Midterm Exam - Lab

11/03/2016

Submit the compressed file as `(ID)_(name).zip` to [ftp://cdl.hanyang.ac.kr → CAE/Midterm_Lab] folder. It should contain the final results (graphs) of each problem using PowerPoint (`ID.ppt`), MATLAB file (`problem#_#.m`), Simulink file (`problem#_#.slx`) and AMESim file (`problem#_#.ame`).

1. [MATLAB] Solve the following initial value problem over the interval from $x = 0$ to 1 where $y(0)=1$

$$\frac{dy}{dx} + y\tan x = \sin 2x$$

(1) Obtain solutions from Euler's method and fourth-order RK method with $h = 0.2$. Compare the two results with the exact solution by using graphical method. (20 pts)

$$\text{Exact solution : } \quad y = 3\cos x - 2\cos^2 x$$

(2) Calculate the error at each point. Suggest the reasonable value of step size h which the maximum error is less than 2% for two different methods. (10 pts)

$$[\text{Euler's method}]$$

$$y_{i+1} = y_i + f(x_i, y_i)h$$

$$[\text{Fourth-order RK}]$$

$$y_{i+1} = y_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)h$$

$$\begin{cases} k_1 = f(x_i, y_i) \\ k_2 = f(x_i + \frac{1}{2}h, y_i + \frac{1}{2}k_1 h) \\ k_3 = f(x_i + \frac{1}{2}h, y_i + \frac{1}{2}k_2 h) \\ k_4 = f(x_i + h, y_i + k_3 h) \end{cases}$$

2. Solve the following initial value problem over the interval from $t = 0$ to 5 where $y(0)=1,\ y'(0)=0$

$$y''+3y'+2.25y=-10e^{-1.5x}$$

(1) [MATLAB] Obtain solution using MATLAB built-in function (ode45). Compare the result with the exact solution by using graphical method (time step for exact sol. : 0.1 s). (10 pts)

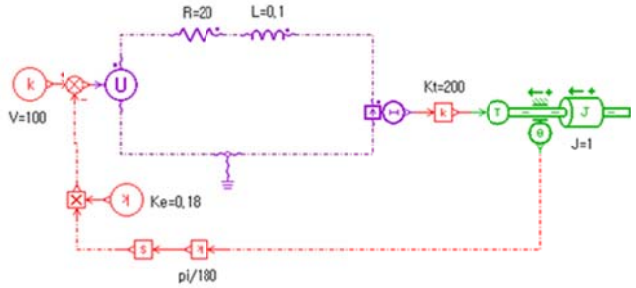
Exact solution : $y=(1+1.5x-5x^2)e^{-1.5x}$

(2) [Simulink] Construct a Simulink model to obtain the solution. Compare the result with the exact solution by using scope block in Simulink library. (10 pts)

(3) [AMESim] This ODE can be converted the following mass-spring-damper equation. Construct an AMESim model by using Mechanical library and compare the result with the exact solution by using Signal library. (10 pts)

$$m\ddot{x}+c\dot{x}+kx=F(t)$$

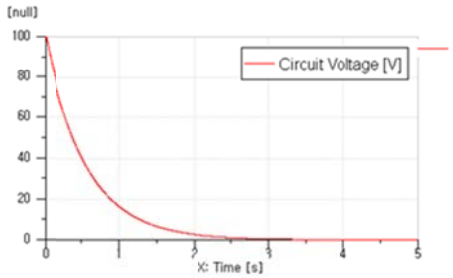
3. Consider this electric motor circuit model by AMESim. The parameter values are indicated on the diagram.

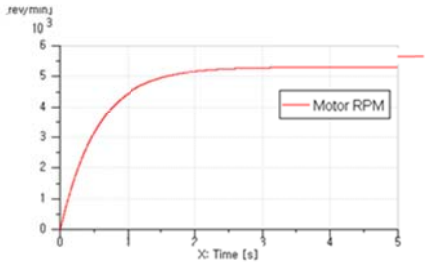


$$T = K_t i$$
$$E = K_e \omega$$
$$J\frac{d\omega}{dt} = T$$
$$L\frac{di}{dt} + Ri = V - E$$

T : motor torque [Nm]
K_t : torque constant [Nm/A]
i : current [A]
E : back EMF [V]
K_e : motor back EMF constant [V s/rad]

J : motor inertia [kgm^2]
ω : motor angular velocity [rad/s]
L : inductance [H]
R : resistance [Ohm]
V : source voltage [V]





(1) [Simulink] Construct a Simulink model for this system. Show the result of circuit voltage and motor RPM by using scope block(Simulation time : 5 s). (25 pts)

(2) [AMESim] This model can be considered a traction motor for the electric vehicle. We want to control the vehicle inertia as 100 RPM. Apply the gear, vehicle inertia(output) and voltage controller model. Show the vehicle inertia RPM. (15 pts)

(Hint : use rigid shaft(K=1e9, C=1e7) and angular velocity sensor. Consider sign of velocity.)