

AGRICULTURAL & FOOD ENGINEERING
IIT, KHARAGPUR

Spring Mid Semester Exam 2008-2009

Date.

Time 2 hours

Full Marks - 30

Subject No - AG 60148

Sub: Instrumentation & Control in Food Industry

No. of Students - 9+2=11

B.Tech (IVth year) and Dual Degree (DFE).

Answer the following (any three).

Q 1(a). Define the terms.

- (i) Drift (ii) resolution (iii) Dynamic error
(iv) Time lag.

(b). Arrive mathematically to show that in a mercury in glass bulb thermometer (a first order instrument), the time constant ' τ ' will be low if the density of thermometer fluid and volume of bulb is kept low while the heat transfer area is increased.

Q 2(a) A resistance strain gauge with $R = 100 \Omega$, gauge factor of 2.5 is placed in equal arm resistance bridge circuit. If the supply voltage is 10V and the detector resistance is 150Ω , calculate the sensitivity of the detector.

(b) Explain with a neat (PENCIL DRAWN) diagram, the vacuum pressure measured by a McLeod Gauge is directly proportional to square of height of compressed gas in the capillary.

Q 3 (a) The power radiated from a hot piece of metal body in a baking oven was measured by a 'total radiation pyrometer'. The temperature was determined as 245°C . assuming the surface emissivity value of 0.75. Later it was found that, the accurate value of emissivity was 0.69. Find the error in determination of temperature.

(b). A copper - constantan thermocouple was found to have linear calibration between $0 - 400^{\circ}\text{C}$ with an emf at maximum temperature (reference temperature junction 0°C) equal to 20.68 mV. (i) Determine the correction which must be made to the indicated emf if the cold junction temperature is 25°C . (ii) If the indicated emf is 8.92 mV in the thermocouple circuit, determine the temperature of system in which this thermocouple is used.

Q 4. A pressure gauge is used to measure fluctuating pressure. The process pressure is cycling from 207 - 250 kPa. within a period of 5 s. The attenuation of the cycle must be limited to 10%. It is needed to determine (i) the maximum time constant is permissible in the pressure gauge with first order type response. (ii) What characteristic time is permissible in a critically damped condition if the pressure gauge is considered to follow second order response.

Hint Sheet for Problem 4

Formula for first order response (cyclic)

$$y = Kx_s \left[\frac{1}{\sqrt{1+(\omega T)^2}} \right] \sin(\omega T - \phi)$$

$$\phi = \tan^{-1} \omega T.$$

Formula for 2nd order response (cyclic)

$$y = Kx_s \left[\frac{1}{\sqrt{\left[\left\{ 1 - \left(\frac{\omega}{\omega_n} \right)^2 \right\}^2 + 4 \zeta^2 \frac{\omega^2}{\omega_n^2} \right]}} \right] \sin(\omega t - \phi).$$

$$\phi = \tan^{-1} \frac{2 \zeta \frac{\omega}{\omega_n}}{1 - \left(\frac{\omega}{\omega_n} \right)^2}.$$