SECTION A

1. This question contains 30 sub-questions of multiple choice type. Each sub-question has only one correct answer.

1.1 $\lim_{x\to 0} \frac{1}{10} \times \frac{1-e^{-j5x}}{1-e^{-jx}}$ is

(A) 0
(B) 1.1
(C) 0.5
(D) 1

1.2. For the waveform V(t)=2+cos ($\omega t+\frac{\pi}{6}$) the ratio V_{rms} / $V_{average}$ is

(A) $\frac{3}{2\sqrt{2}}$
(B) $\sqrt{\frac{3}{2}}$
(C) π
(D) $\frac{\pi}{2}$

1.3. A system with transfer function $\frac{1}{\tau_s+1}$, subjected to a step input takes 10 seconds to reach 50% of the step height. The value of τ is

(A) 6.9 s
(B) 10s
(C) 14.4 s
(D) 20 s

1.4. Relationship between input x(t) and output y(t) of a system is given as

$\frac{d^2y}{dt^2} = x(t-2)+\frac{d^2x}{dt^2}$

The transfer function of this system is

(A) $1 + \frac{e^{-2s}}{s^2}$
(B) $1 + \frac{e^2 s}{s^2}$
(C) $1 + s^2e^{-2s}$
(D) $1 + s^2e^{2s}$

1.5. A transfer function has two zeroes at infinity. Then the relation between the numerator degree (N) and the denominator degree (M) of the transfer function is

(A) N=M+2
(B) N=M-2
(C) N=M+1
(D) N=M -1

1.6. The system $G(s) = \frac{0.8}{s^2+s-2}$ is subjected to a step input. The system output y (t) as $t \to \infty$ is

(A) 0.8
(B) 0.4
(C) -0.4
(D) unbounded

1.7. The transfer function between y_2 and y_1 in Fig. 1.7 is

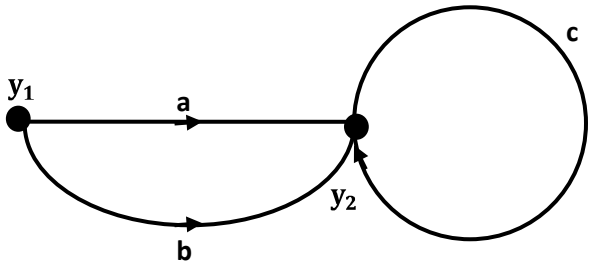


Fig. 1.7

(A) $a + b$
(B) $(a + b)c$
(C) $\frac{a+b}{1-c}$
(D) $\frac{a+b}{1+c}$

1.8. In control system design, gain and phase margins are usually provided to
(A) Account for the uncertainties in the system
(B) Make the system respond fast
(C) Reduce the overshoot in step response
(D) Reduce the steady state offset.

1.9. The lengths of two discrete time sequences x_1 (n) are 5 and 7 respectively. The maximum length of sequence $x_1(n) * x_2(n)$ is
(A) 5
(B) 6
(C) 7
(D) 11

1.10. The output voltage of the circuit in Fig. 1.10 for t > 0 is
(A) $e^{\frac{-t}{RC}}$
(B) $-e^{\frac{-t}{RC}}$
(C) $1 - e^{\frac{-t}{RC}}$
(D) $e^{\frac{-t}{RC}} - 1$

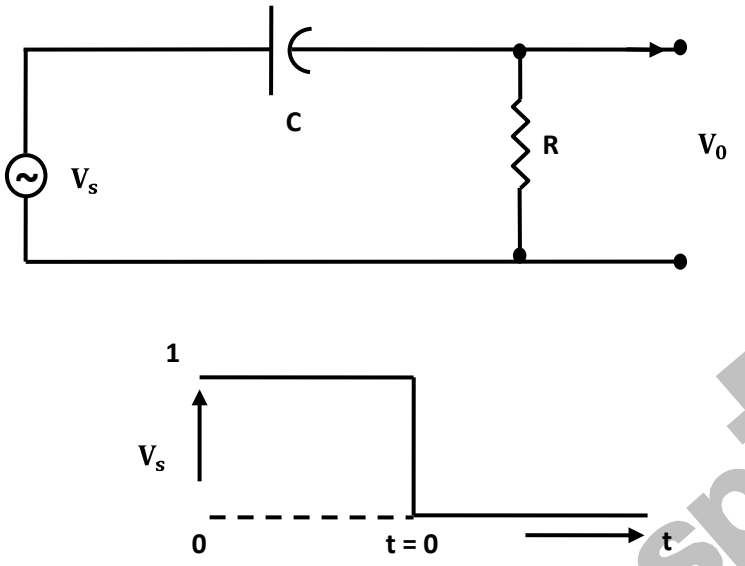


Fig. 1.10.

1.11. In the circuit shown in Fig. 1.11. V_i is 4 V. Assuming the diodes to be ideal, V_0 is

(A) 3 V (C) 4.5 V

(B) 4 V (D) 6 V

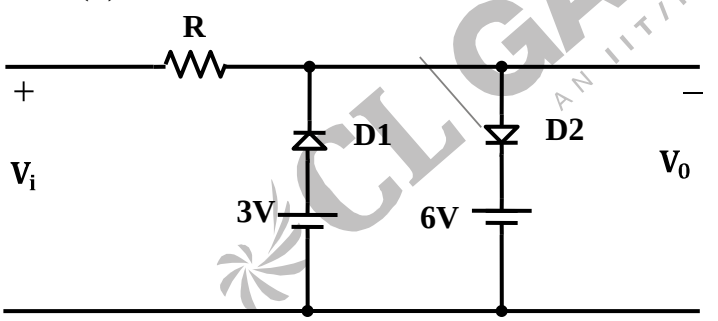


Fig. 1.11

1.12. The input voltage, V_1 is 4 + 3 sin ωt. Assuming all elements to be ideal, the average of the output voltage v_0 in Fig. 1.12 is

(A) −3 V (C) −7 V

(B) +3 V (D) +7 V

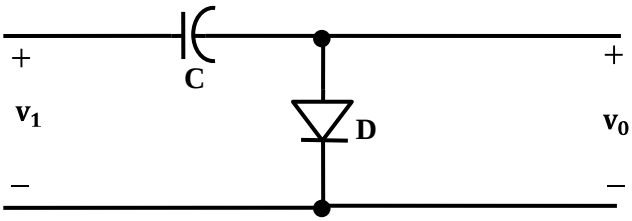


Fig. 1.12

1.13. In the JFET amplifier circuit shown in Fig. 1.13, the signal outputs v_1 and v_2 are related as

(A) $v_2 = \frac{R_d}{R_s} v_1$

(B) $V_2 = -\frac{R_d}{R_s} v_1$

(C) $v_2 = \frac{R_s}{R_d} v_1$

(D) $v_2 = -\frac{R_s}{R_d} v_1$

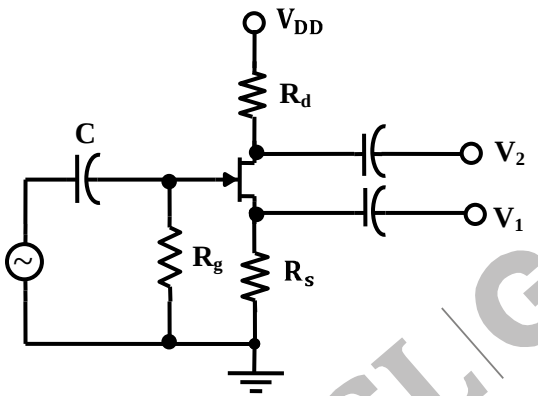
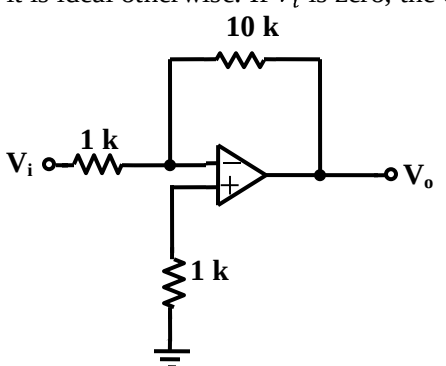


Fig. 1.13

1.14. The op-amp in the amplifier circuit shown in Fig. 1.14 has an offset voltage of 10 mV and it is ideal otherwise. If V_i is zero, the output voltage V_o is



(A) 0
(B) 10 mV
(C) 100 mV
(D) 110 mV

1.15. A voltmeter connected across the 10 kΩ resistor in the Fig. 1.15, reads 5 V. The voltmeter is rated at 1000 ohms/volt and has a full scale reading of 10 V. The supply voltage V_s in volt is

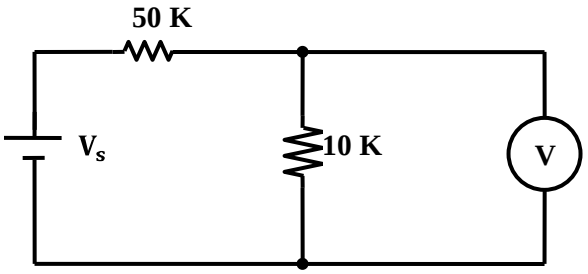


Fig. 1.15

(A) 30
(B) 50
(C) 55
(D) 80

1.16. An oscilloscope input impedance consists of 1MΩ in parallel with 100pF. A compensated 20 : 1 attenuator is obtained by connecting a parallel combination of

(A) 19 M Ω and $\frac{100}{19}$ pF
(B) 20 M Ω and $\frac{100}{20}$ pF
(C) 19 M Ω and 1900 pF
(D) 20 M Ω and 2000 pF

1.17. The bridge circuit in Fig. 1.17 is balanced. The magnitude of current I is

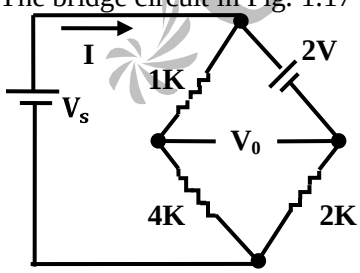


Fig. 1.17

(A) 2mA
(B) 4mA
(C) 5mA
(D) 6mA

1.18. A phase locked loop can be employed for demodulation of
(A) pulse amplitude modulated signals
(B) pulse code modulated signals
(C) frequency modulated signals
(D) single side band amplitude modulated signals.

1.19. A number in 4-bit two's complement representation is $X_3X_2X_1X_0$. This number when stored using 8-bits will be
(A) 0000 $X_3X_2X_1X_0$
(B) 1111 $X_3X_2X_1X_0$
(C) $X_3X_3X_3X_3X_3X_2X_1X_0$
(D) $\overline{X}_3\overline{X}_3\overline{X}_3\overline{X}_3X_3X_2X_1X_0$

1.20. A computer has a memory space of 2^{16} and word length of 24 bits. The memory chips available have 10 address and 8 data lines. The number of chips required for the computer memory space is
(A) 192
(B) 256
(C) 512
(D) 1024

1.21. For a shaft encoder, the most appropriate 2-bit code is
(A) 11, 10, 01, 00
(B) 11, 10, 00, 01
(C) 01, 10, 11, 00
(D) 01, 00, 11, 10

1.22. The term 'precision' used in instrumentation means
(A) gradual departure of the measured value from the calibrated value
(B) smallest increment in the measured that can be detected by the instrument
(C) maximum distance or angle through which any part of a mechanical system may be moved in one direction without causing motion of the next part
(D) the ability of the instrument to give output readings close to each other, when the input is constant.

1.23. A resistance potentiometer has a total resistance of 10000 Ω and is rated 4 W. If the range of potentiometer is 0 to 100 mm, then its sensitivity in V/mm is
(A) 1.0
(B) 2.0
(C) 2.5
(D) 25

1.24. The temperature of fixed points used to define International Temperature Scalc are determined by using
(A) Platinum resistance thermometer
(B) Platinum, Platinum-Rhodium thermo-couples
(C) vapour-pressure thermometer

(D) gas thermometer to which corrections are applied for non-ideal behaviour of the gas.

1.25. The emf-temperature data for a thermocouple with reference junction at $0^{o}C$ is as follows,

Temperature (^{o}C)	20	180	200
emf (mV)	1.2	11.8	13.5

The emf developed in mV with the two junctions at $200^{o}C$ is

(A) 11.8 (C) 13.0

(B) 12.3 (D) 13.5

1.26. A rotameter with a heavy float for measuring gas flow is calibrated with a gas of density 1.2 kg/m^3. It measures the flow rate of a different gas having density of 2 kg/m^3 and indicates a flow rate of 2.2 m^3/min. The actual flow rate in m^3/min is

(A) 0.79 (C) 1.70

(B) 1.32 (D) 2.20

1.27. The sound pressure level (SPL) measured in open space (free field), at a distance of 6 m from a noise source is 80 dB. At a distance of 60 m, the SPL is

(A) 80 dB (C) 8 dB

(B) 60 dB (D) 1.34 dB

1.28. An optical fibre has a refractive index of 1.641 for the core and 1.422 for the cladding. The critical angle above which a ray will be totally internally reflected is

(A) 37° (C) 45°

(B) 41° (D) 60°

1.29. A frequency stablised HeNe laser with a wavelength of 6328 A has a bandwidth of 1 MHz. Its coherence length is

(A) 0.3 m (C) 30 m

(B) 3 m (D) 300 m

1.30. Attenuation of a narrow monochromatic X-ray beam in a metal plate of thickness 'd' is given by the equation

(A) $I=I_0 \exp(-\mu d)$ (C) $I = I_0 \exp(-\mu/d)$

(B) $I= I_0 \exp(-\mu d^2)$ (D) $I= I_0 \exp(-\mu/d^2)$

2. This question contains 15 sub-questions of multiple-choice type. Each sub-question has only one correct answer.

2.1. The transfer function of a passive circuit has its poles and zeroes on
(A) left and right halves respectively of the s-plane
(B) right and left halves respectively of the s-plane
(C) right half of the s-plane
(D) left half of the s-plane.

2.2. A first order system with a proportional controller in the negative feedback loop has an offset to a step/input. This offset can be eliminated by
(A) adding a derivative mode to the controller
(B) adding an integral mode to the controller
(C) decreasing the magnitude of the gain of the proportional controller
(D) adding a delay in the controller loop.

2.3. Bootstrapping in a buffer amplifier circuit is used for
(A) increasing the input resistance
(B) reducing the power consumption
(C) decreasing the output resistance
(D) improving the frequency response.

2.4. A voltmeter has been connected between the input of a TTL inverting gate and ground. The gate is powered by 5 V. The voltmeter reading will be approximately
(A) 0 V
(B) 2 V
(C) 4 V
(D) 5 V

2.5. The advantage of a dual slope converter over successive approximation converter is that the dual slope converter
(A) is faster
(B) eliminates error due to drift
(C) can reduce the errors due to power supply
(D) does not require a stable voltage reference

2.6. The conversion time of an 8-bit successive approximation converter with a 1MHz clock is nearly
(A) 512 μs
(B) 256 μs
(C) 128 μs
(D) 8 μs

2.7. The important feature of a microcontroller is that it has an on-chip
(A) math co-processor
(B) program memory
(C) interface for I/O devices
(D) hardware multiplier.

2.8. The best size of the wire for measuring pitch diameters of ISO metric screw thread in terms of pitch, p, is

(A) p/2
(C) 3p/4
(B) $p/\sqrt{3}$
(D) $p/(2\sqrt{3})$

2.9. An elastic transducer is used to measure pressure in a vessel and it indicates a pressure of 3.2 bar. Atmospheric pressure is 1.01 bar. The absolute pressure in the vessel in bar is

(A) 1.01
(C) 3.20
(B) 2.19
(D) 4.21

2.10. A photo conductive transducer works on the principle that when a light beam strikes

(A) the material, its resistance decreases, which is sensed by an external circuit
(B) the barrier between transparent metal layer and a semi-conductor material, a voltage is generated
(C) the barrier between transparent metal layer and a semi-conductor material, a current is generated in the external circuit
(D) the cathode, it releases electrons, which are attracted towards anode, thereby producing electric current in the external circuit.

2.11. For alignment and testing of two surfaces at right angles, a constant deviation prism, also called an optical square, is used. It is a

(A) right angled prism
(B) square prism
(C) pentagonal prism
(D) hexagonal prism

2.12. C_1 and C_2 are the activities of the ions on the two sides of a membrane. The Nernst potential developed across the membrane is proportional to

(A) $\frac{C_1}{C_2}$
(B) $\frac{C_1^2}{C_2^2}$
(C) $log_e \frac{C_1}{C_2}$
(D) exp (C_1/C_2)

2.13. The bandwidth of an electrocardiogram (ECG) amplifier is

(A) dc to 0.01 Hz
(B) 0.05 to 500 Hz

(C) 550 to 1500 Hz
(D) 2000 to 10000 Hz.

2.14. Korotkoff sounds are used
(A) as a reference for sound level measurement
(B) for studying heart muscle functioning
(C) for blood pressure measurement
(D) for study of heart valve functioning

2.15. In an electromagnetic blood flow meter, the induced voltage is directly proportional to the
(A) blood flow rate
(B) square root of the blood flow rate.
(C) square of the blood flow rate
(D) logarithm of the blood flow rate

SECTION B

Answer any FIFTEEN questions in this Section. Each question carries 5 marks.

3. (A) Find the Eigen values and Eigen vectors of the matrix

$$A = \begin{bmatrix} 3 & -1 \\ -1 & 3 \end{bmatrix}$$

(B) Find A^{100} for the value given in part (a)

4. Dynamic response of a measurement system is given by the differential equation

$$4\frac{d^2y}{dt^2} + 640\frac{dy}{dt} + 40000y = 80000x$$

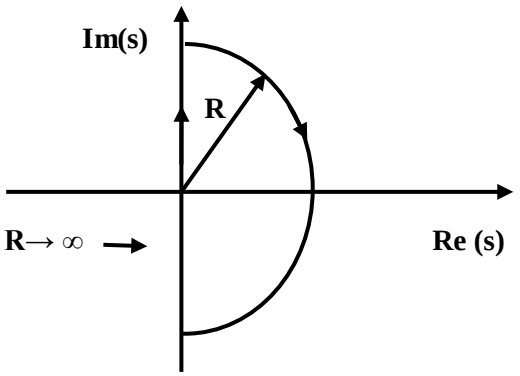
where y is output and x is input.
(A) Determine
(i) natural frequency,
(ii) damping ratio, and
(iii) static sensitivity of the system.

(B) If it is used to measure point of frequency of 10Hz, what would be the ratio of indicated amplitude to input amplitude?

5. The closed loop transfer function of a system consisting of a process G (s) and a proportional controller K is

$$H(s) = \frac{KG(s)}{1+KG(s)}$$

The closed contour obtained by plotting the imaginary part of $\frac{1}{H(s)}$ vs the real part of $\frac{1}{H(s)}$ evaluated along the curve indicated in Fig. 5 encircles the origin N times.



(A) Derive an expression for N, in terms of the number of poles of H(s) in the right half part of the s-plane

(B) From a plot of the imaginary part of $\frac{1}{G(s)}$vs the real part of $\frac{1}{G(s)}$ evalutated along the curve in Fig.5, determine the condition on K that will make the closed loop system stable.

6. A process with transfer function $G_p(s) = \frac{1}{(3s+1)(4s+1)}$ is put in a negative feedback control loop with a measurement device whose transfer function is $G_m(s) = \frac{1}{(8s+1)}$ and a controller.

(A) If a proportional controller is used, what is the ultimate gain and the corresponding frequency of oscillations?

(B) What is the Ziegler Nichols setting if a proportional integral controller is used?

7.

(A) The analog signal $x_a(t)$ is sampled at the rate of100 samples per second. Find the resulting discrete time sequence x(n).

$$x_a(t) = 4cos(25\pi t) + 2\sin(150\pi t)$$

(B) The discrete sequence x(n) obtained in part (a) is written out at the rate of 500 samples per second. The resulting waveform is low pass filtered with a cut-off frequency of 200 Hz. Find the output analog signal $y_a(t)$.

8.

(A) Find an expressed for the discrete time impulse response h(n) in terms of the unit step response of a linear time invariant causal system.

(B) Find the transfer function H(z) for a system whose unit step response is given by

S(n)=$\left\{-\frac{1}{2}, \frac{1}{2}, 1,1,1, \ldots.\right\}$

9.

(A) Find the impulse h(n) of a causal system with transfer function

$H(z)=\frac{1}{6}\frac{1-z^{-6}}{1-z^{-1}}$

(B) Is the above system (i) FIR,(ii) linear phase?

10. In the balanced 3-phase system shown in fig 10, the load in each phase is a resistance, R1 of 100Ω.

(A) Find the power read by the wattmeter, when the switch is in

(i) Position 1

(ii) Position 2

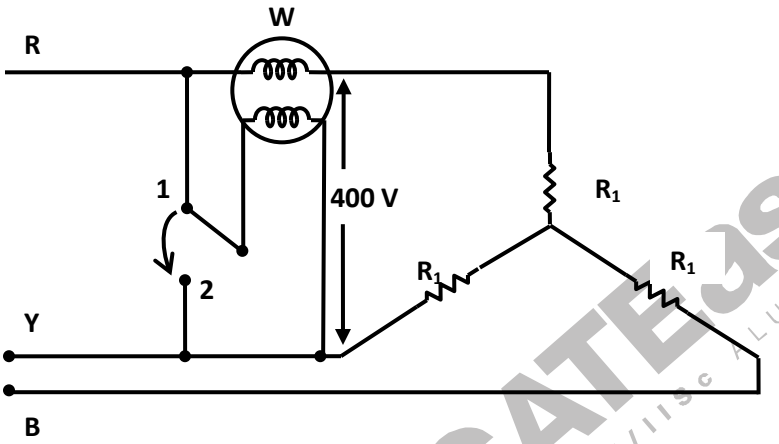


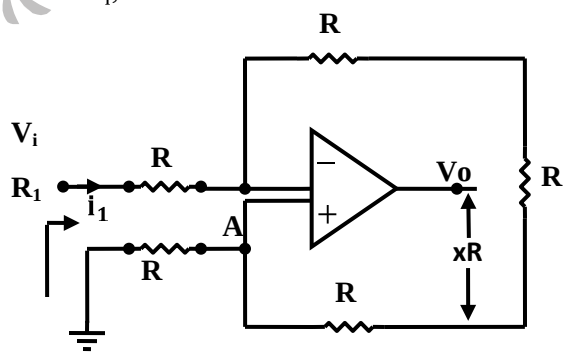
Fig. 10.

(B) For each case in part (*a*) draw the phasor diagram.

11. In the circuit shown in Fig. 11.

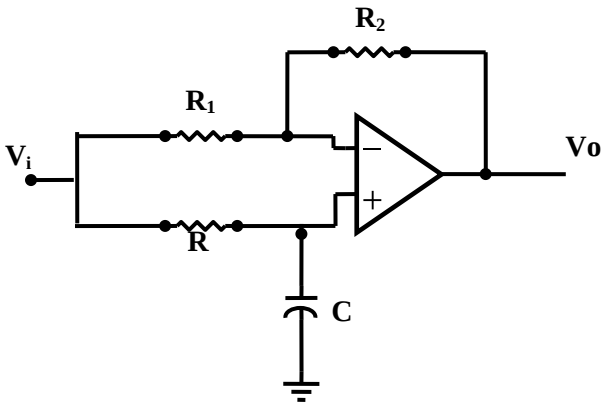
(A) Find an expression for the input resistance R_i, in terms of x and R

(B) What is the value of R_i, when x = 0.5?



12.

(A) Find the transfer function of the circuit in Fig. 12, assuming op-amp to be ideal.



(B) Find the pole and zero of the transfer function. Also find the value of R_2/R_1 for which it becomes an all pass filter.

13.

(A) For the halfwave precision rectifier circuit shown in Fig. 13, the op-amp is an ideal one and the diodes are Si diodes. Input V_i is 2 V peak-to-pcak square wave. Sketch the waveforms $V_i(t), V_x(t)$ and $V_0(t)$.

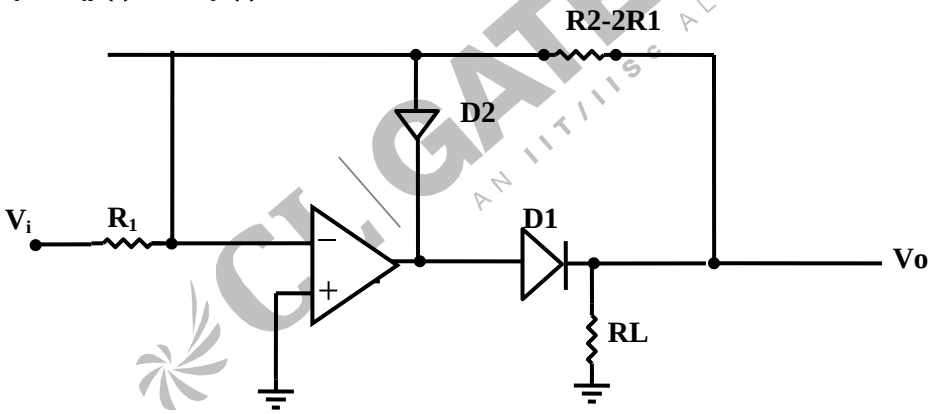


Fig. 13.

(B) Assuming the maximum forward voltage drop across the diode to be 0.7 V and op-amp open loop- gain $A_d=10^6$, find the maximum rectification error.

14. The inputs A_2, A_1, A_0 and the outputs X, Y of a digital circuit are given in the truth table:

A_2	A_1	A_0	X	Y
0	0	0	1	1
0	0	1	0	1
0	1	0	0	0
0	1	1	0	0

1	0	0	1	1
1	0	1	1	1
1	1	0	1	0
1	1	1	1	0

Design the circuit using

(A) 8-1 Multiplexers

(B) 3 bit binary decoder and logic gates.

15.

(A) For the sequential logic circuit shown in Fig. 15, S_1 and R_1 as functions of Q_2, R and T.

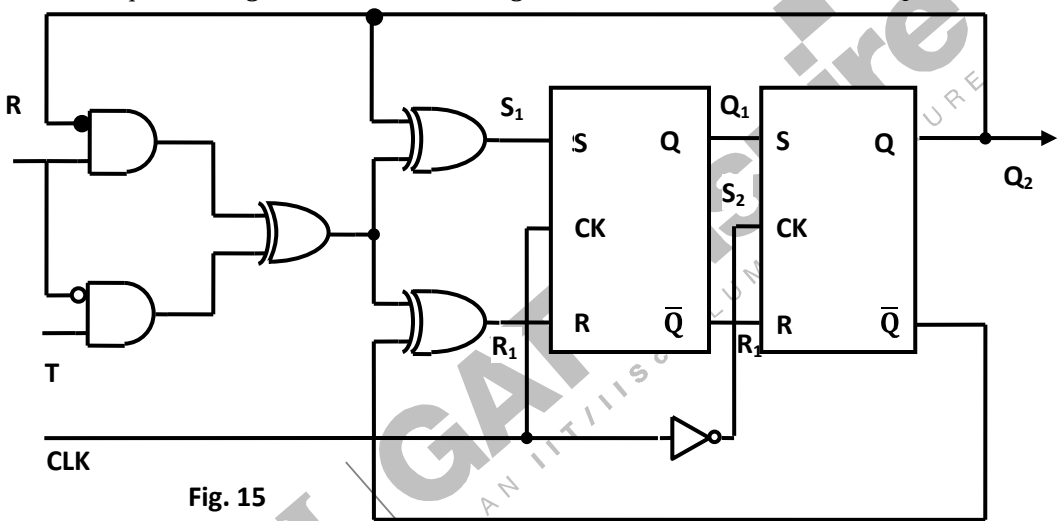


Fig. 15

(B) Give the truth table with inputs Q_2, R and T and outputs S_1 and S_2 .Assume Q_2 to be the most significant bit and T, the least significant bit.

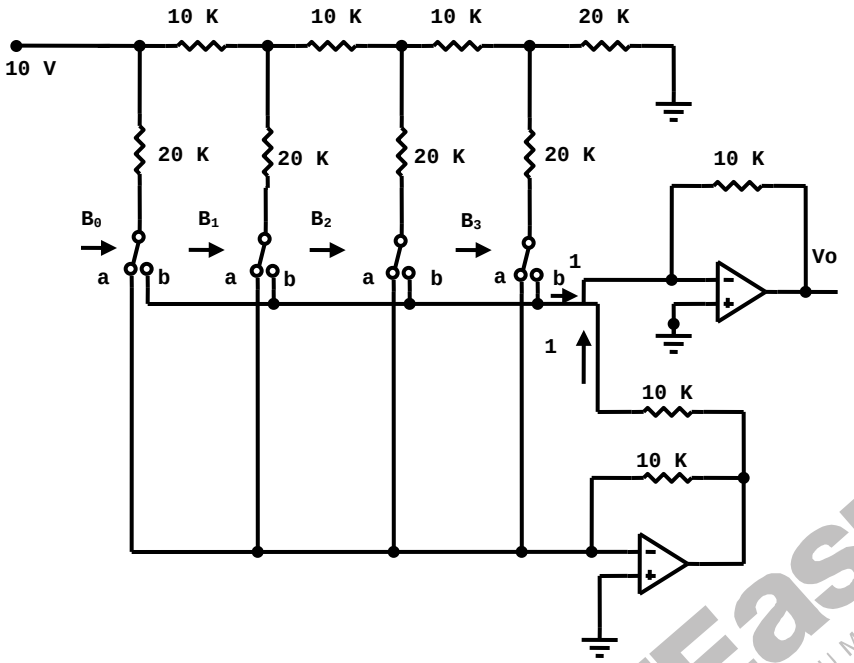
(C) Complete the transition table given below that expresses Q_2 at the next cycle as a function of present value of Q_2 and RT.

	RT			
Q_2	00	01	11	10
0				
1				

16. In the fig. 16 the switches are in position a or b depending on the switch input being 0 or 1. B_3 is the MSB and B_0 is the LSB. Find the output voltage V_0. If the output digital code is

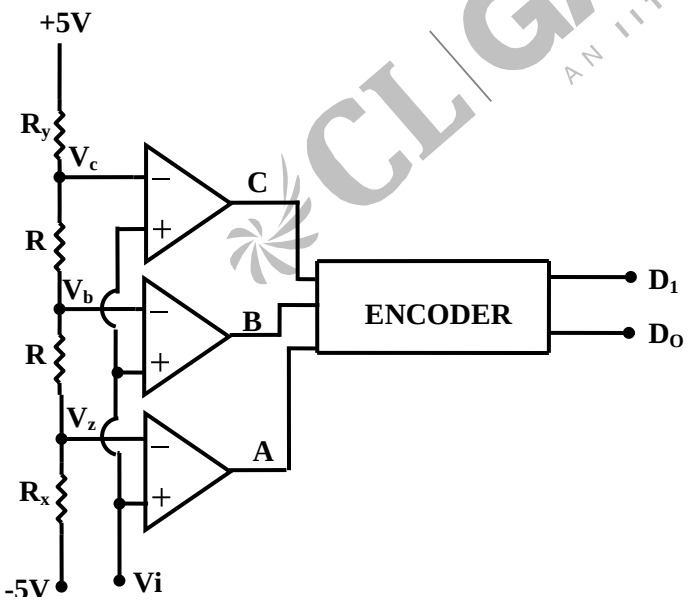
(A) 1 1 0 0

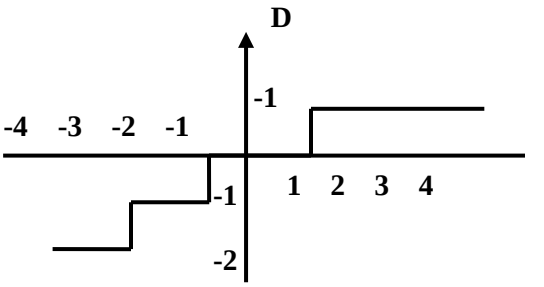
(B) 0 0 0 0



17.

(A) A flash type A/D converter alongwith its input-output relationship is shown in Fig. 17. Find the values of V_a, V_b, V_c. Also find the values of R_x and R_y in terms of R.





(B) The encoder output is in two's complement representation. Write the expression for the encoder outputs D_1 and D_0 as a function of A, B, C in the standard sum form.

18. R is determined using the relationship
$R = \frac{(l-d)^2}{8d}$ where l = 500 mm, d= 25 mm.
(A) Determine the maximum possible uncertainty in the measurement of R, if $\Delta l = \pm 0.005$ mm, $\Delta d = \pm 0.0011$ mm.
(B) Determine the root-sum-square uncertainty in the measurement of R, if $\Delta l = \pm 0.05$ mm, $\Delta d = \pm 0.0010$ mm.

19. A piezoelectric crystal is characterized by a constant, $12\times10^{-3}\ \frac{V/m}{N/m^2}$. It has a dielectric constant of 1.250 x 10^{-8} F/m and Young's modulus of 1.2×10^{11} N/m^2. Its diameter is 8 mm, thickness is 2 mm and its leakage resistance is $10^8\Omega$.
(A) Determine its sensitivity for measurement of displacement in V/m.
(B) What will be the output voltage for an input force of 10 N?
(C) Above crystal is connected to an amplifer with input capacitance of 4×10^{-10} F and resistance of $10^8\Omega$. The connecting cable has a capacitance of 2×10^{-10}F .Determine the time constant for measurement of displacement.

20. For the measurement of torque, for 120 Ω resistance strain gauges having gauge factor 2.0, are mounted on a shaft, 5 cm in diameter, at 45° to the axis of the shaft and are connected in a bridge configuration to get maximum sensitivity. For the shaft material, the Young's modulus is 2.0 x 10^{11} N/m^2 and Poisson's ratio is 0.3. Speed of the shaft is 1500 rpm. Excitation voltage to the bridge is 4.0 V. If the Excitation voltage to the bridge is 4.0 V. If the output voltage of the bridge is 3.5 mV, determine
(A) torque transmitted (B) power transmitted

21. A small amount of solution containing Na^{24} radionuclide with activity of 2000 disintegrations per second was injected into the blood stream of a man. The radioactivity of 1 ml of blood sample taken 5 hours later turned out to be 16 disintegrations per minute per ml. The half life of the radionuclide is T=15 hours. Find the volume of the man's blood.

22.
(A) Light of wavelength 6000 Å is incident normally on a plane transmission grating. Find the difference in the angles of deviation in the second and the third order spectra. The number of lines per cm of the grating is 5000.
(B) In a Michelson interferometer a shift of 100 fringes is observed at a wavelength of 6328 Å, when air in the tube of 20 cm length is removed. Calculate the refractive index of air.