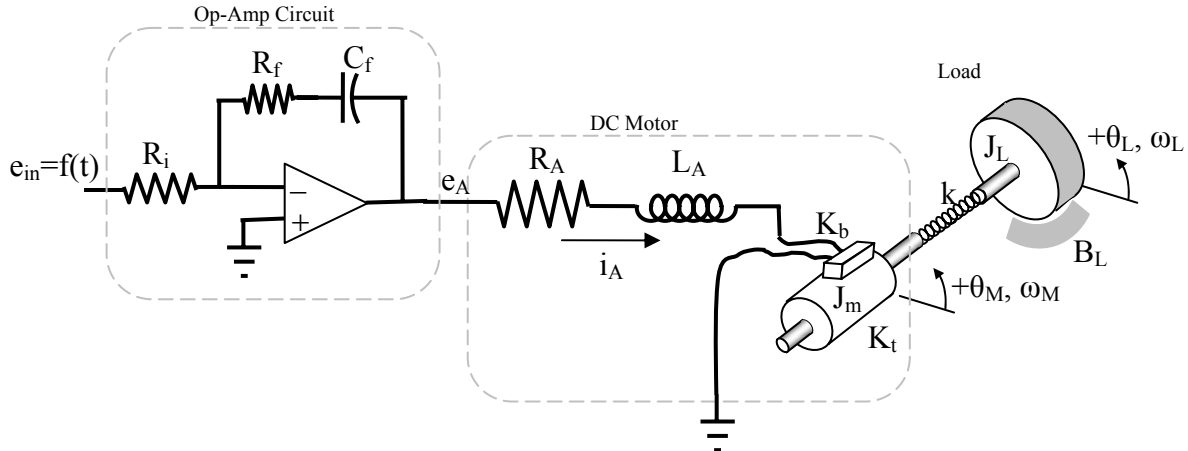


## Lesson 09

### Problem 9.1

In the electromechanical system shown below,  $i_A$  is the current passing through the motor,  $\theta_L$ ,  $\omega_L$ , and  $\alpha_L$  are the load position, velocity, and acceleration, and  $T_L$  is the effective torque acting on the load (this is the combined effect of the torque applied through the spring-like shaft and the damping torque acting on the load.)



Obtain the EOM for this system, then develop models in two forms:

- As a set of six 1<sup>st</sup> order differential equations.
- As a state space matrix and output matrix of the form:

$$\begin{Bmatrix} \dot{e}_A \\ \dot{i}_A \\ \dot{\theta}_M \\ \dot{\omega}_M \\ \dot{\theta}_L \\ \dot{\omega}_L \end{Bmatrix} = [A] \begin{Bmatrix} e_A \\ i_A \\ \theta_M \\ \omega_M \\ \theta_L \\ \omega_L \end{Bmatrix} + [B] \begin{Bmatrix} e_{in} \\ \dot{e}_{in} \end{Bmatrix} \quad \text{and} \quad \begin{Bmatrix} i_A \\ \theta_L \\ \omega_L \\ \alpha_L \\ T_L \end{Bmatrix} = [C] \begin{Bmatrix} e_A \\ i_A \\ \theta_M \\ \omega_M \\ \theta_L \\ \omega_L \end{Bmatrix} + [D] \begin{Bmatrix} e_{in} \\ \dot{e}_{in} \end{Bmatrix}$$

**Problem 9.2**

For the tape drive shown below determine the necessary equations to find the differential equation of motion (EOM) that relates the known input voltage,  $v_a$ , to the unknown output displacement,  $x_1$ . Assume the output shaft of the motor is rigid. Hint: The tension in the tape will change from one side of the idler wheel to the other. **Do not find the EOM but number the equations that you would use and generate a list of the unknown variables.** If you need a parameter that is not explicitly given in the figure below be sure you clearly define your notation.

