EE 302 : Control Systems

Tutorial 2

31 January, 2020

1. Comment on the Linearity and time invariance properties of the system whose dynamics are given by following equations

   (a) $y(t) = ax(t) + c$

   (b) $y(t) = t^2 x^2(t)$

   (c) $y(t) = \frac{d}{dt}x(t) + \int_0^t x(t)dt + x(t)$

   (d) $y(t) = t^2 x(t)$

   (e) $\frac{d^2x}{dt^2} - \mu(1 - x^2)\frac{dx}{dt} + x = 0$ (Van der Pol oscillator dynamics equation)

2. Draw the pole-map on the complex plane for each of the following transfer functions. Comment on the nature of these responses (overdamped, underdamped, or undamped)

   (a) $\frac{2}{s^2+4}$ (Deduce the peak time T_p and percentage overshoot %OS)

   (b) $\frac{10}{s^2+3s+2}$ (Deduce the 2% settling time T_s)

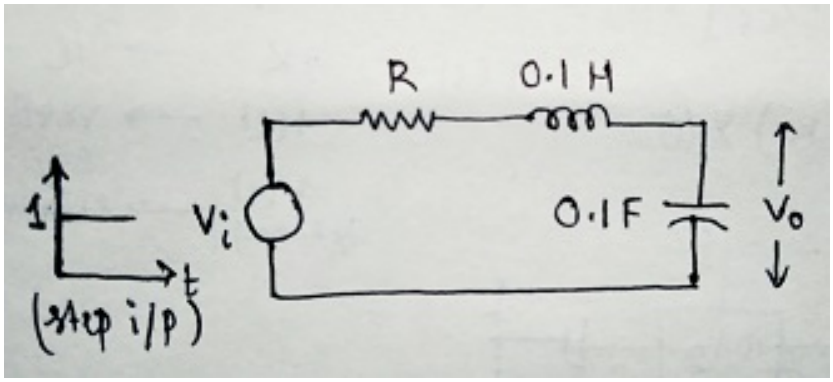
3. Deduce the peak time (if any), percent overshoot, 2% settling time of the step response for the system with transfer function G(s) = $\frac{1}{s^2+8s+16}$. Also comment if it is overdamped, underdamped or undamped.

4. Find the transfer function of the second-order system that yields a 12.3% overshoot and a settling time of 1 sec.

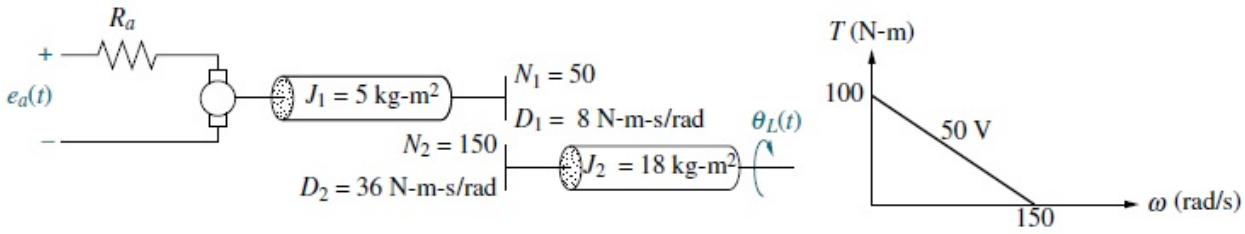
5. Find transfer function of a second order system whose damping ratio is 0.707 and settling time 0.5 sec.

6. Find the step response $y(t)$ of second order system given by $\frac{Y(s)}{U(s)} = \frac{\omega_n^2}{s^2+2\zeta\omega_n+\omega_n^2}$ and with help of $y(t)$, find expression for peak time and peak overshoot when $\zeta < 1$.

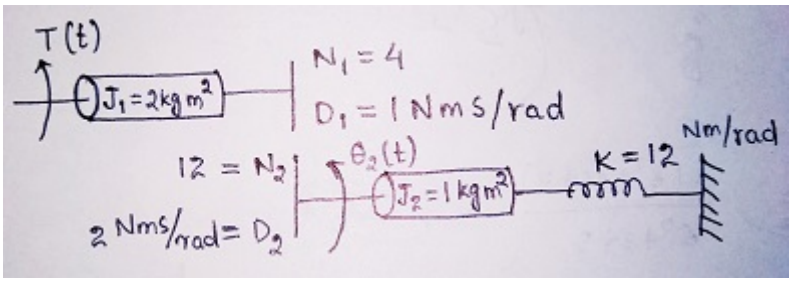
7. Derive the expression for voltage across capacitor $V_c(t)$ in the series RLC circuit given below. For what vales of resistance, $V_c(t)$ will behave a) under damped b) over damped c) critically damped.



8. For the motor, load and torque-speed curve (for motor parameter evaluation) shown, find the transfer function G(s) = $\dfrac{\theta_L(s)}{E_a(s)}$



9. For the rotational system shown, find the transfer function G(s) = $\dfrac{\theta_2(s)}{T(s)}$



10. Compare the qualitative behaviour in terms of settling time, damping ratio, overshoot etc. among the 2nd order systems A, B, C, D whose pole locations are given.