Rolling Resistance Test Set Up
Please read the following document in its entirety before proceeding with testing

Test Method of ISWP Rolling Resistance Test
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The International Society of Wheelchair Professionals (ISWP) and the University of Pittsburgh. University of Pittsburgh scientists are working with the U.S. Agency for International Development (USAID) under sub-awards to develop the International Society of Wheelchair Professionals, a global network to ensure a level of standardization, certification and oversight, to teach and professionalize wheelchair services, and to build affiliations to put better equipment in the right hands. Since 2002, USAID has granted more than $45 million to improve wheelchairs and wheelchair services worldwide. The sub-awards are: Agreement No. APC-GM-0068 and Agreement No. APC-GM-0107, presented by Advancing Partners & Communities, a cooperative agreement funded through USAID under Agreement No. AIDOAA-A-12-00047, beginning Oct. 1, 2012; Agreement No. SPANS-037, presented through World Learning Special Programs to Address the Need of Survivors (SPANS); and FY19-A01-6024, presented through University Research Co. LLC Health Evaluation and Applied Research Development (HEARD) Project. HEARD is funded by United States Agency for International Development (USAID) under cooperative agreement number AID-OAA-A-17-00002. The project team includes prime recipient, University Research Co., LLC (URC) and sub-recipient organizations.

For further information on use of the ISWP Rolling Resistance Test set up instructions, contact the International Society of Wheelchair Professionals at intlsocietywheelchairprof@gmail.com.
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Wheel Test Set-up

The wheels need to have the quick-release axle removed for this test. Instead, use the axle wedge clamp, the appropriately sized spacer, and the axle wedge clamp for this set up. Also, this set up requires the placement of a camber block where the axle wedge clamp slides into.

The main parts to do any wheel test are the camber block, axle wedge clamp, spacer, and wheel.

Make sure to follow the Toe set up and Camber set up steps before adding the wheel and set it at the standard condition of Toe= 0°, Camber=0°, Tire Pressure: 100% (max pressure).

Add/Change the Wheel

**Tools needed:**
Hammer, 3/16” Allen

1. With the arm raised and the camber block in place, place the axle wedge clamp through the selected wheel.
2. Add a spacer and attach the wheel to the camber block. Use this table to select the spacer for the wheel to test. The spacers were custom made to fit each wheel properly.
Table 1. Spacer and wheel set up

<table>
<thead>
<tr>
<th>Spacer</th>
<th>Wheel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner diameter</td>
<td>Outside diameter</td>
</tr>
<tr>
<td>½”</td>
<td>¼”</td>
</tr>
<tr>
<td>½”</td>
<td>2”</td>
</tr>
<tr>
<td>½”</td>
<td>2”</td>
</tr>
</tbody>
</table>

You may need a dead blow to push the axle wedge clamp all the way through and tighten it with the center bolt of the wedge clamp.

3. Turn on the laser and make sure that the center of the axle trails slightly behind the laser.
4. If the axle is not aligned with the laser, adjustment is required on the linkage from the load cell to the truck.
5. Proceed with Tire Pressure and Surface Set up.
6. After the testing condition has been set up, follow the steps to **leveling the arm** every time you change the wheel.
7. Add the desired weight according to the steps from Load set up.

**Toe-set up**

*This set up applies to wheels only*

**Tools needed:**

1/4” Allen

To do this, you will need to see the toe plate from above it. Set Toe to 0° for arm leveling.

1. Loosen the bolt (left), align the toe plate and place the pin at the desired testing condition.
2. Tighten the bolt to secure the degree of toe and confirm the positive or negative toe you selected on the Toe plate is the same as the testing condition.

![Figure 4. Toe plate](image)
**Camber set-up**

*This setup applies to wheels only*

**Tools needed:**

1/8” Allen

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**Note:**

Before continuing, make sure you select the correct camber block from 0° to 5° for the testing condition to perform. Set camber at 0° to level arm.

Connect the lifting to hook to the arm and raise the arm until the wheel is slightly off the drum, about an inch (~2.5 cm) off the drum.

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1. Place the camber block on the plate and tighten it using the shoulder bolts with one washer on each.

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2. You can add the wheel now. Follow the Add/Change the wheel steps.

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**Tire Pressure Set up**

Add pressure to the tire only when raised in the air. If it is a pneumatic tire, inflate it to the pressure listed on the sidewall of the tire. Pressure should be at 100% (max pressure) for arm leveling.
Surface Set up

When adding carpet, treadmill or any different surface to the drum, extend it on the floor the day before testing to avoid creases.

The dimensions required for a surface to be added are: 13 ft (L) x 1 ft (W). You can use binder clips to secure the surface to the drum.

1. Remove shield
2. Set the carpet direction (or the testing surface) against the loop.
3. Secure with binder clips as it is fed onto the drum
4. Place the shield back

To remove the surface, start by removing the shield and binder clips progressively as the carpet is pulled out. At the end place the shield.

Leveling the Arm

**Tools needed:**
- Digital protractor, bubble level, 5/16 Allen

Prior to levelling the arm, make sure to set the machine at standard condition (Toe at 0º, Camber at 0º, and maximum tire pressure). You need to level the arm whenever you change wheels or casters. Do not level the arm when parameters are different to standard condition.

1. Make sure the wheel/caster is in contact with the testing surface. In other words, do not raise the arm.
2. Level the arm along the rods and across the rods. To do so, you can place a digital protractor and a bubble level over the truck (or whichever level combination you prefer).
3. Raise the motorcycle lift until there is some resistance from the double mount. This is to support the arm and protect it from dropping when leveling the arm.

4. Loosen the four (4) bolts slightly, so you can move the horizontal bar up and down by lifting or lowering the jack.
5. Adjust the truck so it is level within 0.1" in both directions.
   *Hint:* One bolt loose and one bolt tight on each side can help you do fine adjustments.
6. Lower the motorcycle lift so it is not in contact anymore and confirm the arm is level. If it is not level, repeat steps 3 to 6 until level.

7. Once the arm is level, remove the digital protractor and bubble level. Follow Load set up steps.

**Load set-up**

Before proceeding, check the magnet on the side of the track is in place and that it is rated to the load cell attached.

1. Connect the lifting to hook and load cell to the arm and raise the arm until the wheel (or caster) is slightly off the drum, about an inch (~2.5 cm) off the drum.
2. Add weights until the digital scale shows the testing weight in a range of ±0.5 lb of the desired load. You may need to use counterweights at the end of the rods and on top of the track to achieve the load desired.

![Figure 12. Load set up. 1. Weights, 2. Counterweights](image)

If necessary, secure the off-load weight with the two clamps, one on each side.

![Figure 13. Counterweight with clamps](image)

3. Lower the arm until the wheel (or caster) is in contact with the surface.
4. Remove the lifting hook and store it out of the way. The image below shows the hook unattached.

![Figure 14. Removal of the lifting hook](image)
Speed set-up

To set the speed, follow Start up steps. You can set the speed for the testing condition in the Connected Components Workbench (CCW) software.

1. In CCW, drag the frequency (Hz) so that the motor runs at the testing speed. Use the table below as a reference when setting the testing speed.

Table 2. Frequency setting for speed set up

<table>
<thead>
<tr>
<th>Speed (m/s)</th>
<th>Frequency (Hz)</th>
<th>Speed (m/s)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>11</td>
<td>1.00</td>
<td>45</td>
</tr>
<tr>
<td>0.50</td>
<td>23</td>
<td>1.25</td>
<td>56</td>
</tr>
<tr>
<td>0.75</td>
<td>34</td>
<td>1.33</td>
<td>60 (max)</td>
</tr>
</tbody>
</table>

Caster Test set-up

The caster test needs the addition of spacer blocks, as shown in the Figure below.

1. Raise the arm with the motorcycle lift. See step 3 under Leveling the arm.
2. Loosen the four bolts from the arm. (Figure 9 - See step 3 under Leveling the arm)
3. Carefully move the arm forward and place the spacer blocks.
4. Tighten the four bolts again.

Figure 15. Spacer blocks for caster test
Place the caster into a fork depending on its size. See the table below.

Table 3. Fork and caster set up

<table>
<thead>
<tr>
<th>Fork</th>
<th>Caster size</th>
<th>Hole to place bolt in Fork</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>Up to 5 in caster</td>
<td>Bottom hole</td>
</tr>
<tr>
<td>Large</td>
<td>5-8 in caster</td>
<td>Top hole</td>
</tr>
</tbody>
</table>

The main parts to do any caster tests are the L-shaped aluminum angle adapter, caster block, fork, and the caster wheel.

1. Connect the lifting to hook to the arm and raise the arm.
2. Add the L-shaped adapter to the same location where the camber block goes when doing the wheel test set-up.
3. Place the caster block on the L-shaped adapter, add the bolts and tighten them up.
4. Lift the arm enough so that the fork’s stem bolt can go through the caster block and tighten it from the top of the caster block. Ensure it still spins freely and is not overtightened.

5. You can add the caster wheel now. Follow the Add/Change the caster steps.
6. Check laser alignment that the for is trailing behind the laser.

**Add/Change Caster**

*Follow these steps after you have finished the Caster Test set-up.*

**Tools needed:**
Air pump, 2 adjustable wrenches

1. Connect the lifting to hook to the arm and raise the arm until the wheel (or caster) is slightly off the drum, about an inch (~2.5 cm) off the drum.

2. Add the caster to the fork and use a bolt and nut to secure it. Check Table 4 above to place the bolt in the right place depending on the caster size. Ensure it still spins freely and is not overtightened. Ensure it has the correct spacers or washers between the fork and the caster.
Make sure that the caster moves freely. If the caster is not moving freely, loosen the bolt. When it is too tight, the caster will not roll smoothly.

In case you need to change the caster, loosen the bolt from the fork using two wrenches. Remove the caster and add a new one. Start from step 2 once you remove the caster.

3. Turn on the laser and confirm the axle (bolt) is behind the laser guide. The location of the bolt is important because the caster always has to trail slightly on the downhill side of the drum.

4. Follow the steps to leveling the arm every time you change the caster.
Startup Protocol
Follow these steps after you have finished levelling the arm and the set up for the wheel or caster is completed. Besides, make sure the lifting hook is stored out of the way. The image below shows the hook unattached.

1. Turn on the main power disconnect.

2. Plug in the air hose to the system.

3. Check the air pressure on the regulator is within 60psi – 100 psi.
4. Confirm the power strip is on, so that the computer, amplifier, and DAQ are powered.
5. Turn on the Main Power.

6. Turn on the computer and open Matlab. Open the code and select the folder where you want to store the data collected.
7. Open Connected Components Workbench (CCW). Go to File menu and select Discover. The following window will open. Select the option at the bottom and expand it to select the last one and click OK.
   a. File > Discover > AB_ETHIP-1 Ethernet > 192.168.10.10 > Ok
8. Click on Control Bar to open the motor command window. Click OK in the following message.
9. Set the frequency for the motor based on the testing speed. For further detail, see Speed Set up.
10. Run the Matlab code. This code will prompt you to enter the information about the test parameters.
    Note: Do not add spaces, special characters or punctuation when entering the parameters, eg neg075 to refer to -0.75
11. After you entered all parameters, the Matlab code will prompt you to open the solenoid, and then click start on the CCW.
12. Turn on the compressed air through the air solenoid and start the drum in CCW with the correct frequency selected.
13. Hit enter on Matlab, as prompted at the end on the code.
14. Once the Matlab code finishes running, after 2mins, stop the drum from CCW and turn off the air solenoid.
    An Excel file will generate in which you can find the collected data.
15. If the test protocol requires more than one trial, repeat steps 10 – 14. Make sure to check the data collected is stored in the correct folder.

Shut down Protocol
1. Close control bar in CCW
2. Close CCW and MATLAB
3. Lock out computer
4. Close the air supply valve (disconnect the air hose).
5. Drain the compressed air using the air nozzle
6. Open the solenoid to drain air in the system.
7. Power off the main breaker.
8. Power off the main power to disconnect.
9. Remove weights from the track.
10. Connect the lifting to hook to the arm and raise the arm until the wheel (or caster) is slightly off the drum, about an inch (~2.5 cm) off the drum.
Adjustment Protocol

1. Connect the lifting to hook to the arm and raise the arm.

2. Mount the correct camber block to the toe plate.
3. Attach or remove the desired surface to the drum.
4. Adjust the toe plate to the desired angle and tighten the two shoulder bolts.
5. If it is a pneumatic tire, inflate it to the correct pressure.
6. Using the correct spacer, attach the wheel to the camber block using the axle wedge clamp.
7. Lower arm and remove the lifting hook. Store it out of the way.
8. Load the weight on the loading rod or unloading bar to achieve desired weight as read on the meter.
9. If necessary, secure the weight on the truck with a plate and nut.
10. If necessary, secure the off-load weight with the two clamps.
11. Lower arm and remove the lifting hook. Store it out of the way.
12. Start the test program in MATLAB and input the testing parameters when prompted.
13. Begin the test.
14. After allotted time, stop the drum from CCW.
15. Turn off the solenoid.
16. If the test protocol calls for more than one trial, repeat steps 12-15.
Test Parameters

For all cases, the air pressure supply is set at 100 psi.

- Tire type
  - solid, pneumatic, inserts
  - must be mounted on wheels using ½” axle
- Tire pressure
  - 40%, 60%, 80%, and 100% of max
- Camber
  - 0-5 degrees, 1 degree increments
- Toe
  - .5 degree increments from true 0 in toe out to max possible
  - -2.2 to 2.5 in 0.25 degree increments is the complete range.
- Load
  - Wheels
    - 35, 55, 75, 95 and 115 lbs
  - Casters
    - 30, 40, 50, 60, and 70 lbs
- Surfaces
  - smooth surface (drum), high, medium, and low pile carpet,
- Speed
  - 1 m/s
  - See chart above for options