**Three-Dimensional Kinematics**

**Position**



**Velocity**















**Acceleration**



















**Jerk**





 NOT angular momentum









 NOT angular momentum











**Snap**



























**2D partial derivatives**



by inspection 





chain rule 

compare to terms in chain rule 

**3D partial derivatives**















chain rule 

compare to terms in chain rule 

partial derivative wrt Euler parameters 





chain rule 

compare to terms in chain rule 

partial derivative wrt  directions 

 