MATLAB- Simulink

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Example 3.3 Inverted pendulum control

Step 1. Used MATLAB to transfer the transfer function from state space

System matrix:

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & -mg/M & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & g/l & 0 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} 0 \\ 1/M \\ 0 \\ -1/(Ml) \end{bmatrix}.$$

$$\dot{\mathbf{x}}(t) = \mathbf{A}\mathbf{x}(t) + \mathbf{B}u(t)$$

$$y(t) = \mathbf{C}\mathbf{x}(t) + \mathbf{D}u(t)$$

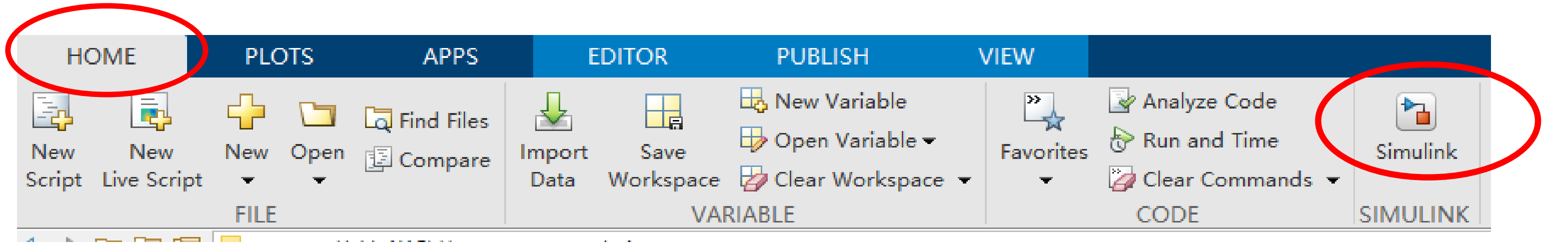
```
%% Problem 1=> calculate transfer function for C=[0 0 1 0];
clc
%inital parameter
g=9.8;
l=0.5;
m=0.01;
M=2;

%system matrix
A=[0 1 0 0 ; 0 0 -m*g/M 0;0 0 0 1; 0 0 g/l 0 ];
B=[0 ;1/M;0;-1/(M*l)];
C=[0 0 1 0];
D=[0];

[num,den] = ss2tf(A,B,C,D)  %ss2tf: state space --> transfer function
```

Command Window

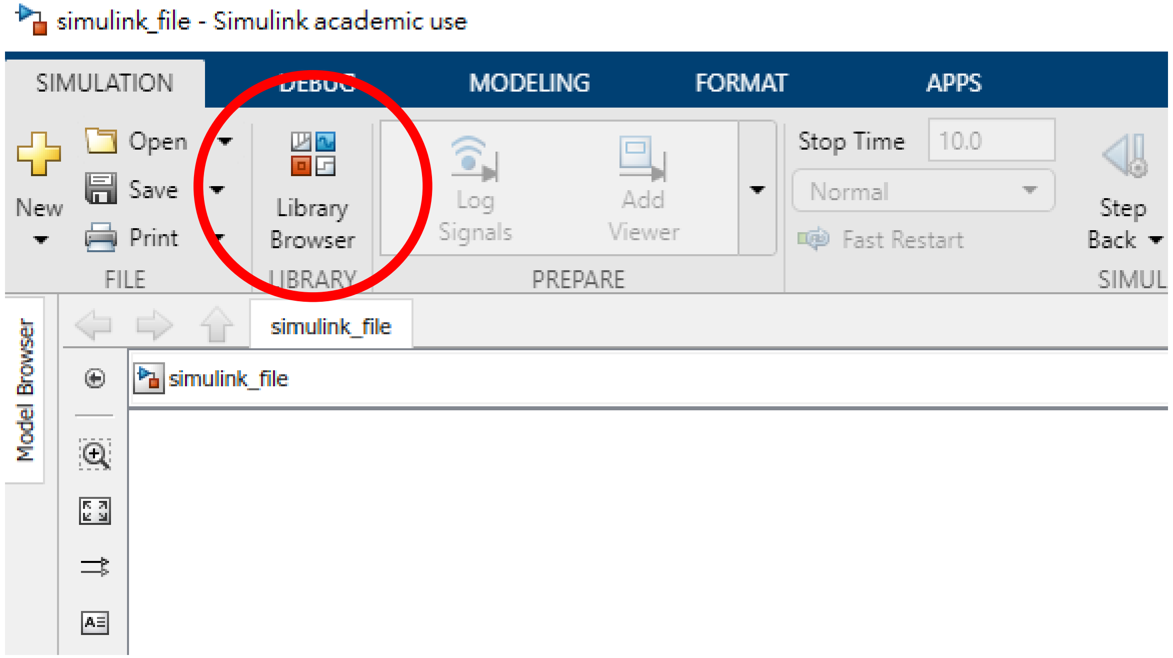
```
num =

         0         0   -1.0000    0.0000    0.0000


den =

    1.0000         0  -19.6000         0         0
```

Step 2. Open Simulink

Home →Simulink →Blank Model (create new model)→save it!!



Once you save the model,
you can search the function blocks from library Browser



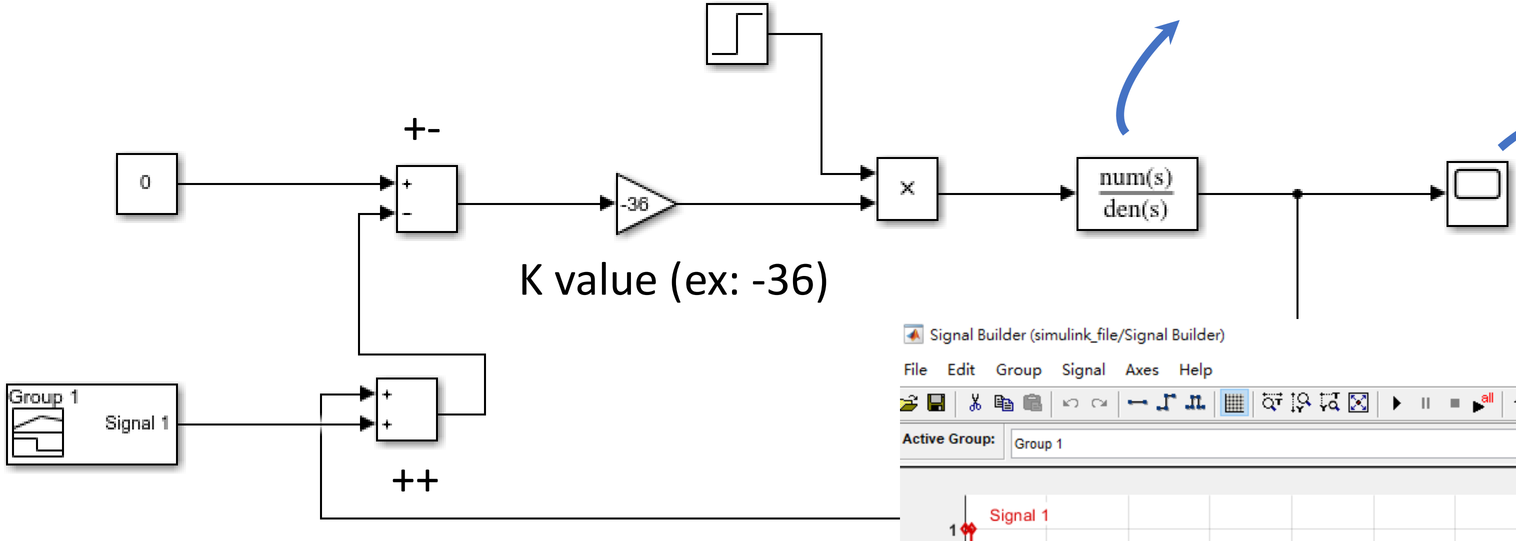
You will need the following function blocks:
Signal Builder
Add
Constant
Product
Gain
Step
Transfer Fcn
Scope (see output result)

Step 3. Create Block Diagram

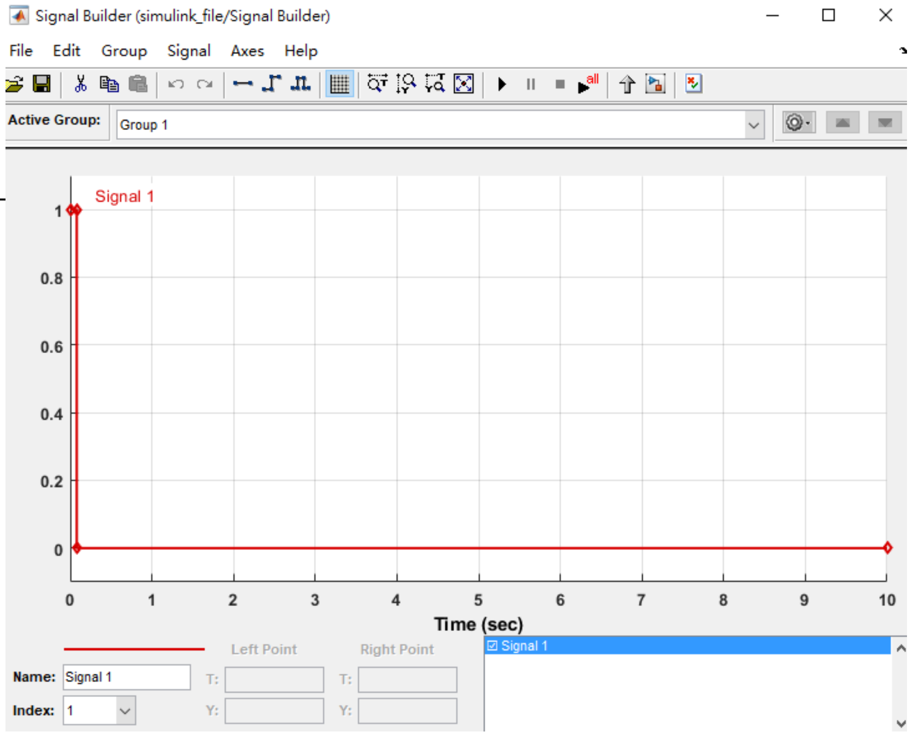
num = [0 0 -1 0 0]

den = [1 0 -19.6 0 0]

C =[0 0 1 0]



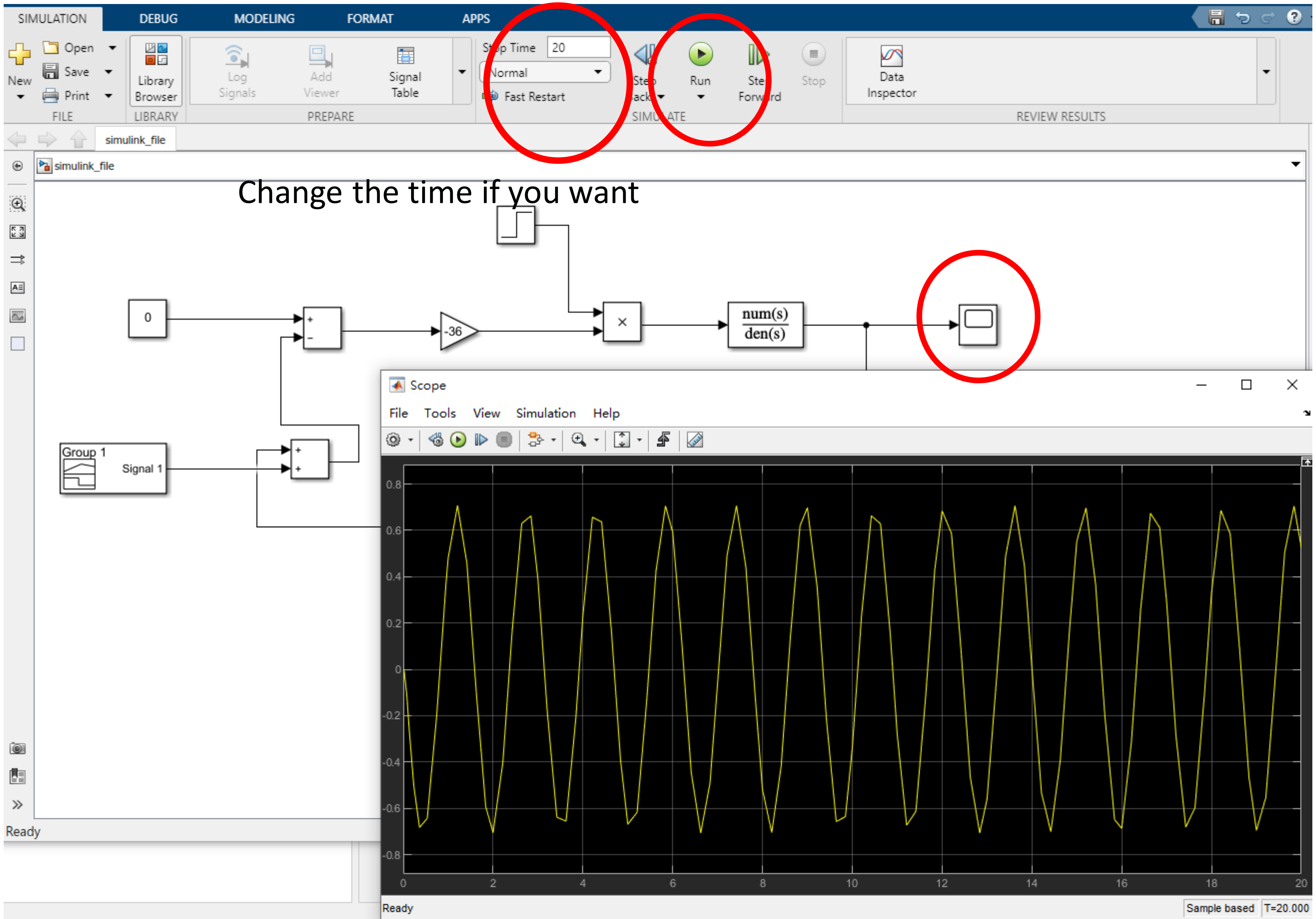
After designing the block diagram,
Press Run and click the scope to see the result



For Signal Builder
You can set
for t= 0~0.1
y=1
else
y=0

to simulate initial condition

Output Result



Problem 2: ODE45 Reference

ODE Solvers: Standard Syntax

- To use standard options and variable time step
  - `[t,y]=ode45('myODE',[0,10],[1;0])`

ODE integrator: 23, 45, 15s

ODE function

Time range

Initial conditions

- Inputs:
  - ODE function name (or anonymous function). This function takes inputs (t,y), and returns dy/dt
  - Time interval: 2-element vector specifying initial and final time
  - Initial conditions: column vector with an initial condition for each ODE. This is the first input to the ODE function
- Outputs:
  - t contains the time points
  - y contains the corresponding values of the integrated variables.

More info:
https://www.mathworks.com/help/matlab/ref/ode45.html

Problem 2 reference

```
%% Problem 2
clc
 tspan = [0 10];   %time interval from 0 - 10
 iniCon = [0;0;0;0];  %initial condition
 [t, y] = ode45(@sys, tspan, iniCon)
 y1=y(:, 1) % y
 y2=y(:, 2) % y'
 y3=y(:, 3) % angle
 y4=y(:, 4) % angle'
 %%plot(t, xxxxxxxx Plot it Yourself xxxxxxxx)
 pulse= rectangularPulse(0,0.1,t);
function  dx = sys(t, x)
%initial parameter
   g=9.8;
   l=0.5;
   m=0.01;
   M=2;
  pulse = rectangularPulse(0,0.1,t);
  A=[0 1 0 0 ; 0 0 -m*g/M 0;0 0 0 1; 0 0 g/l 0 ];  %system matrix
  B=[0 ;1/M;0;-1/(M*l)];
  k=-100;         % Try different value of K
  C=[0 0 1 0]*x; % here can change the value of C
  Gc=(0-(C+pulse))*k;
  u = Gc*heaviside(t);
   dx = A*x + B*u;
end
```