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Automation – A Cost Effective Solution for Small and Mid-Sized Manufacturers

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Today's Agenda

- ***Industry 4.0 Introduction***
- What is Automation?
- Types of Automation in Manufacturing
- Advancements in Automation
- Cost Effectiveness

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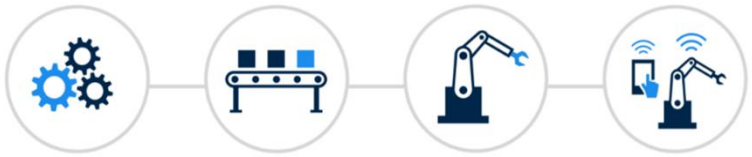
Industry 4.0 Introduction



Industry 1.0	Industry 2.0	Industry 3.0	Industry 4.0
1780's	**1870's**	**1960's**	**Early 2010's - Today**
Introduction of Mechanization	Mass Production	Introduction of **Automation**	Introduction of Cyber-Physical Systems
Steam and Waterpower Augment Human Muscle	Introduction of the Assembly Line	Computers and Electronics Augment Human Brain	Autonomous **Automation** via Big Data
	Electrical Power		

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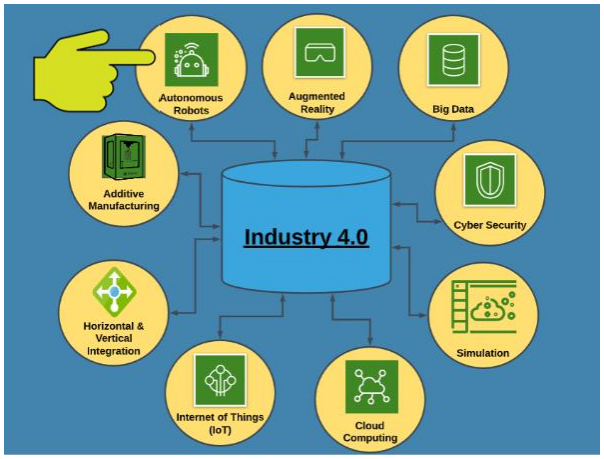
Industry 4.0 Introduction

- The 9 Technologies of Industry 4.0



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- Types of Automation in Manufacturing
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What is Automation?

The OED defines automation as: "the use of largely automatic equipment in a system of manufacturing or other production process."

Automation can also be thought of as an evolution of the mass production equipment that arose in Industry 2.0.

In its first appearance during Industry 3.0, automation was expensive, inflexible, and inherently dangerous

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- ***Types of Automation in Manufacturing***
- Advancements in Automation
- Cost Effectiveness

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Types of Automation in Manufacturing

- Robots
  - Articulated
  - SCARA
  - Delta
  - Cartesian/Gantry
- Autonomous Mobile Robots (AMR)

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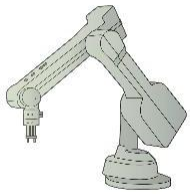
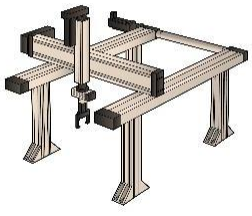
Types of Automation in Manufacturing (Robots)

ROBOTS ARE OFTEN THE FIRST THING THAT COMES TO MIND WHEN THINKING ABOUT AUTOMATION

THERE ARE NUMEROUS DESIGN APPROACHES, EACH WITH STRENGTHS AND WEAKNESSES





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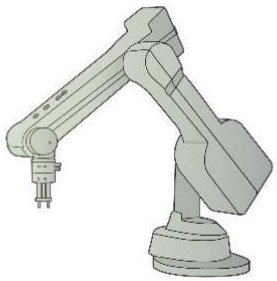
Articulated Robots



- Similar in design to a human arm, articulated robots are classified by the number of axes (6 is most common)
- Key specifications to define are payload and reach
  - Payload ratings range from 1 pound up to 5000 pounds
  - Reach distances range from 10 inches to 15 feet

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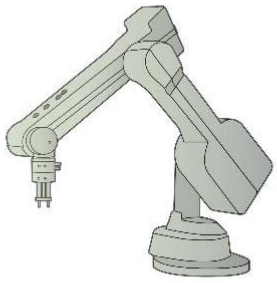
Articulated Robots



- Strengths
  - Highly flexible and dexterous
  - Nearly limitless mounting options (horizontal, vertical, mobile)
  - Sealed joints enable use in dirty or explosive environments

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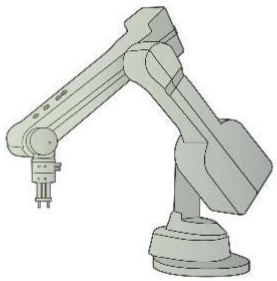
Articulated Robots



- Weaknesses
  - Cost usually higher compared to other types with equal reach and payload ratings
  - Cycle time lower limit of ~5 seconds, typically
  - Precision and accuracy of movement inherently degrades at limit of payload or reach; additional cost required to compensate

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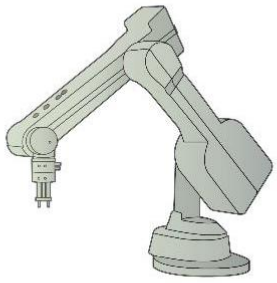
Articulated Robots



- Typical Applications
  - Pick and Place in 3D
  - Machine Tending
  - Assembly
  - Welding
  - Packaging
  - Palletizing
  - Inspection (fixed/mounted camera)
  - Material Removal
  - Dispensing

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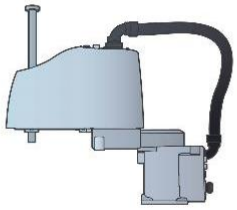
SCARA



- Selective Compliance Articulated Robot Arm (SCARA)
- Generally, 4-Axis design
- "Compliant" in X and Y dimensions only
- Key specifications to define are payload and reach
  - Payload ratings range from ounces up to ~100 pounds
  - Reach distances range from 4 inches to 4 feet

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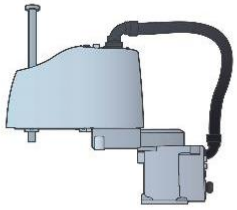
SCARA



- Strengths
  - Very compact design for use in limited space
  - Vertical assembly operations (e.g. pin inserting) are easy to rigidity in Z-axis
  - Cheaper than articulated robots
  - Very fast cycle times (<1 second) are possible
  - Simpler maintenance requirements
  - Longevity of over 10M cycles

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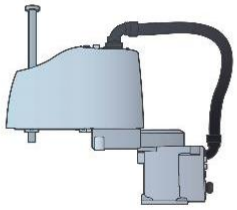
SCARA



- Weaknesses
  - Typically limited to low payloads (<1~5 pounds)
  - Typically limited to low reach distances (~25 inches)
  - Limited ability to "work around" fixturing, jigs, machine tools etc. due to fixed swing arm design

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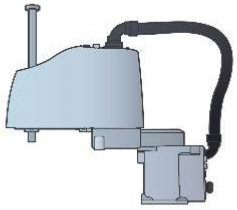
SCARA



- Typical Applications
  - High speed pick and place
  - Simple "single direction" assembly
  - Inspection (moving or fixed camera)
  - Packaging
  - Dispensing

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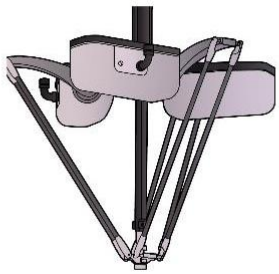
Delta Robots



- Delta Robots are named for triangular shape similar to the Greek letter Delta
- Also called "spider" robots
- Typically, 3-axis design (additional axes for end of arm wrists are possible)
- Actuators mounted to stationary base allow for very light arms, and thus very high acceleration
- Key specifications to define are payload and reach
  - Payload ratings range from ounces up to ~25 pounds
  - Reach distances range up to 5 feet (note that Delta reach is typically measured via diameter vs. radius of other types)

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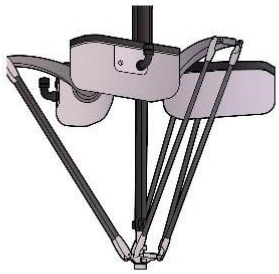
Delta Robots



- Strengths
  - Inherent to design, capable of very high speeds (cycle times <1 sec.)
  - Excel at pick and place operations above moving conveyors "on the fly"

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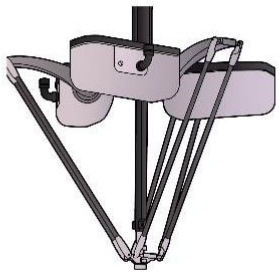
Delta Robots



- Weaknesses
  - Low payload and reach
  - Very limited in applications without parallel planes of operation
  - Multiple linkages and gearboxes led to higher maintenance requirements

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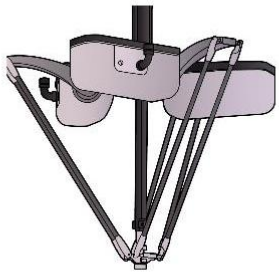
Delta Robots



- Typical Applications
  - Pick and Place (in parallel planes)
  - Assembly
  - Inspection (moving camera)

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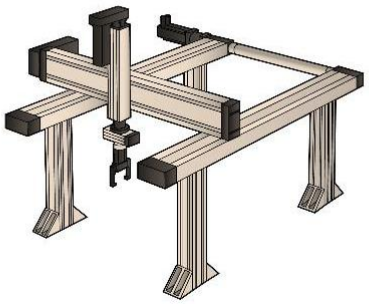
Cartesian/Gantry



- Typically consist of 2 or 3 linear actuators
- Custom built for specific application
- "Gantry" used when installed an elevated system suspended above workspace
- Due to application specific design and relatively simple scaling, reach and payload are nearly unlimited

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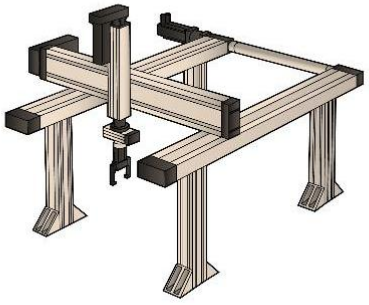
Cartesian/Gantry



- Strengths
  - Relatively low cost compared to other systems
  - Can cover huge workspaces
  - Can deal with huge payloads
  - Possible to mount other robot types, particularly articulated, like end of arm tool for complex tasks in large areas

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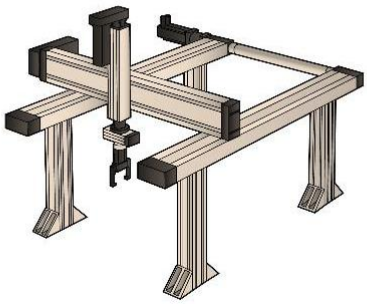
Cartesian/Gantry



- Weaknesses
  - Unable to easily reach into or around objects
  - Exposed sliding mechanisms pose maintenance risks in dirty/dust environments
  - Structure covers entire work area

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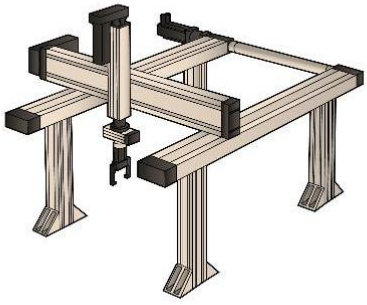
Cartesian/Gantry



- Applications
  - Pick and Place in 3D
  - Dispensing
  - Assembly
  - Inspection (fixed or moving camera)

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Autonomous Mobile Robots (AMR's)

- Autonomous Mobile Robots are an evolution of Industry 3.0 Automated Guided Vehicles (AGV's)
- Typically include on-board LIDAR or RADAR systems for obstacle detection and avoidance
- May use integrated mapping software or physical waypoints for pathfinding

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Autonomous Mobile Robots (AMR's)

- Strengths
  - Truly autonomous once facility is "mapped"
  - Various payload ranges available ("person with a cart" up to "forklift")
  - Can integrate well with mounted articulated robots to create "pick, deliver, and place" systems
  - Inherently safe design

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Autonomous Mobile Robots (AMR's)

- Weaknesses
  - Speeds are typically lower than manual material movement approaches
  - While low, AMR's due to require maintenance, cleaning, and charging times
    - Dirty and dusty environments increase the maintenance/cleaning requirements

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Autonomous Mobile Robots (AMR's)

- Typical Applications
  - Very open-ended application space
  - Range of applications from only point A to point B movement of material all the way to multiple waypoints with multiple pick and place or assembly steps at each stop

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Current Advancements in Automation

- Major advancements in Collaborative Robots, "Cobots"
  - Designed to safely work along side people without safety cages or fences
  - Programming greatly simplified compared to standard industrial robots (e.g. "mimic" systems)
  - Highly flexible for redeployment

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Cost Effectiveness

- Typically, "first order" ROI's can be realized in ~3 years or less
  - Example calculation: Typical articulated cobot overall system cost is ~$150k. A 3-shift operation with a burdened labor rate of $25/hour could expect an offset of ~1.5 FTE's. ROI period in this example is 2 years.
- Secondary effects to also consider
  - Improved consistency leading to lower defect rates
  - Employee Morale – Automation is not viewed as detriment to the millennial/Gen Z work, but a sign of a progressive company that values "human intelligence tasks"
  - Improved ergonomics and safety by eliminating "the 3 D's", Dull, Dirty, or Dangerous

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Thank You!

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