Midterm Exam - Lab

10/24/2023

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`)

1.[MATLAB] The Volume V of liquid in a hollow horizontal cylinder of radius r and length L is related to the depth of the liquid h by

$$V = \left[r^2 \cos^{-1}\left(\frac{r-h}{r}\right) - (r-h)\sqrt{2rh-h^2} \right] L$$

Develop an M-file to create a plot of volume versus depth. (20 pts)

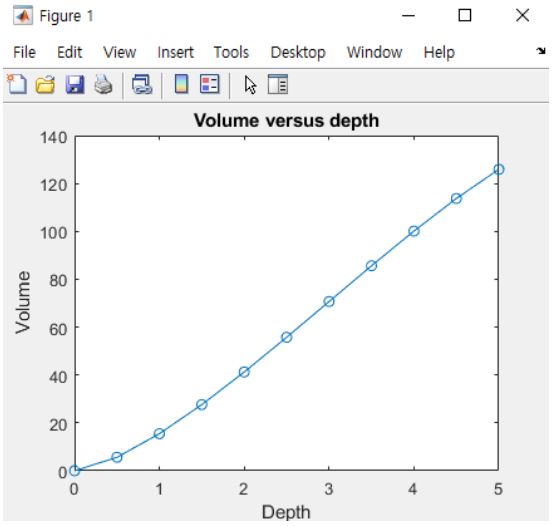
Satisfy all the post-processing styles of the plot provided below. Except font style & size

Here are the first few lines:

```
function problem1(r,L,plot_title)
% volume of horizontal cylinder
% inputs :
% r = radius
% L= length
% plot_title=string holding plot title
```

Test your program with

```
>>problem1(3,5,'Volume versus depth')
```



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 $\frac{dy}{dt} = 1$

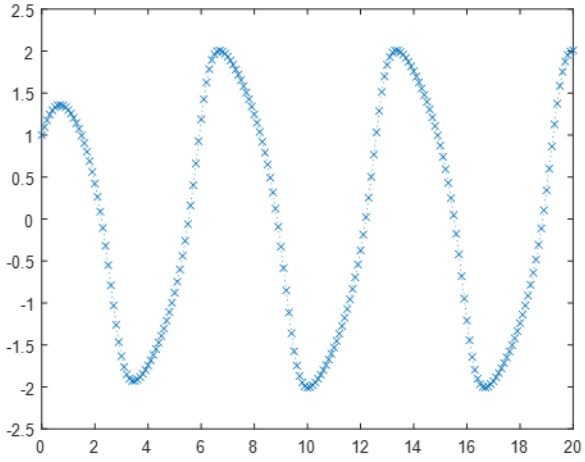
(1) Given the following two scripts (main, vander), Develop a single function script (RK4.m) that covers the fourth-order RK method for second-order ODE and obtain the solution (20 pts)

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

[Fourth-order RK]

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

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



[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)
...
```

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

[main.m]

```
clc; clear all; close all;

h=0.1;
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 $[\mu = 1000, \text{tspan=[0 1000]}, \text{step size h=0.1}]$, 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] Solve the following RLC second order system using signal-based solution Show the transient current and electrical charge on capacitor using scope block. (Simulation time: 10 s) (10 pts)

Equation of the transient RLC circuit

$$L\frac{di}{dt} + Ri + \frac{q}{c} - E(t) = 0 \text{ and } i = \frac{dq}{dt}$$

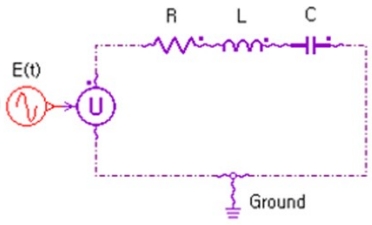
L : inductor

R : resistance

C : capacitance

E : voltage source

q : electrical charge



$$E = E_0 \sin(\omega t)$$

$$L = 2\ \text{H}$$

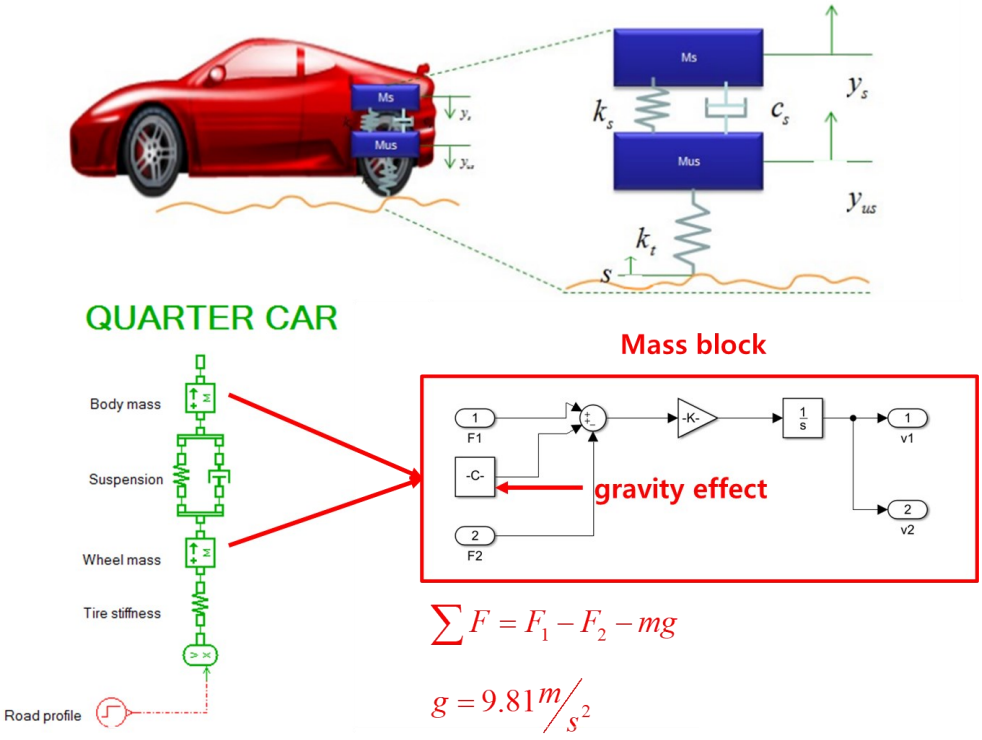
$$E_0 = 5\ \text{V}$$

$$C = 0.25\ \text{F}$$

$$\omega = 5\ \text{rad/s}$$

$$R = 3\,\text{Ohm}$$

4. [Simulink]Consider quarter car model by Simulink. The parameter values in the model are as follows.



$$\sum F = F_1 - F_2 - mg$$

$$g = 9.81\,m/s^2$$

$$m_{body} = 400\,\text{kg}$$

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

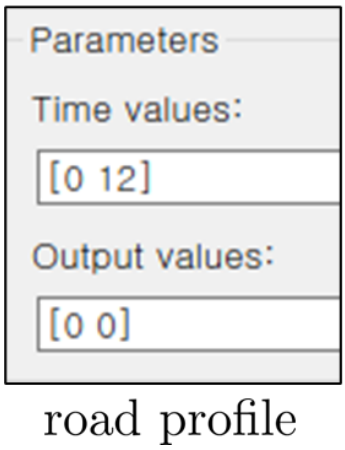
$$m_{wheel} = 50\,\text{kg},\ k_{tire} = 200000\,\text{N/m}$$

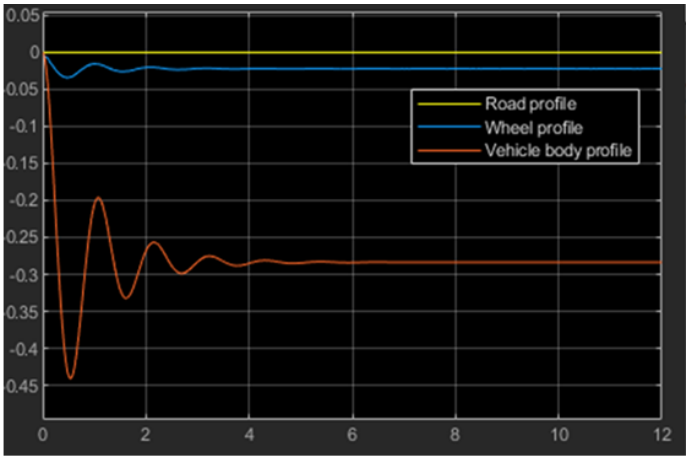
For this problem, you are required to construct a Simulink model of a quarter car to evaluate its suspension behavior under two specific scenarios: (Simulation time: 12 s)

(1) Response to the vehicle's self-weight (10 pts)

-Assume that the car's suspension is subject to the car's self-weight.

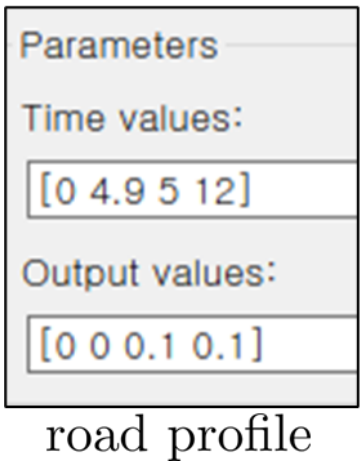
-Build a Simulink model to simulate freefall road profile and obtain following scope plot.

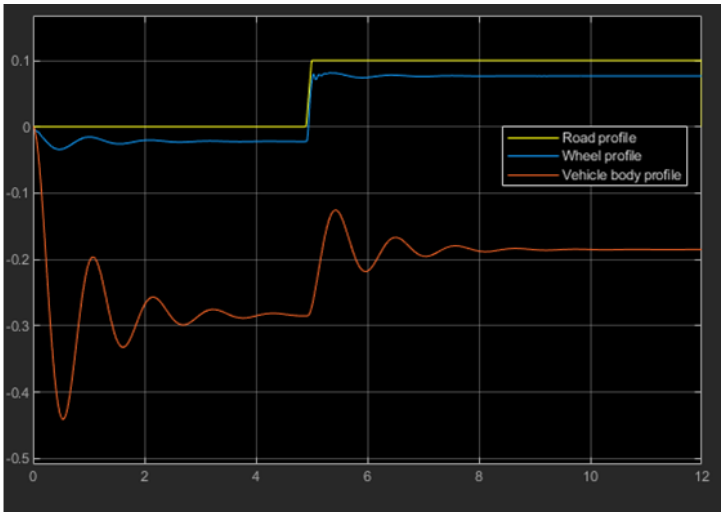




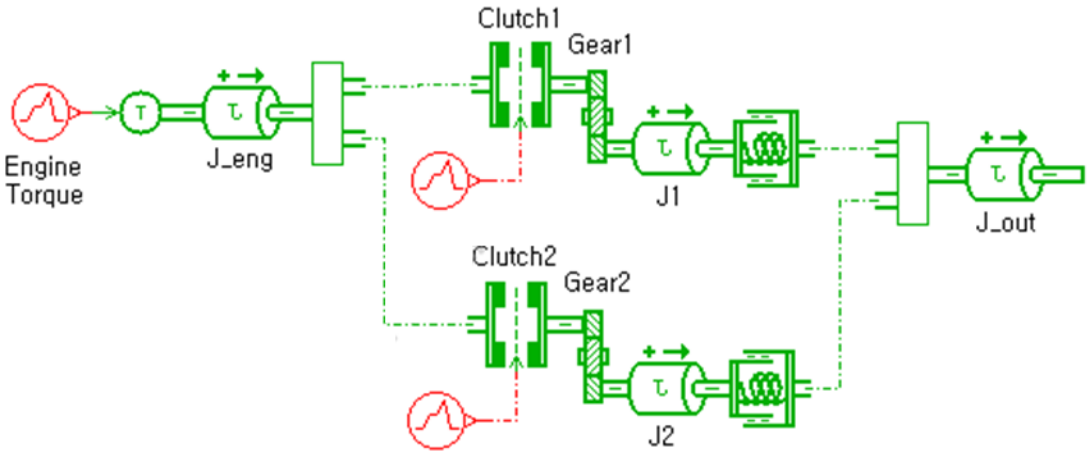
(2) Road Bump Interaction (10 pts)

Starting from the car's stable position after the freefall (from Scenario 1), simulate its response when it encounters a 0.1m road bump at 5 s.





5. [Simulink - Powertrain] Consider 2-speed transmission model. The parameter values in the model are as follows. Construct a Simulink model for this system. Show the engine(J_eng) and vehicle side(J_out) RPM using scope block. (Simulation time: 10 sec) (20 pts)



$J_{eng} = 0.1kg \cdot m^2$

$J_{shaft\_1,2} = 0.01kg \cdot m^2$

$J_{out} = 50kg \cdot m^2$

$k_{shaft\_1,2} = 1e7^{N}/_{m}$

$c_{shaft\_1,2} = 1e5^{N \cdot s}/_{m}$

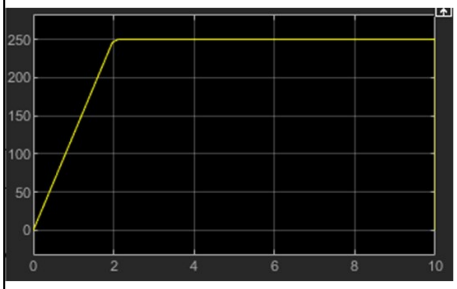
clutch friction torque

$T_{clutch} = 1000N \cdot m$

gear ratio

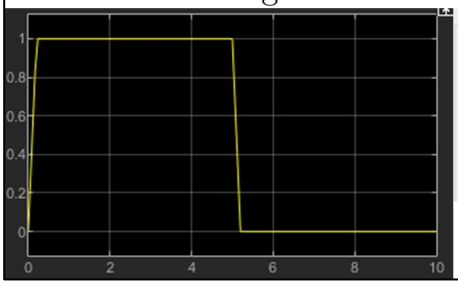
$1^{st} : 4,\ 2^{nd} : 2$

Engine torque



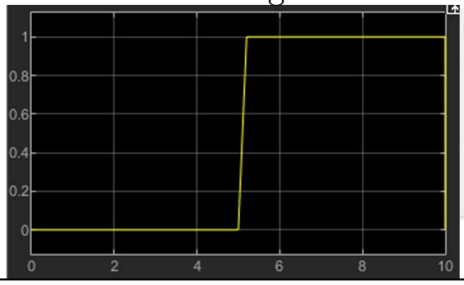
Parameters
Time values:
[0 2 10]
Output values:
[0 250 250]

Clutch 1 Acting Profile



Parameters
Time values:
[0 0.2 5 5.2 10]
Output values:
[0 1 1 0 0]

Clutch 2 Acting Profile



Parameters
Time values:
[0 5 5.2 10]
Output values:
[0 0 1 1]