EE302, Control Systems, Quiz-1 (Feb-25)

Notes & instructions:

- Read all instructions very carefully first.
- Attempt all questions: each question carries 10 marks. Unnecessarily long, convolved, redundant or irrelevant text would attract marks-reduction.
- All plots/sketches need axes labelling.
- Unless otherwise explicitly specified, gain k is real and positive.
- Root locus sketch means: (a) mark poles by $\times$ and zeros by O, (b) on each branch, direction of k increasing from 0 to $+\infty$, for $k > 0$, (or, if explicitly sought for $k < 0$, from 0 to $-\infty$), (c) show real-axis segments, (d) calculate break-away and break-in point values and classify the break-away/break-in points accordingly, (e) $j\mathbb{R}$ axis intersection point value and k-value corresponding to the $j\mathbb{R}$ intersection, (f) obtain angle of arrival/departure for every nonreal zero/pole (if any), (g) asymptotes (if any): their angles and point of intersection.
  All these are to be shown with brief intermediate calculations.
  Make use of shifting if symmetry simplifies sketching/calculating; shift back to get final answer.
- If you feel a question has ambiguity or needs clarification, then assume yourself appropriately, state and justify your assumption and then solve the problem with that assumption.
- Do not call instructor nor any invigilator/TA. Instead read instructions again.

Ques 1: Suppose $y(t)$ is the unit step' response of the system with transfer function $\frac{s+4}{s+5}$. Use Initial Value Theorem (IVT) for finding $y(0^+)$, $\dot{y}(0^+)$, $\frac{d^2y}{dt^2}(0^+)$. Show intermediate calculations briefly. (Non-use of IVT will fetch far lower marks.)
(You can verify yourself final answers by differentiating in time-domain: no need to show those verification calculations.)

Ques 2: Sketch the root-locus of $G(s) = \dfrac{1}{s(s+3)(s+6)}$.

Ques 3: Consider the step response of the system $G(s) = \dfrac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$ with $\zeta > 0$ and $\omega_n > 0$. Plot curves C_1, C_2, C_3 and C_4, within the same figure, with:

C_1: curve along which % Over-Shoot (OS) is constant, C_2: curve along which 2% settling time T_s is constant,
C_3: curve along which peak time T_p is constant, C_4: curve along which natural frequency ω_n is constant

(Please cross-check that C_i are labelled in your plot exactly as above.)

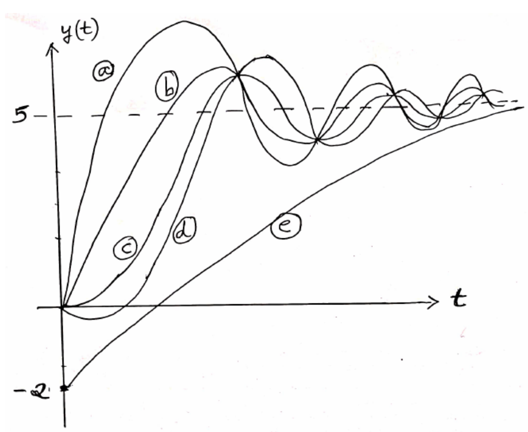
(a) For any two curves (out of C_1, C_2, C_3, C_4 curves), show how T_s vary: write explicitly whether T_s increases or decreases (give a direction along the curve to indicate the increase/decrease.)
T_s has to vary: do not choose the curve along which T_s is constant.

(b) Same as (a) for T_r: the rise time.

Ques 4: Consider the 6 transfer functions below:

$$\frac{s-5}{s^2+s+1}, \quad \frac{-6s+5}{3s+1}, \quad \frac{5}{s^2+s+1}, \quad \frac{2s+5}{s+1}, \quad \frac{s+5}{s^2+s+1}, \quad \frac{2s+5}{s^2+s+1}.$$

Below are 5 plots of step responses $y(t)$.



(a) Match transfer functions to their step-responses, if its step response is shown in the plot. Give a brief one-line reason.

(b) If a response/plot is unmatched to any of the given transfer functions, then suggest a transfer function having same characteristics (like initial value, initial rise rate, underdamped/overdamped, final value, first/second order). Plots are not to scale: use only qualitatively.