

[Time: 3 hour]

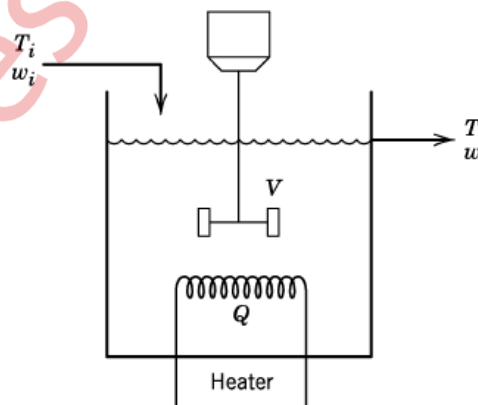
[Total marks: 80]

N.B.:

- 1) Question-1 is compulsory. Answer any three questions from remaining
- 2) Assume data if necessary and specify the assumptions clearly
- 3) Draw neat sketches wherever required
- 4) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other

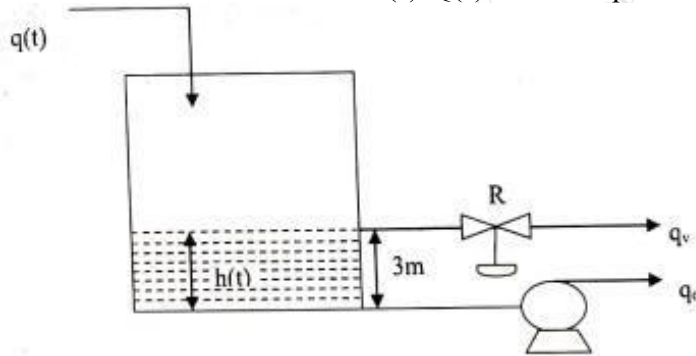
- Q.1)** a) Explain Gain Margin and phase margin (5)
 b) Write the controller equation and derive the transfer function for PID controller (5)
 c) Explain the Characteristics of under-damped response with neat diagram (5)
 d) A process with unknown transfer function is subjected to a unit impulse input. The output of the process is measured accurately and is found to be represented by the function $Y(t) = t e^{-t}$. Determine the unit step response of this process. (5)

- Q.2)** a) Continuous stirred-tank heating system shown in the figure below. The liquid inlet stream consists of a single component with a mass flow rate w_i and an inlet temperature T_i . The tank contents are agitated and heated using an electrical heater that provides a heating rate Q . Density and specific heat capacity of the mixture are constant. Carry out the degrees of freedom analysis, also state the disturbance and manipulated variables, for following two cases (i) holdup is constant, (ii) holdup is varying (10)



- b) An electronic PID temperature controller is at steady state with an output of 12 mA. The set point equals the nominal process temperature initially. At $t = 0$, the set point is increased at the rate of 0.5 mA/min. If the current settings are $K_C=2$ (dimensionless) $\tau_I=1.5$ min, $\tau_D=0.5$ min. Derive an expression for the controller output $p(t)$. (10)

Q.3) a) Derive the transfer function $H(s)/Q(s)$ for the liquid-level system (10)



(a) The tank level operates about the steady-state value of $h_s = 1$ m

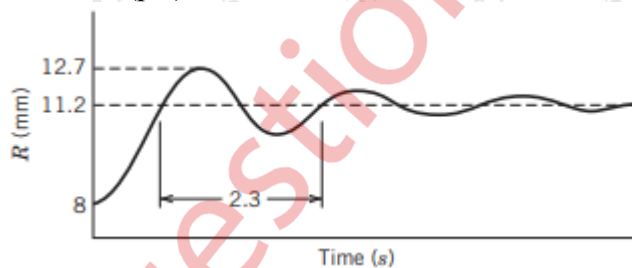
(b) The tank level operates about the steady-state value of $h_s = 3$ m

The pump removes water at a constant rate of $10\text{m}^3/\text{min}$; this rate is independent of head. The cross-sectional area of the tank is 1.0m^2 , and the resistance R is $0.5\text{m}/(\text{m}^3/\text{min})$

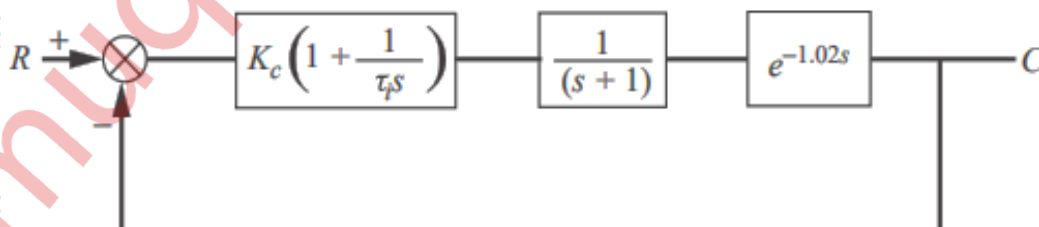
b) A step change from 15 to 31 psi in actual pressure results in the measured response from a pressure-indicating element shown in Figure. Assume a second order dynamics, calculate all important parameters and write an appropriate transfer function in the form (10)

$$\frac{R'(s)}{P'(s)} = \frac{K}{\tau^2 s^2 + 2\zeta\tau s + 1}$$

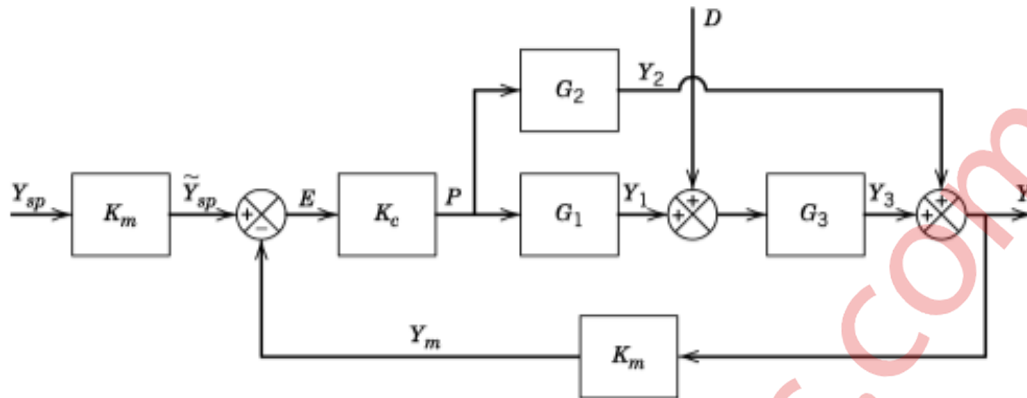
where R' is the instrument output deviation (mm), P' is the actual pressure deviation (psi).



Q.4) a) Using the Ziegler-Nichols rules, determine K_c and τ_I for the control system shown in the figure (10)



- b) A block diagram of a closed-loop system is shown in the Figure. Find Y/Y_{sp} by block diagram reduction (10)



- Q.5) a) A unity feedback system has $G(s) = \frac{e^{-0.2s}}{s(s+1)}$. From bode plot, find GM, PM, phase cross over frequency, and gain cross over frequency? Also Comment on stability (15)
- b) If the system has a characteristic equation as $s^4+10s^3+35s^2+50s+24=0$, determine the stability of the system by Routh Array. (5)
- Q.6) a) Analyze the working principle of ultrasonic level measurement and discuss how environmental factors affect its performance in industrial applications. (10)
- b) Discuss the construction and operating mechanism of a Bourdon Tube pressure gauge and List out the factors that influence its measurement accuracy (10)
