भारतीय सूचना प्रौद्योगिकी संस्थान कोटा
INDIAN INSTITUTE OF INFORMATION TECHNOLOGY KOTA

B.Tech. (ECE), Semester – IV
End Term Examination, Even Semester 2023-24

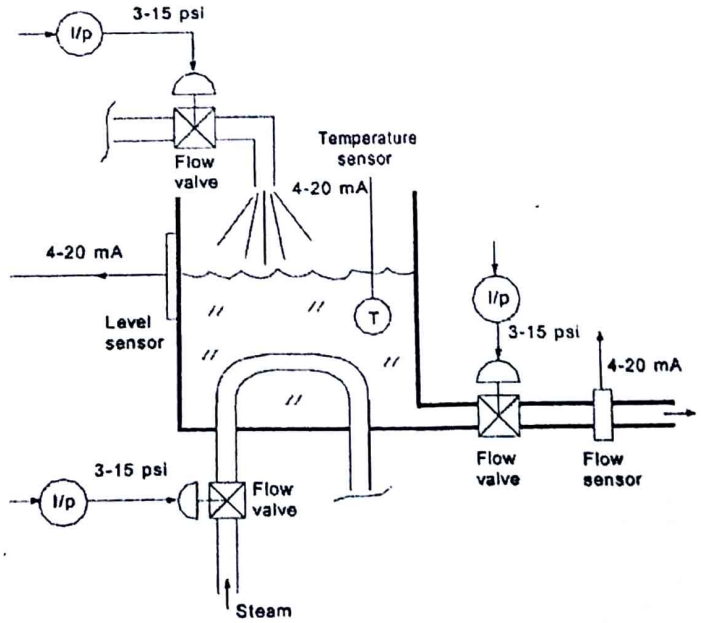
Control Systems (ECT210)

Marks: 40 (Weightage – 40%) **Time: 120 minutes** **Date: May 17, 2024**

Note: Attempt all question and their parts in sequence. Show all the steps.

Q1. A royal soldier stops at a watch store every morning at 9 A.M. and compared and reset his wrist watch with the wall clock in the window. Finally, one day the soldier went into the store and complimented the owner on the accuracy of the wall clock. "Is it set according to Indian Standard Time?" asked the soldier. "No," said the owner, "I set it by the 5 P.M. gunshot fired from the Jaivana cannon at the Jaigarh fort each afternoon. Tell me, sir, why do you stop every day and check your watch?" The soldier replied, "I'm the gunner at the fort!"
(i) The owner's wall clock loses two minutes each 24-hour period and the soldier's wrist watch loses three minutes during each eight hours. What is the total time error of the gunshot firing at the fort after 6 days? Assume that the gunshot fires initially at exactly 5:00 p.m.
(ii) Is the feedback positive or negative? Give reason in support of your answer. [2+1 = 3M]

Q2. Figure below shows a manufacturing process diagram which uses various sensors (level, temperature and flow), flow valves and current-to-pressure (I/P) variable conversion elements. In this process, the following independent control requirements must be satisfied: proportional control of the level at set-point L_{sp}, proportional plus integral control of the temperature at set-point T_{sp}, proportional plus derivative control of the output flow rate at set-point Q_{sp}.
(i) Complete the diagram by using the error-detector and controller blocks.
(ii) Mention the time-domain equation and transfer function of different controllers. Assume all set-points are expressed in equivalent current unit. [3+3 = 6M]



Q3. Define (a) type-N system in pole-zero form; (b) position, velocity and acceleration error constants; (c) static error expression for unit step, ramp and parabolic inputs. [1+1.5+1.5 = 4M]

Q4. Name three performances indices that are used to determine the quality of closed-loop control system. Also mention their utility and mathematical expression. [1.5+1.5 = 3M]

Q5. When subjected to 10 N step force, an oscillatory linear displacement mechanical system is found to have the following response data:

a) First positive peak overshoot displacement = 55 cm
b) Time at which first positive peak overshoot occurred = 0.5 s
c) Final steady state displacement = 35 cm

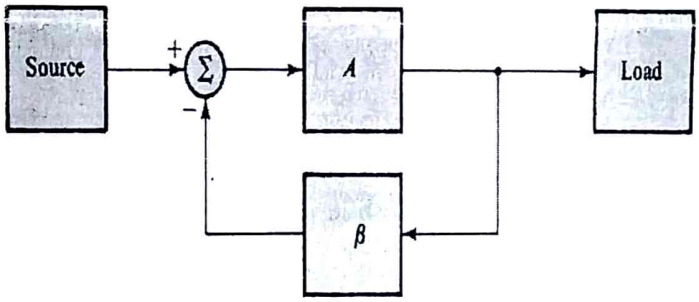
Obtain a second-order transfer function for this physical system. [8M]

Q6. A unity-feedback control system has the forward-path transfer function given below (assume K is greater than or equal to 0).

$$G(s) = \frac{K}{s(s+10)(s+20)}$$

(a) Construct the labeled root locus diagram showing all the steps.
(b) Mention the non-zero values of K for which the system becomes unstable. [6+2 = 8M]

Q7. Consider a negative feedback control system depicted below.



The forward-path transfer function is given below (frequency f in Hz):

$$A = \frac{10^5}{(1+jf/10^5)(1+jf/10^6)(1+jf/10^7)}$$

Assume feedback factor β to be unity.

(a) Draw the labeled Bode plot of loop gain $A\beta$.
(b) Calculate Gain Margin (GM) in dB and Phase Margin (PM) in degrees.
(c) Calculate gain and phase crossover frequencies. [6+1+1 = 8M]

*** *Be Good, Do Good* ***