OpenHand

Model T42
Version 0.3

Assembly Instructions
Last updated: November 28, 2013
# Parts List (Pivot Base)

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Quantity</th>
<th>Usage</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1_pivot.stl</td>
<td>1</td>
<td>Top Plate</td>
<td>3D Print</td>
</tr>
<tr>
<td>a2.stl</td>
<td>1</td>
<td>Top Keeper Plate</td>
<td>3D Print</td>
</tr>
<tr>
<td>a3.stl</td>
<td>1</td>
<td>Bottom Plate</td>
<td>3D Print</td>
</tr>
<tr>
<td>a4.stl</td>
<td>1</td>
<td>Bottom Keeper Plate</td>
<td>3D Print or Lasercut</td>
</tr>
<tr>
<td>b1.stl</td>
<td>1</td>
<td>Central Coupler</td>
<td>3D Print</td>
</tr>
<tr>
<td>b2.stl</td>
<td>2</td>
<td>Servo Pulley</td>
<td>3D Print</td>
</tr>
<tr>
<td>c1.stl</td>
<td>2</td>
<td>Finger Pivot Base</td>
<td>3D Print</td>
</tr>
<tr>
<td>finger-flexure_print.stl</td>
<td>2</td>
<td>Finger Molds – Breakaway</td>
<td>3D Print</td>
</tr>
<tr>
<td>Power Pro Spectra</td>
<td>1</td>
<td>Tendon</td>
<td>Amazon [link]</td>
</tr>
<tr>
<td>PMC-780 Urethane</td>
<td>1</td>
<td>Finger Joint Urethane</td>
<td>Smooth-On [link]</td>
</tr>
<tr>
<td>Vytaflex 30 Urethane</td>
<td>1</td>
<td>Finger Pad Urethane</td>
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* optional
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<tbody>
<tr>
<td>Robotis RX-28 Dynamixel</td>
<td>2</td>
<td>Actuator</td>
<td>Robotis [link]</td>
</tr>
<tr>
<td>Ø1/8”, L1-1/4” steel dowel pin (J1)</td>
<td>4</td>
<td>Support Pin</td>
<td>McMaster [98381A477]</td>
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<tr>
<td>Ø1/8”, L5/8” steel dowel pin (J2)</td>
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<td>Support Pin</td>
<td>McMaster [98381A472]</td>
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<tr>
<td>Ø1/4”, L1-3/4” steel dowel pin (J3)</td>
<td>2</td>
<td>Joint Pin</td>
<td>McMaster [98381A548]</td>
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<tr>
<td>Ø3/8”, Wd1/8” nylon pulley (P1)</td>
<td>6</td>
<td>Tendon Routing</td>
<td>McMaster [3434T31]</td>
</tr>
<tr>
<td>M2.5, L5mm bolt</td>
<td>2</td>
<td>Fastener</td>
<td>Provided w/ Dynamixel</td>
</tr>
<tr>
<td>M2, L5mm bolt</td>
<td>4</td>
<td>Fastener</td>
<td>McMaster [91290A012]</td>
</tr>
<tr>
<td>Socket Cap Screw 8-32, L3/4”</td>
<td>8</td>
<td>Fastener</td>
<td>McMaster [91253A197]</td>
</tr>
<tr>
<td>Ø1/4”, L1-1/2” zinc-plated female standoff (S1)</td>
<td>4</td>
<td>Support</td>
<td>McMaster [93330A482]</td>
</tr>
<tr>
<td>Torsion Spring, Ø0.34”, 0.028” wire diameter, 180°,</td>
<td>4</td>
<td>Joint Return</td>
<td>McMaster [9271K605]</td>
</tr>
</tbody>
</table>

* optional
## Parts List (Flexure Base)

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<td>2</td>
<td>Servo Pulley</td>
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</tr>
<tr>
<td>finger_flexure_print.stl</td>
<td>2</td>
<td>Finger Molds – Breakaway</td>
<td>3D Print</td>
</tr>
<tr>
<td>finger_ff_A.stl, finger_ff_B.stl, shell_ff_A.stl, shell_ff_B.stl, shell_ff_C.stl</td>
<td>2</td>
<td>Finger Molds – Multipart</td>
<td>3D Print</td>
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<td>Actuator</td>
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<tr>
<td>Ø1/8”, L1-1/4” steel dowel pin (J1)</td>
<td>10</td>
<td>Support Pin</td>
<td>McMaster [98381A477]</td>
</tr>
<tr>
<td>Ø3/8”, Wd1/8” nylon pulley (P1)</td>
<td>6</td>
<td>Tendon Routing</td>
<td>McMaster [3434T31]</td>
</tr>
<tr>
<td>M2.5, L5mm bolt</td>
<td>2</td>
<td>Fastener</td>
<td>Provided w/ Dynamixel McMaster [92290A055]</td>
</tr>
<tr>
<td>M2, L5mm bolt</td>
<td>4</td>
<td>Fastener</td>
<td>McMaster [91290A012]</td>
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* optional
Consult DDM (Dieless Deposition Manufacturing) guide for further details on pouring/preparing the joints and pads for fingers.
Drill tendon routing holes such that tendon will run tangent to inserted pin. Minimize contact between tendon and ABS but ensure that tendon runs freely. For the pivot base design, the fingers also have a torsional spring mounting hole to be drilled as shown.
Use `helper_jig.stl` to aid in positioning and orientation during drilling if desired. Routing holes should be drilled perpendicular to hole surface. The fingers are designed such that for each routing hole, there is at least one feature surface that is perpendicular to the direction of drilling, as shown above. It is ideal to minimize the diameter of the tendon routing holes if possible.
File down and deburr bearing surfaces as indicated above. Ensure that no support material remains, if applicable. Complementary piece (ie. pulley, finger) should slide in freely.
PART PREPARATION
REAMING (1/8” PIN HOLES)

Use Ø0.1240” reamer to prepare pin holes as indicated above. This step can be skipped in lieu of precise 3D printer calibration and parameter selection, but manual reaming is the recommended approach.
PART PREPARATION
REAMING (PIVOT BASES)

Use Ø0.2490” reamer to prepare pin holes on pivot bases \( c1.stl \), and Ø0.2510” reamer to prepare pin holes on the corresponding fingers \( \text{finger\_pivot.stl} \). Finger should spin freely and loosely on a Ø0.25” steel pin.
Remove back of Dynamixel RX-28’s. The two Dynamixel servo’s snap onto the coupler piece *b1.stl* as shown above. Connect the two Dynamixel servos in a daisy-chain configuration.
Assemble main drive pulleys onto actuator block sub-assembly as shown. Do not worry about zero-position of servo at this time.

(Optional): It may be beneficial to attach one end of the tendons to the pulleys at this point. Use enough tendon to wrap around the pulley fully at least once and also reach the end of the fingertips after routing.
Assemble main drive pulleys onto actuator block sub-assembly as shown. Do not worry about zero-position of servo at this time.

### Parts

- Sub-assembly from step 8
- a3.stl
- a4.stl
- Ø1/4", L1-1/2" standoffs S1 (x4)
- Socket Cap Screw 8-32, L3/4” (x4)
### Assembly

**Flexure-base fingers**

<table>
<thead>
<tr>
<th>Parts</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexure-based finger (x2)</td>
<td></td>
</tr>
<tr>
<td>Pulley P1 (x6)</td>
<td></td>
</tr>
<tr>
<td>L1-1/4&quot; pin J1 (x10)</td>
<td></td>
</tr>
</tbody>
</table>

For pivot-base fingers, skip to step 12. Use a shim while press-fitting the pins to help ensure that nylon pulley spins freely at finger base.
Insert fingers into top plate from above as illustrated in the figures. Finger base should lie flush with plate `a1_flexure.stl`
Assemble pivot base sub-assembly as shown. Use shim when press-fitting the pin and pulley to ensure that the pulley spins freely after assembly.
Assemble top pivot base plate as shown above. The finger pivot bases should fit flush with the top plate.
## Assembly

**Pivot-base fingers top**

### Parts

<table>
<thead>
<tr>
<th>Description</th>
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</tr>
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<tbody>
<tr>
<td>Sub-assembly from step 13</td>
<td></td>
</tr>
<tr>
<td>Pivot-based Finger (x2)</td>
<td></td>
</tr>
<tr>
<td>Torsion spring (x2)</td>
<td></td>
</tr>
<tr>
<td>Ø1/8”, L1-1/4” pin J1 (x4)</td>
<td></td>
</tr>
<tr>
<td>Ø1/4”, L1-3/4” pin J3 (x2)</td>
<td></td>
</tr>
</tbody>
</table>

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Install the torsion spring as shown above. Position the finger appropriately in *c1.stl*, and then slide the ¼” pin J2 in place to secure this sub-assembly for each finger.
# ASSEMBLY

## FINAL ASSEMBLY – FLEXURE BASE

<table>
<thead>
<tr>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top sub-assembly from step 11</td>
</tr>
<tr>
<td>Base sub-assembly from step 9</td>
</tr>
<tr>
<td>Socket Cap Screw 8-32, L3/4” (x4)</td>
</tr>
</tbody>
</table>

Use remaining socket screws to clamp the entire assembly together in place. The actuator block sub-assembly from step 9 should fit snugly.
Use remaining socket screws to clamp the entire assembly together in place. The actuator block sub-assembly from step 9 should fit snugly.
Tendons for flexure-based fingers run from the drive pulleys, through the top plate, across the 3 pulleys in the finger base, and through the finger routing ports, anchoring at the back of the fingertip, as shown above.

There should be enough tendon to leave slack after tying both ends. It is probably easiest to thread the tendon up from the servo to the fingertip.
Tendons for flexure-based fingers run from the drive pulleys, through the top plate, across the pulley in the finger base, over the finger end, and through the finger routing ports, anchoring at the back of the fingertip, as shown above.

There should be enough tendon to leave slack after tying both ends.
Post-Assembly
SERVO ZERO-ING

1. Remove the M2 bolts from the servo pulley
2. Loosen, but do not remove, the central M2.5 bolt, such that the servo pulley can spin freely
3. Connect the Dynamixel and (in position mode) move it to its zero encoder position
4. By hand, turn the servo pulley until the tendon between the pulley and the main drive block is as taut as possible
5. Re-attach the M2 bolts and tighten the servo pulley
6. Repeat for other servo