TAM 674
Applied Multibody Dynamics

Spring Term 2003, Mon & Wed 10:10-11:00, 202 Thurston Hall, 3 credits.

Homework assignment 10

A simple mechanical model of the human arm consists of two rigid bodies connected by three hinges. The space fixed coordinate system is, seen from a human perspective looking straight ahead North, the z-axis up, the y-axis North, and the x-axis East. The arm is an open loop structure with, starting from the torso, a hinge with an angle α about the x-axis, a hinge with an angle β about the y-axis, the upper arm with length $d = 30$ cm in the minus z-direction, a hinge with an angle γ about the x-axis, and finally the lower arm with length $e = 40$ cm in the plus y-direction. The location of the imaginary hand at the endpoint is now $(0, e, -d)$ with all angles α, β, and γ equal to zero. The upper arm has a concentrated mass of $m_d = 2$ kg at a distance $d/3$ from the shoulder whereas the lower arm has a concentrated mass of $m_e = 2$ kg at $e/2$ from the elbow. We neglect the mass moments of inertia. We assume gravity to work in the minus z-direction with a field strength of $g = 10$ N/kg.

a. Derive the equations of motion for the arm in terms of the independent degrees of freedom α, β, and γ, and check your results by means of a simple dynamic analysis.

b. Picture a ball catch posture given by $(\alpha, \beta, \gamma) = (110°, -20°, -20°)$. Determine the three hinge Torques necessary to maintain this posture.

c. Check your result by means of a forward dynamic analysis of the system for a time period of 5 seconds. Discuss the accuracy and stability of the solution.