T.E (MECHANICAL) (SEM V) (CBSGS)
Mechanical Measurement and Control

24th November, 2014
2.30 pm to 5.30 pm

QP Code :14846

03 Hrs **[Total Marks 80]**

N.B.:
(1) **Question No.1 is compulsory**
(2) Attempt any **three** questions out of remaining **five** questions
(3) Figures to right indicate full marks
(4) Assume suitable data if **necessary**.
(5) Notations carry usual meaning.

Q.1 (A) Following table list the measuring instruments (left hand side column of the table) for measuring mechanical properties (right hand side column of the table) of the system. Students shall match the measuring instrument with the corresponding mechanical property. 04

Measuring Instruments	**Properties**
Optical pyrometer	Temperature
McLeod gauge	Speed
Rotameter	Pressure
Stroboscope	Flow rate

Further student shall explain only the working principle of the measurement instrument listed on left hand side column of the table. 04

(B) Construct the block diagram that combines the following set of equations expressed in the 's' notation (Laplace notation). (1) W=X-Y, (2) V=W-Z, (3) Z(S+6)=V(S+2), (4) $Y(S^2+6S+8)=Z$. Given X is the input to the system and Y is the output from the block diagram. Find the transfer function. 06

(C) Write short note on proportional-integral-derivative (PID) controller. 06

Q.2 (A) Explain the following terms with respect to the measurement system: 05
(i) Threshold and Resolution
(ii) Sensitivity and Drift
(iii) Hysteresis

(B) With a neat sketch explain the working of LVDT 05

(C) Consider the following state-space representation of single input single output system: 10

$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{Bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -3 & -2 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix} + \begin{Bmatrix} 0 \\ 0 \\ 1 \end{Bmatrix} u(t) \text{ , and } y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix}.$$

Here x_1, x_2 and x_3 are state-variables, u(t) is a force vector and y(t) being the system response. Obtain transfer function of the system.

Q.3(A) With a neat sketch explain the constructional feature and working of (i) piezoelectric accelerometer, (ii) Ionization gage for pressure measurement 10

(B) Figure 1 shows the unit step response of a second order system. Determine the following from the plot 10

(i) Gain
(ii) Damping ratio
(iii) Natural Frequency
(iv) Transfer function

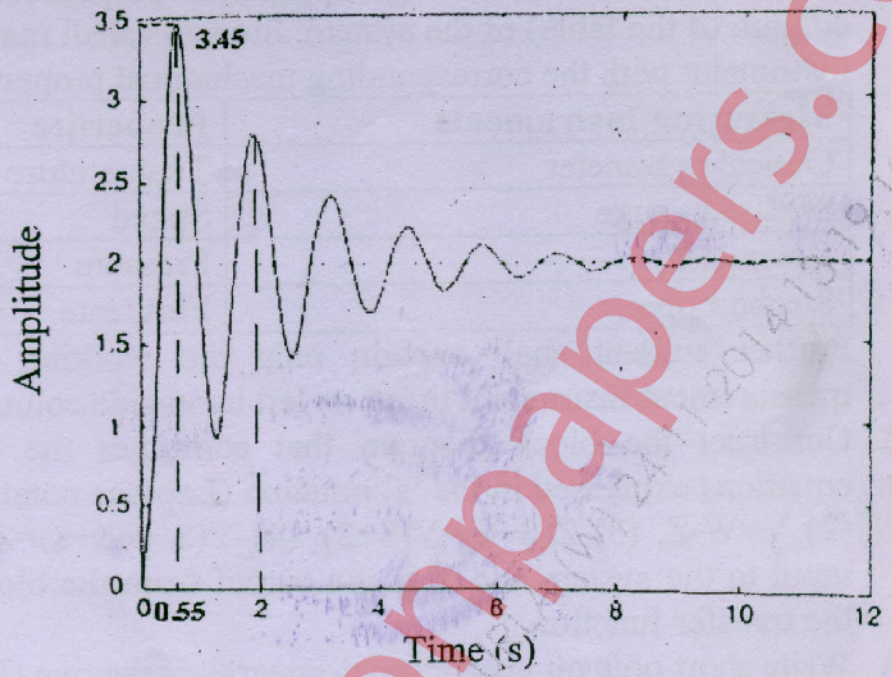

Figure 1

Q.4 (A) Consider a single strain gage of resistance 120 Ω mounted along the axial direction of an axially loaded specimen of steel (E=200 GPa). If the percentage change in length of the rod due to loading is 3% and the corresponding change in resistivity of the strain gage material is 0.3%, estimate the percentage change in the resistance of the strain gage and its gage factor, Poisson ratio=0.3. If the strain gage is connected to a measurement device capable of determining change in resistance with an accuracy of ±0.02 Ω, what is the uncertainty in stress that would result in using this resistance measurement device? 10

(B) For a control system open loop transfer function consist of $G(s)\,H(s) = \frac{K}{S^2(S+2)(S+3)}$. Find the value of "K" to limit steady state error to 10, when input to system is $\{1 + 10t + 20t^2\}$. Here 't' is the time. 10

TURN OVER

Q.5(A) For a particular unity feed-back system

$$G(S) = \frac{242(S+5)}{S(S+1)(S^2+5S+121)}$$ 10

Sketch a Bode plot. Further comment on stability of the system

(B) With a neat sketch explain working of an Operational Amplifier (Op-amp). Enumerate limitations of the same. 10

Q.6 (A) Draw the root-locus of the feedback system whose open-loop transfer function is given by

$$G(S)H(S) = \frac{K}{S^2(S+1)}$$ 10

(B) Explain generalized measurement system elements with block diagram. Describe its functions with suitable example. 10