SECTION A

1. This question consists of TWENTY FIVE sub-questions 1.1 to 1.25 of ONE mark each. For each of these sub-questions, four possible answers (A, B, C, and D) are given, out of which only one is correct. Answer each sub-question by darkening the appropriate bubble using a soft HB pencil against the question number on the left-hand side of the Objective Response Sheet (ORS). Do not use the ORS for any rough work. You may use the last few pages of the main answers book for any rough work.

1.1 An 8-bit DAC with a reference voltage of 2.55 V, when tested gave the following results

Input	20H	21H	22H	23H	24H
Output V	0.320	0.330	0.325	0.350	0.360

The DAC is

(A) Monotonic
(B) Non-monotonic
(C) Bi-polar
(D) Quadratic

1.2 A piezoelectric type 50 MPa full-scale pressure sensor with built-in electronics has a sensitivity of 100 mV per MPa. If this sensor is subjected to a static pressure of 10 MPa then its output will be

(A) 0 mV
(B) 100 mV
(C) 1000/ $\sqrt{2}$ mV
(D) 1000 mV

1.3 In the case of a variable reluctance type inductive transducer, PUSH-PULL arrangement reduces non linearity by eliminating

(A) The ODD order harmonics
(B) The EVEN order harmonics
(C) Both ODD and EVEN harmonics
(D) Offset

1.4 Kelvin double bridge is best suited for the measurement of

(A) Resistances of very low value
(B) Low value capacitance
(C) Resistance of very high value
(D) High value capacitance

1.5 A counter timer has a basic clock of 16 MHz. The count value displayed is in error by 1 count. The frequency at which the error in the displayed value is the same whether the counter-timer is used in the frequency mode of operation or period mode of operation is

(A) 16 MHz
(B) 10 MHz
(C) 8 MHz
(D) 4 MHz

1.6 A seismic type of transducer has a damping constant of 10. The transducer is designed to measure

(A) Acceleration
(B) Velocity
(C) Displacement
(D) Force

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1.7 All metal resistive strain gages have a gauge factor (GF) nearly 2.5 due to the
(A) Young's modulus is the same for all metals and alloys.
(B) Poisson's ratio is the same for all metals and alloys.
(C) The conductivity of the material changes with applied strain the elastic region.
(D) The conductivity of the material is independent of the applied strain.

1.8 Majority of digital voltmeters are built with a Dual-slope ADC because
(A) Dual slope ADCs are less complex than other types of ADCs.
(B) Dual slope ADCs are faster than other types of ADCs.
(C) Dual slope ADCs can be designed to be insensitive to noise and interference.
(D) Dual slope ADCs provide BCD outputs.

1.9 Wien bridge is best suited for the measurement of
(A) Frequency
(B) Capacitor
(C) Inductor
(D) Resistor

1.10 An integral Control is used to
(A) Improve the transient response
(B) Reduce the offset
(C) Eliminate the offset
(D) Reduce the settling time

1.11 A unity feed back system has a forward path transfer function $G(s) = \frac{10}{(s+5)}$. It is subjected to a unit ramp input. The integral of the squarred error (ISE) is
(A) zero
(B) infinity
(C) always negative
(D) 0.5

1.12 The loop transfer function of a system has a pole in the right half of the s – plane. The Nyquist plot makes one clockwise encirclement of (-1, 0) point. The closed loop system is
(A) Unstable
(B) Stable
(C) Marginally stable
(D) Asymptotically stable

1.13 A common practice of reducing hysteresis error in the output for a given value of input is to maintain
(A) High rate change of input
(B) Low rate of change of input
(C) Taking observations either in the ascending or in the descending order
(D) Taking observations both in the ascending and descending orders and take average value of the output.

1.14 A thermocouple is suddenly immersed in a medium of high temperature. The approximate time taken by the thermocouple to reach 98% of the steady – state value is

(A) Equal to the time constant of the thermocouple
(B) Equal to twice the value of the time constant of the thermocouple
(C) Equal to four times the value of the time constant of the thermocouple
(D) Independent of the time constant

1.15 A capillary viscometer, with known dimensions, is used for measuring dynamic viscosity of oil. In order to obtain viscosity, it is necessary and sufficient if one measures

(A) Pressure drop across the capillary
(B) Volume of fluid collected in a given time
(C) Both (a) and (b)
(D) Not only (a) and (b) but also one must ensure that the follow is laminar.

1.16 The sensing element of a thermocouple at its hot junction is provided with a shield while taking measurements in a high temperature gas. The principal reason for providing the shield is

(A) To reduce conduction and convection errors
(B) To reduce radiation error
(C) To provide temperature compensation to the Seebeck voltage
(D) To improve air supply to the sensing element for better response

1.17 A pitot – static tube is used for measuring velocity of a gas, flowing in a duct. The velocity is proportional to

(A) Square root of the total pressure measured by the tube
(B) The total pressure measured by the tube
(C) Difference between total and static pressures
(D) Square root of the difference between total and static pressures

1.18 The following method is widely accepted to determine oxides of Nitrogen in an automobile emission:

(A) Orsat analysis
(B) Gas – chromatography
(C) Chemi – luminescence
(D) Flame – ionization detection

1.19 The minimum number of lines that must be drawn on a grating needed to resolve the Sodium Doublet having nominal wavelengths of 589.0 nm and 589.6 nm is

(A) 600
(B) 1200
(C) 982
(D) 300

1.20 A parallel beam is incident normally on a air-glass interface. If the refractive index of glass is 1.720 then the loss of intensity through reflection is

(A) 7%
(B) 4%
(C) 2%
(D) 1%

1.21 In a He-Ne laser operating at a wavelength of 632.8 nm the actual laser transition takes place between the energy levels of

(A) Helium
(B) Neon
(C) Helium and Neon
(D) None of the above

1.22 To a swimmer viewing a Sodium lamp beside the pool, the color of the lamp seen from underneath the water appears:

(A) Yellow
(B) Yellow with a reddish tinge
(C) Yellow with a greenish tinge
(D) White

1.23 A temperature measuring system consists of a sensor and a thermal-well. Each of them can be considered as a single capacity system with the capacity of the thermal-well higher than that of the sensor. The overall measuring system will

(A) have equal time constants
(B) have zero damping
(C) be a non-interactive system
(D) be an interactive system

1.24 The bilinear transformation $w = \frac{z-1}{z+1}$

(A) maps the inside of the unit circle in the z-plane to left half of the w-plane
(B) maps the outside of the unit circle in the z-plane to left half of the w-plane
(C) maps the inside of the unit circle in the z-plane to right half of the w-plane
(D) maps the outside of the unit circle in the z-plane to right half of the w-plane.

1.25 In an INTEL 8085 microprocessor the ADDRESS-DATA bus and the DATA bus are

(A) Non multiplexed
(B) Multiplexed
(C) Duplicated
(D) Same as CONTROL bus

2. This question consists of TWENTY FIVE sub-question (2.1 to 2.25) of TWO marks each. For each of these sub-questions, four possible answers (A, B, C, and D) are given out of which only one is correct. Answer each sub-question by darkening the appropriate bubble using a soft HB pencil against the question number on the left-hand side of the Objective Response Sheet (ORS). Do not use the ORS for any rough work. You may use the last few pages of the main answer book for any rough work.

2.1 A unit gain buffer amplifier has a bandwidth of 1 MHz. The output voltage of the amplifier for an input of 2 V sinusoid of frequency 1 MHz will be

(A) 2 V

(B) $2\sqrt{2}V$

(C) $\frac{2}{\sqrt{2}}V$

(D) $\frac{4}{\sqrt{2}}V$

2.2 An amplifier of gain 10, with a gain-bandwidth product of 1 MHz and slew rate of 0.1 V/μs is fed with a 10 KHz symmetrical square wave of ± 1 V amplitude. Its output will be

(A) ± 10 V amplitude square wave
(B) ± 2.5 V amplitude square wave
(C) ± 10 V amplitude triangular wave
(D) ± 2.5 V amplitude triangular wave

2.3 A $3\frac{3}{4}$ digit digital voltmeter has an internal reference of 200mV. Its full scale count and resolution are

(A) 2000 and 1 mV
(B) 4000 and 0.1 mV
(C) 2000 and 0.1 mV
(D) 4000 and 1 mV

2.4 Three DC currents I_1, I_2 and I_3 meet at a node with I_1 entering and I_2 and I_3 leaving the node. I_1 and I_2 are measured as 100 mA and 99mA with a $\pm$1% accuracy. Then the value of I_3 and the accuracy of I_3 are

(A) 1 mA$\pm$2%
(B) 199 mA$\pm$2%
(C) 1 mA$\pm$ 2%
(D) 1 mA $\pm$ 199%

2.5 In an 8085 based system the subroutine TEST given below is called by another program. When the processor return from the subroutine TEST, the value, in the accumulator will be

```
TEST    MOVA, #00H
        CALL TESK
TESK    INR A
        RET
```

(A) 02
(B) 00
(C) FF
(D) 20

2.6 A rectifier type PMMC voltmeter has a sensitivity of 20 kΩ/V. A reading of 4.5 V is obtained when measuring a voltage source with an internal resistance on its 5V scale. When the scale is changed to 10 V full scale, a reading of 6 V is obtained. The value of the voltage and its internal resistance R are

(A) 10 V and 100 kΩ
(C) 10 V and 200 kΩ
(B) 9 V and 100 kΩ
(D) 9 V and 200 kΩ

2.7 A $3^{1/2}$ digit multi-meter has an accuracy specification of 0.5% of reading plus 5 counts. The value of an unknown resistance is read as 50.0 Ω on the 200 Ω scale of the meter. The value of the resistance is

(A) 50.0±0.25 Ω
(C) 50.0±0.75 Ω
(B) 50.0±0.5 Ω
(D) 50.0±1.0 Ω

2.8 A 5 A, 110 V electrodynamics type wattmeter has a scale having 110 divisions. Its pressure coil is fed a voltage of $[110\sqrt{2}\cos(314\,t) + \sqrt{2}\sin(942t)]$ V and its current coil carries a current of $[5\sqrt{2}\cos(314t + 60) + 2\sqrt{2s}\,\text{in}(628t + 90) + \sqrt{2}\cos(942t + 90)]$A. The needle of the watt meter will move to

(A) 110 divisions
(C) 54 divisions
(B) 50 divisions
(D) 55 divisions

2.9 The loop transfer function of a system is given by

$$G(s)H(s) = \frac{10e^{-0.1s}}{s(s+5)(s^2+4s+16)}$$

When the system is subjected to a parabolic input of $t^2/2$, the steady state error is

(A) Zero
(C) Infinity
(B) 0.1
(D) $e^{-0.1}/0.1$

2.10 The partial Routh array of the characteristic equation of a system is given by:

S^4	1	a	8
S^3	3	12	

The system oscillates with a frequency of 2 rad/s. The value of the parameter 'a' of the system is

(A) 6
(C) 8
(B) 2
(D) 12

2.11 The transfer function of a PID Controller is given by $G(s) = 4\left(1 + \frac{1}{2s} + 0.5s\right)$, as ω tends to infinity

(A) Magnitude of G(jω) tends to zero and phase angle of G(jω) tends to infinity
(B) Magnitude of G(jω) tends to infinity and phase angle of G(jω) tends to zero.
(C) Magnitude tends of G(jω) to infinity and phase angle of G(jω) tends to −90°.
(D) Magnitude tends of G(jω) to zero and phase angle of G(jω) tends to + 90°

2.12 The loop transfer function of a system is given by G(s) H(s) = $\frac{10e^{-Ls}}{s}$. The phase cross-over frequency is 5 rad/s. The value of the dead time L is

(A) $\pi/20$
(B) $\pi/10$
(C) $-\pi/20$
(D) zero

2.13 The forward path transfer function of an unity feedback system is given by

$$G(s) = \frac{(1+5s)(1+10s)(1+2s)}{(1+s)(1+8s)(1+20s)}$$

If e(t) is the error to a unit impulse input the value of the performance index

$$J = \int_0^\infty e(t)\, dt \text{ is equal to}$$

(A) Zero
(B) Infinity
(C) -12
(D) 0.5

2.14 A quartz crystal (Young's modulus, E = 9×10^{10} N/m^2) with piezo-electric properties has a diameter of 10 mm and thickness of 2 mm. Its voltage sensitivity constant is 4500 V/μm. If the voltage output is 127.3 V, the applied load is approximately

(A) 100 N
(B) 200 N
(C) 127.3 N
(D) 6.4 N

2.15 One method of measuring the radius of an arc (R) is to allow a roller of radius (r) to oscillate to and fro on the arc and measure the average time per oscillation, T seconds. The roller will then have a linear acceleration of 2g/3 where g is acceleration due to gravity. In such an experiment, the value of radius of arc can be found from the expression:

(A) $(T^2 g/6\pi^2) + r$
(B) $(T^2 g/6\pi^2) - r$
(C) $(T^2 g/6\pi^2)$
(D) $(6r^2/T^2 g)$

2.16 A He-Ne laser beam having a wavelength of 632.8 mm is expanded to a diameter of 1 meter and then pointed towards the moon. If the distance of the moon from earth is 3.8×10^5 km, the diameter of the central maxima on the surface of the moon is.

(A) 1 m
(B) 100 m
(C) 587 m
(D) 720 m

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2.17 An unpolarized He-Ne laser beam of wavelength 632.8 nm is reflected from the flat face of a dielectric (see Fig. 2.17). A detector analyzes the reflected beam. It is found that when the angle between the incident and the reflected beams is 115° - 34' the light is completely plane polarized. The refractive index of the dielectric at this wavelength is:

(A) 1.521
(B) 1.587
(C) 1.621
(D) 1.571

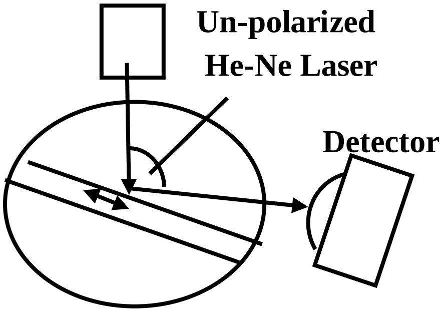

Fig. 2.17.

2.18 Two narrow straight slits, 0.25 mm apart are illuminated by an unknown monochromatic source of light. If the fifth bright fringe is 12 mm away from the central fringe when the screen distance is 0.8. The wave length of the unknown source is

(A) 540 nm
(B) 600 nm
(C) 700 nm
(D) 750 nm

2.19 A microscope uses a micro-objective 10X, numerical aperture 0.25 and an eyepiece focal length of 25 mm. The magnification of the microscope is

(A) 25
(B) 50
(C) 100
(D) 125

2.20 In a rotameter, used for measuring flow rate of a fluid, Pa: pressure above the float, Pb: pressure below the float, A: area of float, V: volume of the float, d_1: density of float material, d_2: density of the fluid, g: acceleration due to gravity. The following equation describes the equilibrium of the float.

(A) (Pb - Pa) A = V_g (d2 - d1)
(B) (Pa + Pb) A = V_g (d2 + d1)
(C) (Pa - Pb) A = V_g (d2 - d1)
(D) (Pb - Pa) A = V_g (d2 + d1)

2.21 The expression for the capacitance (C in pf) of a parallel plate capacitor is given by: C = $6.94\times 10^{-3}(d^2/s)$. The diameter (d) of each plate is 20 mm and the spacing between the plates (S) is 0.25 mm. The displacement sensitivity of the capacitor is approximately:

(A) 44.4 pF/mm
(B) -44.4 pF/mm
(C) 11.1 pF/mm
(D) -11.1 pF/mm

2.22 The radius of a sphere is given as (40.0$\pm$0.5) mm. The estimated error in its mass is:

(A) $\pm$3.75 %
(B) $\pm$1.25 %
(C) $\pm$12.5 %
(D) $\pm 0/125$ %

2.23 It is reported that an engine is producing a sound pressure level of 100 dB, by considering the reference pressure as 2×10^{-5} Pa. The root mean square (r.m.s) of the fluctuating component of the source pressure is given by:

(A) 2.0 Pa
(B) 0.2 Pa
(C) 20.0 Pa
(D) 2.0 mPa

2.24 A minimal microcomputer system is constructed using INTEL 8085 microprocessor, an 8156 RAM and an 8355 ROM. The chip enable CE of 8156 and chip enable CE of 8355 are connected to the address line. A_{12} of 8085. The address of port A of the 8156 chip is

(A) 21H
(B) 12H
(C) 11H
(D) 20H

2.25 The 14-bit timer of 8156 is loaded with the counter value of 07DOH. The timer input is connected to a clock with a frequency of 800 kHz. The timer is programmed to produce a continuous signature wave output. The frequency of the square wave output is

(A) 400 kHz
(B) 800 kHz
(C) 400 Hz
(D) 2000 kHz

SECTION B

This section consists of TWENTY questions of FIVE marks each, numbered as 3 to 22. Write answers to ANY FIFTEEN out of these twenty questions in the Answer book. Start your answer to a question on a NEW PAGE.

3. A batch of 11 resistors of 100 Ω nominal value, when measured gave the following readings.

No	1	2	3	4	5
R	104.000	96.000	95.000	101.414	105.000

No R	6 98.586	7 102.000	8 96.000	9 105.000	10 95.000
No R	11 102.000				

Determine the % tolerance of the batch. 120 Ω resistors are made using these 100 Ω resistors having a tolerance of 3%. Determine the tolerance of the 120 Ω resistors.

(5)

4. A100/1 A, 5VA UPF bar primary current transformer (CT), when measuring 100 A draws a magnetizing current of $\sqrt{2}\ \lfloor\underline{45}$ A. Reference phasor is the flux in the core. Determine the ratio and phase errors of the CT. If one turn were removed from the secondary of the CT then what would its ratio and phase errors?

(5)

5. A simple series pass transistor regulator is shown in Fig. 5. The current gain β of the transistor is 24 and it has a base-to-emitter drop V_{BE} of 0.6 V. Determine the currents through the 5.0 Ω and 100 Ω resistors and the power dissipated in the 5.6 V Zener diode.

(5)

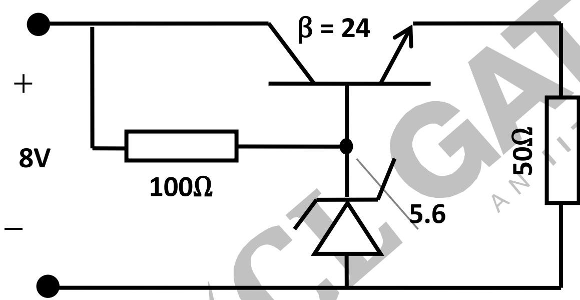

Fig. 5

6. A 4-bit successive approximation register (SAR) type ADC has a reference voltage of 1.5 V. The (MSB-1) bit of this ADC is permanently stuck at "logic one" but otherwise the ADC functions well. Trace the states the SAR will take to convert an input voltage of 1.0 V into a 4-bit binary number. Determine the error in the digital reading for this voltage.

(5)

7. A Q meter is employed to measure the distributed capacitance of a coil. Let C_1 be the capacitance required to obtain resonance at a frequency f and C_2 the capacitance needed for resonance at a frequency 3f. Derive an expression for the distributed capacitance of the coil C_0 in terms of C_1 and C_2. For a particular coil C_1 = 1.7 nF and C_2 = 0.1 nF were obtained. Determine

the distributed capacitance of the coil.

(5)

8. Derive $\frac{V_0(j\omega)}{V_i(j\omega)}$ for the opamp circuit in Fig. 8. Determine the value of C so that the output voltage is shifted in phase by 60^0 for an input having an ω of 1732 rad/s.

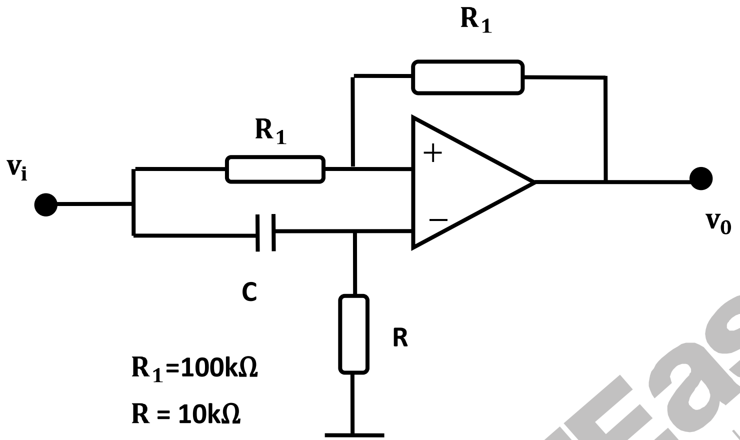

Fig. 8.

9. The impulse response of a system S_1 is given by $x_1(t) = 4\ e^{-2t}$. The step response of a system S_2 is given by $x_2\ (t) = 2(1-e^{-3t})$.
   (A) Find the transfer functions of the systems S_1 and S_2 (2)
   (B) The two systems are cascaded together without any interaction. Find the unit ramp response of the cascaded system.
   (2)
   (C) Sketch the unit ramp response of the cascaded system.
   (1)

10. The block diagram of a second order servomechanism is shown in Fig. 10 Tests conducted on the servomechanism resulted in the following:
   (i) A unit step response produced a maximum overshoot of 16%.
   (ii) Keeping the reference shaft fixed, a torque of 10 Nm applied to the output shaft resulted in a steady state error of 0.2 rad.

   Find the parameters of the servo-mechanism. J and K. (assume the gear ratio n = 0.1 and B = 0.125 Nm/rad/s.)

   (5)

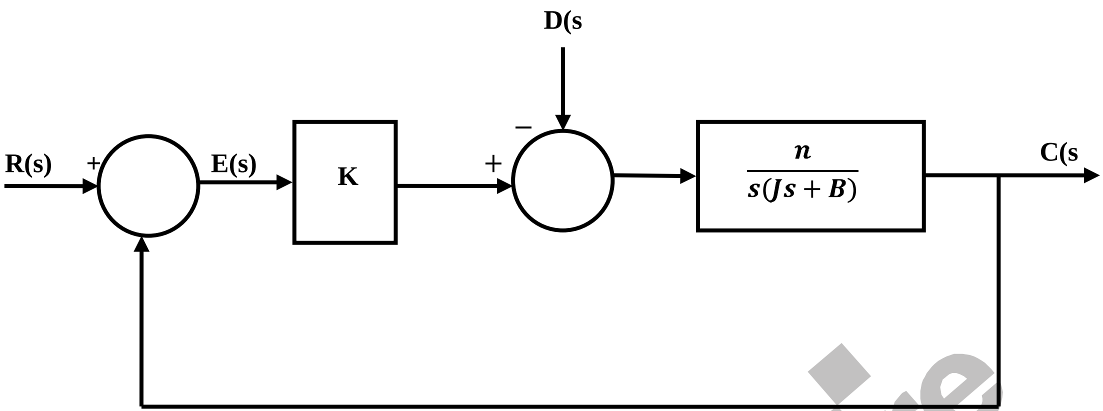

Fig. 10.

11. Consider the following digital filter:

$$y(n) = \frac{1}{2}x(n-2) + \frac{1}{4}x(n-1) + \frac{1}{4}x(n-3)$$

Find the Fourier magnitude and phase spectra of the filter and sketch the magnitude and phase spectra.

(5)

12. Fig. 12 Shows the Bode magnitude and phase plots of a system (not to scale). Determine from the plots the transfer function of the system.

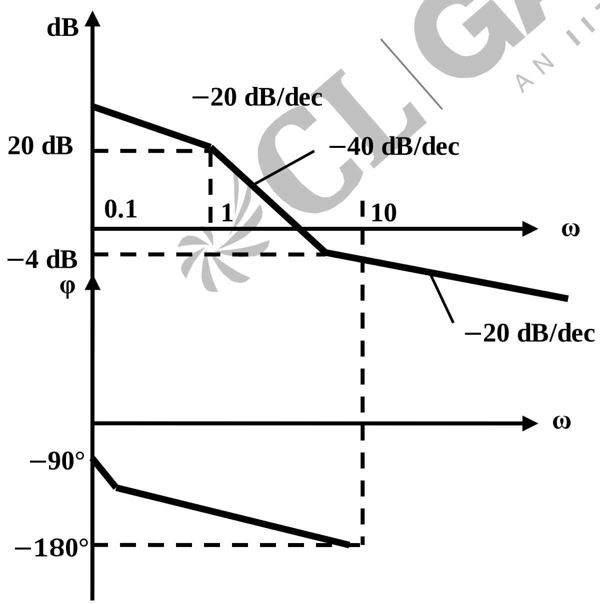

Fig. 12.

13. The transfer function of a LTI system is given by

$$H(z) = \frac{1+0.5z^{-1}}{1+0.1z^{-1}-0.3z^{-2}}$$

(A) Show a parallel realization of the transfer function (2)

(B) Show a cascade realization of the transfer function (2)

(C) Sketch the pole – zero locations in the z – plane (1)

14. Three JK flip-flops C, B and A are connected in such a way that Q_A output of flip-flop A is connected to the clock input of a flip-flop B. The Q_B output of the flip-flop B is connected to the clock input of flip-flop C. A clock is connected to the clock input of flip-flop A. The JK inputs of all the flip-flops are kept at logic high and all the flip-flops are negative edge triggered.

(A) Draw the output waveforms of Q_A, Q_B and Q_C (3)

(B) Write the count sequence generated by Q_C Q_B Q_A (2)

15. A thrust-producing device is tested in a laboratory by measuring the deflection of a spring element (spring constant K = 750 N/m) attached to the front end of the device. The mass of the device is 25 kg. Assuming that the thrust is idealized as step input to the system.

(A) Calculate the natural frequency of the system (1)

(B) Calculate the damped natural frequency of the system, if the damping ratio is 0.7 (2)

(C) Write the differential equation governing the measuring system (2)

16. The diaphragm element of a pressure gauge is a circular foil of steel (young's modulus, E = 2×10^{11} N/m^2, Poisson's ratio v = 0.3) which is firmly clamped around its circumference. The radius (R) and thickness (t) of the element are 25 mm and 1.1 mm respectively. On the application of uniform pressure (p), the deflection (y) at any radial position (r) measured from the centre is given by the expression.

$$y = \frac{3p(1-v^2)(R^2-r^2)^2}{16Et^3}$$

(A) Find the maximum design pressure if the allowable deflection of the element is limited to 0.3 times its thickness. (3)

(B) Schematically show the variations of deflection, the radial and tangential stresses from the centerline to the edge of the diaphragm element. (2)

17. An electrical resistance strain gauge of resistance 120Ω has a gauge factor of 2. It is bounded to a steel specimen (modulus of elasticity, $E = 2 \times 10^{11} \mathrm{N/m^2}$) for measuring strain Estimate:

(A) Strain induced in the specimen if a tensile stress of $60 \times 10^{6} \mathrm{N/m^2}$ is applied on the specimen (1)

(B) Change in the electrical resistance of the gauge due to the tensile stress as given in (a) (1)

(C) Change in the electrical resistance of the gauge if there is an increase of temperature by 40°C (3)

Assume the following data:
Temperature coefficient of resistance of gauge is 20×10^{-6} per °C
Thermal coefficient of linear expansion of the gauge is 16×10^{-6} per °C
Thermal coefficient of linear expansion of steel specimen is 12×10^{-6} per °C

18. A hollow circular steel shaft (shear modulus $G = 8 \times 10^{10} N/m^2$) with outer and inner radii of 33 mm and 25 mm respectively, has a length of 150 mm. It is transmitting a torque of T N – m. The strain indicated by a strain gauge fixed on the outer periphery at an angle of 45° to the axis of the shaft is 5.5 micro − strain (micrometer per meter). Estimate the value of T and the angular deflection of the shaft. (5)

19. In a Newton's ring kind of arrangement, a thin wire is placed between the two glass plates AB and CD, so as to form a wedge as shown in schematic diagram Fig. 19.

(A) Will there be a maxima or a minima of interference at the point of contact of two plates, F and why? (2)

(B) The wavelength of Sodium light used in the experiment is 589.3 nm. The number of interference fringes observed between the contact point of two glass plates and the place where wire is in contact with the plates (FE) is found to be 241, find the diameter of the wire. (3)

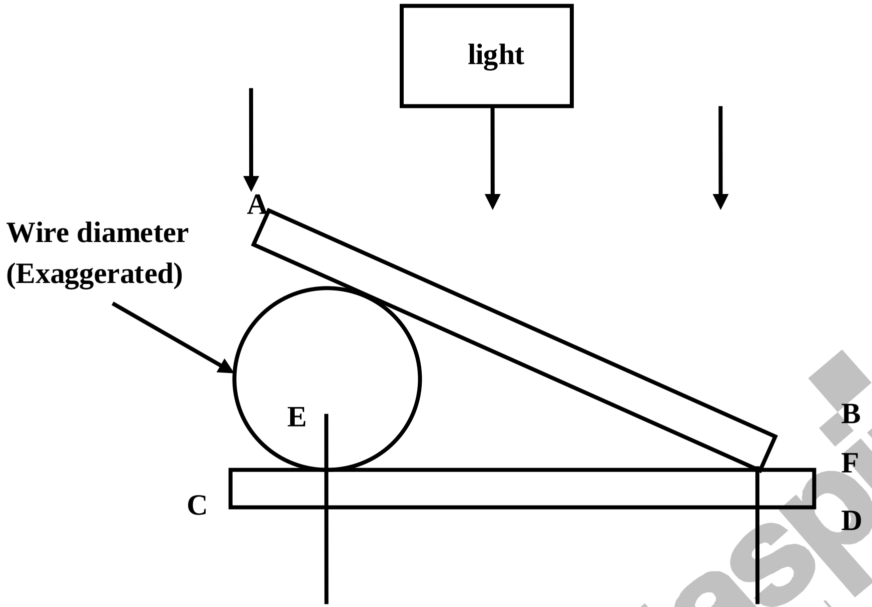

Fig. 19

20. A calibrated orifice meter is used in a pipeline of 103mm ID to calibrate the probe of constant temperature hotwire anemometer (CTA). The orifice meter readings are recorded in mm of Hg and the CTA readings in volts. It is independently found that the average velocity in the pipeline is exactly equal to the velocity at its axis the volume flow rate of the fluid (Q) can be measured from the orifice meter calibration equation Q = $6.311\times10^{-4}\sqrt{h}$ where h is in mm of Hg and Q is in m^3/s. The readings of the CTA are correlated in the form of $(\text{volt})^2 = a + b(velocity)^{\frac{1}{2}}$ Determine the constants (a) and (b) in this equation if the voltage readings are 0.284 and 0.323 V respectively when the corresponding orifice meter readings are 77 and 154 mm Hg.

(5)

21. A rectangular block of glass of refractive index 1.60 is immersed in water of refractive index 1.333. What is the maximum angle α in water with Y interface (as shown in Fig. 21) at which the light beam can be launched, so that light is totally internally reflected at the X interface of glass with water.

(5)