NYU TANDON SCHOOL OF ENGINEERING

NSF

Promoting robotic design and entrepreneurship experiences among students and teachers

Lesson 17: Grippers and End-effectors

Innovative Technology Experiences for Students and Teachers (ITEST), Professional Development Program, July 2017 - 19

Mechatronics, Controls, and Robotics Laboratory, Department of Mechanical and Aerospace Engineering, NYU Tandon School of Engineering

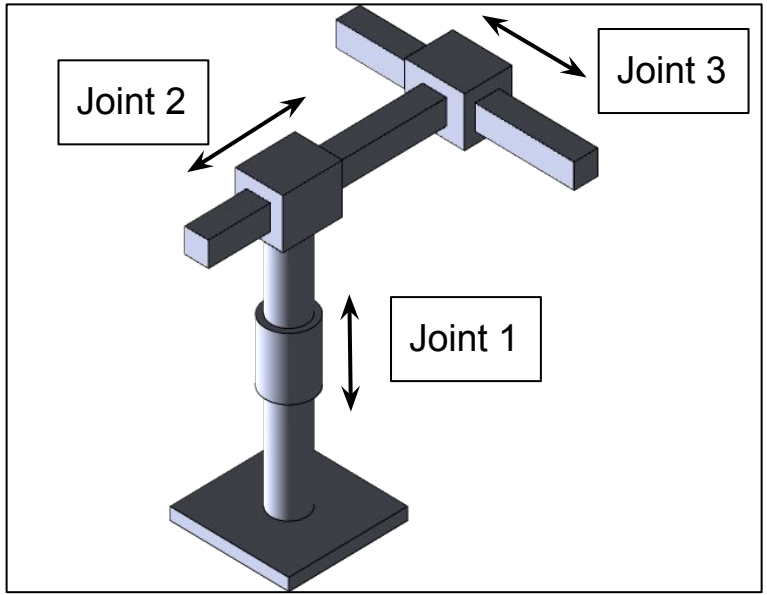
CONTENTS

- Robot configurations
- Grippers and end-effectors
- Robot arm work envelope

ROBOT CONFIGURATION

CARTESIAN COORDINATE ROBOT

- They consist of three prismatic/linear/sliding joints
- The motion of the joints is linear
- Two of the joint axes are are orthogonal to each other, i.e., the motion of two links will be perpendicular



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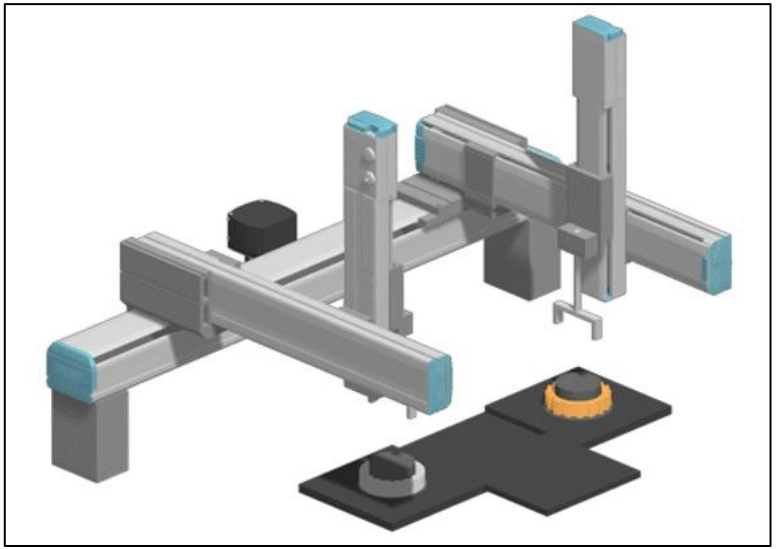
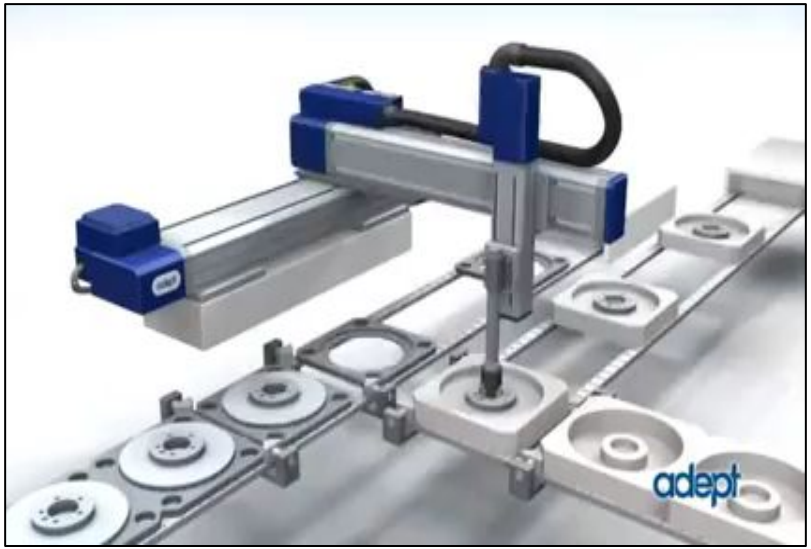
CARTESIAN COORDINATE ROBOT EXAMPLES



Part assembly system

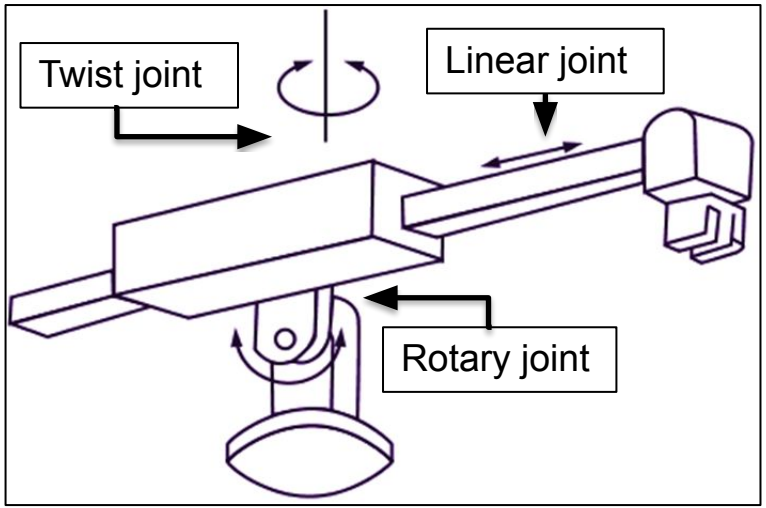


Transferring parts from a conveyer belt to a holding location

ROBOT CONFIGURATION

POLAR/SPHERICAL COORDINATE ROBOT

- It consists of a linear joint (L), a twisting joint (T) and a rotary joint (R)
- Linear movement allows arm to extend and retract at the linear joint
- The arm is placed on top of a twisting joint for vertical movement perpendicular to base
- Vertical movement about the pivot point because of a rotary joint



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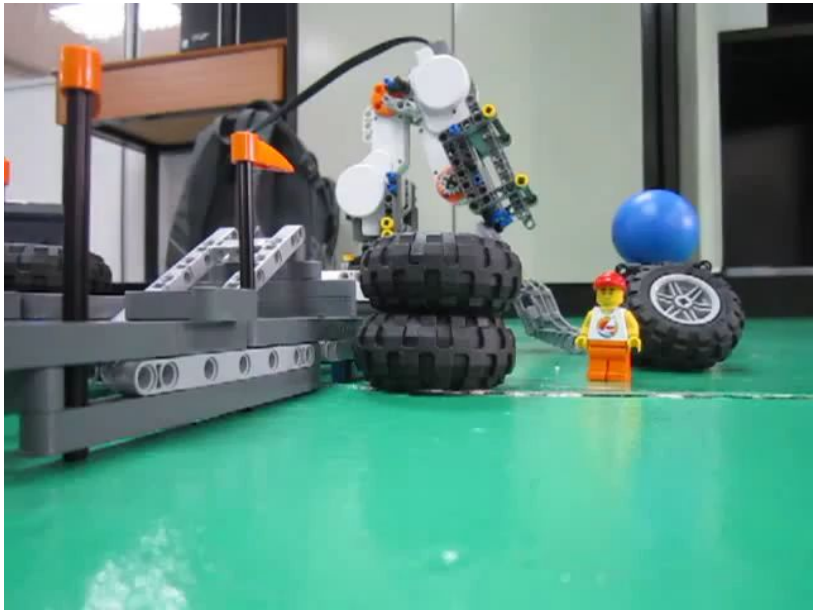
POLAR COORDINATE ROBOT EXAMPLES

Unimate robot

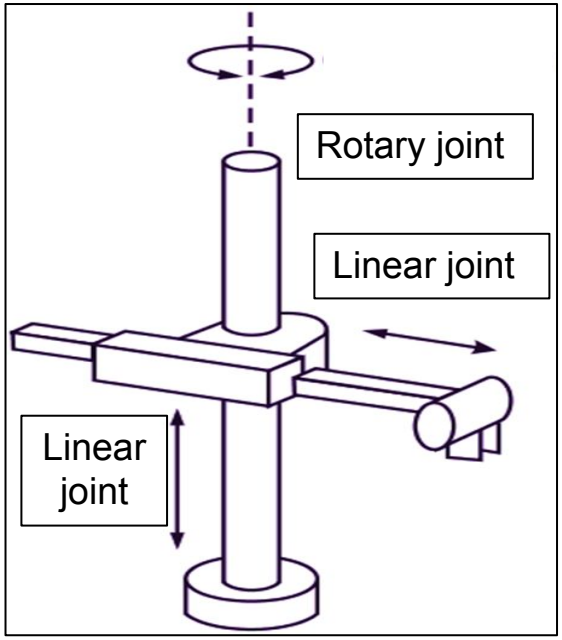


Video: Polar/Spherical coordinate robot

ROBOT CONFIGURATION

CYLINDRICAL COORDINATE ROBOT

- It consists of a vertical column, relative to which an arm is moved up or down making a vertical linear joint (L)
- The arm can be moved in or out relative to the column with a second linear joint (L)
- The arm can rotate along the vertical axis with a rotary joint (R)



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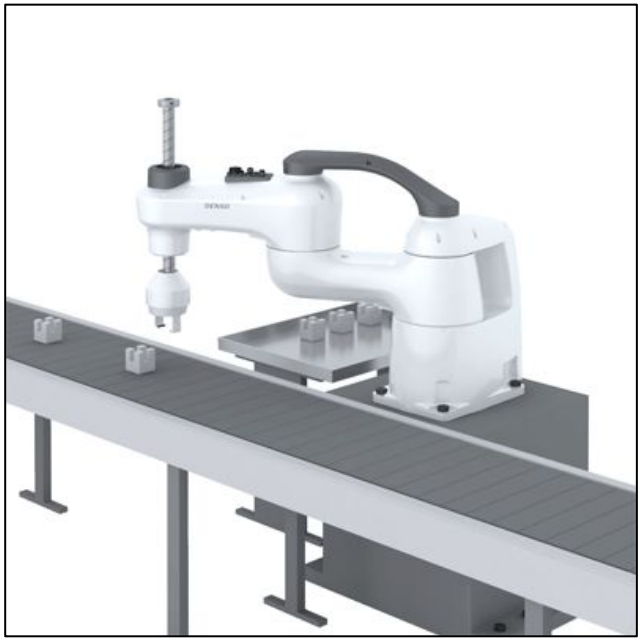
CYLINDRICAL COORDINATE ROBOT EXAMPLE

Video: Cylindrical robot

ROBOT CONFIGURATION: SCARA

- **SCARA** (Selective Compliance Assembly Robot Arm) is a type of industrial robot
- This type of robots are used for various material handling tasks such as pick and place applications
- It consists of two rotary joints (R) and a prismatic/linear joint (L)

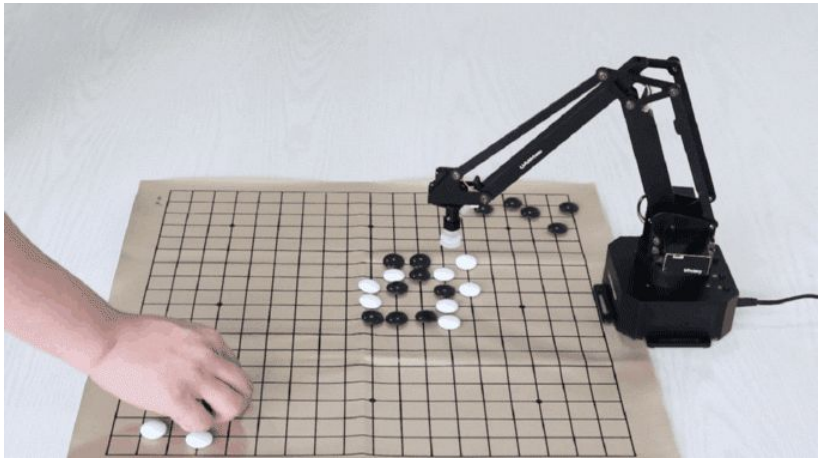


SCARA robot at a conveyer belt

GRIPPERS AND END-EFFECTORS

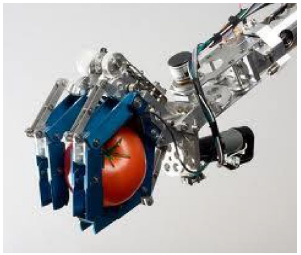
- **End-effector** is attached at the end of robot arm or the wrist to interact with the environment

- It increases the number of degrees of freedom in a robot arm with its ability to manipulate the environment

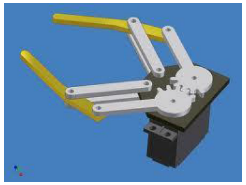


Robot arm with a suction cup type end effector

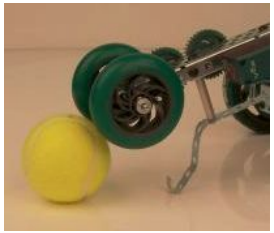
TYPES OF GRIPPERS AND MECHANISMS

Mechanism	Advantages	Disadvantages
Vacuum cup mechanism 	• Suitable for flat, clean and smooth surfaces • Potentially can create large gripping forces • Can also be used for manipulating small objects	• Unsuitable for porous materials • Requires continuous air pressure supply
Finger gripping mechanism 	• Produces sufficient force (variable and according to need) • High versatility and adaptability	• Actuation can potentially be complex

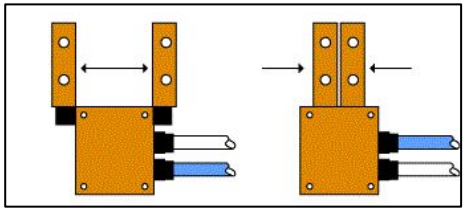
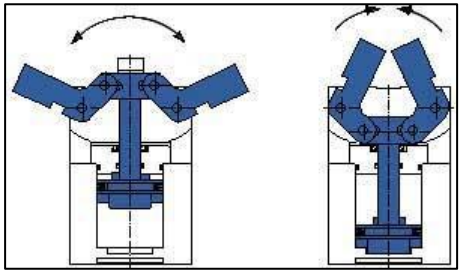
TYPES OF GRIPPERS AND MECHANISMS

Mechanism	Advantages	Disadvantages
Pneumatic powered grippers 	• Smaller units, quicker assembly • High cycle rate • Easy maintenance	• Maintaining constant air pressure to provide constant force is difficult
Hydraulic powered grippers 	• High strength and speed • Mechanical simplicity • Heavy payloads can be withstood	• Large robots that take up space and are noisy • Possibility of oil leakage
Motor Actuation 	• High accuracy, repetitive power • Less floor space, low cost, easy maintenance	• Requires Electronic control system, may be complex • Small load compared with hydraulic powered grippers

TYPES OF GRIPPERS AND MECHANISMS

Mechanism	Advantages	Disadvantages
Magnetic mechanism (electromagnetic magnets) 	• Suitable for magnetic materials • Single surface gripping is possible • Invariant with respect to type of object - universal, and quick	• Highly specific • Chance of slipping during movement, or if lubrication is present
Roller mechanism 	• Allows for realignment of object during gripping	• Slow action • May not be suitable for irregular objects

TYPES OF GRIPPERS AND MECHANISMS

Mechanism	Advantages	Disadvantages
Parallel / Linear / Translational mechanism 	• Accurate form of gripping	• Possible loss of stability during tangential force application
Angular /Contour mechanism 	• Very useful for irregular objects	• Difficult to implement, expensive and complex

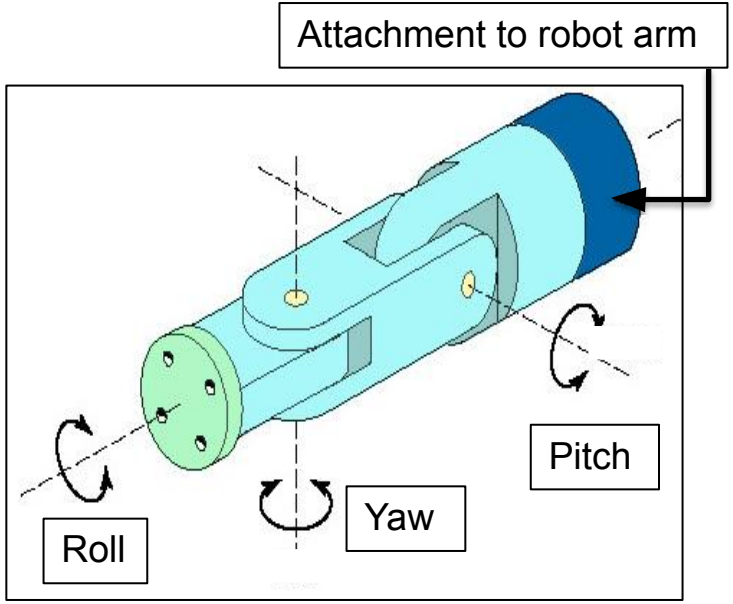
ACTIVITY

- Can you list an industrial gripper except the VEX Clawbot? Which category should you put it into? Can you list an disadvantage and advantage of it?

- Observe the VEX Clawbot and tell the disadvantages and advantages of its manipulator

WRIST CONFIGURATION

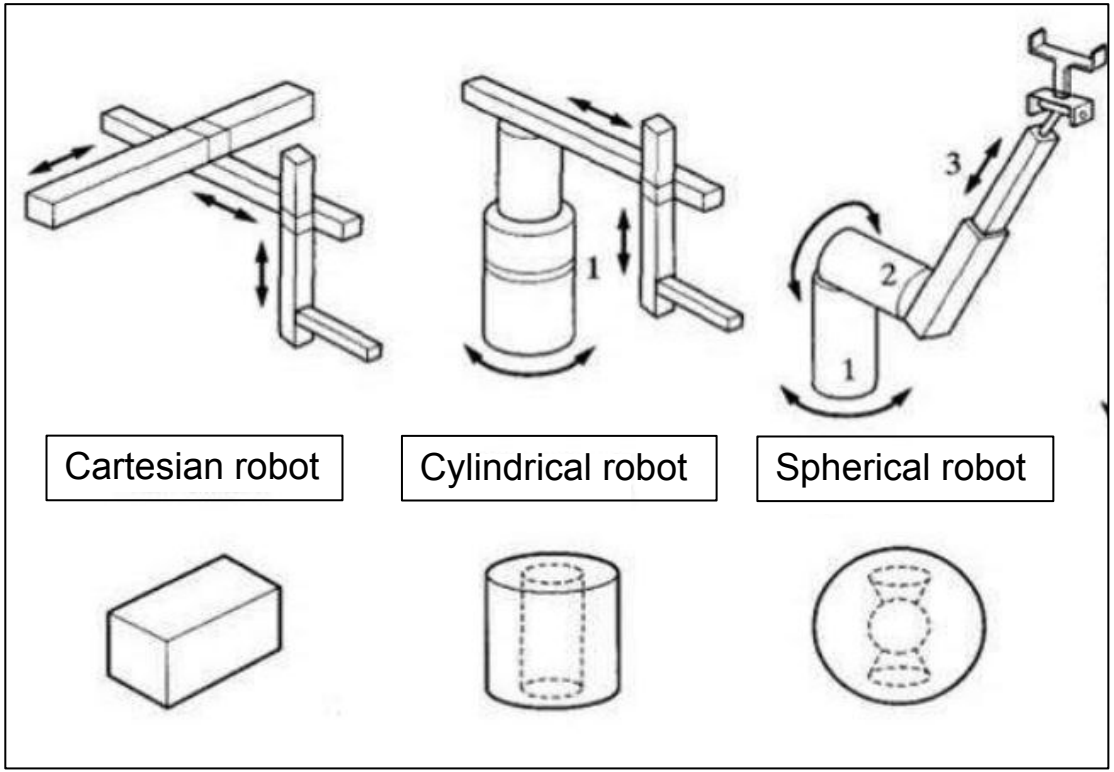
- The end-effector is attached to wrist assembly
- The function of wrist assembly is to orient end-effector to manipulate its environment
- It can have two or three degrees of freedom:
  - Roll - This is also called wrist swivel; this involves rotation of the wrist mechanism about the arm axis
  - Pitch - It involves up & down rotation of the wrist, also called as wrist bend
  - Yaw - It involves right or left rotation of the wrist



WORK ENVELOPE

- **Work envelope** is a three-dimensional shape that defines the boundaries that the robot manipulator can reach
- It is determined by the maximum distance the arm with manipulator can reach when extended forward, backward, left and right, i.e., in all possible directions
- For example, a spherical coordinate robot has spherical envelope, a cartesian coordinate robot has a cuboid envelope and so on.

WORK ENVELOPE



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WORK ENVELOPE

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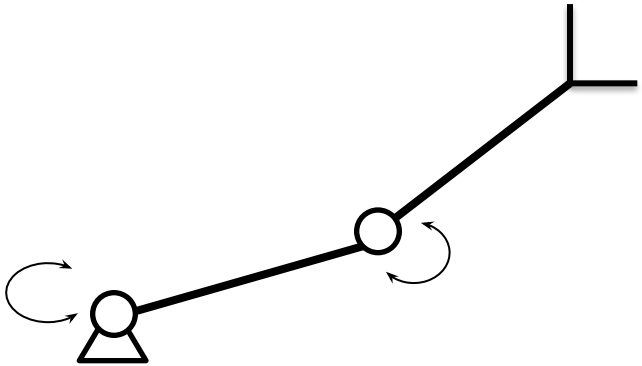
TASK/ACTIVITY - SOLUTION

Can you draw the work envelope for these mechanisms on a paper?



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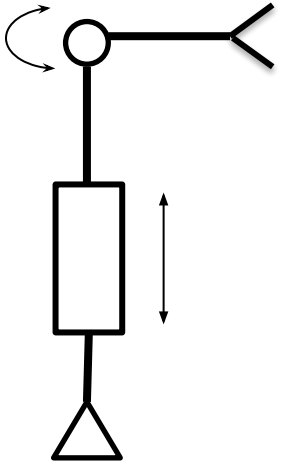

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Thank You!

Questions and Feedback?