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The Arthur M. Blank Family Foundation

2007 TE Sessions
Manipulators
10/16/07

www.robojackets.org

Keys to Understanding Manipulators

- What is a manipulator?
- What kinds of manipulators are there?
- What are the different types of joints and linkages in a robotic arm?
- How can joints and linkages control an arm's motion (geometrically)?
- What kind of manipulation is a roller / conveyor system good for?
- How can a several manipulator concepts be combined?

What is a Manipulator?

- A mechanism that interacts directly with an object (or objects) or interest

- Can take many forms
  - Dexterous arms
  - Roller/ conveyor systems
  - Combinations

Types of manipulators

- Dexterous arms
  - Serial
  - Parallel
- Roller / Conveyor systems
  - Single path
  - Mass flow
- Combinations

DEXTEROUS ARMS

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Dexterous Arms: Definitions

- Rotation
  - Change in an objects orientation
- Translation
  - Change in an objects position
- Linkages
  - Rigid or flexible lengths of material
- Joints
  - Connection points between linkages can allow for rotation (rotary joints) or translation (sliding / prismatic joints)

Dexterous Arms: Definitions

- Dexterous
  - able to move to several positions and orientations
- Serial Manipulator
  - Arm formed by a single chain of linkages
- Parallel Manipulator
  - formed by multiple linkage chains
- End Effector
  - Mechanism at the end of an arm that directly contacts the object of interest

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DEMONSTRATION

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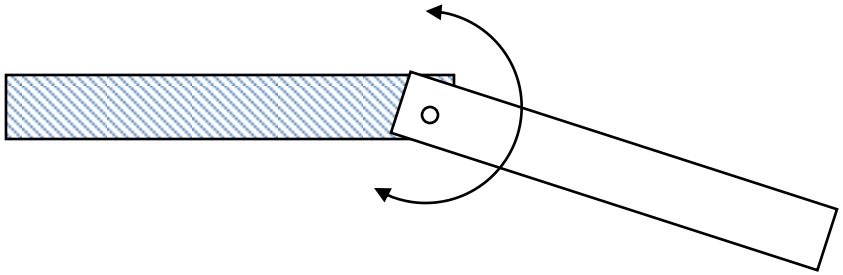
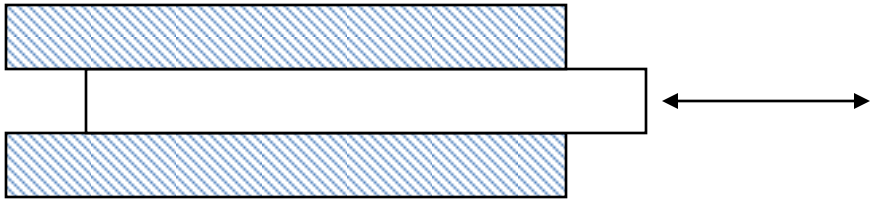
Joints

- Joints allow for controlled motion of one linkage relative to another
- Rotary or hinge joints allow rotation around a pivot

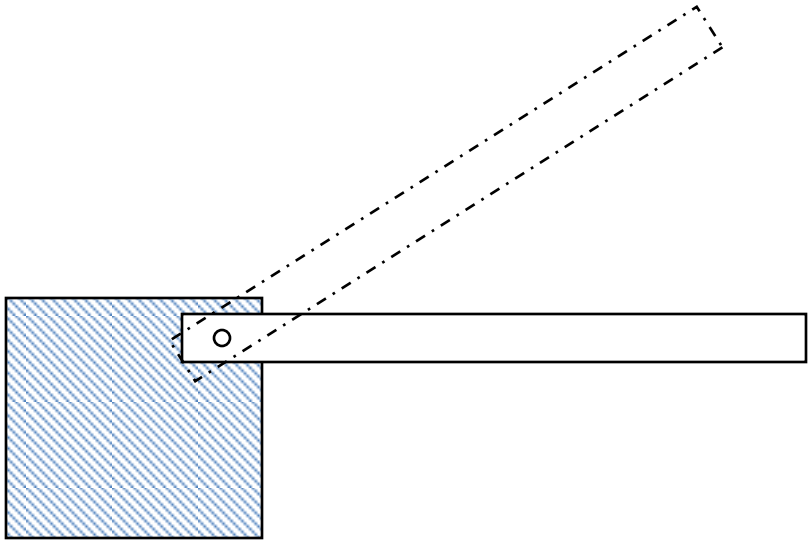


- Prismatic or sliding joints allow translation along one axis



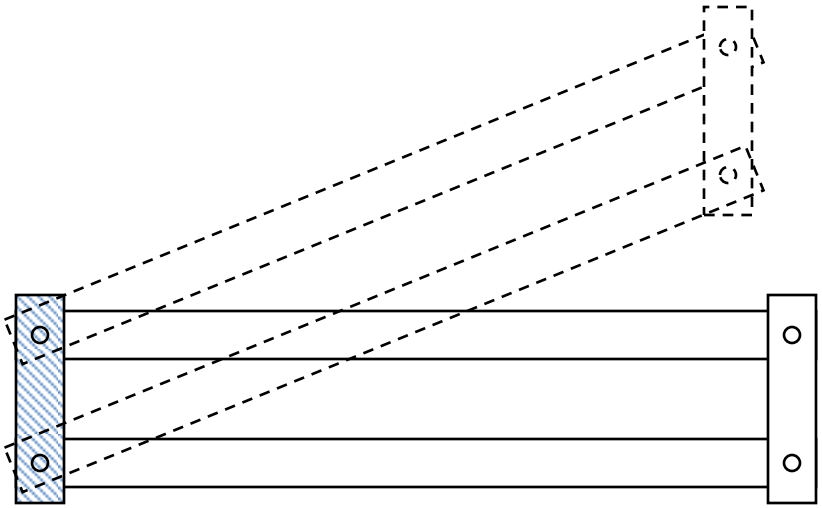
Linkages

- Single bar
  - Mostly rigid long piece of material
  - End of the bar changes orientation as the bar rotates



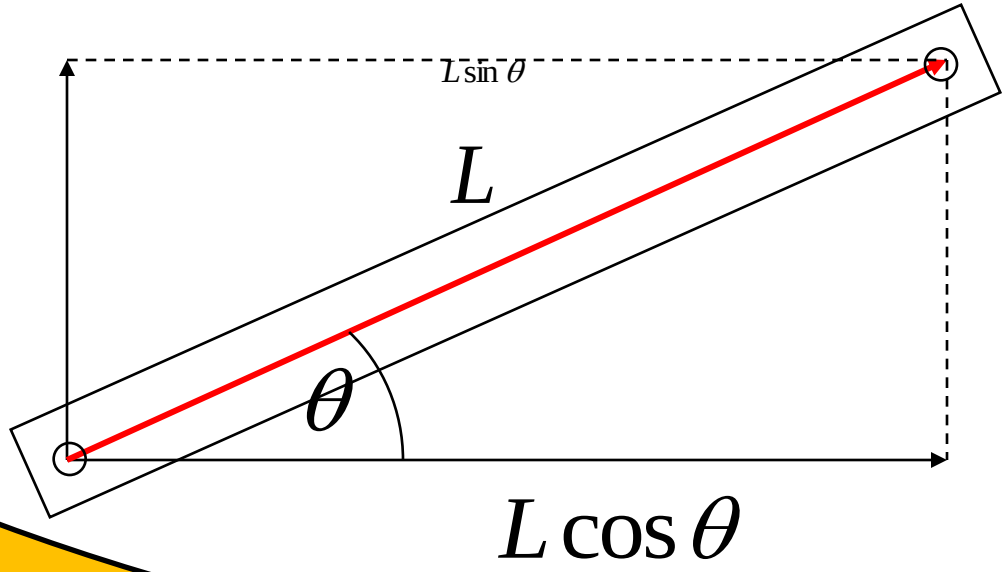
Linkages

- Parallel bar
  - A parallelogram created using single bars and hinge joints
  - Can move along an arc without changing orientation of one set of bars



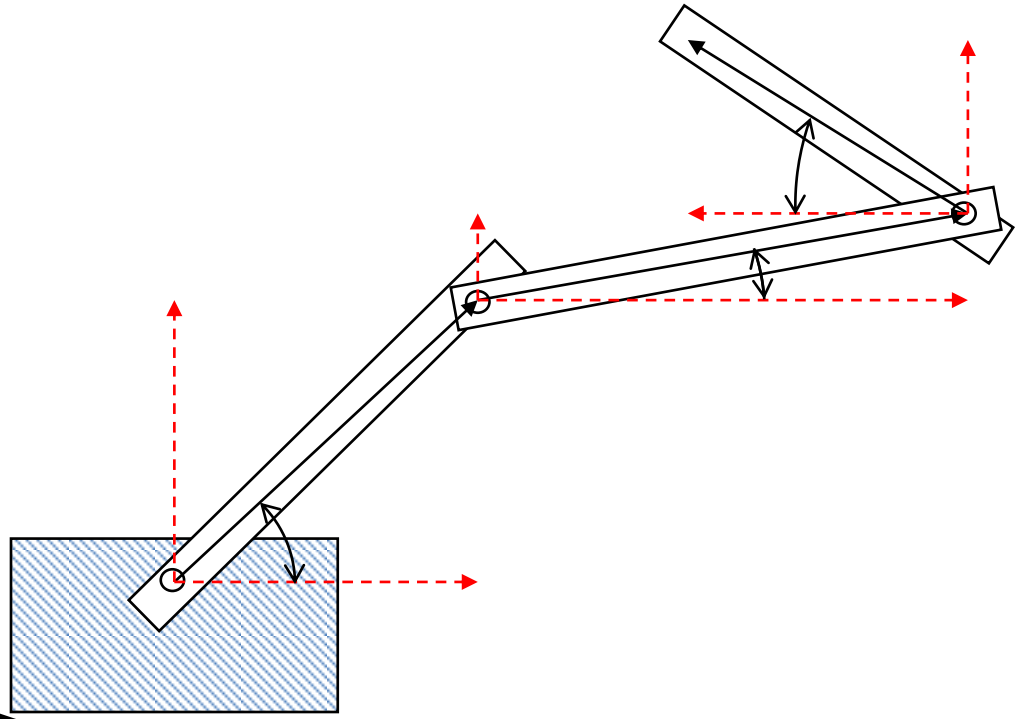
Arm Geometry

- Trigonometry
  - By using arm angles and linkage lengths, the position of the end can be found.
  - This can be simplified using projections of the linkages onto the x and y axes.



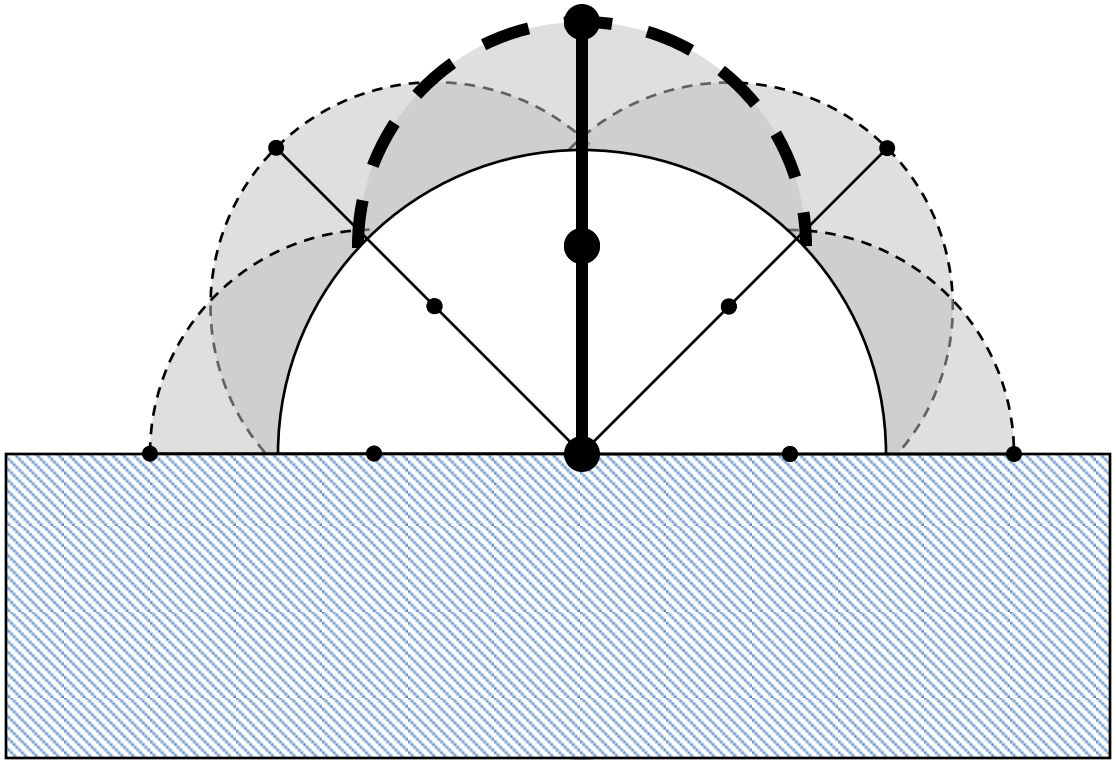
Arm Geometry

- With multiple linkages and joints the projections on the x and y axes just need to be added to find the final position of the arm's end.



Workspaces

- Maximum reachable workspace
  - The largest possible reachable area around your arm



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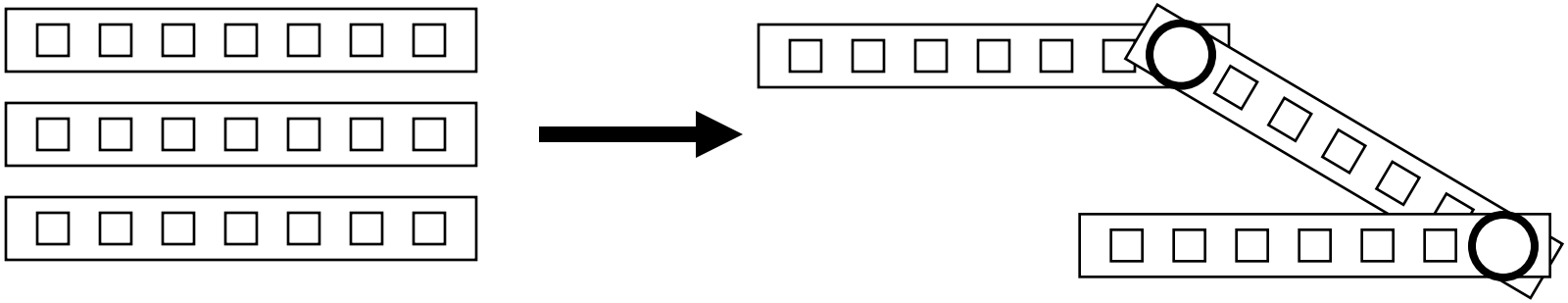
Activity

- Build a flat, unpowered arm with 2 rotary joints and 3 linkages.
  - Each link must be 6 holes long
  - You can forego bearings and spacers for this exercise

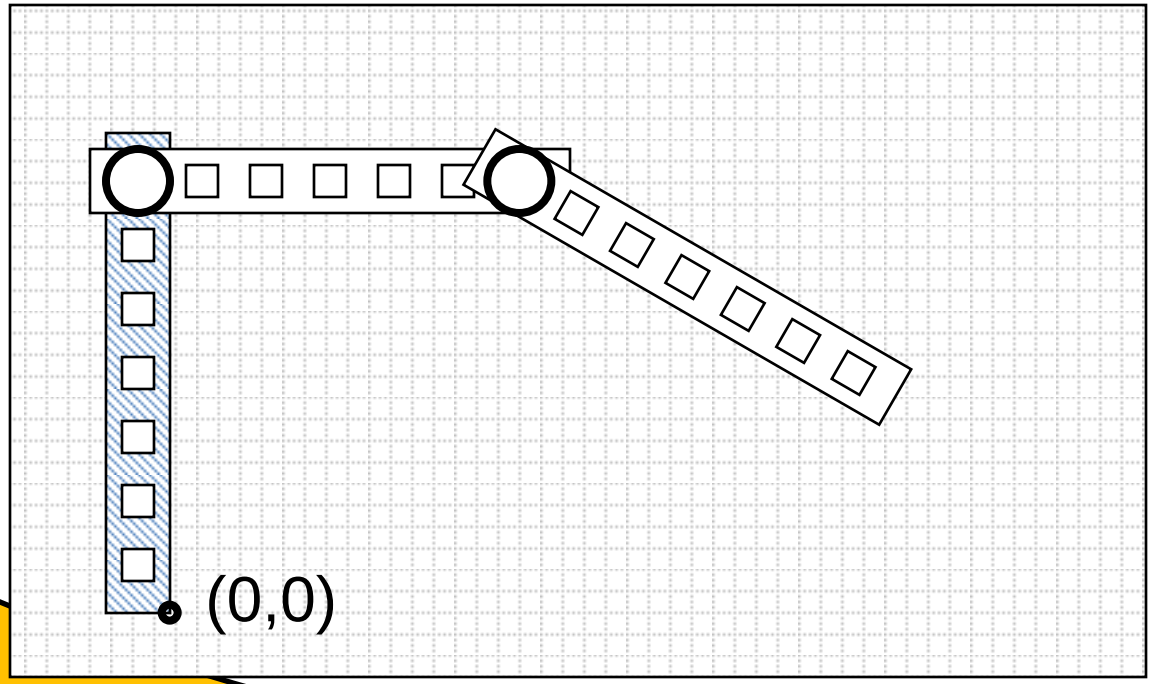


Competition 1

- If the first linkage can not move and the joints can move 90 degrees each way from the parallel direction draw the maximum reachable workspace using your model
  - You must demonstrate with your model for the reward

Competition 2

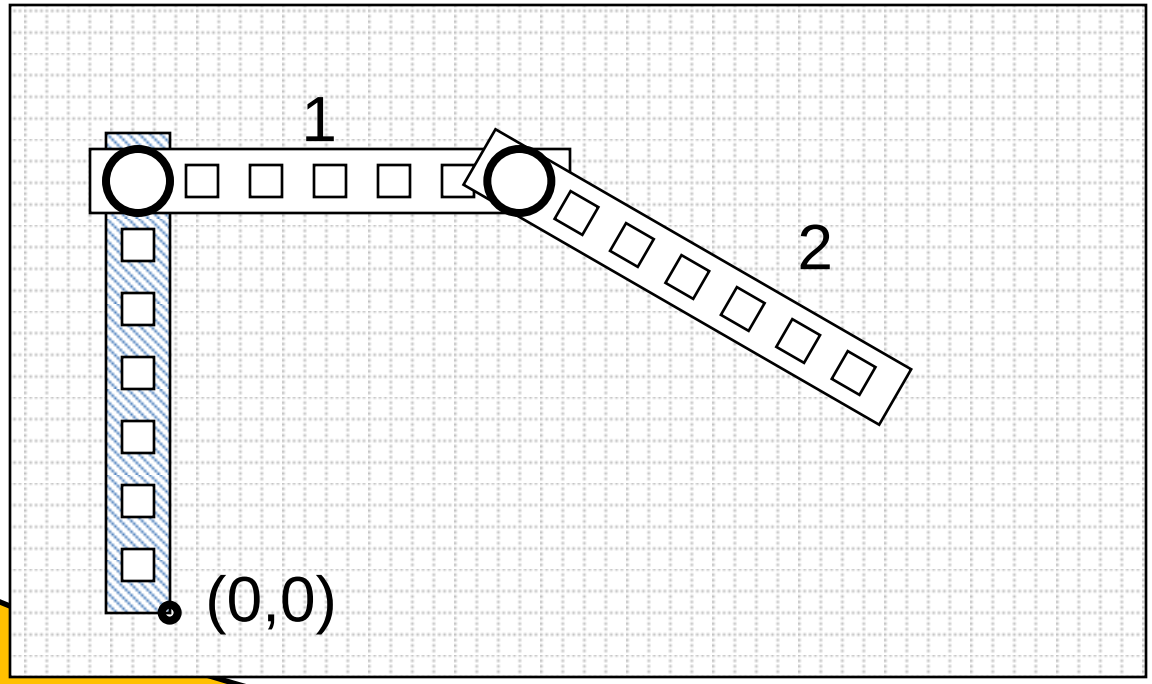
- Using a sheet of graph paper find and trace two ways to make your end effector reach the following coordinates. Your model should be oriented as follows.



Competition 3

- Given the following angles from horizontal for the respective linkages find the end effector coordinates.

* Find the exact coordinates in terms of vex hole spacing ex. (8.5 holes, 6.7 holes)

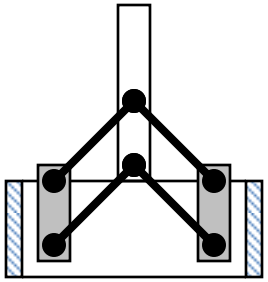


End effectors

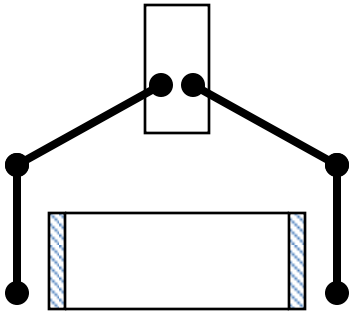
- End effectors are at the end of a robot arm and interact with the objects being manipulated.
  - Passive
    - Hooks and adhesive end effectors that do not have a powered grip
  - Active
    - Grippers, suction cups and other powered grasping deviced

End effectors

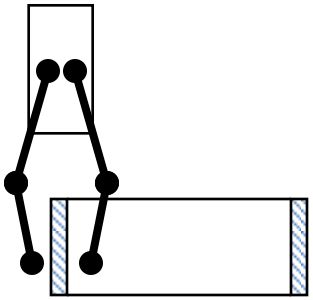
- Active grippers
  - More complex, but end up being more reliable in cases where the robot is moving with an object.
  - Geometry must match the object(s) being grasped



Inside gripper



Outside gripper



Wall gripper

Rollers/Conveyors

- Good at moving large amounts of similar objects quickly.

- Past FIRST and Vex scoring objects that have been scored with conveyors or rollers.
  - Storage bins
  - Foam balls
  - Rubber balls
  - Softballs

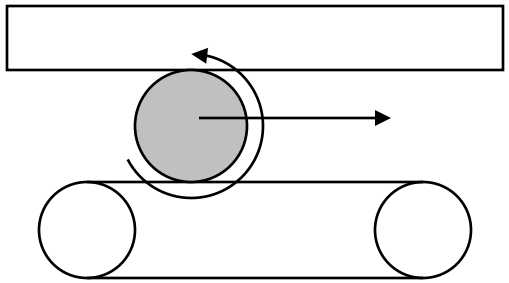
Types of Rollers

- Rigid rollers are generally good at picking up uniformly-sized, deformable objects
  - Foam balls
  - Inflatable balls

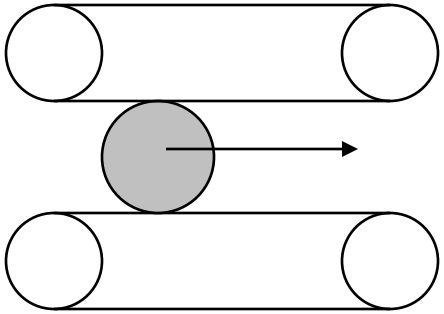
- Soft or deformable rollers are generally better at picking up harder or variable sized objects
  - softballs

Enclosed Conveyor Systems

- Single belt
  - Rolls the object against a stationary surface

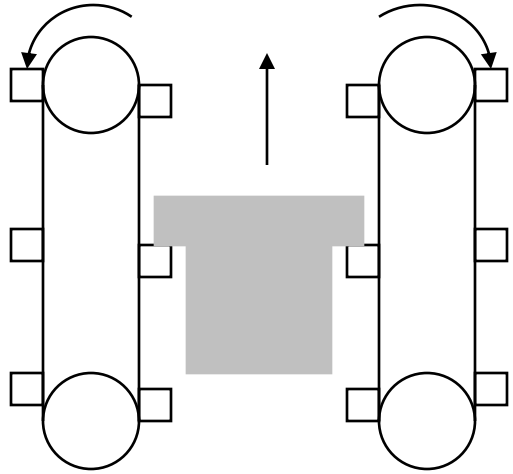


- Double belt
  - Translates the object between two conveyor belts
  - Object moves twice as fast as in a single belt system with the same belt speed



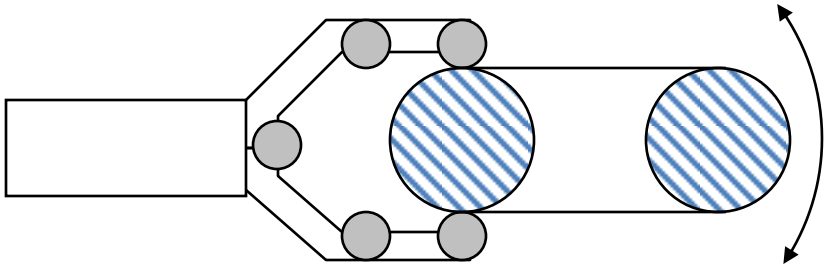
Enclosed Conveyor Systems

- Smooth belt
  - Belt provides more contact area with object
  - Has the ability to slide if there is a buildup of objects
- Profiled
  - Belt does not rely on friction but uses the geometry of the object to provide support
    - Used to stack boxes in 2003 FRC



Conveyor / Arm / Roller Combinations

- Grippers can use rollers to grasp objects and rotate them in their grasp



- Arms with limited dexterity can use rollers or conveyors to align objects for pickup
- Enclosed conveyors can be articulated like a simple arm to score several items quickly and semi-dexterously

Legal

These slides and more are available at

http://www.robojackets.org

For more information contact the RoboJackets.

(contact info available via the web)

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