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M.E. ELECTRICAL ENGINEERING FIRST YEAR FIRST SEMESTER – 2025
&
M.E. CONTROL SYSTEM ENGG FIRST YEAR FIRST SEMESTER – 2025

ADVANCED INDUSTRIAL CONTROL

Time: Three Hours; Full Marks: 100

Answer any *five* questions

1. a) State and explain the objectives of industrial process control. **6+5+6+3**
   b) Draw the piping and instrumentation diagram for a section of pipe in which the flow rate of the fluid flowing through the pipe section has to be controlled. Label each component clearly using standard notations.
   c) Explain the terms *Quick Opening Valve*, *Linear Valve* and *Equal Percentage Valve*.
   d) What is *Final Control Element*?

2. a) Explain the terms *modulating control* and *sequential control*. **4+4+4+4+4**
   b) Explain the difference between the terms *load* and *disturbance* with the help of an example.
   c) State why the 4-20 mA range is preferred as the standard output range for transmitters.
   d) Find the output reading of a 4-20 mA transmitter with an input range of 1200°C and 30% reading.
   e) With the help of diagrams, explain the differences between two wire transmitters and four wire transmitters used for industrial systems.

3. a) Explain why models for chemical processes often contain a delay element. **5+5+10**
   b) Write a short note on Pade approximation and its uses. State the first order and second order Pade approximations for delay.
   c) An electrically heated metallurgical furnace with unit step input reached a steady state temperature of 1600 deg-C after about 6 hours. Temperatures measured 10 minutes and 50 minutes after switch on, were respectively 160 and 1040 deg-C. Assuming an ambient of 20 deg-C, fit a first order model – with delay for the plant.

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4. An upright conical tank with a height L and a cross section A (m-sq) at the top, is fed from the top at a rate of q_i litres/second. The tank is connected to a water supply system through a valve such that the outlet discharge rate in litres/sec is given by the linear relation $q_o = kh$, where k is a constant and h is the instantaneous height of water level in the tank. **5+5+5+5**
   a) Derive the nonlinear differential equation of the system with q_i and h as the variables.
   b) Derive the (nonlinear) differential equation of the system relating q_i as the input and the outflow rate q_o as the output variable.
   c) Linearize the differential equation relating q_i and q_o when the tank is 75% full.
   d) Derive the transfer function between h and q_i.

5. a) With appropriate diagrams, explain the physical significance of the terms *Proportional Band* and *Ultimate Gain.* **6+10 +2**
   b) Given a first order plant with a time constant of 60 s and a delay of 10 s. Determine the Proportional controller setting to obtain 45 degree phase margin.
   c) What is a *Roll-Off Pole*?

6. a) Discuss the advantages and disadvantages of *Reset* control. **4+2+10 +4**
   b) State and explain the significance of Reset Time?
   c) Given a first order plant with a time constant of 20 s and a delay of 3 s, determine the P-I controller settings to obtain 40 degree phase margin.
   d) Determine the *PCF* of the plant with the above controller.

7. a) State the transfer function of a PID controller. Sketch its asymptotic Bode magnitude plot and the phase plot. **4+8+8**
   b) Given a first order plant with a time constant of 40 s and a delay of 8 s, (i) at what minimum proportional gain would the plant oscillate in closed loop and at what frequency? (ii) Hence, determine the PID controller settings by Zeigler Nichols method.