ASSIGNMENT 2: GATE 2014 IN: INSTRUMENTATION ENGINEERING

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1) Choose the most appropriate word from the options given below to complete the following sentence.

   A person suffering from Alzheimer's disease _________ short-term memory loss.

   a) experienced
   b) has experienced
   c) is experiencing
   d) experiences

2) Choose the most appropriate word from the options given below to complete the following sentence. _________ is the key to their happiness; they are satisfied with what they have.

   a) Contentment
   b) Ambition
   c) Perseverance
   d) *(Option not provided)*

3) Which of the following options is the closest in meaning to the sentence below?
   "As a woman, I have no country."
   a) Women have no country.
   b) Women are not citizens of any country.
   c) Women's solidarity knows no national boundaries.
   d) Women of all countries have equal legal rights.

4) In any given year, the probability of an earthquake of Magnitude 6 occurring in the Garhwal Himalayas is 0.04. The average time between successive occurrences of such earthquakes is _________ years.

5) The population of a new city is 5 million and is growing at 20% annually. How many years would it take to double at this growth rate?

   a) 3-4 years
   b) 4-5
   c) 5-6 years
   d) 6-7 years

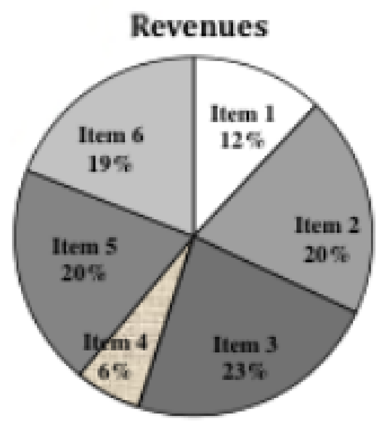
6) In a group of four children, Som is younger to Riaz. Shiv is elder to Ansu. Ansu is youngest in the group. Which of the following statements is/are required to find the eldest child in the group?
   1. Shiv is younger to Riaz.
   2. Shiv is elder to Som.
   a) Statement 1 by itself determines the eldest child.
   b) Statement 2 by itself determines the eldest child.
   c) Statements 1 and 2 are both required to determine the eldest child.
   d) Statements 1 and 2 are not sufficient to determine the eldest child.

7) Moving into a world of big data will require us to change our thinking about the merits of exactitude. To apply the conventional mindset of measurement to the digital, connected world of the twenty-first century is to miss a crucial point. As mentioned earlier, the obsession with exactness is an artefact of the information-deprived analog era. When data was sparse, every data point was critical, and thus

great care was taken to avoid letting any point bias the analysis.
From ”BIG DATA” Viktor Mayer-Schonberger and Kenneth Cukier
The main point of the paragraph is:

a) The twenty-first century is a digital world
b) Big data is obsessed with exactness
c) Exactitude is not critical in dealing with big data
d) Sparse data leads to a bias in the analysis

8) The total exports and revenues from the exports of a country are given in the two pie charts below. The pie chart for exports shows the quantity of each item as a percentage of the total quantity of exports. The pie chart for the revenues shows the percentage of the total revenue generated through export of each item. The total quantity of exports of all the items is 5 lakh tonnes and the total revenues are 250 crore rupees. What is the ratio of the revenue generated through export of Item 1 per kilogram to the revenue generated through export of Item 4 per kilogram?



a) 1:2 b) 2:1 c) 1:4 d) 4:1

9) X is 1 km northeast of Y. Y is 1 km southeast of Z. W is 1 km west of Z. P is 1 km south of W. Q is 1 km east of P. What is the distance between X and Q in km?

a) 1 b) $\sqrt{2}$ c) $\sqrt{3}$ d) 2

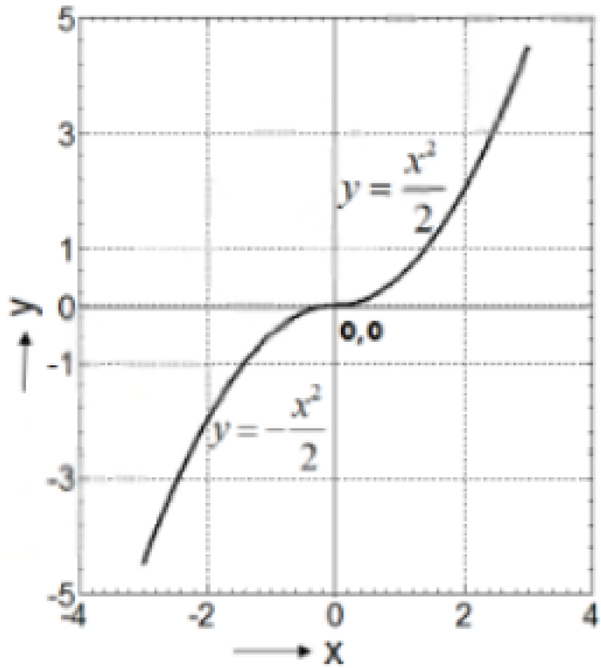
10) 10% of the population in a town is HIV+. A new diagnostic kit for HIV detection is available; this kit correctly identifies HIV+ individuals 95% of the time, and HIV- individuals 89% of the time. A particular patient is tested using this kit and is found to be positive. The probability that the individual is actually positive is __________.

1) Given $x(t) = 3\sin(1000\pi t)$ and $y(t) = 5\cos(1000\pi t + \frac{\pi}{4})$. The x-y plot will be

a) a circle
b) a multi-loop closed curve
c) a hyperbola
d) an ellipse

2) Given that x is a random variable in the range $[0, \infty]$ with a probability density function $\frac{e^{-x/2}}{K}$, the value of the constant K is _________.

3) The figure shows the plot of y as a function of x.

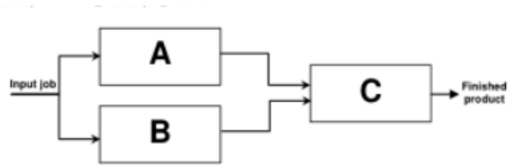


The function shown is the solution of the differential equation (assuming all initial conditions to be zero) is:

a) $\frac{d^2y}{dx^2} = 1$
b) $\frac{dy}{dx} = x$
c) $\frac{dy}{dx} = -x$
d) $\frac{dy}{dx} = |x|$

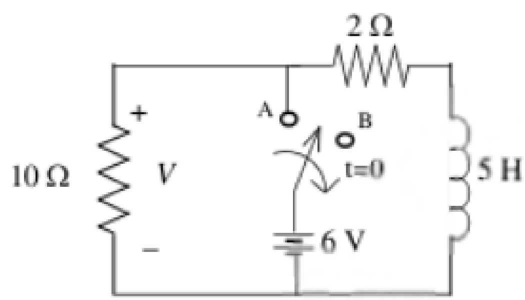
4) A vector is defined as $\mathbf{f} = y\hat{i} + x\hat{j} + z\hat{k}$ where $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors in Cartesian (x,y,z) coordinate system. The surface integral $\oint_S \mathbf{f} \cdot d\mathbf{s}$ over the closed surface S of a cube with vertices having the following coordinates: (0,0,0), (1,0,0), (1,1,0), (0,1,0), (0,0,1), (1,0,1), (1,1,1), (0,1,1) is _________.

5) The figure shows the schematic of a production process with machines A, B and C. An input job needs to be pre-processed either by A or by B before it is fed to C, from which the final finished product comes out. The probabilities of failure of the machines are given as: $P_A = 0.15$, $P_B = 0.05$, $P_C = 0.1$.



Assuming independence of failures of the machines, the probability that a given job is successfully processed (up to the third decimal place) is _________.

6) The circuit shown in figure was at steady state for $t < 0$ with the switch at position 'A'. The switch is thrown to position 'B' at time $t = 0$. The voltage V (volts) across the 10 Ω resistor at time $t = 0^+$ is _________.



7) The average real power in watts delivered to a load impedance $Z_L = (4 - j2)\Omega$ by an ideal current source $i(t) = 4\sin(\omega t + 20°)A$ is _________.

8) Time domain expressions for the voltage $v_1(t)$ and $v_2(t)$ are given as $v_1(t) = V_m \sin(10t - 130°)$ and $v_2(t) = V_m \cos(10t + 10°)$.

a) $v_1(t)$ leads $v_2(t)$ by 130°
b) $v_1(t)$ lags $v_2(t)$ by 130°
c) $v_1(t)$ lags $v_2(t)$ by $-130°$
d) $v_1(t)$ leads $v_2(t)$ by $-130°$

9) A pH electrode obeys Nernst equation and is being operated at 25°C. The change in the open circuit voltage in millivolts across the electrode for a pH change from 6 to 8 is _________.

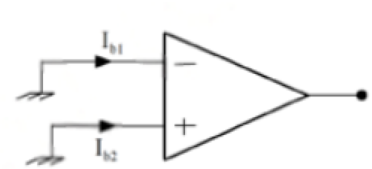
10) The pressure and velocity at the throat of a Venturi tube, measuring the flow of a liquid, are related to the upstream pressure and velocity, respectively, as follows:
a) pressure is lower but velocity is higher
b) pressure is higher but velocity is lower
c) both pressure and velocity are lower
d) pressure and velocity are identical

11) Semiconductor strain gages typically have much higher gage factors than those of metallic strain gages, primarily due to:
a) higher temperature sensitivity
b) higher Poisson's ratio
c) higher piezoresistive coefficient

d) higher magnetostrictive coefficient

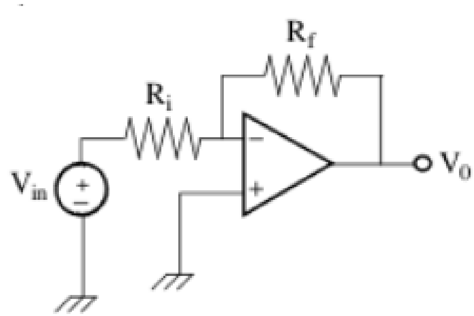
12) For a rotameter, which one of the following statements is TRUE?
   a) the weight of the float is balanced by the buoyancy and the drag force acting on the float
   b) the velocity of the fluid remains constant for all positions of the float
   c) the measurement of volume flow rate of gas is not possible
   d) the volume flow rate is insensitive to changes in density of the fluid

13) For the op-amp shown in the figure, the bias currents are I_{b1} = 450 nA and I_{b2} = 350 nA. The values of the input bias current (I_B) and the input offset current (I_f) are:



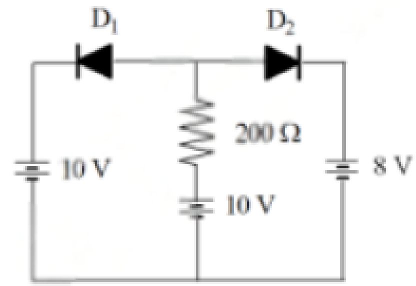
a) I_B = 800 nA, I_f = 50 nA
b) I_B = 800 nA, I_f = 100 nA
c) I_B = 400 nA, I_f = 50 nA
d) I_B = 400 nA, I_f = 100 nA

14) The amplifier in the figure has gain of -10 and input resistance of 50 kΩ. The values of R_i and R_f are:



a) R_i = 500 kΩ, R_f = 50 kΩ
b) R_i = 50 kΩ, R_f = 500 kΩ
c) R_i = 5 kΩ, R_f = 10 kΩ
d) R_i = 50 kΩ, R_f = 200 kΩ

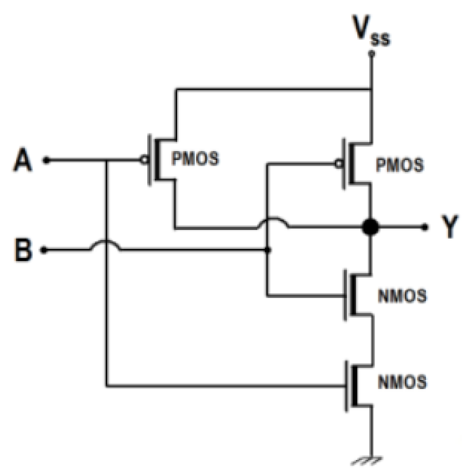
15) For the circuit shown in the figure assume ideal diodes with zero forward resistance and zero forward voltage drop. The current through the diode D_2 in mA is _________.



16) The system function of an LTI system is given by $H(z) = \frac{1-\frac{1}{3}z^{-1}}{1-\frac{1}{4}z^{-1}}$. The above system can have stable inverse if the region of convergence of H(z) is defined as

a) $|z| > \frac{1}{3}$ b) $|z| < \frac{1}{12}$ c) $|z| > \frac{1}{4}$ d) $|z| < \frac{1}{3}$

17) The figure is a logic circuit with inputs A and B and output Y. Vss = +5V. The circuit is of type



a) NOR b) AND c) OR d) NAND

18) The impulse response of an LTI system is given as: $h[n] = \frac{\sin(\omega_c n)}{\pi n}, n \neq 0$; $h[n] = \frac{\omega_c}{\pi}, n = 0$. It represents an ideal

a) non-causal, low-pass filter
b) causal, low-pass filter
c) non-causal, high-pass filter
d) causal, high-pass filter

19) A discrete-time signal $x[n]$ is obtained by sampling aConsider the contron analog signal at 10 kHz. The signal $x[n]$ is filtered by a system with impulse response $h[n] = 0.5\{\delta[n] + \delta[n-1]\}$. The 3dB cutoff frequency of the filter is:

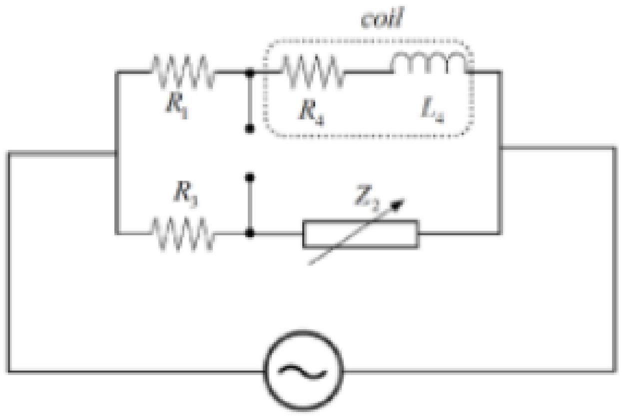
a) 1.25 kHz b) 2.50 kHz c) 4.00 kHz d) 5.00 kHz

20) A full duplex binary FSK transmission is made through a channel of bandwidth 10 kHz. In each direction of transmission the two carriers used for the two states are separated by 2 kHz. The maximum baud rate for this transmission is:

a) 2000 bps   b) 3000 bps   c) 5000 bps   d) 10000 bps

21) A loop transfer function is given by: $G(s)H(s) = \frac{K(s+2)}{s^2(s+10)}$. The point of intersection of the asymptotes of $G(s)H(s)$ on the real axis in the s-plane is at ________.

22) The resistance and inductance of an inductive coil are measured using an AC bridge as shown in the figure. The bridge is to be balanced by varying the impedance Z2. For obtaining balance, Z2 should consist of element(s):



a) R and C
b) R and L
c) L and C
d) Only C

23) A plant has an open-loop transfer function, $G_p(s) = \frac{20}{(s+0.1)(s+2)(s+100)}$. The approximate model obtained by retaining only one of the above poles, which is closest to the frequency response of the original transfer function at low frequency is

a) $\frac{0.1}{s+0.1}$
b) $\frac{2}{s+2}$
c) $\frac{100}{s+100}$
d) $\frac{20}{s+0.1}$

24) In order to remove respiration related motion artifacts from an ECG signal, the following filter should be used:

a) low-pass filter with $f_c = 0.5$ Hz
b) high-pass filter with $f_c = 0.5$ Hz
c) high-pass filter with $f_c = 49.5$ Hz
d) band-pass filter with passband between 0.1 Hz and 0.5 Hz

25) In a time-of-flight mass spectrometer if q is the charge and m the mass of the ionized species, then the time of flight is proportional to

a) $\frac{\sqrt{m}}{\sqrt{q}}$

b) $\frac{\sqrt{q}}{\sqrt{m}}$

c) $\frac{m}{\sqrt{q}}$

d) $\frac{q}{\sqrt{m}}$

26) A scalar valued function is defined as $f(\mathbf{x}) = \mathbf{x}^T A\mathbf{x} + \mathbf{b}^T\mathbf{x}$, where A is a symmetric positive definite matrix with dimension $n \times n$; b and x are vectors of dimension $n \times 1$. The minimum value of $f(\mathbf{x})$ will occur when $\mathbf{x}$ equals

a) $(A^T A)^{-1}b$
b) $-(A^T A)^{-1}b$
c) $-\frac{1}{2}A^{-1}b$
d) $\frac{1}{2}A^{-1}b$

27) The iteration step in order to solve for the cube roots of a given number N using the Newton Raphson's method

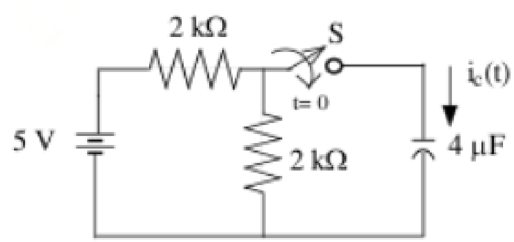
a) $x_{k+1} = x_k + \frac{1}{3}(x_k^3 - N)$
b) $x_{k+1} = \frac{1}{2}\left(x_k + \frac{N}{x_k^2}\right)$
c) $x_{k+1} = x_k - \frac{1}{3}(x_k^3 - N)$
d) $x_{k+1} = \frac{1}{2}\left(x_k - \frac{N}{x_k^2}\right)$

28) For the matrix A satisfying the equation given below, the eigenvalues are

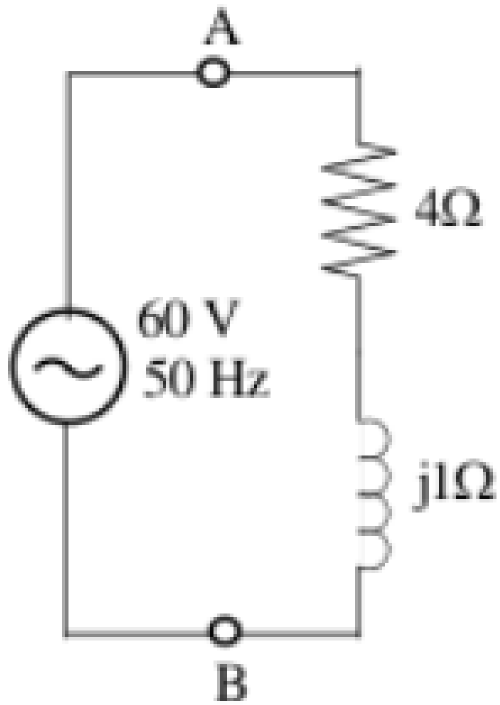
$$\left(A\right)\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

a) (1, j, -j)
b) (1, 1, 0)
c) (1, 1, -1)
d) (1, 0, 0)

29) In the circuit shown in the figure, initially the capacitor is uncharged. The switch 'S' is closed at $t = 0$. Two milliseconds after the switch is closed, the current through the capacitor (in mA) is _________.

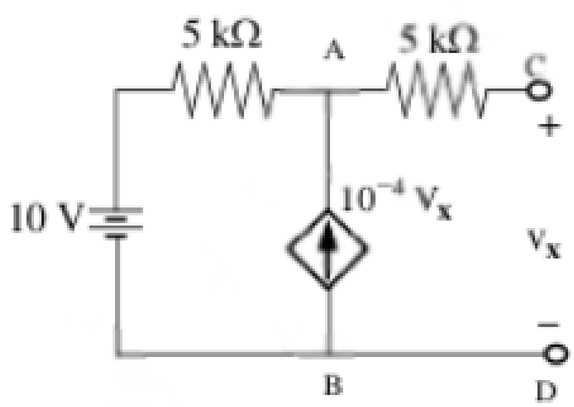


30) A capacitor 'C' is to be connected across the terminals 'A' and 'B' as shown in the figure so that the power factor of the parallel combination becomes unity. The value of the capacitance required in μF is _________.



31) The resistance of a wire is given by the expression $R = \frac{4\rho L}{\pi D^2}$, where, ρ is the resistivity (Ω-meter), L is the length (meter) and D (meter) is the diameter of the wire. The error in measurement of each of the parameters ρ, L, and D is ±1.0%. Assuming that the errors are independent random variables, the percent error in measurement of R is _________.

32) The circuit shown in the figure contains a dependent current source between A and B terminals. The Thevenin's equivalent resistance in kΩ between the terminals C and D is _________.



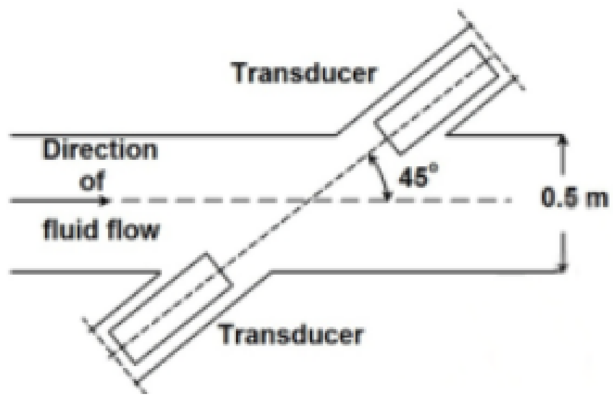
33) A thermistor has a resistance of 1 kΩ at temperature 298 K and 465 Ω at temperature 316 K. The temperature sensitivity in K^{-1} [i.e. $(1/R)(dR/dT)$, where R is the resistance at the temperature T (in K)], of this thermistor at 316 K is _________.

34) A barium titanate piezoelectric crystal with d_{33} = 150 pC/N, $C_{crystal}$ = 25 pF and $R_{crystal}$ = 10^{10}Ω is used to measure the amplitude of a step force. The voltage output is measured using a digital voltmeter

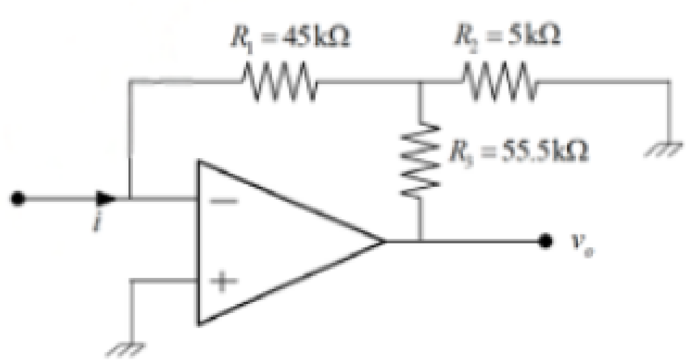
with input impedance $10^{13}\Omega$ connected across the crystal. All other capacitances and resistances may be neglected. A step force of 2 N is applied from direction "3" on the crystal. The time in milliseconds within which the voltmeter should sample the crystal output voltage so that the drop from the peak value is no more than 0.12V is _________.

35) A thermopile is constructed using 10 junctions of Chromel-Constantan (sensitivity $60\mu V/°C$ for each junction) connected in series. The output is fed to an amplifier having an infinite input impedance and a gain of 10. The output from the amplifier is acquired using a 10-bit ADC, with reference voltage of 5 V. The resolution of this system in units of $°C$ is _________.

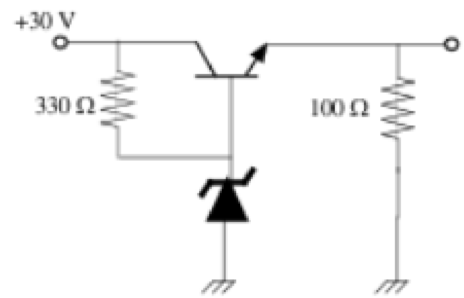
36) A transit time ultrasonic flowmeter uses a pair of ultrasonic transducers placed at 45° angle, as shown in the figure. The inner diameter of the pipe is 0.5 m. The differential transit time is directly measured using a clock of frequency 5 MHz. The velocity of the fluid is small compared to the velocity of sound in the static fluid, which is 1500 m/s and the size of the crystals is negligible compared to the diameter of the pipe. The minimum change in fluid velocity (m/s) that can be measured using this system is _________.



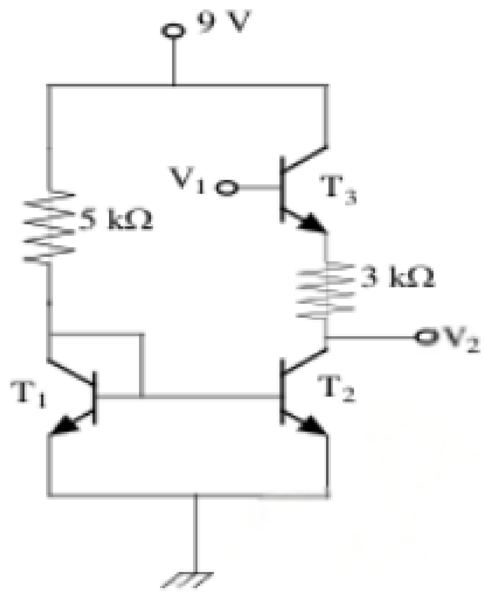
37) Assuming an ideal op-amp in linear range of operation, the magnitude of the transfer impedance $\frac{v_0}{i}$ in MΩ of the current to voltage converter shown in the figure is _________.



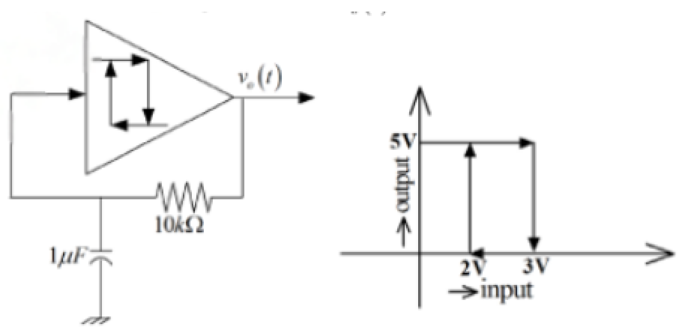
38) For the circuit shown in the figure, the transistor has $\beta = 40$, $V_{BE} = 0.7$ V, and the voltage across the Zener diode is 15 V. The current (in mA) through the Zener diode is _________.



39) In the figure, transistors T1 and T2 have identical characteristics. $V_{CE(sat)}$ of transistor T3 is 0.1 V. The voltage V_1 is high enough to put T3 in saturation. Voltage V_{BE} of transistors T1, T2 and T3 is 0.7 V. The value of $(V_1 - V_2)$ in V is _________.



40) The figures show an oscillator circuit having an ideal Schmitt trigger and its input-output characteristics. The time period (in ms) of $v_o(t)$ is _________.



41) An N-bit ADC has an analog reference voltage V. Assuming zero mean and uniform distribution of the quantization error, the quantization noise power will be:

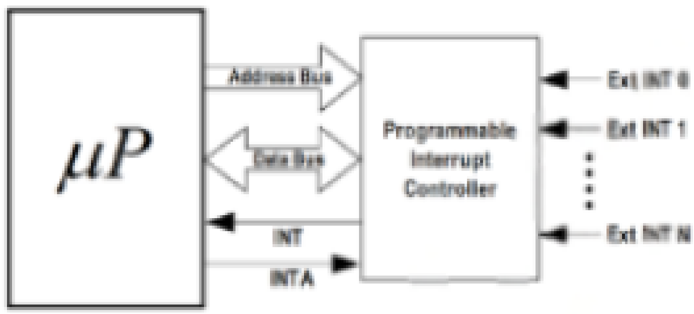
a) $\frac{V^2}{12(2^N-1)^2}$

b) $\frac{V^2}{12(2^N-1)}$

c) $\frac{V}{12(2^N-1)}$

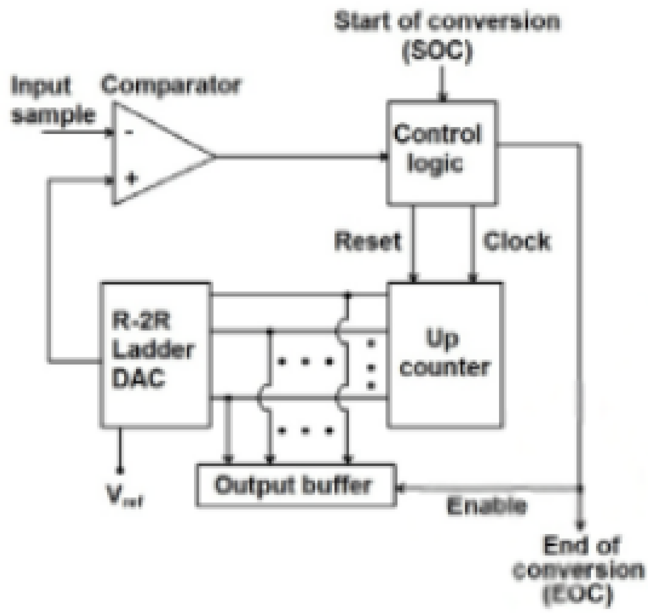
d) $\frac{V^2}{\sqrt{12}}$

42) A microprocessor accepts external interrupts (Ext INT) through a Programmable Interrupt Controller as shown in the figure. Assuming vectored interrupt, a correct sequence of operations when a single external interrupt (Ext INT1) is received will be:



a) Ext INT1 → INTA → Data Read → INT
b) Ext INT1 → INT → INTA → Data Read
c) Ext INT1 → INT → INTA → Address Write
d) Ext INT1 → INT → Data Read → Address Write

43) The circuit in the figure represents a counter-based unipolar ADC. When SOC is asserted the counter is reset and clock is enabled so that the counter counts up and the DAC output grows. When the DAC output exceeds the input sample value, the comparator switches from logic 0 to logic 1, disabling the clock and enabling the output buffer by asserting EOC. Assuming all components to be ideal, V_{ref}, DAC output and input to be positive, the maximum error in conversion of the analog sample value is:



a) directly proportional to V_{ref}
b) inversely proportional to V_{ref}
c) independent of V_{ref}
d) directly proportional to clock frequency

44) $X(k)$ is the Discrete Fourier Transform of a 6-point real sequence $x(n)$. If $X(0) = 9 + j0, X(2) = 2 + j2, X(3) = 3 - j0, X(5) = 1 - j1$, then $x(0)$ is

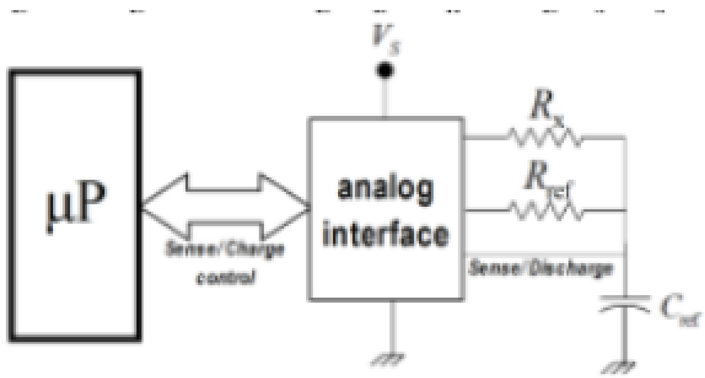
a) 3 b) 9 c) 15 d) 18

45) The transfer function of a digital system is given by: $H(z) = \frac{b_0}{1 - az^{-1} + 2z^{-2}}$; where a is real. The transfer function is BIBO stable if the value of a is:

a) -1.5 b) -0.75 c) 0.5 d) 1.5

46) The transfer function of a system is given by $G(s) = \frac{e^{-s/500}}{s+500}$. The input to the system is $x(t) = \sin(100\pi t)$. In periodic steady state the output of the system is found to be $y(t) = A\sin(100\pi t - \phi)$. The phase angle ($\phi$) in degree is __________.

47) In the microprocessor controlled measurement scheme shown in the figure, R_x is the unknown resistance to be measured, while R_{ref} and C_{ref} are known. C_{ref} is charged from voltage V_L to V_H (by a constant DC voltage source V_S), once through R_{ref} in T_{ref} seconds and then discharged to V_L. It is again charged from voltage V_L to V_H through R_x in T_x seconds. If $T_x = kT_{ref}$ then



a) $R_x = kR_{ref}(1 - \frac{V_L}{V_H})$
b) $R_x = kR_{ref}\ln(\frac{V_H}{V_L})$
c) $R_x = kR_{ref}$
d) $R_x = \ln(k)R_{ref}$

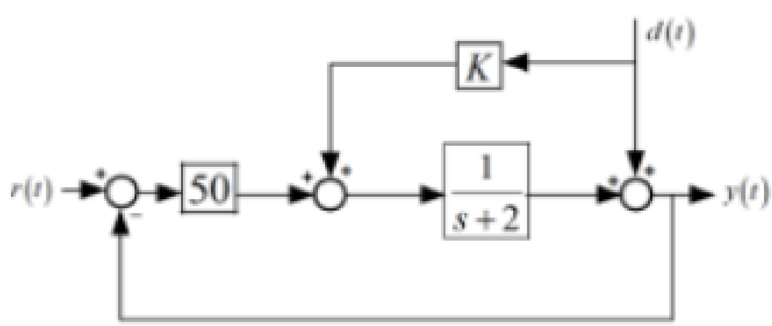
48) Frequency of an analog periodic signal in the range of 5kHz - 10kHz is to be measured with a resolution of 100Hz by measuring its period with a counter. Assuming negligible signal and transition delays the minimum clock frequency and minimum number of bits in the counter needed, respectively, are:

a) 1 MHz, 10-bits
b) 10 MHz, 10-bits
c) 1 MHz, 8-bits
d) 10MHz, 8-bits

49) The loop transfer function of a feedback control system is given by $G(s)H(s) = \frac{1}{s(s+1)(s+9)}$. Its phase crossover frequency (in rad/s), approximated to two decimal places, is __________.

50) Consider a transport lag process with a transfer function $G_p(s) = e^{-s}$. The process is controlled by a purely integral controller with transfer function $G_c(s) = \frac{K_i}{s}$ in a unity feedback configuration. The value of K_i for which the closed loop plant has a pole at $s = -1$, is __________.

51) Consider the control system shown in figure with feedforward action for rejection of a measurable disturbance $d(t)$. The value of K, for which the disturbance response at the output $y(t)$ is zero mean, is:



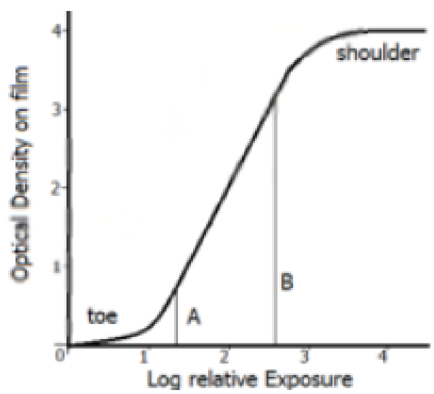
a) 1
b) -1
c) 2
d) -2

52) A mixture contains two mutually inert solutions 'X' and 'Y' in equal volumes. The mixture is examined in a spectrophotometer using a cuvette. It is observed that the transmittance is 0.40. With

only the solution 'X' in the same cuvette, the transmittance is 0.20. With only solution 'Y' in the cuvette the transmittance is _________.

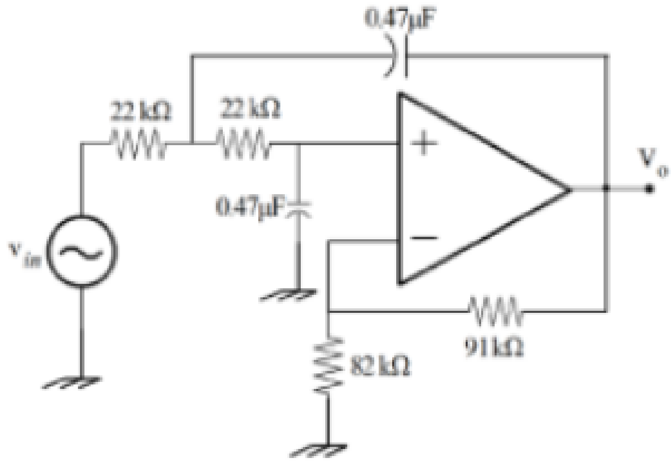
53) Monochromatic light from a step index ($n_1 = 1.500; n_2 = 1.485$), multimode optical fiber of core diameter 100 μm is incident through air (n = 1.000) onto a linear photo-detector array placed at 1 mm distance from the tip of the fiber. The tip of the fiber is polished and its exit plane is perpendicular to the axis of the fiber. The detector array is oriented parallel to the exit plane of the tip. The array consists of photo-detector elements each of 5 μm diameter. The distance between the edges of two adjacent elements can be assumed to be zero. The number of elements illuminated by the light coming out of the fiber is _________.

54) An image of the chest of a patient is taken with an X-ray machine on a photographic film. The Hurter-Driffield (HD) curve of the film is shown in the figure. The highly absorbing parts of the body (e.g. bones), show up as low exposure regions (mapped near A) and the less absorbing parts (e.g. muscles) show up as high exposure regions (mapped near B).



If the exposure time is increased 10 times, while keeping the voltages and currents in the X-ray machine constant, in the image,

a) contrast decreases since B moves into the shoulder region
b) contrast decreases since both A and B move into the shoulder region
c) contrast increases since A moves into the toe region
d) contrast decreases since both A and B move into the toe region



55) For the given low-pass circuit shown in the figure, the cutoff frequency in Hz will be _________.