GATE-2015

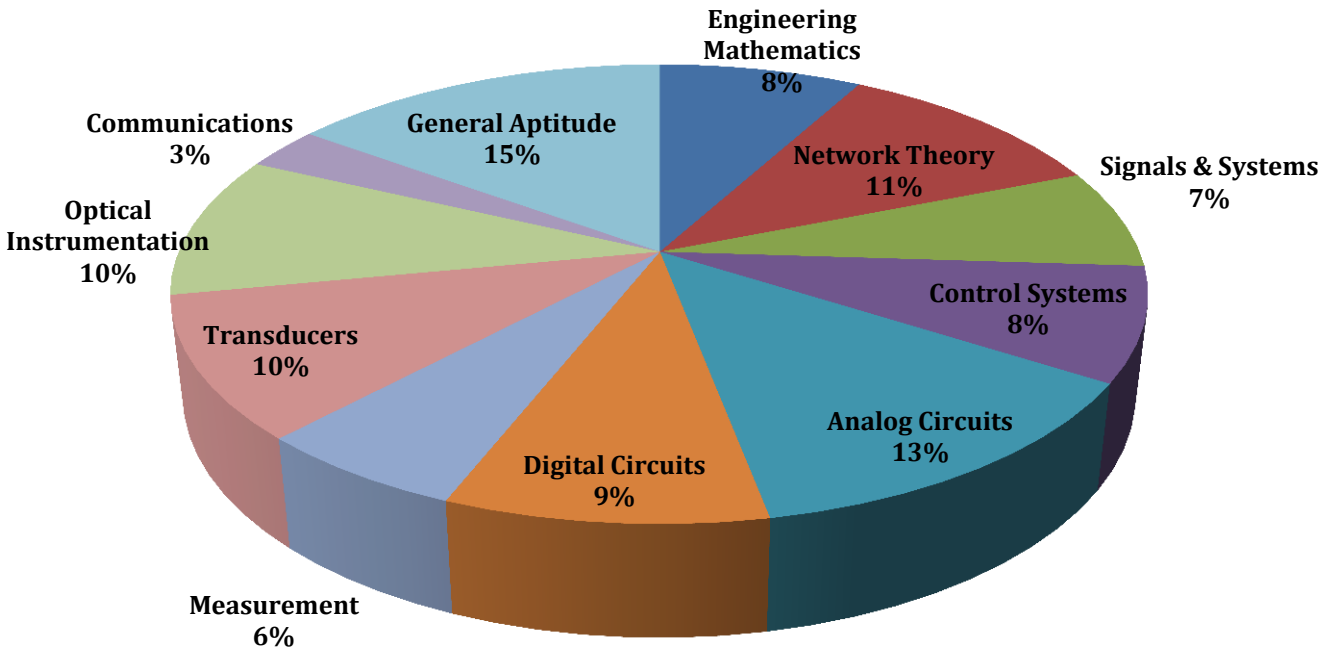
Question Paper

&

Answer Keys

Index

ANALYSIS OF GATE 2015
Instrumentation Engineering



GATE-2015- IN

SUBJECT	NO OF QUESTION	Topics Asked in Paper	Total Marks
Engineering Mathematics	1M:4 2M:2	Linear Algebra, Probability and Distribution Calculus, Complex Variable	8
Network Theory	1M:3 2M:4	Network Solution and methodology Transient /Steady State Analysis of RLC Circuit to DC input, Laplace transforms, Two –port Network	11
Signals & Systems	1M:1 2M:3	Introduction to S&S, Z-Transform DSP	7
Control Systems	1M:2 2M:3	Time domain Analysis, Root Locus Technique Frequency Response Analysis Nyquist Plot Frequency response Analysis using bode plot State Variable Analysis	8
Analog Circuits	1M:1 2M:6	Diode –Circuit –Analysis &Application AC&DC Biasing-BJTs, Small Signal Modeling of BJT & FET, BJT &JFET Frequency Response Operational Amplifier and Its Application	13
Digital Circuits	1M:3 2M:3	Logic Gates, Combinational Digital Circuit / Sequential Digital Circuits, Introduction to Microprocessor	9
Measurement	1M:2 2M:2	Measurement of Basic Electrical Quantities-1 Measurement of Basic Electrical Quantities-2	6
Transducers	1M:4 2M:3	Resistive Transducers, Inductive transducer Capacitive transducers, Mechanical Transducers in instrumentation, Measurements of nonlinear Quantities	10
Optical Instrumentation	1M:4 2M:3	UV Visible and IR Spectrometry, Mass Spectrometer, X-ray and Nuclear Radiation Measurements, Optical Source and detector ECG EEG,EMG	10
Communication	1M:1 2M:1	Noise Angle modulation, Digital Communication	3
General Aptitude	1M:5 2M:5	Numerical Ability Verbal Ability	15
Total	**65**		**100**

GATE 2015 Examination

Instrumentation Engineering

Test Date: 1/02/2015

Test Time: 2:00 AM 5:00 PM

Subject Name: IN INSTRUMENTATION ENGINEERING

Section: General Aptitude

1. Tanya is older than Eric.
Cliff 15 older than Tanya.
Eric is older than Cliff
If the first two statements are true, then the third statement is:
(A) True
(B) False
(C) Uncertain
(D) Data insufficient
[Ans. B]

2. Choose the statement where underlined word is used correctly.
(A) When the teacher eludes to different authors, he is being elusive.
(B) When the thief keeps eluding the police, he is being elusive.
(C) Matters that are difficult to understand, identify or remember are allusive.
(D) Mirages can be allusive, but a better way to express them is illusory
[Ans. B]

3. Five teams have to compete in a league, with every team playing every other team exactly once, before going to the next round. How many matches will have to be held to complete the league round of matches
(A) 20
(B) 10
(C) 8
(D) 5
[Ans. B]

4. Choose the appropriate word/phrase out of the four options given below, to complete the following sentence:
Apparent life less ness _____ dormant life
(A) harbours
(B) leads to
(C) supports
(D) affects
[Ans. A]

5. Fill in the blank with the correct idiom/phrase.
That boy from the town was a _____ in the sleepy village.
(A) dog out of herd
(B) sheep from the heap
(C) fish out of water
(D) bird from the flock
[Ans. C]

6. Right triangle PQR is to be constructed in the xy-plane so that the right angle is at P and line PR is parallel to the x-axis. The x and y coordinates of P, Q and R are to be integers that satisfy the inequalities: $-4 \leq x \leq 5$ and $6 \leq y \leq 16$. How many different triangles could be constructed with these properties?

(A) 110
(B) 1,100
(C) 9,900
(D) 10,000

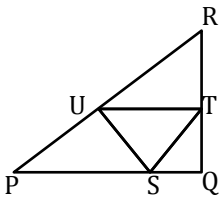
[Ans. B]

7. A coin is tossed thrice. Let X be the event that head occurs in each of the first two tosses. Let Y be the event that a tail occurs on the third toss. Let Z be the event that two tails occur in three tosses. Based on the above information which one of the following statements is TRUE?

(A) X and Y are not independent
(B) Y and Z are dependent
(C) Y and Z are independent
(D) X and Z axe independent

[Ans. D]

8. In the given figure angle Q is a right angle. PS: QS = 3:1. RT: QT = 5:2 and PU: UR =1: 1. If area of triangle QTS is 20 cm^2 then the area of triangle PQR in cm^2 is_____



[Ans. *] Range; 280 to 280

9. Select the appropriate option in place of underlined part of the sentence.
Increased productivity necessary reflects greater efforts made by the employees.

(A) Increase in productivity necessary
(B) Increase productivity is necessary
(C) Increase in productivity necessarily
(D) No improvement required

[Ans. C]

10. Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows.

Statements:
I No manager is a leader
II. All leader are executives.

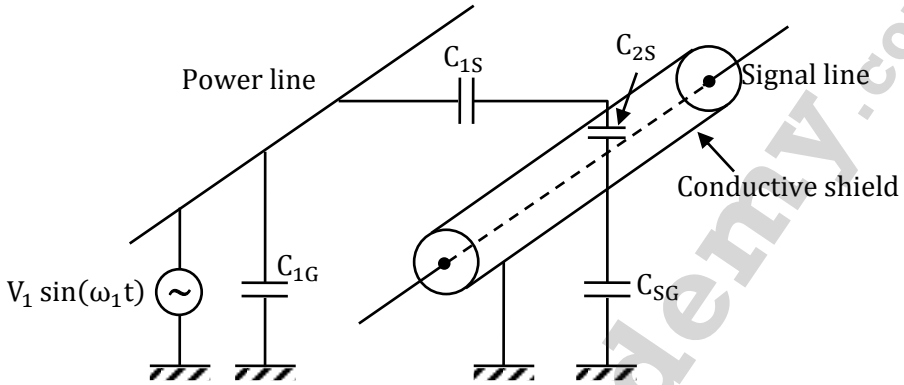
Conclusions:
I. No manager is an executive.
II. No executive is a manager.

(A) Only conclusion I follows
(B) Only conclusion II follows.
(C) Neither conclusion I nor II follows.
(D) Both conclusions I and II follow.

[Ans. D]

Section: Instrumentation Engineering

1. A power line is coupled capacitively through various parasitic capacitances to a shielded signal line as shown in the figure. The conductive shield is grounded solidly at one end Assume that the length of the signal wire extending beyond the shield, and the shield resistance are negligible. The magnitude of the noise voltage coupled to the signal line is



(A) directly proportional to C_{1G}
(B) inversely proportional to the power line frequency
(C) inversely proportional to C_{1S}
(D) zero
[Ans. D]

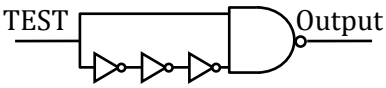
2. The highest frequency present in the signal x(t) is f_{max} The highest frequency present in the signal $y(t) = x^2(t)$ is

(A) $\frac{1}{2} f_{max}$
(B) f_{max}
(C) $2 f_{max}$
(D) $4 f_{max}$
[Ans. C]

3. The magnitude of the directional derivative of the function $f(x, y) = x^2 + 3y^2$ in a direction normal to the circle $x^2 + y^2 = 2$, at the point (1, 1), is

(A) $4\sqrt{2}$
(B) $5\sqrt{2}$
(C) $7\sqrt{2}$
(D) $9\sqrt{2}$
[Ans. A]

4. Consider the logic circuit with input signal TEST shown in the figure. All gates in the figure shown have identical non-zero delay. The signal TEST which was at logic LOW is switched to logic HIGH and maintained at logic HIGH. The output



(A) stays HIGH throughout
(B) stays LOW throughout
(C) pukes from LOW to HIGH to LOW
(D) pulses from HIGH to LOW to HIGH

5. The bridge most suited for measurement of a four-terminal resistance in the range of 0.001Ω to 0.1 Ω is

(A) Wien's bridge
(B) Maxwell's bridge
(C) Kelvin double bridge
(D) Schering bridge

[Ans. B]

6. The double integral $\int_0^a \int_x^y f(x,y)dx\,dy$ is equivalent to

(A) $\int_0^x \int_0^y f(x,y)dx\,dy$
(B) $\int_0^a \int_x^y f(x,y)dx\,dy$
(C) $\int_0^a \int_x^a f(x,y)dy\,dx$
(D) $\int_0^a \int_0^a f(x,y)dx\,dy$

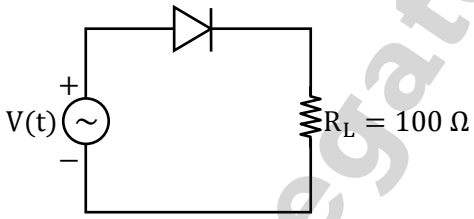
[Ans. C]

7. The voltage (E_0) developed across a glass electrode for pH measurement is related to the temperature (T) by the relation

(A) $E_0 \propto \frac{1}{T^2}$
(B) $E_0 \propto \frac{1}{T}$
(C) $E_0 \propto T$
(D) $E_0 \propto T^2$

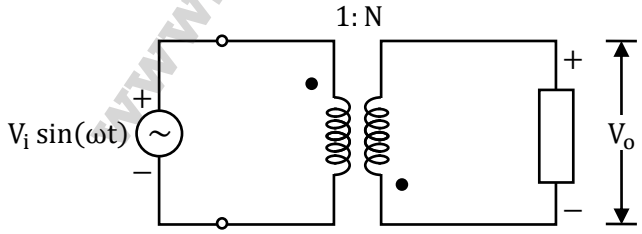
[Ans. C]

8. The figure shows a half-wave rectifier circuit with input voltage $V(t) = 10 \sin (100\,\pi t)$ Volts. Assuming ideal diode characteristics with zero forward voltage drop and zero reverse current, the average power consumed in watts by the load resistance RL is _____W.



[Ans. *] Range: 0.25to 0.25

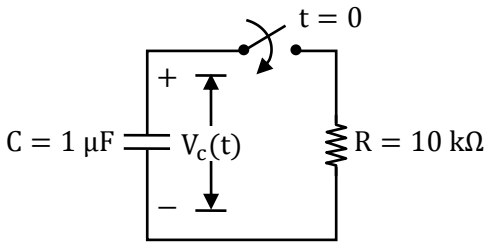
9. The output voltage of the ideal transformer with the polarities and dots shown in the figure is given by



(A) $NV_i \sin \omega t$
(B) $-NV_i \sin \omega t$
(C) $\frac{1}{N} V_i \sin \omega t$
(D) $-\frac{1}{N} V_i \sin \omega t$

[Ans. B]

10. The capacitor shown in the figure is initially charged to +10 V. The switch closes at time $t = 0$ Then the value of $V_c(t)$ in Volts at time t =10 ms is _____ V

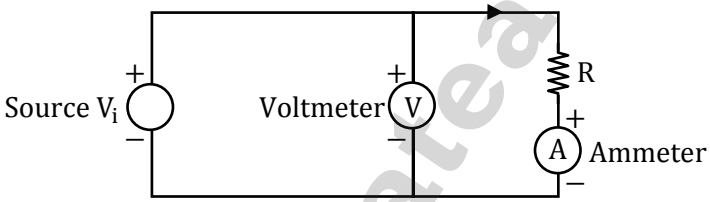


[Ans. *] Range: 3.5 to 3.7

11. A p-type semiconductor strain gauge has a nominal resistance of 1000 Ω and a gauge factor of +200 at 25°C. The resistance of the strain gauge in ohms when subjected to a strain of $+10^{-4}$ m/m at the same temperature is _____ Ω

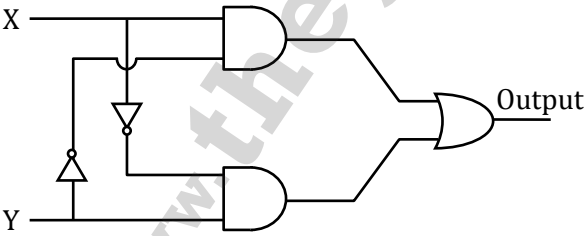
[Ans. *] Range: 1020 to 1020

12. Consider the ammeter-voltmeter method of determining the value of the resistance R using the circuit shown in the figure. The maximum possible errors of the voltmeter and ammeter are known to be 1% and 2% of their readings, respectively. Neglecting the effects of meter resistances, the maximum possible percentage error in the value of R determined from the measurements, is _____ %.



[Ans. *] Range: 3 to 3

13. The logic evaluated by the circuit at the output is



(A) $X\bar{Y} + Y\bar{X}$
(B) $(\overline{X + Y})XY$
(C) $\overline{X}\overline{Y} + XY$
(D) $\bar{X}Y + X\bar{Y} + X + Y$

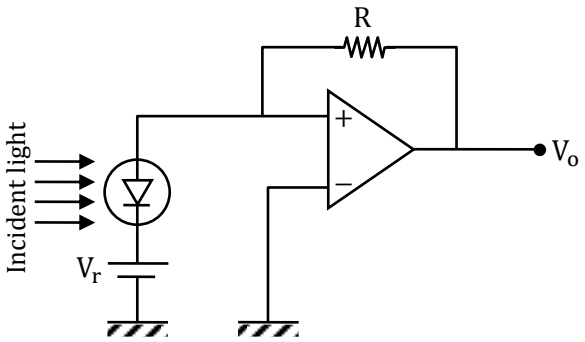
[Ans. A]

14. The filter whose transfer function is of the form $G(s) = \frac{s^2 - bs + c}{s^2 + bs + c}$ is

(A) a high-pass filter
(B) a low-pass filter
(C) an all-pass filter
(D) a band-reject filter

[Ans. C]

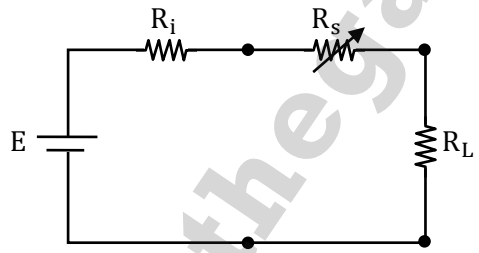
15. A light detector circuit using an ideal photo-diode is shown in the figure. The sensitivity of the photo-diode is 0.5 μA/μW. With $V_r = 6$ V, the output voltage $V_o = -1.0$ V for 10 μW of incident light. If V_r is changed to 3 V, keeping all other parameters the same, the value of V_0 Volts is _____ V.



[Ans. *] Range: -1 to -1

16. An apparatus to capture ECG signals has a filter followed by a data acquisition system. The filter best suited for this application is
(A) low pass with cutoff frequency 200 Hz
(B) high pass with cutoff frequency 200 Hz
(C) band pass with lower and upper cutoff frequencies 100 Hz and 200 Hz for its pass band
(D) band reject with lower and upper cutoff frequencies 1 Hz and 200 Hz for its stop band
[Ans. A]

17. A load resistor R_L is connected to a battery of voltage E with internal resistance R_i through a resistance R_S as shown in the figure. For fixed values of R_L and R_i, the value of $R_s(\geq 0)$ for maximum power transfer to R_L is



(A) 0
(B) $R_L - R_i$
(C) R_L
(D) $R_L + R_i$
[Ans. A]

18. Let $3 + 4j$ be a zero of a fourth order linear-phase FIR filter. The complex number which is NOT a zero of this filter is
(A) $3 - 4j$
(B) $\frac{3}{25} + \frac{4}{25}j$
(C) $\frac{3}{25} - \frac{4}{25}j$
(D) $\frac{1}{3} - \frac{1}{4}j$
[Ans. D]

19. Let A be an $n \times n$ matrix with rank r $(0 < r < n)$. Then $Ax = 0$ has p independent solutions, where p is

(A) r
(B) n
(C) $n - r$
(D) $n + r$

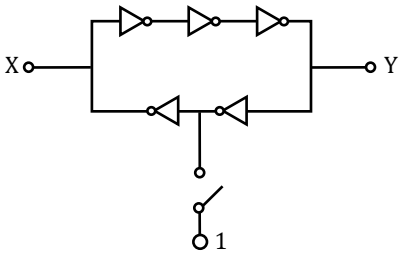
[Ans. C]

20. Liquid flow rate is measured using

(A) a Pirani gauge
(B) a pyrometer
(C) an orifice plate
(D) a Bourdon tube

[Ans. C]

21. In the circuit shown, the switch is momentarily closed and then opened. Assuming the logic gates to have equal non-zero delay, at steady state, the logic states of X and Y are



(A) X is latched, Y toggles continuously
(B) X and Y are both latched
(C) Y is latched, X toggles continuously
(D) X and Y both toggle continuously

[Ans. D]

22. A system with transfer function $G(s) = \frac{1}{s^2+1}$ has zero initial conditions. The percentage overshoot in its step response is _____%.

[Ans. *] Range: 100 to 100

23. The torque transmitted by a cylindrical shaft is to be measured by using two strain gauges. The angles for mounting the strain gauges relative to the axis of the shaft for maximum, sensitivity are

(A) $\pm 45°$
(B) $\pm 60°$
(C) $\pm 90°$
(D) $\pm 180°$

[Ans. A]

24. The value of $\oint \frac{1}{z^2} dz$, where the contour is the unit circle traversed clockwise, is

(A) $-2\pi i$
(B) 0
(C) $2\pi i$
(D) $4\pi i$

[Ans. B]

25. A mass-spring-damper system with force as input and displacement of the mass as output has a transfer function $G(s) = 1/(s^2 + 24s + 900)$. A force input $F(t) = 10\sin(70t)$ newtons is applied at time $t = 0$ s. A beam from an optical stroboscope is focused on the mass. In steady state, the strobe frequency in hertz at which the mass appears to be stationary is

(A) $5/\pi$
(B) $15/\pi$
(C) $35/\pi$
(D) $50/\pi$

[Ans. C]

26. The probability that a thermistor randomly picked up from a production unit is defective is 0.1. The probability that out of 10 thermistors randomly picked up, 3 are defective is

(A) 0.001
(B) 0.057
(C) 0.107
(D) 0.3

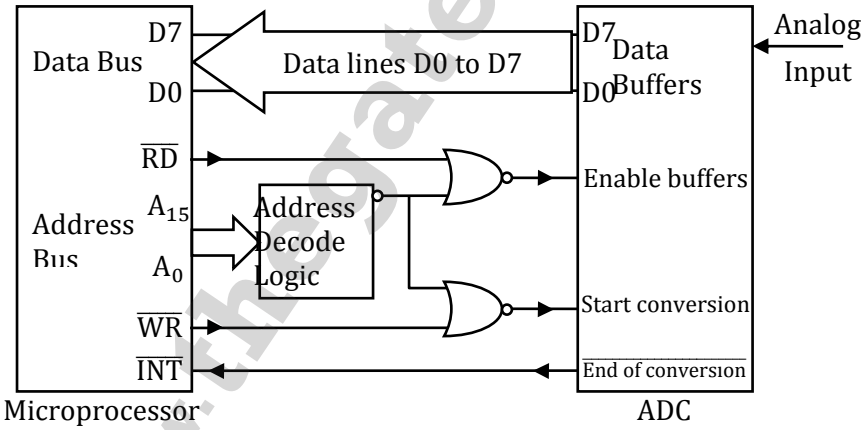
[Ans. B]

27. A beam of monochromatic light passes through two glass slabs of the same geometrical thickness at normal incidence. The refractive index of the first slab is 1.5 and that of the second, 2.0. The ratio of the time of passage of the beam through the first to the second slab is

_____

[Ans. *] Range: 1.3333 to 1.3333

28. An ADC is interfaced with a microprocessor as shown in the figure. All signals have been indicated with typical notations. Acquisition of one new sample of the analog input signal by the microprocessor Involves.



(A) One READ cycle only
(B) One WRITE cycle only
(C) One WRITE cycle followed by one READ cycle
(D) One READ cycle followed by one WRITE cycle

[Ans. D]

29. The open loop transfer function of a system is $G(s) = \frac{s^2+6s+10}{s^2+2s+2}$. The angles of arrival of its root loci are

(A) $\pm\frac{\pi}{4}$
(B) $\pm\frac{\pi}{3}$
(C) $\pm\frac{\pi}{2}$
(D) $\pm\frac{5\pi}{6}$

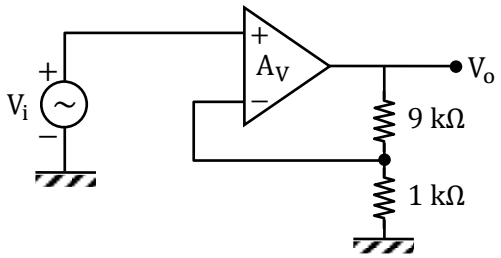
[Ans. A]

30. Consider a low-pass filter module with a pass-band ripple of δ in the gain magnitude. If M such identical modules are cascaded, ignoring the loading effects, the pass-band ripple of the cascade is

(A) $1-(1-\delta)^M$
(B) δ^M
(C) $(1-\delta^M)$
(D) $(1-\delta)^M$

[Ans. *]

31. An op-amp has ideal characteristics except that its open loop gain is given by the expression $Av(s) = 10^4/(1+10^{-3}s)$. This op-amp is used in the circuit shown in the figure. The 3-dB bandwidth of the circuit, in rad/s, is



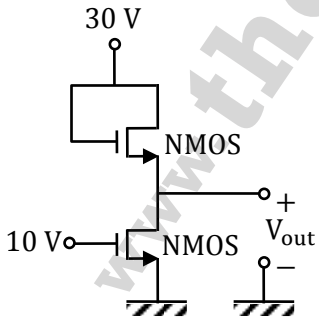
(A) 10^2
(B) 10^3
(C) 10^4
(D) 10^6

[Ans. D]

32. A signal is band-limited to 0 to 12 kHz. The signal spectrum is corrupted by additive noise which is band-limited to 10 to 12 kHz. Theoretically, the minimum rate in kilohertz at which the noisy signal must be sampled so that the UNCORRUPTED PART of the signal spectrum can be recovered, is _____ kHz.

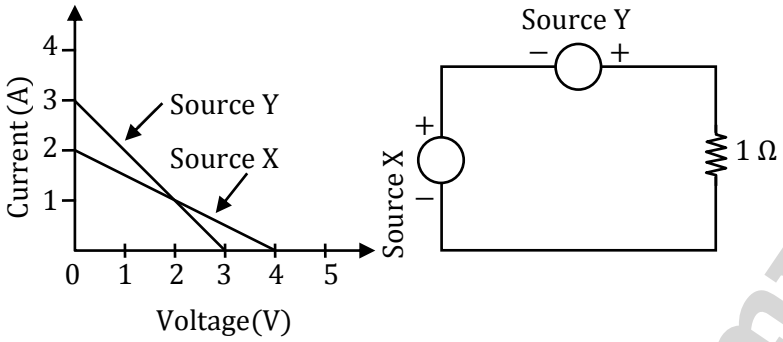
[Ans. *] Range: 20 to 20

33. In the circuit shown in the figure, both the NMOS transistors are identical with their threshold voltages being 5V. Ignoring channel length modulation, the output voltage V_{out} in volt is _____ V.



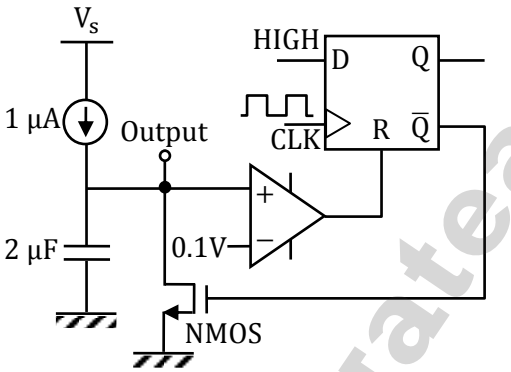
[Ans. *] Range: 10 to 10

34. The linear I-V characteristics of 2-terminal non-ideal dc sources X and Y are shown in the figure. If the sources are connected to a 1Ω resistor as shown, the current through the resistor in amperes is _____ A.



[Ans. *] Range: 1.75 to 1.75

35. For the circuit shown in the figure, the rising edge triggered D-flip flop with asynchronous reset has a clock frequency of 1 Hz, The NMOS transistor has an ON resistance of 1000 Ω and an OFF resistance of infinity. The nature of the output waveform is



(A)

(B)

(C)

(D)

[Ans. A]

36. A system is represented in state-space as $\dot{x} = Ax + Bu$, where $A = \begin{bmatrix} 1 & 2 \\ \alpha & 6 \end{bmatrix}$ and $B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. The value of $\propto$ for which the system is not controllable is _____.

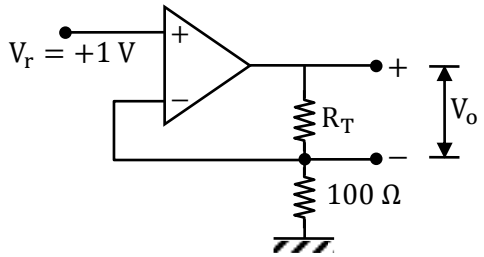
[Ans. *] Range: -3 to -3

37. The signal $x[n] = \sin(\pi n/6)/(\pi n)$ is processed through a linear filter with the impulse response $h[n] = \sin(\omega_c n)/(\pi n)$ where $\omega_c > \pi/6$. The output of the filter is

(A) $\sin(2\omega_c n)/(\pi n)$
(B) $\sin(\pi n)3/(\pi n)$
(C) $[\sin(\pi n/6)/(\pi n)]^2$
(D) $\sin(\pi n/6)/(\pi n)$

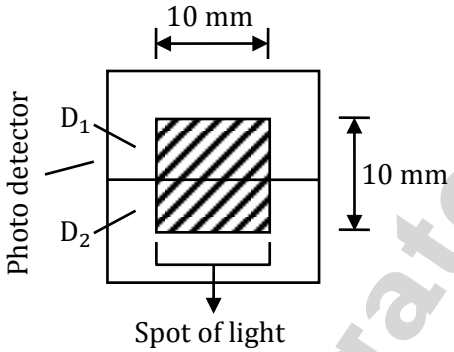
[Ans. D]

38. In the figure shown, R_T represents a resistance temperature device (RTD), whose characteristic is given by $R_T = R_o(1 + \alpha T)$, where $R_o = 100\Omega, \alpha = 0.0039°C^{-1}$ and T denotes the temperature in °C. Assuming the op-amp to be ideal, the value of V_0 in volts when T = 100 °C, is _____ V



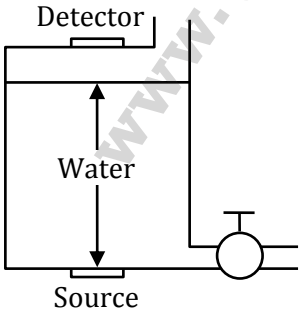
[Ans. *] Range: 1.39 to 1.40

39. The figure shows a spot of light of uniform intensity 50 W/m^2 and size 10 mm × 10 mm incident at the exact center of a photo-detector, comprising two identical photo-diodes D_1 and D_2. Each diode has a sensitivity of 0.4 A/W and is operated in the photoconductive mode. If the spot of light is displaced upwards by 100 μm, the resulting difference between the photocurrents generated by D_1 and D_2 in micro amperes, is _____ μA



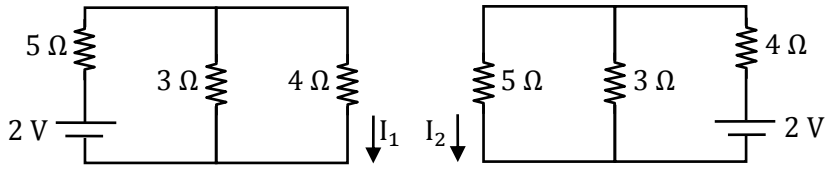
[Ans. *] Range: 40 to 40

40. A liquid level measurement system employing a radio-isotope is mounted on a tank as shown in the figure The absorption coefficient of water for the radiation is 7.7 m^{-1} . If the height of water in the tank is reduced from 100 mm to 90 mm, the percentage change in the radiation intensity received by the detector, neglecting absorption of the radiation by air, is _____ %



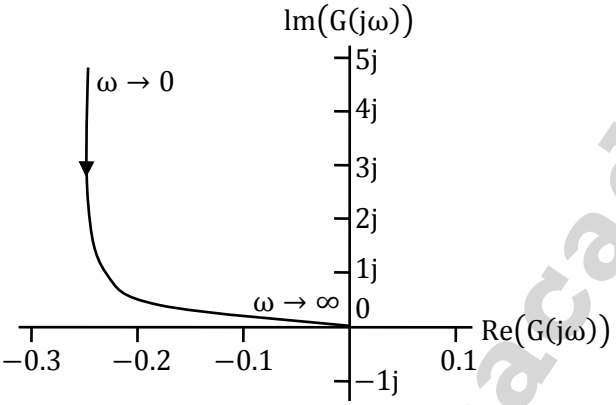
[Ans. *] Range: 8 to 8

41. Consider the circuits shown in the figure. The magnitude of the ratio of the currents, i.e., $|I_1/I_2|$, is _____ .



[Ans. *] Range: 1 to 1

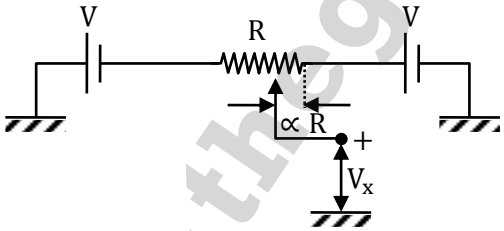
42. A transfer function G(s) with the degree of its numerator polynomial zero and the degree of its denominator polynomial two has a Nyquist plot shown in the figure. The transfer function represents



(A) A stable, type-0 system
(B) A stable, type-1 system
(C) An unstable, type-0 system
(D) An unstable, type-1 system

[Ans. B]

43. In the potentiometer circuit shown in the figure, the expression for V_x is



(A) $(1-2\alpha)V$
(B) $(1-\alpha)V$
(C) $(\alpha-1)V$
(D) αV

[Ans. A]

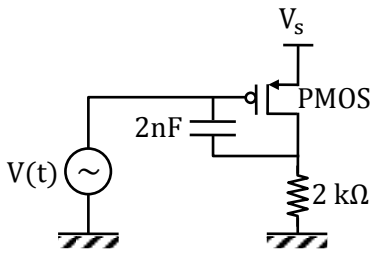
44. The z-transform of $x[n] = \alpha^{|n|}, 0 < |\alpha| < 1$, is X(z). The region of convergence of X(z) is

(A) $|\alpha| < |z| < \frac{1}{|\alpha|}$
(B) $|z| > \alpha$
(C) $|z| > \frac{1}{|\alpha|}$
(D) $|z| < \min\left[|\alpha|, \frac{1}{|\alpha|}\right]$

[Ans. A]

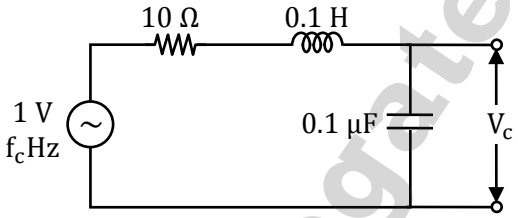
45. The resolving power of a spectrometer consisting of a collimator. a grating and a telescope can be increased, by
(A) increasing the angular magnification of the telescope
(B) increasing the period of the grating
(C) decreasing the period of the grating
(D) decreasing the slit-width of the collimator
[Ans. C]

46. In the circuit shown, the voltage source $V(t) = 15 + 0.1\sin(100t)$ volts. The PMOS transistor is biased such that it is in saturation with its gate-source capacitance being 4 nF and its transconductance at the operating point being 1 mA/V. Other parasitic impedances of the MOSFET may be ignored. An external capacitor of capacitance 2 nF is connected across the PMOS transistor as shown. The input impedance in mega ohm as seen by the voltage source is_____ MΩ



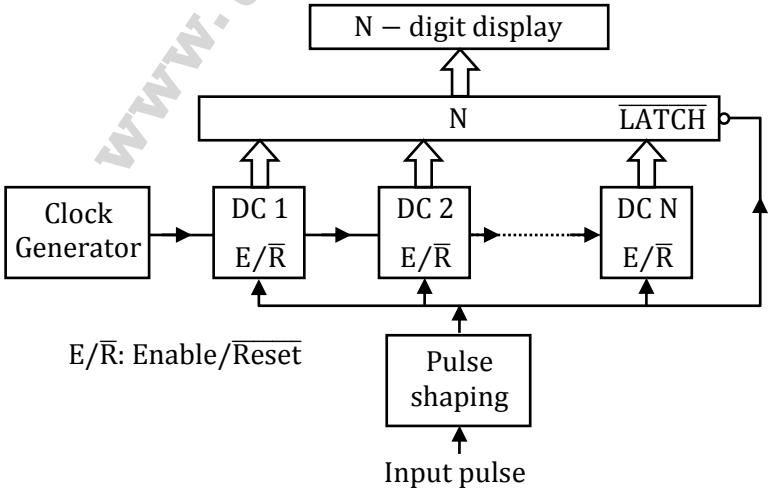
[Ans. *] Range: 0.5 to 0.5

47. The circuit shown in the figure is series resonance at frequency f_cHz. The value of V_c in volts is _____ V.



[Ans. *] Range: 100 to 100

48. The number of clock cycles for the duration of an input puke is counted using a cascade of N decade counters (DC 1 to DC N) as shown in the figure. If the clock frequency in mega-hertz is f, the resolution and range of measurement of input puke width, both in μs. are respectively



(A) $\frac{1}{f}$ and $\frac{(2^N-1)}{f}$

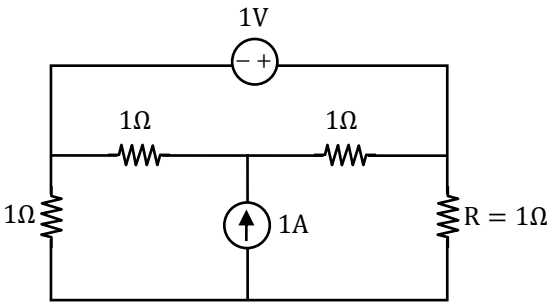
(B) $\frac{1}{f}$ and $\frac{(10^N-1)}{f}$

(C) $\frac{10^N}{f}$ and $\frac{(10^N-1)}{f}$

(D) $\frac{2^N}{f}$ and $\frac{(2^N-1)}{f}$

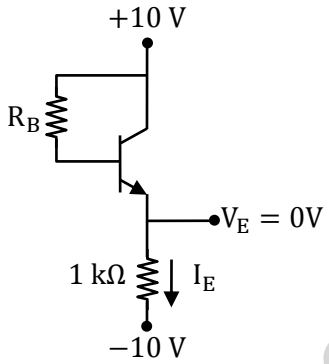
[Ans. B]

49. The current in amperes through the resistor R in the circuit shown in the figure is _____ A



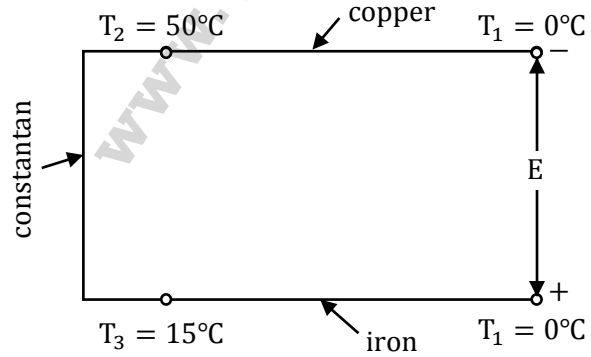
[Ans. *] Range: 1 to 1

50. In the circuit shown in the figure, it is found that $V_{BE} = 0.7$ V and $V_E = 0$ V. If $\beta_{dc} = 99$ for the transistor, then the value of RB in kilo ohms is _____ kΩ



[Ans. *] Range: 93 to 93

51. The Seebeck coefficients in μV/°C, for copper, constantan and iron, with respect to platinum, are 1.9, −38.3 and 13.3, respectively. The magnitude of the thermo emf E developed in the circuit shown in the figure, in millivolts is _____ mV.



[Ans. *] Range: 2.784 to 2.784

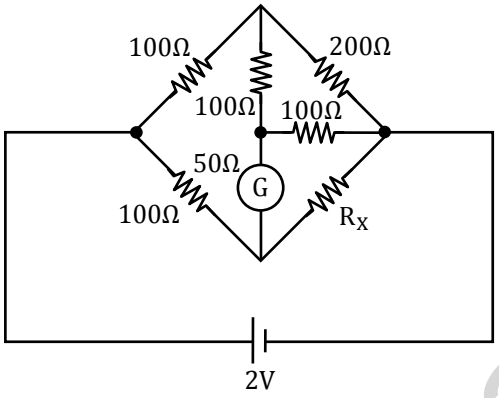
52. The output frequency of an LC tank oscillator employing a capacitive sensor acting as the capacitor of the tank is 100 kHz. If the sensor capacitance increases by 10 %, the output frequency in kilo-hertz becomes _____ kHz

[Ans. *] Range: 95. 2 to 95.4

53. The probability density function of a random variable X is $p_x(x) = e^{-x}$ for $x \geq 0$ and 0 otherwise. The expected value of the function $g_x(x) = e^{3x/4}$ is _____

[Ans. *] Range: 4 to 4

54. If the deflection of the galvanometer in the bridge circuit shown in the figure is zero, then the value of R_x in ohms is _____ Ω



[Ans. *] Range: 33.33 to 33.33

55. The fundamental period of the signal $x(t) = 2\cos\left(\frac{2\pi t}{3}\right) + \cos(\pi t)$, in seconds, is _____ s.

[Ans. *] Range: 6 to 6