Cassie rigid body details
Agility Robotics, 2016/12/13

Robot-forward along the X axis (red).
Robot-up along the Z axis (blue).
Robot-left along the Y axis (green).

All joints rotate around their local Z axis and obey the right-hand rule for positive rotations.

Toe and Toe Crank are parallel to eachother.

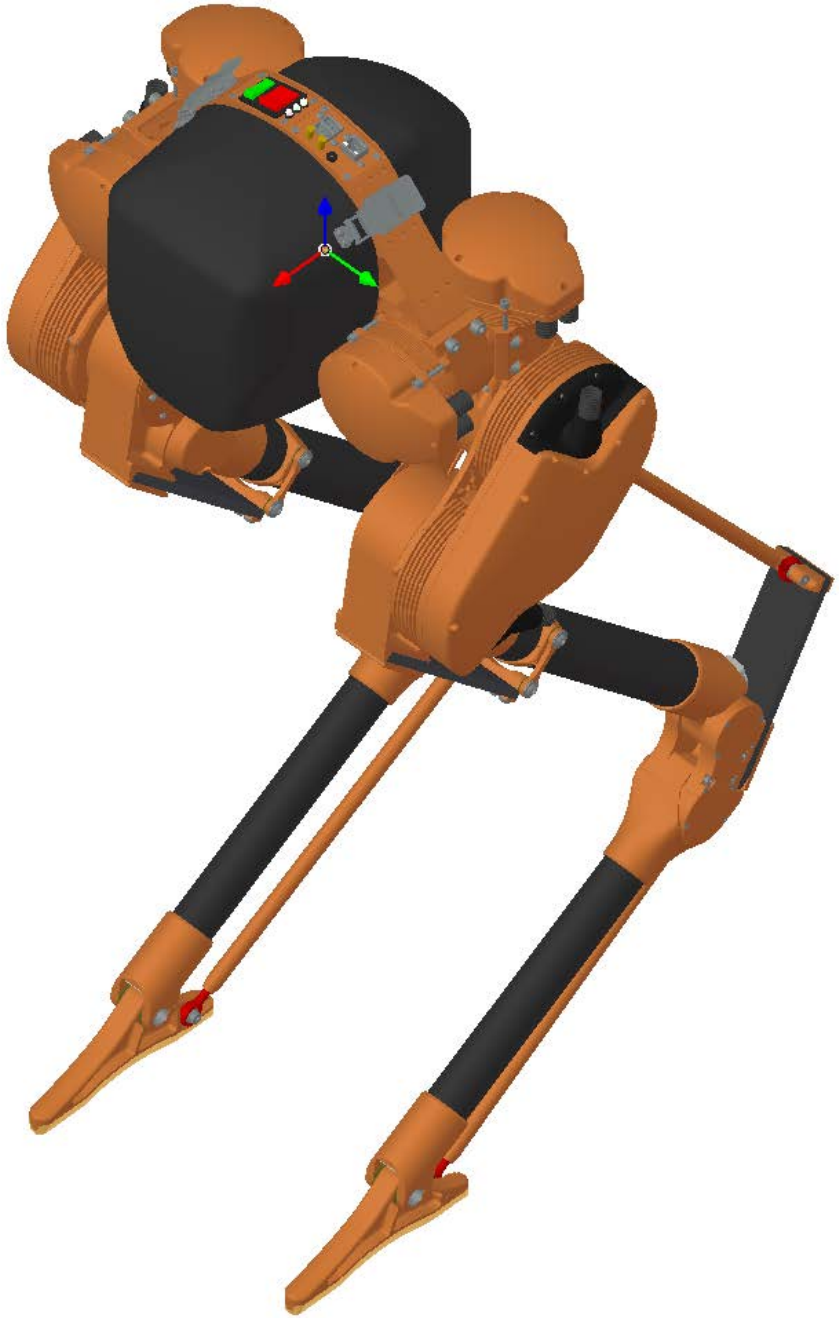
Thigh and tarsus remain 13 degrees from parallel for undeflected springs.

Neutral pose aligns all leg coordinate frames, straightening the leg.

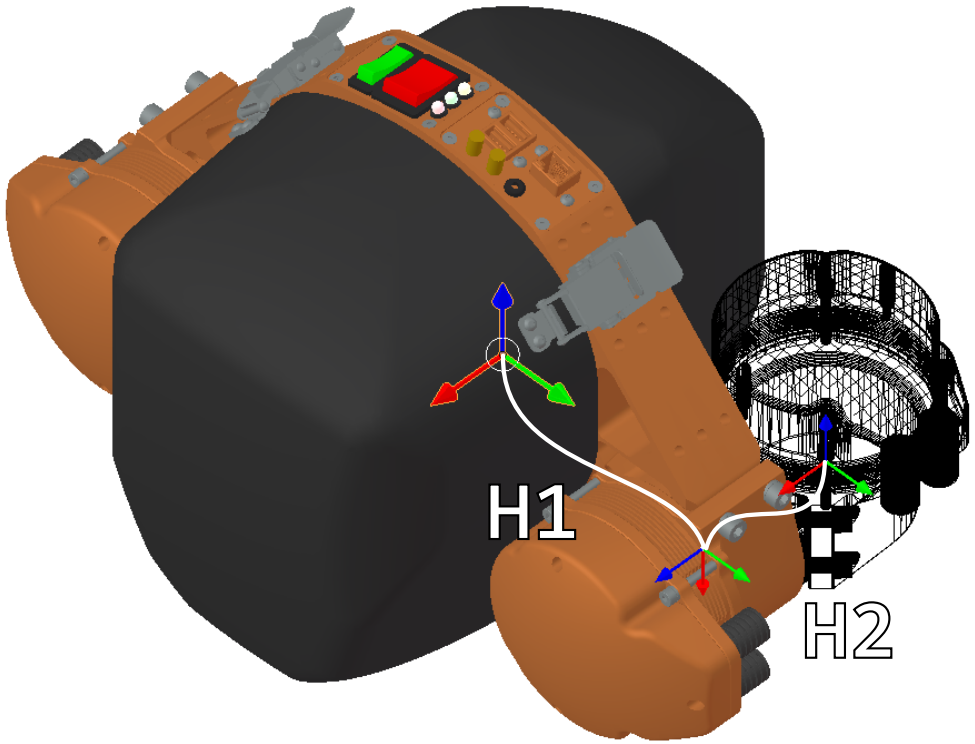
The following pages detail the **left leg's links**. The right leg has identical orientations, and negates all offsets in the global Y dimension.

Joint data (input-side inertia, gear ratio):

```
% Gimbals
J = 61; % kg.mm^2
G = 25;
% Knee, Hip
J = 365; % kg.mm^2
G = 16;
% Toe Actuator
J = 4.9; % kg.mm^2
G = 50;
```

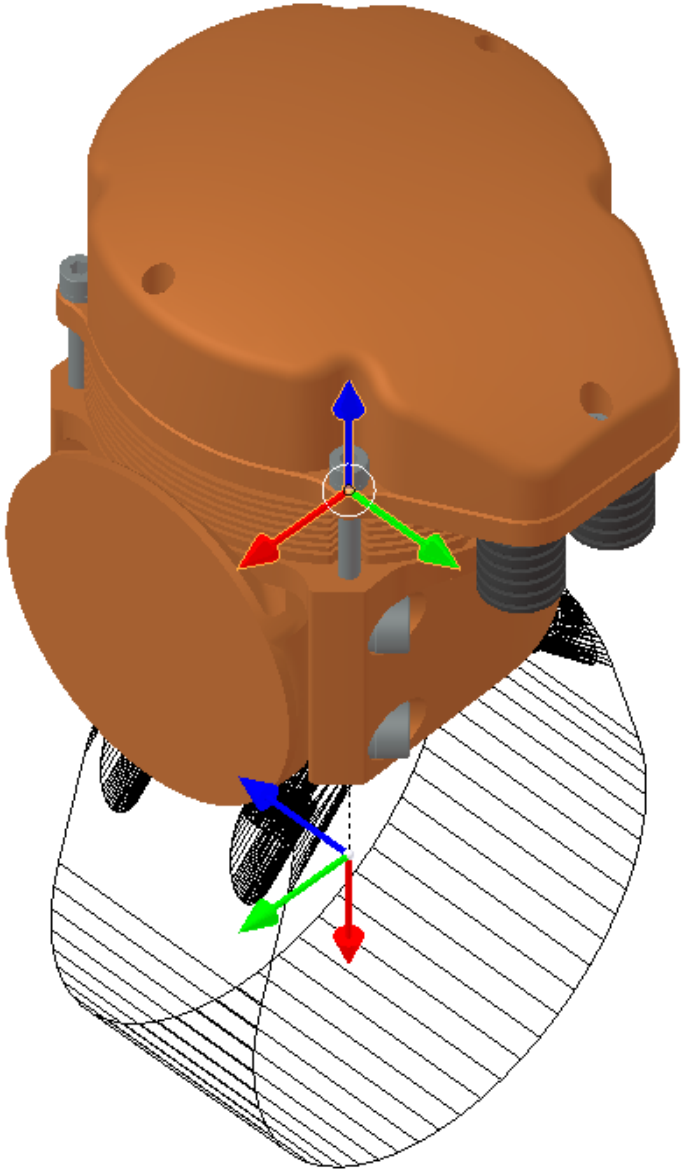


Pelvis



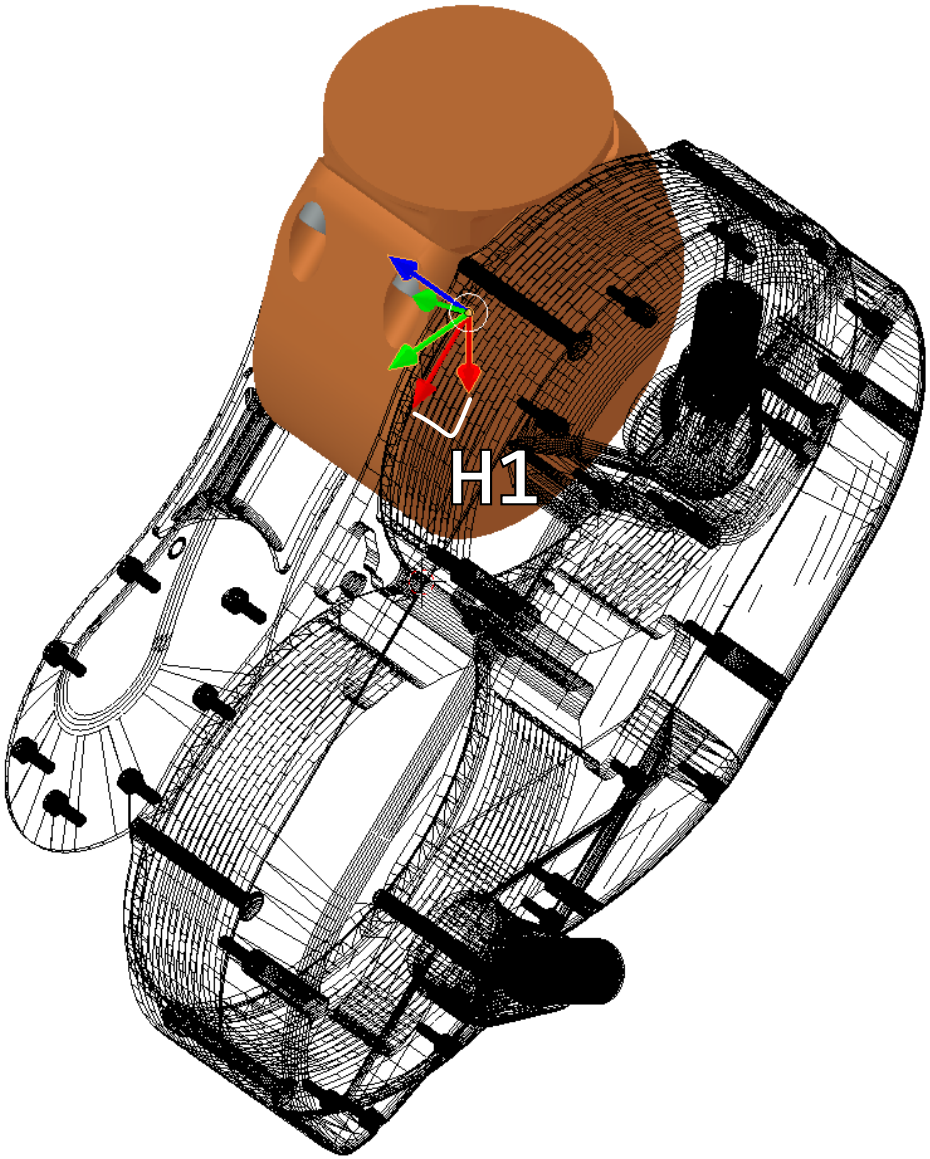

```
% Pelvis --> Abduction Axis @ Neutral
% Joint rotates around Z
H1 = [ 0, 0, -1,  21
       0, 1,  0, 135
       1, 0,  0,   0
       0, 0,  0,   1 ]; % mm

% Abduction --> Yaw Axis @ Neutral
% Joint rotates around Z
H2 = [  0, 0, 1,   0
        0, 1, 0,   0
       -1, 0, 0, -70
        0, 0, 0,   1 ]; % mm

% Inertia
J = [ 94200,   169,  15000
        169, 84000,    516
      15000,   516, 113000 ]; % kg.mm^2

% Mass
m = 10.33; % kg

% CoM
p = [ 50.7, 0, 28.4 ]'; % mm
```

Yaw



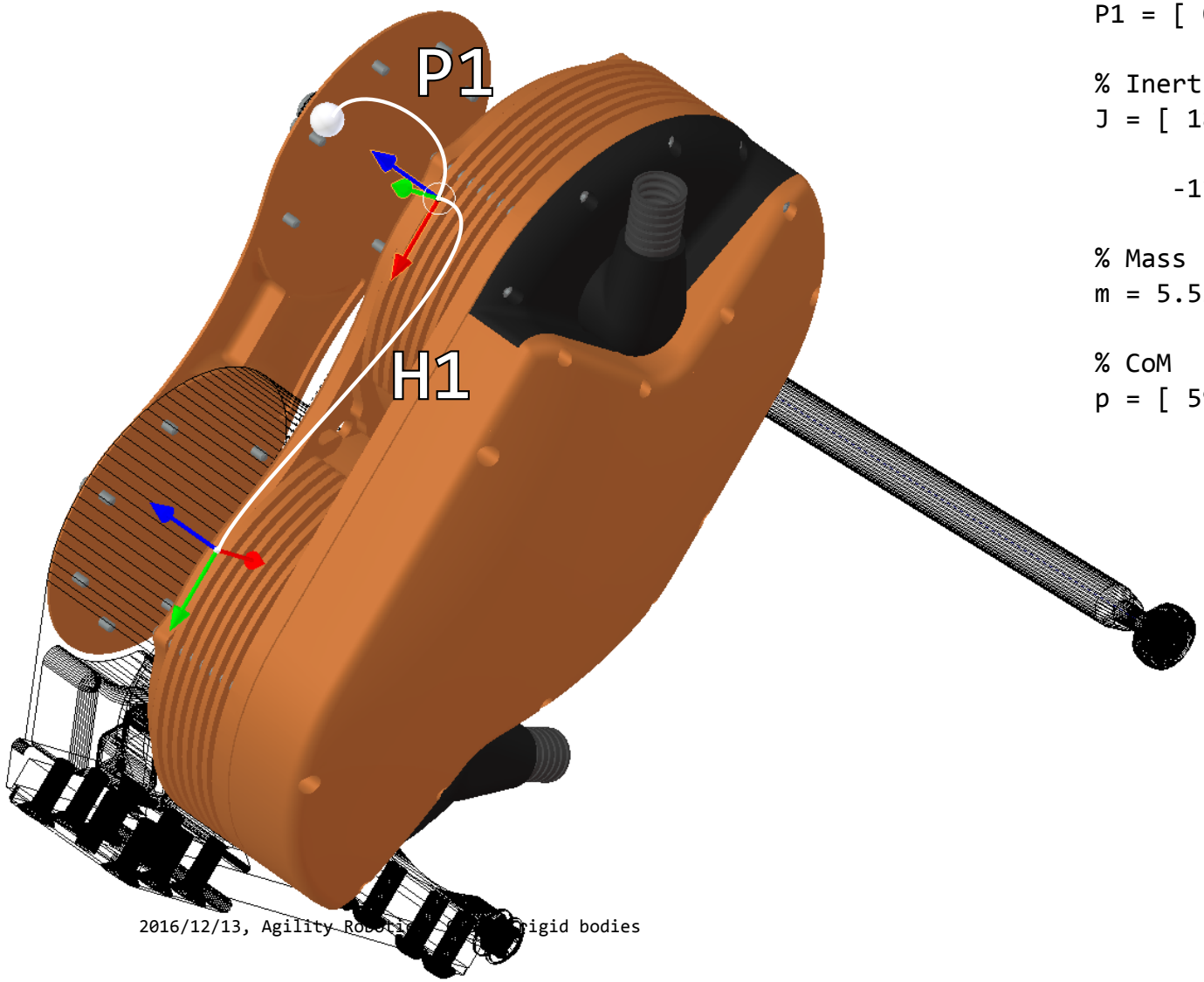
```
% Yaw --> Hip @ Neutral
% Joint rotates around Z
H = [ 0,  0, -1,   0
      1,  0,  0,   0
      0, -1,  0, -90
      0,  0,  0,   1 ]; % mm

% Inertia
J = [  2720, 0.703, 1.53
      0.703,  5590, 2.61
       1.53,  2.61, 4640 ]; % kg.mm^2

% Mass
m = 1.82; % kg

% CoM
p = [ 25.7, 0.1, 17.9 ]'; % mm
```

Hip




```
% Hip --> Thigh @ Neutral
% Joint rotates around Z
H1 = [ 1, 0, 0, 0
       0, 1, 0, 0
       0, 0, 1, 0
       0, 0, 0, 1 ]; % mm

% Inertia
J = [   842, 0.246, -0.625
      0.246,  6080,  -0.04
     -0.625, -0.04,   6440 ]; % kg.mm^2

% Mass
m = 1.17; % kg

% CoM
p = [-55.7, 0, 0]'; % mm
```

Thigh

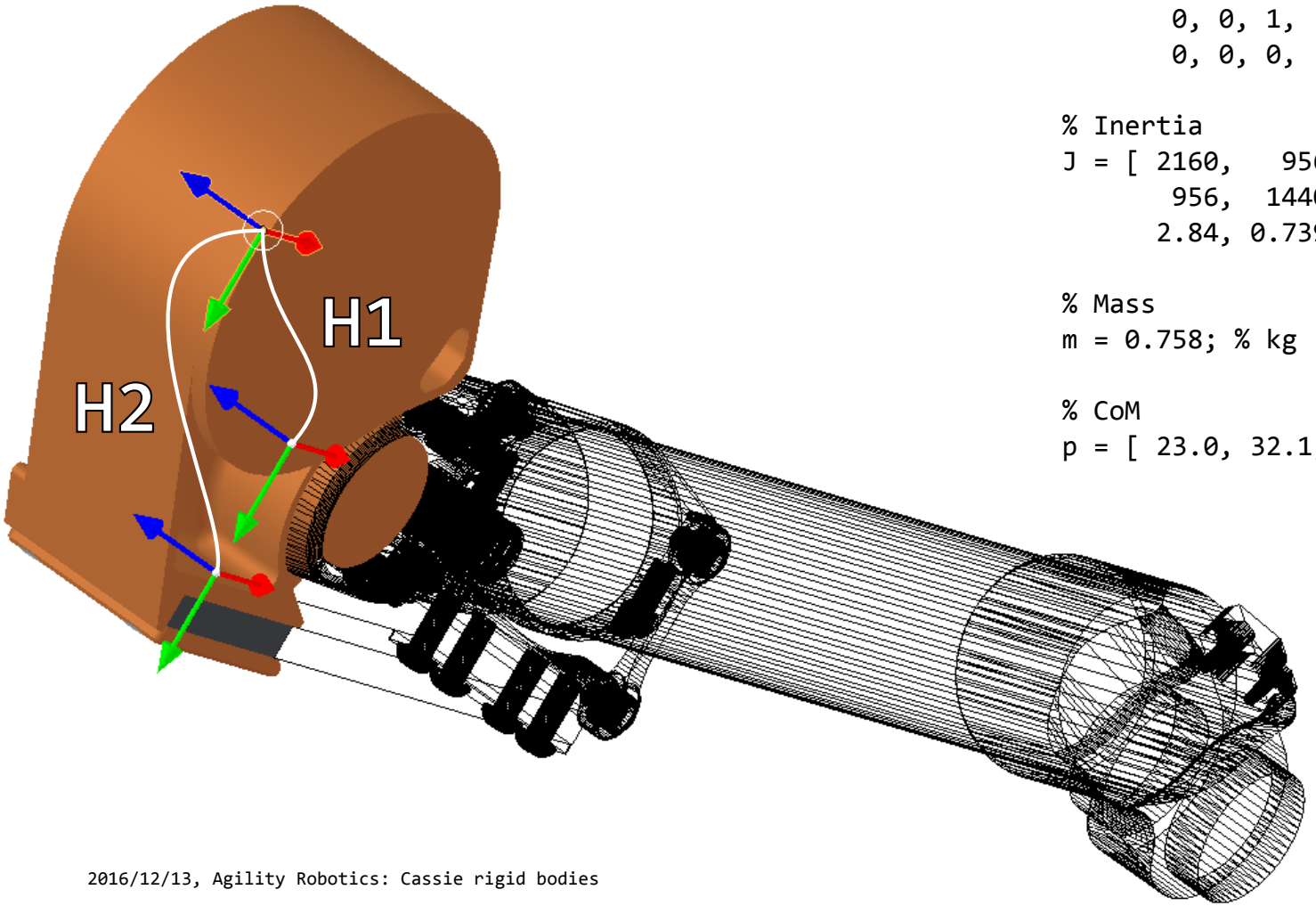



```
% Thigh --> Knee @ Neutral
% Joint rotates around Z
H1 = [ 1, 0, 0, 120
       0, 1, 0,   0
       0, 0, 1, 4.5
       0, 0, 0,   1 ]; % mm

% Thigh --> Achilles Rod End
% Spherical joint
P1 = [ 0, 0, 45 ]'; % mm

% Inertia
J = [ 18000,   284, -11700
        284, 56300,  -19.3
     -11700, -19.3,  49800 ]; % kg.mm^2

% Mass
m = 5.52; % kg

% CoM
p = [ 59.5, 0.1, -35.8 ]'; % mm
```

Achilles Rod

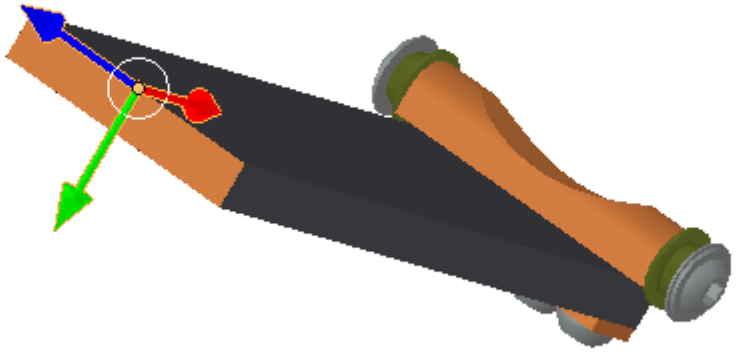
```
% Connects Thigh --> Heel Spring
% No transforms

% Inertia
J = [ 3.75,     0,     0
         0, 14060,     0
         0,     0, 14060 ]; % kg.mm^2

% Mass
m = 0.157; % kg

% CoM
p = [ 247.2, 0, 0 ]'; % mm
```

Knee



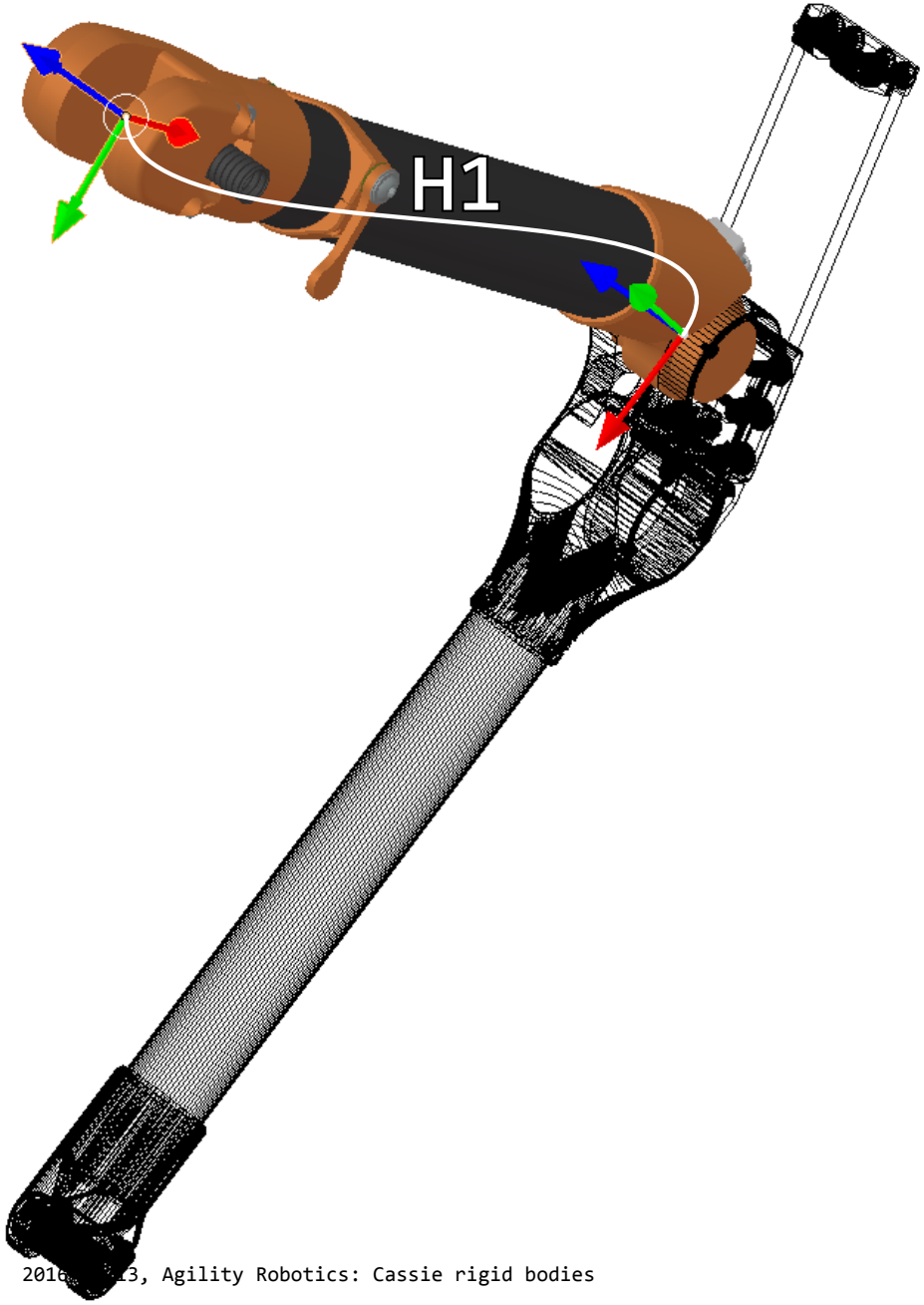

```
% Knee --> Shin @ Neutral
% Joint rotates around Z
H1 = [ 1, 0, 0, 60.7
       0, 1, 0, 47.4
       0, 0, 1,    0
       0, 0, 0,    1 ]; % mm

% Knee --> Knee Spring Base @ Neutral
% Joint rotates around Z
H2 = [ 1, 0, 0, 60.7
       0, 1, 0, 82.4
       0, 0, 1,    0
       0, 0, 0,    1 ]; % mm

% Inertia
J = [ 2160,   956,  2.84
       956,  1440, 0.739
      2.84, 0.739,  3340 ]; % kg.mm^2

% Mass
m = 0.758; % kg

% CoM
p = [ 23.0, 32.1, -2.2] '; % mm
```

Knee Spring



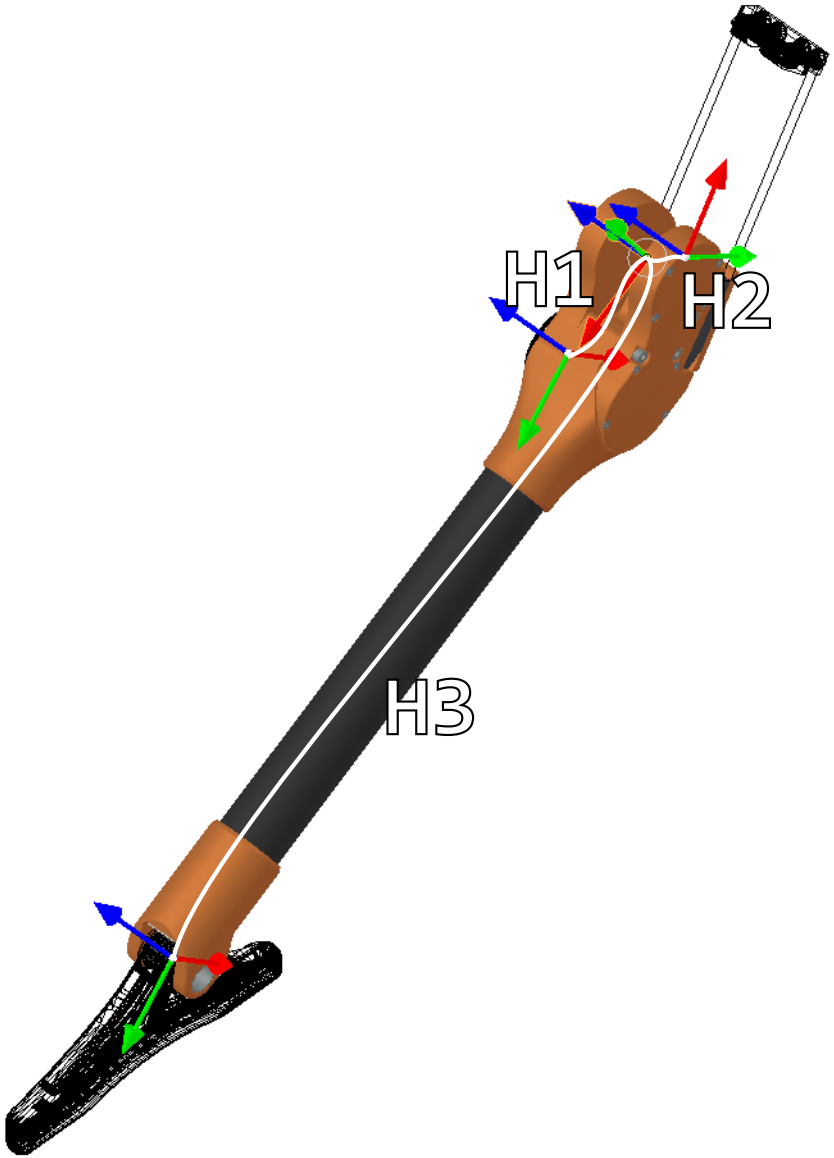
```
% Knee Spring Base --> Knee Spring Link @ Neutral
% Joint rotates around Z
H = [ 1, 0, 0, 132
      0, 1, 0,  -5
      0, 0, 1,   0
      0, 0, 0,   1 ]; % mm

% Inertia
J = [ 54.3, 46.0,    0
      46.0, 1710,    0
         0,    0, 1670 ]; % kg.mm^2

% Mass
m = 0.186; % kg

% CoM
p = [ 83.6, 3.4, 0 ]'; % mm
```

Shin



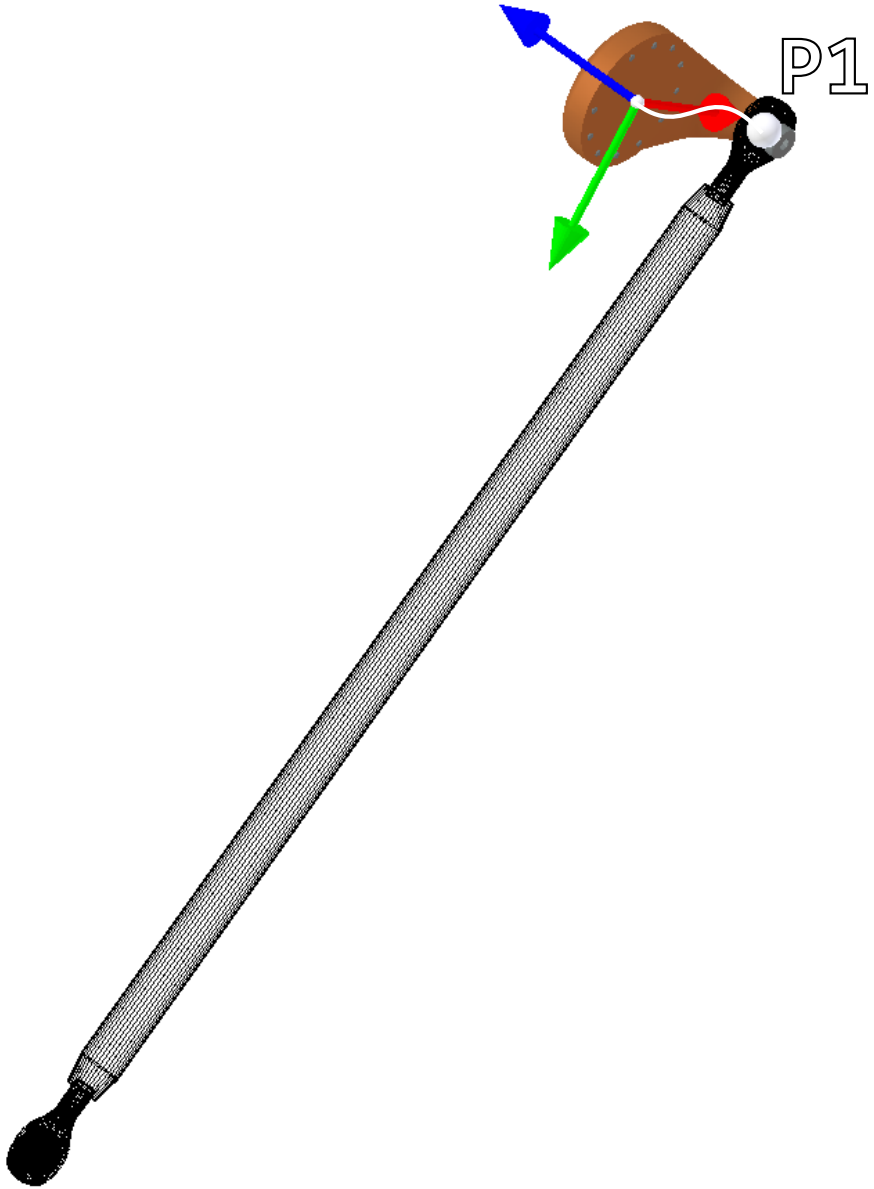

```
% Shin --> Ankle @ Neutral
% Joint rotates around Z
H1 = [ 1, 0, 0, 434.8
       0, 1, 0,    20
       0, 0, 1,     0
       0, 0, 0,     1 ]; % mm

% Inertia
J = [    360,   334, -0.194
         334, 34100,  0.265
      -0.194, 0.265,  34100 ]; % kg.mm^2

% Mass
m = 0.577; % kg

% CoM
p = [ 183.4, 1.2, 0.2 ]'; % mm
```

Tarsus



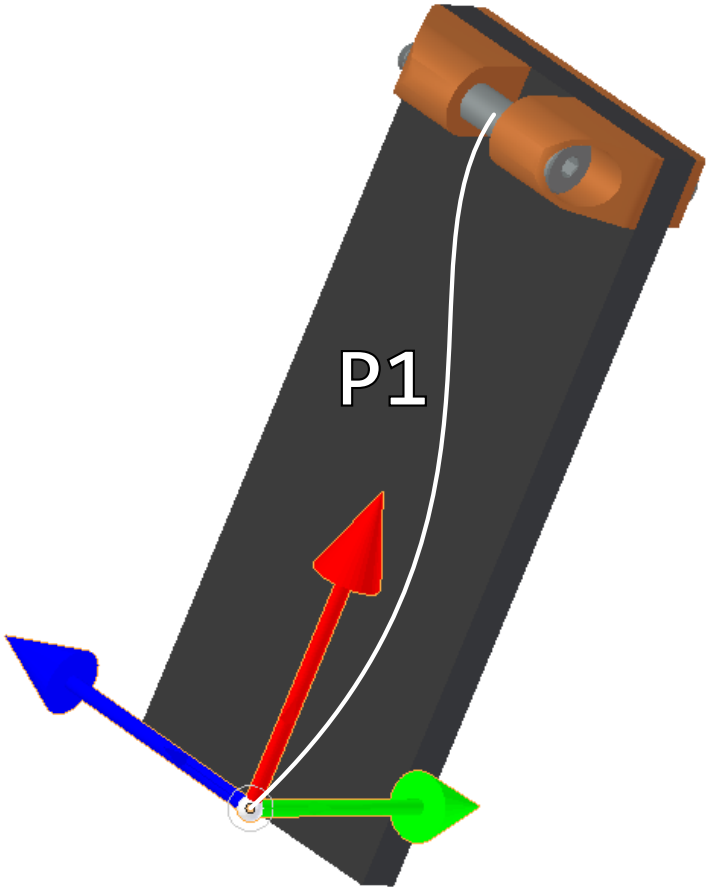

```
% Tarsus Axis --> Toe Crank Axis
% Joint rotates around Z
H1 = [ 1, 0, 0,   58
       0, 1, 0,   34
       0, 0, 1, 22.8
       0, 0, 0,    1 ]; % mm

% Tarsus Axis --> Achilles Spring Axis
% Joint rotates around Z
H2 = [ -0.9121266047,  -0.4098716742, 0.005501613619, -12.7
        0.4082402433,  -0.9095420663, -0.07793031078, -30.6
       0.03694537597, -0.06883632969,   0.9969436288,   0.9
                   0,              0,              0,     1 ]; % mm
% Euler Angles (XYZ)
ang = [ 4.47, 0.315, 155.8 ]; % degrees

% Tarsus Axis --> Toe Axis
% Joint rotates around Z
H3 = [ 1, 0, 0, 408
       0, 1, 0,  40
       0, 0, 1,   0
       0, 0, 0,   1 ]; % mm

% Inertia
J = [  1130, -2880, -63.3
      -2880, 23100,  36.2
      -63.3,  36.2, 23900 ]; % kg.mm^2

% Mass
m = 0.782; % kg

% CoM
p = [ 110.5, -30.6, -1.3 ]'; % mm
```

Toe Output Crank



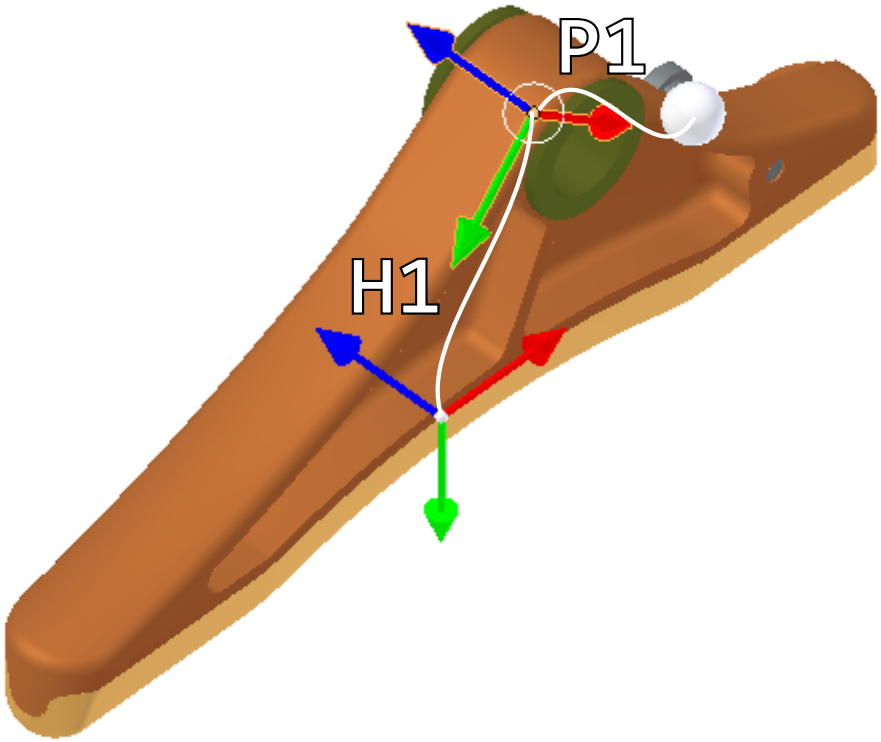

```
% Toe Output Crank --> Plantar Rod Connection
% Spherical joint
P1 = [ 55, 0, -7.9 ]'; % mm

% Inertia
J = [ 30700,  2.07,  2630
        2.07, 57100,  6.58
        2630,  6.58, 63400 ]; % kg.mm^2

% Mass
m = 0.129; % kg

% CoM
p = [ 4.8, 0, -2.9 ]'; % mm
```

Heel Spring




```
% Heel Spring Base --> Achilles Rod End @ Neutral
% Spherical Joint
P1 = [ 118.8, -10, 0 ]'; % mm

% Inertia
J = [  30.2,   15.3, -0.575
       15.3,   1050, 0.0557
     -0.575, 0.0557,   1030 ]; % kg.mm^2

% Mass
m = 0.126; % kg

% CoM
p = [ 81, 2.2, 0 ]'; % mm
```

Toe




```
% Toe Axis --> Midfoot
% End-effector coordinate frame
% Rotate/align at will
H1 = [ 1, 0, 0, 17.7
       0, 1, 0, 52.2
       0, 0, 1,    0
       0, 0, 0,    1 ]; % mm

% Toe Axis --> Plantar Rod Connection
% Spherical joint
P1 = [ 55, 0, 0 ]';

% Inertia
J = [   287, -98.6, -1.46
      -98.6,   171, 0.172
      -1.46, 0.172,   449 ]; % kg.mm^2

% Mass
m = 0.150; % kg

% CoM
p = [ 4.7, 27.5, -0.1 ]'; % mm
```

Plantar Rod

```
% Connects Toe Actuator Crank --> Toe
% No transforms

% Inertia
J = [   449, 0.172, -1.46
      0.172,   171, -98.6
      -1.46, -98.6,   287 ]; % kg.mm^2

% Mass
m = 0.119; % kg

% CoM
p = [177.9, 0, 0]'; % mm
```