

Assembly Instructions

Cart Pole Project
DAIR Lab

Frame

Parts required From Bill of Materials:

Part #	Quantity	Description
1	4	These T-Slot rails will be used to make the sides of the frame
2	4	These T-Slot rails will be used to make the sides of the frame
3	2	These two long T-Slot rails will connect the two sides of the frame
9	4	These shaft collars will be used to hold the rails
7	16	These corner brackets will be used to attach the T-Slot rails to one another Belt 3
17	1	This will mount the Pulley to the tensioner
16	1	This will allow the pulley to spin freely
18	1	This will help tension the timing belt
19	1	This will interface with the tensioner and the frame
29	1	This will mount the motor to the frame
11	2	These Pulleys will interface with the timing belt

Instructions

1. Cut T-Slot Aluminum for the frame to size using a band saw
 - a. Reference B.O.M for sizes and quantities needed
2. Assemble two sides (see engineering drawing *1-SimpleSide*)
 - a. Assemble T-Frame with brackets
 - b. Add Shaft Supports but do not fully tighten (wait until you slide cart to properly space the shafts)
3. Attach sides together (see engineering drawing *2-MechanicalBase*)
 - a. Use long T-Frame pieces and corner brackets to connect sides from step 2
4. Build the Belt Tensioner Assembly (see engineering drawing *3-BeltTensionerAssemb*)
 - a. Machine the pulley mount (see engineering drawing *4-PulleyMount*)
 - i. Press fit the bearing into the mount
 - ii. Press fit the pulley onto the short 6mm shaft
 - iii. Press fit the other side of the 6mm shaft into the bearing
 - b. Machine the tensioner, screw press, and twist guard (see engineering drawings *5-BeltTensioner*, *6-ScrewPress*, *16-TwistGuard*)
 - c. Attach the pulley assembly to the frame

5. Attach the motor mount to the opposite side of the frame
 - a. 3D print motor mount (see STL files) and screw motor into mount
 - b. Since the timing belt pulley does not come with a set screw, drill and tap a hole on the lower shaft for a 4-40 set screw
 - c. Attach the pulley to the shaft of the motor

Cart

Parts required From Bill of Materials:

Part #	Quantity	Description
20	1	This will be the base of the cart where everything is attached to
12	4	These are the linear bearings that will allow the cart to slide on the rails
13	2	These bearings will allow the shaft connected to the pole to rotate
21	1	This piece will allow us to precisely mount the encoder
38	1	This encoder will keep track of the orientation of the pole
23	1	This piece will mount the belt clamp to the underside of the cart
30	1	This clamp will tightly clamp the timing belt to the cart and enable linear motion
14	1	This shaft will rotate on the bearing and be connected to the "pole" via a hub
15	1	This is known as the "pole" and will spin freely as the cart moves
31	1	This hub will connect the rotation shaft to the pole
25	1	This top will sit at the end of the pole and house the force sensors
36	2	These force sensors will be placed at the top of the pole
34	1	This squash ball will be cut in half and be used as a cap to press against the force sensor
27	2	These parts will interface between the squash ball and force sensor

Instructions

1. Fabricate cart base (see engineering drawing *7-CartBase*)
2. Fabricate encoder mount (see engineering drawing *8-EncoderMount*)
3. Attach linear and sleeve bearings to base (see engineering drawing *9-CartAssembly*)
4. Loosely Attach rotational bearings with housing
5. Machine hub for connecting rod to encoder (see engineering drawing *10-EncoderHub*)
 - a. Connect rod and encoder using hub
6. Attach encoder mount to cart base and attach the encoder.
 - a. Ensure that the rod slides through the rotational bearings
 - b. Tighten rotational bearings once rod is in place

7. Attach the belt clamp mount and loosely attach the belt clamp to the bottom of the cart
 - a. Machine belt clamp mount (see engineering drawing *11-ClampMount*)
 - b. 3D print belt clamp (see STL files)
8. Machine hub for connecting rod and pole (see engineering drawing *12-PoleHub*)
 - a. Fasten pole to rod using hub
9. Machine the top for the pole (see engineering drawing *13-PoleCap*)
 - a. Attach the flintec force sensors to the top using super glue
10. Build squash ball caps and fasten to the top
 - a. Cut squash ball in half, sand for even finish
 - b. Laser cut flat caps (see DWG folder)
 - c. Use super glue to epoxy squash balls to flat caps
 - d. Use hot glue to secure caps to force sensor
11. Attach the top to the pole itself

Mounting Cart onto Frame

Parts Required from B.O.M

Part #	Quantity	Description
8	2	These are the rails where the cart will slide along
10	1	Timing Belt

Instructions:

1. Run the rails through the linear bearings on the cart and shaft supports
 - a. Tighten the screws for the linear bearings
 - b. Move the cart all the way to both sides and tighten the shaft supports to the frame
2. Run the timing belt around the motor and pulley and attach it to the cart
 - a. Unscrew the two linear bearings across from the belt clamp.
 - b. Lift up the cart from the detached bearings to access the belt clamp
 - c. Tighten both ends of the timing belt in the belt clamp
 - d. Fasten the cart back into the two linear bearings
 - e. Adjust the belt tensioner until it is taught

Adjustable Walls

Parts Required from B.O.M

Parts required From Bill of Materials:

Part #	Quantity	Description
6	2	These T-Slot rails will be used to attach the wall to the frame
5	2	These T-Slot rails will be used set the height of the walls

26	2	These brackets will interface the T-Slot rails with the force sensors
7	8	These corner brackets will be used to attach the T-Slot rails to one another
35	2	These force sensors will measure the force on the wall
31, 32, 33	2	The foam will act as a spring constraint on the wall
28	2	These pieces will be used to mount the foam to the walls

Instructions

1. Cut T-Slot Aluminum to size using a band saw
 - a. Reference B.O.M for sizes and quantities needed
2. Machine brackets from connection force sensors to T-Slot rails (see engineering drawing *14-PCMount*)
3. Use corner brackets to attach T-slot pieces together, mount brackets, and attach Force Sensors (see engineering drawing *15-Wall*)
4. Laser cut MDF foam mounts (see DWG folder) and use adhesive (hot glue) to secure foam to mounts
5. Screw foam mounts into other side of Flintec force sensor
6. Attach walls to frame using corner brackets

Miscellaneous

Add cushioning to the end of the rails and cart as well as the back side of the walls to prevent parts breaking during testing. We used foam window seal tape.

Updates

Adding a New Encoder:

Instead of finding the motor position using the maxon encoder, we wanted to be able to use an encoder similar to the one used for measuring the angle of the pole. To do this, we made two additional parts for a new belt-tensioning system.

Parts required From Bill of Materials:

Part #	Quantity	Description
11	1	This Pulley will interface with the timing belt
39	1	This will tension the timing belt

40	1	This will help mount the encoder to the belt tensioner
41	1	This encoder will measure the position of the cart

Instructions:

1. Machine the new belt tensioner and encoder mount (see engineering drawings *17-beltTensionerEM*, *18-outerEM*)
2. Attach the encoder to the mount, and secure the timing belt pulley to its shaft using a set screw.
3. Attach the assembly from the previous step to the belt tensioner (using 3 M4 screws) and slide the belt tensioner into the rail replacing the old tensioner.
4. Fasten the belt tensioner to the edge of the frame using a M6 screw.

Building a Lighter Cart

Another update we made was to reduce the cart size to minimize the mass. We switched from a four bearing to a two bearing system on the rails. For this, the instructions are the exact same as previously described except instead of machining part 20, machine part 42 following engineering drawing *19-smallerCartBase*. Also, you will now only need two linear bearings (part # 12). The holes for all of the other components that attach to the base will be identically spaced from the centerline of the cart base.