**Three-Dimensional Generalized Forces**

**Moment about local origin**

 global directions

 local directions

**Generalized force on body i about local origin**

 note that force is in global directions and torque is in local directions

**Pure force**



**Pure moment**



**Translational spring-damper-actuator often with cylindrical or prismatic**































**Rotational spring-damper-actuator about revolute, cylindrical or screw joint**

 measured +CCW about  along axis of rotation







 use  but not  just in case 









**Axial Coulomb friction in cylindrical or prismatic joints**

1) Start with coefficient of friction 

2) Use  along axis of translation

3) Compute constraint force  and find all components of  in local directions

4) Determine normal force 

5) Compute 

6) repeat steps 3) through 5) until convergence by relaxation

**Torsional Coulomb friction in revolute or cylindrical joints**

1) Start with coefficients of friction  and 

2) Use  along axis of rotation

3) Compute constraint force  and find components all of  in local directions

4) Determine radial force 

5) Compute  for cylindrical joint

6) Compute  for revolute joint

7) repeat steps 3) through 6) until convergence by relaxation

**Torsional Coulomb friction in spherical joint**

1) Start with coefficient of friction 

2) Use  for axis of rotation (note global directions)

3) Compute constraint force  and find  (note global directions)

4) Determine axial force 

5) Determine radial force 

6) Compute  for  (note global directions)

7) 

8) repeat steps 2) through 5) until convergence by relaxation