ME729 Advanced Robotics - Lab #9

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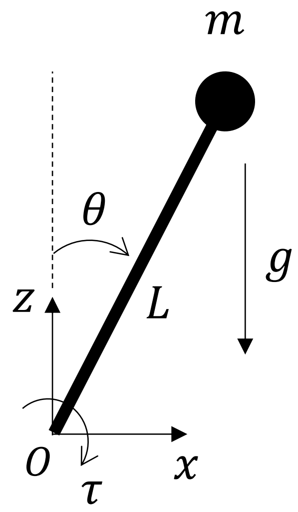
- [ ] Getting started with Simulink
    - Graphical editor for building and managing hierarchical block diagrams.
    - Libraries of predefined blocks for modeling continuous-time and discrete-time systems.
    - Capabilities to directly interact with hardware and real time systems.

- [ ] Example #1

- Consider the following system given by the lecture.
- Let m = 35 kg, L = 0.9 m.
- Initial conditions : $\theta = 0$ and $\dot{\theta} = 0.35\, rad/s$



$$\begin{bmatrix} \dot{\theta} \\ \ddot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ \frac{g}{L} & 0 \end{bmatrix} \begin{bmatrix} \theta \\ \dot{\theta} \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{mL^2} \end{bmatrix} \tau$$

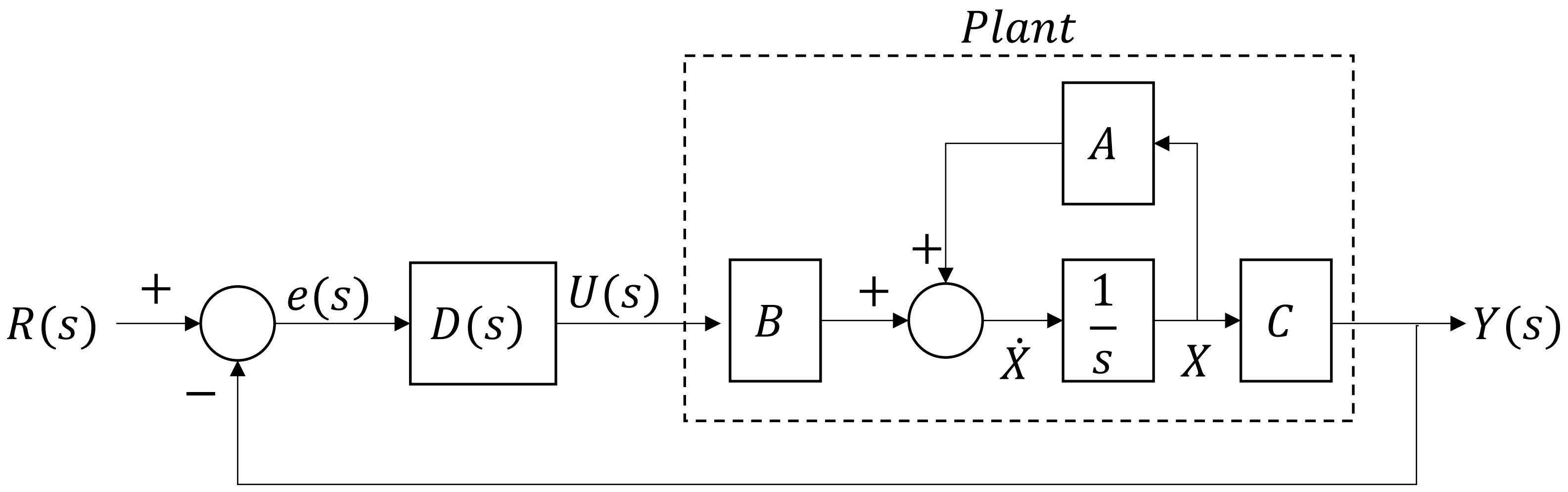
$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} \theta \\ \dot{\theta} \end{bmatrix}$$

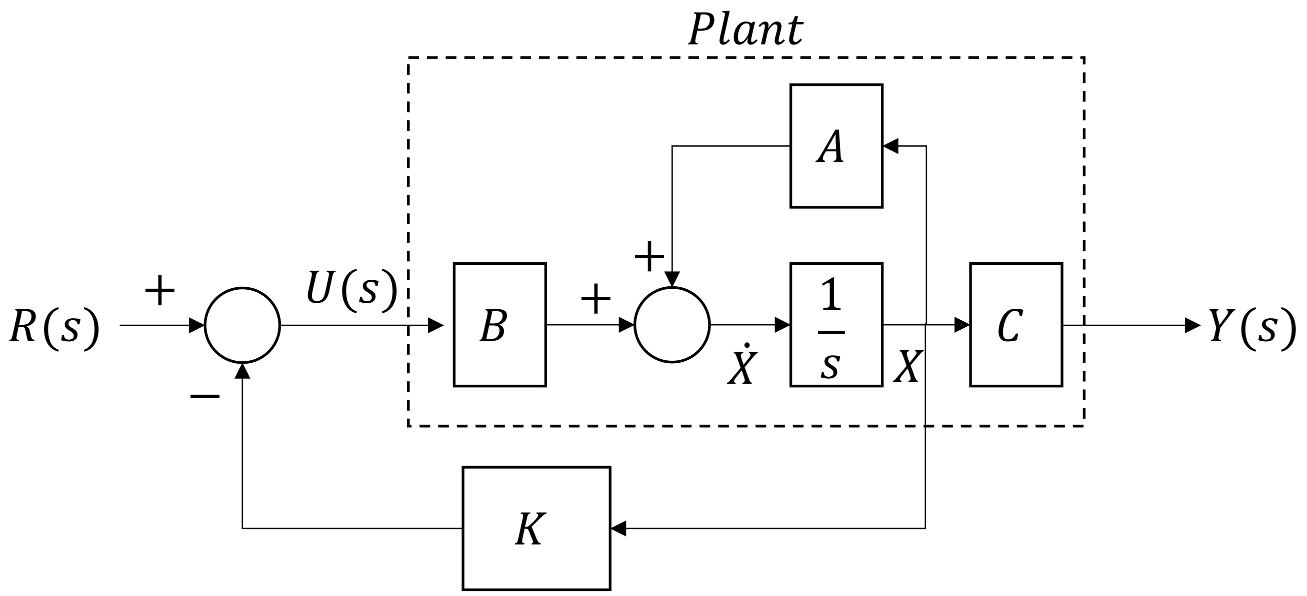
1. Using Simulink, realize PID control, and control the system to keep it upright.

2. When desired poles are -4, and -5, find feedback gains using pole-placement method.

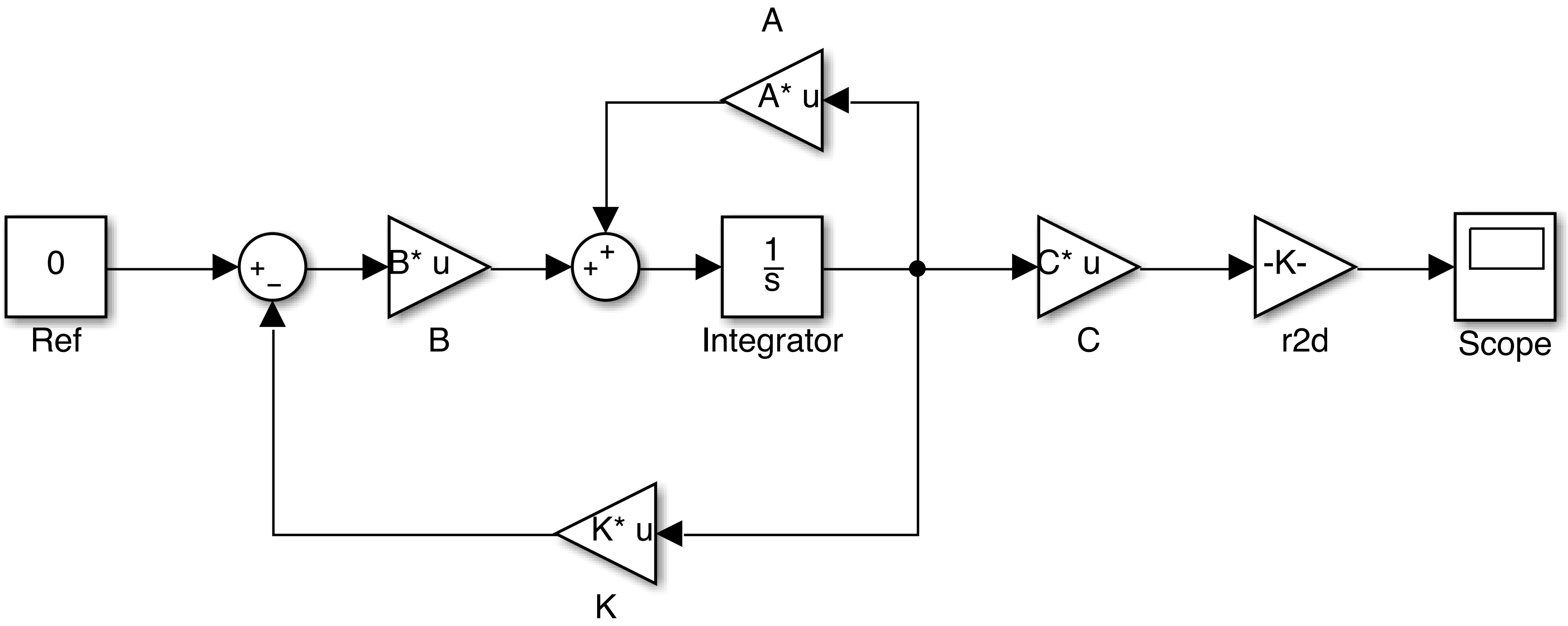
3. Implement the pole-placement method through Simulink, and control the system to keep it upright.

- Example #1
  - Implement two block diagrams using Simulink.





- Example #1
  - The result about the pole-placement method



- Example #2
  - Lecture note computed-torque control example: the two-link planar manipulator
  - The manipulator's equations of motion

$$\tau = M(\theta)\ddot{\theta} + V(\theta,\dot{\theta})$$

$$\begin{bmatrix}\tau_1\\ \tau_2\end{bmatrix} = \begin{bmatrix}3+2c_2 & 1+c_2\\ 1+c_2 & 1\end{bmatrix}\begin{bmatrix}\ddot{\theta}_1\\ \ddot{\theta}_2\end{bmatrix} + \begin{bmatrix}-\left(2\dot{\theta}_1\dot{\theta}_2+\dot{\theta}_2^2\right)s_2\\ \dot{\theta}_1^2 s_2\end{bmatrix}$$

  - Let the desired trajectory θ_d

$$\theta_{1d} = 0.1\sin\pi t$$
$$\theta_{2d} = 0.1\cos\pi t$$

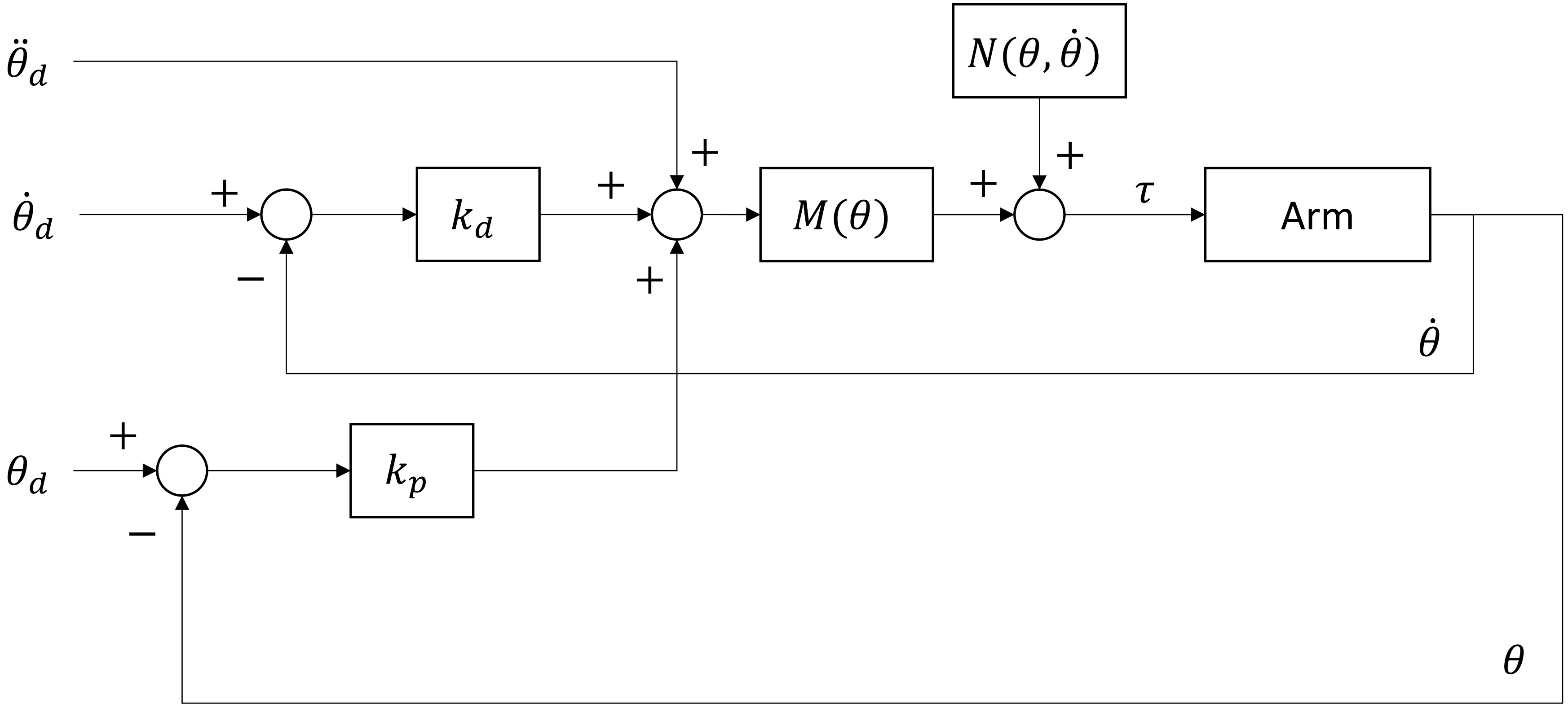
  - Differentiate the desired trajectory

$$\dot{\theta}_{1d} = 0.1\pi\cos\pi t$$
$$\dot{\theta}_{2d} = -0.1\pi\sin\pi t$$
$$\ddot{\theta}_{1d} = -0.1\pi^2\sin\pi t$$
$$\ddot{\theta}_{2d} = -0.1\pi^2\cos\pi t$$

  - Set the gains as

$$k_p = 100, k_v = 20$$

- Example #2
  - Make PD computed-torque controller blocks as



- Example #2
  - The result about PD computed-torque controller blocks