Duration: 3 hours **Max. Marks 80**

N. B.: 1. Question No. 1 is Compulsory.

2. Attempt any 3 Questions from Question no. 2 to 6.

3. Figures to the right indicate the full Marks.

4. Statistical tables are allowed.

Que. 1 a If λ is an eigen value of square matrix A then prove that λ^n is an eigen value of matrix A^n 5

b Let X be a continuous random variable with probability density function f(x)=kx(1-x), $0 \le x \le 1$. Find k and determine the number 'b' such that $P(X \le b) = P(X \ge b)$ 5

c Verify Cauchy – Schwartz inequality $U = (2, 3, 1)$ and $V = (3, 0, 4)$ also find the angle between U and V 5

d Evaluate $\int_{-2}^{2} \frac{2z+3}{z} dz$ along the upper half of the circle $|z| = 2$ 5

Que.2. a If $A=\begin{bmatrix} 2 & 3 & 4 \\ 0 & 4 & 2 \\ 0 & 0 & 3 \end{bmatrix}$ find eigen values and eigen vectors of A^2-2A+I. 6

b In a precision bombing attach there is a 50% chance that any one bomb will strike the target. Two direct hits are required to destroy the target completely. How many bombs must be dropped to give a 99% chance or better of completely destroying the target. 6

c Find all Taylor and Laurent series expansions for $f(z) = \frac{z}{(z-2)(z-3)}$ about z=1 indicating the region of convergence. 8

Que.3. a Three factories A, B, and C produces 35%, 45% and 20% of the total production of an item. Out of their production 90%, 50%,and 10% are defective. Find probability that it is produced by factory A 6

b Verify Cayley-Hamilton theorem for $A=\begin{bmatrix} 2 & 1 & 1 \\ 0 & 1 & 0 \\ 1 & 1 & 2 \end{bmatrix}$ and hence find A^{-1} 6

c Obtain the equations of the lines of regression for the following data. Also obtain the estimate of X for Y=70. 8

X	65	66	67	67	68	69	70	72
Y	67	68	65	68	72	72	69	71

TURN OVER

Que.4. a By using Cauchy's residue theorem, evaluate $\oint_C \frac{\sin \pi z + \cos \pi z}{(z-1)(z-2)} dz$ 6

where C is $|z| = 3$

b Construct an orthonormal basis of R^3 using Gram Schmidt process to S={(3, 0, 4), (-1, 0, 7), (2, 9, 11)} 6

c Determine whether the matrix $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$ is diagonalizable, if yes diagonalise it. 8

Que. 5 a Show that the matrix $A = \begin{bmatrix} 5 & -6 & -6 \\ -1 & 4 & 2 \\ 3 & -6 & -4 \end{bmatrix}$ is derogatory and find the minimal polynomial of the matrix. 6

b The weekly wages of 1000 workmen are normally distributed around a mean of Rs 70 and standard deviation Rs 5. Estimate the number of workers whose weekly wages will be (i) between 65 and 75 (ii) more than 75 6

c By using Cauchy residue theorem, evaluate 8

i. $\int_0^\infty \frac{dx}{x^2+9}$ ii. $\int_0^{2\pi} \frac{1}{5+4\cos\theta} d\theta$

Que.6. a If $A = \begin{bmatrix} 2 & 3 \\ -3 & -4 \end{bmatrix}$ show that $A^{100} = \begin{bmatrix} -299 & -300 \\ 300 & 301 \end{bmatrix}$ 6

b Between 2 pm and 4 pm, the average number of phone calls per minute coming into a switchboard of a company is 2.5. Find the probability that during one particular minute there will be (i) no phone call at all, (ii) at least 5 calls. 6

c If X is a r.v. whose moment generating function is given by $M_X(t) = e^{t^2/2}$, Prove that $E(X^{2k}) = \frac{(2k)!}{2^k k!}$ and $E(X^{2k+1}) = 0$ 8

Duration: 3 Hours **Total Marks : 80**

Note:

1. Question one is compulsory.

2. Solve any three from remaining and assume suitable data wherever necessary.

Q1. **Attempt any four** **20**

a. Define strain and gauge factor. What is Poisson's ratio? Explain why it is always negative.

b. Explain "Vena Contracta" and draw its pressure flow diagram.

c. State Piezo resistive effect and piezo electric effect.

d. Derive Bernoulli's equation.

e. Explain construction and working of Bourdon tube.

Q2. a Explain different arrangements of strain gauges for better sensitivity and temperature compensation. **10**

Q2. b A strain gauge is bonded to a steel beam 0.1 m long and has a cross sectional area of 4 cm2. Young's modulus of elasticity for steel is 207 GN/m^2. The semiconductor strain gauge has a unstrained resistance of 240Ω and gauge factor 2.2 when load is applied the gauge's resistance changes by 0.013Ω. Calculate force applied to the beam. **10**

Q3.a State the basic principle and explain McLeod gauge. **10**

Q3.b. Classify pressure transducer. Describe working of different types of manometer with advantages and limitations of each type. **10**

Q4.a. Explain working of variable area flow meter. **10**

Q4.b. Derive an expression for fluid flow discharge in variable head type flow meters (Venturi, Orifice, Nozzle). **10**

Q5.a. Describe in detail with neat sketch pH measurement also give its applications. **10**

Q5.b. A venturi tube of throat diameter 60mm is placed in a water pipe of diameter100 mm to measure the volumetric flow. The volumetric flow rate through the tube is 0.08 m^3/s and the water has a density of 1000 kg/m^3 and viscosity of 10^{-3} NS/m^2. **10**

a) Determine the Reynold's number for these conditions.
b) The coefficient of discharge is 0.99. Determine the upstream to throat differential pressure.

Q6. Write a short note on (Any two) :- **20**

a. Dead weight tester
b. Smart sensor
c. Viscosity meter

Duration: 3 Hours **Max. Marks 80**

N.B.

1. **Q.1** is compulsory. Attempt **any three** from the remaining questions.
2. All questions carry equal marks.
3. Figures to the Right indicate full marks.
3. Assume suitable data if necessary

Q.1 Attempt **any four** **20**

a. Write difference between open-loop and closed-loop systems.

b. Define gain margin and phase margin.

c. For a feedback control system with forward path transfer function $G(s)$ and feedback transfer function $H(s)$, define 'Order' and 'Type' of the system.

d. Determine steady state error in unit step response for the system $\frac{Y(s)}{R(s)} = \frac{3}{(s^2+1.5s+2)}$.

e. Write difference between open-loop and closed-loop systems.

f. Define 'time-constant' for the first order system. How much time the first order system response will take to reach at 99% final value?

Q.2 A. For the following system, compute risetime (t_r), peak time (t_p), peak overshoot ($\%M_p$) and settling time (t_s) for 2% tolerable error in response. **10**

$$G(s) = \frac{1}{s^2 + 1.414s + 1}$$

B. Define Transfer function. Obtain the transfer function for the system in **Fig.1** using block diagram reduction techniques. **10**

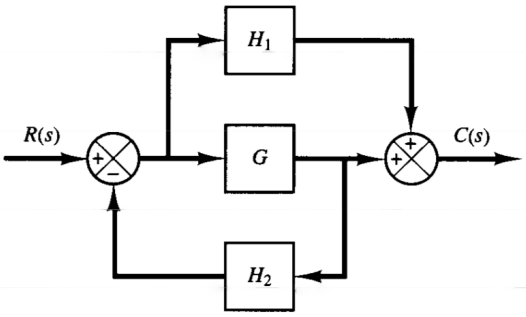

Fig.1

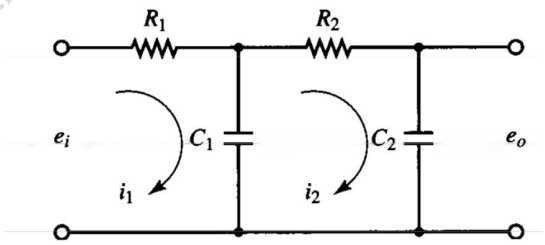

Fig.2

Q.3 A. Obtain the mathematical model of the system in **Fig.2**. What will be the transfer function of this system if $R_1 = R_2 = 1k\Omega$ and $C_1 = C_2 = 0.01\mu F$? **10**

B. Determine the stability of the system having a characteristic equation **10**

$$P(s) = s^5 + 2.1s^4 + 1.51s^3 + 0.471s^2 + 0.064s + 0.0030 = 0$$

using Routh's criterion.

Turn Over

Q.4 A. Determine the position, velocity and acceleration error constants for unity feedback systems with open loop transfer functions **10**

$$\textbf{(i)}\ G(s) = \frac{k}{(T_1 s + 1)(0.5T_1 s + 1)} \qquad \textbf{(ii)}\ G(s) = \frac{1}{s(s+2)}$$

Where T_1 is a positive constant.

B. Construct the root locus for the system **10**

$$G(s) = \frac{K}{s^3 + 11.5s^2 + 15.5s + 5}$$

with feedback $H(s) = 1$.

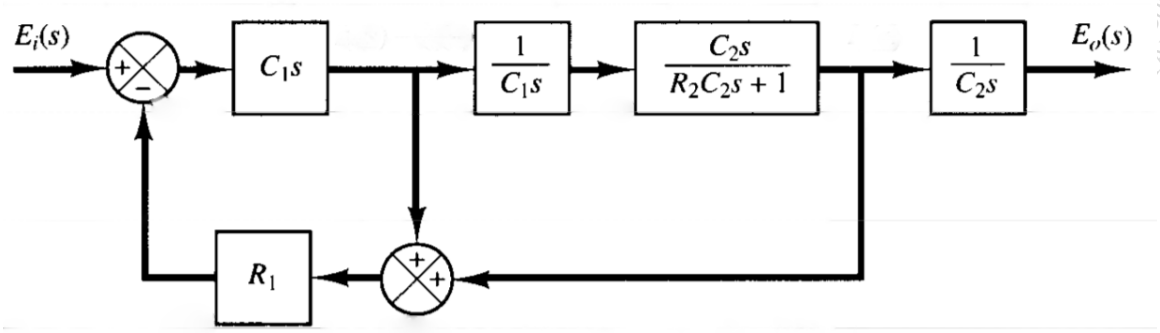

Fig.3

Q.5 A. Construct the signal flow graph and obtain $E_o(s)/E_i(s)$ for the system in **Fig.3** using Mason's gain formula. **10**

B. If the poles of the system are $s = -1 \pm j$. Compute risetime (t_r), peak time (t_p), peak overshoot ($\%M_p$) and settling time (t_s) for 2% tolerable error in response. **10**

Q.6 A. Draw Nyquist plot for the system, **10**

$$G(s) = \frac{1}{s(T_1 s + 1)(T_2 s + 1)}$$

What frequency does the response will cross the real axis and what will be the magnitude at that frequency?

B. Draw Bode plot for the system, **10**

$$G(s) = \frac{1}{(s+1)(s+100)}$$

and obtain gain and phase margins from plot.

(3 Hours) [Total Marks: 80]

N.B: (1) Question No. **1** is compulsory.
(2) Attempt any **Three** questions from remaining.
(3) Figures to the right indicate full marks.

1. Answer the following: - [20]

(a) Explain the causes for deviation from Beer's law.
(b) Calculate the energy of 530 nm photon of visible radiation.
(c) Explain Time decay of radioactive isotopes.
(d) Explain the principle of Raman Spectroscopy.

2. (a) With neat diagram, explain double beam spectrophotometer. [10]
(b) Explain the differences between AAS and AES. [10]

3. (a) With neat diagram, explain the working of ionisation chamber. [10]
(b) Explain CO_2 analyser with neat diagram. [10]

4. (a) With neat diagram, explain NMR Spectrometer. [10]
(b) With a neat sketch explain working of a high-pressure liquid chromatography. [10]

5. (a) Explain the concept of Fluorescence and Phosphorescence.
Also explain the working of single beam filter fluorimeter with neat diagram. [10]
(b) Explain the sample handling techniques for solids and liquids in
Mass Spectrometer. [10]

6. Write Short Note on: - [Any Two] [20]
(a) Gas Chromatograph.
(b) Photomultiplier Tube.
(c) Sources used in Spectrophotometers.

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54497

Total Marks : 80 **(3 Hours)**

Note: (1) **Q1 is compulsory**
(2) Attempt **any three** from the remaining
(3) Assume suitable data wherever necessary

Q1 Answer any four from the following **20**

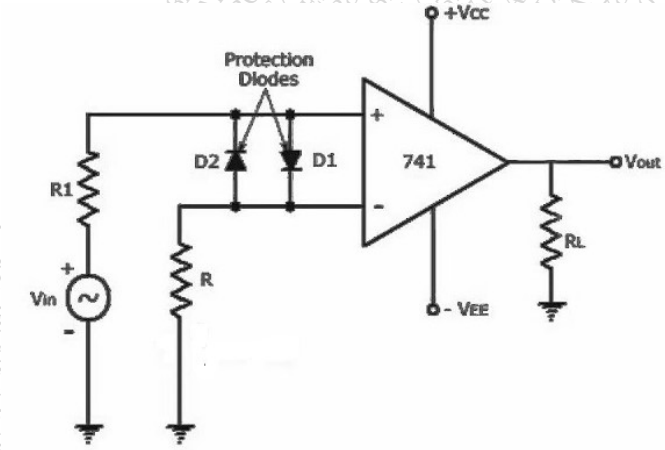
a. An amplifier outputs a voltage that is 10 times the voltage on its input terminals. It has an input resistance of 10kΩ . A sensor outputs a voltage proportional to temperature with a transfer function of 20mV/°C. The sensor has an output resistance of 5kΩ. If the temperature is 50°C, find the amplifier output considering the effect of loading.

b. Draw the absolute value circuit using Op Amp and sketch its input output waveform

c. Explain the block diagram of a SMPS.

d. Discuss the different types of filters with their input output characteristics.

e. Sketch the output of the following circuit:



What could be the function of the circuit?

Q2.

a. Derive the expression for output voltage for an Instrumentation amplifier with a transducer bridge. Also list the applications of the same. **10**

b. A Solid –state pressure sensor that outputs 25mV/kPa for a pressure variation of 0.0 to 25kPa will be used to measure the level of a liquid with a density of $1.3*10^3 Kg/m^3$.What voltage output will be expected for level variations from 0 to 2.0m?What is the sensitivity for level measurement expressed in mV/cm? **10**

Q3.

a. Describe typical R-2R ladder type Digital to Analog converter for 4 bits data. Determine its step size when R_f=20kΩ. Also calculate the output voltage if b0=b1=b2=0 and b3=5V. **10**

b. Explain how Op-Amp can be used as a voltage to current convertor with (a) floating load and (b) grounded load **10**

Q4.

a. What is a RTD? Explain its construction and the signal conditioning circuitry associated with it. **10**

b. Explain monostable multivibrator using IC 555 with neat input output waveforms. Also design a monostable multivibrator to have an output pulse width of 100ms. **10**

Q5.

a. Design a general signal conditioning circuit to convert sensor output i.e. LDR output to 0 volt (Dark) to 5 volt (Light) for resistance range 90KΩ to 5.1KΩ respectively. **10**

b. What is a voltage regulator? What are its types? Design an adjustable voltage regulator using IC 7805 to obtain an output of 12V. **10**

Q6.

a. List the different types of analog to digital convertors. Explain one of them with a neat diagram. **10**

b. What is operating principle of photovoltaic cell. Give its equivalent circuit and hence discuss the signal conditioning circuit associated with it. **10**