



ROBOTICS 1

End Effectors

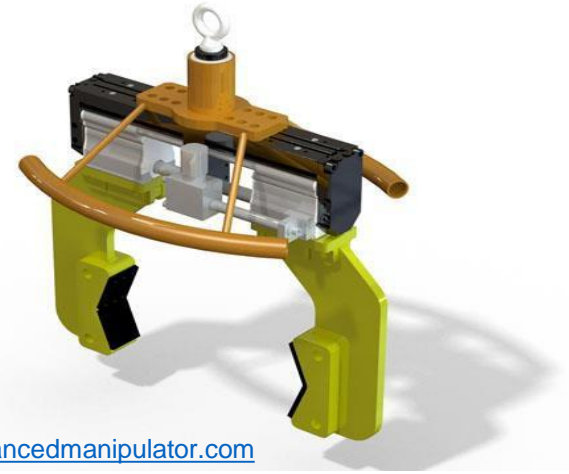
IMRAN KHAN

Resources: Text Book: Industrial Robotics (Larry T. Ross)-GW Publisher

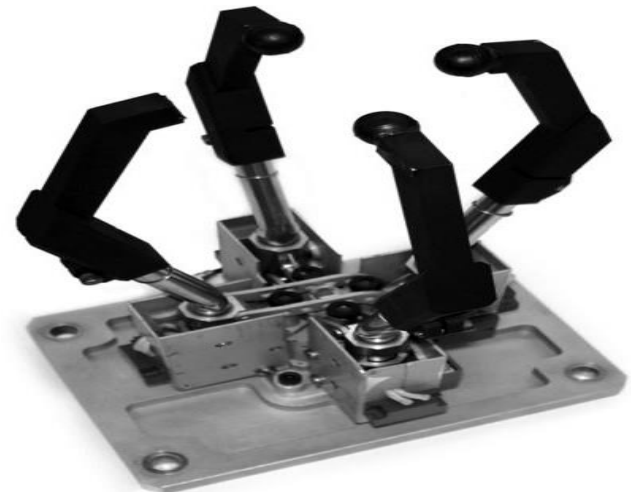
School of Applied Technology Robotics and Automation

End-Effectors

The last link of the robotic arm that interact with the environment through the tool is called an end-effector.



Source: www.advancedmanipulator.com



Source: wikipedia.org/wiki/File:Endeffector.png

End Effectors Movement

- Prehensile Movement

Use of thumb and fingers to grasp an object.

- Non-prehensile Movement

movements that do not dexterity or use of the thumb

Prehensile Movements

- Five basic prehensile, or gripping, movements



Palmar Grip



Cylindrical Grip



Spherical Grip



Lateral Grip



Oppositional Grip

Non prehensile Movements

- Do not require finger dexterity or use of opposable thumb



Hook



Spread

Classifications of End effector

- Two Major Classifications:
 - Gripper
 - Mechanical Grippers
 - Collet Grippers
 - Vacuum Grippers
 - Electromechanical Grippers
 - Tools
 - Welding Tools
 - Material Application Tools
 - Machining and Assembly tools

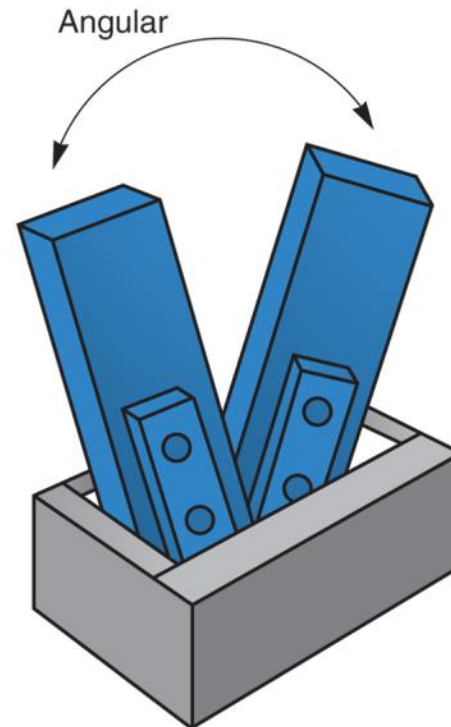
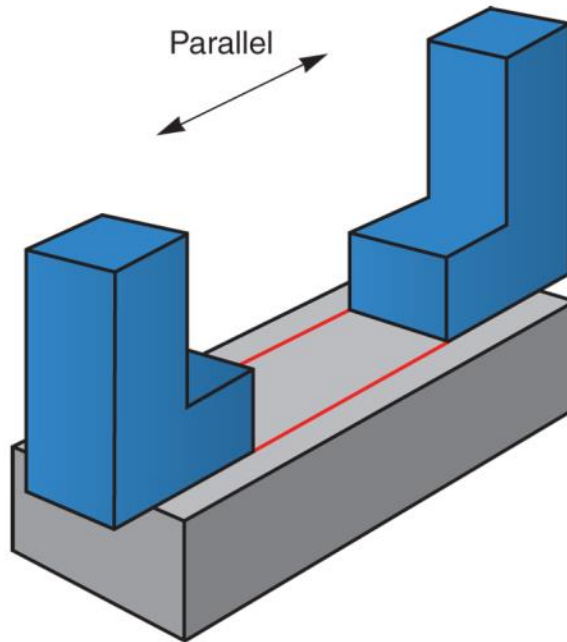
Gripper Types

Gripper End Effectors			
Gripper Type	Gripper Configuration	Gripper Movement	Internal/External Gripping
Mechanical finger	Two-finger Three-finger Four-finger	Parallel or angular	Internal and external
Collet	Round Square Hexagonal	360° clamping contact	Internal and external
Vacuum	One or more suction cups	Vacuum/suction	External
Electromechanical	Permanent magnet Electromagnet	Magnetic attraction	External

Goodheart-Willcox Publisher

Grippers

- *Mechanical finger grippers*
Move in parallel or angular motion



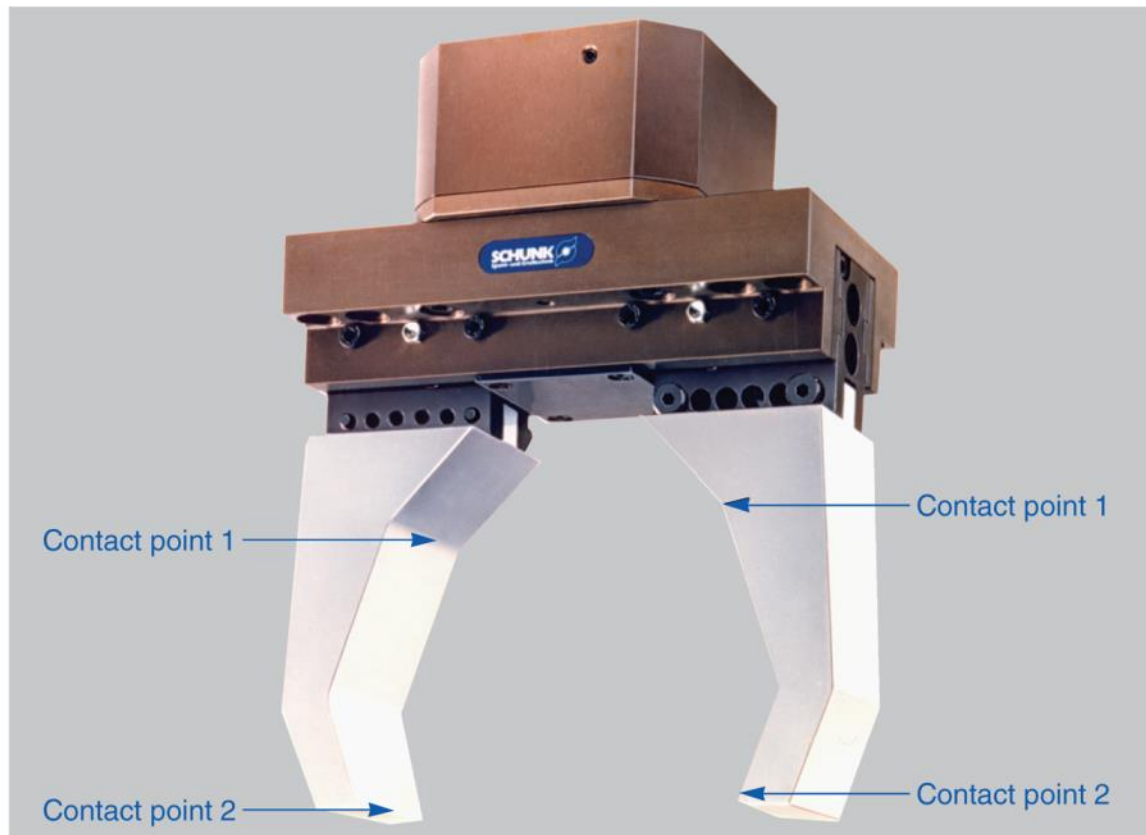
Grippers

- Two-finger grippers
Human thumb and
index finger



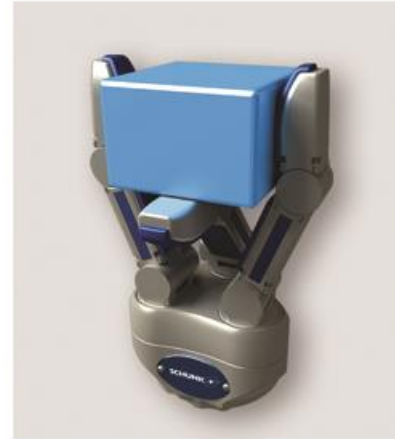
Grippers

- V-shaped fingers with two points of contact on each finger

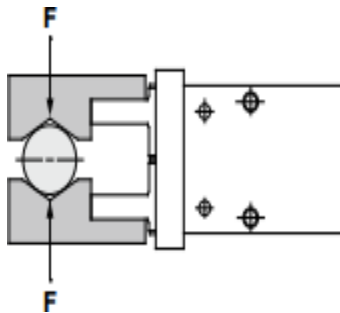


Grippers

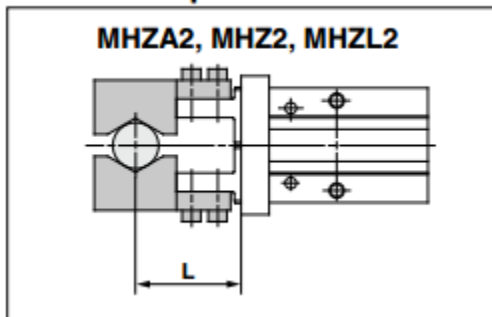
- Three-finger grippers
 - Human thumb, index finger, and third finger



GRIPPER FORCE

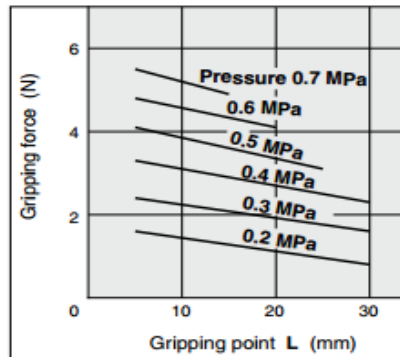


External Grip

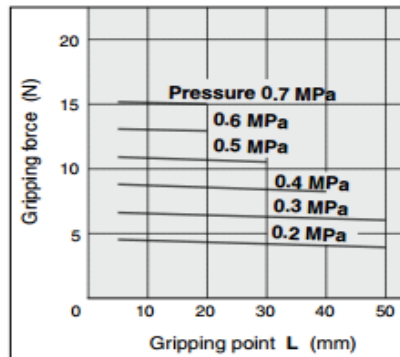


External Gripping Force

MHZ2-6D/MHZA2-6D

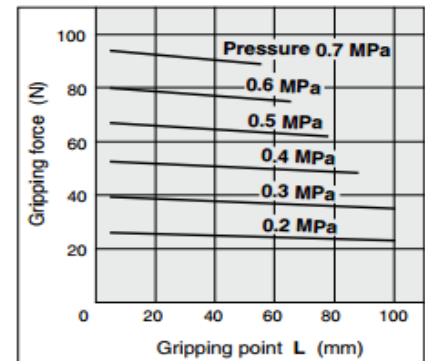


MHZ2-10D/MHZA2-10D

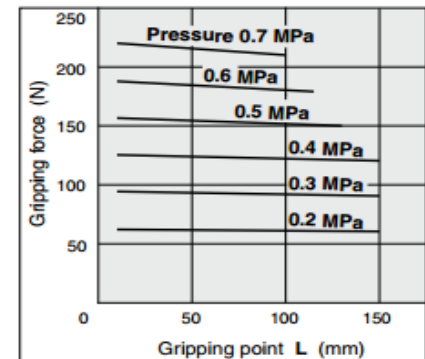


External Gripping Force

MHZ2-25D/MHZA2-25D

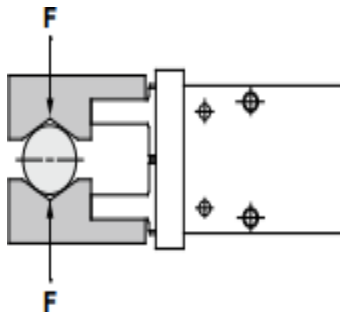


MHZ2-32D

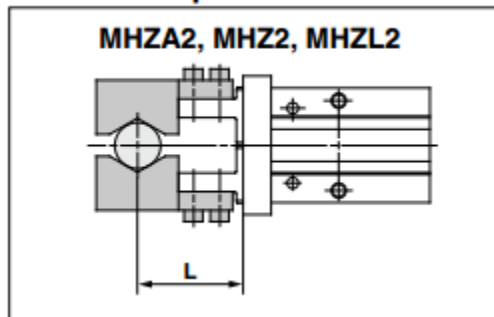


GRIPPER FORCE

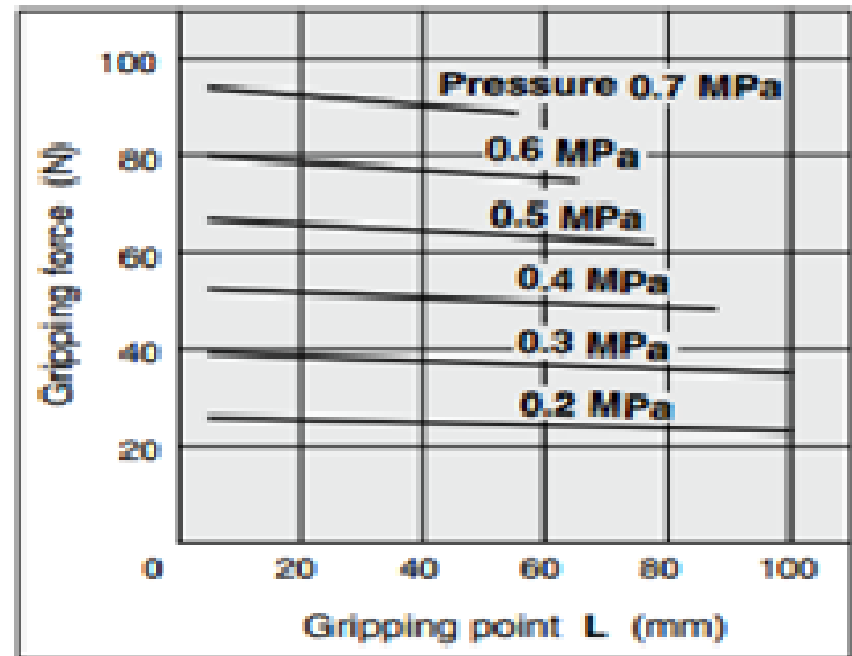
In LAB : From Round 02 onward, gripper force will be estimated based on the following graph (MHZ2-25D) at 0.3 Mpa.



External Grip

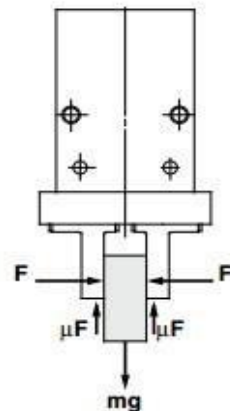


MHZ2-25D/MHZL2-25D



FORCE CALCULATION

Model Selection Illustration



“Gripping force at least 10 to 20 times the workpiece weight”

The “10 to 20 times or more of the workpiece weight” recommended by SMC is calculated with a safety margin of $a = 4$, which allows for impacts that occur during normal transportation, etc.

When $\mu = 0.2$	When $\mu = 0.1$
$F = \frac{mg}{2 \times 0.2} \times 4$ $= 10 \times mg$	$F = \frac{mg}{2 \times 0.1} \times 4$ $= 20 \times mg$

10 x Workpiece weight

20 x Workpiece weight

When gripping a workpiece as in the figure to the left, and with the following definitions,

F: Gripping force (N)

μ : Coefficient of friction between the attachments and the workpiece

m: Workpiece mass (kg)

g: Gravitational acceleration ($= 9.8 \text{ m/s}^2$)

mg: Workpiece weight (N)

the conditions under which the workpiece will not drop are

$$2 \times \mu F > mg$$

↑
Number of fingers

and therefore,

$$F > \frac{mg}{2 \times \mu}$$

With “**a**” representing the extra margin, “**F**” is determined by the following formula:

$$F = \frac{mg}{2 \times \mu} \times a$$

Example 1

Calculate the 2-finger gripper force required to hold the mass of 2 Kg.

Consider coefficient of friction $\mu=0.2$ and factor of safety (fos=4)?

Solution :

$$F = \frac{mg}{n\mu} \times (\text{fos})$$

$$F = \frac{(2)(9.8)}{(2)(0.2)} \times (4)$$

Where,

m= mass in Kg

g= gravitational accelerations

n= number of fingers

μ = Coefficient of friction

fos = factor of safety

$$F = 196 \text{ N}$$

Example 2

Calculate the force of a 3-finger gripper. If the gripper is holding a block of 2Kg and moving with an acceleration of 3 m/s². Consider the coefficient of friction $\mu=0.2$ and factor of safety (fos) is 4

Solution :

$$F = \frac{mg}{n\mu} \times (\text{fos})$$

$$F = \frac{(2)(9.8 + 3)}{(3)(0.2)} \times (4)$$

Where,

m= mass in Kg

g= gravitational accelerations

n= number of fingers

μ = Coefficient of friction

fos = factor of safety

$$F = 170 \text{ N}$$

Note: If additional acceleration is given for moving the mass then

$g = 9.8 + \text{additional acceleration value}$

Collets Gripper

- Use to pick and place cylindrical parts that are uniform in size. It provides 360° clamping contact.



Vacuum Grippers

- Multi-cup vacuum grippers increase contact surface area

Vacuum grippers

Use

One or more
suction cups

Exact positioning
not as critical



Electro-Mechanical Grippers

Electromechanical grippers, also called magnetic grippers, are end effectors that use a magnetic field created by a permanent magnet or an electromagnet to pick up an object. An electromagnetic gripper is energized by a DC power source.



Tools

- Welding Tools
 - Arc welding
 - Spot welding
- Material Application Tools
 - Palletizing
 - Packaging
 - Handling Operations
- Machining and Assembly tools
 - Drilling
 - Cutting
 - Deburring

Tools

- Typical automatic tool changer applications



Changeable End Effectors

Robots for machining and assembly require different tools

Rapid tool changing critical to productivity

Material application for palletizing, packaging, and handling operations

Rapid tool changing automates and improves process

Automatic Tool Exchanger

An automatic tool exchanger is used that has more than one end effectors and can change end effectors when needed to execute the operation.

We have ABB robot with automatic tool exchanger.

In Robotic II we will do automatic tool exchanger with ABB Robot.



Engineering 360°

Consideration - Changeable End Effectors

- Quick-change tooling
- Interface adapters must be standardized
- Change end effectors with minimum downtime

End Effectors Design characteristics

- Payload capacity
- Size and shape
- Type of materials
- Inertial
- Gripping force
- Gripper sensing capabilities
- Overload Sensor
- Compliance
- Part orientation
- Compensates for workpiece misalignment or irregularities
(Remote Center Compliance)
- Guard against strain damage
- Strength to carry out tasks

Custom-Designed End Effectors

- Can be designed for a particular application
- Broaden range of tasks that can be performed
- Can be designed to handle fragile or oddly shaped parts

Custom-Designed End Effectors

- Dual end effector has internal and external gripping capabilities



Custom-Designed End Effectors

Vision guidance system allows robot to find objects not placed symmetrically

