ME41055
Multibody Dynamics B

Spring Term 2018, Tue 13:45-15:30, room 3mE-CZ C, 4 ECTS credits.

Homework Assignment 6 (HW6)

Determine the motion of the double pendulum from homework assignment 1 by numerical integration of the equations of motion expressed in terms of independent generalized coordinates as derived in homework assignment 4. The initial conditions are both bars vertically up at zero speed. We assume a gravitational field operating in the *horizontal* direction with a field strength of $g = 9.81$ N/kg. We have to determine the angle, in radians, of both bars with respect to the horizontal axis after 3.0 seconds with a maximal absolute error of 10^{-6} rad.

a. Determine the accordingly maximum constant step size for the following numerical integration methods:

   (1) Euler.

   (2) Heun.

   (3) A Runge-Kutta 3^{rd} order.

   (4) Classical Runge-Kutta 4^{th} order.

   Use an error estimate method based on the method-inherent truncation error and the round-off error due to the finite precision as explained in the course. Plot for each angle in one figure the $\log_{10}$(estimated error) versus the $\log_{10}$(step size) for all four methods. In some cases it may not be feasible to find such a maximum step size. Either the method used is unstable or the step size becomes so small that it is impractical to reach the end point at $t = 3.0$ seconds. If so, please do not spend too much time on that, but state your case clearly!

b. Finally use the three ODE solvers `ode23`, `ode45`, and `ode113` from Matlab. Set the error tolerance `RelTol` and `AbsTol` such that you get the same final accuracy (that is global error!) as above and integrate the equations of motion for 3.0 seconds.

   (1) Compare the angles of both bars at $t = 3.0$ sec with the results from above.

   (2) Determine the average step size and the total number of function evaluations (calls to the differential equation $f(t, y)$) as used in the three methods. Do these agree with your previous results?

Please tabulate all your results (with enough digits [for instance 15] to show convergence) and discuss.