M.TECH/AEIE/2ND SEM/AEIE 5202/2021

PROCESS CONTROL SYSTEM DESIGN
(AEIE 5202)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The z-transform of 0.05^k is

(a) $\frac{z}{0.05+z}$ (b) $\frac{z}{z-0.05}$ (c) $\frac{0.05}{z-0.05}$ (d) $\frac{0.05}{z}$

(ii) The level of water in a tank is represented by _____order system

(a) 1 (b) 2 (c) 3 (d) 4

(iii) The order of the transfer function of distillation tray in a Distillation column is

(a) zero order (b) first order
(c) second order (d) third order

(iv) The transfer function of transportation lag of 5 sec. is represented by

(a) $1/(s+5)$ (b) e^{5s} (c) e^{-5s} (d) $e^{-s/5}$

(v) In an electro-pneumatic system analogy of the current is considered analogous to

(a) velocity (b) pressure
(c) air flow (d) air flow rate

(vi) Parity bits are used in digital systemsfor the purpose of _____.

(a) power monitoring (b) symmetry generation
(c) diagnostic monitoring (d) error detection

(vii) $\mu_{M\cup N}(x,y); x\in M, y\in N$ in fuzzy set is represented by

(a) complement operator (b) minimum operator
(c) maximum operator (d) power set operator

(viii) If $\tilde{A}=\{(x_1,0.2),(x_2,0.3),(x_3,0.5)\}; \mu_{A^3}(x_1)$ equals to

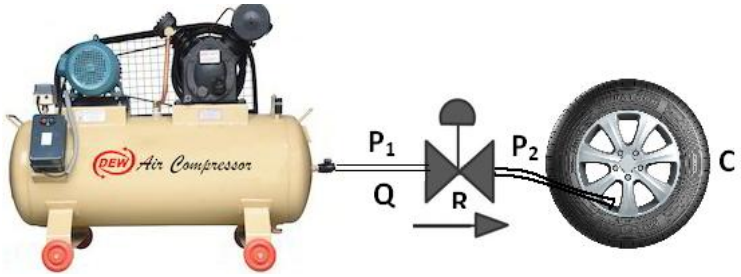
(a) 0.0025 (b) 0.009
(c) 0.008 (d) 0.0008

(ix) Many digital control systems utilize Ethernet as a communications network, because
(a) No terminating resistors are necessary
(b) Speed is not affected by traffic
(c) It is a wireless network standard
(d) It is robust and inexpensive

(x) The TF of a Distillation column is $\frac{1.5e^{-\theta s}}{(25.5s+1)^{10}}$; the time constant and number of trays respectively
(a) 25.5, 1.5 (b) 10, θ
(c) 25.5, 10 (d) 10, 1.5

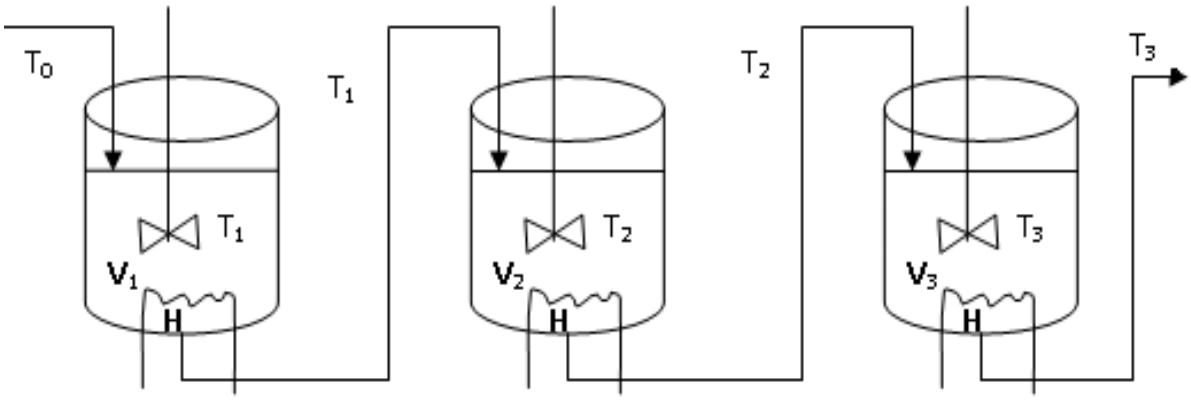
Group – B

2. (a)



Derive the mathematical model of the above compressor-tyre model connected through a valve of resistance R. 'C' is the capacity of the tyre, P_1 and P_2 are the input and output pressure and Q is the air flow rate.

(b) A series of 3 heat exchangers, where a liquid of density ρ and specific heat capacity of c_p is heated. T_0, T_1, T_2 and T_3 refer the temperature and V_1, V_2 and V_3 are respective volumes of the liquid in the heat exchangers. Derive the followings:
(i) Dynamic heat balance equation / equations for uniform volumetric flow rate of q and heat inputs of H as shown in Fig below.
(ii) Steady state model of the system.



4 + (6 + 2) = 12

3. (a) Justify the application of Smith predictor in systems with large dead time. Describe with block diagram.

(b) The time constants T_1 and T_2 of a typical second order system are 2 sec and 3 sec, respectively. Derive the followings for unity gain and 0.5 sec delay (L)
(i) Write the transfer function of the system.
(ii) Establish the relation: first moment $m_1=T_1+T_2+L$.
(iii) Calculate the time ti (time at the point of intersection of the slope of process reaction curve).

4 + (1 + 4 + 3) = 12

Group – C

4. (a) With suitable block diagram, describe a real time optimization system commonly used in process plant.

(b) How to estimate process model parameters using least squares method?

6 + 6 = 12

5. (a) Draw the supervisory control scheme used for designing of a process control system and describe the same.

(b) Explain how centralized TDMA scheme used for data transfer in field-bus of DCS.

6 + 6 = 12

Group – D

6. (a) Explain two merits of adaptive control over conventional control.

(b) Design an adaptive control scheme for a Phosphate Drying Furnace.

(c) A fuzzy set B is given as $\left[(x_1,0.7),(x_2,0.5),(x_3,0.3)\right]$. Evaluate the power set $\mu_{B^3}(x)$. Also determine the values of $\mu_{B^2}(x_2)$ and $\mu_{B^4}(x_3)$.

2 + 5 + (3 + 1 + 1) = 12

7. (a) The discretized membership functions of fuzzy set A and B are represented by :

$$\mu_A=\left\{\frac{0.2}{1}+\frac{0.4}{2}+\frac{0.8}{3}+\frac{0.9}{4}+\frac{1}{5}\right\}$$

$$\mu_B=\left\{\frac{0.9}{1}+\frac{0.6}{2}+\frac{0.5}{3}+\frac{0.4}{4}+\frac{0.1}{5}\right\}$$

Find the union, intersection and difference of the given fuzzy sets; also calculate the complement of fuzzy set B.

(b) Design a fuzzy control rule base from a typical second order underdamped system response. Consider two input variables are error and change of error. Where error e(k)= set-value r(k) – process value y(k) and change of error $\Delta e(k) = e(k) - e(k-1)$.

(2 × 4) + 4 = 12

Group – E

8. (a) Draw the negative feedback closed loop block diagram of an oven temperature control system with digital controller.

   (b) Derive the transfer function $G_{ZOH}(s)$ of D/A converter for Zero order hold circuit.

   (c) The transfer function of the oven is $G(s)=\frac{1.63e^{-300s}}{1+3480s}$; Then Derive $G_D(z)$, where $G_D(z)=G_{ZOH}(z)\times G(z)$.

   (d) For feedback transfer function of $H(z)=z^{-2}$ and feed-forward transfer function $G_D(z)$; find the overall transfer function of the oven temperature control system.

3 + 2 + 4 + 3 = 12

9. (a) What are the main aims of enhanced boiler drum level control?

   (b) With a diagram, show the main physical features of a typical boiler.

   (c) Give an explanation of the action of the control system in a boiler drum level control.

2 + 6 + 4 = 12

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AEIE	https://classroom.google.com/c/MzExOTM4MTYyODI4/a/MzczOTY0ODQyMzY3/details