Q.1-5 Carry One Mark Each

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

Answer: D

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) Hunger

Answer: A

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.

Answer: C

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

Answer: 25 years.

Exp:

$$P = 0.04 = \frac{4}{100}$$

For 1 earth quake

$$\frac{100}{4} P = 1 \text{ earth quake}$$

25 years

} Reverse probability

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 years (C) 5-6 years (D) 6-7 years

Answer: A

Exp: $= \frac{20}{140} \times 8$

After 1 year =P = 6

2 years = 7.2

$\text{After } 3 = \frac{20}{100} \times 1.2 = 8.65$

$\text{After 4 years} = \frac{20}{100} \times 8.65 \approx 10$

Time will be in between 3−4 years.

Q. 6 – 10 Carry Two Marks Each.

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?

Statements: 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.

Answer: A

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

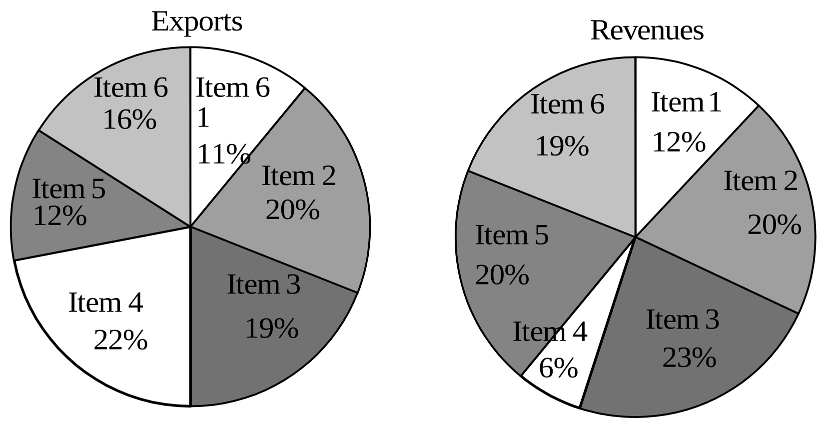
(C) Exactitude is not critical in dealing with big data

(D) Sparse data leads to a bias in the analysis

Answer: C

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

Answer: D

Exp:

revenue glurted through export of item 1 Kg

$$\Rightarrow \frac{\text{Item}}{\text{quantity}} = \frac{11}{100}\times 5 = \frac{11}{20}(\text{lakhs tows})$$

$$\left.\begin{matrix}\text{revenue, gen}\\ \text{Item}\end{matrix}\right\} \frac{12}{100}\times 6\times 250\times(\text{C}) = \frac{30\text{cr}}{11}\times 20 \qquad \ldots (1)$$

$$\text{Revenue gen Item } 4 = \frac{6}{100}\times 250.(\text{C})$$

$$= \frac{15\text{ cr}}{22}\times 20\text{ Lt.} \qquad \ldots (2)$$

1 : 2

$$\frac{30}{11}\times\frac{20\times 22}{15\times 20} = 4:1$$

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

Answer: C

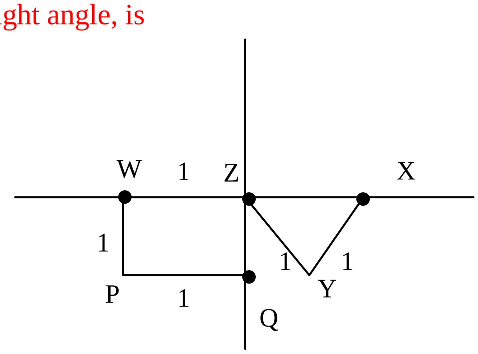
Exp: From the fig: $zx = \sqrt{2}$. [Pythagoras theorem zQ = 1 Given

$\Rightarrow$ Considering ZQX, which is right angle, is

$$\Rightarrow Qx^2 = ZQ^2 + Zx^2$$

$$= \sqrt{1+2}$$

$$= \sqrt{3}$$



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 _________.

Answer: 0.48 to 0.49

Exp: Let total population = 100

HIV + patients = 10

For the patient to be +Ve, should be either +VE and test is showing the or the patient should be – Ve but rest is showing +Ve

$$\Rightarrow \frac{0.1\times0.95}{0.1\times0.95+0.9\times0.11} = 0.489$$

Q.1 – 25 Carry One Mark Each.

1. Given

$$x(t)=3\sin(1000\pi t)\text{ and } y(t)=5\cos\left(1000\pi t+\frac{\pi}{4}\right)$$

The x-y plot will be

(A) a circle (B) a multi-loop closed curve

(C) a hyperbola (D) an ellipse

Answer: D

Exp: $\phi=\pi/4 \Rightarrow$ An ellipse will occur in x – y plot

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

Answer: 2

Exp: $\int_0^\infty \frac{e^{-x/2}}{K} = 1$

$$\Rightarrow \frac{1}{K}\left.\frac{e^{-x/2}}{(-1/2)}\right|_0^\infty = 1$$

$$\Rightarrow \frac{-2}{K}(0-1)=1 \Rightarrow \frac{2}{K}=1 \Rightarrow K=2$$

(OR)

. Probability density function must satisfy

$$\int_0^\infty f_x(x)dx=1\ [\text{since x is ranging from 0 to } \infty]$$

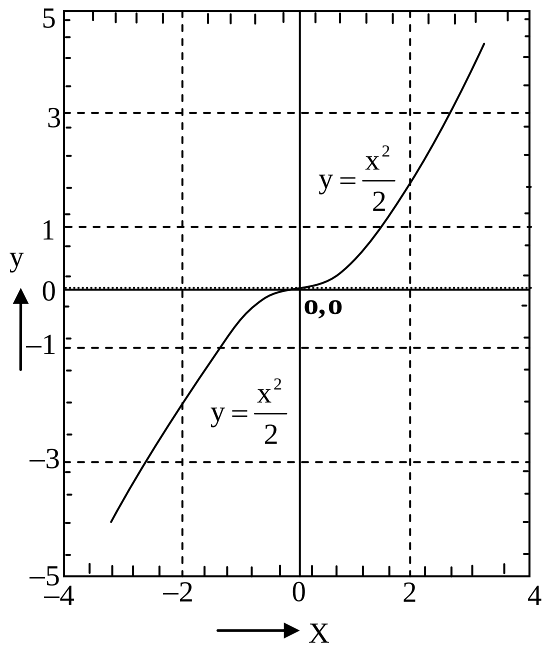
$$\Rightarrow \frac{1}{k}\int_0^\infty e^{-x/2}dx=1$$

$$\Rightarrow \phi\frac{2}{k}\left[e^{-x/2}\right]_0^\infty=1$$

$$\Rightarrow \frac{2}{k}=1$$

$$\Rightarrow k=2$$

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) $\frac{dy}{dx}=|x|$

Answer: D

Exp: By back tracking, from option (D)

$$\frac{dy}{dx} = |x| = x \text{ for } x \geq 0$$

$$= -x \text{ for } x<0$$

Integrating

$$\Rightarrow \int \frac{dy}{dx} = \int x\, dx \text{ for } x \geq 0 = \int -x\, dx \text{ for } x<0$$

$$\Rightarrow y = \frac{x^2}{2} \text{ for } x \geq 0 \qquad = \frac{-x^2}{2} \text{ for } x<0$$

4. A vector is defined as $f = y\hat{i} + x\hat{j} + z\hat{k}$

where $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors in Cartesian (x, y, z) coordinate system.

The surface integral $\oiint \mathbf{f}.\, \mathbf{d}s$ 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 __________.

Answer: 1

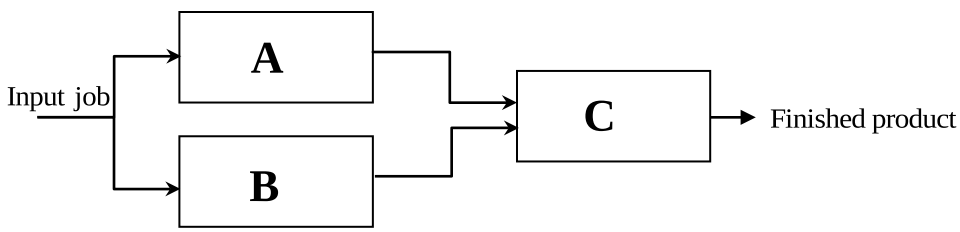
Exp: From Gauss divergence theorem, we have

$$\int_s \bar{f}.d\bar{s} = \int_v \text{div}\,\bar{f}\; dv = \int_v \nabla.\bar{f}\; dv = \int_v \left(\frac{\partial f_1}{\partial x} + \frac{\partial f_2}{\partial y} + \frac{\partial f_3}{\partial z}\right) dxdydz$$

$$= \int_{x=0}^{1}\int_{y=0}^{1}\int_{z=0}^{1} (0+0+1)\; dxdydz = 1$$

$$\left[\begin{array}{l} \because \bar{f} = y\hat{i} + x\hat{j} + z\hat{k} \\ \Rightarrow f_1 = y_1,\ f_2 = x,\ f_3 = z \end{array}\right]$$

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 ___________.

Answer: 0.890 to 0.899

Exp: Let X, Y, Z be respectively that machines A, B, C success (works) then

$P(x) = 0.85, P(y) = 0.95, P(z) = 0.9$

$\therefore$ P[Job to be completed successful] = P[(machines A or machine B success) and (machine C success)]

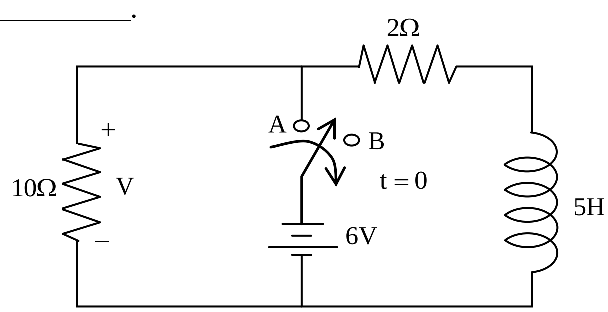
$$= P((X \cup Y) \cap Z)$$

$$= P(X \cap Z) + P(Y \cap Z) - P(X \cap Y \cap Z)$$

$$= (0.85)(0.9) + (0.95)(0.9) - (0.85)(0.95)(0.9)$$

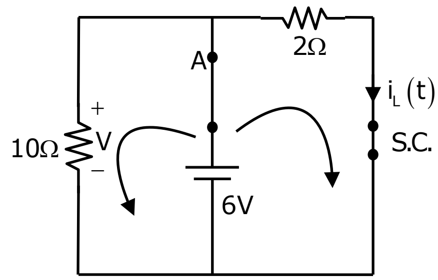
$$= 0.89325 \simeq 0.893$$

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 10Ω resistor at time $t = 0^+$ is ___________.



Answer: -30

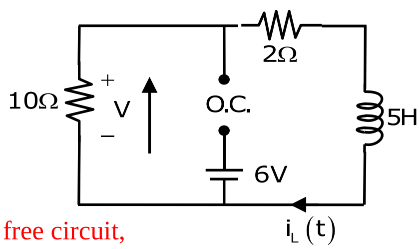
Exp: At t < 0, switch is at position "A" and it was at steady state.



Steady state inductor behaves like short circuit

$i_L(\theta) = \frac{6}{2} \Rightarrow 3A \;\; i_L(0^+) = i_L(0^-) = 3A$

At $t = 0^+$



In a source free circuit,

$i_L(t) = I_0.e^{-t/\tau}$

$i_L(t) = 3.e^{-t/\tau} \quad \text{where } \tau = \frac{L}{R} = \frac{5}{12}$

$i_L(t) = 3.e^{-12t/5}$

$v(t) = 10\left[-3e^{-12t/5}\right]$

$v(t) = -30e^{-12t/5} \Rightarrow \text{At } t = 0^+; V = -30\,\text{Volts}$

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

Answer: 32

Exp:

Given $Z_L = (4 - j2)\Omega$

Current source $i(t) = 4\sin(\omega t + 20^o)A$

The average real power $P = I_{rms}{}^2.R$ Watts

$P = \left[\frac{4}{\sqrt{2}}\right]^2 .4 = 32\,\text{Watts}$

8. Time domain expressions for the voltage $v_1(t)$ and $v_2(t)$ are given as

$v_1(t) = V_m \sin(10t - 130^o)$ and $v_2(t) = V_m \cos(10t + 10^o)$

Which one of the following statements is TRUE?

(A) $v_1(t)$ lead $v_2(t)$ by 130^o (B) $v_1(t)$ lags $v_2(t)$ by 130^o

(C) $v_1(t)$ lags $v_2(t)$ by -130^o (D) $v_1(t)$ leads $v_2(t)$ by -130^o

Answer: A

Exp:

$$\text{Given } v_1(t) = v_m \sin(10t - 130^o)$$

$$v_2(t) = v_m \cos(10t + 10^o) - v_2$$

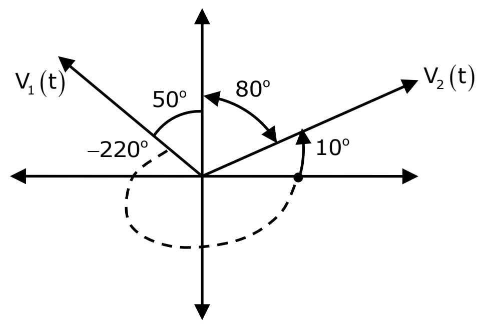
$$v_1(t) = v_m \cos(10t - 130^o - 90^o)$$

$$v_1(t) = v_m \cos(10t - 220^o) - v_1$$

$\phi \to +\text{ve in A.C.W}$

$\phi \to -\text{ve in C.W.}$

$v_1(t)$ leads $v_2(t)$ by 130^o.



9. A pHelectrode 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 ___________.

Answer: 118

Exp: The potential (E) of the PH electrode may be written by means of Nernst equation as

$$E = E_0 - \frac{2.3036RT}{F}(\Delta pH)$$

We have to find change in open ckt voltage across the electrode (i.e) $(E_0 - E)$

$$\text{So, } E_0 - E = \frac{2.3036.R.T}{F}(\Delta pH)$$

Where R=gas constant =8.31 $\frac{\text{volt} - \text{columb}}{\text{mol} - k}$

F=96500 coulombs mol^{-1}

$$E_0 - E = \frac{2.3036 \times 8.31 \times 298}{96500}(8-6) \simeq 118mV$$

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

Answer: A

Exp: The convergent entrance of venture-tube is called as “upstream”. As pipe becomes narrow towards throat, a gradual decrease in cross-sectional area of the conduct causes higher fluid velocity according to continuity equation). Due to this, pressure drops.

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 piezoresitive coefficient

(D) higher magnetostrictive coefficient

Answer: C

Exp: The resistance of the semiconductors changes with change in applied strain, due to change in resistivity. While the resistance of metallic gauges changes with change in dimensions. Hence semiconductor strain gauge depend on piezoresistive effect for their action.

Piezoresistive coefficient is a measure of change in the value of resistance by straining the gauge.

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

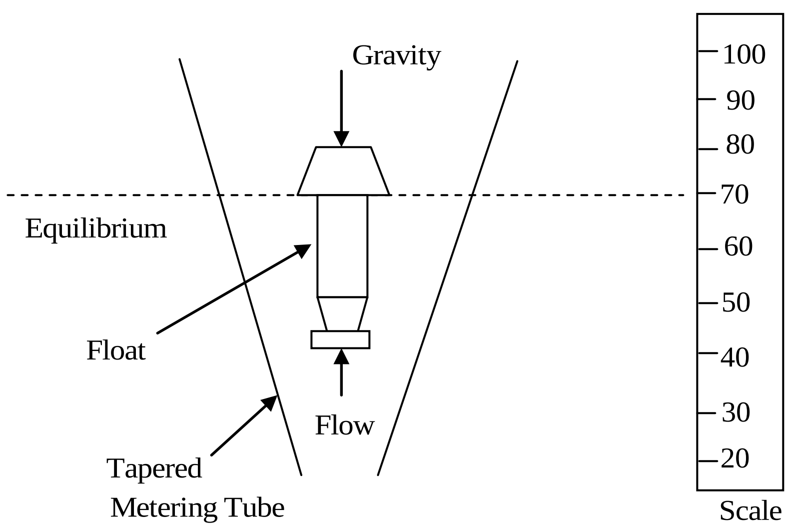
(B) the velocity of the fluid remains constant for all positions of the float

(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

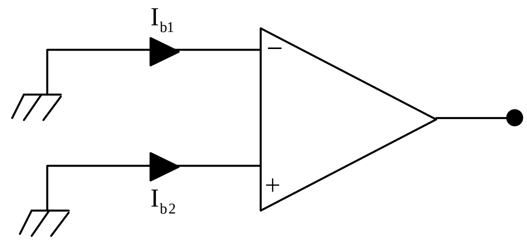
Answer: A

Exp: Rotameters or variable area flow meters, operate on the principle that the variation in area, of flow stream required to produce a constant pressure differential, is proportional to flow rate.



The flowing fluid enters the bottom of the meter, passes upward through a tapered metering tube, and around a float, exiting at the top. The float is forced upward until the force is balanced by gravitational force and drag force on float acting downwards.

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:



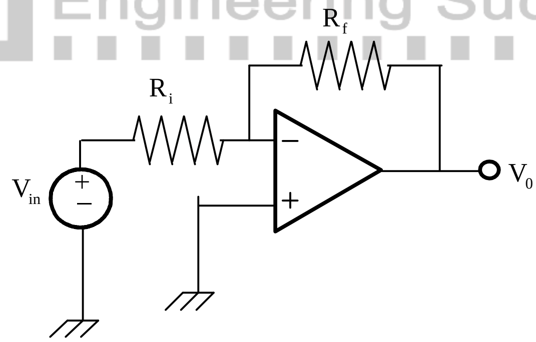
(A) I_B= 800 nA, I_f=50 nA
(B) I_B= 800 nA, I_f=100nA
(C) I_B= 400 nA, I_f=50nA
(D) I_B= 400 nA, I_f=100nA

Answer: D

Exp: $$\text{Input bias current} = \frac{|I_{b_1}| + |I_{b_2}|}{2} = \frac{450\text{nA} + 350\text{nA}}{2} = 400\,\text{nA}$$

$$\text{Input offset current} = |I_{b_1} - I_{b_2}| = 450\text{nA} - 350\text{nA} = 100\,\text{nA}$$

14. The amplifier in the figure has gain of −10 and input resistance of 50 kΩ. The values of Ri and



(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

Answer: B

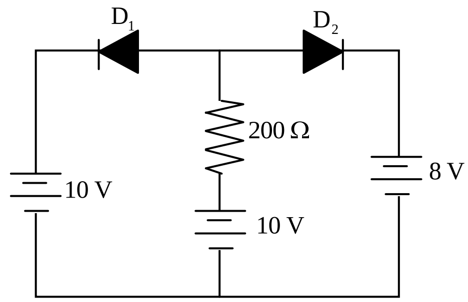
Exp:

$$\text{Gain} = \frac{-R_f}{R_i} = -10 \Rightarrow R_f = 10R_i$$

$$\text{Input impedance} = R_i = 50\text{k}\Omega$$

$$\therefore R_f = 500\,\text{k}\Omega$$

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_________.



Answer: 10

Exp: D_1 – OFF and D_2 – ON

$$\therefore I_{D_2} = \frac{10-8}{200} = 10\,mA$$

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

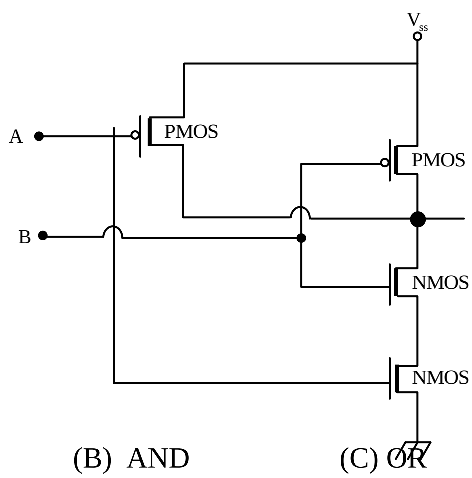
(A) $|Z| < \frac{1}{4}$ (B) $|z| < \frac{1}{12}$ (C) $|Z| > \frac{1}{4}$ (D) $|Z| < \frac{1}{3}$

Answer: C

Exp: If poles lie inside the unit circle then it will be stable only if R_{OC} include unit circle or R_{OC} is extension of circle whose radius is given by outer most pole.

In this case $|z| > \frac{1}{4}$ R_{oc} will give stable system.

17. The figure is a logic circuit with inputs A and B and output Y.V_{ss} = + 5 V. The circuit is of type



(A) NOR (B) AND (C) OR (D) NAND

Answer: D

Exp: Given circuit is cmos implementation of digital function. Cmos containing two type of transistant network, generally upper network containing pmos and lower network containing Nmos.

Irrespective of detail operation of any individual network or transistors, by inspection we can find out the output expression.

If the Nmos transistors are connected in series, then take the products of their inputs with overall complement, OR if the pmos transistor are connected in parallel, then take the products of their inputs with overall complement

So, $Y = \overline{A \,.\, B}$ and this is the Boolean expression

Q18. The impulses response of an LTI system is given as:

$$= \begin{cases} \dfrac{\omega_c}{\pi} & n = 0 \\ \dfrac{\sin \omega_c n}{\pi n} & n \neq 0 \end{cases}$$

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

Answer: A

Exp: It is non-causal, since $h[n] \neq 0$ for $h < 0$.

It is an low-pass filter

19. A discrete-time signal $x[n]$ is obtained by sampling an 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

Answer: B

Exp: Given $h[n] = 0.5\left[f(n) + f[n-1]\right]$

$$\Rightarrow H\left(e^{j\Omega}\right) = 0.5\left[1 + e^{-j\Omega}\right] = \frac{1}{2}\left[1 + \cos\Omega + j\sin\Omega\right]$$

$$\left|H\left(e^{j\Omega}\right)\right| = \frac{1}{2}\sqrt{(1+\cos\Omega)^2 + \sin^2\Omega} = \frac{1}{2}\sqrt{1 + \cos^2\Omega + 2\cos\Omega + \sin^2\Omega}$$

$$= \frac{1}{2}\sqrt{2 + 2\cos\Omega} = \cos\left(\Omega/2\right)$$

$$\text{3dB cut off} = \frac{1}{\sqrt{2}}\left|H\left(e^{j\Omega}\right)\right| = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \cos\frac{\Omega}{2} = \frac{1}{\sqrt{2}} \Rightarrow \frac{\Omega}{2} = \frac{\pi}{4} \text{ or } \Omega = \frac{\pi}{2}$$

$$2\pi \text{ rad / sample} \rightarrow 10\,\text{KHz}$$

$$\frac{\pi}{2}\text{rad / sample} \rightarrow \frac{10}{2\pi} \times \frac{\pi}{2} = 2.5\,\text{KHz}$$

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

Answer: B

Exp: Because the transmission is full duplex,only 5000(5KHz) allocated for each direction.

B.W=Baud rate + f_2 - f_1

given $f_2 - f_1$ =2K=2000

Baud rate = B.W- $(f_2 - f_1)$ = 5000- 2000

Baud rate=3000 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 __________.

Answer: -4

Exp: The point of intersection of the asymptotes is nothing but a centroid.

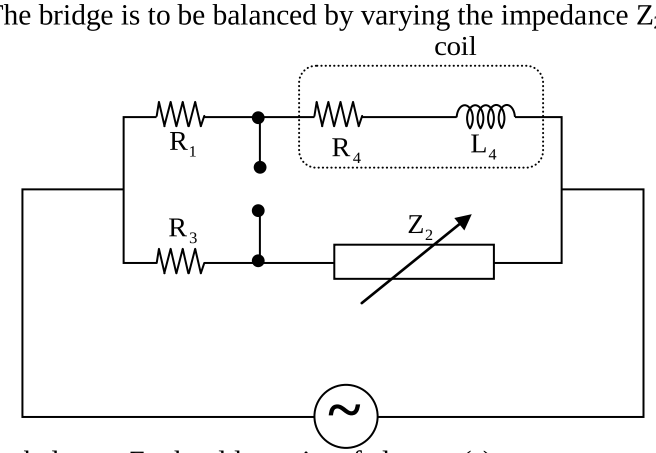
$$\text{Centroid, } \sigma = \frac{\sum \text{real part of poles} - \sum \text{real part of zeros}}{(P-Z)}$$

$$\text{Given, } G(s)H(s) = \frac{K(s+2)}{s^2(s+10)}$$

$$P = 3; Z = 1 \Rightarrow (P-Z) = 2$$

$$\sigma = \frac{[-10+0+0]-[-2]}{2} = \frac{-8}{2} = -4$$

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 Z_2.



For obtaining balance, Z_2 should consist of element(s):

(A) R and C (B) R and L (C) L and C (D) Only C

Answer: B

Exp: At Balanced condition,

$$Z_1Z_2 = Z_3Z_4$$

$$R_1.Z_2 = R_3\left[R_4 + j\omega L_4\right]$$

$$Z_2 = \frac{R_3}{R_1}\left[R_4 + j\omega L_4\right]$$

$\therefore Z_2$ should be combination of R and L.

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) $\frac{20}{s+0.1}$

Answer: A

Exp:

$$\text{Given } G(s) = \frac{20}{(s+0.1)(s+2)(s+100)}$$

$$= \frac{20}{(0.1)(2)(100)\left(1+\frac{s}{0.1}\right)\left(1+\frac{s}{2}\right)\left(1+\frac{s}{100}\right)}$$

$$G(s) = \frac{1}{\left(1+\frac{s}{0.1}\right)\left(1+\frac{s}{2}\right)\left(1+\frac{s}{100}\right)}$$

Approximate model at low frequency

$$\text{then } G(s) = \frac{1}{\left(1+\frac{s}{0.1}\right)}$$

$$\Rightarrow \boxed{G(s) = \frac{0.1}{(s+0.1)}}$$

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 pass band between 0.1 Hz and 0.5 Hz

Answer: B

Exp: The useful bandwidth of an ECG signal range from 0.5 Hz to 50 Hz. A standard ECG application has a bandwidth of 0.05Hz to 100Hz. Respiration related motion artifacts are often denoted as low-frequency noise in the skin-electrode interface. So, it can be removed by a HPF with $f_c = 0.5$ Hz.

25. In a time-of-flight mass spectrometer if q is the charge and m is 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) $\frac{q}{\sqrt{m}}$

Answer: A

Exp: $t = \frac{d}{\sqrt{2V}}\sqrt{\frac{m}{q}}$

$t \propto \sqrt{\frac{m}{q}}$ Hence (A)

Q. 26 – 55 Carry Two Marks Each

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

(A) $(A^TA)^{-1}b$ (B) $-(A^TA)^{-1}b$ (C) $-\left(\frac{A^{-1}b}{2}\right)$ (D) $\frac{A^{-1}b}{2}$

Answer: C

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

(A) $x_{k+1} = x_k + \frac{1}{3}(N - x_k^3)$

(B) $x_{k+1} = \frac{1}{3}\left(2x_k + \frac{N}{x_k^2}\right)$

(C) $x_{k+1} = x_k - \frac{1}{3}(N - x_k^3)$

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

Answer: B

Exp: Newtons's formula for finding $\sqrt[m]{N}$ is

$$x_{K+1} = \frac{1}{m}\left[(m-1)x_k + \frac{N}{x_k^{m-1}}\right]$$

For $m = 3$;

$$x_{k+1} = \frac{1}{3}\left[2x_k + \frac{N}{x_k^2}\right]$$

28. For the matrix A satisfying the equation given below, the eigen values are

$$[A]\begin{bmatrix}1&2&3\\7&8&9\\4&5&6\end{bmatrix}=\begin{bmatrix}1&2&3\\4&5&6\\7&8&9\end{bmatrix}$$

(A) (1, −j, j) (B) (1, 1, 0) (C) (1, 1, −1) (D) (1, 0, 0)

Answer: C

Exp: $[A]\begin{bmatrix}1&2&3\\7&8&9\\4&5&6\end{bmatrix}=\begin{bmatrix}1&2&3\\4&5&6\\7&8&9\end{bmatrix}$

$$\Rightarrow |A|\begin{vmatrix}1&2&3\\7&8&9\\4&5&6\end{vmatrix}=\begin{vmatrix}1&2&3\\4&5&6\\7&8&9\end{vmatrix}$$

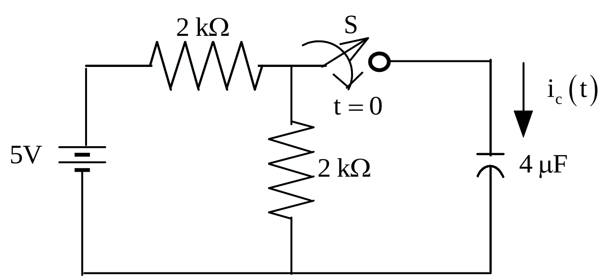
$$\Rightarrow |A|\begin{vmatrix}1&2&3\\7&8&9\\4&5&6\end{vmatrix}=-\begin{vmatrix}1&2&3\\7&8&9\\4&5&6\end{vmatrix}$$

$$\Rightarrow |A| = -1$$

Product of eigen values = -1

∴ Option (C) is correct.

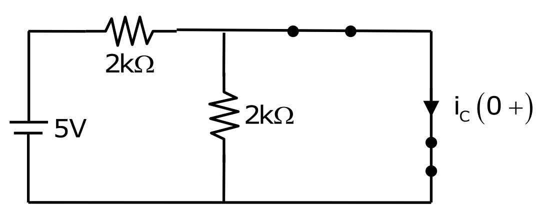
29. In the circuit shown in the figure, initially the capacitor is uncharged. The switch 'S' is closed at $t=0$. Two milliseconds after the switch is closed, the current through the capacitor (in mA) is ________.



Answer: 1.51

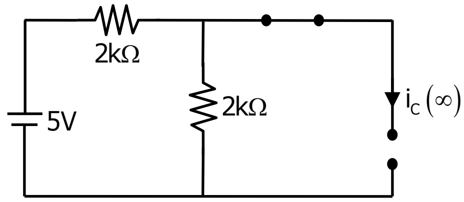
Exp: When switch 'S' is closed,

At t=0 :



$$i_C(0+)=\frac{5}{2k}\Rightarrow 2.5\text{mA}$$

At $t=\infty$:



$i_C(\infty) = 0A$

$i_C(t) = (\text{Initial Value} - \text{Final Value})e^{-t/\tau} + \text{Final Value}$

$\tau = R_{eq}C_{eq}$ sec

$\tau = 1K * 4\mu$

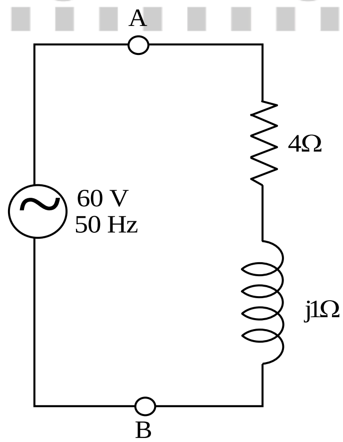
$\boxed{\tau = 4\,\text{msec}}$

$i_C(t) = \left[[2.5 - 0]e^{-t/4*10^{-3}}\right]10^{-3} + (0)$

$\boxed{i_C(t) = 2.5e^{-250t}\,\text{mA}}$

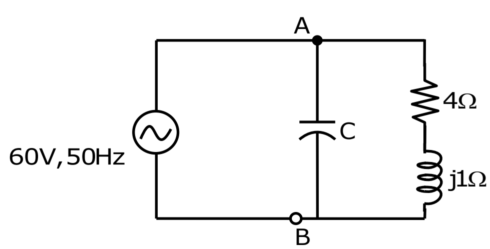
At $t = 2*10^{-3}$ sec ; $\boxed{i_C(2*10^{-3}) = 1.51\text{mA}}$

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 ________.



Answer: 187.24

Exp:



Power factor of the parallel combination is unity.

i.e., in total impedance equate the imaginary term to zero, which gives the capacitance required.

$$Z_{total} = [4 + j1\Omega] || \frac{1}{j\omega C}$$

$$= \frac{[4+j].\frac{1}{j\omega C}}{4+j\left[1-\frac{1}{\omega C}\right]} * \frac{4-j\left[1-\frac{1}{\omega C}\right]}{4-j\left[1-\frac{1}{\omega C}\right]}$$

$$Z_{Total} = \frac{\left[\frac{-j4}{\omega C}+\frac{1}{\omega C}\right]\left[4-j\left(1-\frac{1}{\omega C}\right)\right]}{16+\left[1-\frac{1}{\omega C}\right]^2}$$

$$Z_{Total} = \frac{\frac{4}{\omega^2 C^2} - j\left[\frac{1}{\omega C}-\frac{1}{\omega^2 C^2}+\frac{16}{\omega C}\right]}{16+\left[1-\frac{1}{\omega C}\right]^2}$$

Equate the imaginary term to zero

$$\frac{16}{\omega C}+\frac{1}{\omega C}=\frac{1}{w^2 c^2} \Rightarrow C = \frac{1}{17\omega}$$

$$\Rightarrow C = \frac{1}{17\times 2\pi\times 50} = 187.24\mu F$$

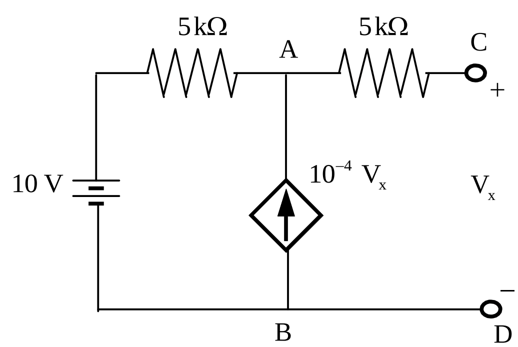
31. The resistance of a wire is given by the expression

$$R = \frac{4\rho L}{\pi D^2},$$

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 $\pm 1.0\%$. Assuming that the errors are independent random variables, the percent error in measurement of R is ________.

Answer: 2.3 to 2.5

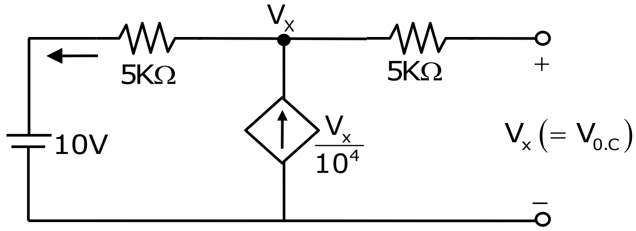
32. The circuit shown in the figure contains a dependent current source between A and B terminals. The Thevenin's equivalent resistance in kΩ between the terminals C and D is ___________.



Answer: 20

Exp: When dependent source is present; to find R_{Th}, V_{Th} & $I_{S.C.}$ are required.

$V_{Th}\left(=V_{O.C}\right)$:



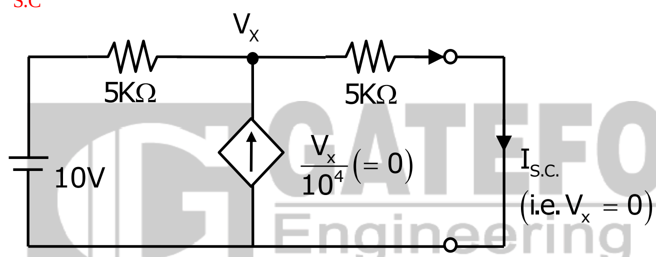
By Nodal Analysis,

$$\frac{V_x-10}{5*10^3}-\frac{V_x}{10^4}=0$$

$$\Rightarrow \boxed{V_x=20\,\text{Volts}}$$

i.e. $V_{Th}=\left(V_{O.C}\right)=20\,\text{Volts}$

$I_{S.C}$:



$$I_{S.C.}=\frac{10}{10\,k}\Rightarrow 1\text{mA}$$

$$\therefore R_{Th}=\frac{V_{Th}}{I_{S.C.}}\Rightarrow\frac{20}{1\times10^{-3}}\Rightarrow 20\,k\Omega$$

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 _________.

Answer: -0.042 to -0.038

Exp: $R_T=aR_0\exp\left(\frac{b}{T}\right)$ … (i)

$R_T\rightarrow$ Resistance of thermistor at temp T

$R_0\rightarrow$ Resistance of thermistor at ice point

$$1000=aR_0^{\exp}\left(\frac{b}{298}\right) \quad \text{… (ii)}$$

$$465=aR_0\exp\left(\frac{b}{316}\right) \quad \text{… (iii)}$$

By (i) and (ii)

$$\frac{1000}{465}=\frac{\exp\left(\frac{b}{298}\right)}{\exp\left(\frac{b}{316}\right)}$$

$$\exp\left(\frac{b}{316}\right)=0.465\exp\left(\frac{b}{298}\right)$$

$$\frac{b}{316}=-0.766+\frac{b}{298}$$

$$0.766=\frac{b}{298}-\frac{b}{316}=\frac{18b}{298\times 316}$$

$$b=\frac{0.766\times 298\times 316}{18}=4007.37$$

Now differentiating equation (i)

$$\frac{dR_T}{dt}=-aR_0\left(\frac{b}{T^2}\right)\exp\left(\frac{b}{T}\right)$$

$$\frac{1}{R_T}\frac{dR_T}{dt}=-\frac{b}{T^2}=\frac{-4007.37}{(316)^2}$$

$$=-0.040$$

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} Ω 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 ________.

Answer: 2.48

Exp: τ=R.C

$$=\left(10^{10}\|10^{13}\right).\left(25\times 10^{-12}\right)$$

$$=10^{10}\times 25\times 10^{-12}\text{ sec}$$

$$=250\text{ m sec}$$

The voltage output after 't' msec is given by

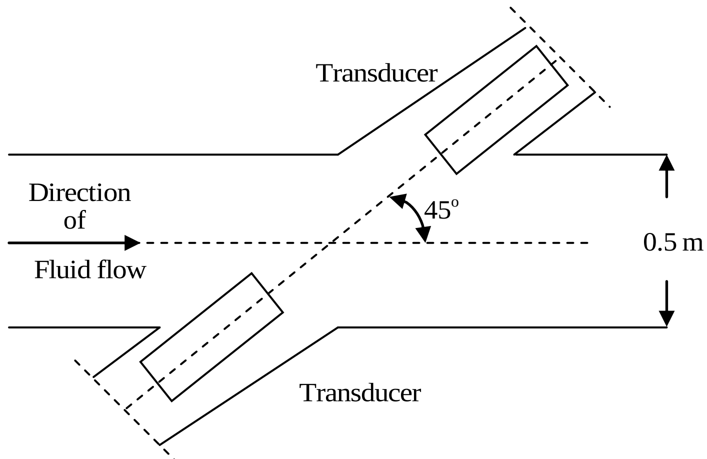
$$e=\frac{d.F}{C}\left[\exp\left(\frac{-t}{\tau}\right)-1\right]$$

$$0.12=\frac{(150\times 10^{-12})(2)}{(25\times 10^{-12})}\left[\exp\left(\frac{-t}{0.25}\right)-1\right]\Rightarrow t=2.48\text{ m.sec}$$

35. A thermopile is constructed using 10 junctions of Chromel-Constantan (sensitivity 60μ 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 ________.

Answer: 0.800 to 0.833

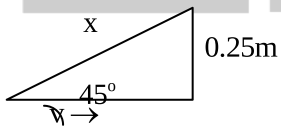
36. A transit time ultrasonic flowmeter uses a pair of ultrasonic transducers placed at 45^o angle, as shown in the figure.



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 _________.

Answer: 0.45 to 0.45

Exp:



$$x = \frac{0.25}{\sin 45} = 0.354\text{m}$$

Distance between transmitter and receiver transducer is (2 × 0.354) = 0.707m

Change in fluid velocity = Δv

Velocity of sound in fluid = 1500 m/s

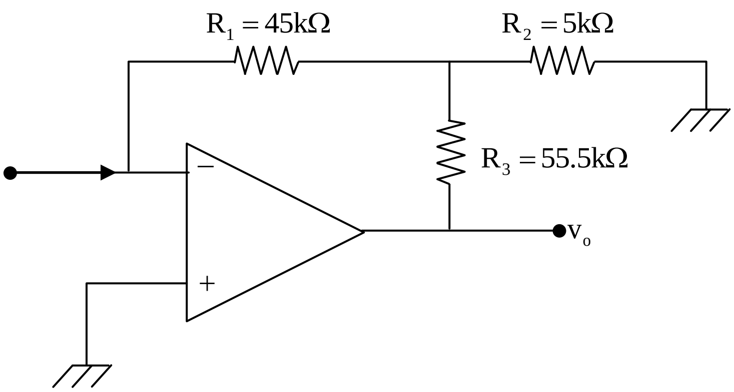
$$\Delta t = \frac{2d(\Delta v)\text{Cos}\theta}{c^2} \quad \text{as } c >> v$$

$$\frac{1}{5\times10^6} = \frac{2\times0.707\times\vartheta\cos 45^o}{(1500)^2}$$

$$\Delta v = \frac{(1500)^2}{2\times0.707\times0.707\times5\times10^6}$$

$$\boxed{\Delta v = 0.45}$$

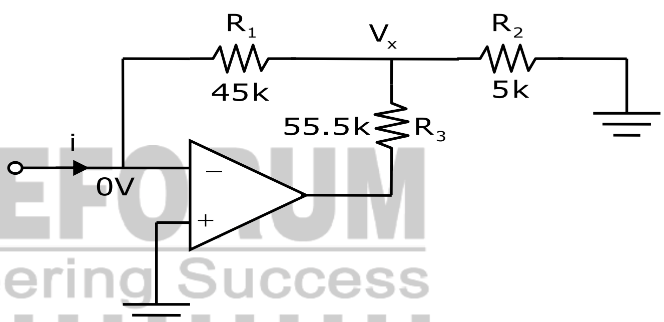
37. Assuming an ideal op-amp in linear range of operation, the magnitude of the transfer impedance $\frac{v_0}{i}$ in MΩ of the current to voltage converter shown in the figure is _______.



Answer: 0.6

Exp: $i = \dfrac{0 - V_x}{R_1}$

$\left|\dfrac{V_x}{R_1}\right| = i$ ....(1)



KCL at V_x node,

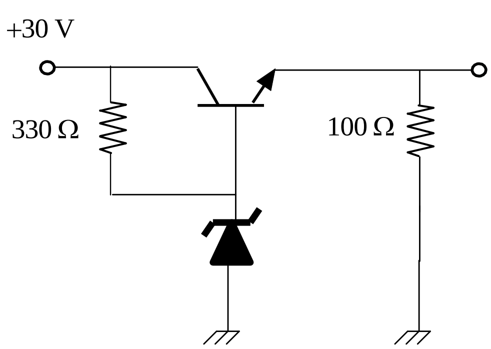
$$\frac{V_x - 0}{R_1} + \frac{V_x - V_0}{R_3} + \frac{V_x - 0}{R_2} = 0$$

$$\frac{V_0}{V_x} = \frac{R_3}{R_1} + \frac{R_3}{R_2} + 1$$

$$\frac{\;\frac{V_0}{V_x}\;}{R_1} = \frac{V_0}{i} = 55.5k + \frac{(45k)(55.5k)}{5k} + 45k$$

$$\frac{V_0}{i} = 0.6\,M\Omega$$

38 . For the circuit shown in the figure, the transistor has β = 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 _________.



Answer: 41.96

Exp: $I = \frac{30-15}{330} = 45.45\,mA$

$V_0 = V_3 - V_{BE}$

$= 15 - 0.7$

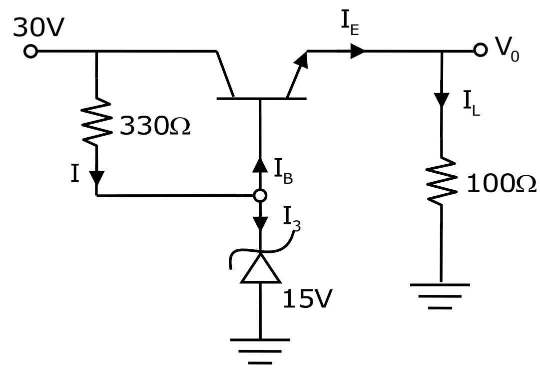
$= 14.3V$

$\therefore I_E = I_L = \frac{V_0}{100} = \frac{14.3}{100} = 143\,mA$

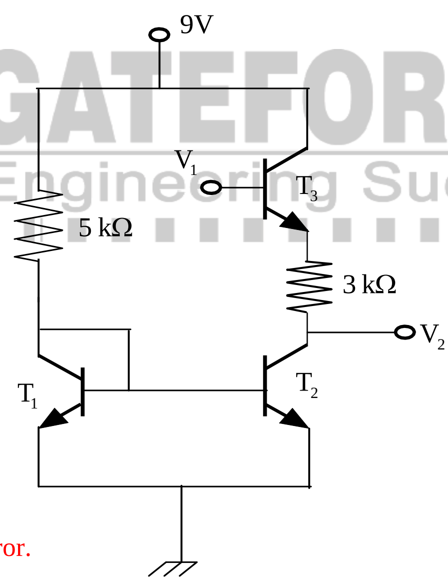
$I_B = \frac{I_E}{1+\beta} = \frac{143\,mA}{41} = 3.487\,mA$

$\therefore I_3 = 45.45\,mA - 3.487\,mA$

$= 41.96\,mA$



39. In the figure, transistors T_1 and T_2 have identical characteristics. $V_{CE(sat)}$ of transistor T_3 is 0.1 V. The voltage V_1 is high enough to put T_3 in saturation. Voltage V_{BE} of transistors T_1, T_2 and T_3 is 0.7V. The value of $(V_1 - V_2)$ in V is _________.



Answer: 5.68

Exp: Given circuit is current mirror.

$\therefore I = I_{C_2} = \frac{9-0.7}{5k} = 1.66\,mA$

$\because T_3$ is in saturation,

$V_{E_3} = 9 - 0.1 = 8.9V$

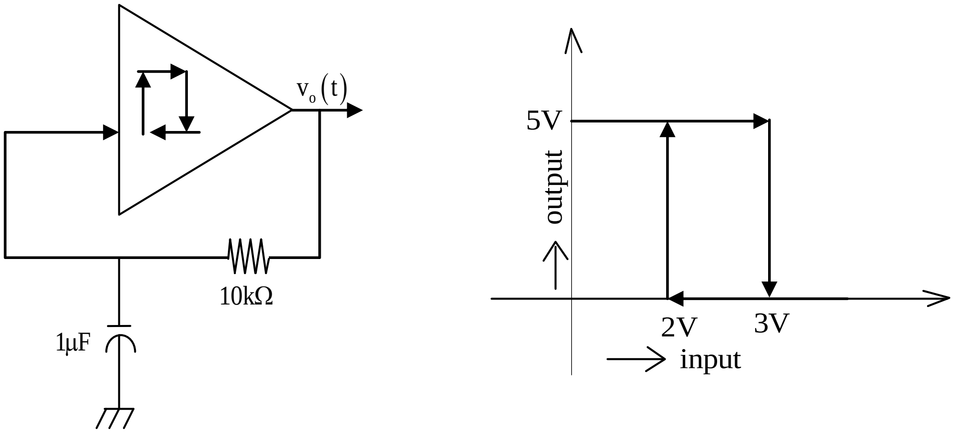
$\therefore \quad V_1 = 8.9 + 0.7V = 9.6V$

and $V_2 = 9 - I_{C_2}(3k) - 0.1$

$= 8.9 - 1.66 \times 3 = 3.92\,V$

$\therefore V_1 - V_2 = 9.6 - 3.92 = 5.68V$

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 __________.



Answer: 8.109

Exp: From figure, $V_{sat}=5V; UTP=3V;\ LTP=2V$

$$V_C(t)=V_{final}+\left(V_{initial}-V_{final}\right)e^{-t/\tau}$$

$$\therefore\ UTP=+V_{sat}+\left(LTP-V_{sat}\right)e^{-T_1/RC}$$

$$\Rightarrow e^{-T_1/RC}=\frac{V_{sat}-UTP}{V_{sat}-LTP}$$

$$\Rightarrow T_1=RC\ln\left[\frac{V_{sat}-LTP}{V_{sat}-UTP}\right]$$

$$\therefore \text{Total } T=2T_1=2RC\ln\left[\frac{5-2}{5-3}\right]$$

$$\Rightarrow T=8.109\,ms$$

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) $\frac{V^2}{12\left(2^N-1\right)^2}$ (B) $\frac{V^2}{12\left(2^N-1\right)}$ (C) $\frac{V}{12\left(2^N-1\right)}$ (D) $\frac{V^2}{\sqrt{12}}$

Answer:A

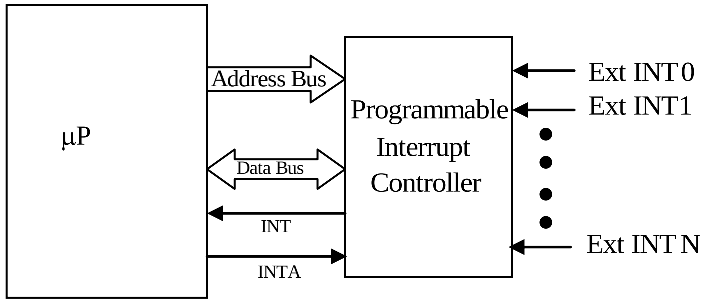
Exp: Quantization noise power $=\frac{\Delta^2}{12}=X$

Here $\Delta=\frac{V}{2^N-1}=\text{step size in N-bit}$

$$X=\left(\frac{V}{2^N-1}\right).\frac{1}{12}$$

$$X=\frac{V^2}{12\left(2^N-1\right)^2}$$

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

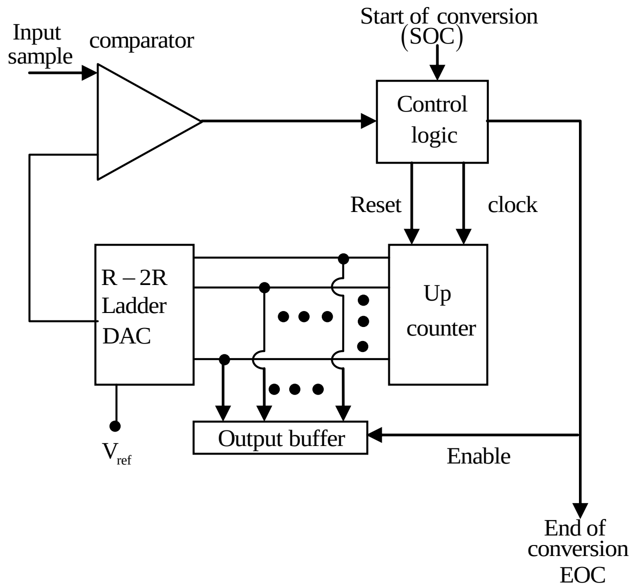
(C) Ext INT1 → INT → INTA → Address Write

(D) Ext INT1 → INT → Data Read → Address Write

Answer: B

Exp: When a single external interrupt (Exp INT1) is raised then it is sensed by programmable interrupt controller and as per their priority it is serviced first and now INT signal is raised by interrupt controller and it is sensed by microprocessor, then microprocessor first completes their current machine cycle and raised the INTA (interrupt acknowledge) signal back to PI controller. This is vectored interrupt so, their address is fixed and ISR (interrupt service Routine) execution will takes place from that address. So, this sequences is mactching with option (B) only

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

Answer: A

Exp: Shoulder

shoulder

So, the maximum error is directly proportional to V_{ref} of R-2R ladder type D_{AC}

44. X(k) is the Discrete Fourier Transform of a 6-point real sequence x(n).

If $X(0)=9+j0,\ X(2)=2+j2,\ X(3)=3-j0,\ X(5)=1-j1,\ x(0)$ is

(A) 3 (B) 9 (C) 15 (D) 18

Answer: A

Exp: Given 6 point DFT of x[n] with

$$X(0)=9+j0$$
$$X(1)=1$$
$$X(2)=2+j2$$
$$X(3)=3-j0$$
$$X(4)=2$$
$$X(5)=1-j$$

$\Rightarrow$ By symmetry properties

$$X(1)=X^*(5)=1+j$$
$$X(4)=X^*(2)=2-j2$$
$$\Rightarrow X[0]=\frac{1}{6}\left[X(0)+X(1)+X(2)+X(3)+X(4)+X(5)\right]$$
$$=\frac{1}{6}\left[9+1+2+3+2+1\right]=3$$

45. The transfer function of a digital system is given by:

$$\frac{b_0}{1-z^{-1}+a_2z^{-2}}$$; where a_2 is real.

The transfer function is BIBO stable if the value of a_2 is:

(A) −1.5 (B) −0.75 (C) 0.5 (D) 1.5

Answer: C

Exp: Transfer function of the digital system is,

$$H(z)=\frac{b_a}{1-z^{-1}+a_2z^{-2}};\ a_2 \text{ is real}$$
$$=\frac{b_oz^2}{z^2-z+a_2};\ a=-1$$

The stability of a two-pole system can be investigated by a stability criterion method called "schr−cohn" stability test".

In this approach the reflection coefficients K_1 and K_2 are to be calculated from the denominator pdynomial. This method states that a second order system is stable if its reflection coefficients $|k_1| < 1$ and $|k_2| < 1$. It is also given that,

$$K_2 = a_2 \text{ and } K_1 = \frac{a}{1+a_2}$$

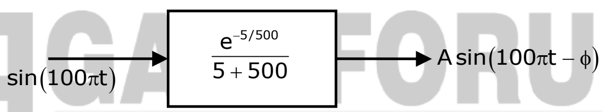
Thus $\boxed{-1 < a_2 < +1; -1 < \frac{a_1}{1+a_2} < +1}$

These two conditions are satisfied by 0.5

Note: An alternative approach to solve this problem is trial and error method. Each option is substituted for 'a_2' in the system function and poles are to be calculated. The value 'a_2' which gives both the poles inside the unit-circle is the suitable 'a_2'. Here a_2 = 0.5 satisfies the condition.

46. The transfer function of a system is given by

$$G(s) = \frac{e^{-s/500}}{s+500}$$



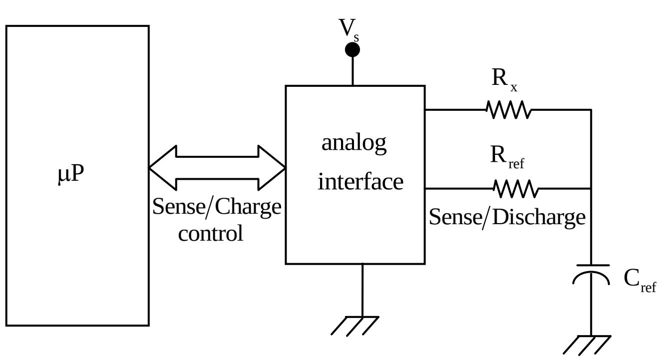
The input to the system is $x(t) = \sin 100\pi t$. In periodic steady state the output of the system is found to be $y(t) = A\sin(100\pi t - \phi)$. The phase angle (ϕ) in degree is ________.

Answer: 68

Exp:

$$(-\phi) = \left|\frac{e^{-j\omega/500}}{j\omega + 500}\right|_{w=100\pi} = -\frac{\pi}{5} - \tan^{-1}\left(\frac{\pi}{5}\right) = -36 - 32 = -68 \Rightarrow \phi = 68$$

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) $R_x = kR_{ref}\left(1-\frac{V_L}{V_H}\right)$

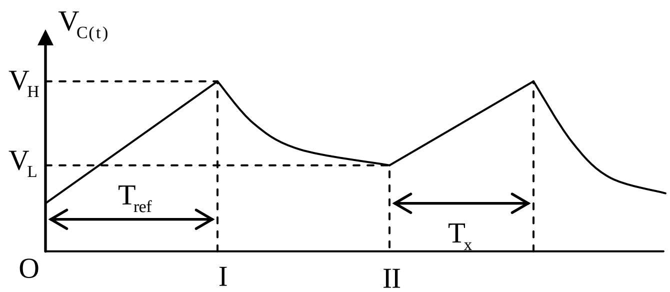
(B) $R_x = kR_{ref}\ln\left(\frac{V_H}{V_L}\right)$

(C) $R_x = kR_{ref}$

(D) $R_x = R_{ref}\ln k$

Answer: (C)

Exp:



$$V_c(t) = V_{final} + [V_{initial} - V_{final}]e^{-t/\tau}$$

$$\tau = RC$$

I. $\quad V_C(t) = V_H + (V_L - V_H)e^{-\frac{T_{ref}}{R_{ref}C_{ref}}}$ ... (1)

II. $\quad V_C(t) = V_H + (V_L - V_H)e^{-\frac{T_x}{R_x C_{ref}}}$ ... (2)

Equation (1) = (2) $\quad T_x = KT_{ref}$

$$\frac{T_{ref}}{R_{ref}C_{res}} = \frac{T_x}{R_x c_{res}} = \frac{K.T_{ref}}{R_x C_{ref}}$$

$$R_x = K.R_{ref}$$

48. Frequency of an analog periodic signal in the range of 5 kHz – 10 kHz is to be measured with a resolution of 100 Hz 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

Answer: (C)

Exp: Minclock frequency = 10K × 100 = 106 Hz = 1 MHz

$$5000 \geq \frac{10^6}{2^n}$$

$$\therefore n = 8\,(\min)$$

49. The loop transfer function of a feedback control system is given by

$$G(s)H(s)=\frac{1}{s(s+1)(9s+1)}$$

Its phase crossover frequency (in rad/s), approximated to two decimal places, is __________.

Answer: 0.33

Exp:

$$\text{Given } G(s)H(s)=\frac{1}{s(s+1)(9s+1)}$$

Phase cross over frequency $W_{pc} \Rightarrow \angle G(j\omega_{pc})H(j\omega_{pc}) = -180^o$

$$\angle G(j\omega)H(j\omega) = -180^o$$

$$-90^o - \tan^{-1}(\omega) - \tan^{-1}(9\omega) = -180^o$$

$$\Rightarrow \tan^{-1}(\omega)+\tan^{-1}(9\omega)=90^o \Rightarrow \tan^{-1}\left[\frac{\omega+9\omega}{1-9\omega^2}\right]=90^o \Rightarrow 1-9\omega^2=0 \Rightarrow \omega=\frac{1}{3}$$

$$\boxed{\omega = 0.33 \text{ r/sec}}$$

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

$$G_c(s)=\frac{K_i}{s}$$

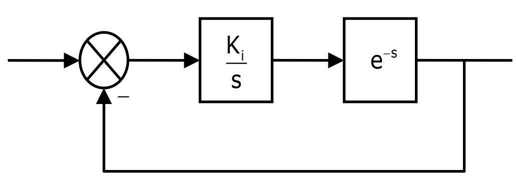
in a unity feedback configuration. The value of K_i for which the closed loop plant has a pole at $s=-1$, is __________.

Answer: 0.367

Exp:

Given $G_P(s)=e^{-s}$

$$G_C(s)=\frac{K_i}{s}$$



$$\text{C.L.T.F} = \frac{\frac{K_i.e^{-s}}{s}}{1+\frac{K_i - e^{-s}}{s}}$$

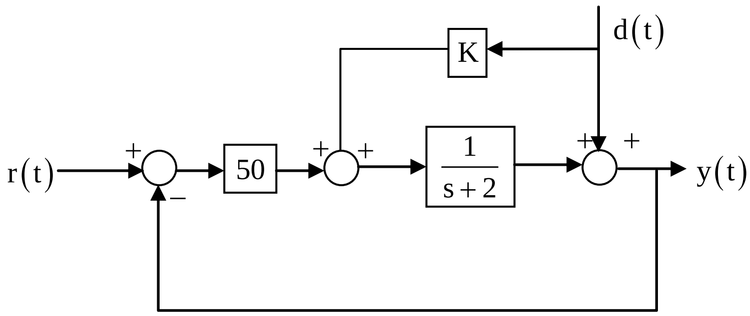
$$\text{C.L.T.F} = \frac{K_i.e^{-s}}{s+K_i.e^{-s}}$$

When $s=-1;\ K_i = ?$

$$-1+K_ie^{-(-1)}=0$$

$$K_i=\frac{1}{e}\Rightarrow 0.367$$

51. Consider the control system shown in figure with feed forward 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

Answer: D

Exp:

$$Y(s) = D(s) + \frac{1}{(s+2)}\left[K.d(s) + 50\left(R(s) - Y(s)\right)\right]$$

$$Y(s)\left[1 + \frac{50}{(s+2)}\right] = D(s)\left[\frac{s+2+K}{s+2}\right] + \frac{50}{(s+2)}.R(s)$$

$$Y(s) = D(s)\left[\frac{s+2+K}{s+52}\right] + \frac{50}{(s+52)}.R(s)$$

i.e., $s + 2 + K = 0$

$\Rightarrow K + 2 = 0$

$\Rightarrow \boxed{K = -2}$

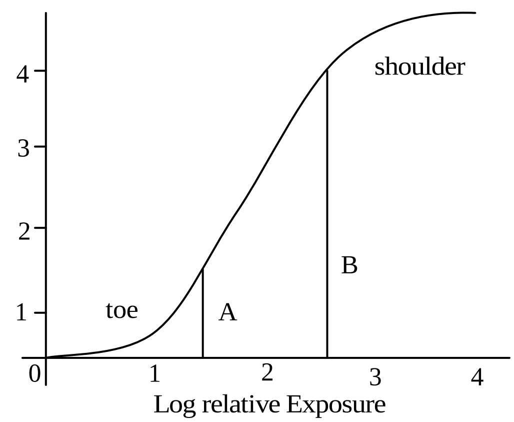
52. A mixture contains two mutually inert solutions 'X' and 'Y' in equal volumes. The mixture is examined in a spectrophotometer using a cuvette. It is observed that the transmittance is 0.40. With only the solution 'X' in the same cuvette, the transmittance is 0.20. With only solution 'Y' in the cuvette the transmittance is _________. .

Answer: 0.795 to 0.805

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 ________.

Answer: 106 to 108

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

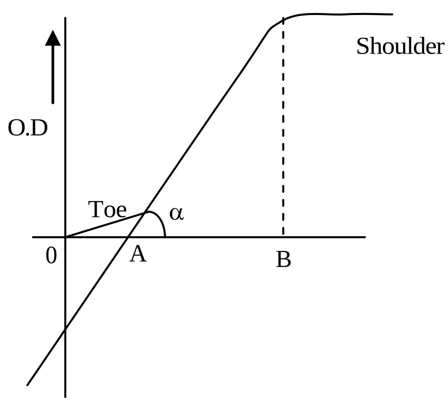
(B) contrast decreases since both A and B move into the shoulder region

(C) Contrast increases since A moves into the toe region

(D) Contrast decreases since both A and B move into the toe region

Answer: A

Exp: If the exposure is increased beyond the toe of the curve, the density begins to increase in direct proportion to log E. If the exposure is increase further, the density saturates after an intermediate region called the "shoulder". In the saturated region, there is no further increase in the density of the developed grains as the exposure increases.



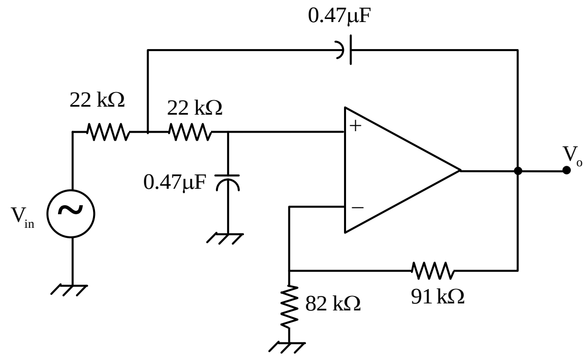
Optical density, $D = -\log_{10} E$

Where E is the exposure given by integral of the intensity per unit area over the exposure time Δt intensity per unit area over the exposure time Δt

$$E = \int_{\Delta t} I.dt$$

If exposure time is increased 10 times then optical density will be also increased.
For human eye, increase in optical density means decrease in brightness.
Hence, contrast decreases since B moves into the shoulder region.

Q55. For the given low-pass circuit shown in the figure, the cutoff frequency in Hz will be ________.



Answer: 15.39

Exp: It is second-order low pass system. It's high cut-off-frequency.

$$f_H = \frac{1}{2\pi\sqrt{R_2R_3C_2C_3}}(H_z)$$

Here $R_2 = f_3 = 22k$

$$c_2 = c_3 = 0.47\ \mu F$$

$$f_H = \frac{1}{2\pi\sqrt{(22k)^2(0.47\mu)^2}}$$

$$= \frac{1}{2\pi \times 22k \times 0.47\mu} = \frac{1}{0.0649} = 15.39\ Hz$$