



ISTITUTO ITALIANO DI TECNOLOGIA  

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ADVANCED ROBOTICS

# Walk-man

## Dims and Inertia

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ADVR Dept.28/11/2014

Legs Link section

# JOINT RANGES

LINK	DEG	RAD
<b>hip roll</b>		
ab	-50	-0.87222
ad	40	0.697778
<b>hip yaw</b>		
Sup.	-90	-1.57
Pron.	50	0.872222
<b>hip pitch</b>		
Ext.	-120	-2.09333
Flex.	60	1.046667
<b>knee pitch</b>		
Ext.	0	0
Flex.	140	2.442222
<b>ankle pitch</b>		
Ext.	-80	-1.39556
Flex.	40	0.697778
<b>ankle roll</b>		
ab	-45	-0.785
ad	45	0.785

# Pelvis

Note: the origin is in the middle of the pelvis

VOLUME = 1.6985800e+06 MM<sup>3</sup>

SURFACE AREA = 1.0613625e+06 MM<sup>2</sup>

AVERAGE DENSITY = 3.7726163e-06 KILOGRAM / MM<sup>3</sup>

MASS = 6.4080904e+00 KILOGRAM

**CENTER OF GRAVITY with respect to URDF\_ORIGIN\_FRAME coordinate frame:**

**X Y Z -3.2862932e+01 -5.0930727e-01 -1.2899617e+00 MM**

INERTIA with respect to URDF\_ORIGIN\_FRAME coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

INERTIA TENSOR:

Ixx Ixy Ixz 3.8838403e+04 1.8322173e+02 4.1810469e+02

Iyx Iyy Iyz 1.8322173e+02 3.1981597e+04 -1.7580654e+01

Izx Izy Izz 4.1810469e+02 -1.7580654e+01 5.4977508e+04

**INERTIA at CENTER OF GRAVITY with respect to URDF\_ORIGIN\_FRAME coordinate frame:**

**(KILOGRAM \* MM<sup>2</sup>)**

INERTIA TENSOR:

Ixx Ixy Ixz 3.8826078e+04 2.9047605e+02 6.8975598e+02

Iyx Iyy Iyz 2.9047605e+02 2.5050374e+04 -1.3370623e+01

Izx Izy Izz 6.8975598e+02 -1.3370623e+01 4.8055286e+04

**PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)**

**I1 I2 I3 2.5044218e+04 3.8780966e+04 4.8106554e+04**

ROTATION MATRIX from URDF\_ORIGIN\_FRAME orientation to PRINCIPAL AXES:

-0.02113 -0.99702 0.07413

0.99978 -0.02116 0.00036

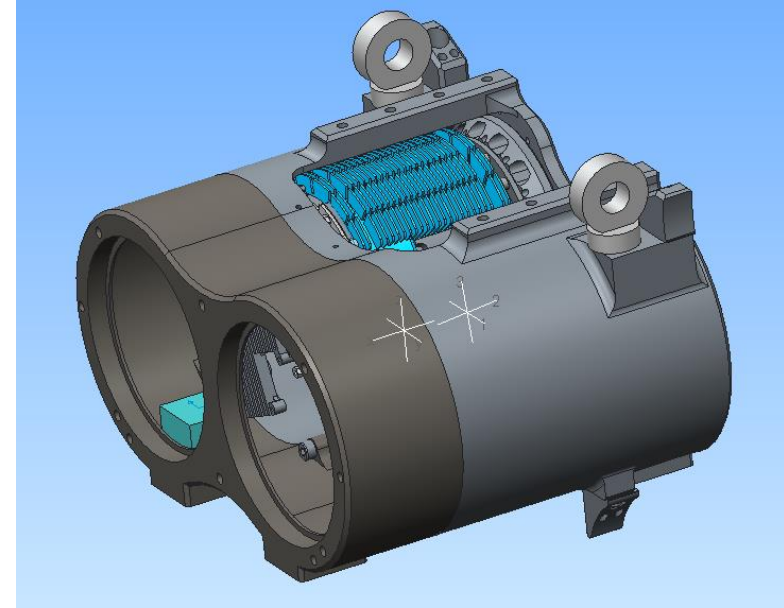
0.00121 0.07412 0.99725

ROTATION ANGLES from URDF\_ORIGIN\_FRAME orientation to PRINCIPAL AXES (degrees):

angles about x y z 0.000 4.251 91.214

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 6.2515746e+01 7.7793803e+01 8.6643863e+01 MM

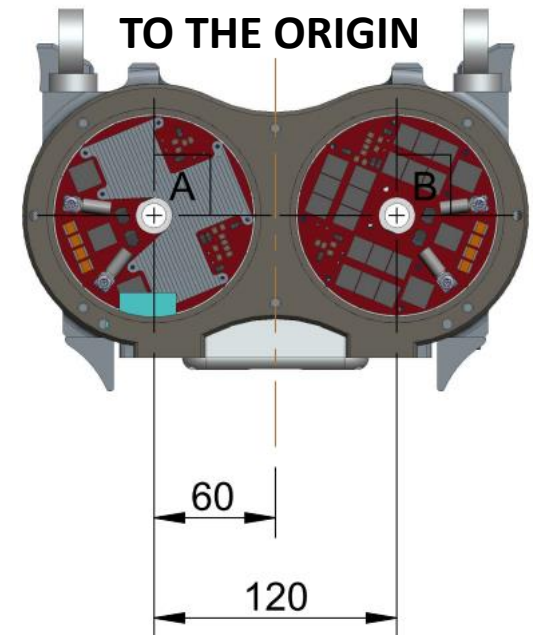


**JOINT FRAME  
LOCATION RESPECT  
TO THE ORIGIN**

**X:105.9 mm**

**Y:-60/+60 mm**

**Z: 0 mm**



# HIP ROLL LINK (RX)

VOLUME = 1.0946176e+06 MM^3  
SURFACE AREA = 6.2449456e+05 MM^2  
AVERAGE DENSITY = 3.4677130e-09 TONNE / MM^3  
MASS = 3.7958197e-03 TONNE

CENTER OF GRAVITY with respect to JOINT\_URDF\_AXIS coordinate frame:  
X Y Z -1.0348188e+02 -1.0919813e+02 -6.4924056e+01 MM

INERTIA with respect to JOINT\_URDF\_AXIS coordinate frame: (TONNE \* MM^2)

INERTIA TENSOR:  
Ixx Ixy Ixz 7.6901138e+01 -4.1042402e+01 -2.3111296e+01  
Iyx Iyy Iyz -4.1042402e+01 8.0167166e+01 -2.9241106e+01  
Izx Izy Izz -2.3111296e+01 -2.9241106e+01 1.0686341e+02

INERTIA at CENTER OF GRAVITY with respect to JOINT\_URDF\_AXIS coordinate frame: (TONNE \* MM^2)

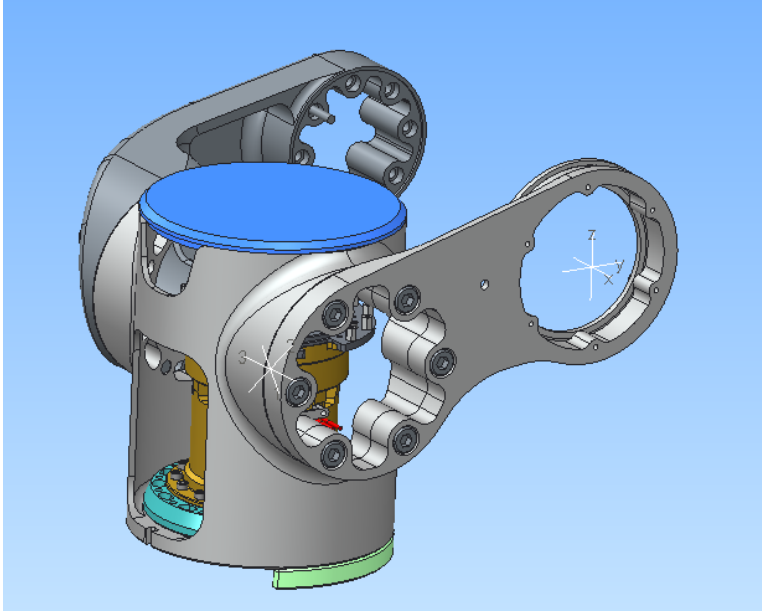
INERTIA TENSOR:  
Ixx Ixy Ixz 1.5639017e+01 1.8504661e+00 2.3907793e+00  
Iyx Iyy Iyz 1.8504661e+00 2.3519749e+01 -2.3303162e+00  
Izx Izy Izz 2.3907793e+00 -2.3303162e+00 2.0953643e+01

PRINCIPAL MOMENTS OF INERTIA: (TONNE \* MM^2)  
I1 I2 I3 1.4009617e+01 2.1187212e+01 2.4915580e+01

ROTATION MATRIX from JOINT\_URDF\_AXIS orientation to PRINCIPAL AXES:  
0.87992 0.47253 -0.04955  
-0.26744 0.40641 -0.87368  
-0.39270 0.78202 0.48398

ROTATION ANGLES from JOINT\_URDF\_AXIS orientation to PRINCIPAL AXES (degrees):  
angles about x y z 61.016 -2.840 -28.236

RADII OF GYRATION with respect to PRINCIPAL AXES:  
R1 R2 R3 6.0751966e+01 7.4710926e+01 8.1018223e+01 MM



## HIP YAW JOINT FRAME LOCATION RESPECT TO THE ROLL JOINT AXIS

X:-88.9 mm  
Y:-121.032mm  
Z:-217.872 mm

JOINT RANGE:  
-50deg abduction/ -0.872 rad  
+40deg adduction/ 0.698 rad

PEAK TORQUE: 220Nm

# HIP YAW LINK (RX)

VOLUME = 8.2179047e+05 MM^3  
SURFACE AREA = 5.4269426e+05 MM^2  
AVERAGE DENSITY = 3.9428625e-06 KILOGRAM / MM^3  
MASS = 3.2402068e+00 KILOGRAM

CENTER OF GRAVITY with respect to URDF\_JOINT\_AXIS coordinate frame:  
X Y Z -5.2929709e+00 -2.2561833e+01 5.6701669e+00 MM

INERTIA with respect to URDF\_JOINT\_AXIS coordinate frame: (KILOGRAM \* MM^2)

INERTIA TENSOR:  
Ixx Ixy Ixz 1.1855656e+04 -2.7835780e+02 3.5015913e+02  
Iyx Iyy Iyz -2.7835780e+02 6.9096514e+03 4.9796466e+02  
Izx Izy Izz 3.5015913e+02 4.9796466e+02 1.2225289e+04

INERTIA at CENTER OF GRAVITY with respect to URDF\_JOINT\_AXIS coordinate frame:  
(KILOGRAM \* MM^2)

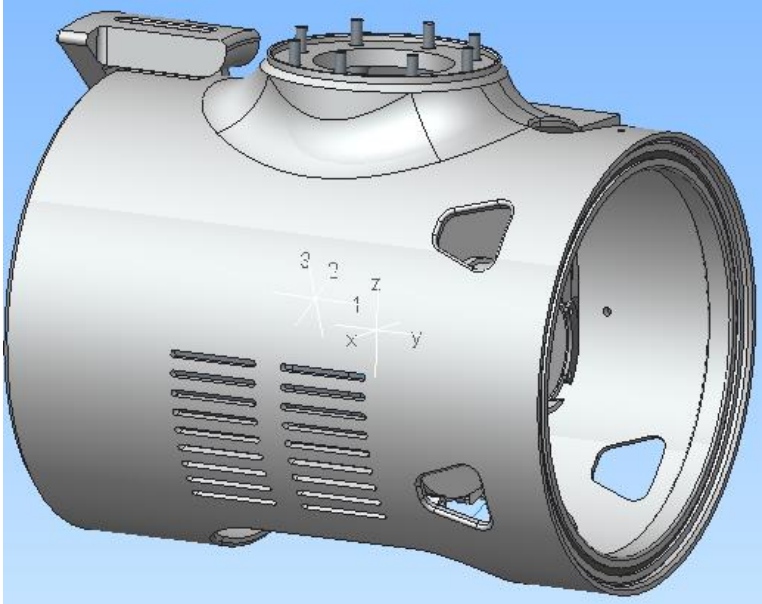
INERTIA TENSOR:  
Ixx Ixy Ixz 1.0102097e+04 1.0858487e+02 2.5291395e+02  
Iyx Iyy Iyz 1.0858487e+02 6.7147000e+03 8.3447072e+01  
Izx Izy Izz 2.5291395e+02 8.3447072e+01 1.0485130e+04

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM^2)  
I1 I2 I3 6.7097129e+03 9.9774679e+03 1.0614747e+04

ROTATION MATRIX from URDF\_JOINT\_AXIS orientation to PRINCIPAL AXES:  
-0.03049 -0.89372 0.44759  
0.99933 -0.01828 0.03158  
-0.02005 0.44825 0.89368

ROTATION ANGLES from URDF\_JOINT\_AXIS orientation to PRINCIPAL AXES (degrees):  
angles about x y z -2.024 26.589 91.954

RADII OF GYRATION with respect to PRINCIPAL AXES:  
R1 R2 R3 4.5505679e+01 5.5491160e+01 5.7235892e+01 MM



## HIP PITCH JOINT FRAME LOCATION RESPECT TO THE YAW JOINT AXIS

X:0 mm  
Y:0mm  
Z: 0mm

JOINT RANGE:  
-90deg / -1.57rad  
+50deg / 0.872rad

PEAK TORQUE: 120Nm

# HIP PITCH LINK (RX)

VOLUME = 1.5735748e+06 MM^3  
SURFACE AREA = 1.0039812e+06 MM^2  
AVERAGE DENSITY = 3.2378974e-06 KILOGRAM / MM^3  
MASS = 5.0950736e+00 KILOGRAM

CENTER OF GRAVITY with respect to URDF\_PITCH\_JOINT coordinate frame:  
X Y Z 3.7746286e+01 -2.8539939e+01 -1.9310133e+02 MM

INERTIA with respect to URDF\_PITCH\_JOINT coordinate frame: (KILOGRAM \* MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	2.4574367e+05	7.7141514e+03	3.9590247e+04
Iyx	Iyy	Iyz	7.7141514e+03	2.4159425e+05	-3.2180155e+04
Izx	Izy	Izz	3.9590247e+04	-3.2180155e+04	3.4783904e+04

INERTIA at CENTER OF GRAVITY with respect to URDF\_PITCH\_JOINT coordinate frame:  
(KILOGRAM \* MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	5.1607858e+04	2.2253472e+03	2.4529790e+03
Iyx	Iyy	Iyz	2.2253472e+03	4.4349153e+04	-4.1006942e+03
Izx	Izy	Izz	2.4529790e+03	-4.1006942e+03	2.3374453e+04

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM^2)

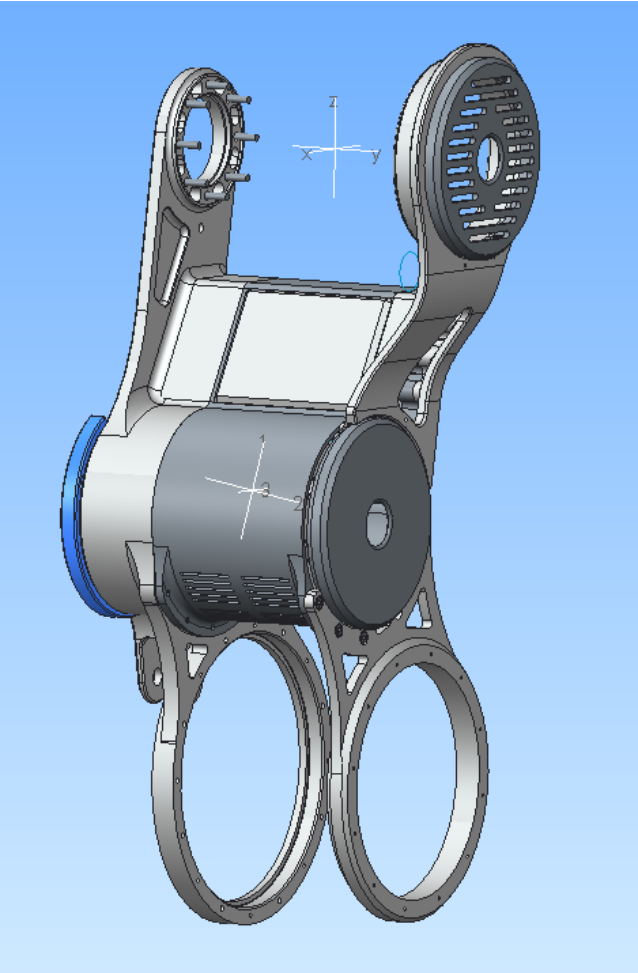
I1	I2	I3	2.2327869e+04	4.4708982e+04	5.2294613e+04
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ROTATION MATRIX from URDF\_PITCH\_JOINT orientation to PRINCIPAL AXES:

			-0.09639	-0.23201	-0.96793
			0.19162	0.94994	-0.24678
			0.97672	-0.20926	-0.04711

ROTATION ANGLES from URDF\_PITCH\_JOINT orientation to PRINCIPAL AXES (degrees):  
angles about x y z 100.807 -75.449 112.561

RADII OF GYRATION with respect to PRINCIPAL AXES:  
R1 R2 R3 6.6198539e+01 9.3674668e+01 1.0131022e+02 MM



KNEE PITCH JOINT FRAME  
LOCATION RESPECT TO THE HIP  
PITCH JOINT AXIS

X:0 mm  
Y:0mm  
Z: -356mm

JOINT RANGE:  
-120deg / -2.093rad  
+60deg / 1.046rad

PEAK TORQUE: 220Nm

# KNEE PITCH LINK (RX)

VOLUME = 1.5350398e+06 MM^3  
SURFACE AREA = 8.4278252e+05 MM^2  
AVERAGE DENSITY = 3.4552450e-06 KILOGRAM / MM^3  
MASS = 5.6495309e+00 KILOGRAM

CENTER OF GRAVITY with respect to CALF\_URDF coordinate frame:  
X Y Z -5.0828668e+00 3.7732093e+00 -7.2605017e+01 MM

INERTIA with respect to CALF\_URDF coordinate frame: (KILOGRAM \* MM^2)

INERTIA TENSOR:  
Ixx Ixy Ixz 1.3521729e+05 -4.7364144e+02 -4.1055231e+02 Iyx Iyy Iyz -4.7364144e+02 1.2778519e+05 -1.8293069e+03 Izx Izy Izz -4.1055231e+02 -1.8293069e+03 2.1080478e+04

INERTIA at CENTER OF GRAVITY with respect to CALF\_URDF coordinate frame: (KILOGRAM \* MM^2)

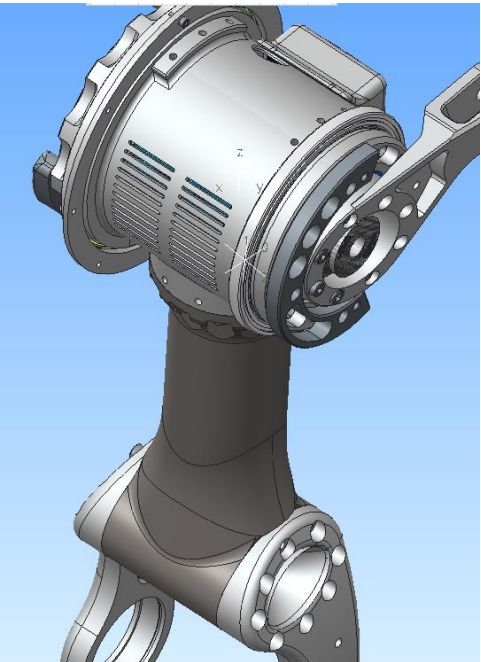
INERTIA TENSOR:  
Ixx Ixy Ixz 1.0535542e+05 -5.8199221e+02 1.6743598e+03 Iyx Iyy Iyz -5.8199221e+02 9.7857796e+04 -3.3770181e+03 Izx Izy Izz 1.6743598e+03 -3.3770181e+03 2.0854086e+04

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM^2)  
I1 I2 I3 2.0674223e+04 9.7948028e+04 1.0544505e+05

ROTATION MATRIX from CALF\_URDF orientation to PRINCIPAL AXES:  
-0.01945 0.08762 -0.99596  
0.04356 0.99528 0.08671  
0.99886 -0.04169 -0.02318

ROTATION ANGLES from CALF\_URDF orientation to PRINCIPAL AXES (degrees):  
angles about x y z -104.964 -84.850 -102.516

RADII OF GYRATION with respect to PRINCIPAL AXES:  
R1 R2 R3 6.0493457e+01 1.3167146e+02 1.3661768e+02 MM



ANKLE PITCH JOINT FRAME  
LOCATION RESPECT TO THE  
KNEE PITCH JOINT AXIS

X:0mm  
Y:0mm  
Z: 400mm

JOINT RANGE:  
0deg / 0 rad  
+140deg / 2.442rad

PEAK TORQUE: 220Nm



# ANKLE PITCH LINK (RX)

VOLUME = 7.9991704e+05 MM^3  
SURFACE AREA = 5.1081364e+05 MM^2  
AVERAGE DENSITY = 4.1059456e-06 KILOGRAM / MM^3  
MASS = 3.2844159e+00 KILOGRAM

CENTER OF GRAVITY with respect to ANKLE\_PITCH\_URDF coordinate frame:  
X Y Z -2.2024173e+01 2.5677238e+00 9.4588455e-01 MM

INERTIA with respect to ANKLE\_PITCH\_URDF coordinate frame: (KILOGRAM \* MM^2)

INERTIA TENSOR:  
Ixx Ixy Ixz 7.5796613e+03 8.6062318e+02 1.2675491e+02 Iyx Iyy Iyz 8.6062318e+02 1.2837254e+04 -1.5349790e+02 Izx Izy Izz 1.2675491e+02 -1.5349790e+02 1.5006672e+04

INERTIA at CENTER OF GRAVITY with respect to ANKLE\_PITCH\_URDF coordinate frame:  
(KILOGRAM \* MM^2)

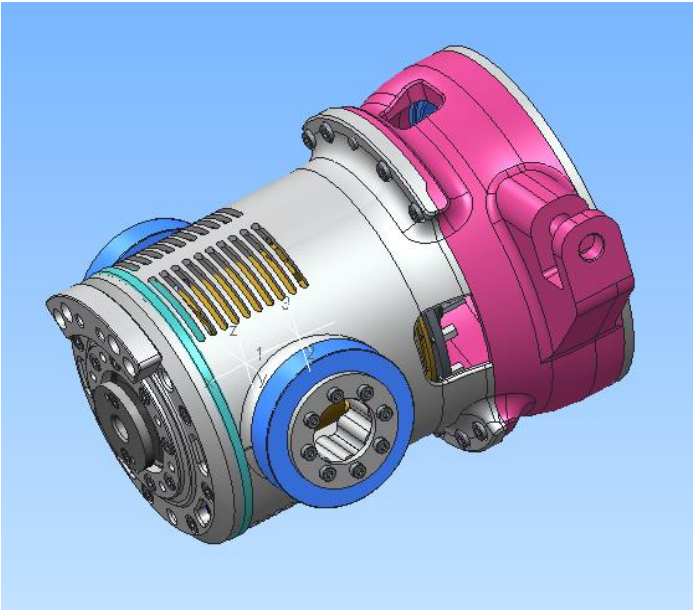
INERTIA TENSOR:  
Ixx Ixy Ixz 7.5550679e+03 6.7488292e+02 5.8332889e+01 Iyx Iyy Iyz 6.7488292e+02 1.1241163e+04 -1.4552081e+02 Ixz Izy Izz 5.8332889e+01 -1.4552081e+02 1.3391865e+04

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM^2)  
I1 I2 I3 7.4342371e+03 1.1352163e+04 1.3401695e+04

ROTATION MATRIX from ANKLE\_PITCH\_URDF orientation to PRINCIPAL AXES:  
0.98446 0.17559 0.00228  
-0.17505 0.98231 -0.06649  
-0.01392 0.06506 0.99778

ROTATION ANGLES from ANKLE\_PITCH\_URDF orientation to PRINCIPAL AXES (degrees):  
angles about x y z 3.813 0.131 -10.113

RADI OF GYRATION with respect to PRINCIPAL AXES:  
R1 R2 R3 4.7576132e+01 5.8790918e+01 6.3877925e+01 MM



ANKLE ROLL JOINT FRAME  
LOCATION RESPECT TO THE  
YAW JOINT AXIS

To check with lewis,  
Below there is the placement  
I suggest

X:0mm  
Y:0mm  
Z: 0mm

JOINT RANGE:  
-80deg / -1.395 rad  
+40deg / 0.697rad

PEAK TORQUE: 220Nm

## ANKLE ROLL LINK (RX)

OTHER DATA  
FROM Lewis

### JOINT RANGE:

-45deg / -0.785 rad

+45deg / 0.785rad

**PEAK TORQUE: 120Nm**

# Actuators section

# Big actuator: Shaft before gear box

VOLUME = 2.0455367e+04 MM^3  
SURFACE AREA = 2.1304325e+04 MM^2  
AVERAGE DENSITY = 3.1174016e-09 TONNE / MM^3  
MASS = 6.3767593e-05 TONNE

CENTER OF GRAVITY with respect to \_ROTOR\_ASSEMBLY coordinate frame:  
X Y Z 0.0000000e+00 -5.8448818e-02 3.2146704e+00 MM

INERTIA with respect to \_ROTOR\_ASSEMBLY coordinate frame: (TONNE \* MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	3.8595581e-02	0.0000000e+00	0.0000000e+00
Iyx	Iyy	Iyz	0.0000000e+00	3.8675520e-02	3.3875902e-05
Izx	Izy	Izz	0.0000000e+00	3.3875902e-05	2.1059873e-02

INERTIA at CENTER OF GRAVITY with respect to \_ROTOR\_ASSEMBLY coordinate frame: (TONNE \* MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	3.7936382e-02	0.0000000e+00	0.0000000e+00
Iyx	Iyy	Iyz	0.0000000e+00	3.8016539e-02	2.1894374e-05
Izx	Izy	Izz	0.0000000e+00	2.1894374e-05	2.1059656e-02

PRINCIPAL MOMENTS OF INERTIA: (TONNE \* MM^2)

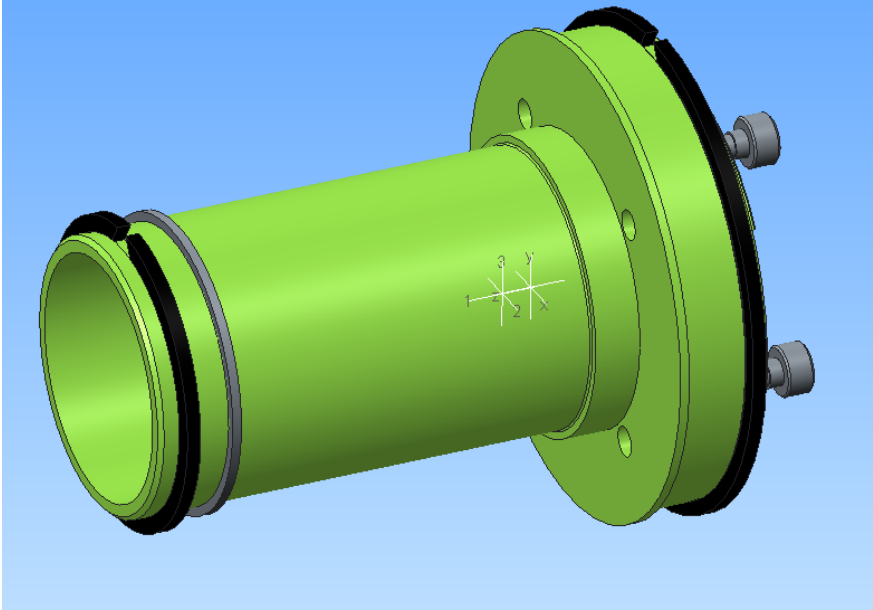
I1	I2	I3	2.1059627e-02	3.7936382e-02	3.8016567e-02
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ROTATION MATRIX from \_ROTOR\_ASSEMBLY orientation to PRINCIPAL AXES:

0.00000	1.00000	-0.00011
-0.00129	0.00011	1.00000
1.00000	0.00000	0.00129

ROTATION ANGLES from \_ROTOR\_ASSEMBLY orientation to PRINCIPAL AXES (degrees):  
angles about x y z -89.926 0.000 -90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:  
R1 R2 R3 1.8172946e+01 2.4390906e+01 2.4416670e+01 MM



**Inertia of the motor rotor:**  
5.43 x10-5 kg m^2  
from the datasheet

**Inertia of the harmonic drive:**  
0,263 x 10 -4 kg m^2 from the  
datasheet

Reduction ratio: 80.

# Big actuator: Shaft after gear box

VOLUME =  $8.3525405 \times 10^4$  MM<sup>3</sup>  
SURFACE AREA =  $9.0330408 \times 10^4$  MM<sup>2</sup>  
AVERAGE DENSITY =  $4.0560145 \times 10^{-9}$  TONNE / MM<sup>3</sup>  
MASS =  $3.3878025 \times 10^{-4}$  TONNE

CENTER OF GRAVITY with respect to \_WM0028A0 coordinate frame:  
X Y Z  $1.8150407 \times 10^{-4}$   $-1.8434214 \times 10^{-4}$   $1.7579705 \times 10^1$  MM

INERTIA with respect to \_WM0028A0 coordinate frame: (TONNE \* MM<sup>2</sup>)

INERTIA TENSOR:

Ixx Ixy Ixz  $1.1302565 \times 10^0$   $7.2527702 \times 10^{-6}$   $1.7490136 \times 10^{-6}$   
Iyx Iyy Iyz  $7.2527702 \times 10^{-6}$   $1.1299437 \times 10^0$   $-1.7573702 \times 10^{-6}$   
Izx Izy Izz  $1.7490136 \times 10^{-6}$   $-1.7573702 \times 10^{-6}$   $1.7595213 \times 10^{-1}$

INERTIA at CENTER OF GRAVITY with respect to \_WM0028A0 coordinate frame: (TONNE \* MM<sup>2</sup>)

INERTIA TENSOR:

Ixx Ixy Ixz  $1.0255578 \times 10^0$   $7.2527589 \times 10^{-6}$   $2.8299896 \times 10^{-6}$   
Iyx Iyy Iyz  $7.2527589 \times 10^{-6}$   $1.0252450 \times 10^0$   $-2.8552488 \times 10^{-6}$   
Izx Izy Izz  $2.8299896 \times 10^{-6}$   $-2.8552488 \times 10^{-6}$   $1.7595213 \times 10^{-1}$

PRINCIPAL MOMENTS OF INERTIA: (TONNE \* MM<sup>2</sup>)

I1 I2 I3  $1.7595213 \times 10^{-1}$   $1.0252448 \times 10^0$   $1.0255580 \times 10^0$

ROTATION MATRIX from \_WM0028A0 orientation to PRINCIPAL AXES:

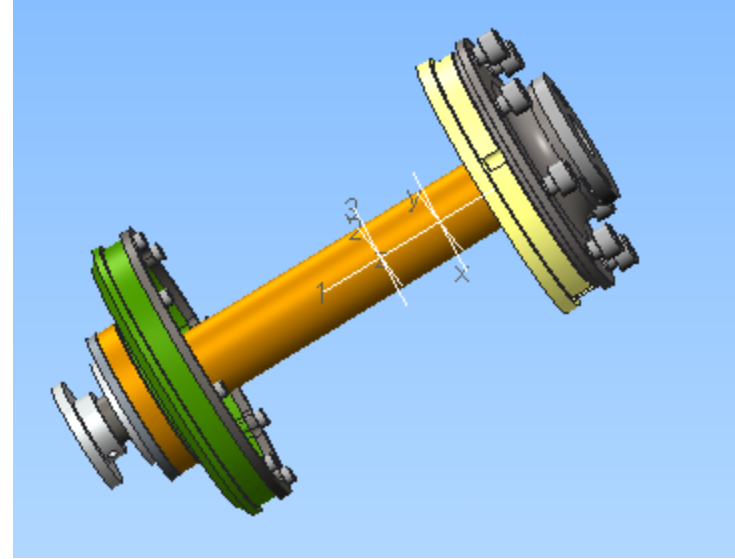
0.00000	-0.02317	-0.99973
0.00000	0.99973	-0.02317
1.00000	0.00000	0.00000

ROTATION ANGLES from \_WM0028A0 orientation to PRINCIPAL AXES (degrees):

angles about x y z 90.008 -88.673 90.008

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3  $2.2789679 \times 10^1$   $5.5011660 \times 10^1$   $5.5020061 \times 10^1$  MM



# Big actuator: Shaft after gear box with test rig parts

VOLUME = 4.0397776e+05 MM<sup>3</sup>

SURFACE AREA = 1.5604711e+05 MM<sup>2</sup>

AVERAGE DENSITY = 5.5858351e-09 TONNE / MM<sup>3</sup>

MASS = 2.2565532e-03 TONNE

CENTER OF GRAVITY with respect to \_WM0028A0 coordinate frame:

X Y Z 4.8974444e+01 1.1826665e+02 -6.3984696e+01 MM

INERTIA with respect to \_WM0028A0 coordinate frame: (TONNE \* MM<sup>2</sup>)

INERTIA TENSOR:

Ixx Ixy Ixz 7.2036101e+01 -2.4397073e+01 8.9323242e+00

Iyx Iyy Iyz -2.4397073e+01 2.3241235e+01 2.1568499e+01

Izx Izy Izz 8.9323242e+00 2.1568499e+01 6.9434852e+01

INERTIA at CENTER OF GRAVITY with respect to \_WM0028A0 coordinate frame: (TONNE \* MM<sup>2</sup>)

INERTIA TENSOR:

Ixx Ixy Ixz 3.1235271e+01 -1.1327020e+01 1.8611555e+00

Iyx Iyy Iyz -1.1327020e+01 8.5904790e+00 4.4925850e+00

Izx Izy Izz 1.8611555e+00 4.4925850e+00 3.2460110e+01

PRINCIPAL MOMENTS OF INERTIA: (TONNE \* MM<sup>2</sup>)

I1 I2 I3 3.0921155e+00 3.3265314e+01 3.5928431e+01

ROTATION MATRIX from \_WM0028A0 orientation to PRINCIPAL AXES:

0.37763 0.06262 0.92384

0.91143 0.15088 -0.38279

-0.16336 0.98657 -0.00009

ROTATION ANGLES from \_WM0028A0 orientation to PRINCIPAL AXES (degrees):

angles about x y z 90.014 67.493 -9.415

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.7017328e+01 1.2141519e+02 1.2618169e+02 MM

