Assignments

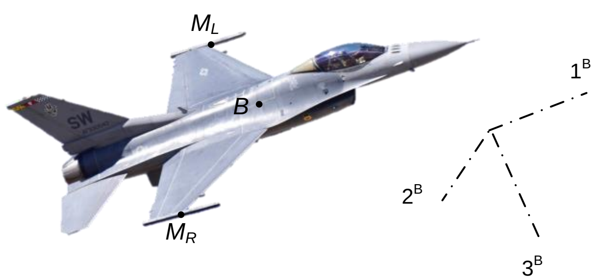
Modeling Flight Dynamics with Tensors

Lecture 7

Problem1 Tensor Identity

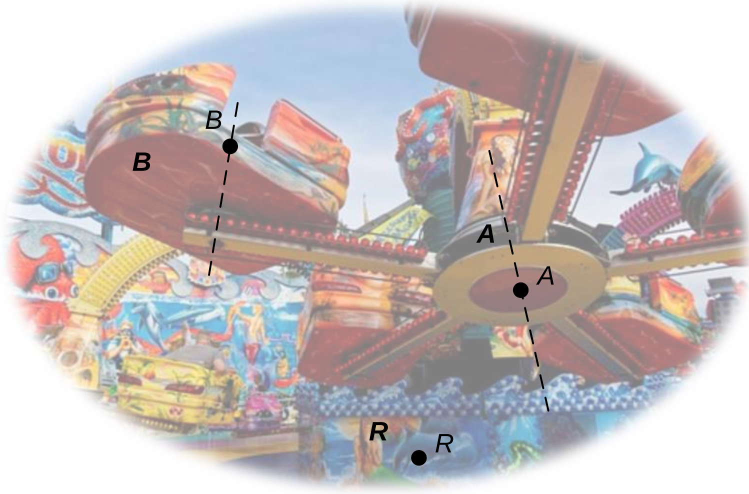
On Slide 6 I use the tensor identity $\bar{\mathbf{s}}_{iR}\mathbf{s}_{iR}\mathbf{E} - \mathbf{s}_{iR}\bar{\mathbf{s}}_{iR} = \bar{\mathbf{S}}_{iR}\mathbf{S}_{iR}$ for the moment of inertia tensor. Though the proof using tensor calculus is quite advanced, you should confirm the validity of this identity by using the 3x1 matrix $[\bar{s}] = [a \quad b \quad c]$.

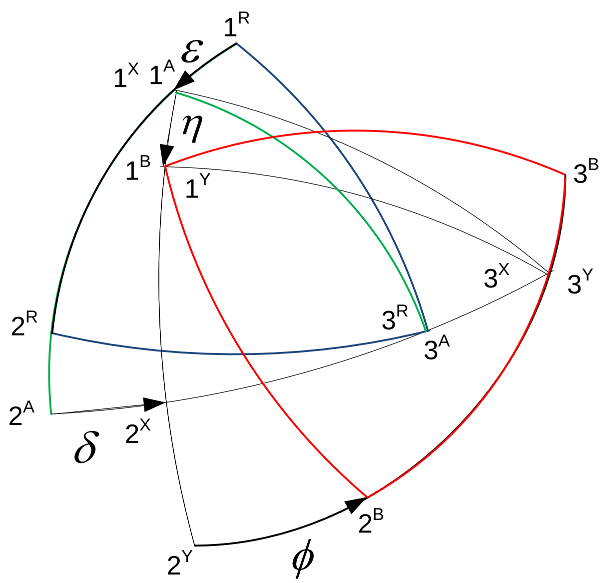
Problem 2 Moment of Inertia



Before take-off, the flight-line crew uploads two sidewinders at the wing tips of the F16 aircraft. The shape of the sidewinder is approximated by a cylinder of 2.6 *m* length and 0.127 *m* diameter, topped by a cone of 0.4 *m*, having the total mass of 85 kg. What is the contribution of the two sidewinders to the F16 moment of inertia, if the displacement of the c.m. M_R of the right sidewinder from the center of mass *B* of the F16 is in aircraft body coordinates $[\overline{s_{M_rB}}]^B = [-1 \quad 5 \quad 0]$ *m*? (Both sidewinders are aligned with the 1^B axis.)

Problem 3 Rotary and Point-Mass Angular Momenta





Let's go to the amusement park and whirl around in the chair ***B*** *w*hich in turn is orbiting with the arms assembly ***A*** relative to the ground ***R***. After all that fun you are to calculate your angular momentum caused by the rotating chair and the orbiting arm, using the equation of Slide 9.

The coordinate system arrangement is quite complex, so I have given you my orange-peel diagram to help you along. Study it carefully and associate it with the picture above. Then you are ready to calculate your angular momentum in your body coordinates $[l_R^{BR}]^B$ and satisfy your curiosity of the contribution of the rotary vs the point-mass part to your total angular momentum.

Here are some details. The arm assembly ***A*** with its coordinate system $]^A$ is tilted wrt the ground ***R*** and its coordinate system $]^R$ by the angle $\varepsilon = 20$ *deg*, and orbits about its 1^A axis with the angle $\delta = \dot{\delta} t, \dot{\delta} = 6\, RPM$. The displacement vector of the c.m. *B* of the chair wrt to the center of the arm assembly *A* is $[\overline{s_{BA}}]^A = [0.8 \quad 3 \quad 0]\, m$, and *A* wrt *R* $[\overline{s_{AR}}]^R = [2 \quad 0 \quad 0]\, m$. In turn the chair ***B*** is also tilted wrt ***A*** by the angle $\eta = 10$ deg and rotates about its 1^B axis with the angle $\phi = \dot{\phi} t, \dot{\phi} = 120\ RPM$. Finally, the MOI of the chair with you sitting in it is approximated by a cylinder of *r*= 0.75 *m* and *h*=1 *m* at uniform density *d*=1500 *kg/m^3*.

Now it is up to you, sitting in the chair, to determine your *rotary* and *point-mass* angular momenta in the chair's body coordinates. Display the result for one orbit of the chair.