

```

>> syms Ix Iy Iz
>> I = [Ix 0 0; 0 Iy 0; 0 0 Iz]

I =

[ Ix, 0, 0]
[ 0, Iy, 0]
[ 0, 0, Iz]

>> syms p q r
>> w = [p;q;r]

w =

p
q
r

>> Ws = [0 -r q; r 0 -p; -q p 0]

Ws =

[ 0, -r, q]
[ r, 0, -p]
[ -q, p, 0]

>> syms L F1 F2 F3 M1 M2 M3 M4
>> u = [L*(F2-F4); L*(F3-F1); M1-M2+M3-M4]
Unrecognized function or variable 'F4'.

Did you mean:
>> u = [L*(F2-f14); L*(F3-F1); M1-M2+M3-M4]

u = [L*(F2-f14); L*(F3-F1); M1-M2+M3-M4]

u =

L*(F2 - 10)
F2*L
L*(F2 - 2)
L*(F2 - 1)

```

```

          F2*L
      L*(F2 - 1)
      L*(F2 - 2)
    -L*(F1 - F3)
M1 - M2 + M3 - M4

```

```
u =
```

```

      L*(F2 - 10)
          F2*L
      L*(F2 - 2)
      L*(F2 - 1)
          F2*L
      L*(F2 - 1)
      L*(F2 - 2)
    -L*(F1 - F3)
M1 - M2 + M3 - M4

```

```
>> u
```

```
u =
```

```

      L*(F2 - 10)
          F2*L
      L*(F2 - 2)
      L*(F2 - 1)
          F2*L
      L*(F2 - 1)
      L*(F2 - 2)
    -L*(F1 - F3)
M1 - M2 + M3 - M4

```

```
>>
```

```
>> syms F4
```

```
>> u = [L*(F2-F4); L*(F3-F1); M1-M2+M3-M4]
```

```
u =
```

```

      L*(F2 - F4)
    -L*(F1 - F3)

```

$$M1 - M2 + M3 - M4$$

```
>> u = [L*(F2-F4); L*(F3-F1); M1-M2+M3-M4]
```

```
u =
```

$$\begin{array}{c} L*(F2 - F4) \\ -L*(F1 - F3) \\ M1 - M2 + M3 - M4 \end{array}$$

```
>> u = [L*(F2-F4); L*(F1-F3); M1-M2+M3-M4]
```

```
u =
```

$$\begin{array}{c} L*(F2 - F4) \\ L*(F1 - F3) \\ M1 - M2 + M3 - M4 \end{array}$$

```
>>
```

```
>> u = [L*(F2-F4); L*(F3-F1); M1-M2+M3-M4]
```

```
u =
```

$$\begin{array}{c} L*(F2 - F4) \\ -L*(F1 - F3) \\ M1 - M2 + M3 - M4 \end{array}$$

```
>> Ws*I*w+u
```

```
ans =
```

$$\begin{array}{c} L*(F2 - F4) - I_y*q*r + I_z*q*r \\ I_x*p*r - L*(F1 - F3) - I_z*p*r \\ M1 - M2 + M3 - M4 - I_x*p*q + I_y*p*q \end{array}$$

```
>> H = inv(I)*ans
```

```
H =
```

$$\begin{array}{c} (L*(F2 - F4) - I_y*q*r + I_z*q*r)/I_x \\ -(L*(F1 - F3) - I_x*p*r + I_z*p*r)/I_y \end{array}$$

$$(M1 - M2 + M3 - M4 - I_x p^* q + I_y p^* q) / I_z$$

```
>> inv(I)*(-Ws*I*w+u)
```

```
ans =
```

$$\begin{aligned} & (L*(F2 - F4) + I_y q^* r - I_z q^* r) / I_x \\ & - (L*(F1 - F3) + I_x p^* r - I_z p^* r) / I_y \\ & (M1 - M2 + M3 - M4 + I_x p^* q - I_y p^* q) / I_z \end{aligned}$$

```
>> syms u2 u3 u4
```

```
>> u = [u2;u3;u4]
```

```
u =
```

```
u2
```

```
u3
```

```
u4
```

```
>> inv(I)*(-Ws*I*w+u)
```

```
ans =
```

$$\begin{aligned} & (u2 + I_y q^* r - I_z q^* r) / I_x \\ & (u3 - I_x p^* r + I_z p^* r) / I_y \\ & (u4 + I_x p^* q - I_y p^* q) / I_z \end{aligned}$$

```
>> syms roll pitch yaw
```

```
>> syms phi theta psi
```

```
>> H = [1 sin(psi)*tan(theta) cos(psi)*tan(theta); 0 cos(psi) -sin(psi); 0 ✓  
sin(psi)/cos(theta) cos(psi)/cos(theta)]
```

```
H =
```

$$\begin{bmatrix} 1, & \sin(\psi) \tan(\theta), & \cos(\psi) \tan(\theta) \\ 0, & \cos(\psi), & -\sin(\psi) \\ 0, & \sin(\psi) / \cos(\theta), & \cos(\psi) / \cos(\theta) \end{bmatrix}$$

```
>> H*w
```

```
ans =
```

```
p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)
      q*cos(psi) - r*sin(psi)
(r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta)

>> G = H*w

G =

p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)
      q*cos(psi) - r*sin(psi)
(r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta)

>> w

w =

p
q
r

>> size(G)

ans =

      3      1

>> G

G =

p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)
      q*cos(psi) - r*sin(psi)
(r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta)

>> G*w
Error using symengine
Dimensions do not match.

Error in sym/privBinaryOp (line 1032)
    Csym = mupadmex(op,args{1}.s, args{2}.s, varargin{:});
```

```
Error in * (line 322)
    X = privBinaryOp(A, B, 'symobj::mtimes');

>> w

w =

p
q
r

>> G

G =

p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)
      q*cos(psi) - r*sin(psi)
(r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta)

>> G*w
Error using symengine
Dimensions do not match.

Error in sym/privBinaryOp (line 1032)
    Csymb = mupadmex(op,args{1}.s, args{2}.s, varargin{:});

Error in * (line 322)
    X = privBinaryOp(A, B, 'symobj::mtimes');

>> size(G)

ans =

     3     1

>> size(w)

ans =

     3     1
```

```
>> G
```

```
G =
```

```
p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)
      q*cos(psi) - r*sin(psi)
(r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta)
```

```
>> Gs = [0 -G(3) G(2);G(3) 0 -G(1);-G(2) G(1) 0]
```

```
Gs =
```

```
[
                                0, - (r*cos(psi))/cos(theta) - (q*sin(psi))/cos(theta),
(psi) - r*sin(psi)]
[ (r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta),
0, - p - r*cos(psi)*tan(theta) - q*sin(psi)*tan(theta)]
[
                                r*sin(psi) - q*cos(psi),    p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta),
0]
```

```
>> inv(I)*(-Gs*I*G+u)
```

```
ans =
```

```
(u2 + Iy*((r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(q*cos(psi) - r*sin(psi)) - Iz*((r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(q*cos(psi) - r*sin(psi)))/Ix
(u3 - Ix*((r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)) + Iz*((r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)))/Iy
(u4 + Ix*(q*cos(psi) - r*sin(psi))*(p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)) - Iy*(q*cos(psi) - r*sin(psi))*(p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta)))/Iz
```

```
>> Sys = ans;
```

```
>> sys
```

Unrecognized function or variable 'sys'.

Did you mean:

>> Sys

Sys =

```

                                (u2 + Iy*((r*cos(
(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(q*cos(psi) - r*sin(psi)) -
Iz*((r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(q*cos(psi) -
r*sin(psi)))/Ix
    (u3 - Ix*((r*cos(psi))/cos(theta) + (q*sin(psi))/cos(theta))*(p + r*cos
(psi)*tan(theta) + q*sin(psi)*tan(theta)) + Iz*((r*cos(psi))/cos(theta)
+ (q*sin(psi))/cos(theta))*(p + r*cos(psi)*tan(theta) + q*sin(psi)*tan
(theta)))/Iy
                                (u4 + Ix*(q*cos(
(psi) - r*sin(psi))*(p + r*cos(psi)*tan(theta) + q*sin(psi)*tan(theta))
- Iy*(q*cos(psi) - r*sin(psi))*(p + r*cos(psi)*tan(theta) + q*sin(psi)
*tan(theta)))/Iz

```

>> pretty(Sys)

```

/ u2 + Iy #1 #3 - Iz #1 #3 \
| ----- |
|           Ix           |
|                         |
| u3 - Ix #1 #2 + Iz #1 #2 |
| ----- |
|           Iy           |
|                         |
| u4 + Ix #3 #2 - Iy #3 #2 |
| ----- |
|           Iz           |
\

```

where

$$\#1 == \frac{r \cos(\psi)}{\cos(\theta)} + \frac{q \sin(\psi)}{\cos(\theta)}$$

$$\#2 == p + r \cos(\psi) \tan(\theta) + q \sin(\psi) \tan(\theta)$$


```
#3 == q cos(psi) - r sin(psi)
```

```
>>
```