Midterm Exam - Lab

10/25/2022

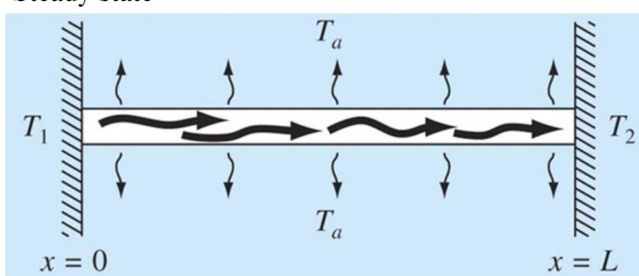
Submit the compressed file as `(ID)_(name).zip` to [ftp://cdl.hanyang.ac.kr → Undergraduate_CAE → lab → midterm] folder. It should contain the final results (graphs) of each problem using PowerPoint (`ID.ppt`), MATLAB file (`problem#_#.m`), Simulink file (`problem#_#.slx`), and AMESim file (`problem#_#.ame`).

1.[MATLAB] Consider a boundary value problem with respect to the heat balance for a long, thin rod. The governing equation at steady state, boundary conditions, and parameter values are as follows:

Heat balance for a long, thin load

-Not insulated along its length

-Steady state



(1)Obtain solution using the shooting method, which includes MATLAB built-in function (ODE 45) and linear interpolation. (10 pts)

Linear (conduction/convection)

$$\frac{d^2T}{dx^2} + h'(T_a - T) = 0$$

$$T(0) = T_1 = 40°C$$

$$T(L) = T_2 = 200°C$$

$$T_a = 20°C,\ L = 10m,\ h' = 0.01m^{-2}$$

(2) Obtain solution using the nonlinear shooting method which includes MATLAB built-in function (ODE 45) (5 pts)

[hint] residual function r(za) =y(b)-200

Use Built-in function "fzero" with initial value 0

Nonlinear (conduction/convection & radiation)

$$\frac{d^2T}{dx^2} + h'(T_a - T) + h''(T_a^4 - T^4) = 0$$

$$T(0) = T_1 = 40°C$$

$$T(L) = T_2 = 200°C$$

$$T_a = 20°C,\ L = 10m,\ h' = 0.01m^{-2},\ h'' = 2.7\times10^{9}°C^{-3}m^{-2}$$

2.[MATLAB] Solve the Van der poll equation with initial value

$$\frac{d^2y}{dt^2} - \mu\left(1-y^2\right)\frac{dy}{dt} + y = 0$$

initial condition

at t=0, y=1 $\frac{dy}{dt} = 1$

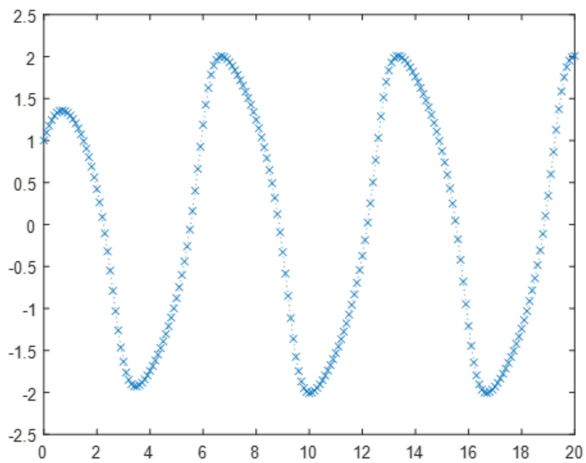
(1) Given the following two scripts (main, vander), Develop a single function script (RK4.m) that covers the fourth-order RK method for second-order ODE and obtain the solution (20 pts)

$\mu = 1$, tspan=[0 20],step size h=0.1 plot style “x:” ex: plot(x,y,’x:’)

[Fourth-order RK]

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

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



[main.m]

```
clc; clear all; close all;

h=0.01;
tf=20;
[t,y]= RK4(@vander,[0 tf],[1,1],h);

figure(1)
plot(t,y(:,1),'x:')
```

[vander.m]

```
function yp = vander(t,y)
mu=1;
yp=[y(2); mu*(1-y(1).^2)*y(2)-y(1)];
end
```

(2) Modify main.m and vander.m to obtain MATLAB built in function ODE45 solution, compare the results, and explain the difference between the two ODE solvers. (5 pts)

$\mu = 10$, tspan=[0 20],step size h=0.1

[main.m]

```
clc; clear all; close all;

h=0.01;
tf=20;
[t,y]= RK4(@vander,[0 tf],[1,1],h);
[t,y]= ode45(@vander,[0 tf],[1,1]);


figure(1)
subplot(2,1,1)
plot(t,y(:,1),'x:')
subplot(2,1,2)
plot(t,y(:,1),'o-')
```

(3) When solving the equation with parameter setting in $[\mu = 1000$, tspan=[0 1000],step size h=0.1$]$, ode45 takes an excessive amount of computation. Explain this phenomenon and Apply MATLAB built-in function solution for it. Compare with the step size with ode45 results and the built-in function. (5 pts)

3. [Simulink/AMESIM] Solve the following RLC second order system using Signal based ODE solution (in AMESIM, Use Signal, Control block only)

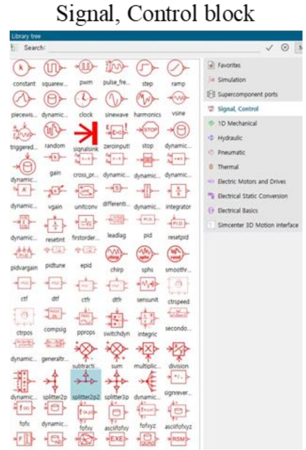
(1) AMESIM model (5 pts)

(2) Simulink (5 pts)

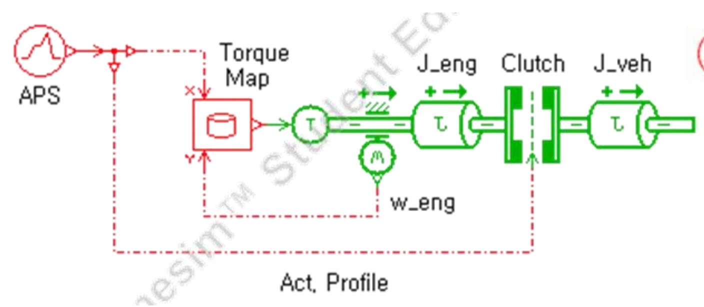
$$L\frac{di}{dt} + Ri + \frac{q}{C} - E(t) = 0 \quad \text{where} \begin{cases} L = 1H \\ E_0 = 1V \\ C = 0.25C \\ \omega = \sqrt{3.5}\,\text{rad/s} \\ R = 0.05\Omega \end{cases}, \text{tspan}[0\ 100]$$

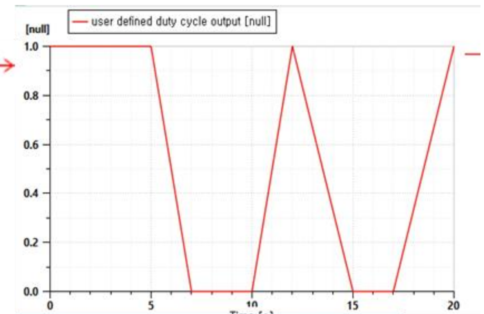
initial condition $q(t) = 0, i(t) = 0$

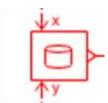
Signal, Control block



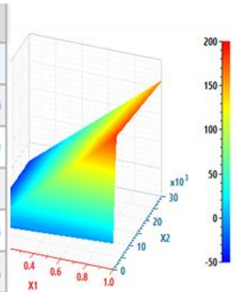
4. Consider the following engine model by AMESim.







		1	2
	X2 \ X1	0	1
1	0	0	0
2	1000	-18	129
3	1500	-22	161
4	2000	-25	186
5	2500	-30	186
6	3000	-35	161



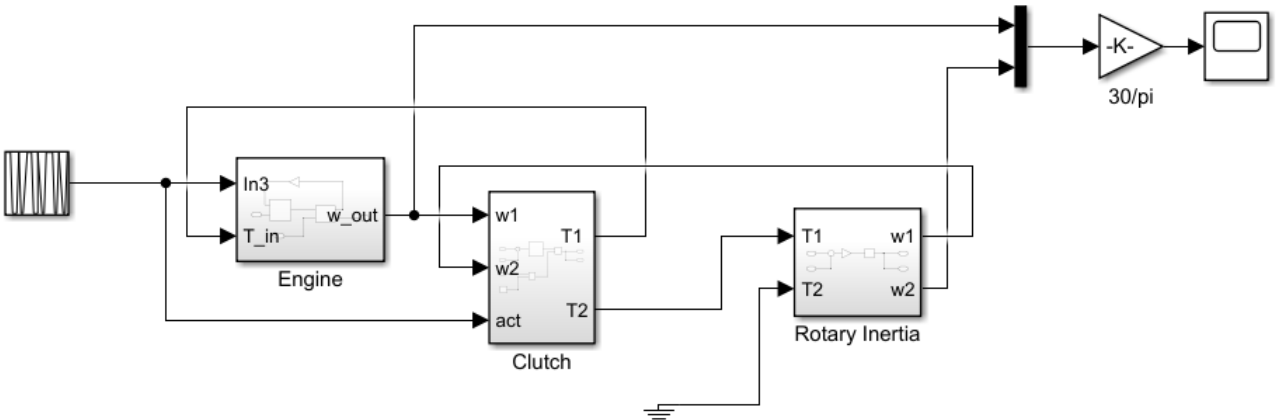
① J_eng = 0.1 kgm^2, w_eng = 0 RPM
② J_veh = 50 kgm^2, w_veh = 200 RPM
③ clutch friction torque = 200 Nm

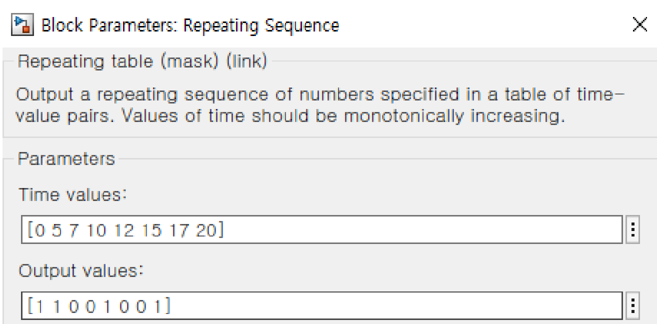
number of stages		7	nstages
cyclic		no	iscyclic
time at which duty cycle starts	s	0	tstart
output at start of stage 1	null	1	start1
output at end of stage 1	null	1	end1
duration of stage 1	s	5	t1
output at start of stage 2	null	1	start2
output at end of stage 2	null	0	end2
duration of stage 2	s	2	t2
output at start of stage 3	null	0	start3
output at end of stage 3	null	0	end3
duration of stage 3	s	3	t3
output at start of stage 4	null	0	start4
output at end of stage 4	null	1	end4
duration of stage 4	s	2	t4
output at start of stage 5	null	1	start5
output at end of stage 5	null	0	end5
duration of stage 5	s	3	t5
output at start of stage 6	null	0	start6
output at end of stage 6	null	0	end6
duration of stage 6	s	2	t6
output at start of stage 7	null	0	start7
output at end of stage 7	null	1	end7
duration of stage 7	s	3	t7

(1) Construct this AMESim model. Compare the engine- and vehicle-side RPM.

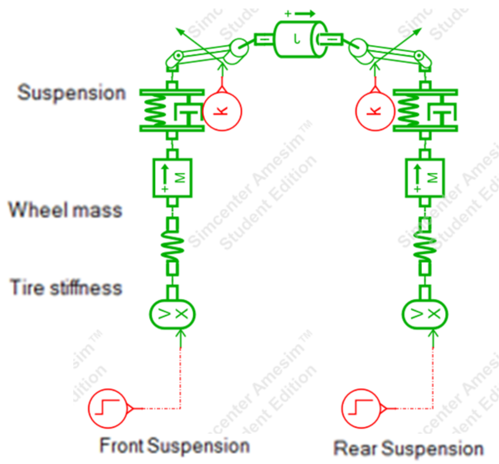
(Simulation time: 20 s, Print interval: 0.001 s) (10 pts)

(2) Construct a Simulink model for this system. Show the engine- and vehicle-side RPM by using scope block (10 pts)





5. [AMESim/Simulink] Consider half car model by AMESim. The parameter values in the model are as follows.



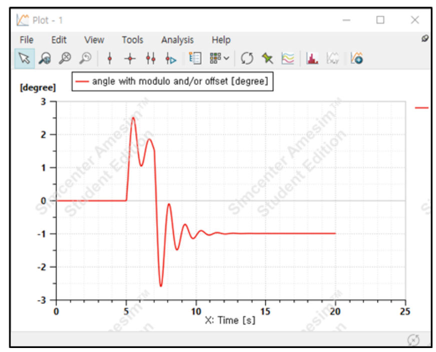
$$J_p = 2000\,\text{kg m}^2$$

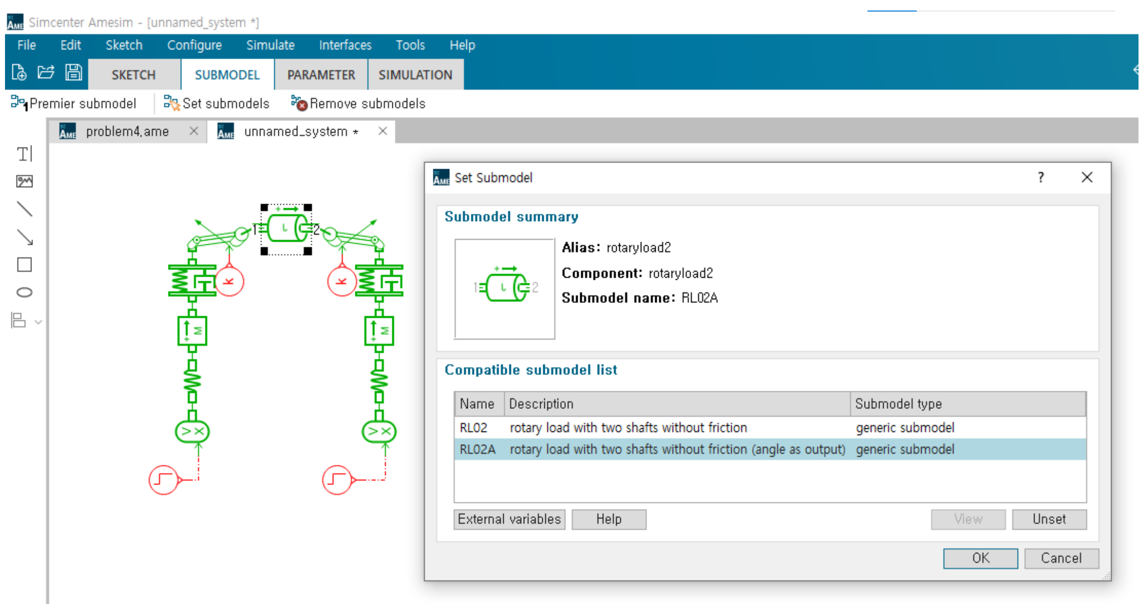
$$L_{front} = 1.2\,\text{m},\ L_{rear} = 1.5\,\text{m}$$

$$k_{front} = 15000\,\text{N/m},\ c_{front} = 1000\,\text{Ns/m}$$

$$k_{rear} = 20000\,\text{N/m},\ c_{rear} = 1500\,\text{Ns/m}$$

$$m_{wheel} = 50\,\text{kg},\ k_{tire} = 200000\,\text{N/m}$$



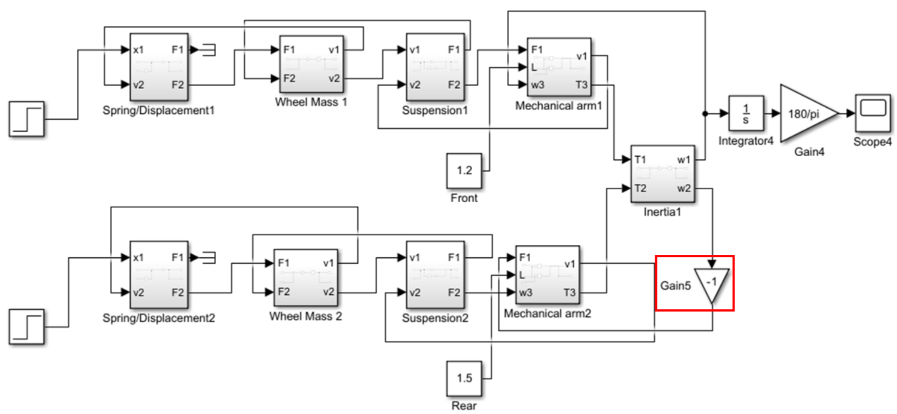


Rotary inertia에서 pitch angle 출력을 위한 설정

Submodel table 에서 rotaryload block 클릭

RL02A 선택 후 ok

(1)[AMESim] Construct this AMESim model for this system. Show the result of vehicle pitch angle(Simulation time: 20 s, print interval: 0.01 s) (10 pts)



(2) [Simulink] Construct a Simulink model for this system. Show the result of vehicle pitch angle by using scope block (Simulation time: 20 s, solver – ode23tb) (10 pts)

(3) Explain why (1) AMESIM model and (2) Simulink model need to add gain (in red box) to become equivalent model. (5 pts)