Problem 1 (10 Points) Given the block diagram and the torque speed curve in Figure 1, (a) find the transfer function $\theta(s)/E_a(s)$. Assume negligible input inductance in the circuit; (b) convert the transfer function to a state space representation for the system.

![D.C. Motor Model with Torque-speed Curve](image1.png)

Problem 2 (10 Points) (a) Find the transfer function $V_L(s)/V(s)$ from circuit in Figure 2 containing a nonlinear resistor following $i_r = 2e^{0.1v_r}$ relationship, and the voltage signal $v(t)$ in the figure is a small signal variation. (b) Convert the transfer function to a state space representation for the system.

![Nonlinear Circuit](image2.png)

Problem 3 (10 Points) Given the rotational mechanical system of Figure 3 find $J$ and $D$ to obtain 20% overshoot and settling time of 2 seconds for a step input torque.

![Rotational Mechanical System](image3.png)