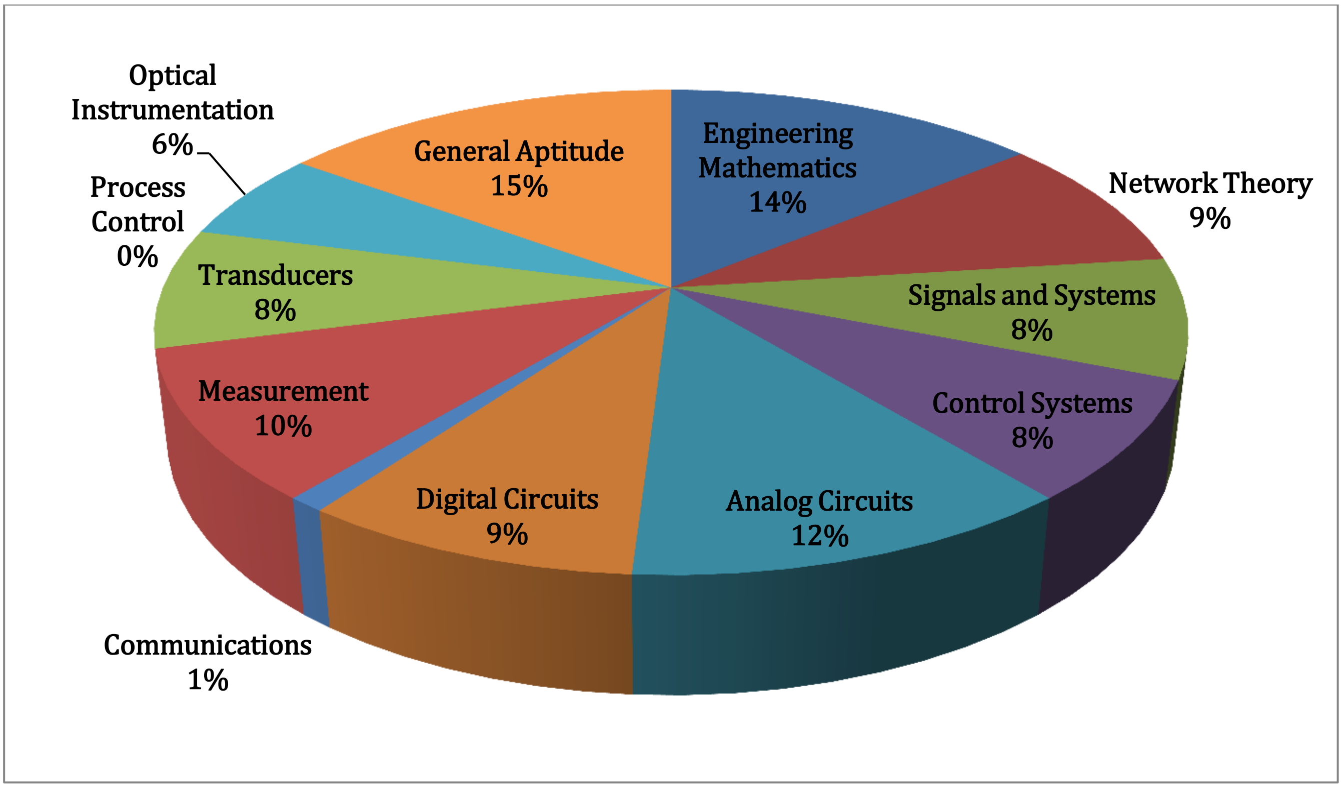
ANALYSIS OF GATE 2018

Instrumentation Engineering



IN ANALYSIS-2018_4-Feb_Afternoon

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 4 2 Marks: 5	Linear Algebra; Statistics and Probability; Calculus;	Easy	14
Network Theory	1 Marks: 3 2 Marks: 3	Basic Components and types of circuits; Basic Laws and Methods; Steady state analysis of AC Circuits	Tough	9
Signals and Systems	1 Marks: 2 2 Marks: 3	Fourier Representation of Signals; Frequency Response of LTI Systems and Diversified Topics	Tricky/Easy	8
Control Systems	1 Marks: 2 2 Marks: 3	Bode Plots; Phase Margin.	Tricky/Easy	8
Analog Circuits	1 Marks: 4 2 Marks: 4	Diode Circuits-Analysis and Application; Operational Amplifiers & Its Applications	Tough	12
Digital Circuits	1 Marks: 3 2 Marks: 3	Combinational & Sequential Digital Circuits; Introduction to Microprocessor	Tricky/Easy	9
Communications	1 Marks: 1 2 Marks:0	Modulation index of Analog Modulation	Easy	1
Measurement	1 Marks: 2 2 Marks: 4	Basics of Measurements and Error Analysis; Measurements of Basic Electrical Quantities Electronic Measuring Instruments	Tough/Medium	10
Transducers	1 Marks: 2 2 Marks: 3	Strain Gauge; Ultrasonic Flow Meter	Medium	8
Process Control	1 Marks: 0 2 Marks: 0	-	-	0
Optical Instrumentation	1 Marks: 2 2 Marks:2	Optical Sources and Detectors;	Tough	6
General Aptitude	1 Marks: 5 2 Marks: 5	Algebra, Vocabulary, Data Interpretation, TSD	Easy	15
Total	**65**			**100**
Faculty Feedback	Majority of the question were concept based. General Aptitude And Mathematics is Very Easy. Core Subject Questions were 50% easy, 30% medium and 20% tough.			

GATE 2018 Examination*

Instrumentation Engineering

Test Date: 4/02/2018

Test Time: 2:00 PM 5:00 PM

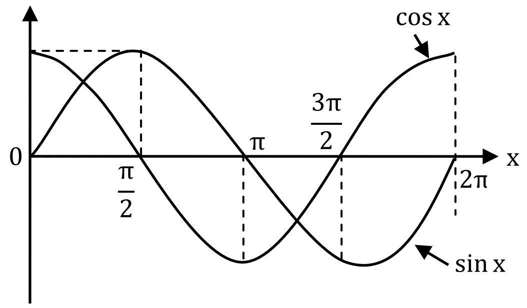
Subject Name: Instrumentation Engineering

General Aptitude

Q.1 - Q.5 Carry One Mark each.

1. "In spite being warned repeatedly, he failed to correct his _____ behaviour."
The word that best fills the blank in the above sentence is
(A) rational (B) reasonable
(C) errant (D) good
[Ans. C*]
Errant means misbehaving, exhibiting inappropriate behavior / offending conduct.

2. For $0 \le x \le 2\pi$, $\sin x$ and $\cos x$ are both decreasing functions in the interval _______
(A) $\left(0, \frac{\pi}{2}\right)$ (B) $\left(\frac{\pi}{2}, \pi\right)$
(C) $\left(\pi, \frac{3\pi}{2}\right)$ (D) $\left(\frac{3\pi}{2}, 2\pi\right)$
[Ans. B*]



From the curve it is clear that $\sin x$ and $\cos x$ both are decreasing in the interval $\left(\frac{\pi}{2}, \pi\right)$.S

3. Arrange the following three-dimensional objects in the descending order of their volumes:
(i) A cuboid with dimensions 10 cm, 8 cm and 6 cm
(ii) A cube of side 8 cm
(iii) A cylinder with base radius 7 cm and height 7 cm
(iv) A sphere of radius 7 cm
(A) (i), (ii), (iii), (iv) (B) (ii), (i), (iv), (iii)
(C) (iii), (ii), (i), (iv) (D) (iv), (iii), (ii), (i)
[Ans. D*]
i. Cuboid volume $= 8 \times 10 \times 6 = 480\ \text{cm}^3$
ii. Cube volume $= 8 \times 8 \times 8 = 512\ \text{cm}^3$

iii. Cylinder volume $= \pi r^2 h = \frac{22}{7} \times 7 \times 7 \times 7 = 1078\ cm^3$

iv. Sphere volume$= \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \times (7)^3 = 1436.75\ cm^3$

Hence, the descending order of their volumes is (iv), (iii), (ii), (i).

4. The area of an equilateral triangle is $\sqrt{3}$. What is the perimeter of the triangle?

(A) 2
(B) 4
(C) 6
(D) 8

[Ans. C*]

Area of equilateral triangle= $\sqrt{3}$

$\frac{\sqrt{3}}{4} a^2 = \sqrt{3}$

$a^2 = 4$

$a = 2$

Perimeter= $3a = 3 \times 2 = 6$

5. "When she fell down the ____, she received many _____ but little help."

The words that best fill the blanks in the above sentence are

(A) stairs, stares
(B) stairs, stairs
(C) stares, stairs
(D) stares, stares

[Ans. A*]

Stairs - A construction designed to bridge a large vertical distance by dividing it into smaller vertical distances, called steps

Stares - To look at someone for a long time

Q.6 - Q.10 Carry Two Mark each.

6. A set of 4 parallel lines intersect with another set of 5 parallel lines. How many parallelograms are formed?

(A) 20
(B) 48
(C) 60
(D) 72

[Ans. C*]

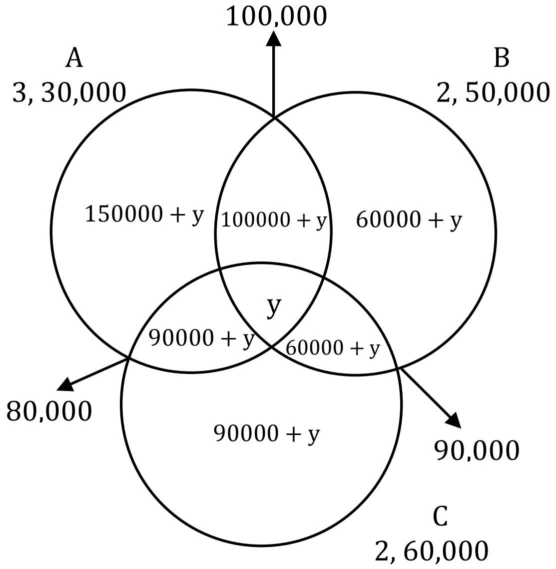
Number of parallelogram $= {}^4C_2 \times {}^5C_2$

$= 6 \times 10 = 60$

7. To pass a test, a candidate needs to answer at least 2 out of 3 questions correctly. A total of 6,30,000 candidates appeared for the test. Question A was correctly answered by 3,30,000 candidates. Question B was answered correctly by 2,50,000 candidates. Question C was correctly by 2,60,000 candidates. Both questions B and C were answered correctly by 90,000 candidates. Both questions A and C were answered correctly by 80,000 candidates. If the number of students answering all questions correctly is the same as the number answering none, how many candidates failed to clear the test?

(A) 30,000
(B) 2,70,000
(C) 3,90,000
(D) 4,20,000

[Ans. D]



$6{,}30{,}000 = 2y + 1{,}50{,}000 + 100000 + 80000 + 60000 + 90000 + 90000$

$6{,}30{,}00 - 5{,}70{,}000 = 2y$

$y = 30000$

Students who failed to clear the test $= 150000 + 60000 + 90000 + 4y$

$= 300000 + 4 \times 30000$

Students who failed to clear the test $= 420000$

8. If $x^2 + +x - 1 = 0$ what is the value of $x^4 + 1/x^4$?

(A) 1 (B) 5

(C) 7 (D) 9

[Ans. C*]

$x^2 + x = 1$

$x(x+1) = 1$

$x + 1 = \frac{1}{x}$

$\left(x - \frac{1}{x}\right) = (-1)$

Squaring above equation,

$x^4 + \frac{1}{x^4} + 2 = 9$

$x^4 + \frac{1}{x^4} = 7$

9. An automobile travels from city A to city B and returns to city A by the same route. The peed of the vehicle during the onward and return journeys were constant at 60 km/h and 90 km/h, respectively. What is the average speed in km/h for the entire journey?

(A) 72 (B) 73

(C) 74 (D) 75

[Ans. A*]

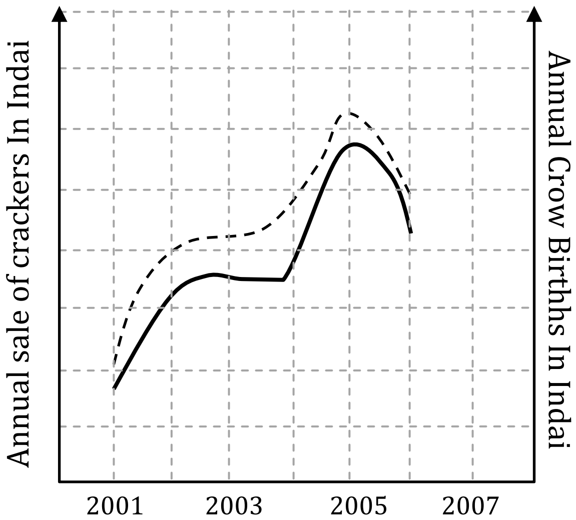
Total distance $= x$

(Onward journey) $S_1 = 60$ km/h
(Return journey) $S_2 = 90$ km/h

Average speed$= \frac{\text{Tatal distance}}{\text{Total time}} = \frac{x+x}{\frac{x}{60}+\frac{x}{90}} = \frac{2x}{x\left[\frac{3+2}{90\times 2}\right]}$

$= \frac{2\times 90\times 2}{5} = 72$ km/h

10. In a detailed study of annual crow births in India, it was found that there was relatively no growth during the period 2002 to 2004 and a sudden spike from 2004 to 2005. In another unrelated study, it was found that the revenue from cracker sales in India which remained fairly flat from 2002 to 2004, saw a sudden spike in 2005 before declining again in 2006. The solid line in the graph below refers to annual sale of crackers and the dashed line refers to the annual crow births in India. Choose the most appropriate inference from the above data.



(A) There is a strong correlation between crow birth and cracker sales.
(B) Cracker usage increases crow birth rate.
(C) If cracker sale declines, crow birth will decline.
(D) Increased birth rate of crows will cause an increase in the sale of crackers.

[Ans. A*]

Technical

Q.1 - Q.25 Carry One Mark each.

1. X and Y are two independent random variables with variances 1 and 2, respectively. Let Z = X – Y. The variance of Z is

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

[Ans. D*]

$\text{Var }(z) = \text{var }(x - y) = \text{var }(x) + \text{var }(y) - 2\,\text{Cov}(x, y)$

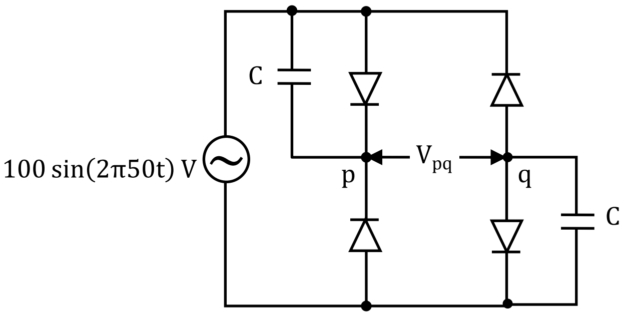
Since x, y an independent random variable

$\text{cov}(x, y) = 0$

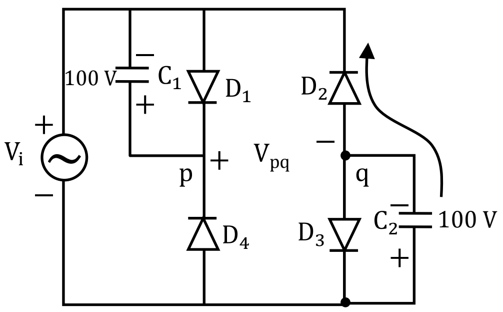
$\text{van }(x - y) = \text{var }(x) + \text{var }(y) - 0$

$= 1 + 2 = 3$

2. The diodes given in the circuit are ideal. At t = 60 ms, V_{pq} (in Volts) is________



[Ans. *]Range: 200 to 200



During +ve cycle: D_2 and D_4 are OFF and no current flows.

During −ve cycle:

C_1 Charges through D_4 upto 100 V

C_2 charges through D_2 upto 100 V

KVL:

$-V_i - 100 + V_{pq} - 100 = 0$

$V_{pq} = 200 + V_i$

At $t = 60$ msec, $V_i = 0$

$Vpq = 200$ V

3. Let $f_{1(z)} = z^2$ and $f_2(z) = \bar{z}$ be two complex variable functions. Here $\bar{z}$ is the complex conjugate of z. Choose the correct answer.

(A) Both $f_1(z)$ and $f_2(z)$ are analytic

(B) Only $f_1(z)$ is analytic

(C) Only $f_2(z)$ is analytic

(D) Both $f_1(z)$ and $f_2(z)$ are not analytic

[Ans. B*]

$f_1(z) = z^2$

$= (x + iy)^2$

$f_1(z) = \underbrace{x^2 - y^2}_{u} + \underbrace{izxy}_{v}$

$\frac{\partial u}{\partial x} = 2x\,; \frac{\partial v}{\partial x} = 2y$

$\frac{\partial u}{\partial y} = -2y; \frac{\partial v}{\partial y} = 2x$

$f_2(z) = \bar{z}$

$= \underbrace{x}_{u} - \underbrace{iy}_{v}$

$\frac{\partial u}{\partial x} = 1; \frac{\partial v}{\partial x} = 0$

$\frac{\partial u}{\partial y} = 0; \frac{\partial v}{\partial y} = -1$

According CR- equations

$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$

$2x = 2x$

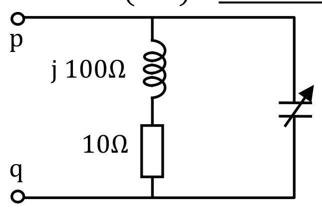
$\frac{\partial u}{\partial y} = \frac{-\partial v}{\partial x}$

$-2y = -2y$

$f_1(z)$ Satisfying CR equations

$f_2(z)$ Not satisfying CR equations

4. A coil having an impedance of $(10 + j100)\Omega$ is connected in parallel to a variable capacitor as shown in figure. Keeping the excitation frequency unchanged, the value of the capacitor is changed so that parallel resonance occurs. The impedance across terminals p-q at resonance (inΩ) is_________.



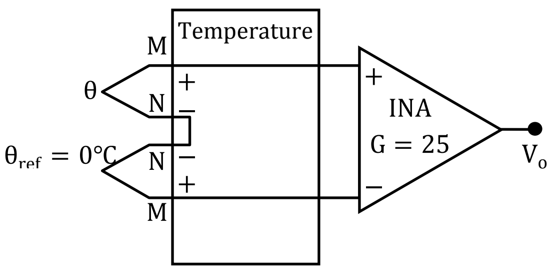
[Ans. *]Range: 1009 to 1011

At resonance, $I_m(Y_{eq}) = 0$

At resonance, $\text{Re}(Y_{eq}) = G = \frac{R}{R^2+X_L^2} = \frac{10}{10^2+100^2}$

$$z = \frac{1}{G} = \frac{10100}{10} = 1010\ \Omega$$

5. As shown in the figure, temperature θ is measured using a K type thermocouple. It has a sensitivity of 40 μV/°C. The gain (G) of the ideal instrumentation amplifier is 25. If the output V_o is 96 mV, then the value of θ (in °C) is ________.



[Ans. *]Range: 95 to 97

From the given figure,

Output f thermocouple, $V_{OT} = e_{MIN}(\theta - \theta_{Ref})$

Where, e_{MIN} is sensitivity of thermocouple.

Total output voltage after instrumentation amplifier is

$V_o = A_I \times V_{OT}$

Where, A_I is gain instrumentation amplifier

$96 \times 10^{-3} = 25 \times e_{MIN}(\theta - 0)$

$$\theta = \frac{96 \times 10^{-3}}{25 \times 40 \times 10^{-6}} = 96°\text{C}$$

6. A piezoelectric pressure sensor has a band pass characteristic with cut-off frequencies of 0.1 Hz and 1 MHz, and a sensitivity of 100 mV/kPa. The sensor is subjected to a static constant pressure of 100 kPa. Its steady-state output will be.

(A) 0 V
(B) 0.1 V
(C) 1 V
(D) 10 V

[Ans. A*]

The given Piezo-electric pressure sensor has bandwidth "0.1 Hz to 1 MHz".

As the given input pressure is "static-input" means "0 Hz" signal. The output voltage at steady state =0 V

7. Consider a sequence of tossing of a fair coin where the outcomes of tosses are independent. The probability of getting the head for the third time in the fifth toss is

(A) $\frac{5}{16}$
(B) $\frac{3}{16}$
(C) $\frac{3}{5}$
(D) $\frac{9}{16}$

[Ans. B*]

Probability of getting head in a toss $= p = \frac{1}{2}$

Probability of getting tail in a toss= $q = \frac{1}{2}$

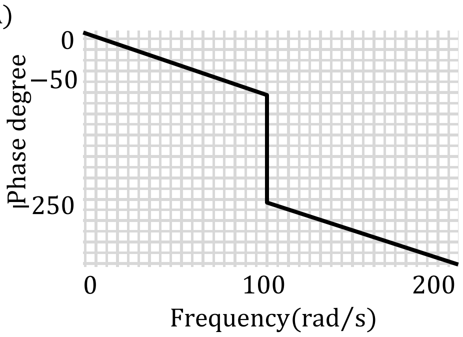
Required probability= (Probability of getting 2 heads in first 4 tosses)× (Probability of getting head in 5^{th} toss)

$$= ({}^4C_2 p^2 q^2) \times \left(\frac{1}{2}\right)$$

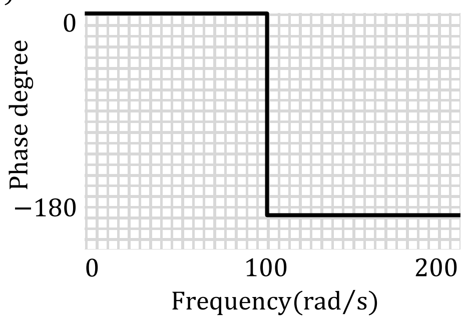
$$= 6 + \frac{1}{4} \times \frac{1}{4} \times \frac{1}{2} = \frac{6}{32} = \frac{3}{16}$$

8. The approximate phase response of $\frac{100^2 e^{-0.01\,s}}{s^2+0.2s+100^2}$ is

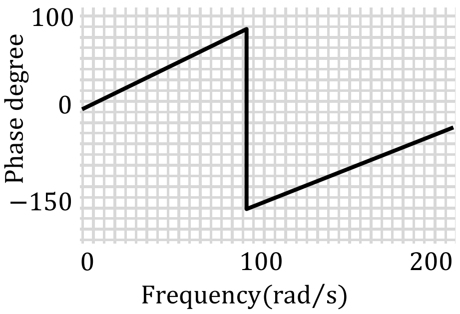
(A)



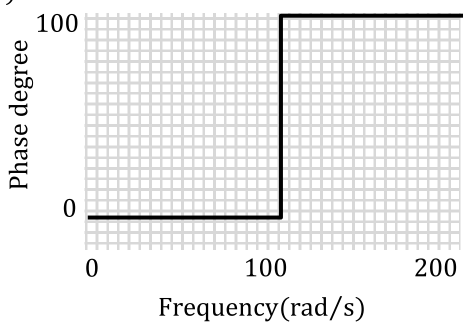
(B)



(C)



(D)



[Ans. A*]

$$TF = \frac{100^2 e\text{^} - 0.01s}{s^2 + 0.2s + 100^2}$$

Here, phase of $\frac{100^2}{s^2+0.2s+100^2}$ Varies from 0° to −180° as $\omega: 0 \rightarrow \infty$,

Therefore $e^{-0.01s}$ causes further phase lag, hence the correct answer is (A).

9. An input $p(t) = \sin(t)$ is applied to the system $G(s) = \frac{s-1}{s+1}$. The corresponding steady state output is $y(t) = \sin(t + \varphi)$ where the phase φ (in degrees), when restricted to $0° \leq \varphi \leq 360°$, is ____.

[Ans. *] Range: 60 to 60

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

$$p((t) = \sin t$$

$$y(t) = \sin(t + 0)$$

$\therefore 0 = \angle p(t) + \angle G(j\omega)$ at $\omega = 1$

$= 0° + 180° - 90°$

$= 90°$

10. The representation of the decimal number $(27.625)_{10}$ in base-2 number system is

(A) 11011.110
(B) 11101.101
(C) 11011.101
(D) 10111.110

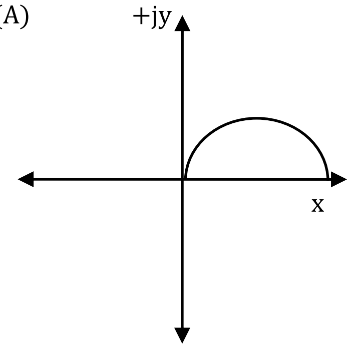
[Ans. C*]

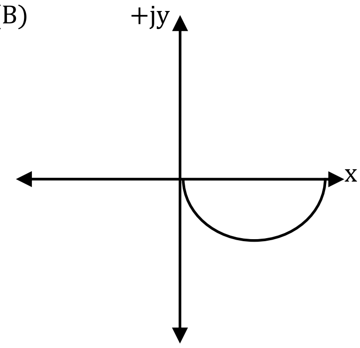
$16 + 8 + 2 + 1 + 0.5 + 0.125$

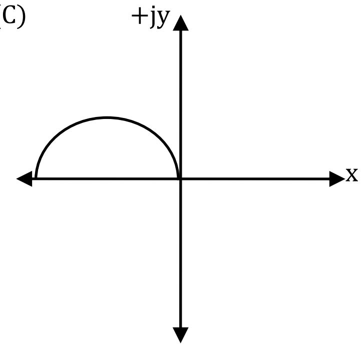
$2^4(1) + 2^3(1) + 2^2(0) + 2^1(1) + 2^0(1) + 2^{-1}(1) + 2^{-2}(0) + 2^{-3}(1)$

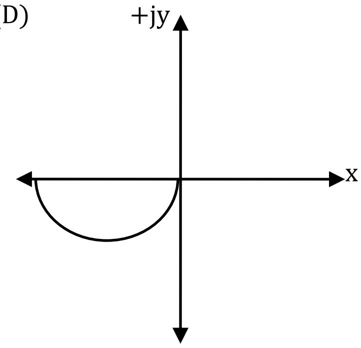
$(11011.101)_2$

11. A series R-C circuit is excited by a $1\angle 0$ V sinusoidal ac voltage source. The locus diagram of the phasor current $I = (x + ij)$ A, when C is varied, while keeping R fixed, is

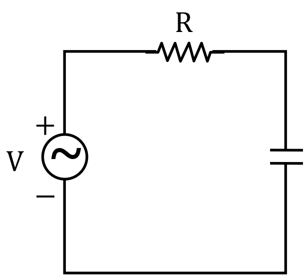
(A)


(B)


(C)


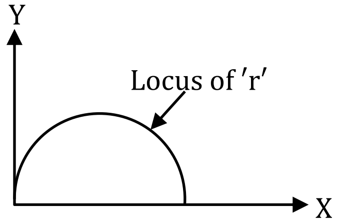
(D)


[Ans. A*]

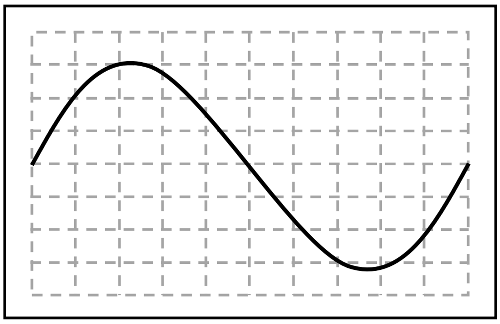


$C = \infty$	$C\downarrow$	
$X_C = 0$	$X_C = \uparrow$	$C = 0$
$Z = R$	$Z\uparrow$	$X_c = \infty$
$I = V/R$	$I\downarrow$	$Z = \infty$

$\theta = 0$ | $\theta = \tan^{-1}\left(\frac{-X_C}{R}\right) \uparrow$ | $I = 0$



12. A voltage of $6\cos(100\,\pi t)$ V is fed as y-input to a CRO. The waveform seen on the screen of the CRO is shown in the figure. The Y and X axes settings for the CRO are respectively



(A) 1 V/div and 1 ms/div
(B) 1 V/div and 2 ms/div
(C) 2 V/div and 1 ms/div
(D) 2 V/div and 2 ms/div

[Ans. D*]

Upon observing the waveform 3 divisions on the Y axis means that he Y setting is 2 N/div.
An angular frequency of πt would corresponds to frequency of 50 Hz.

i.e. Time period$= \frac{1}{50} = 20$ msec

∴ 10 correspond to a X setting of

$$\frac{20}{10} = 2\frac{\text{msec}}{\text{div}}$$

∴ option (D)is correct.

13. Consider two functions$f(x) = (x-2)^2$and $g(x) = 2x - 1$, where x is real. The smaller value of x for which $f(x) = g(x)$ is _____.

[Ans. *]Range: 1 to 1

$(x-2)^2 = 2x - 1$

$x^2 - 6x + 5 = 0$

$x = 1, 5$

Smallest value of x is 1

14. A 300 V, 5A, 0.2 pf low power factor wattmeter is used to measure the power consumed by a load. The wattmeter scale has 150 divisions and the pointer is on the 100th division. The power consumed by the load (in Watts) is _____.

[Ans. *]Range: 200 to 200

At full scale the wattmeter will indicate

$300 \times 5 \times 0.2 = 300$ Watts

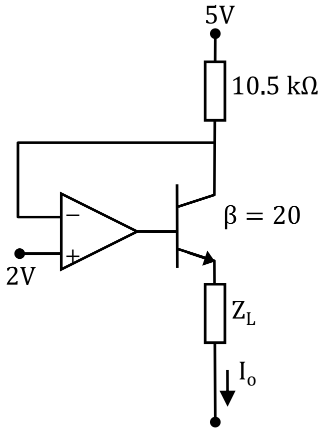
As the scale of the wattmeter is uniform.

$300\ \text{W} \rightarrow 150\ \text{division}$

$? \rightarrow 100$ division

$= \dfrac{300 \times 100}{150} = 200$ Watts

15. In the given circuit, assume that the op-amp is ideal and the transistor has a β of 20. The current Io (in μA) flowing through the load Z_L is ____.



[Ans.*] Range: 295 to 305 **

$V_c = 2\ \text{V}$

$I_c = \dfrac{5\text{V} - 2\text{V}}{10.5\ \text{k}\Omega} = \dfrac{3}{10.5}\text{mA}$

$I_0 = I_E = \dfrac{(1+\beta)I_c}{\beta} = \dfrac{21 \times 3}{20 \times 10.5}\text{mA}$

$= 0.3\ \text{mA} = 300\mu\text{A}$

16. Let N be a 3 by 3 matrix with real number entries. The matrix N is such that $N^2 = 0$. The eigen values of N are

(A) 0, 0, 0 (B) 0, 0, 1

(C) 0, 1, 1 (D) 1, 1, 1

[Ans. A*]

$N^2 = 0$

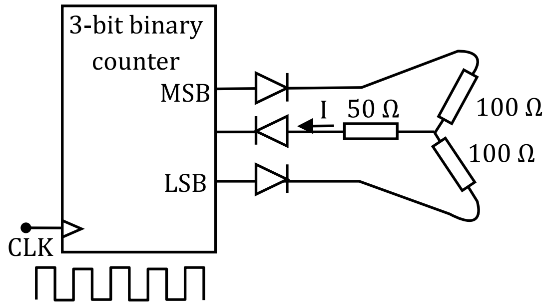
Let Eigen values of N are $\lambda_1, \lambda_2, \lambda_3$;

Eigen value of N^2 are $\lambda_1^2, \lambda_2^2 \lambda_3^2$

But $N^2 = 0$

$\Rightarrow \lambda_1^2 = 0, \lambda_2^2 = 0, \lambda_3^2$

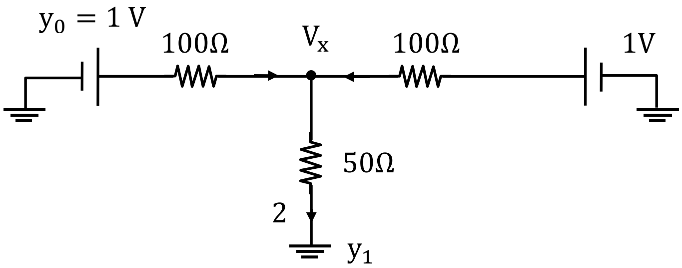
17. For the 3-digit counter shown in the figure, the output increments at every positive transition in the clock (CLK). Assume ideal diodes and the starting state of the counter as 000. If output high is 1V and output low is 0 V, the current I (in mA) flowing through the 50Ω resistor during the 5th clock cycles is (up to one decimal place) _____.



[Ans. *]Range: 10 to 10

	y_2	y_1	y_0
1st clock	0	0	0
2nd clock	0	0	1
3rd clock	0	1	0
4th clock	0	1	1
5th clock	1	0	0
	1	0	1

After 5^{th} clock cycle o/p is $y_2 = 1; y_1 = 0; y_0 = 1$



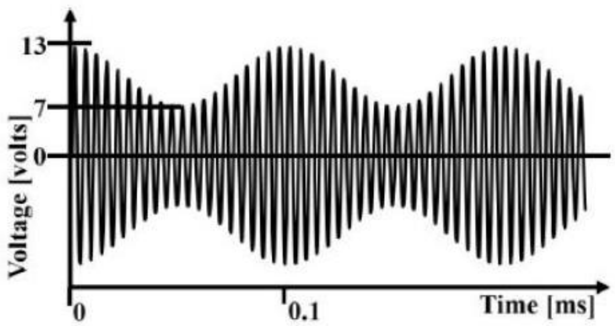
Nodal analysis

$$\frac{1 - V_x}{100} + \frac{1 - V_x}{100} = \frac{V_x}{50}$$

$$\frac{1}{50} - \frac{V_x}{50} = \frac{V_x}{50} \Rightarrow V_x = 0.5 \text{ V}$$

$$I_2 = \frac{V_x}{50} = \frac{0.5}{50} = 10 \text{ mA}$$

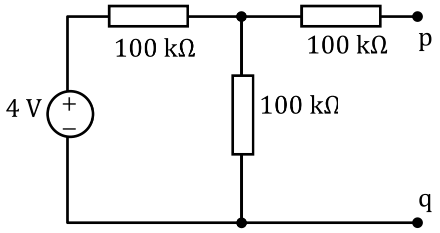
18. An amplitude signal is shown in the figure. The modulation index is (up to one decimal place)________.



[Ans. *]Range: 0.3 to 0.3

Modulation index, $\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{13-7}{13+7} = \frac{6}{20}$=0.3

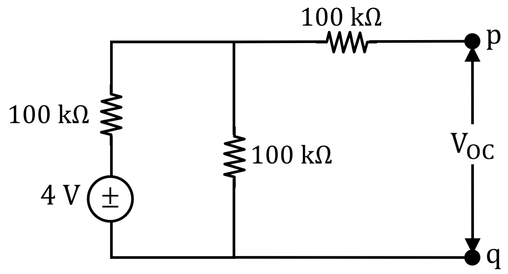
19. The Thevenin's equivalent circuit representation across terminals p-q of the circuit shown in the figure is a



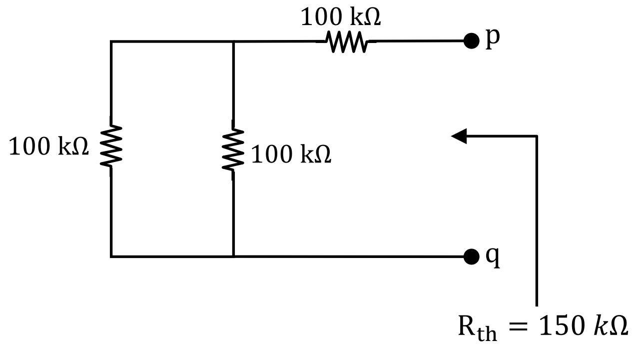
(A) 1 V source in series with 150 kΩ
(B) 1 V source in parallel with 100 kΩ
(C) 2 V source in series with 150 kΩ
(D) 2 V source in parallel with 200 kΩ

[Ans. C*]

Case I: (V_{OC})



Case II: (R_{Th})



$R_{Th} = 150\ \text{k}\Omega$

20. An optical pulse containing 6×10^6 photons is incident on a photodiode and 4.5×10^6 electron hole pairs are created. The maximum possible quantum efficiency (in %) of the photodiode is________.

[Ans. *]Range: 75 to 75

Number of incident photons 'N' $= 6 \times 10^{10}$

Number of electron-hole pairs generated 'n'$= 4.5 \times 10^6$

Quantum efficiency of photo-diode

$$= \frac{n}{N} \times 100 = \frac{4.5 \times 10^{10}}{6 \times 10^6} = 75$$

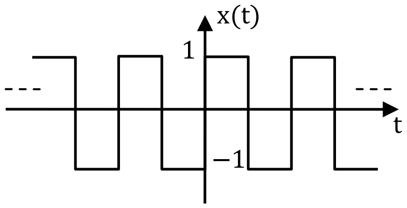
21. The number of comparators required for implementing an 8-bit flash analog-to-digital converter is

(A) 8 (B) 128
(C) 255 (D) 256

[Ans. C*]

In general, in n-bit flash type ADC, the number of comparators needed is equal to, $2^n - 1$.
Hence, for 8-bit ADC, the number of comparators needed= $2^8 - 1 = 255$.

22. An ideal square wave with period of 20 ms shown in the figure is passed through an ideal low pass filter with cut-off frequency 120 Hz. Which of the following is an accurate description of the output?



(A) Output is zero
(B) Output consists of both 50 Hz and 100 Hz frequency components.
(C) Output is a pure sinusoid of frequency 50 Hz.
(D) Output is a square wave of fundamental frequency 50 Hz

[Ans. C*]

$t = 20$ msec
Fundamental frequency,

$$f_0 = \frac{1000}{20} = 50 \text{ Hz}$$

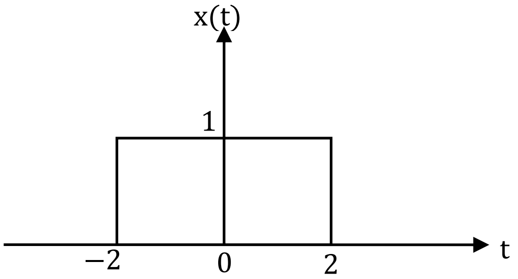
The given signal is an odd signal and it also has half wave symmetry. So it will have spectral components only for odd harmonics. So, the spectrum of the signal will have component of 50 Hz, 150 Hz, 250 Hz, 350 Hz, ……
When passed through an LPF of cutoff frequency 120 Hz, the output of filter has only 50 Hz component. So, option (C) is correct.

23. Consider signal$x(t) = \begin{cases} 1, & |t| \le 2 \\ 0 & |t| > 2 \end{cases}$. Let $\delta(t)$ denote the unit impulse (Dirac-delta) function.
The value of the integral $\int_0^5 2x(t-3)\delta(t-4)dt$ is

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

[Ans. A*]

$$2\int_0^5 x(t-3).\delta(t-4)dt = 2x(1) = 2$$



24. Consider the transfer function $G(s) = \frac{2}{(s+1)(s+2)}$. The phase margin of G(s) in diagram is ______.

[Ans. 1*]Range: −180 to − 180

$$|G(j\omega)H(j\omega)| = \frac{2}{(j\omega+1)(j\omega+2)} \ldots\ldots\ldots (1)$$

$$|G(j\omega)H(j\omega)| = \frac{2}{\sqrt{\omega^2+1}\sqrt{\omega^2+4}} \ldots\ldots\ldots (2)$$

$$\angle G(j\omega) = -\tan^{-1}\left(\frac{\omega}{1}\right) - \tan^{-1}\left(\frac{\omega}{2}\right) \ldots\ldots. (3)$$

$\boldsymbol{\omega_{gc}}$:

$$\frac{2}{\sqrt{\omega^2+1}\sqrt{\omega^2+4}} = 1$$

$$(\omega^2+1)(\omega^2+4) = 4$$

$$\omega^4 + 5\omega^2 + 4 = 4$$

$$\omega^2(\omega^2+5) = 0$$

$$\omega_{gc} = 0$$

$$\angle G(j\omega)_{\omega_{gc}} = 0 = \phi$$

$$\text{Phase margin} = 180 + \phi$$

$$\text{Phase margin} = 180^\circ$$

25. Two periodic signals x (t) and y (t) have the same fundamental period of 3 seconds. Consider the signal $z(t) = x(-t) + y(2t+1)$. The fundamental period of z(t) in seconds is

(A) 1
(B) 1.5
(C) 2
(D) 3

[Ans. D]

$$X(-t) \to 3 \to \omega_{01} = \frac{2\pi}{3}$$

$$y(2t+1) \to \frac{3}{2} \to \omega_{02} = \frac{2\pi}{\frac{3}{2}} = \frac{4\pi}{3}$$

$$\omega_0 = \text{GCD}\left\{\frac{2\pi}{3}, \frac{4\pi}{3}\right\} = \frac{2\pi}{3}$$

$$\text{To} \frac{2\pi}{2\pi/3} = 3 \text{ sec}$$

Q.26 - Q.55 Carry Two Mark each.

26. The product of sum expression of a Boolean function F(A,B,C) of three variable is given by

$F(A, B, C) = (A + B + \bar{C})(A + \bar{B} + \bar{C})(\bar{A} + B + C)(\bar{A} + \bar{B} + \bar{C})$

The canonical sum of product expression F (A,B,C) is given by

(A) $\bar{A}\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + ABC$

(B) $\bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}C + AB\bar{C}$

(C) $AB\bar{C} + A\bar{B}\bar{C} + \bar{A}BC + \bar{A}\bar{B}\bar{C}$

(D) $\bar{A}\bar{B}\bar{C} + \bar{A}BC + AB\bar{C} + ABC$

[Ans B*]

The function is given in POs form as,

$F = (A + B + \bar{C})(A + \bar{B} + \bar{C})(\bar{A} + B + C)(\bar{A} + \bar{B} + \bar{C})$

The above function can also be expressed as,

$F(A, B, C) = IIM(1, 3, 4, 7)$

The function can be expressed in SOP form as,

$F(A, B, C) = \sum m\,(0, 2, 5, 6)$

$\bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}C + AB\bar{C}$

27. Consider a standard negative feedback configuration with $G(s) = \frac{1}{(s+1)(s+2)}$ and $H(s) = \frac{s+\alpha}{s}$.For the closed loop system to have pole on the imaginary axis, the value of α should be equal to (up to one decimal places)

[Ans. *] Range: 8.9 to 9.1

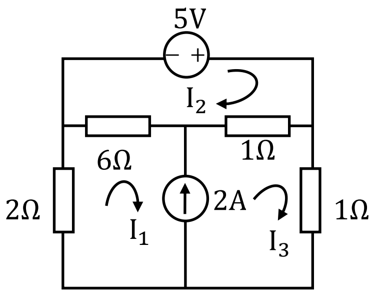
$$G(s) = \frac{1}{(s + 1)(s + 2)}; H(s) = \frac{s + \alpha}{s}$$

$$q(s) = s^3 + 3s^2 + 3s + \alpha = 0$$

For poles on imaginary axis i.e.

Marginal stability, $\alpha = 3 \times 3 = 9$

28. In the given circuit, the mesh current I_1, I_2 *and* I_3 *are*



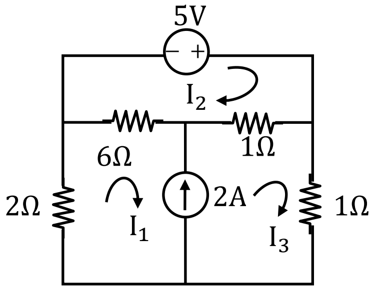
(A) $I_1 = 1\,A, I_2 = 2A$ *and* $I_3 = 3A$

(B) $I_1 = 2\,A, I_2 = 3A$ *and* $I_3 = 4A$

(C) $I_1 = 3\,A, I_2 = 4A$ *and* $I_3 = 5A$

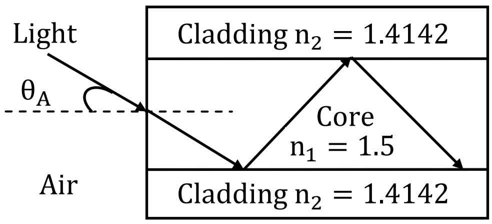
(D) $I_1 = 4\,A, I_2 = 5A$ *and* $I_3 = 6A$

[Ans. A*]



$8I_1 - 6I_2 + 2I_2 - I_2 = 0$.......... (i)
$I_3 - I_1 = 2\ A$.......................... (ii)
$-6I_1 + 7I_2 - I_3 = 5$................ (iii)
By solving above equations,
$I_1 = 1\ A, I_2 = 2\ A\ amd\ I_3 = 3\ A$

29. A multi-mode optical fiber with a large core diameter has a core refractive index $n_1 = 1.5$ and cladding refractive $n_2 = 1.4142$. The maximum value of θ_A (in degrees) for which the incident light from air will be guided in the optical fiber is $\pm$ ____.



[Ans. *]Range: 29 to 31
From the given figure

$$N.A. = n_o \sin\theta_A = \sqrt{n_1^2 - n_2^2}$$

Where,

$n_0 \rightarrow$ Refractive index of air $[n_0 = 1]$
$n_1 \rightarrow$ Refractive index of core $[n_1 = 1.5]$
$n_2 \rightarrow$ Refractive index of cladding $[n_2 = 1.4142]$
$\theta_A \rightarrow$ Maximum acceptance angle

$$\theta_A = sin^{-1}[\sqrt{n_1^2 - n_2^2}]$$
$$\theta_A = sin^{-1}[\sqrt{(1.5)^2 - (1.4142)^2}]$$
$$\theta_A = 30°$$

30. The voltage and current drawn by a resistive load are measured with a 300 V voltmeter of accuracy $\pm 1\%$ of full scale and a 5 A ammeter of accuracy $\pm 0.5\%$ of full scale. The readings obtained are 200 V and 2.5 A. The limiting error (in %) in computing the load resistance is (up to two decimal places) _____.
[Ans. *] Range: 2.49 to 2.51

31. $3x + 2ky = -2$

$kx + 6y = 2$

Here x and y are the unknowns and k is a real constant. The value of k for which there is infinite number of solution is

(A) 3

(B) 1

(C) -3

(D) -6

[Ans. C*]

$3x + 2ky = -2$

$kx + 6y = 2$

$\rho(A/B) = \begin{bmatrix} 3 & 2k & -2 \\ k & 6 & 2 \end{bmatrix}$

$\rho(A) = \rho(A/B) \neq no\ \Omega\ varaiables$

Hence number of variable = 2

$\rho\left(\frac{A}{B}\right) \Rightarrow R_2 \leftarrow R_2 + R_1 \begin{bmatrix} 3 & 2k & -2 \\ k+3 & 6+2k & 0 \end{bmatrix}$

To satisfy above condition

$k + 3 = 0,$

$k = -3$

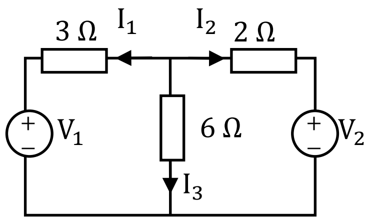
6+2k=0

$k = -3$

For $k - 3$ above equation have infinite solutions

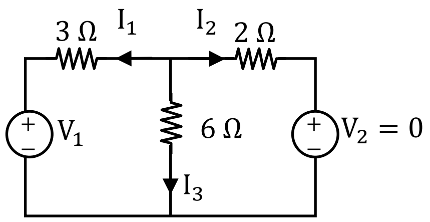
Value of 'k' for which then is infinity solution

32. In the given circuit, superposition is applied when V_2 is set to 0 V, the current I_2 is –6A. when V_1 is set to 0V, the current I_1 $is + 6A$,current I_3 $(in\ A)$when both sources are applied will be (up to two decimal places) _________ .



[Ans. *] Range: 0.95 to 1.05

Case I:

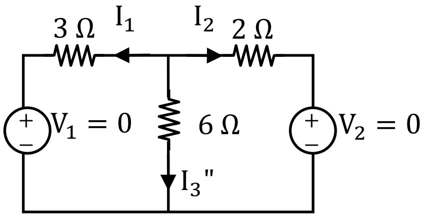


$I_2 = -6\ A$

Apply current division and KCL we get

$I_3' = 2\ A$

Case II:



$I_1 = 6\,A$
Apply current division we get
$I_3" = 3\text{ A}$
$I_3 = I_3' = -2 + 3 = 1\text{ A}$

33. Let $y[n] = x[n] * h[n]$, where * denotes convolution and x[n] and h[n] are two discrete time sequences. Given that the z-transform of y[n] is $Y(z) = 2 + 3z^{-1} + z^{-2}$, the z-transform of $p[n] = x[n] * h[\text{n}-2]$ is

(A) $2 + 3z + z^{-2}$
(B) $3z + z^{-2}$
(C) $2z^2 + 3z + 1$
(D) $2z^{-2} + 3z^{-3} + z^{-4}$

[Ans. D*]

$y[n] = x[n] * h[n]$
$Y(z) = 2 + 3z^{-1} + z^{-1} = X(z) \times H(z)$
$P(z) = z^{-2}[X(z) \times H(z)] = 2z^{-1} + z^{-4}$

34. Given $\vec{F} = (x^2 - 2y)\vec{\imath} - 4yz\vec{\jmath} + 4xz^2\vec{k}$. The value of the line integral $\int_c \vec{F}.d\vec{l}$ along the straight line c from (0, 0, 0) to (1, 1, 1) is

(A) 3/16
(B) 0
(C) $-\frac{5}{12}$
(D) -1

[Ans. D*]

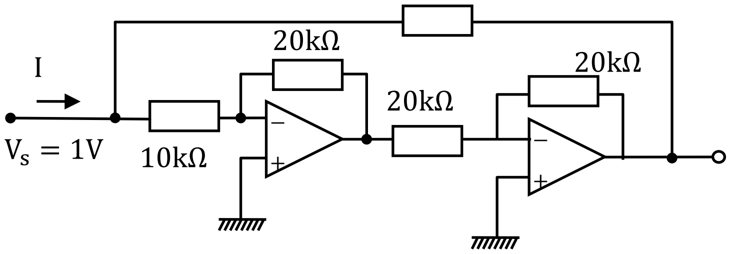
$\vec{f} = (x^2 - 2y)\vec{\imath} - uyz\vec{\jmath} + uxz^2\vec{k}$
$\overrightarrow{di} = d \times \vec{\imath} + dy\vec{\jmath} + dz\vec{k}$
$$\int \vec{f}.\overrightarrow{di} = \int (x^2 - 24)dx - uyz\,dy + uxz^2.dz$$

Giving join two points $\begin{pmatrix} x_2 & y_1 & z_1 \\ 0 & 0 & 0 \\ & p & \end{pmatrix}$ and $\begin{pmatrix} x_2 & y_1 & z_1 \\ 1 & 1 & 1 \end{pmatrix}$ is

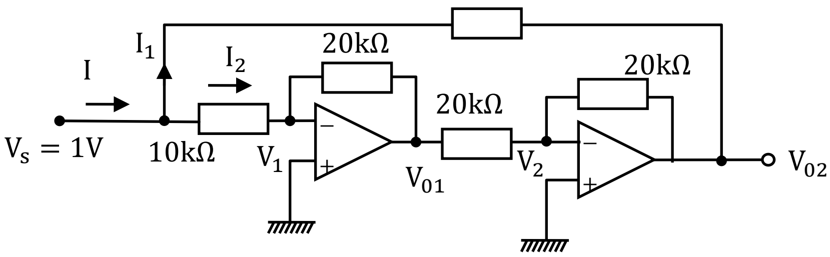
$$\frac{x - x_1}{x_2 - 1} = \frac{y - y1}{y_2 - y_1} = \frac{z - z_1}{z_2 - z_1} = t$$
$$\frac{x - 0}{1 - 0} = \frac{y - 0}{1 - 0} = \frac{z - 0}{1 - 0}t$$
$x = y = z = t \quad (x \to 0\ to\ 1; y \to 0\ to\ 1; z \to 0\ to\ 1\ ; \therefore t \to 0\ to\ 1)$
$dx = dy = dz = dt$
$$\int (x^2 - 2y)dx - uyzdy + uxz^2dz = \int_0^1 (t^2 - 2t)dt - (.ut^2)dt + ut^3dt$$
$$\int_0^1 (-3t^2)dt - 2tdt + ut\text{^}3dt$$

$-3.\frac{t^3}{3}-2\frac{t^2}{2}+u.\frac{t^4}{4}]_0^1 = (-1-1+1)-0$
$= -1$

35. The circuit given uses two ideal op-amps. The current I($in\ \mu A$) drawn from source (up to two decimal places)



[Ans.*] Range: 0.98 to 1.00



Given op-amps are ideal

$V_1 = V_2 = 0V$

$\frac{1-V_1}{10k} = \frac{V_1 - V_{01}}{20k}$

$\Rightarrow (1-0)\times 2 = 0^2 - V_{01}$

$\Rightarrow V_{01} = -2V Now, \frac{V_{01}-V_2}{20k} = \frac{V_2 - V_{02}}{20k}$

$\Rightarrow -2-0 = 0 - V_{02}$

$\Rightarrow V_{02} = 2V$

$\therefore I = I_1 + I_2$

$= \frac{V_s - V_{02}}{1.01k} + \frac{V_s - V_1}{10k}$

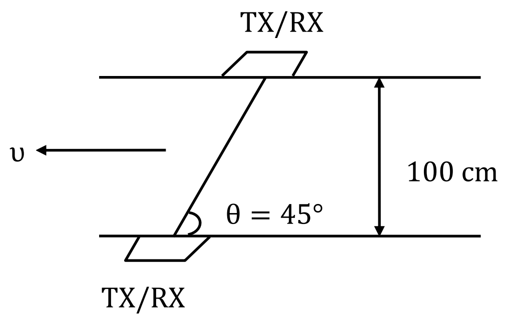
$= \frac{1-2}{10.1\text{ k}} + \frac{1-0}{10k}$

$= \left[\frac{-1}{10.1\ k} + \frac{1}{10k}\right] mA$

$= 0.00099\ mA$

$I = 0.99\ \mu A$

36. The average velocity v of flow of clear water in a 100 cm (inner) diameter tube is measured using the ultrasonic flow meter as shown in the figure. The angle θ is 45°.The measured transit times are $t_1 = 0.9950$ ms and $t_2 = 1.0000$ ms. The velocity v (in m/s) in the pipe is (up to one decimal place) ____.



[Ans. *] Range: 3.9 to 5.7

From the given figure and information

Transit time, $t_1 = 0.995 \times 10^{-3} = \frac{L}{C+v\cos\theta}$

Transit time, $t_2 = 1 \times 10^{-3} = \frac{L}{C+v\cos\theta}$

Where 'L' is the length of the line joining both the transducers.

'C' is velocity of ultra sound in water.

'v' is velocity of fluid in pipe.

$'\theta'$ is the given angle 45°

From the given figure,

$$\sin\theta = \frac{D}{L}$$

$$L = \frac{D}{\sin\theta}$$

$$So, C + v\cos\theta = \frac{L}{0.995 \times 10^{-3}} \ldots\ldots (i)$$

$$C - v\cos\theta = \frac{L}{1 \times 10^{-3}} \ldots\ldots (ii)$$

$(i)-$ (ii)

$$2v\cos\theta = 1000.L\left[\frac{1}{0995} - 1\right]$$

$$2 \times v \times \cos 45 = 1000 \times \frac{100 \times 10^{-2}}{\sin 45}\left[\frac{1}{0.995} - 1\right] \left(\because \frac{LD}{\sin\theta}\right)$$

$$2 \times v \times \frac{1}{\sqrt{2}} = 10^3 \times \sqrt{2} \times (0.00502)$$

V=5.02 m/sec

37. Two bags A and B have equal number of balls. Bag A has 20% red balls and 80% green balls. Bag B has 30% red balls, 60% green balls and 10% yellow balls. Contents of bags A and B are mixed thoroughly and a ball is randomly picked from the mixture. What is the chance that the ball picked is red?

(A) 20%
(B) 25%
(C) 30%
(D) 40%

[Ans. B*]

2 R 8 G

A

3 R 6 G 1 Y

B

Required probability $= \frac{5}{20} = 0.25\ or\ 25\%$

38. Consider the standard negative feedback configuration with $G(s) = \frac{s^2+0.2s+100}{s^2-0.2s+100}$ and $H(s) = \frac{1}{2}$. The number of clockwise encirclements of $(-1, 0)$ in the Nyquist plot of the Loop transfer-function G(s) H(s) is ________

[Ans. *] Range: 0 to 0

$Given, G(s) = \dfrac{s^2 + 0.2s + 100}{s^2 - 0.2s + 100}, H(s) = \dfrac{1}{2}$

$q(s) = 1 + G(s)H(s) = 0$

$= 3s^2 - 0.2s + 300 = 0$

This system is unstable with two roots in right side of s-plane.

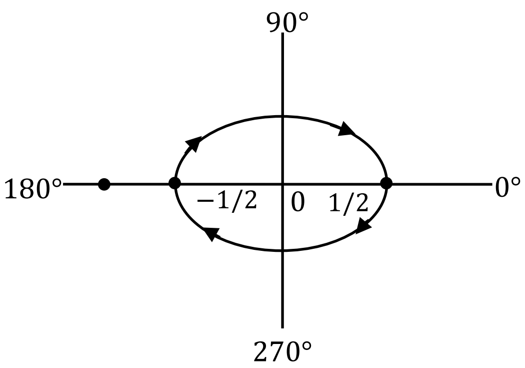
$\therefore P - N = 2$

P=2 since OLTF has two poles in right side of s-plane.

$\therefore N = 0$

Or,

Nyquist plot:



$\because (-1, 0)$ lies outside the circle,

$\therefore \mathrm{N} = 0$

39. A high Q coil having distributed (self) capacitance is tested with a Q-meter. First resonance at $\omega_1 = 10^6 rad/s$ is obtained with a capacitance of 990 pF. The second resonance at $\omega_2 = 2 \times 10^6$is obtained with a 240 pF capacitance. The value of the inductance (in mH) of the coil is (up to one decimal place) _____.

[Ans. *] Range: 0.9 to 1.1

Given, $\omega_1 = 10^6\ rad/sec \quad C_1 = 990\ pF$

$\omega_2 = 2 \times 10^6 \frac{rad}{sec} \quad C_2 = 240\ pF$

Here, $\omega_2 = 2\omega_1$

$\therefore C_d = \dfrac{C_1 - 4C_2}{3} \dfrac{990 - 4 \times 240}{3} 10\ pF$

We know @ resonance

$$f = \frac{1}{2\pi\sqrt{L(C + C_d)}}$$

Or $L = \frac{1}{4\pi^2 f^2 (C+Cd)}$

Total $C = C_1 = 990\ pF$

$$L = \frac{1}{\omega_1^2 (c + C_d)} = \frac{1}{10^6 \times 10^6 \times (990 + 10) \times 10^{-12}}$$

$= 1.0\ mH$

40. A portion of an assembly language program written for an 8-bit microprocessor is given below along with explanations. The code is intended to introduce a software time delay. The processor is driven by a 5 MHz clock. The time delay (in μs) introduced by the program is ____.

MVI B, 64H; Move immediate the given byte into register B. Takes 7 clock periods.
Loop: DCR B; Decrement register B. Affects flags. Takes 4 clock periods.
JNZ LOOP; Jump to address with Label if zero flag is not set. Takes 10 clock periods when jump is performed and 7 clock periods when jump is not performed.

[Ans.*] Range: 279 to 281

$(64\ H)_{16} \rightarrow (100)_{10}$

$Total\ delay\ time$

$= (7 + (100 \times 4) + (99 \times 10) + 7)^{Tclock}$

$Tclock \times (1404)$

$$Tclock = \frac{1}{5\ MHz}$$

$$= \frac{1}{5 \times 10^{-6}} \times (1404)$$

$= 280.8\ \mu sec$

41. An op-amp that is powered from a $\pm$ 5V supply is used to build a non-inverting amplifier having a gain of 1.5. The slew rate of the op-amp is $0.5 \times 10^6 V/s$. For a sinusoidal input with amplitude of 0.3 V, the maximum frequency (in kHz) up to which it can be operated without any distortion is (up to one decimal place) ____.

[Ans. *] Range: 17.5 to 17.9

Given Slew Rate (SR)= $0.5 \times 10^6\ V/s$

$|V_{in}| = 0.3\ V$

$Opamp\ gain = 15$

$|V_o| = 0.3615 = 4.5\ V$

$V_o = |V_o|\ sin(2\pi f t)$

Maximum rate of change of signal to prevent distortion,

$= 2\pi f |V_o|$

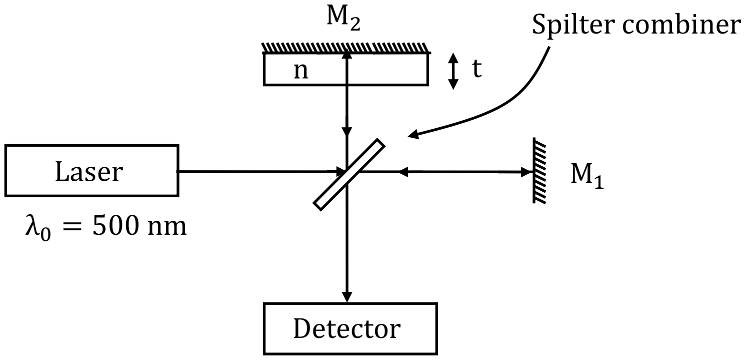
$= 2\pi f |V_o| \leq SR$

$= 2\pi f \times 4.5 = 0.5 \times 10^6$

$\Rightarrow f \leq 500000$

$\therefore f_{max} = 17.6\ kHz$

42. A Michelson Interferometer using a laser source of wavelength $\lambda_0 = 500$ nm, with both the mirrors (M_1 & M_2) fixed and positioned equidistant from the splitter/combiner is shown in the figure. When a dielectric plate of refractive index n = 1.5, of thickness t, is placed in front of the mirror M_2, a dark fringe is observed on the detector. When the dielectric plate is removed without changing the position of the mirrors (M_1 & M_2), a bright fringe is observed on the detector. The minimum thickness t (in nm) of the dielectric is ________



[Ans. *] Range: 249 to 251

From the given explanation, we can understand that, "when a tissue of thickness 't' of refractive index 'N', is placed then a dark fringe is observed'

So, path difference= $\frac{\lambda_0}{2}$

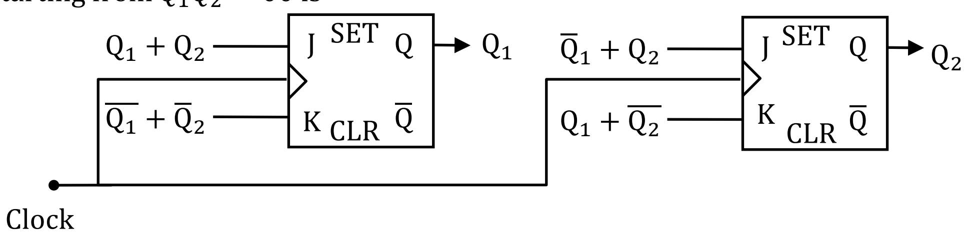
Path difference $= 2(N-1)t$

$$2(N-1)t = \frac{\lambda_0}{2}$$

$$2(105-1)t = \frac{500\ nm}{2}$$

$$t = 250\ nm$$

43. A 2-bit synchronous counter using two J-K flip flops is shown. The expressions for the inputs to the J-K flip flops are also shown in the figure. The output sequence of the counter starting from $Q_1Q_2 = 00$ is



(A) $00 \to 11 \to 10 \to 01 \to 00 \ldots ....$

(B) $00 \to 01 \to 10 \to 11 \to 00 \ldots ....$

(C) $00 \to 01 \to 11 \to 10 \to 00 \ldots ....$

(D) $00 \to 10 \to 11 \to 01 \to 00 \ldots ....$

[Ans. C]

Present state		Flip-Flop Inputs				Next state	
Q_1	Q_2	J_1 (Q_1+Q_2)	K_1 (Q_1+Q_2)	J_2 (Q_1+Q_2)	K_2 (Q_1+Q_2)	Q_1	Q_2
0	0	0	1	1	1	0	1
0	1	1	1	1	0	1	1
1	1	1	0	1	1	1	0
1	0	1	1	0	1	0	0

Hence the sequence of states followed by the counter is,
00, 01, 11, 10, 00, 01…

44. The sampling rate for Compact Discs (CDs) is 44,000 samples/s. If the samples are quantized to 256 levels and binary coded, the corresponding bit rate (in bits per second) is ______

[Ans.*] Range: 352000 to 352000

45. Consider the following

$$\frac{\partial V(x,y)}{\partial x} = px^2 + y^2 + 2xy$$

$$\frac{\partial V(x,y)}{\partial y} = x^2 + qy^2 + 2xy$$

Where p and q are constants, V(x, y) that satisfies the above equation is

(A) $p\frac{x^3}{3} + q\frac{y^3}{3} + 2xy + 6$

(B) $p\frac{x^3}{3} + q\frac{y^3}{3} + 5$

(C) $p\frac{x^3}{3} + q\frac{y^3}{3} + x^2y + xy^2 + xy$

(D) $p\frac{x^3}{3} + q\frac{y^3}{3} + x^2y + xy^2$

[Ans. D*]

Simply check options

Option (A) $V(X_1\, y) = P\frac{X^3}{3} + q\frac{y^3}{3} + 2xy + 6$

$\frac{\partial u}{\partial x} = px^2 + 0 + 2y$ which is not equal t given question

Option (B) $V(x_1 y): \frac{P\,x^3}{3} + q\frac{y^3}{3} + 5$

$\frac{\partial u}{\partial x} = px^2$ This is also wrong

Option (C) $V(x_1 y) = P\frac{x^3}{3} + q\frac{y^3}{3} + x^2y + xy^2 + xy$

$V(x_1 y) = px^2 + 2xy + y^2 + y$ This is also wrong

Option (D) $V(x_1 y) = P\frac{x^3}{3} + q\frac{y^3}{3} + x^2y + xy^2$

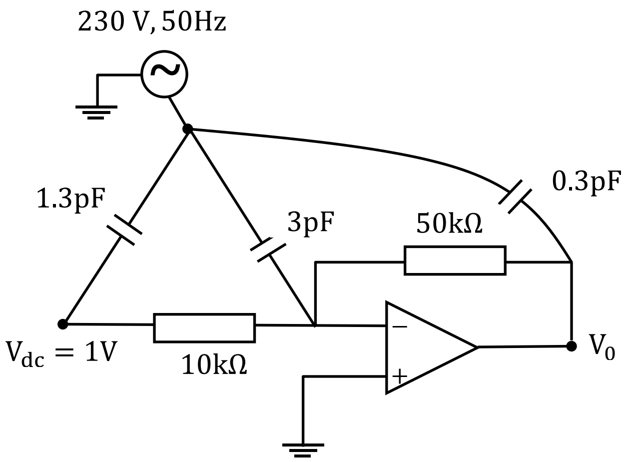
$$\frac{\partial u}{\partial x} = px^2 + 2xy + y^2$$

$$\frac{\partial u}{\partial y} = qy^2 + x^2 + 2xy$$

It is satisfying both conditions so option (D) is correct.

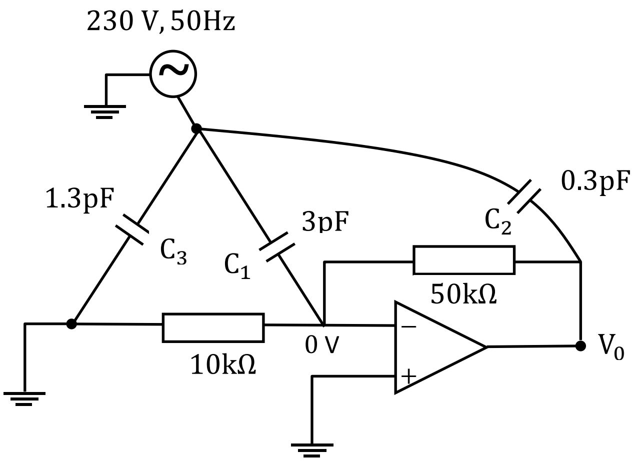
46. Assuming ideal op-amp, RMS voltage (in mV) in the output V_o only due to the 230V, 50Hz

interference is (up to one decimal place) _____.

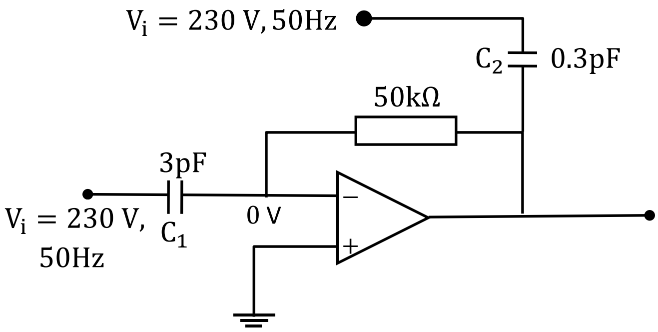


[Ans.*] Range: 10.6 to 11.0

When voltage at the output due to only 230 V, 50 Hz supply is to be calculated, the DC supply should be short circuited as shown below.



C_3 and 10 $k\Omega$ does not play any role in the value of V_0. So, the reduced equivalent circuit can be given as shown below.



$$V_0 = \frac{50\ k\Omega}{1/j\omega C_1} V_i = -j\omega C_1 (50\ k) V_i$$

$$V_{0(rms)} = (2\pi \times 50) \times 3 \times 10^{-12} \times 50 \times 10^3 \times V_{i(rms)}$$

$$= 2\pi \times 75 \times 10^{-7} \times 230\ V$$

$$= \frac{345\pi}{100} mV = 10.84\ mV$$

47. Unit step response of a linear time invariant (LTI) system is given by $y(t) = (1 - e^{-2t})u(t)$.Assuming zero initial condition, the transfer function of the system is

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

[Ans. D*]

$x(t) = u(t) \rightarrow y(t) = (1 - e^{-2t})u(t)$

$\frac{1}{s} \rightarrow Y(s) = \frac{1}{s} - \frac{1}{s+2}\frac{s+2-s}{s(s+2)} = \frac{2}{s(s+2)}$

$H(s) = \frac{2}{s+2}$

48. For the sequence $x(n) = \{1, -1, 1, -1\}$ with n=0,1,2,3 ,the DFT is computes as $X(k) = \sum_{n=0}^{3} x(n)e^{-\frac{j2\pi}{4}nk}$,for k=0,1,2,3.The value of k which X(k) is not zero is

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

[Ans. C*]

$$X[K] = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -j & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}\begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix}$$

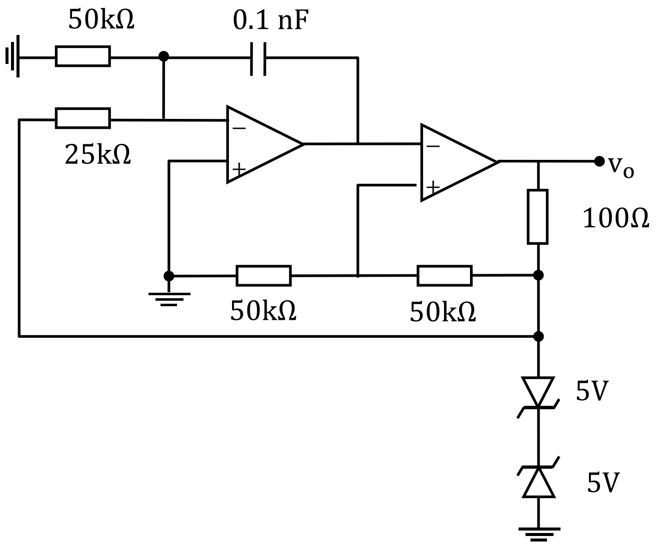
$X[k] = 0$

$X[1] = 1 + j \pm 1 - j = 0$

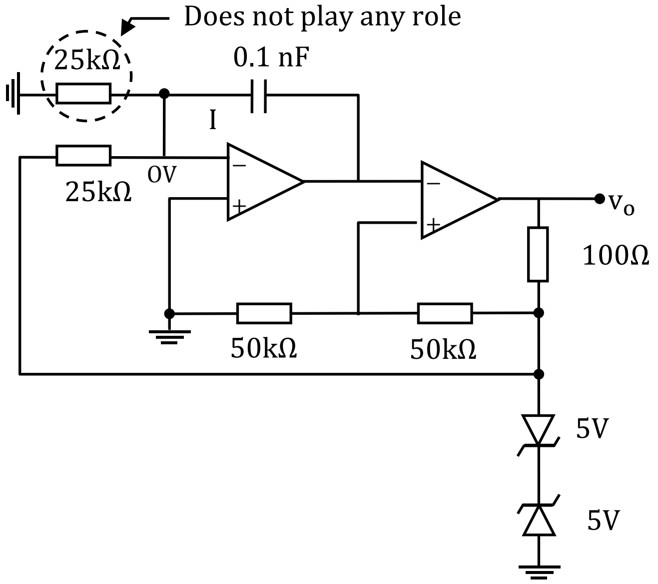
$X[2] = 1 + 1 + 1 + 1 = 4$

X[2] is non-zero

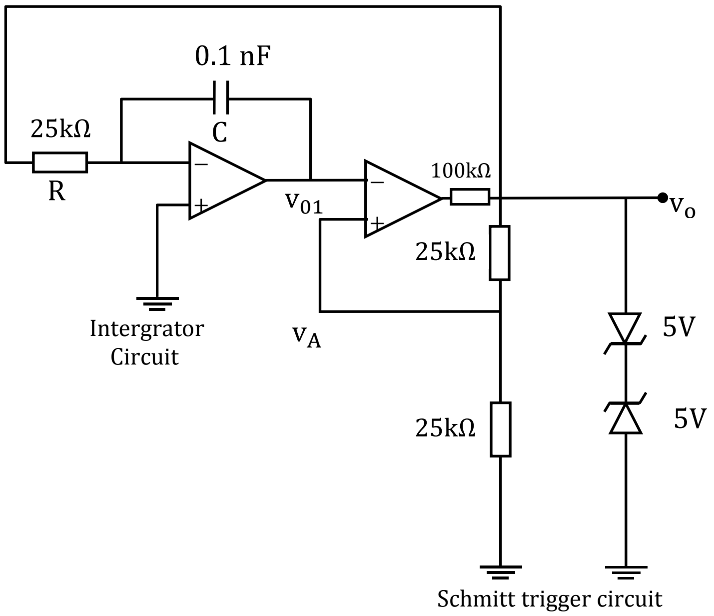
49. In the given relaxation oscillator, the op-amps and the zener diodes are ideal. The frequency (in kHz) of the square wave output v_o is ______.



[Ans.*] Marks to All

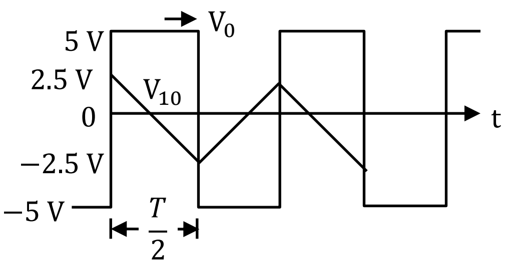


The above circuit can be redrawn as follows:



$$V_{01} = -\frac{1}{RC}\int V_0 dt = k$$

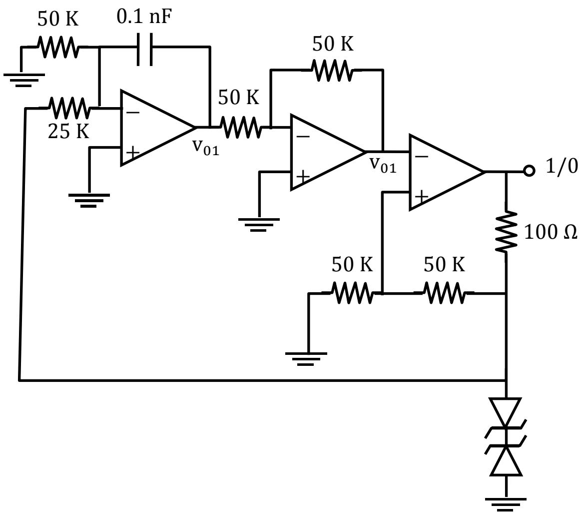
When V_{01} exceed 2.5 V, V_0 falls from 5V to $-5V$.
When V_{01} falls below -2.5 V, V_0 falls from $-5V$ to $-5V$.
Therefore,



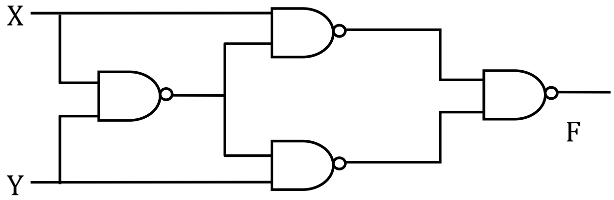
$0 < t < \frac{T}{2}$: $V_0 = +5V; V_A = 2.5\ V$

$$V_{01} = -\frac{1}{RC}\int V_0 dt + k_1 = \frac{-v_0}{RC}t + k_1$$
$$= -\frac{5}{RC}t + 2.5\,V$$
$$\Rightarrow T = 2RC$$
$$\Rightarrow f = \frac{1}{2RC} = \frac{1}{2\times 25\times 10^3 \times 0.1\times 10^{-9}} = 200\,kHz$$

Note: Actually the problem given is wrong. There should be an inventing amplifier circuit with unity gain between the two op-amp circuits. The expected circuit should be as shown below.



50. The Boolean function F(X,Y) realized by the given circuit is



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

(C) $X + Y$ (D) $\bar{X}.\bar{Y}$

[Ans. A*]

$z = \overline{\overline{x.\overline{xy}}.\overline{y.\overline{xy}}}$

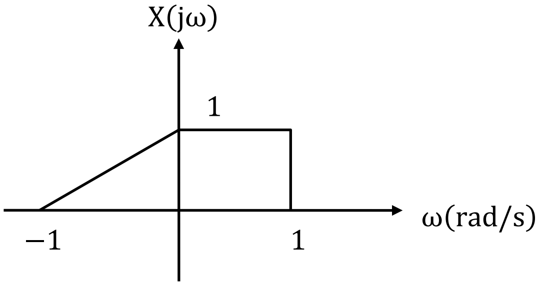
$= x.\overline{xy} + y.\overline{xy}$

$= x(\bar{x} + \bar{y}) + y(\bar{x} + \bar{y})$

$= x\,\bar{y} + \bar{x}\,y$

$z = x \oplus y$

51. The Fourier transform of a signal x(t), denoted by $X(j\omega)$ is shown in the figure.
$Let\ y(t) = x(t) + e^{jt}x(t)$. The value of Fourier transform of y (t) evaluated at the angular
Frequency $\omega = 0.5\,rad/s$ is

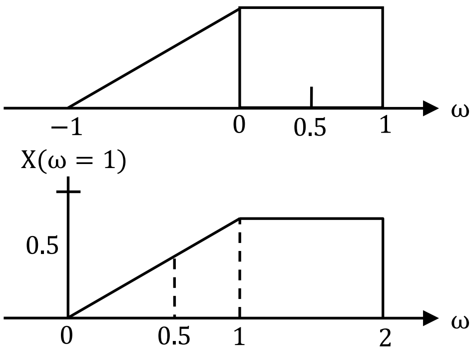


(A) 0.5
(B) 1
(C) 1.5
(D) 2.5

[Ans. C*]

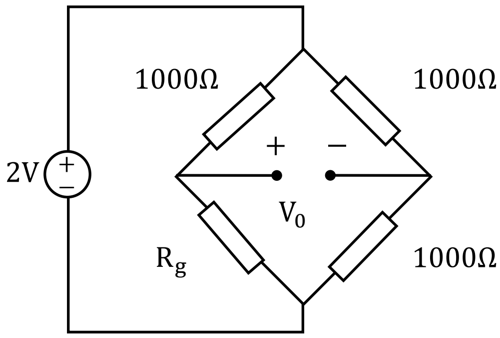
$y(t0 = x(t) + e^{it}x(t)$

$Y(\omega) = X(\omega) + X(\omega - 1)$



$Y(\omega)|_{\omega=0.5} = 1.5$

52. A 1000 Ω strain gage (R_g) has a gage factor of 2.5. It is connected in the bridge as shown in figure. The strain gage is subjected with a positive strain of $400\mu m/m$. The output V_o (in mV) of the bridge is (up to two decimal places) _____.



[Ans. *]Range: 0.49 to 0.51

From the given "Quarter Bridge"

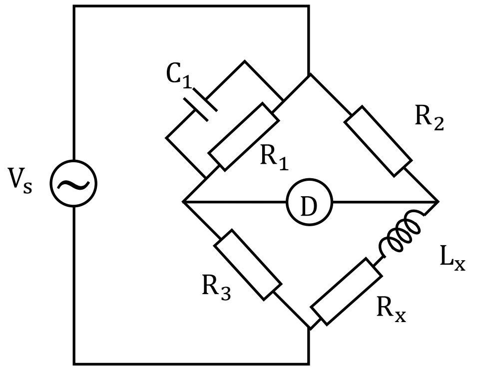
Output voltage of the bridge is

$V_0 = \frac{V_s}{4F_b}.\Delta R$ [where $V_s = 2$ v]

$V_0 = \frac{2}{4R_b}.R_o G_f. \in$ [$\Delta R = R. G_f \in$

$V_o = \frac{2}{4} \times \frac{1000}{1000} \times 2.5 \times 400 \times 10^{-6}; V_o = 0.5$ mV

53. The inductance of a coil is measured using the bridge shown in the figure. Balance (D=0) is obtained with $C_1 = 1\,nF, R_1 = 2.2\,M\Omega, R_2 = 22.2k\Omega, R_4 = 10\,k\Omega$. The value of the inductance $L_x (in\ mH) is$ ________



[Ans. *]Range: 221 to 223

In the given bridge CKT.

$Z_1 = \dfrac{R_1}{1 + j \in C_1 R_1}$

$Z_2 = R_2$

$Z_3 = R_x + j \in L_x$

$Z_4 = R_4$

(2) balance product of impedance of opposite arms are equal.

i.e. $Z_1 Z_3 = Z_2 Z_4$

$\dfrac{R_1}{1 + j \in C_1 R_1}(R_x + j \in L_x) = R_2 R_4$

$R_1 R_x + j \in R_1 L_x = R_2 R_4 = j \in C_1 R_1 R_2 R_4$

Equality the imaginary parts

$L_x = C_1 R_2 R_4$

Substituting the values we have

$L_x = 1 \times 10^{-9} \times 22.2 \times 10^3 \times 10 \times 10^3$

$= 222$ mH.

54. Consider the linear system $\dot{x} = \begin{pmatrix} -1 & 0 \\ 0 & -2 \end{pmatrix} x, with\ initial\ condition\ x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. The solution x(t) for this system is

(A) $x(t) = \begin{bmatrix} e^{-t} & te^{-2t} \\ 0 & e^{-2t} \end{bmatrix}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(B) $x(t) = \begin{bmatrix} e^{-t} & 0 \\ 0 & e^{2t} \end{bmatrix}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(C) $x(t) = \begin{bmatrix} e^{-t} & -te^{-2t} \\ 0 & e^{-2t} \end{bmatrix}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(D) $x(t) = \begin{bmatrix} e^{-t} & 0 \\ 0 & e^{-2t} \end{bmatrix}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$

[Ans. D]

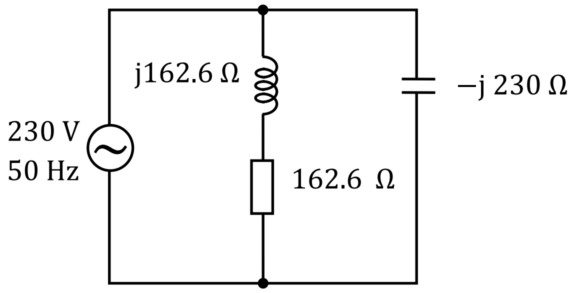
$X = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}; x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

$X(t) = \phi(t).x(0)$

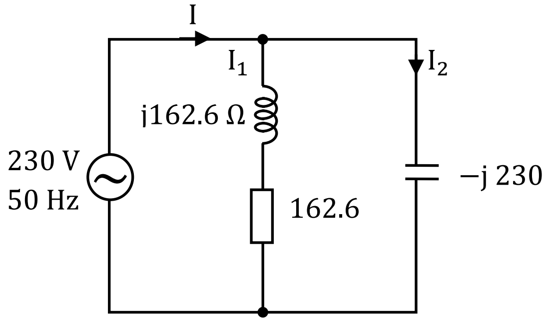
$\phi(t) = L^{-1}[(sI - A)^{-1}] = \begin{bmatrix} e^{-t} & 0 \\ 0 & e^{-2t} \end{bmatrix}$

$\therefore X(t) = \begin{bmatrix} e^{-t} & 0 \\ 0 & e^{-2t} \end{bmatrix}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$

55. In the figure, an RLC load is supplied by a 230 V,50Hz single phase source. The magnitude of the reactive power(in VAR) supplied by the source is ________



[Ans. *]Range: 66 to 68



$$I_1 = \frac{230}{162.6 + j162.6} = 1\angle -45$$

$$I_2 = \frac{230}{230\angle -90} = 1 1\angle -90$$

$$I = I_1 + I_2 = \frac{1}{\sqrt{2}} - j\frac{1}{\sqrt{2}} + j1$$

$$I = 0.707 + j0.293$$

$$= 0.765\angle 22.51$$

$$Q = VI\sin(22.15)$$

$$= 67.36 \text{ VAR}$$