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Memory Based Questions of

GATE 2020

Electrical Engineering

Detailed Solutions

Date of Exam : 8/2/2020

Forenoon Session

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Q.1 NPA is the asset that a customer borrows and holds it for a period of time without paying any interest. RBI has reduced the holding period for NPA thrice during the period 1993-2004. In 1993 it was four quarters (360 days) how many days is the holding period in 2004?

(a) 90 (b) 180
(c) 45 (d) 270

Ans. (a)

End of Solution

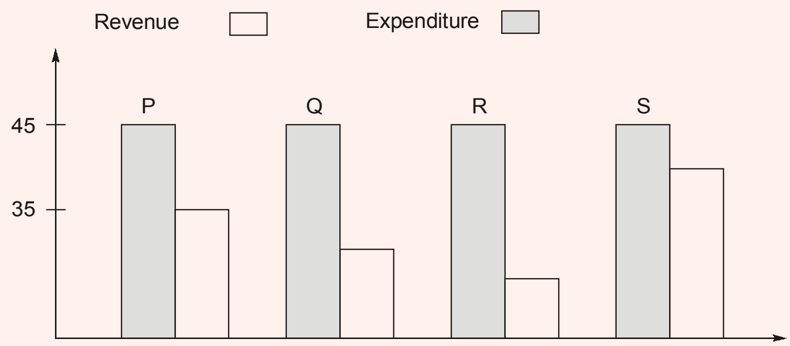
Q.2 Number between 1001 to 9999 how many times 37 occurs in same sequence?

(a) 279 (b) 280
(c) 270 (d) 299

Ans. (a)

End of Solution

Q.3 The revenue and expenditure of four companies P, Q, R, S as shown in the figure below company Q earns a profit of 10% on expenditure of 2014, the revenue of Q in 2015 is ________.



Ans. ()
Data insufficient

End of Solution

Q.4 Stock markets _______ at the news of the coup.

(a) plugged (b) plunged
(c) probed (d) poised

Ans. (b)

End of Solution

Q.5 This book, including all its chapters, ________ interesting. The students as well as instructor ________ in agreement with it.
(a) is, was
(b) is, are
(c) were, was
(d) are, are

Ans. (b)

End of Solution

Q.6 People were prohibited ________ there vehicles near the entrance of the main administrative building.
(a) to park
(b) to have parked
(c) from parking
(d) parking

Ans. (c)

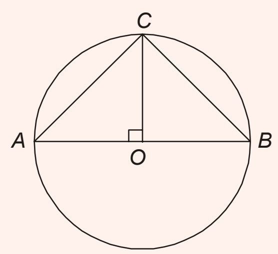
End of Solution

Q.7 Select the word do : undo : : trust :
(a) distrust
(b) entrust
(c) intrust
(d) untrust

Ans. (a)

End of Solution

Q.8 Find the ratio of $\frac{\overline{AC}+\overline{BC}}{\overline{AB}}$ where O is center of the circle shown below.



$\overline{AB}$, $\overline{AC}$ and $\overline{BC}$ are chords.

Ans. (1.414)

End of Solution

Q.9 Z : WV : RQP : ?
(a) KIJH
(b) JIHG
(c) HIJK
(d) KJIH

Ans. (d)

End of Solution

Q.10 If P, Q, R, S are four individual, how many team of size exceeding one can be formed with Q as a member?

(a) 5 (b) 7
(c) 8 (d) 6

Ans. (b)

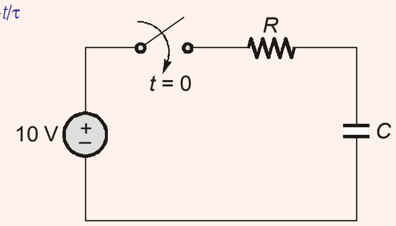
End of Solution

Q.11 A resistor and a capacitor are connected in series to a 10 V dc supply through a switch is closed at $t = 0$, and the capacitor voltage is found to cross '0' voltage at $t = 0.4\tau$ (τ = time constant). The absolute value of % change required in the initial capacitor voltage if the zero crossing has to happen at $t = 0.2\tau$ is _____.

Ans. (54.989)

If initial charge polarities on the capacitor is opposite to the supply voltage then only the capacitor voltage crosses the zero line.

$V_c(t) \Rightarrow$ Final value + (Initial value – Final value) $e^{-t/\tau}$



$$0 = 10 + (-V_0 - 10)\, e^{-0.4}$$
$$10 = (V_0 + 10)\, e^{-0.4}$$
$$V_0 = 4.918 \text{ V}$$

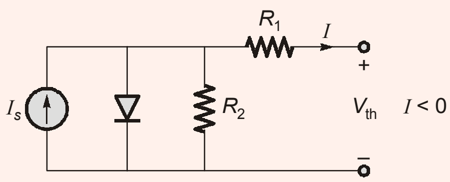
Now, $t = 0.2\tau$

$$0 = 10 + (-V_0' - 10)e^{-0.2}$$
$$V_0' = 2.214$$

$$\%\text{change in voltage} = \frac{4.918 - 2.214}{4.918} \times 100\% = 54.989\%$$

End of Solution

Q.12 To ensure the maximum power transfer across V_{th} the values of R_1 and R_2 will be (Diode in figure is silicon diode)

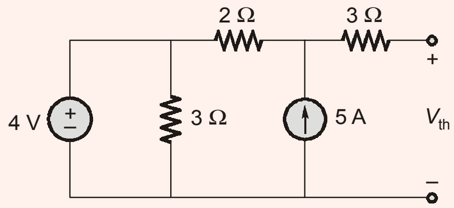


(a) R_1 high, R_2 high (b) R_1 low, R_2 low
(c) R_1 low, R_2 high (d) R_1 high, R_2 low

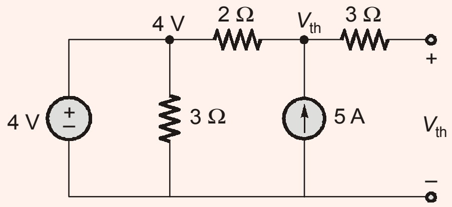
Ans. (b)

End of Solution

Q.13 For the given circuit the value of V_{th} is ______.



Ans. **(14)**

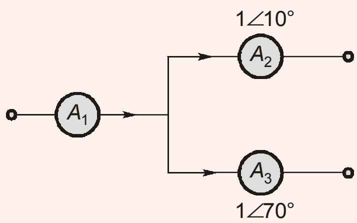


$$\frac{V_{th} - 4}{2} = 5$$

$$V_{th} = 14 \text{ V}$$

End of Solution

Q.14 In the given circuit rms value of I_1 is _____.



Ans. **(1.732)**

From KCL,

$$I_1 = 1\angle 10 + 1\angle 70$$

$$I_1 = 1.732\angle 40$$

End of Solution

Q.15 If 2001 → 98H
2002 → B1H

```
LXI   H, 2001H
MVI   A, 21H
INX   H
ADD   M
INX   H
MOV   M, A
HLT
```

The content of 2003H is $(\_\_\_\_)_{10}$.

Ans. (210)

LXI H, 2001 H → $\overset{H}{\boxed{20}}\overset{L}{\boxed{01}}$

MVI A, 21 H → $\overset{A}{\boxed{21\,H}}$

INX H → HL + 1 $\overset{H}{\boxed{20}}\overset{L}{\boxed{02}}$

ADD M → [A] + data @ reference of HL pair
21 H + B1H = D2H → [A]

INX H → [HL] + 1 → 2002H + 1H → 2003H

MOV M, A → [A] to Memory, i.e., @ reference of HL pair

2003H $\boxed{D2} \leftarrow \overset{A}{\boxed{D2}}$

HLT → Stop

∴ content in the 2003 H is D2H

Converting in decimal

$D \times 16^1 + 2 \times 16^\circ \Rightarrow 13 \times 16 + 2 = (210)_{10}$

End of Solution

Q.16 A differential equation with $y(t)$ → output and $x(t)$ → input is

$$\frac{d^2y(t)}{dx^2} + 4y(t) = 6x(t)$$

The poles of the input

(a) $-2j, +2j$
(b) $+4, -4$
(c) $-2, +2$
(d) $+4j, -4j$

Ans. (a)

$$\frac{d^2y(t)}{dt^2} + 4y(t) = 6x(t)$$

Taking Laplace transform,

$$s^2Y(s) + 4Y(s) = 6X(s)$$

$$\frac{Y(s)}{X(s)} = \frac{6}{s^2+4}$$

$\therefore$ Poles are at $s^2 + 4 = 0$

$$\Rightarrow \quad s = \pm 2j$$

End of Solution

Q.17 A PMDC motor is connected to 5 V at t = 0. Its speed increases from 0 to 6.32 rad/sec monotonically from t = 0 to t = 0.5s and finally settles down to 10 rad/sec. Assume negligible armature inductance. Find the transfer function?

(a) $\frac{10}{1+0.5s}$

(b) $\frac{10}{s+0.5s}$

(c) $\frac{2}{1+0.5s}$

(d) $\frac{2}{s+0.5}$

Ans. (c)

6.32 is 63% of 10.

$\therefore$ t = 0.5s is nothing but time constant

Also, output is double of input.

$\therefore$ DC gain of system is 2.

Hence, option (c) is correct.

Alternative Solution :

When the armature inductance is neglected the transfer function of PMDC motor becomes,

$$\frac{\omega_m(s)}{V_a(s)} = \frac{k_m}{1+sT_m} \quad \text{...(i)}$$

$$\Rightarrow \quad \omega_m(s) = V_a(s)\cdot\frac{k_m}{1+sT_m}$$

As input is 5 V i.e. $V_a(s) = \frac{5}{s}$

$$\therefore \quad \omega_m(s) = \frac{5\,k_m}{s(1+sT_m)} \quad \text{...(ii)}$$

As the final value of w_m = 10 rad/sec

Using final value theorem,

$$\lim_{x\to 0} s\omega_m(s) = \lim_{s\to 0} s\frac{5k_m}{s(1+sT_m)} = 10$$

$$\Rightarrow \quad k_m = 2$$

From (ii) equation, $\omega_m(s) = \frac{10}{s(1+sT_m)} = \frac{a_0}{s} + \frac{a_1}{1+sT_m}$

$$\omega_m(s) = \frac{10}{s} - \frac{10T_m}{1+sT_m}$$

$$\omega_m(t) = 10 - 10^{-t/T_m}$$

It is given that at $t = 0.5$ sec,

$$\omega_m = 6.32 \text{ rad/sec}$$

$$\therefore \quad 6.32 = 10 - 10e^{-0.5/T_m}$$

$$\Rightarrow \quad e^{-0.5/T_m} = 0.368$$

$$\frac{-0.5}{T_m} = \ln(0.368)$$

$$\frac{-1}{2T_m} = -0.999$$

$$T_m = \frac{1}{1.999} \simeq \frac{1}{2} = 0.5$$

Substituting the value of k_m and T_m in T.F. in equation (i)

$$\frac{\omega_m(s)}{V_a(s)} = \frac{2}{1+0.5s}$$

End of Solution

Q.18 For the given open loop transfer function $\frac{K}{(s+a)(s-b)(s+c)}$. If $1 + G(s)H(s)$ plane encircles the origin once in counter clockwise direction then number of closed loop poles in right side of s-plane will be

Ans. (0)

$$N_+ = P_+ - Z_+$$

$$N_+ = +1 \text{ (as CCW direction)}$$

$$P_+ = 1$$

$$\therefore \quad Z_+ = P_+ - N_+$$

$$= 1 - 1 = 0$$

End of Solution

Q.19 For the given open loop transfer function with unity negative feed back gain,

$$G(s)H(s) = \frac{s^2+s+1}{s^3+2s^2+2s+K}$$

The value of gain K. For which closed loop system is marginally stable will be ________ .

Ans. (8)

CE is $\quad 1 + G(s)H(s) = 0$

$$\Rightarrow \quad 1 + \frac{s^2+s+1}{s^3+2s^2+2s+K} = 0$$

$$\Rightarrow \quad s^3 + 3s^2 + 3s + (1 + K) = 0$$

R.H. criteria

$$\begin{array}{c|cc} s^3 & 1 & 3 \\ s^2 & 3 & (1+K) \\ s^1 & 9-(1+K) & 0 \end{array}$$

for marginal stability

$$9 - (1 + K) = 0$$

$$\Rightarrow \quad K = 8$$

End of Solution

Q.20 A stable LTI system with single pole P, has a transfer function $G(s)H(s) = \dfrac{s^2+100}{s-P}$ with DC gain of 5; the smallest possible frequency in radian/sec at only gain is

(a) 11.08
(b) 70.13
(c) 122.07
(d) 8.84

Ans. (d)

$$G(s)\,H(s) = \frac{s^2+100}{s-p}$$

Given, $K = 5$

$$\frac{s^2+100}{-P\left(1-\frac{S}{P}\right)} = 100\frac{\left(1+\frac{s^2}{100}\right)}{-P\left(1-\frac{s}{P}\right)}$$

$$\text{DC gain} = -\frac{100}{P} = 5$$

$$\Rightarrow \quad P = -20$$

$$\therefore \quad G(s)\,H(s) = \frac{s^2+100}{s+20}$$

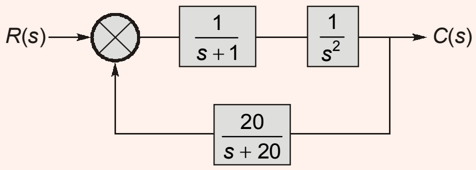
$$G(j\omega)\,H(j\omega) = \frac{100-\omega^2}{20+j\omega}$$

$$|G(j\omega)H(j\omega)| = \frac{100-\omega^2}{\sqrt{20^2+\omega^2}} = 1$$

$$\Rightarrow \quad \omega = 8.84 \text{ rad/sec}$$

End of Solution

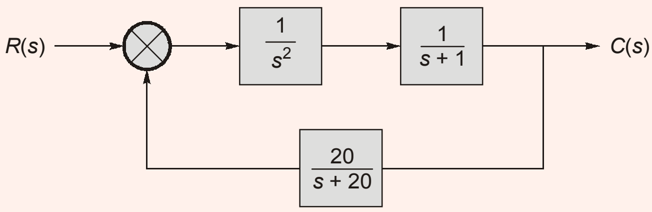
Q.21 For the given block diagram of the system



which of the following is true regarding order and stability of the system

(a) 4^{th} order and stable
(b) 4^{th} order and unstable
(c) 3^{rd} order and unstable
(d) 3^{rd} order and stable

Ans. (b)



CE is $\quad 1 + G(s)\,H(s) = 0$

$$1+\frac{1}{s^2(s+1)}\times\frac{20}{(s+20)} = 0$$

$$\Rightarrow \quad (s^3 + s^2)\,(s + 20) + 20 = 0$$

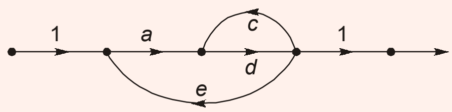
$$s^4 + 21s^3 + 20s^2 + 20 = 0$$

$$s^4 + 21s^3 + 20s^2 + 20 = 0$$

As coefficient of s' is missing system is of 4^{th} order and unstable.

End of Solution

Q.22 Which of the given below signal flow is analogous to given below system?



Ans. ()

End of Solution

Q.23 Given $\vec{D} = 15\hat{a}_\rho + 2P\hat{a}_\phi - 3Pz\hat{a}_z \left(\frac{\text{C}}{\text{m}^2}\right)$, find electric flux crossing the cylinder $\rho = 3$ m; 3 varying from 0 to 5.

Ans. (180π)

$$\psi/\text{Crossing closed surface} = \oint\!\!\oint \vec{D}\cdot\vec{ds} = \iiint(\vec{\nabla}\cdot\vec{D})\,dv \qquad ...(i)$$

$$\vec{\nabla}\cdot\vec{D} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho D_\rho)+\frac{1}{\rho}\frac{\partial D_\phi}{\partial\phi}+\frac{\partial D_z}{\partial z}$$

$$= \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho 15) + \frac{1}{\rho}\frac{\partial}{\partial \phi}(2\rho) + \frac{\partial}{\partial z}(-3\rho z) = \frac{1}{\rho}15 - 3P$$

$$\iiint (\vec{\nabla}\cdot\vec{D})\, dv = \iiint\left(\frac{15}{\rho} - 3\rho\right)\rho\, d\rho\, d\phi\, dz$$

$$= \iiint 15\, d\rho\, d\phi\, dz - 3\iiint \rho^2\, d\rho\, d\phi\, dz$$

$$= 15\int_{\rho=0}^{3} d\rho \int_{\phi=0}^{2\pi} d\phi \int_{z=0}^{5} -3\int_{\rho=0}^{3}\rho^2 d\rho \int_{\phi=0}^{2\pi} d\phi \int_{z=0}^{5} dz$$

$$= 15(3-0)(2\pi)(5) - 3\left(\frac{3^3}{3}\right)(\in\pi)(5)$$

$$= 45(10\pi) - 27\,(10\pi) = 180\pi = 565.2 \text{ C}$$

End of Solution

Q.24 The vector function expressed by

$$F = a_x(5y - k_1 z) + a_y(3z + k_2 x) + a_z(k_3 y - 4x)$$

represent a conservative field, where a_x, a_y, a_z are unit vector along x, y, z directions, respectively the value of constant k_1, k_2 and k_3 ________.

(a) 4, 5, 3
(b) 8, 3, 7
(c) 0, 0, 0
(d) 3, 8, 5

Ans. (a)

$$\bar{F} = (5y - k_1 z)\hat{i} + (3z + k_2 x)\hat{j} + (k_3 y - 4x)\hat{k}$$

is conservative field

$\bar{F}$ is irrotational, $\nabla \times \bar{F} = 0$

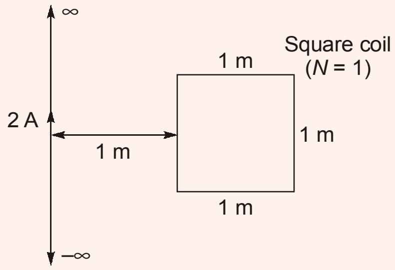
$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 5y - k_1 z & 3z + k_2 x & k_3 y - 4x \end{vmatrix} = 0$$

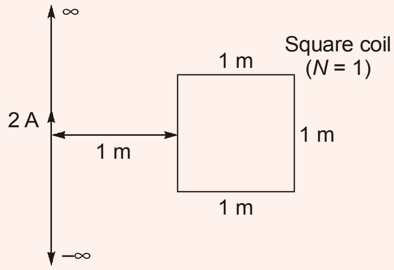
$$\hat{i}(k_3 - 3) - \hat{j}(-4 + k_1) + \hat{k}(k_2 - 5) = 0$$

$k_3 - 3 = 0$	$4 - k_1 = 0$	$k_2 - 5 = 0$
$k_3 = 3$	$k_1 = 4$	$k_2 = 5$
$k_1 = 4$	$k_2 = 5$	$k_3 = 3$

End of Solution

Q.25 The value of mutual inductance figure shows long wire carrying current 2 A placed in away from square coil as shown in figure. The value mutual inductance will be ____. nH.





Ans. (138.6)

$$\phi \propto I$$
$$\phi = MI$$
$$\vec{B} = \frac{\mu_o I}{2\pi\rho}\hat{a}_\phi \quad (\vec{B} \text{ due to infinite long line})$$

Magnetic flux crossing square loop is

$$\phi = \iint \vec{B}\cdot\vec{ds}$$
$$= \iint \frac{\mu_o I}{2\pi\rho}\hat{a}_\phi \cdot (d\rho\, dz)\,\hat{a}_\phi = \frac{\mu_o I}{2\pi}\int_{\rho=1}^{2}\frac{d\rho}{\rho}\int_{z=0}^{1} dz$$
$$\phi = \frac{\mu_o I}{2\pi}(\ln\rho)_{\rho=1}^{2}(z)_{z=0}^{1}$$
$$\phi = \frac{\mu_o I}{2\pi}(\ln 2)$$
$$m = \frac{\phi}{I}$$
$$m = \frac{\mu_o(\ln 2)}{2\pi} = \frac{4\pi\times 10^{-7}(\ln_2)}{2\pi}$$
$$m = 1.386 \times 10^{-7} \text{ Henry}$$

End of Solution

Q.26 In a dielectric medium $\varepsilon_r = 2.25$ and $\vec{E} = 2r\,\hat{a}_r + \frac{3}{r}\hat{a}_\phi + 6\hat{a}_z$ in cylindrical, then find volume charge density

(a) $2\epsilon_o$
(b) $3\epsilon_o$
(c) $4\epsilon_o$
(d) $9\epsilon_o$

Ans. (d)

$$\vec{D} = \epsilon\,\vec{E} = \epsilon_o\epsilon_r\,\vec{E}$$
$$\vec{D} = \epsilon_o\, 2.25\left(2r\,\hat{a}_r + \frac{3}{r}\hat{a}_\phi + 6\hat{a}_z\right)$$

$$\vec{D} = 4.5 \epsilon_o r \hat{a}_r + \frac{6.75 \epsilon_o}{r} \hat{a}_\phi + 13.5 \epsilon_o \hat{a}_z$$

Volume charge density

$$\rho_v = \vec{\nabla} \cdot \vec{D}$$

$$\rho_v = \frac{1}{r}\frac{\partial}{\partial r}(rD_r) + \frac{1}{r}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z}$$

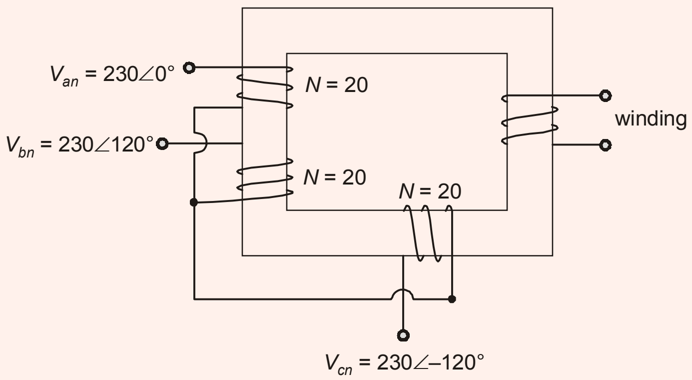
$$\rho_v = \frac{1}{r}\frac{\partial}{\partial r}(r4.5\epsilon_o r) + \frac{1}{r}\frac{\partial}{\partial \phi}\left(\frac{6.75\epsilon_o}{r}\right) + \frac{\partial}{\partial z}(13.5\epsilon_o)$$

$$= \frac{1}{r}\frac{\partial}{\partial r}(4.5\epsilon_o r^2) + 0 + 0$$

$$= \frac{1}{r}(4.5\epsilon_o)(2r) = 9\epsilon_o$$

End of Solution

Q.27 In the given figure, the three windings having polarity as shown above, are connected to 3-ϕ, balanced supply. The number of turns in the supply winding is 20, the voltage seen in winding X having N = 2 turns will be



Ans. (46)

$$V_4 = \frac{2}{20}(230\angle 0° - 230\angle 120° - 230\angle -120°)$$

$$= 46\angle 0° \text{ V}$$

End of Solution

Q.28 A cylindrical rotor synchronous generator delivering constant active power at a constant terminal voltage, a current of 100 A at a 0.9 p.f. lagging. A shunt reactor is connected so that the reactive power demand doubles then the new value of armature current is ______ A.

Ans. (125.29)

At $P_{constant}$, $\quad I_{a1} \cos \phi_1 = I_{a2} \cos \phi_2$

$$\cos \phi_1 = 0.9$$

$$\tan \phi_1 = 0.484 = \frac{Q}{P}$$

$$\Rightarrow \quad \frac{2Q}{P} = 0.9686 = \tan \phi_2$$

$$\cos \phi_2 = 0.7182$$

$$\therefore \quad 100 \times 0.9 = I_{a2} \times 0.7182$$

$$\Rightarrow \quad I_{a2} = 125.29 \text{ A}$$

End of Solution

Q.29 A cylindrical rotor generator having internal emf $1 + j0.7$ V and terminal voltages $(1 + j\,00$ V). The synchronous reactance is 0.7 pu whereas subtransient reactance is 0.2 pu for 3-ϕ bolted short circuit at generator the value of subtransient generated internal emf is ______.

Ans. (1.019)

Prefault current, $I_0 = \dfrac{E_f - V_t}{jX_d} = \dfrac{1 + j0.7 - 1}{j0.7} = 1$

Subtransient induced emf,

$$E_f'' = V_0 + jX_d'' I_0 = 1 + j0.2 \times 1 = 1 + j0.2$$

End of Solution

Q.30 4 kVA, 200/100 V, 50 Hz single phase transformer has no load core loss of 450 W. If high voltage side is energized by 160 V, 40 Hz, the core loss will be 320 W. Find the core loss if the high voltage side is energized by 100 V, 25 Hz.

Ans. (162.5)

200 V, 50 Hz, $P_c = 450$ Watt

160 V, 40 Hz, $P_c = 320$ Watt

100 V, 25 Hz, $P_c = ?$ Watt

$$\frac{V}{f} = \text{const.} = \frac{200}{50} = \frac{160}{40} = \frac{100}{25}$$

So, $\quad P_c = Af + Bf^2$

$$450 = A \times (50) + B \times (50)^2 \quad \text{...(i)}$$

$$320 = A \times (40) + B \times (40)^2 \quad \text{...(ii)}$$

From (i) and (ii),

$$\frac{450}{50} = A + B(50) \quad \text{...(iii)}$$

$$\frac{320}{40} = A + B(40) \quad \text{...(iv)}$$

(iii) – (iv),

$$(9 - 8) = B(10)$$

$$B = \frac{1}{10}$$

and $$A = 9 - \frac{1}{10} \times 50$$

$$A = 4$$

Now at 100 V, 25 Hz,

$$P_c = 4 \times 25 + \frac{1}{10} \times (25)^2$$

$$= 100 + 62.5 = 162.5 \text{ Watt}$$

End of Solution

Q.31 A 3-ϕ, 50 Hz, 4 pole induction motor runs at no load with a slip of 1%, at full load the motor runs at a slip of 5%. The percentage speed regulation of the motor is _____.

Ans. (4.02)

4 pole, 50 Hz I.M has no load slip 1%

4 pole, 50 Hz I.M has full load slip 5%

$$N_S = 1500 \text{ rpm}$$

$$N_0 = N_s(1 - s) = 1500(1 - 0.01) = 1485$$

$$N = N_s(1 - s) = 1500(1 - 0.01) = 1425$$

Speed regulation is

$$\%\text{S.R.} = \frac{N_0 - N}{N} \times 100 = \frac{1485 - 1425}{1425} \times 100 = 4.02\%$$

End of Solution

Q.32 A sequence detector is designed to detect precisely 3 digital inputs, with overlapping sequence detectable. For the sequence (1, 0, 1) and input data (1,1,0,1,0,0,1,1,0,1,0,1,1,0) the output is

Ans. ()

End of Solution

Q.33 A synchronous generator has lossless reactance X_s. Then V_A is terminal voltage and E_f is internal emf voltage.

P : If power factor is leading then always $V_A > E_f$

Q : If power factor is lagging then always $V_A < E_f$

Which of the statement is true?

(a) P is false, Q is true
(b) P is false, Q is false
(c) P is true, Q is true
(d) P is true, Q is false

Ans. (a)

End of Solution

Q.34 A 250 DC shunt motor having armature resistance of 0.2 Ω and field resistance of 100 Ω. It draws a no load current of 5 A at 1200 rpm. The brush drop is 1 V per brush at all operating conditions. If motor draws 50 A at fulled load and flux per pole is decreased by 5% because of armature reaction. The speed of the motor at full load is ____ rpm.

(a) 900
(b) 1000
(c) 1200
(d) 1220

Ans. (d)

No load current 5 A

$$\text{B.R.D} = 1 \text{ V per brush}$$

$$\text{loaded, } I_L = 50 \text{ A}$$

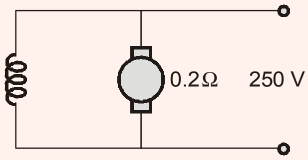
$$R_{sh} = 100\ \Omega$$

$$I_{sh} = \frac{250}{100} = 2.5 \text{ A}$$

$$I_{a0} = 2.5 \text{ A}$$

$$I_{aL} = 47.5 \text{ A}$$

$$V = E_b + I_a R_a + \text{B.R.D}$$



$$E_{b\text{ no load}} = V - I_{a0} R_a - \text{B.R.D}$$

$$= 250 - 2.5(0.2) - 1 \times 2$$

$$= 247.5 \text{ Volts}$$

$$E_{b\text{ load}} = 250 - 47.5(0.2) - 1 \times 2$$

$$= 238.5 \text{ volts}$$

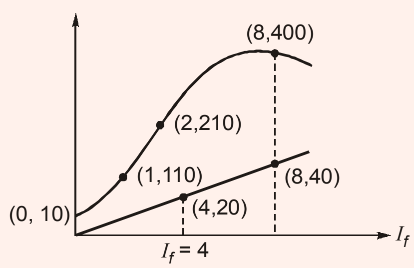
$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2}$$

$$\frac{N_2}{1200} = \frac{238.5}{247.5} \times \frac{\phi_1}{0.95\phi_1}$$

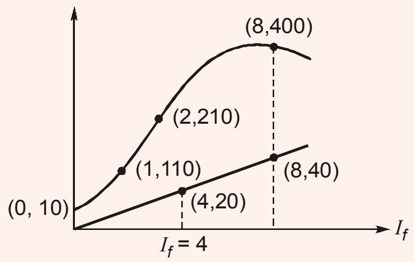
$$N_2 = 1217.22 \text{ rpm}$$

End of Solution

Q.35 Find $\dfrac{Z_{(\text{unsaturated})}}{Z_{(\text{Saturated})}} = ?$



Ans. **(2.05)**



$$X_{s\ unsat} = \frac{410}{20} = 20.5\ \text{V}$$

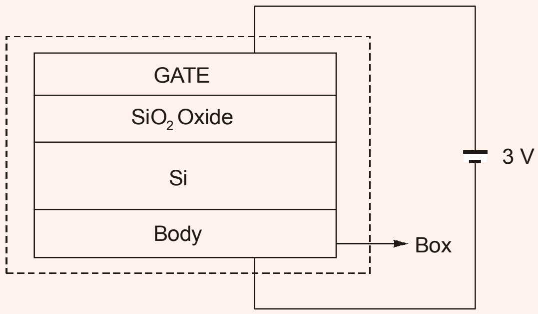
$$X_{sat} = \frac{400}{40} = 10\ \Omega$$

$$\Rightarrow \qquad \frac{X_{s\,un\,sat}}{X_{s\,sat}} = 2.05$$

(Data may not be accurate as it is a memory based graphical question.)

End of Solution

Q.36 DC bias voltage of 13 V is applied between gate and body time. The charge measured in the silicon dioxide layer is +Q,



The total charge in the box region is ________ multiple of +Q. (Give answer to nearest integer)

Ans. **(#)**

A

End of Solution

Q.37 A diode is biased of –0.03 V having an ideality factor of $\frac{15}{13}$; and V_T = 26 mV; if the current has to be rased to 1.5 times of the than required voltage will be

(a) –4.5 V
(b) –0.09 V
(c) –0.02 V
(d) None of above

Ans. **(c)**

Given data: $V_{D1} = 0.03\ \text{V} = -30\ \text{mV}$

$$\eta = \frac{15}{13}; \quad V_T = 26\ \text{mV}$$

$$I_{D2} = 1.5\, I_{D1}$$

$$I_{D2} = I_s e^{V_{D2}/\eta V_T} \qquad \ldots(i)$$

$$I_{D1} = I_s e^{V_{D1}/\eta V_T} \qquad \ldots(ii)$$

Equation (i) and (ii),

$$\frac{I_{D2}}{I_{D1}} = e^{V_{D2}-V_{D1}/\eta V_T}$$

$$V_{D2} - V_{D1} = \eta V_T \ln\left(\frac{I_{D2}}{I_{D1}}\right)$$

$$= \frac{15}{13}\times 26 \text{ mV} \ln\left(\frac{1.5 I_{D1}}{I_{D1}}\right)$$

$$= 15 \times 2 \text{ mV} \ln(1.5)$$

$$= 30 \text{ mV} \times 0.40 = 12 \text{ mV}$$

$$V_{D2} - (-30 \text{ mV}) = 12 \text{ mV}$$

$$V_{D2} = 12 \text{ mV} - 30 \text{ mV}$$

$$= -18 \text{ mV} = -0.018 \text{ V}$$

End of Solution

Q.38 For a common source amplifier $g_m = 520\ \mu A/V^2$ and $r_d = 4.7\ k\Omega$ calculate gain of amplifier.

(a) –2.447 (b)

(c) (d)

Ans. (a)

$$g_m = 520\ \mu A/V^2$$

$$r_d = 4.7\ k\Omega$$

$$A_v = -g_m r_d$$

$$= -520\ \mu A/V^2 \times 4.7\ k\Omega$$

$$= -2.447$$

End of Solution

Q.39 A causal control system having poles at (–2, 1), (2, –1) and zeros at (2, 1) and (–2, –1). Identify the nature of transfer function.

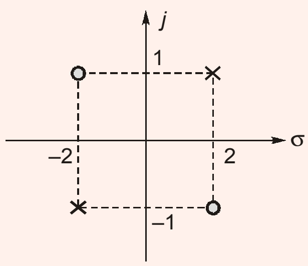
(a) Unstable, complex, all pass (b) Stable, real, all pass

(c) Unstable, complex, HP (d) Stable, real, HPF

Ans. (a)

All pass filter because poles and zeros are mirror-image of eachother (i..e for each pole there is a mirror-image zero).

Unstable because one pole in the RHS of s-plane.



$$\Rightarrow \quad H(s) = \frac{[s-(-2+j)\,[s-(2-j)]}{s-(2+j)]\,[s-(-2-j)]}$$

$$= \frac{[s+(2-j)\,[s-(2-j)]}{[s-(2+j)]\,[s+(2+j)]}$$

$$= \frac{s^2-(2-j)^2}{s^2-(2+j)^2} = \frac{s^2[4-1-4j]}{s^2-[4-1+4j]} = \frac{s^2-(3-4j)}{s^2-(3+4j)}$$

Transfer function is complex.

$h(t)$ or impulse response will be also complex because poles are not occuring in conjugate pair as well as zeros are also not occuring in conjugate pair.

End of Solution

Q.40 $x(t) * h(t) = y(t)$, where $h(t)$ is impulse response.

$|x(t)| * |h(t)| = z(t)$ then which of the following is correct.

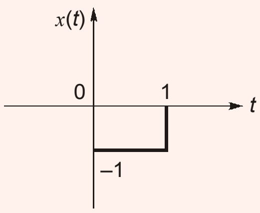
(a) For every $-\infty < t < \infty$, $z(t) \le y(t)$
(b) For every $-\infty < t \le \infty$, $z(t) \ge y(t)$
(c) For some $-\infty < t < \infty$, $z(t) \le y(t)$
(d) For some $-\infty < t \le \infty$, $z(t) \ge y(t)$

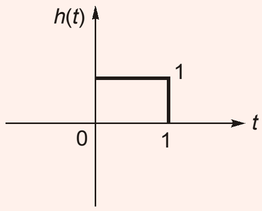
Ans. (b)

Since, $y(t) = x(t) + h(t)$

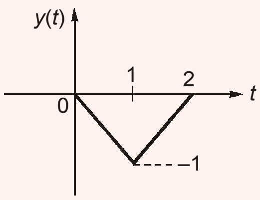
and $z(t) = |x(t)| \times |h(t)|$

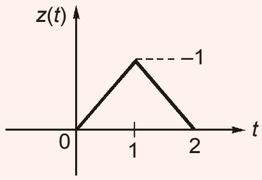
Case-1:



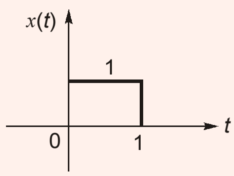


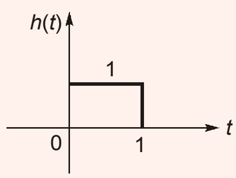
then, $y(t)$ and $z(t)$



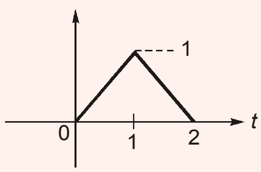


Case-2:





then, $y(t) = z(t)$



Thus, $z(t) \ge y(t)$, for all 't'

End of Solution

Q.41 A signal $x(n)$ is given by $\left(\frac{1}{2}\right)^n 1(n)$ where,

$$1(n) = \begin{cases} 1 & n \geq 0 \\ 0 & n < 0 \end{cases}$$

Z-transform $x(n-K)$ is $\frac{Z^{-K}}{1-\frac{1}{2}Z^{-1}}$, then what will be ROC of $x(n-K)$

(a) $Z > \frac{1}{2}$
(b) $Z < 2$
(c) $Z > 2$
(d) $Z < \frac{1}{2}$

Ans. (a)

$$x(n) = \left(\frac{1}{2}\right)^n u(n), \quad \text{ROC of } x(n) : |z| > \frac{1}{2}$$

$$x(n-K) \Longleftrightarrow X(z) = \frac{Z^{-K}}{1-\frac{1}{2}Z^{-1}}, \quad \text{ROC of } x(n-K) : |Z| > \frac{1}{2}$$

For $x(n-K)$ ROC will be $|Z| > \frac{1}{2}$.

End of Solution

Q.42 If x_A and x_R are average and rms values of signal $x(t) = x(t-T)$ respectively. y_A and y_R are average and rms value of signal $y(t) = Kx(t)$ respectively. K and T are independent of t.

(a) $y_A = Kx_A, y_R = Kx_R$
(b) $y_A \neq Kx_A, y_R = Kx_R$
(c) $y_A = Kx_A, y_R \neq Kx_R$
(d) $y_A \neq Kx_A, y_R \neq Kx_R$

Ans. (a)

Given that,

$\Rightarrow$ $\text{Average } x(t) = X_a$, $\quad \text{Rms } x(t) = X_R$

$\Rightarrow$ $\text{Average } y(t) = Y_a$, $\quad \text{Rms } y(t) = Y_R$

$\Rightarrow$ $x(t) = x(t-T)$

$\Rightarrow$ $y(t) = Kx(t)$ ...(i)

$\Rightarrow$ $Y_a = KX_a$

Since, $\text{Power } y(t) = |K|^2 \text{ power } x(t)$

$\Rightarrow$ $\text{Rms } y^2(t) = |K|^2 \text{ Rms } x^2(t)$

$\Rightarrow$ $\text{Rms } y(t) = |K|^2 \text{ Rms } x(t)$

$\Rightarrow \quad Y_R = |K|\, X_R$

Assuming K as real and positive,

$$Y_R = KX_R$$

End of Solution

Q.43 Which of the following statement is true about the two sided Laplace transform?

(a) It always exists for a signal that may or may not have Fourier transform.

(b) It has no poles for any bounded signal that is non-zero only inside a finite time interval.

(c) If a signal can be expressed as a weighted sum of shifted one sided exponentials, then its Laplace transform will have no poles.

(d) The number of finite poles finite zeros must be equal.

Ans. (b)

End of Solution

Q.44 A 50 Hz, power system network is operated under load of 100 MW. When the load is increases, the power input by the synchronous generator is increases by 10 MW and frequency of the rpm fall to 49.75 Hz. What will be the load at power system for the frequency falls to 49.25 Hz?

Ans. (130)

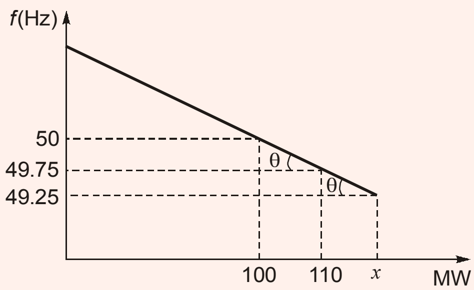
Assumed full load frequency is 50 Hz

$$\tan\theta = \frac{50-49.75}{110-100} = \frac{49.75-49.25}{(x-(110))}$$

$$\frac{0.25}{10} = \frac{0.5}{(x-150)}$$

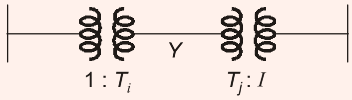
$$x - 110 = \frac{0.5\times 10}{0.25}$$

$$x = 110 + 20 = 130 \text{ MW}$$



End of Solution

Q.45 Find admittance matrix 2 bus is connected by 2 transformers having ratios 1 : T_i and T_j : 1 respectively and line having Y admittance.



(a) $\begin{bmatrix} T_i^2 & -T_iT_j \\ -T_iT_j & T_j^2 \end{bmatrix}$

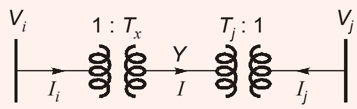
(b) $\begin{bmatrix} -T_i^2 & T_iT_j \\ T_iT_j & -T_j^2 \end{bmatrix}$

(c) $\begin{bmatrix} T_iT_j & -T_j^2 \\ -T_i^2 & T_iT_j \end{bmatrix}$

(d) $\begin{bmatrix} T_iT_j & -T_j^2 \\ -T_i^2 & T_iT_j \end{bmatrix}$

Ans. (a)

$$I = Y(T_iV_i - V_jT_j)$$
$$I_i = T_iI$$
$$= T_i^2YV_i - T_iT_jYV_j$$
$$I_j = -T_jI$$
$$= -I_iT_jYV_i + T_j^2YV_j$$



$$\begin{bmatrix} I_i \\ I_j \end{bmatrix} = \begin{bmatrix} T_i^2Y & -T_iT_jY \\ -T_iT_jY & T_j^2Y \end{bmatrix} \begin{bmatrix} V_i \\ V_j \end{bmatrix}$$

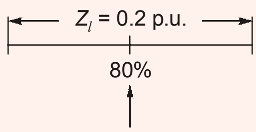
End of Solution

Q.46 A transmission line is being protected by distance protection. 80% of the line is being protected. The transfer reactance is 0.2 p.u. A solid 3-ϕ, fault occurred at the end of the transmission line. The minimum level of fault current to activate the relay

(a) 6.25
(b) 5
(c) 1.25
(d) 3

Ans. (a)

$$I_f = \frac{1}{Z_{Th}} = \frac{1}{0.2} = 5 \text{ pu for } 100\% \text{ of line}$$



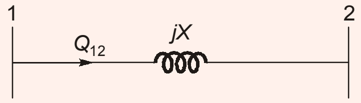
Relay is operated for 80%

$$Z_f = 0.8\ Z_l \Rightarrow 0.8 \times 0.2 = 0.16 \text{ p.u.}$$

For 80% of line, $\quad I_f = \dfrac{1}{0.16} = 6.25$ p.u.

End of Solution

Q.47 Voltage at bus 1 = 1.1 p.u.
Voltage at bus 2 = 1 p.u.

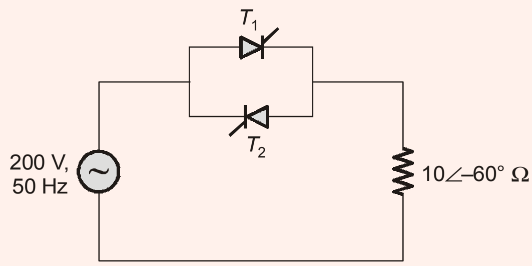


Voltage at bus 2 is kept constant, Q_{12} is the sending reactive power from 1 to 2. On changing the bus 1 voltage, Q_{12} increases by 20%.
Active power is zero in both the condition find the new value of bus 1 voltage.

Ans. (#)
A

End of Solution

Q.48 In AC voltage controller shown below. Thyristor T_1 is fired at α and T_2 is fired at $180° + \alpha$. To control the output power over range 0 to 2 kW. The minimum range of variation in α is



(a) 0° to 60°
(b) 0° to 120°
(c) 60° to 120°
(d) 60° to 180°#

Ans. (d)

End of Solution

Q.49 A 1-ϕ, fully controlled rectifier is connected to highly inductive RL load with $R = 10\ \Omega$ at 230 V, 50 Hz. The source inductance is 2.28 mH. If the firing angle $\alpha = 45°$, then the overlapping angle will be

Ans. (4.25)
1-ϕ, SCR bridge rectifier

$$\alpha = 45°,\ R = 10\ \Omega$$

supply 230 V, 50 Hz

$$L_s = 2.28 \text{ mH}$$
$$\mu = ?$$
$$\Delta V_d = \frac{V_m}{\pi}[\cos\alpha - \cos(\alpha+\mu)] = 4f\,L_s I_0$$
$$V_0 = \frac{2V_m}{\pi}\cos\alpha - 4f\,L_s I_0$$
$$I_0 R = \frac{2V_m}{\pi}\cos\alpha - 4f\,L_s I_0$$

Find I_0

$$I_0\,10 = \frac{2.230\sqrt{2}}{\pi}\cdot\cos 45 - 4\times 50\times 2.28\times 10^{-3} I_0$$

$$I_0(10 + 0.456) = 146.64$$

$$I_0 = \frac{146.49}{10.456} = 14.01\ \text{A}$$

$$\Delta V_{d0} = \frac{230\sqrt{2}}{\pi}[\cos 45 - \cos(45+\mu)] = 4 \times 50 \times 2.28 \times 10^{-3} \times 14$$

$$= 6324$$

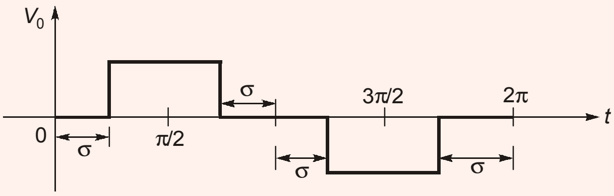
$$\cos 45° - \cos(45° + \mu) = 0.061$$

$$45 + \mu = 49.75$$

$$\therefore \quad \mu = 4.25°$$

End of Solution

Q.50 Value of σ adjusted so that 3rd harmonic is completely eliminated. Find the percentage magnitude of 5th harmonic w.r.t. fundamental component at this condition.



Ans. (20)

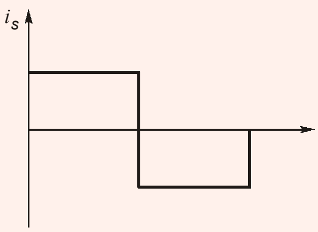
End of Solution

Q.51 A single-phase, 50 Hz full bridge rectifier with highly inductive RL load. The two most dominant frequency components will be

(a) 50 Hz, 150 Hz
(b) 50 Hz, 100 Hz
(c) 150 Hz, 250 Hz
(d) 50 Hz, 0 Hz

Ans. (a)

1-ϕ full bridge rectifier,

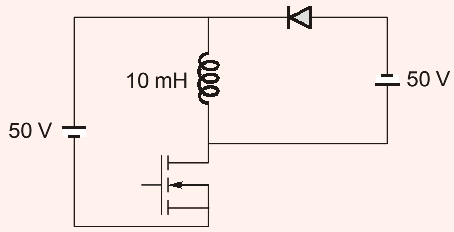


$n = 1, 3, 5, \ldots$

$f = 50, 150, 250$ dominant

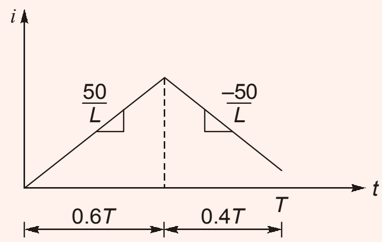
End of Solution

Q.52 A DC-DC converter shown below having switching frequency of 10 kHz with duty ratio 0.6. All the components are ideal and initial inductor current is zero. Energy stored in the inductor (in mJ) at the end of 10 switching cycles is



Ans. (5)

Buck boost converter



$$D = 0.6 \rightarrow \text{stores energy}$$

$$D = \frac{T_{ON}}{T} = 0.6$$

$$T_{ON} = 0.6T \rightarrow \text{store energy}$$

$$T_{OFF} = 0.4\text{ T} \rightarrow \text{releasing energy}$$

For one cycle: Rise in current for 0.2T

For 10 cycles: Find rise in current $(0.2T) \times 10 = 2T$

$$i = \frac{50}{L}t$$

$$i = \frac{50}{L}(2T) = \frac{50 \times 2}{LP} = \frac{100}{10 \cdot 10^{-3} \times 10 \cdot 10^{3}} = 1\text{ A}$$

$$\therefore \qquad \text{Energy stored} = \frac{1}{2}Li^2 = \frac{1}{2} \times (10 \cdot 10^{-3}) \cdot (1)^2 = 5\text{ mJ}$$

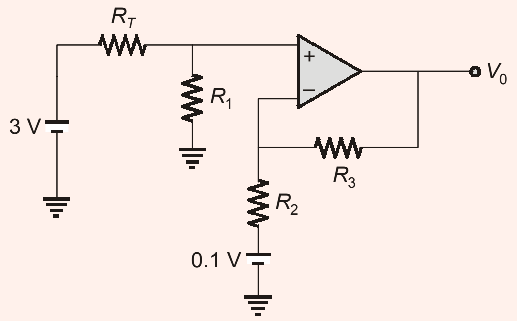
End of Solution

Q.53 $R_T \rightarrow$ Thermistor

$$R_T = 2(1 + \alpha T)$$

Temperature rise = 150%

Find errors in the output voltage?

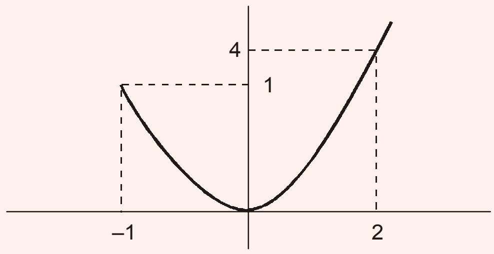


R_1 = 1 kHz, R_2 = 1.3 kΩ, R_3 = 2.6 kΩ

Ans. ()

End of Solution

Q.54 A vector function is given by $\vec{F} = y\hat{a}_x - x\hat{a}_y$. The line integral of the above function $\int_C \vec{F} \cdot d\vec{l}$ along the curve C given by $y = x^2$ as shown below ________.



Ans. (–2.33)

$$\bar{F} = y\hat{a}_x - x\hat{a}_y$$

$$\bar{F} = y\bar{i} - x\bar{j}$$

$$\int_C \bar{F} \cdot d\bar{r} = \int_C F_1 dx + F_2 dy$$

$$y = x^2$$

$$dy = 2x\ dx$$

$$= \int x^2 dx - x \cdot 2x\, dx$$

$$= \int (x^2 - 2x^2)dx = \int_{-1}^{2} -x^2 dx = \left(-\frac{x^3}{3}\right)\Bigg|_{-1}^{2}$$

$$= \frac{-8}{3} + \frac{1}{3} = \frac{-7}{3} = -2.33$$

End of Solution

Q.55 $\frac{dy}{dx} = 2x - y$, $y(0) = 1$. Find y at $x = \ln 2$

Ans. **(0.886)**

$$\frac{dy}{dx} = 2x - y; \qquad y(0) = 1,\ y \text{ at } x = \ln 2$$

$$\frac{dy}{dx} + y = 2x$$

$$P = 1, \qquad Q = 2x$$

$$I.F. = e^{\int P dx} = e^{\int 1 dx} = e^x$$

Solution, $y(I.F) = \int Q(I.F.)dx$

$$ye^x = \int 2x \cdot e^x dx = 2(xe^x - e^x) + C$$

$$y = 2x - 2 + ce^{-x}$$

$$y(0) = 1$$

$$1 = 0 - 2 + C$$

$$C = 3$$

$\therefore$ $y = 2x - 2 + 3e^{-x}$

At $x = \ln 2$

$$y = 2(\ln 2) - 2 + 3e^{-\ln 2}$$

$$= 1.386 - 2 + \frac{3}{2} = 0.886$$

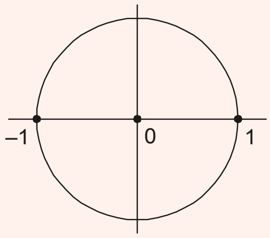
End of Solution

Q.56 Value of integral $\oint \frac{z^2+1}{z^2-2z}$ along the contour $|z| = 1$ is

(a) πi
(b) $-\pi i$
(c) $8\pi i$
(d) $-8\pi i$

Ans. (b)

$\int \frac{z^2+1}{z^2-2z}dz$ where C is $|z| = 1$



$$= \int \frac{z^2+1}{z(z-2)}dz$$

$$= \int \frac{\frac{z^2+1}{z-2}}{z}dz$$

By integral formula,

$2\pi i\ f(0)$ where, $\quad f(z) = \frac{z^2+1}{z-2} = 2\pi i\left(\frac{1}{-2}\right) = -\pi i$

End of Solution

Q.57 The number of purely real elements in lower triangular representation of given 3×3 matrix obtained through given decomposition is

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 1 & 2 \\ 3 & 6 & 5 \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

Ans. (#)

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 1 & 2 \\ 3 & 6 & 5 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ 0 & u_{22} & u_{23} \\ 0 & 0 & u_{33} \end{bmatrix}$$

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 1 & 2 \\ 3 & 6 & 5 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix} \begin{bmatrix} 1 & u_{12} & u_{13} \\ 0 & 1 & u_{23} \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 1 & 2 \\ 3 & 6 & 5 \end{bmatrix} = \begin{bmatrix} l_{11} & l_{11}u_{12} & l_{11}u_{13} \\ l_{21} & l_{21}u_{12} + l_{22} & l_{21}u_{13} + l_{22}u_{23} \\ l_{31} & l_{31}u_{12} + l_{32} & l_{31}u_{13} + l_{32}u_{23} + l_{33} \end{bmatrix}$$

$l_{11} = 2 \qquad l_{11}u_{12} = 3 \qquad l_{11}u_{13} = 3$

$\qquad 2u_{12} = 3 \qquad 2u_{13} = 3$

$l_{21} = 3 \qquad u_{12} = \frac{3}{2} \qquad u_{13} = \frac{3}{2}$

$l_{31} = 3$

$$l_{21}u_{12} + l_{22} = 1$$

$$3\left(\frac{3}{2}\right) + l_{22} = 1$$

$$l_{21}l_{13} + l_{22}u_{23} = 2$$

$$u_{23} = \frac{2-\frac{9}{2}}{\frac{-7}{2}} = \frac{5}{7}$$

$$u_{23} = \frac{5}{7}$$

$$l_{22} = 1-\frac{9}{2} = \frac{-7}{2}$$

$$l_{22} = \frac{-7}{2}$$

$$l_{31}u_{12} + l_{32} = 6$$

$$(3)\left(\frac{3}{2}\right) + l_{32} = 6$$

$$l_{32} = 6-\frac{9}{2} = \frac{3}{2}$$

$$l_{32} = \frac{3}{2}$$

$$l_{31}u_{13} + l_{32}u_{23} + l_{33} = 5$$

$$l_{33} = 5-\frac{9}{2}-\frac{15}{14}$$

$$l_{33} = \frac{70-63-15}{14} = \frac{-8}{14} = \frac{-4}{7}$$

$$l_{33} = \frac{-4}{7}$$

End of Solution

Q.58 If $y = 3x^2 + 3x + 1$, for $x \in [-2, 0]$, find maximum and minimum value in the given range.

(a) 4 and 1

(b) 7 and $\frac{1}{4}$

(c) $\frac{1}{4}$ and 1

(d) -2 and $\frac{1}{-2}$

Ans. (b)

$$y = 3x^2 + 3x + 1 \quad \text{in } [-2, 0]$$

$$\frac{\partial y}{\partial x} = 6x + 3, \qquad \frac{\partial^2 y}{\partial x^2} = 6$$

$$\frac{dy}{dx} = 0$$

$$6x + 3 = 0$$

$$x = \frac{-1}{2}$$

$$\frac{d^2y}{dx^2} = 6 > 0 \text{ minimum}$$

Maximum value of y in [–2, 0] is maximum $\{f(-2), f(0)\}$

$$\max\{7, 1\} = 7$$

Minimum value of y in [–2, 0]

$$\min\left\{\begin{matrix} f(-2) & f(0) & f\left(-\frac{1}{2}\right) \\ \downarrow, & \downarrow, & \downarrow \\ 7 & 1 & \frac{1}{4} \end{matrix}\right\} = \frac{1}{4}$$

Maximum value 7, minimum value $\frac{1}{4}$.

End of Solution

Q.59 Which of the following is true?

(a) $\frac{1}{\pi}\int_0^{\pi} \sin m\omega t \sin n\omega t = 0 \quad m \neq n$

(b) $\frac{1}{\pi}\int_{-\pi}^{\pi} \sin p\omega t \sin q\omega t = 0$

(c) $\frac{1}{2\pi}\int_0^{\pi} \cos p\omega t \cos q\omega t = 0$

(d) $\frac{1}{2\pi}\int_{-\pi}^{\pi} \sin p\omega t \cos q\omega t = 0$

Ans. **(d)**

End of Solution

■■■■