# Inertia

```
syms theta_tilt L_tilt_vert L_tilt_horz L_pan_vert
L_pan_horz  m_tilt_vert m_tilt_horz m_pan_vert  m_pan_horz
```

## Tilt Axis

```
I_tilt = 2 * ( (1/12 * m_tilt_vert * L_tilt_vert^2) + 2 * m_tilt_horz * (L_tilt_vert/2)^2 )
```

I_tilt =

$$\frac{{L_{\mathrm{tilt,vert}}}^2\, m_{\mathrm{tilt,vert}}}{6} + {L_{\mathrm{tilt,vert}}}^2\, m_{\mathrm{tilt,horz}}$$

## Pan Axis

Inertia of the base pan frame

```
I_pan_base = (1/12 * m_pan_horz * L_pan_horz^2) + 2 * m_pan_vert * (L_pan_horz/2)^2
```

I_pan_base =

$$\frac{{L_{\mathrm{pan,horz}}}^2\, m_{\mathrm{pan,vert}}}{2} + \frac{{L_{\mathrm{pan,horz}}}^2\, m_{\mathrm{pan,horz}}}{12}$$

Inertia of the tilt system as a function of its angle

```
I_pan_tilt_asm_horz = 2 * ( 1/12 * m_tilt_horz * L_tilt_horz^2 ...
    + m_tilt_horz * (L_tilt_vert * sin(theta_tilt))^2 );
I_pan_tilt_asm_vert = 2 * ( 1/12 * m_tilt_vert * (m_tilt_vert*sin(theta_tilt))^2 )
+ m_tilt_vert * (m_tilt_horz/2)^2;
I_pan_tilt_asm = I_pan_tilt_asm_horz + I_pan_tilt_asm_vert
```

I_pan_tilt_asm =

$$2\, {L_{\mathrm{tilt,vert}}}^2\, m_{\mathrm{tilt,horz}} \sin(\theta_{\mathrm{tilt}})^2 + \frac{{L_{\mathrm{tilt,horz}}}^2\, m_{\mathrm{tilt,horz}}}{6} + \frac{{m_{\mathrm{tilt,vert}}}^3 \sin(\theta_{\mathrm{tilt}})^2}{6} + \frac{m_{\mathrm{tilt,vert}}\, {m_{\mathrm{tilt,horz}}}^2}{4}$$

Adding them up!

```
I_pan = simplify(I_pan_tilt_asm + I_pan_base)
```

I_pan =

$$\frac{{m_{\mathrm{tilt,vert}}}^3 \sin(\theta_{\mathrm{tilt}})^2}{6} + \frac{{L_{\mathrm{pan,horz}}}^2\, m_{\mathrm{pan,vert}}}{2} + \frac{{L_{\mathrm{pan,horz}}}^2\, m_{\mathrm{pan,horz}}}{12} + \frac{{L_{\mathrm{tilt,horz}}}^2\, m_{\mathrm{tilt,horz}}}{6} + \frac{m_{\mathrm{tilt,vert}}\, {m_{\mathrm{tilt,horz}}}^2}{4} + 2\, {L_{\mathrm{tilt,vert}}}^2\, m$$

# Actual Lengths and Masses

```
m_pr_meter = 0.4284/0.28
```

m_pr_meter = 1.5300

First, make all the masses functions of rod length

```
s     = [theta_tilt L_tilt_vert L_tilt_horz L_pan_vert L_pan_horz  m_tilt_vert
    m_tilt_horz            m_pan_vert            m_pan_horz           ];
s_new = [theta_tilt L_tilt_vert L_tilt_horz L_pan_vert L_pan_horz  L_tilt_vert
    *m_pr_meter L_tilt_horz*m_pr_meter L_pan_vert*m_pr_meter L_pan_horz*m_pr_meter];

I_tilt = simplify(subs(I_tilt, s, s_new));
I_pan = simplify(subs(I_pan, s, s_new));

vpa(I_tilt, 3)
```

ans = $0.255\, L_{\mathrm{tilt,vert}}^2\; (L_{\mathrm{tilt,vert}} + 6.0\, L_{\mathrm{tilt,horz}})$

```
vpa(I_pan, 3)
```

ans = $0.127\, L_{\mathrm{pan,horz}}^3 + 0.765\, L_{\mathrm{pan,vert}}\, L_{\mathrm{pan,horz}}^2 + 0.597\, L_{\mathrm{tilt,vert}}^3 \sin(\theta_{\mathrm{tilt}})^2 + 3.06\, L_{\mathrm{tilt,vert}}^2\, L_{\mathrm{tilt,horz}} \sin(\theta_{\mathrm{tilt}})^2 + 0.895\, L$

Now, for the lengths

```
s      = [ theta_tilt L_tilt_vert L_tilt_horz L_pan_vert L_pan_horz ];
s_real = [ theta_tilt 0.21        0.28        0.207      0.43       ];

I_tilt = subs(I_tilt, s, s_real);
vpa(I_tilt, 3)
```

ans = $0.0213$

```
I_pan  = subs(I_pan, s, s_real);
vpa(I_pan, 3)
```

ans = $0.0433 \sin(\theta_{\mathrm{tilt}})^2 + 0.0598$

For use in other scripts

```
J_tilt_out = I_tilt
```

J_tilt_out =

$$\frac{4250799}{200000000}$$

```
J_pan_out = I_pan
```

J_pan_out =

$$\frac{86626088199 \sin(\theta_{\mathrm{tilt}})^2}{2000000000000} + \frac{14939128233}{250000000000}$$