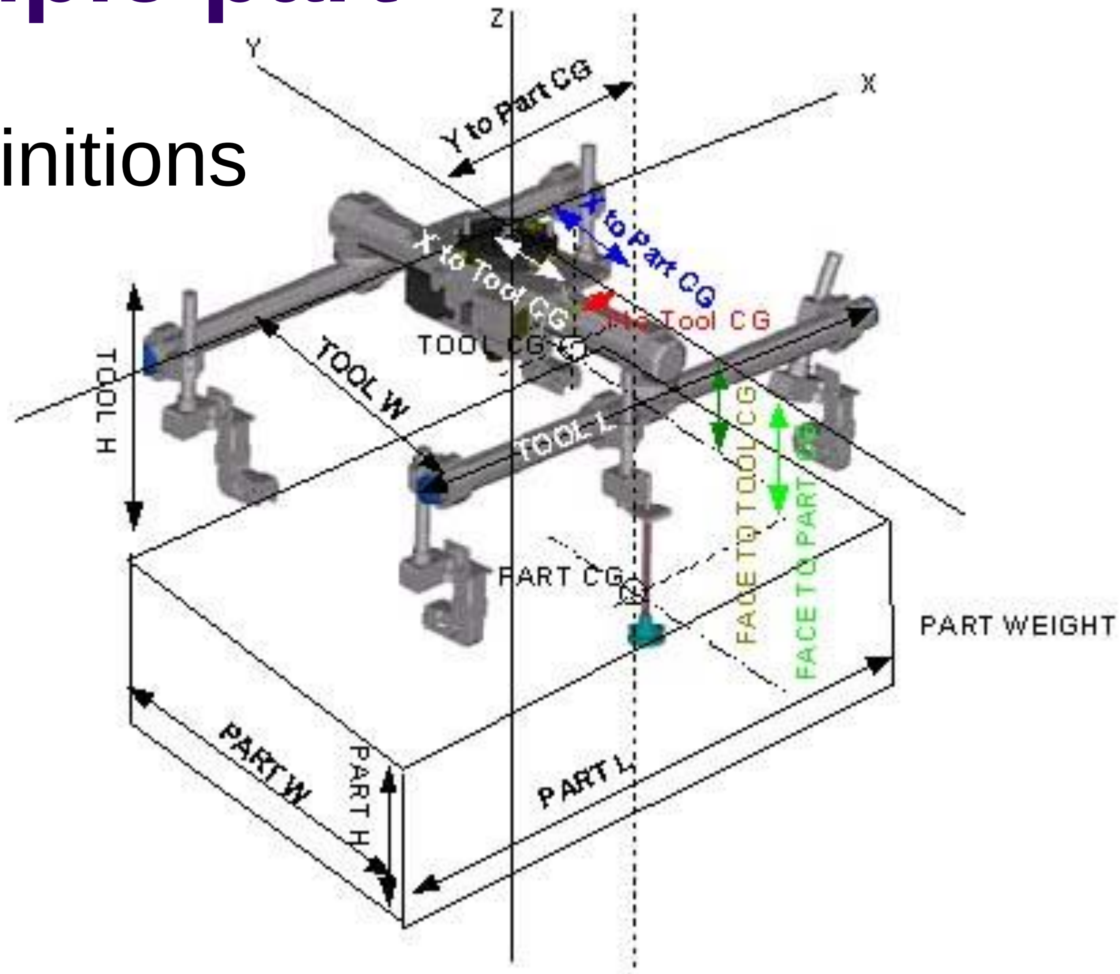
Sample part

- Definitions



DEFINITIONS

- **MOMENT**

- The effectiveness of a force to produce rotation about an axis, measured by the product of the force and the perpendicular distance from the line of action of the force to the axis. If a force F acts to produce rotation about a center at a distance d from the line in which the force acts, the force has a torque.

$$\sum T = J\alpha$$

ROTATIONAL INERTIA

- **ROTATIONAL INERTIA** is a measure of the effectiveness of mass in rotation. In the rotation of a rigid body not only the body's mass, but the distribution of the mass about the axis of rotation determines the change in the angular velocity resulting from the action of a given torque for a given time. Moment of inertia in rotation is analogous to mass (inertia) in simple translation. If m1,m2,m3,... represent the masses of infinitely small particles of a body; r1,r2,r3,... their respective distances from an axis of rotation, the moment of inertia about this axis will be I=m1r12 + m2r22 + m3r32 + m4r42 +...........

INERTIA

- If a body is considered to be composed of a number of parts, its moment of inertia about an axis is equal to the sum of the moments of inertia of the several parts about the same axis or $I = I_1 + I_2 + I_3 + I_4 + \ldots\ldots$

INERTIA

- The moment of inertia of an area or solid about any given axis is equal to the moment of inertia about a parallel axis through the center of gravity plus the square of the distance between the two axis times the area or mass. The End Effector calculator takes all of the dimensions and weights you have entered into account when determining inertia’s. Because your CG and part dimensions will vary, the inertia will vary for each axis of rotation.

INERTIA

- The moment of inertia of a solid is often called the flywheel effect in the solution of problems dealing with rotating bodies. The kinetic energy goes up with the square of the distance of the mass from the center of rotation and the square of the rotational speed. Therefore, End Effectors should be tightly designed, especially when high accelerations are expected.

INERTIA

- Robot literature states a maximum allowable inertia on the robot arm. This is to keep the drive motors from becoming unstable with unwieldy End Effectors and parts and from overloading the arm during high acceleration. After you have determined your and effector and part inertia, you should make certain that you do not exceed the inertia of the robot you anticipate using.

INERTIA

- The torque exerted on the motor axis can be determined by multiplying the inertia times the angular acceleration or $T=I * \alpha$ rad/sec^2. There is a torque associated with each axis of rotation as the robot moves in it's gyrations. This software only uses the wrist roll and the Iz inertia to determine moment on the z axis.
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- *Portions from: CRC Handbook of Physics, 57th Edition, pg F113*
- *and Mark's Mechanical Engineer Handbook, section 3*

Use calculator at: http://www.eoa.com/

END EFFECTOR (Tool)		**Tool Weight (lb)**	
X to Tool CG	inches	Tool Width	inches
Y to Tool CG	inches	Tool Height	inches
Face to Tool CG	inches	Tool Length	inches
% Acceleration assuming 1g=100%	%		
PART		**Part Weight (lb)**	
X to art CG	inches	PartWidth	inches
Y to Part CG	inches	Part Height	inches
Face to Part CG	inches	Part Length	inches

DESIRED OUTPUT MOMENT UNITS
DESIRED OUTPUT INERTIA UNITS

CALCULATION ALGORITHM

Assumptions:

K is a constant which varies for each calculation being performed based upon desired units.

The software compensates for mass and weight and takes gravity into account when necessary based upon the units you have selected.

Moment has static (standing still) and dynamic (due to acceleration) components.

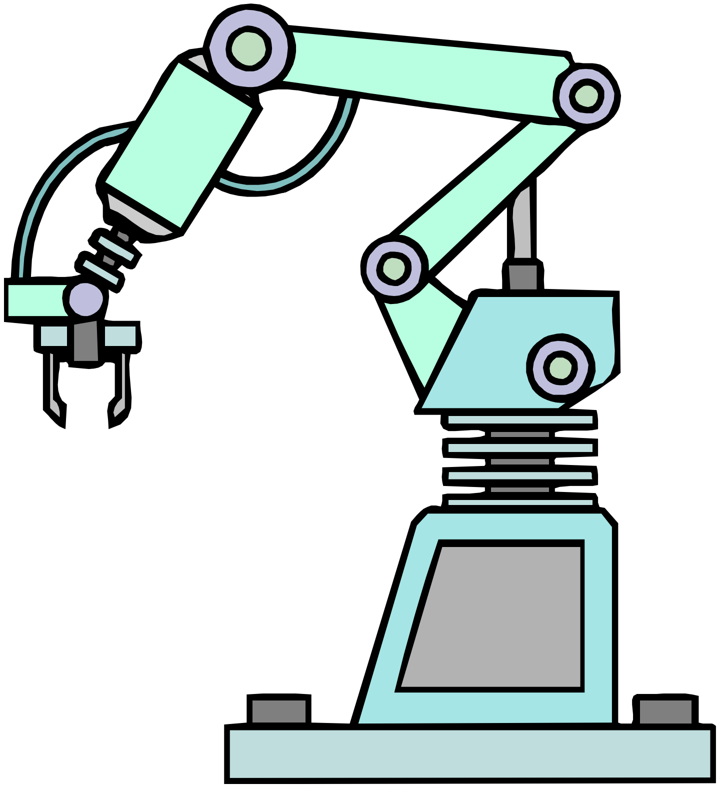
The absolute value of the static and dynamic components are added to give you the worst case scenario of the moment the robot will see.

Because of the complex motions the robot can produce, moments will often be less.

The robot acceleration can vary greatly. High acceleration robots can move near 2g's or more. Calculations are based upon 1g at 100%. You can vary the acceleration to 2g or more by changing the acceleration to 200%. Acceleration is extremely subjective and almost impossible to determine precisely without placing accelerometers on the robot since it is dependent upon so many variables such as axis movement and coordinated direction.

Arm and wrist

- The first three links, called the major links, carry the gross manipulation tasks. Examples of robots that use the major links include arc welding, spray painting, and water jet cutting applications. The last three links, or the minor links, carry the fine force and tactile manipulation tasks.



Robot requirements that need to be determined for the application

- Payload and working range
- Arm and wrist configuration
- End-effector required
- Method of actuation
- Operation (servo or non-servo)
- Precision required
- Special features
- Commercial units available

Configurations fit applications

- Cartesian
- Application – assembly and machine loading
- Configuration – PPP
- Percentage – 18
- Advantage – equal resolution, simple kinematics
- Disadvantage – Poor space utilization, slow speed

Commercial robot selection worksheet

Criteria	Requirement	Commercial Robot Candidate 1	Commercial Robot Candidate 2	Commercial Robot Candidate 3
Payload capacity				
Arm configuration				
Outer reach				
Inner reach				
Upper reach				
Lower reach				
Horizontal reach or sweep				
Wrist configuration				

Keep benefits in mind

- Five benefits that frequently are achieved through the application of industrial robots.
- Reduced costs
- Improved productivity
- Improved quality
- Elimination of hazards
- Greater flexibility

Any questions?