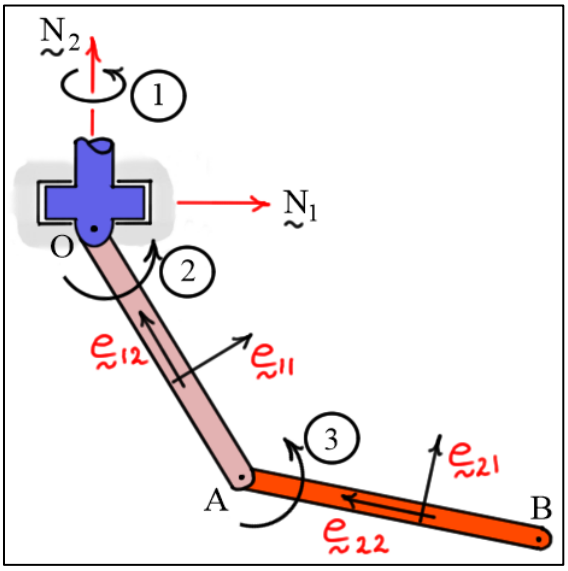
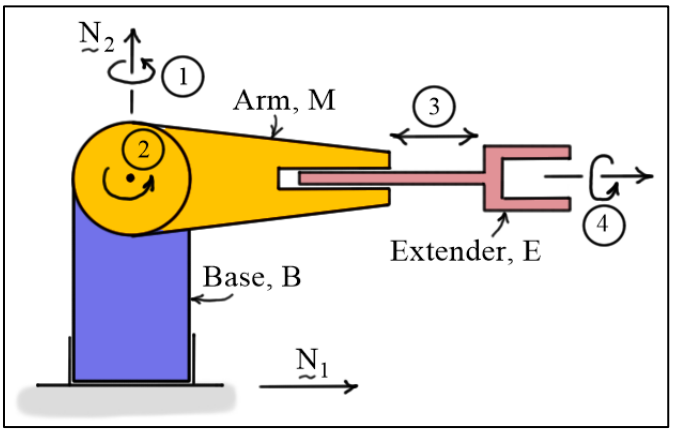
Multibody Dynamics
Exercises #4

1. Shown at the right is a ***three-dimensional pendulum*** with two links (OA and AB). Link OA is connected to ground using a two-axis rotational joint (indicated by degrees-of-freedom 1 and 2 in the diagram). Link AB is connected to link OA using a single-axis rotational joint (indicated by degree-of-freedom 3).



   Write the ***nine*** $\left((2\times6)-3 = 9\right)$ constraint equations for this system using a) ***relative coordinates*** and b) ***absolute coordinates***. Express the rotational constraints directly in terms of the angular velocity components. Use body-fixed angular velocity components.

2. Shown below is a ***robotic arm*** with three bodies and four degrees-of-freedom. Base B is connected to the ground with a single-axis rotational joint (indicated by degree-of-freedom 1 in the diagram). Arm M is connected to B with a single-axis rotational joint (indicated by degree-of-freedom 2). The extender E is connected to M using a two degree-of-freedom joint that allows both translation and rotation of E relative to M (indicated by degrees-of-freedom 3 and 4).



   Write the ***fourteen*** $\left((3\times6)-4 = 14\right)$ constraint equations for this system using a) ***relative coordinates*** and b) ***absolute coordinates***. Express the rotational constraints directly in terms of the angular velocity components. Use body-fixed angular velocity components.