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 a following free-falling bungee jumper problem over the interval from t_i to t_f, where $v(0) = v_i$ and a step size of Δt.

$$\frac{dv}{dt} = g - \frac{c_d}{m} v|v|, \text{ where } v_{i+1} = v_i + \frac{dv_i}{dt}\Delta t$$

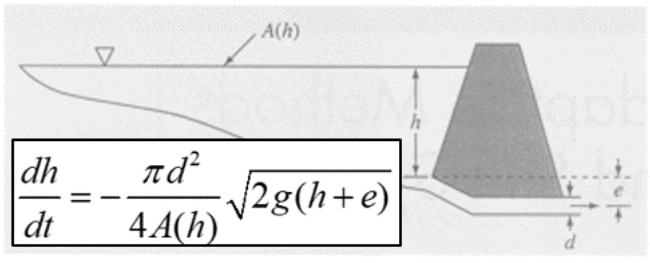
$$g = 9.81,\ c_d = 0.25,\ m = 68.1$$

Develop a function script of MATLAB given the input parameters (t_i, t_f, v_i, Δt). Obtain final velocity (v) when the step size (Δt) are 1 and 0.01 with other parameter values as follows. (10 pts)

```
>> velocity(0,5,10,1)

ans =

   44.0651
```

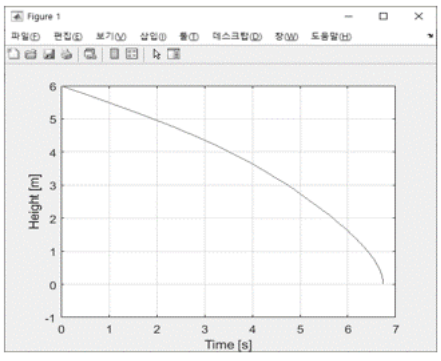
```
>> velocity(0,5,10,0.01)

ans =

   42.2002
```

2. [MATLAB] A pond drains through a pipe as shown in following figure. Under a number of simplifying assumptions, the following differential equation describes how depth changes with time. Based on the following area-depth table, solve this differential equation to determine the time (t) at the pond to empty ($h = 0$), given that $h(0) = 6,\ d = 0.25,\ e = 1,\ g = 9.81$ and over the interval from $t = 0$ to 8. In addition, plot the depth (h) according to the time (t) as follows. Use MATLAB built-in function (ode23). (15 pts)

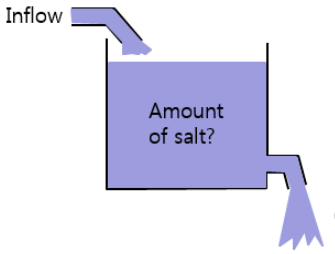


h, m	6	5	4	3	2	1	0
$A(h)$, m²	1.17	0.97	0.67	0.45	0.32	0.18	0

```
>> P2_pond
The time to height 0 : 6.739 s
```



3. [MATLAB] Mixing problems with water and salt in a single tank can be modelled as the following ODE. $y(t)$ denotes the amount of salt in the tank at time t. The salt inflow rate is 10 and the salt outflow rate is $0.025y$. Solve the following initial value problem over the interval from $t=0$ to 200 where $y(0)=40$.



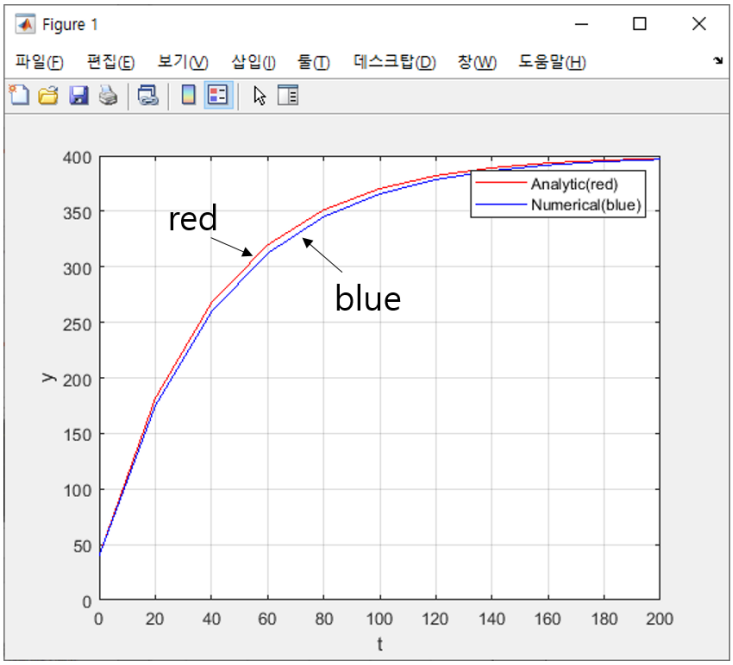
$$\frac{dy}{dt} = 10 - 0.025y$$

(1) Obtain solutions from Midpoint's method with step size $h=20$. Compare the two results with the exact solution by using graphical method. Use plot options to effectively describe a figure. (10 pts)

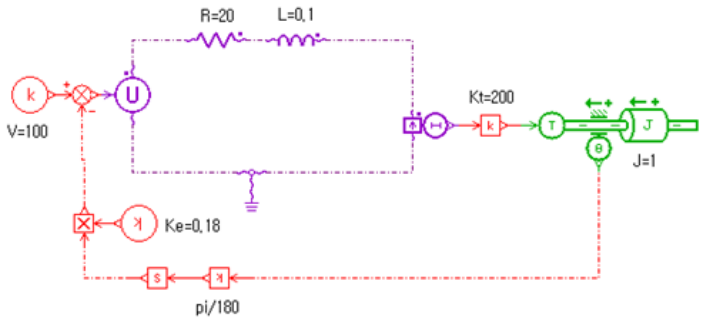
Analytic solution: $y(t) = 400 - 360e^{-0.025t}$

(2) Calculate the relative error at each point. Suggest the reasonable value of step size h, which the maximum error is less than 1% except for the initial point ($t=0$). Develop a script to find this step size automatically not by using trial and error. (7 pts)

$$[\text{Midpoint's method}] \begin{cases} \text{Predictor } y_{i+1/2} = y_i + f(t_i, y_i)\dfrac{h}{2} \\ \text{Corrector } y_{i+1} = y_i + f(t_{i+1/2}, y_{i+1/2})h \end{cases} \quad [\text{Relative error}]\ error = \frac{\left|Sol_{numerical} - Sol_{analytic}\right|}{Sol_{analytic}}$$



4. [Simulink] 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]

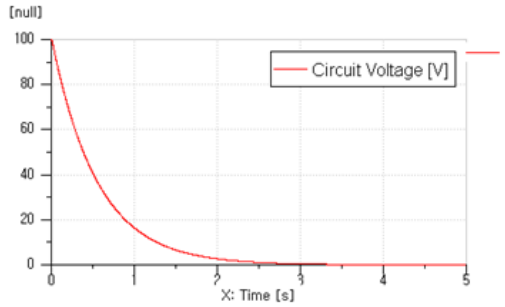
J : motor inertia [kgm^2]

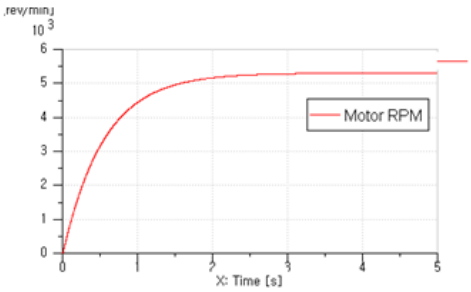
ω : motor angular velocity [rad/s]

L : inductance [H]

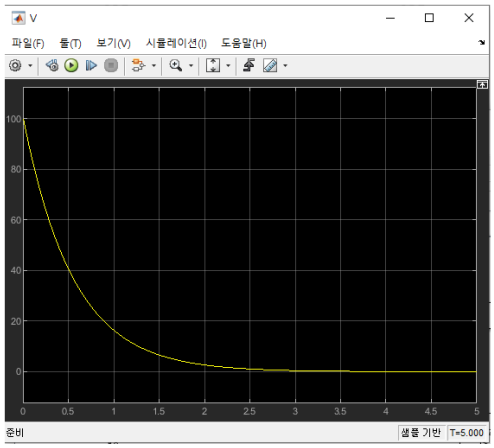
R : resistance [Ohm]

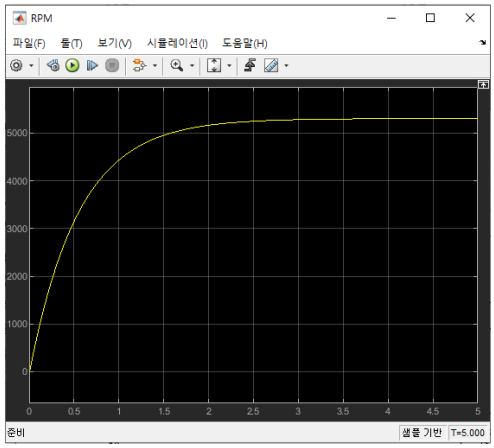
V : source voltage [V]



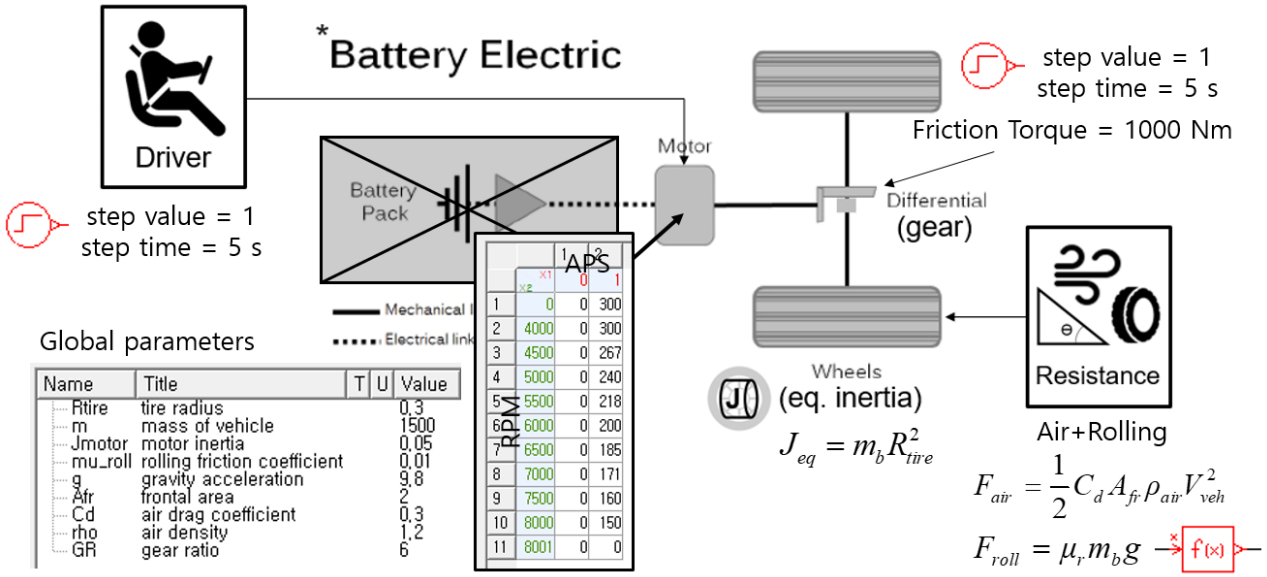


Construct a Simulink model for this system. Show the result of circuit voltage and motor RPM by using scope block (Simulation time: 5 s). (25 pts)





5. [AMESim] The purpose of an EV shown in the figure is to evaluate 0-100 km/h acceleration time and maximum speed.

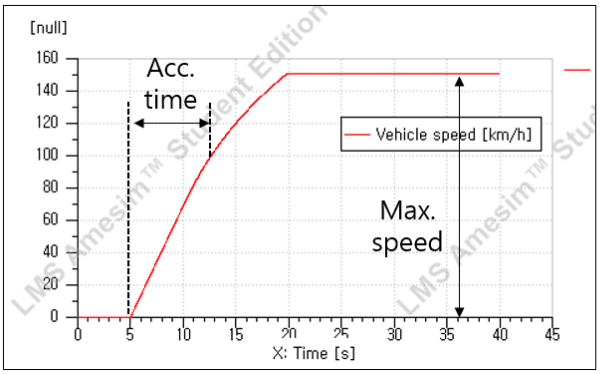


Name	Title	T	U	Value
Rtire	tire radius			0.3
m	mass of vehicle			1500
Jmotor	motor inertia			0.05
mu_roll	rolling friction coefficient			0.01
g	gravity acceleration			9.8
Afr	frontal area			2
Cd	air drag coefficient			0.3
rho	air density			1.2
GR	gear ratio			6

RPM \ APS	0	1
0	0	300
4000	0	300
4500	0	267
5000	0	240
5500	0	218
6000	0	200
6500	0	185
7000	0	171
7500	0	160
8000	0	150
8001	0	0

(1) Construct an AMESim model for this system. Parameterize the all input values in the model blocks by using the "Global Parameters Option". Confirm the acceleration time and maximum speed. (Simulation time: 40 s, Print interval: 0.01 s) (25 pts)

(2) From the AMESim model, when you change the gear ratio and vehicle mass values as shown in the following table, check the acceleration time and maximum speed and fill the table. How do you think the gear ratio and vehicle mass affect the acceleration time and maximum speed, respectively? (8 pts)



Time / Speed	GR=5	GR=6	GR=7
m (-20%)			
m (0%)		7.64 / 150.81	
m (+20%)			