IN : INSTRUMENTATION ENGINEERING

Duration: Three Hours *Maximum Marks*: 100

Read the following instructions carefully.

1. This question paper contains **16** pages including blank pages for rough work. Please check all pages and report discrepancy, if any.

2. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the Optical Response Sheet (**ORS**).

3. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.

4. All questions in this paper are of objective type.

5. Questions must be answered on the **ORS** by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **For each question darken the bubble of the correct answer**. In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as an incorrect response.

6. There are a total of 65 questions carrying 100 marks.

7. Questions Q.1 – Q.25 will carry 1-mark each, and questions Q.26 – Q.55 will carry 2-marks each.

8. Questions Q.48 – Q.51 (2 pairs) are common data questions and question pairs (Q.52, Q.53) and (Q.54, Q.55) are linked answer questions. The answer to the second question of the linked answer questions depends on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question in the pair will not be evaluated.

9. Questions Q.56 – Q.65 belong to General Aptitude (GA). Questions Q.56 – Q.60 will carry 1-mark each, and questions Q.61 – Q.65 will carry 2-marks each. The GA questions will begin on a fresh page starting from page **12**.

10. Un-attempted questions will carry zero marks.

11. Wrong answers will carry **NEGATIVE** marks. For Q.1 – Q.25 and Q.56 – Q.60, ⅓ mark will be deducted for each wrong answer. For Q.26 – Q.51 and Q.61 – Q.65, ⅔ mark will be deducted for each wrong answer. The question pairs (Q.52, Q.53), and (Q.54, Q.55) are questions with linked answers. There will be negative marks only for wrong answer to the first question of the linked answer question pair i.e. for Q.52 and Q.54, ⅔ mark will be deducted for each wrong answer. There is no negative marking for Q.53 and Q.55.

12. Calculator (without data connectivity) is allowed in the examination hall.

13. Charts, graph sheets or tables are NOT allowed in the examination hall.

14. Rough work can be done on the question paper itself. Additionally, blank pages are provided at the end of the question paper for rough work.

SEAL

Q.1 – Q.25 carry one mark each.

Q.1 The infinite series $f(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} \ldots\ldots\infty$ converges to

(A) $\cos(x)$ (B) $\sin(x)$ (C) $\sinh(x)$ (D) e^x

Q.2 The diameters of 10000 ball bearings were measured. The mean diameter and standard deviation were found to be 10 mm and 0.05 mm respectively. Assuming Gaussian distribution of measurements, it can be expected that the number of measurements more than 10.15 mm will be

(A) 230 (B) 115 (C) 15 (D) 2

Q.3 A person weighing 60 kg receives radiation energy of 0.3 J over the entire body. The dose of radiation absorbed (in rad) is

(A) 0.005 rad (B) 0.1 rad (C) 0.3 rad (D) 0.5 rad

Q.4 $u(t)$ represents the unit step function. The Laplace transform of $u(t-\tau)$ is

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

Q.5 A measurement system with input $x(t)$ and output $y(t)$ is described by the differential equation $3\frac{dy}{dt} + 5y = 8x$. The static sensitivity of the system is

(A) 0.60 (B) 1.60 (C) 1.67 (D) 2.67

Q.6 Poisson's ratio for a metal is 0.35. Neglecting piezo-resistance effect, the gage factor of a strain gage made of this metal is

(A) 0.65 (B) 1 (C) 1.35 (D) 1.70

Q.7 Match the following :

P. Radiation Pyrometer	W. Angular velocity measurement
Q. Dall tube	X. Vacuum pressure measurement
R. Pirani gauge	Y. Flow measurement
S. Gyroscope	Z. Temperature measurement

(A) P-Z, Q-W, R-X, S-Y (B) P-Z, Q-Y, R-X, S-W
(C) P-W, Q-X, R-Y, S-Z (D) P-Z, Q-X, R-W, S-Y

Q.8 In a pulse code modulated (PCM) signal sampled at f_s and encoded into an n-bit code, the minimum bandwidth required for faithful reconstruction is

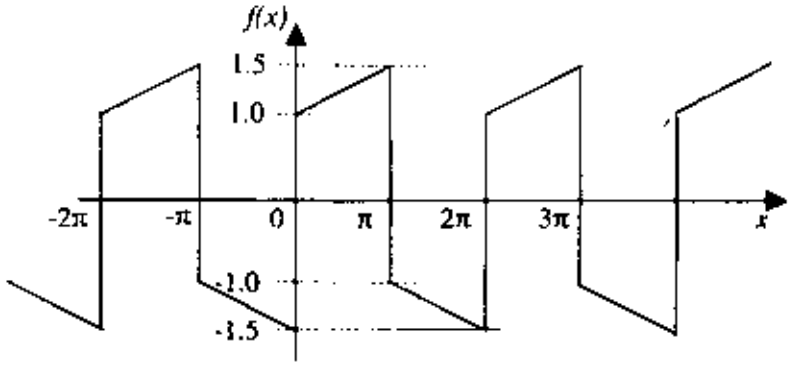
(A) $2nf_s$ (B) nf_s (C) $nf_s/2$ (D) f_s

Q.9 A beam of unpolarized light is first passed through a linear polarizer and then through a quarter-wave plate. The emergent beam is

(A) unpolarized (B) linearly polarized
(C) circularly polarized (D) elliptically polarized

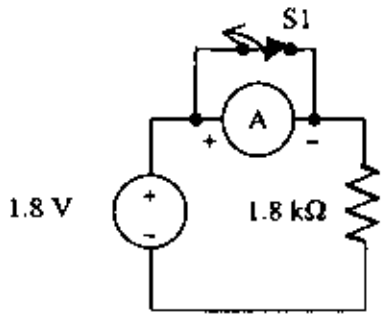
Q.10 $f(x)$, shown in the adjoining figure is represented by

$$f(x) = a_0 + \sum_{n=1}^{\infty} \{a_n \cos(nx) + b_n \sin(nx)\}$$. The value of a_0 is



(A) 0 (B) $\pi/2$ (C) π (D) 2π

Q.11 The PMMC ammeter A in the adjoining figure has a range of 0 to 3 mA. When switch S1 is opened, the pointer of the ammeter swings to the 1 mA mark, returns and settles at 0.9 mA. The meter is



(A) critically damped and has a coil resistance of 100 Ω
(B) critically damped and has a coil resistance of 200 Ω
(C) under damped and has a coil resistance of 100 Ω
(D) under damped and has a coil resistance of 200 Ω

Q.12 The open loop transfer function of a unity gain feedback system is given by:

$$G(s) = \frac{k(s+3)}{(s+1)(s+2)}.$$

The range of positive values of k for which the closed loop system will remain stable is:

(A) $1 < k < 3$ (B) $0 < k < 10$
(C) $5 < k < \infty$ (D) $0 < k < \infty$

Q.13 A real $n \times n$ matrix $A = [a_{ij}]$ is defined as follows:

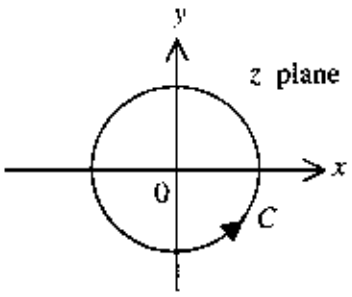
$a_{ij} = i$, if $i = j$

$= 0$, otherwise

The summation of all n eigenvalues of A is

(A) $n(n+1)/2$ (B) $n(n-1)/2$ (C) $\frac{n(n+1)(2n+1)}{6}$ (D) n^2

Q.14 The contour C in the adjoining figure is described by $x^2 + y^2 = 16$.

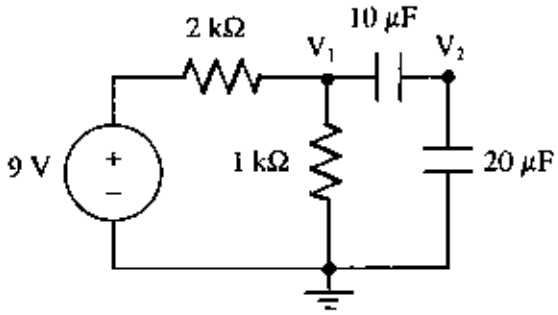


The value of $\oint_C \frac{z^2 + 8}{0.5z - 1.5j} dz$ is

(Note: $j = \sqrt{-1}$)

(A) $-2\pi j$ (B) $2\pi j$ (C) $4\pi j$ (D) $-4\pi j$

Q.15 In the dc circuit shown in the adjoining figure. the node voltage V_2 at steady state is



(A) 0 V (B) 1 V (C) 2 V (D) 3 V

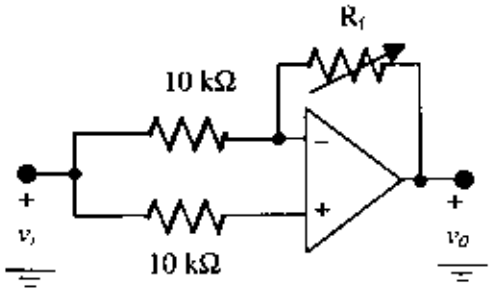
Q.16 A 100 Ω, 1 W resistor and a 800 Ω, 2 W resistor are connected in series. The maximum dc voltage that can be applied continuously to the series circuit without exceeding the power limit of any of the resistors is

(A) 90 V (B) 50 V (C) 45 V (D) 40 V

Q.17 The seismic mass of an accelerometer oscillates sinusoidally at 100 Hz with a maximum displacement of 10 mm from its mean position. The peak acceleration of the seismic mass is

(A) 3947.84 m/s^2 (B) 3141.50 m/s^2 (C) 314.15 m/s^2 (D) 100.00 m/s^2

Q.18 In the ideal opamp circuit given in the adjoining figure, the value of R_f is varied from 1 kΩ to 100 kΩ. The gain G = (v_o/v_i) will



(A) remain constant at +1 (B) remain constant at –1
(C) vary as –(R_f/10,000) (D) vary as (1+R_f/10,000)

Q.19 A signal with frequency components 50 Hz, 100 Hz and 200 Hz only is sampled at 150 samples/s. The ideally reconstructed signal will have frequency component(s) of

(A) 50 Hz only (B) 75 Hz only
(C) 50 Hz and 75 Hz (D) 50 Hz, 75 Hz and 100 Hz

Q.20 The subroutine SBX given below is executed by an 8085 processor. The value in the accumulator immediately after the execution of the subroutine will be:

```
SBX:  MVI A,99h
      ADI 11h
      MOV C,A
      RET
```

(A) 00h (B) 11h (C) 99h (D) AAh

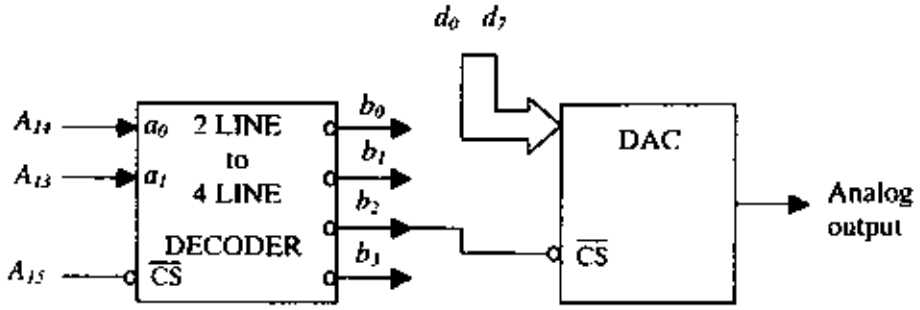
Q.21 The integral $\int_{-\infty}^{\infty} \delta(t-\pi/6)\,6\sin(t)dt$ evaluates to

(A) 6 (B) 3 (C) 1.5 (D) 0

Q.22 The deflection angle of the pointer of an ideal moving iron ammeter is 20° for 1.0 ampere dc current. If a current of $3\sin(314t)$ amperes is passed through the ammeter then the deflection angle is

(A) 0° (B) 42° (C) 60° (D) 90°

Q.23 An 8-bit DAC is interfaced with a microprocessor having 16 address lines (A_0 ... A_{15}) as shown in the adjoining figure. A possible valid address for this DAC is



(A) 3000h (B) 4FFFh (C) AFFFh (D) C000h

Q.24 $H(z)$ is a discrete rational transfer function. To ensure that both $H(z)$ and its inverse are stable its

(A) poles must be inside the unit circle and zeros must be outside the unit circle.
(B) poles and zeros must be inside the unit circle.
(C) poles and zeros must be outside the unit circle.
(D) poles must be outside the unit circle and the zeros should be inside the unit circle.

Q.25 The output voltage of a transducer with an output resistance of 10 kΩ is connected to an amplifier. The minimum input resistance of the amplifier so that the error in recording the transducer output does not exceed 2 % is

(A) 10 kΩ (B) 49 kΩ (C) 490 kΩ (D) 1.2 MΩ

Q. 26 – Q.55 carry two marks each.

Q.26 $\mathbf{X}$ and $\mathbf{Y}$ are non-zero square matrices of size $n \times n$. If $\mathbf{XY} = \mathbf{0}_{n\times n}$ then

(A) $|\mathbf{X}| = 0$ and $|\mathbf{Y}| \neq 0$ (B) $|\mathbf{X}| \neq 0$ and $|\mathbf{Y}| = 0$
(C) $|\mathbf{X}| = 0$ and $|\mathbf{Y}| = 0$ (D) $|\mathbf{X}| \neq 0$ and $|\mathbf{Y}| \neq 0$

Q.27 Consider the differential equation $\frac{dy}{dx} + y = e^x$ with $y(0) = 1$. The value of $y(1)$ is

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

Q.28 The electric charge density in the region $R: x^2 + y^2 \le 1, y \le 0$ is given as $\sigma(x, y) = 1$ C/m^2, where x and y are in meters. The total charge (in coulomb) contained in the region R is

(A) 4π (B) 2π (C) $\pi/2$ (D) 0

Q.29 The input $x(t)$ and the corresponding output $y(t)$ of a system are related by $y(t) = \int_{-\infty}^{5t} x(\tau)\,d\tau$.

The system is

(A) time invariant and causal
(B) time invariant and noncausal
(C) time variant and noncausal
(D) time variant and causal

Q.30 A digital filter having a transfer function $H(z) = \frac{p_0 + p_1 z^{-1} + p_3 z^{-3}}{1 + d_3 z^{-3}}$ is implemented using Direct Form – I and Direct Form – II realizations of IIR structure. The number of delay units required in Direct Form – I and Direct Form – II realizations are, respectively

(A) 6 and 6 (B) 6 and 3 (C) 3 and 3 (D) 3 and 2

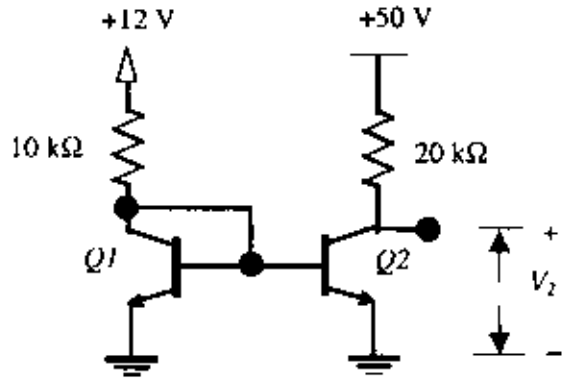
Q.31 The velocity v (in m/s) of a moving mass, starting from rest, is given as $\frac{dv}{dt} = v + t$. Using Euler forward difference method (also known as Cauchy-Euler method) with a step size of 0.1 s, the velocity at 0.2 s evaluates to

(A) 0.01 m/s (B) 0.1 m/s (C) 0.2 m/s (D) 1 m/s

Q.32 The rotor of the control transformer of a synchro pair gives a maximum voltage of 1.0 V at a particular position of the rotor of the control transmitter. The transmitter rotor is now rotated by 30° anticlockwise keeping the transformer rotor stationary. The transformer rotor voltage for this position is

(A) 1.0 V (B) 0.866 V (C) 0.5 V (D) 0 V

Q.33 The matched transistors $Q1$ and $Q2$ shown in the adjoining figure have $\beta = 100$. Assuming the base-emitter voltages to be 0.7 V, the collector-emitter voltage V_2 of the transistor $Q2$ is

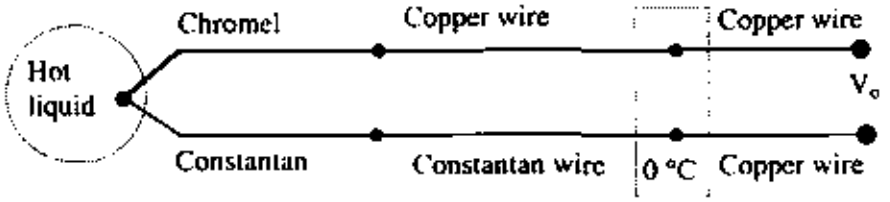


(A) 33.9 V (B) 27.8 V (C) 16.2 V (D) 0.7 V

Q.34 The volume of a cylinder is computed from measurements of its height (h) and diameter (d). A set of several measurements of height has an average value of 0.2 m and a standard deviation of 1%. The average value obtained for the diameter is 0.1 m and the standard deviation is 1%. Assuming the errors in the measurements of height and diameter are uncorrelated, the standard deviation of the computed volume is

(A) 1.00% (B) 1.73% (C) 2.23% (D) 2.41%

Q.35 A thermocouple based temperature measurement system is shown in the adjoining figure. Relevant thermocouple emf data (in mV) is given below. The cold junction is kept at 0°C. The temperature is 30°C in the other parts of the system. The emf V_o is measured to be 26.74 mV. The temperature of the hot liquid is



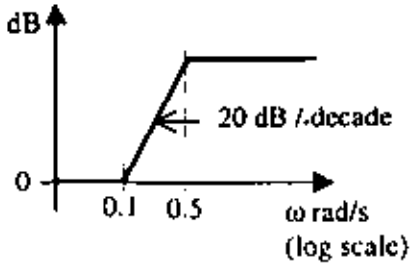
Temperature	emf of Chromel-Constantan	emf of Copper-Constantan
10°C	0.591	0.391
20°C	1.192	0.789
30°C	1.801	1.196
370°C	26.549	19.027
380°C	27.345	19.638

(A) 370.0 °C (B) 372.4 °C (C) 376.6 °C (D) 380.0 °C

Q.36 A differential pressure transmitter is used to measure the flow rate in a pipe. Due to aging, the sensitivity of the pressure transmitter is reduced by 5%. All other aspects of the flow meter remaining constant, change in the sensitivity of the flow measurement is

(A) 10.0% (B) 5.0% (C) 2.5% (D) 2.2%

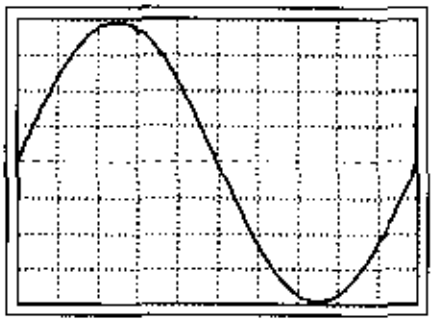
Q.37 The asymptotic Bode magnitude plot of a lead network with its pole and zero on the left half of the s-plane is shown in the adjoining figure. The frequency at which the phase angle of the network is maximum (in rad/s) is



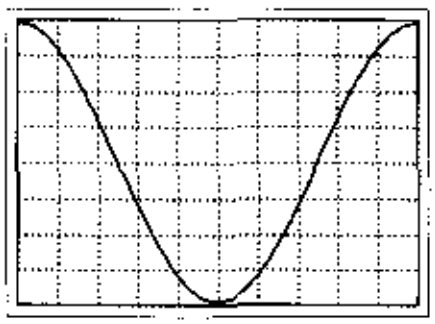
(A) $\frac{3}{\sqrt{10}}$ (B) $\frac{1}{\sqrt{20}}$ (C) $\frac{1}{20}$ (D) $\frac{1}{30}$

Q.38 In an analog single channel cathode ray oscilloscope (CRO), the x and y sensitivities are set as 1 ms/div. and 1 V/div. respectively. The y-input is connected to a voltage signal $4\cos(200\pi t - 45°)$ V. The trigger source is internal, level chosen is zero and the slope is positive. The display seen on the CRO screen is

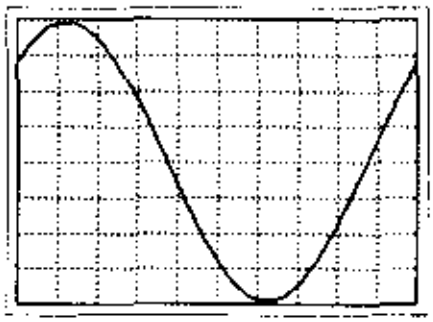
(A)



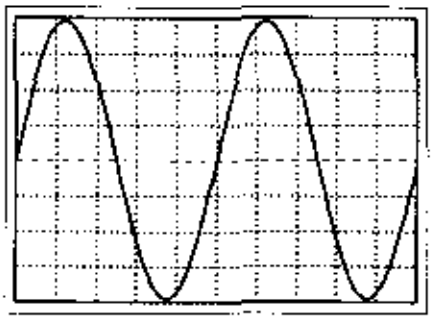
(B)



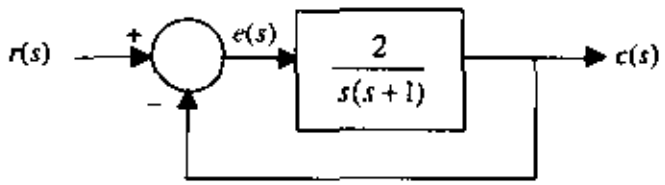
(C)



(D)



Q.39 A unit ramp input is applied to the system shown in the adjoining figure. The steady state error in its output is



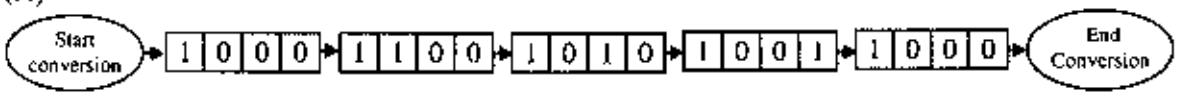
(A) 0 (B) 0.5 (C) 1 (D) 2

Q.40 A unity feedback system has an open loop transfer function $G(s) = \frac{k}{s(s+3)}$. The value of k that yields a damping ratio of 0.5 for the closed loop system is

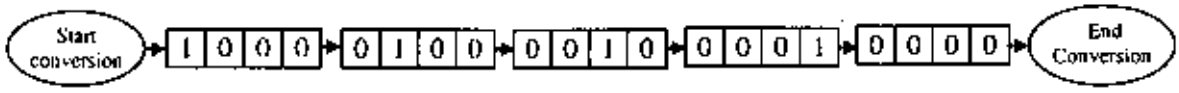
(A) 1 (B) 3 (C) 5 (D) 9

Q.41 A 4-bit successive approximation type ADC has a full scale value of 15 V. The sequence of the states, the SAR will traverse, for the conversion of an input of 8.15 V is

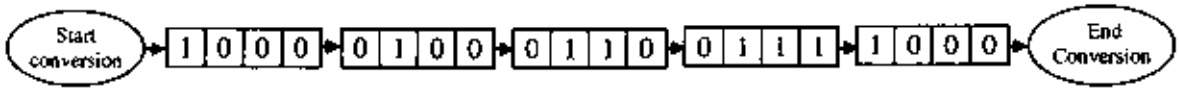
(A)



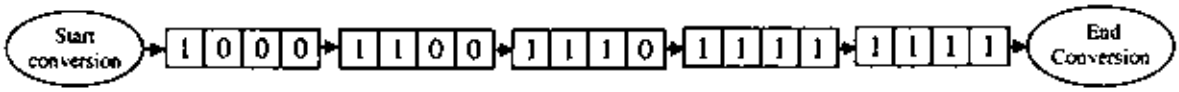
(B)



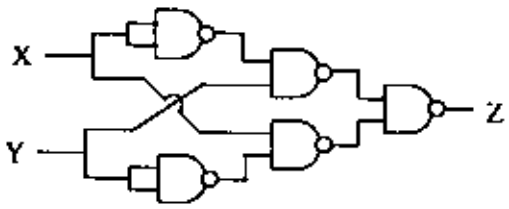
(C)



(D)



Q.42 The logic gate circuit shown in the adjoining figure realizes the function



(A) XOR (B) XNOR
(C) Half adder (D) Full adder

Q.43 In an 8085 processor, the main program calls the subroutine SUB1 given below. When the program returns to the main program after executing SUB1, the value in the accumulator is

Address	Opcode	Mnemonic	
2000	3E 00	SUB1:	MVI A,00h
2002	CD 05 20		CALL SUB2
2005	3C	SUB2:	INR A
2006	C9		RET

(A) 00 (B) 01 (C) 02 (D) 03

Q.44 Light coming out of an optical fiber is incident on a plane perpendicular to the fiber axis and 50 mm away from the end of the fiber. The light coming out creates a circular spot that can at most be of 20 mm diameter. Neglecting the diameter of the fiber, the numerical aperture of the fiber is, approximately,

(A) 0.14 (B) 0.20 (C) 0.34 (D) 0.40

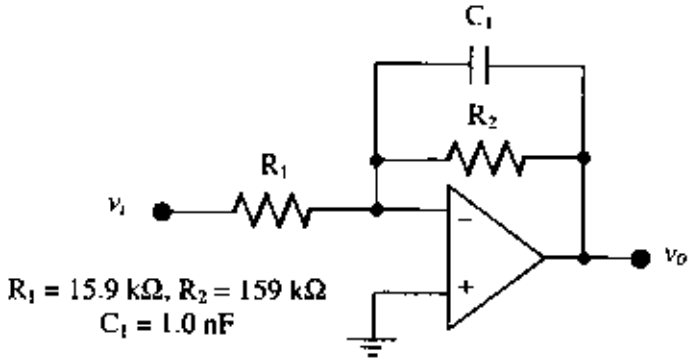
Q.45 A solution "P" is put in a spectrophotometer cuvette of optical path length 1 cm. The transmittance is found to be 10%. Another solution "Q" has a transmittance of 40% under the same circumstances. If equal volumes of P and Q are mixed together, the transmittance of the resulting solution (assuming the constituents of P and Q do not react with each other) is, approximately,

(A) 15% (B) 20% (C) 25% (D) 30%

Q.46 4-point DFT of a real discrete-time signal $x[n]$ of length 4 is given by $X[k]$, $n = 0, 1, 2, 3$ and $k = 0, 1, 2, 3$. It is given that $X[0] = 5$, $X[1] = 1+j1$, $X[2] = 0.5$, $X[3]$ and $x[0]$ respectively are

(A) 1 – j, 1.875 (B) 1 – j, 1.500 (C) 1 + j, 1.875 (D) 0.1 – j0.1, 1.500

Q.47 An active filter is shown in the adjoining figure. The dc gain and the 3 dB cut-off frequency of the filter respectively, are, nearly

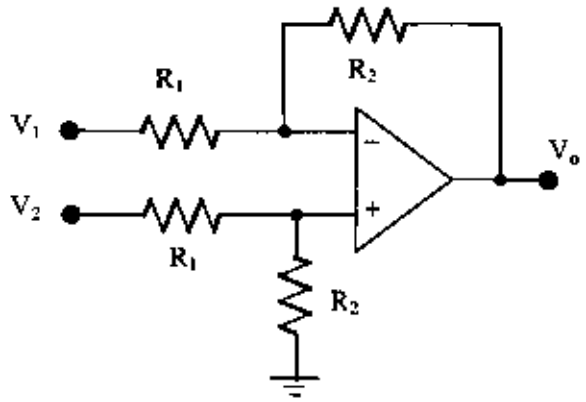


(A) 40 dB, 3.14 kHz (B) 40 dB, 1.00 kHz
(C) 20 dB, 6.28 kHz (D) 20 dB, 1.00 kHz

Common Data Questions

Common Data for Questions 48 and 49:

A differential amplifier is constructed using an ideal opamp as shown in the adjoining figure. The values of R_1 and R_2 are 47 kΩ and 470 kΩ respectively.



Q.48 The input impedances seen looking into the terminals V_1 and V_2, with respect to ground, respectively are

(A) 47 kΩ and 43 kΩ (B) 47 kΩ and 47 kΩ
(C) 47 kΩ and 517 kΩ (D) 517 kΩ and 517 kΩ

Q.49 V_1 and V_2 are connected to voltage sources having an open circuit output of +1 V each and internal resistances of 13 kΩ and 3 kΩ respectively. The output voltage V_o is

(A) 0 V (B) 0.15 V (C) 1.5 V (D) 10 V

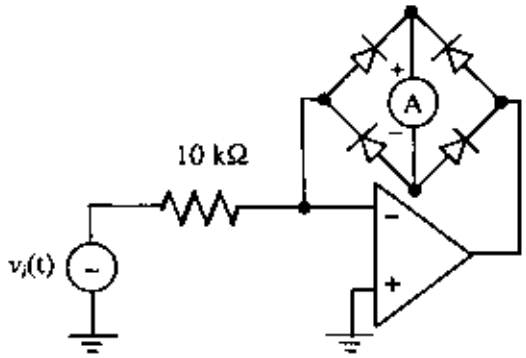
Common Data for Questions 50 and 51:

A PMMC type ammeter has full scale current of 100 μA and a coil resistance of 100 Ω.

Q.50 The resistance required to convert the 100 μA ammeter into a 1A full scale dc ammeter is

(A) 10 mΩ in series with the meter (B) 10 mΩ in parallel with the meter
(C) 1 mΩ in series with the meter (D) 1 mΩ in parallel with the meter

Q.51 The above PMMC meter is connected in the circuit shown in the adjoining figure. The opamp is ideal. The voltage $v_i(t) = 1.0 \sin 314t$ V. Assuming the source impedance of $v_i(t)$ to be zero, the ammeter will indicate a current of



(A) 100 μA (B) 70.7 μA (C) 63.7 μA (D) 31.8 μA

Linked Answer Questions

Statement for Linked Answer Questions 52 and 53:
A coil having an inductance (L) of 10 mH and resistance R is connected in series with an ideal 100 μF capacitor (C). When excited by a voltage source of value $10\sqrt{2}\cos(1000t)$ V, the series RLC circuit draws 20 W of power.

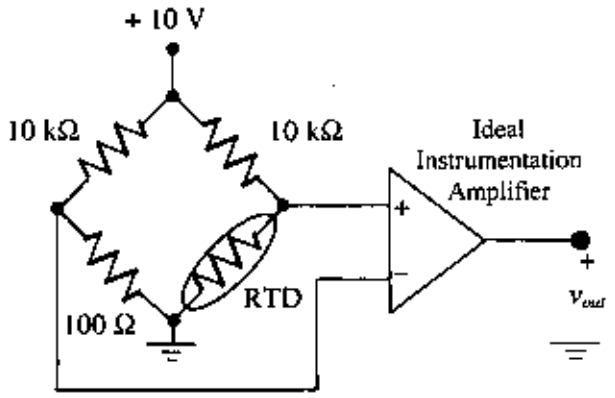
Q.52 The value of the coil resistance R is

(A) 1 Ω (B) 2 Ω (C) 4 Ω (D) 5 Ω

Q.53 The Q factor of the coil at an angular frequency of 1000 rad/s is

(A) 1 (B) 2 (C) 4 (D) 5

Statement for Linked Answer Questions 54 and 55:
Consider a temperature measurement scheme shown in the adjoining figure. It uses an RTD whose resistance at 0°C is 100 Ω and temperature coefficient of resistance (α) is 0.00392 / °C.



Q.54 The differential gain of the instrumentation amplifier to achieve a voltage sensitivity of 10 mV/°C at 0°C, should be approximately

(A) 13.41 (B) 26.02 (C) 57.53 (D) 90.14

Q.55 The RTD is placed in a hot water bath of temperature 100°C. Based on the gain calculated in Q.54, the error in the measured value of the temperature due to bridge nonlinearity is

(A) –0.1°C (B) · 0.4°C (C) –0.9°C (D) +1.2°C

General Aptitude (GA) Questions

Q.56 – Q.60 carry one mark each.

Q.56 25 persons are in a room. 15 of them play hockey, 17 of them play football and 10 of them play both hockey and football. Then the number of persons playing neither hockey nor football is:

(A) 2 (B) 17 (C) 13 (D) 3

Q.57 *Choose the most appropriate word from the options given below to complete the following sentence:*

If we manage to _____ our natural resources, we would leave a better planet for our children.

(A) uphold
(B) restrain
(C) cherish
(D) conserve

Q.58 *The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair.*

Unemployed : Worker

(A) fallow : land
(B) unaware : sleeper
(C) wit : jester
(D) renovated : house

Q.59 *Which of the following options is the closest in meaning to the word below:*

Circuitous

(A) cyclic
(B) indirect
(C) confusing
(D) crooked

Q.60 *Choose the most appropriate word from the options given below to complete the following sentence:*

His rather casual remarks on politics _____ his lack of seriousness about the subject.

(A) masked
(B) belied
(C) betrayed
(D) suppressed

Q.61 – Q.65 carry two marks each.

Q.61 Hari (H), Gita (G), Irfan (I) and Saira (S) are siblings (i.e. brothers and sisters). All were born on 1st January. The age difference between any two successive siblings (that is born one after another) is less than 3 years. Given the following facts:

i. Hari's age + Gita's age > Irfan's age + Saira's age.
ii. The age difference between Gita and Saira is 1 year. However, Gita is not the oldest and Saira is not the youngest.
iii. There are no twins.

In what order were they born (oldest first)?

(A) HSIG (B) SGHI (C) IGSH (D) IHSG

Q.62 5 skilled workers can build a wall in 20 days; 8 semi-skilled workers can build a wall in 25 days; 10 unskilled workers can build a wall in 30 days. If a team has 2 skilled, 6 semi-skilled and 5 unskilled workers, how long will it take to build the wall?

(A) 20 days (B) 18 days (C) 16 days (D) 15 days

Q.63 **Modern warfare has changed from large scale clashes of armies to suppression of civilian populations. Chemical agents that do their work silently appear to be suited to such warfare; and regretfully, there exist people in military establishments who think that chemical agents are useful tools for their cause.**

Which of the following statements best sums up the meaning of the above passage:

(A) Modern warfare has resulted in civil strife.
(B) Chemical agents are useful in modern warfare.
(C) Use of chemical agents in warfare would be undesirable.
(D) People in military establishments like to use chemical agents in war.

Q.64 Given digits 2, 2, 3, 3, 3, 4, 4, 4, 4 how many distinct 4 digit numbers greater than 3000 can be formed?

(A) 50 (B) 51 (C) 52 (D) 54

Q.65 If 137 + 276 = 435 how much is 731 + 672?

(A) 534 (B) 1403 (C) 1623 (D) 1513

END OF THE QUESTION PAPER

Space for Rough Work

Space for Rough Work

Space for Rough Work

SEAL