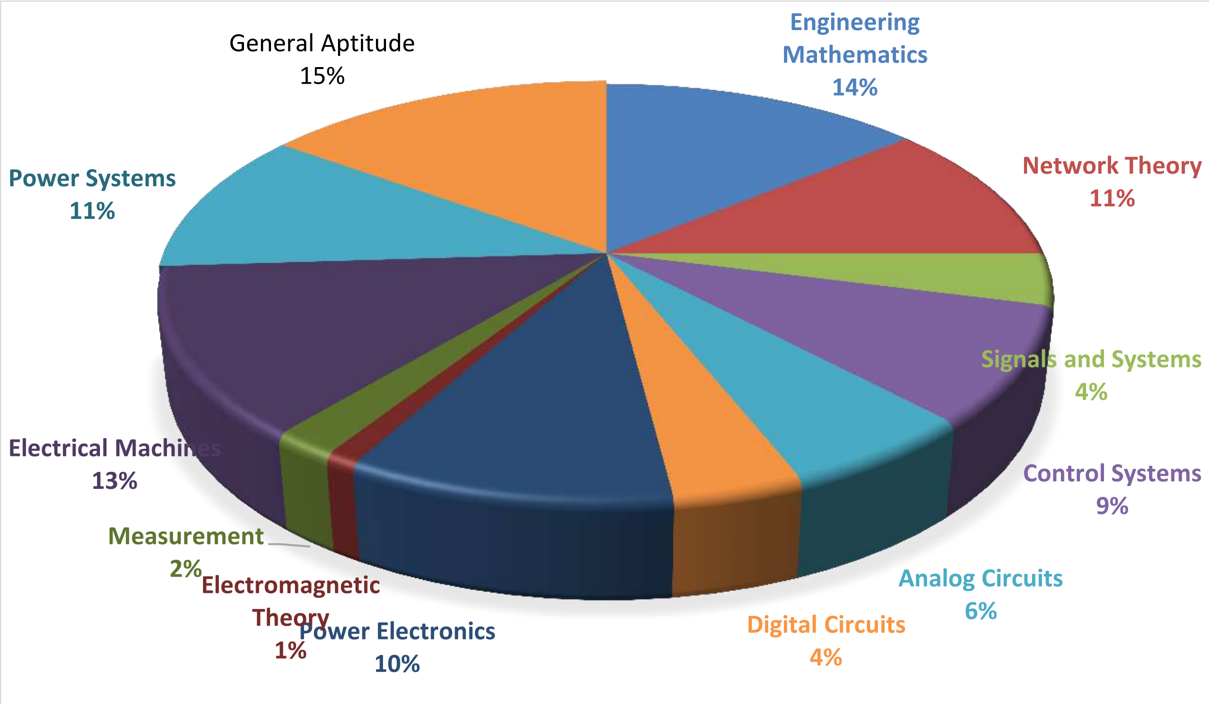
ANALYSIS OF GATE 2019

Electrical and Electronics Engineering



EE ANALYSIS-2019_Feb-9_Afternoon

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 6 2 Marks: 4	Z-transform, Complex variables, Vector Calculus	Medium	14
Network Theory	1 Marks: 3 2 Marks: 4	KVL, KCL, Transient Analysis	Easy	11
Signals and Systems	1 Marks: 2 2 Marks: 1	Laplace transform, Z-transform	Medium	4
Control Systems	1 Marks: 3 2 Marks: 3	Bode plot, Nyquist plot, Error analysis	Easy	9
Analog Circuits	1 Marks: 2 2 Marks: 2	NMOS, Differential Amplifier	Medium	6
Digital Circuits	1 Marks: 0 2 Marks: 2	Logic gates, K- map	Easy	4
Power Electronics	1 Marks:2 2 Marks: 4	Rectifier, Inverter, Chopper	Medium	10
Electromagnetic Theory	1 Marks: 1 2 Marks: 0	Divergence, Capacitance	Medium	1
Measurement	1 Marks: 0 2 Marks: 1	Extension of Range	Medium	2
Electrical Machines	1 Marks: 3 2 Marks: 4	Transformer, Synchronous, Induction	Easy	13
Power Systems	1 Marks: 3 2 Marks: 5	Transmission line, fault, Protection	Easy	11
General Aptitude	1 Marks: 5 2 Marks: 5	Percentage, Number system, Set theory, Grammar	Medium	15
Total	65			100
Faculty Feedback	Overall paper was of moderate level difficulty. Compare to 2017 and 2018 papers, 2019 EE paper is easy.			

GATE 2019 Examination

Electrical and Electronics Engineering

Test Date: 9-FEB-2019

Test Time: 2.30 PM to 5:30 PM

Subject Name: Electrical and Electronics Engineering

General Aptitude

Q.1 - Q.5 Carry One Mark each

1. The passengers were angry ________ the airline staff about the delay.
(A) towards
(B) on
(C) with
(D) about
[Ans. C]
"angry with" is used in case of person
"angry on" is used in case of person's behavior.

2. The missing number in the given sequence 343, 1331, ______, 4913 is
(A) 3375
(B) 2744
(C) 2197
(D) 4096
[Ans. C]
$$\left.\begin{aligned}343 &= 7^3\\ 1331 &= 11^3\\ 2197 &= 13^3\\ 4913 &= 17^3\end{aligned}\right\}\text{Cubes of consecutive prime numbers}$$

3. Newspapers are a constant source of delight and recreation for me. The _______ trouble is that I read _________ many of them.
(A) even, quite
(B) even, too
(C) only, quite
(D) only, too
[Ans. D]
'quite' is used in case of few i.e. "quite a few of them"
'too' is used in many numbers i.e. "too many of them"

4. I am not sure if the bus that has been booked will be able to _______ all the students.
(A) deteriorate
(B) sit
(C) fill
(D) accommodate
[Ans. D]
Accommodate means to provide sufficient space.

5. It takes two hours for a person X to mow the lawn. Y can mow the same lawn in four hours. How long (in minutes) will it take X and Y, if they work together to mow the lawn?
(A) 90
(B) 80
(C) 60
(D) 120
[Ans. B]
Time taken by **X** to mow the lawn= 2 hours
Means in 1 hour, part of lawn mowed =1/2
Time taken by **Y** to mow the lawn = 4 hours
Means in 1 hour, part of lawn mowed =1/4
If both X and Y work simultaneously at their respective constant rates; part of work completed in 1 hour $= \frac{1}{2} + \frac{1}{4} = \frac{3}{4}$
So, the lawn will be mowed in $\frac{4}{3}$ hours $= \frac{4}{3} \times 60 = 80$ minutes

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

6. Consider five people – Mita, Ganga, Rekha, Lakshmi and Sana. Ganga is taller than both Rekha and Lakshmi. Lakshmi is taller than Sana. Mita is taller than Ganga. Which of the following conclusions are true?
I. Lakshmi is taller than Rekha.
II. Rekha is shorter than Mita.
III. Rekha is taller than Sana
IV. Sana is shorter than Ganga.

(A) 3 only
(B) 1 and 3
(C) 2 and 4
(D) 1 only
[Ans. C]

M > G > (R, L) >S

Height of Rekha and Lakshmi cannot be commented.

7. The ratio of number of boys and girls who participated examination is 4:3. The total percentage of candidates who passed the examination is 80 and the percentage of girls who passed is 90. The percentage of boys who passed is ________.
(A) 55.50
(B) 72.50
(C) 80.50
(D) 90.00
[Ans. B]

Ratio of number of boys and girls 4:3
Let the total number of students who participated in exam= 700
So, number of boys=400 and number of girls=300
90% of girls passed $\Rightarrow$ 90% of 300 = 270 girls
Total 80% students passed $\Rightarrow$ 80% of 700 = 560 students passed.
So, number of boys passed =560 − 270 = 290

$$\% \text{ of boys passed } = \frac{290}{400} \times 100$$

= 72.50%

8. How many integers are there in between 100 and 1000 all of whose digits are even?
(A) 60
(B) 80
(C) 100
(D) 90
[Ans. C]

We have to choose numbers between 101 and 999.
So, we have to choose three digit numbers. ____ ____ ____
First place can be filled by 4 ways (2, 4, 6, 8) because 0 can't be accepted because it will make two digit numbers.
Second place can be filled by 5 ways (2, 4, 6, 8, 0)
Similarly, third place can be filled by 5 ways (2, 4, 6, 8, 0)
So total number of integers between 100 and 1000, all of whose digits are even = $4 \times 5 \times 5 = 100$

9. An award winning study by a group of researchers suggests that men are as prone to buying on impulse as women but women feel more guilty about shopping.
Which one of the following statements can be inferred from the given text?
(A) Some men and women indulge in buying on impulse.
(B) Many men and women indulge in buying on impulse
(C) Few men and women indulge in buying on impulse
(D) All men and women indulge in buying on impulse
[Ans. A]

10. Given two sets X = {1, 2, 3}and Y = {2, 3, 4}, we construct a set of Z of all possible fractions where the numbers belong to set X and the denominators belongs to set Y. The product of elements having minimum and maximum values in the set Z is _______
(A) $\frac{1}{8}$
(B) $\frac{1}{12}$
(C) $\frac{1}{16}$
(D) $\frac{3}{8}$
[Ans. D]
Set X = [1, 2, 3]
Set Y = [2, 3, 4]
$\because Z = \frac{X}{Y}$
To make Z as minimum, we have to choose least value from set X (i.e. 1) and greatest value from set Y (i. e. 4) $\Rightarrow Z_{min} = \frac{1}{4}$
Similarly, to make Z as maximum, we have to choose greatest value from set X (i.e. 3) and least
value from set Y (i. e. 2) $\Rightarrow Z_{max} = \frac{3}{2}$
So, the product of element having minimum and maximum value in set Z is
$\frac{1}{4} \times \frac{3}{2} = \frac{3}{8}$

Technical

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

1. Which one the following functions in analytic in the region $|z| \leq 1$?

(A) $\frac{z^2-1}{z-0.5}$

(B) $\frac{z^2-1}{z+2}$

(C) $\frac{z^2-1}{z+j\,0.5}$

(D) $\frac{z^2-1}{z}$

[Ans. B]

Given the region

$|z| \leq 1$

$f(z) = \frac{z^2-1}{z^2+2}$ is not analytic at $z = -2$

and $|z| = |-2| = 2 > 1$ lies outside of the given region $|z| = 1$

$\therefore f(z) = \frac{z^2-1}{z^2+2}$ is analytic in the given region.

2. M is 2×2 matrix with eigen values 4 and 9. The eigen values of M^2 are

(A) -2 and -3

(B) 2 and 3

(C) 4 and 9

(D) 16 and 81

[Ans. D]

We know the property that if eigen of M is λ, then eigen M^2 is λ^2, so

Eigen (M) are 4 and 9

Then, eigen (M^2) are 16 and 81

3. The symbols, a and T, represent positive quantities, and u(t) is the unit step function. Which one of the following impulse response is NOT the output of causal linear time – invariant system?

(A) $e^{-a(t+T)}u(t)$

(B) $e^{-a(t-T)}u(t)$

(C) $e^{+at}\,u(t)$

(D) $1 + e^{-at}\,u(t)$

[Ans. D]

Given u(t) is unit step function and impulse response

$h(t) = 1 + e^{-at}u(t)$ is not causal, as the causality condition for impulse response is

$h(t) = 0$ for $t < 0$
but $h(t) = 1$ for $t < 0 \neq 0$
Hence it is not causal
Hence it is not the output of causal LTI system.

4. The mean – square of a zero – mean random process is $\frac{kT}{c}$, where k is Boltzmann's constant ,T is the absolute temperature, and C is a capacitance. The standard deviation of the random process is

(A) $\frac{c}{kT}$

(B) $\sqrt{\frac{kT}{c}}$

(C) $\frac{kT}{c}$

(D) $\frac{\sqrt{kT}}{c}$

[Ans. B]

Given

Mean square, $E(x^2) = \frac{KT}{c}$

Mean, $E\,(x) = 0$

Standard deviation, $\sqrt{V(x)} = \sqrt{E(x^2) - [E(x)]^2}$

$= \sqrt{\left(\frac{KT}{c} - (0)^2\right)}$

$= \sqrt{\frac{KT}{c}}$

5. If $f = 2x^3 + 3y^2 + 4z$, the value of line integral $\int_c$ grad f. dr evaluated over contour C formed by segments $(-3,-3,2) \to (2,-3,2) \to (2,6,2) \to (2,6,-1)$ is ________.

[Ans. *]Range: 139 to 139

Given

$f = 2x^3 + 3y^2 + 4z$

$\text{grad } f = \left(\frac{\partial \hat{i}}{\partial x} + \frac{\partial \hat{j}}{\partial y} + \frac{\partial \hat{k}}{\partial z}\right) f$

$= 6x^2\hat{i} + 6y\hat{j} + 4\hat{k}$

$(\text{grad. f}).\,\text{dr} = (6x^2\hat{i} + 6y\hat{j} + 4\hat{k})(dx\hat{i} + dy\hat{j} + dz\hat{k})$

$= (6x^2dx + 6ydy + 4dz)$

$$\int_C (\text{grad} f).dr = \int_{(-3,-3,2)}^{(2,6,-1)} (6x^2dx + 6ydy + 4dz)$$

$$= \int_{-3}^{2} 6x^2dx + \int_{-3}^{6} 6ydy + \int_{2}^{-1} 4dz$$

$$= 6\left(\frac{x^3}{3}\right)_{-3}^{2} + 6\left(\frac{y^2}{2}\right)_{-3}^{6} + 4(z)_2^{-1}$$

$$= 2(2^3 - (-3)^3) + 3(6^2 - (-3)^2) + 4(-1-2)$$

$$= 2(8 + 27) + 3(36 - 9) + 4(-3)$$

$$= 2(35) + 3(27) - 12$$

$$= 70 + 81 - 12$$

$$= 139$$

6. The output response of a system is denoted as y(t), and its Laplace transform is given by

$$Y(s) = \frac{10}{s(s^2 + s + 100\sqrt{2})}$$

The steady state value of y(t) is

(A) $\frac{1}{10\sqrt{2}}$

(B) $10\sqrt{2}$

(C) $\frac{1}{100\sqrt{2}}$

(D) $100\sqrt{2}$

[Ans. A]

Steady state value of y (1) is given by

$$\lim_{t\to\infty} y(t) = y(\infty) = \lim_{s\to 0} s\,y(s)$$

$$= \lim_{s\to 0} s \frac{10}{s(s^2 + s + 100\sqrt{2})}$$

$$= \frac{10}{100\sqrt{2}}$$

$$= \frac{1}{10\sqrt{2}}$$

7. The open loop transfer function of a unity feedback system is given by

$$G(s) = \frac{\pi e^{-0.25s}}{s}$$

In G(s) plane, the Nyquist plot of G(s) passes through the negative real axis at the point

(A) $(-0.5,\ j0)$

(B) $(-1.5,\ j0)$

(C) $(-0.75,\ j0)$

(D) $(-1.25,\ j0)$

[Ans. A]

$$G(s) = \frac{3e^{-0.25s}}{s}$$

$$\phi = -90 - 0.25\omega \times \frac{180}{\pi}$$

NP cut real axis if $\phi = -180°$

$$\Rightarrow -90 - 0.25\omega \times \frac{180}{\pi} = -180$$

$$= 0.25\omega \times \frac{180}{\pi} = 90$$

$$\omega = \frac{\pi}{0.25 \times 2} = \frac{\pi}{0.5} = 6.28 \text{ rad/sec}$$

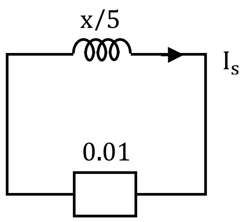
$$|G(j\omega)| = \frac{\pi}{\omega}\Big|_{at}\quad \omega = 6.28 \text{ rad/sec}$$

$$|G(j\omega)| = \frac{\pi}{2\pi} = \frac{1}{2} = 0.5$$

$$NP = (-0.5, j0)$$

8. The total impedance of the secondary winding, leads, and burden of a 5 A CT is 0.01Ω. If the fault current is 20 times the rated primary current of the CT , the VA output of the CT is ____________.

[Ans. *]Range: 100 to 100



$$\text{CT ratio} = \frac{X}{5}$$

Where X-rated line current for fault current 20x.

Current in secondary of CT

$$\text{If } I_s = \frac{5}{x} \times 20x = 100$$

$$VA = 0.01 \times 10^4 = 100$$

9. The output voltage of a single – phase full bridge voltage inverter is controlled by unipolar PWM with one pulse per half cycle. For the fundamental rms component of output voltage to be75% of DC voltage, the required pulse width in degrees (round off up to one decimal place) is __________

[Ans. *]Range: 112.5 to 113.2

Fundamental rms component

$$(V_{o1})_{Rms} = \frac{2\sqrt{2}\,V_{dc}}{\pi}\,\text{Sin d}$$

$$(V_{o1})_{Rms} = 0.75V_{dc}$$

$$0.75V_{dc} = \frac{2\sqrt{2}}{\pi}V_{dc}\,\text{Sin d}$$

$$\frac{0.75\times\pi}{2\sqrt{2}} = \text{Sin d}$$

$$d = \text{Sin}^{-1}\left(\frac{0.75\times\pi}{2\sqrt{2}}\right) = 56.41$$

Pulse width $= 2d = 2\times 56.41 = 112.82$ degree

10. The Y_{bus} matrix of a two bus power system having two identical parallel lines connected between them input is given as

$$Y_{bus} = \begin{bmatrix} -j8 & j20 \\ j20 & -j8 \end{bmatrix}.$$

The magnitude of the series reactances of each line input (round off up to one decimal place) is ________.

[Ans.*]Range: 0.095 to 0.105

$$Y_{bus} = \begin{bmatrix} -j8 & j20 \\ j20 & -j8 \end{bmatrix}$$

The series admittance of line connected between bus 1 & bus 2 is $Y_{12} = -Y_{12} = -j20$

As two line are in parallel, each line admittance will be

$$Y_{line} = -\frac{j20}{2} = -j10\text{ p.u.}$$

$$Z_{line} = \frac{1}{-j10} = 0.1j\text{ pu.}$$

11. The characteristic equation of a linear time – invariant (LTI) system is given by $\Delta(s) = s^4 + 3s^3 + 3s^2 + s + k = 0$.

The system is BIBO stable if

(A) $0 < k < \frac{12}{9}$

(B) $k > 6$

(C) $0 < k < \frac{8}{9}$

(D) $k > 3$

[Ans. C]

From sufficient condition

$C.E = s^4 + 3s^3 + 2s^2 + s + k = 0$

s^4	1	3	K
s^3	3	1	0
s^2	$8/3$	k	
s^1	$\frac{\frac{8}{3} - 3k}{8/3}$	0	
s^0	k		

$k > 0$

$\frac{8}{3} - 3k > 0$

$3k < 8/3$

$k < 8/9$

$0 < k < 8/9$

12. The inverse Laplace transform of

$H(s) = \frac{s+3}{s^2+2s+1}$ for $t \geq 0$ is

(A) $4te^{-t} + e^{-t}$

(B) $3e^{-t}$

(C) $2te^{-t} + e^{-t}$

(D) $3te^{-t} + e^{-t}$

[Ans. C]

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

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

$(t) = 2te^{-t} + e^{-t}$

13. A current controlled current source (CCCS) has an input impedance of 10Ω and output impedance of 100 kΩ. When this CCCS is used in a negative feedback closed with a loop gain of 9, the closed loop output impedance is

(A) 10Ω

(B) 100 kΩ

(C) 100 Ω

(D) 1000 kΩ

[Ans. D]

Current controlled current source

$\text{output} - \text{current(series)} - \text{input} - \text{current(shunt)}$
$\text{series} - \text{shunt Amplifier}$
$Z_o \uparrow Z_i \downarrow$
$Z_{of} = Z_o(1+\beta A)$
Feed back is unity $\beta = 1$
$A - \text{oL gain} = 9$
$Z_{of} = 100\text{k}\Omega(1 + 1 \times 9) = 1000\text{k}\Omega$

14. A six – pulse thyristor bridge rectifier is connected to a balanced three – phase, 50 Hz AC source. Assuming that the DC output current of the rectifiers is constant, the lowest harmonic component in the AC input current is
(A) 100 Hz
(B) 150 Hz
(C) 250 Hz
(D) 300 Hz
[Ans. C]
As we know the AC input current weave form is quassi square wave form
Fourier series of this will be

$$I_s = \sum_{0}^{\infty} \frac{4I_o}{n\pi} \sin\frac{n\pi}{3} \sin(n\omega t - n\alpha)$$

$n = 1, 3, 5$
For $n = 3$,
$I_s = 0$
So, lowest harmonic is 5^{th}
Hence
$= 50 \times 5 = 250\text{Hz}$

15. A co- axial cylindrical capacitor shown in the figure (i) has dielectric with relative permittivity $\varepsilon_{r1} = 2$. When one – fourth portion of the dielectric is replaced with another dielectric of relative permittivity ε_{r2}, as shown in figure (ii), the capacitance is doubled. The value of ε_{r2} is ________.

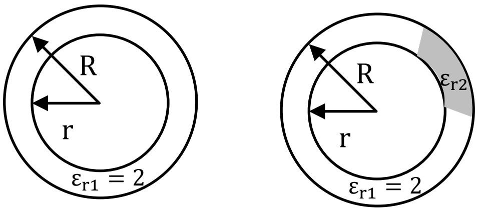


Figure (i) Figure (ii)

[Ans. *]Range: 9 to 11

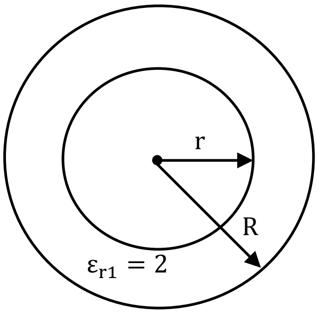


Fig (i)

$$C_1 = \frac{\alpha\pi \in l}{\ln\left(\frac{b}{a}\right)}$$

$$C_1 = \frac{\alpha\pi\varepsilon_o \times 2 \times l}{\ln\left(\frac{R}{r}\right)}$$

$$C_1 = \frac{4\pi \in_o l}{\ln\left(\frac{R}{r}\right)}$$

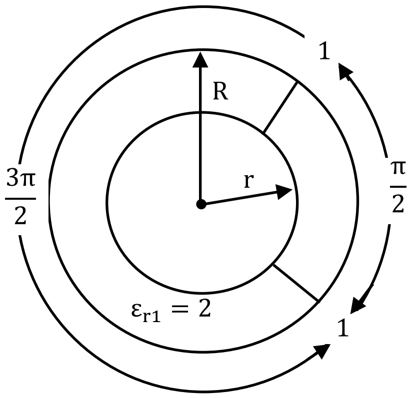


Fig (ii)

$$C_2 = \frac{\frac{3\pi}{2} \in_o \times 2l}{\ln\left(\frac{R}{r}\right)} + \frac{\frac{\pi}{2}\varepsilon_o\varepsilon_r l}{\ln\left(\frac{R}{r}\right)}$$

$$C_2 = \frac{\pi\varepsilon_o h}{\ln\left(\frac{R}{r}\right)}\left[3 + \frac{\varepsilon_{r2}}{2}\right]$$

Given

$$C_2 = 2C_1$$

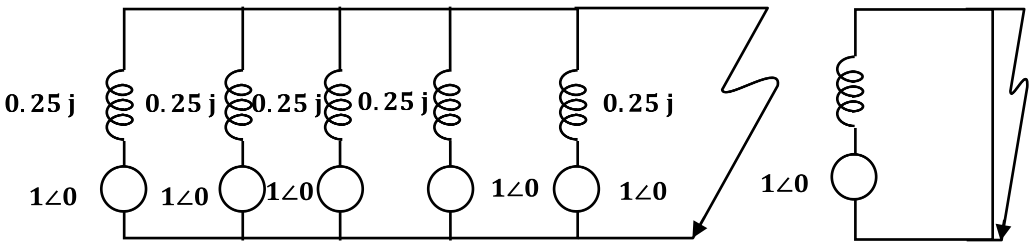
$$\frac{\pi\varepsilon_o h}{\ln\left(\frac{R}{r}\right)}\left[3 + \frac{\varepsilon_{r2}}{2}\right] = 2\left[\frac{4\pi\varepsilon_o h}{\ln\left(\frac{R}{r}\right)}\right]$$

$$3 + \frac{\varepsilon_{r2}}{2} = 8$$

$$\varepsilon_{r2} = 10$$

16. Five alternators each rated 5 MVA. 13.2 kV with 25% of reactance on its own base are connected in parallel to busbar. The short – circuit level in MVA at the busbar is ______

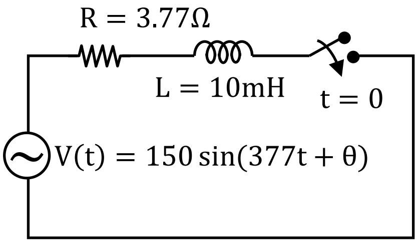
[Ans. *]Range: 100 to 100



$(I_f)_{pu} = (\text{fault MVA})_{pu} = \dfrac{1}{0.05} = 20$

MVA rating $= 20 \times 5$ MVA $= 100$ MVA

17. In the circuit shown below, the switch is closed at t = 0. The value of θ in degrees which will give the maximum value of DC offset of the current at the time of switching is



(A) 60
(B) −45
(C) −30
(D) 90

[Ans. B]

For maximum value of DC offset

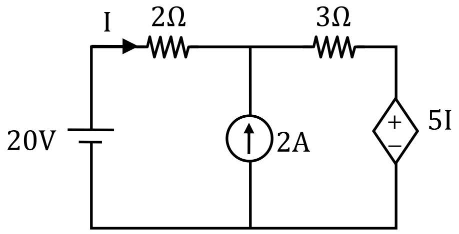
$\omega t_0 + \theta = \tan^{-1}\dfrac{\omega L}{R}$ at $t = t_0$

$R = 3.77\Omega; L = 10\text{mH}; W = 377$

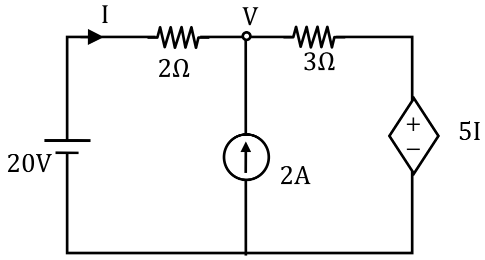
$t_0 = 0$ sec

$\theta = -\tan^{-1}\left(\dfrac{377 \times 10 \times 10^{-3}}{3.77}\right) = -45°$

18. The current I flowing in the circuit shown below in amperes (round off to one decimal places) is ________.



[Ans. *]Range: 1.3 to 1.5



$$\frac{V-20}{2}+\frac{V-5I}{3}=2$$

$3V-60+2V-10I=12$

$5V-60-10I=12$

$$I=\frac{20-V}{2}$$

$\Rightarrow 2I=20-V$

$\Rightarrow 10I=100-5V$

$5V-60-100+5V=12$

$10V=12+160=172$

$V=17.2V$

$$I=\frac{20-17.2}{2}$$

$=\frac{2.8}{2}=1.4$ amp

19. A 5 kVA, 50 V/100V, single – phase transformers has a secondary terminal voltage of 95 V when loaded. The regulation of the transformers is

(A) 4.5%

(B) 9%

(C) 5%

(D) 1%

[Ans. C]

$$\frac{V_{NL}-V_{FL}}{V_{NL}}=\frac{100-90}{100}\times 100=5\%$$

20. The rank of the matrix,

$$M = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}, \text{ is } \_\_\_\_\_\_\_\_.$$

[Ans. *]Range: 3 to 3

$$M = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

Converting this matrix into row echelon form

$R_2 \leftrightarrow R_1$

$$M = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

$R_3 \rightarrow R_3 - R_1$

$$M = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 1 & -1 \end{bmatrix}$$

$R_3 \rightarrow R_3 - R_2$

$$M = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & -2 \end{bmatrix}$$

Now row are becoming completely zero. Hence

$\rho(M) = 3$

21. The parameters of an equivalent circuit of a three – phase induction motor affected by reducing the rms values of the supplying voltage at the rated frequency is

(A) rotor resistance
(B) rotor leakage reactance
(C) magnetizing reactance
(D) stator resistance

[Ans. C]

22. A system transfer function is$H(s) = \frac{a_1s^2+b_1s+c_1}{a_2s^2+b_2s+c_2}$. If $a_1 = b_1 = 0$, and all other coefficients are positive, the transfer function represents a

(A) low pass filter
(B) high pass filter
(C) notch filter
(D) band pass filter

[Ans. A]

$$H(s) = \frac{a_1s^2 + b_1s + c_1}{a_2s^2 + b_2s + c_2}$$

$a_1 = b_1 = 0$

$$H(s) = \frac{c_1}{a_2 s^2 + b_2 s + c_2}$$

at $\omega = 0, H(0) = \frac{c_1}{c_2}$

at $\omega = \infty, H(\infty) = 0$

$\therefore$ LPF

23. A three – phase synchronous motor draws 200 A from the line at unity power factor at rated load. Considering the same line voltage and load, the line current at a power factor of 0.5 leading is

(A) 200 A
(B) 300 A
(C) 100 A
(D) 400 A

[Ans. D]

PF = 0.5

$\theta = 60$

$\cos 60° = \frac{200}{I}$

$I = 400$ A

24. Given V_{gs} is the gate – source voltage V_{ds} is the drain source voltage, and V_{th} is the threshold voltage of an enhancement type NMOS transistor, the condition for transistor to be biased in saturation are

(A) $V_{gs} < V_{th}$; $V_{ds} \geq V_{gs} - V_{th}$
(B) $V_{gs} > V_{th}$; $V_{ds} \geq V_{gs} - V_{th}$
(C) $V_{gs} > V_{th}$; $V_{ds} \leq V_{gs} - V_{th}$
(D) $V_{gs} < V_{th}$; $V_{ds} \leq V_{gs} - V_{th}$

[Ans. B]

For saturation

$V_{GS} > V_{Th}$

And $V_{DS} \geq (V_{GS} - V_{Th})$

25. The partial differential equation

$\frac{\partial^2 u}{\partial t^2} - C^2\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) = 0$; where $C \neq 0$ is known as

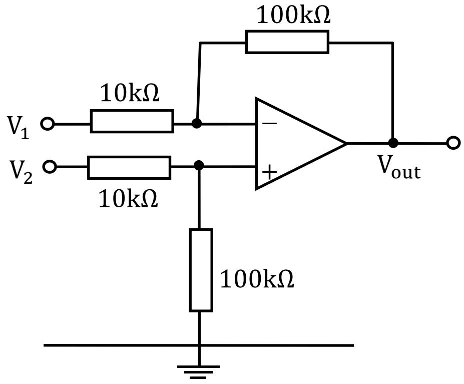
(A) heat equation
(B) Wave equation
(C) Laplace equation
(D) Poisson's equation

[Ans. B]

The above form of equation is known as wave equation.

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

26. In the circuit below, the operational amplifier is ideal.
If $V_1 = 10\text{mV}$ and $V_2 = 50\text{mV}$, the output voltage (V_{out}) is:



(A) 600mV
(B) 400mV
(C) 100mV
(D) 500mV

[Ans. B]

By virtual ground

$V_a = V_b$

$$\frac{100k}{110k} V_2 = \frac{V_1 \times 100k + V_0 \times 10k}{110k}$$

$100kV_2 = 100kV_1 + 10kV_0$

$100 \times 50\text{ m} = 100 \times 10\text{m} + 10 \times V_0$

$4000\text{m} = 10\ V_0$

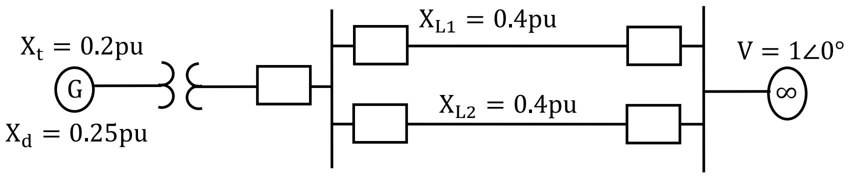
$V_0 = 400\text{ mV}$

27. In a 132kV system, the series inductance up to the point of circuit breaker location is 50mH. The shunt capacitance at the circuit breaker terminal is 0.05μF. The critical value of resistance in ohms required to be connected across the circuit breaker contacts which will give no transient oscillation is____________

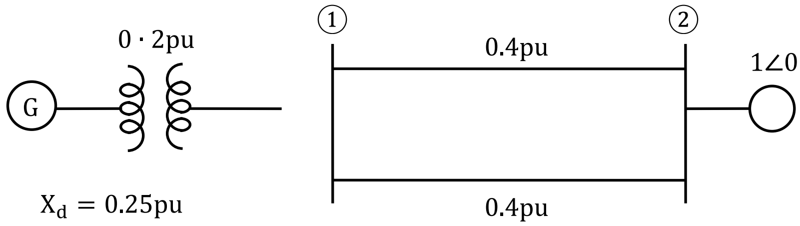
[Ans. *]Range: 500 to 500

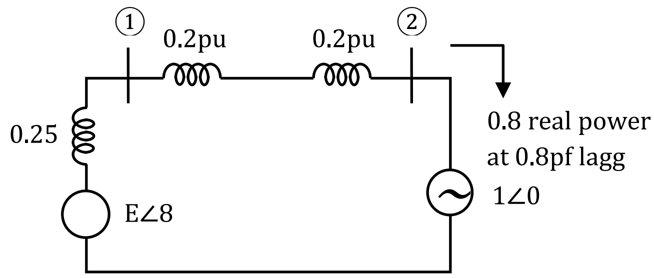
$$r = \frac{1}{2}\sqrt{\frac{L}{C}} = \frac{1}{2} \times \sqrt{\frac{50\text{m}}{0.05\text{H}}} = \frac{1}{2} \times 10^3 = 500\Omega$$

28. In the single machine infinite bus system shown below, the generator is delivering the real power of 0.8pu at 0.8 power factor lagging to the infinite bus. The power angle of the generator in degrees (round off to one decimal place) is ____________



[Ans. *]Range: 20 to 22





$P = VI\cos\phi$

$0.8 = 1 \times I \times 0.8$

$I = 1$

$i = I\angle -\cos^{-1}0.8 = 1\angle -\text{Cos}^{-1}0.8$

$E\angle\delta = V\angle 0 + \underset{i}{\rightarrow}\ \underset{x}{\rightarrow}$

$= 1\angle 0 + 1\angle -\cos^{-1}0.8 \times 0.65\angle 90$

$|E| = 1.484$

$P = \left|\frac{VF}{X}\right|\sin\delta \Rightarrow E\sin\delta = 0.8 \times 0.65 \Rightarrow \delta = \sin^{-1}\left(\frac{0.8 \times 0.65}{1.484}\right) = 20.512°$

29. The line currents of a three-phase four wire system are square waves with amplitude of 100 A. These three currents are phase shifted by 120° with respect to each other. The rms value of neutral current is:

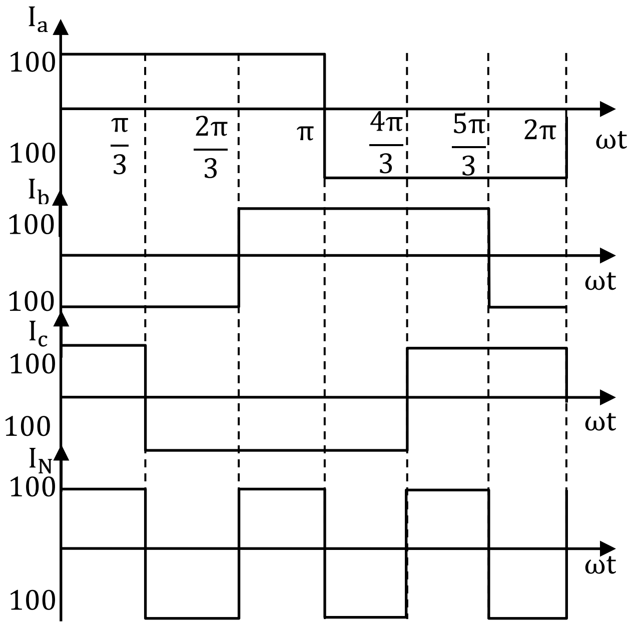
(A) $\frac{100}{\sqrt{3}}$ A

(B) 0A

(C) 100 A

(D) 300 A

[Ans. C]



$I_N = I_a + I_b + I_c$

So, RMS of I_N = 100 Amperes

30. Consider a state-variable model of a system

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -\alpha & -2\beta\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ \alpha\end{bmatrix} r$$

$$y = \begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

Where y is the output , and r is the input. The damping ratio ξ and the undamped natural frequency ω_n (rad/sec) of the system are given by:

(A) $\xi = \frac{\beta}{\sqrt{\alpha}};\ \ \omega_n = \sqrt{\alpha}$

(B) $\xi = \sqrt{\alpha};\ \ \omega_n = \frac{\beta}{\sqrt{\alpha}}$

(C) $\xi = \sqrt{\beta};\ \ \omega_n = \sqrt{\alpha}$

(D) $\xi = \frac{\sqrt{\alpha}}{\beta};\ \ \omega_n = \sqrt{\beta}$

[Ans. A]

$$A = \begin{bmatrix}0 & 1\\ -\alpha & -2\beta\end{bmatrix}\ B = \begin{bmatrix}0\\ \alpha\end{bmatrix}\ C = \begin{bmatrix}1 & 0\end{bmatrix}$$

$$SI - A = \begin{bmatrix}s & 0\\ 0 & s\end{bmatrix} - \begin{bmatrix}0 & 1\\ -\alpha & -2\beta\end{bmatrix} = \begin{bmatrix}s & -1\\ \alpha & s+2\beta\end{bmatrix}$$

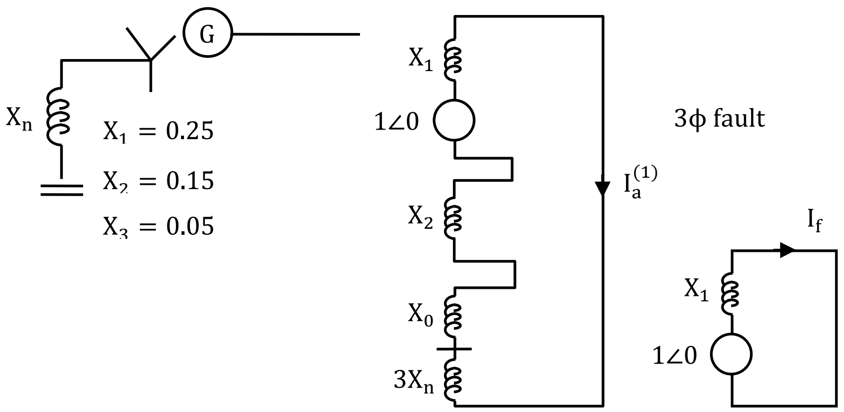
$$(SI - A)^{-1} = \frac{1}{(s(s+2\beta)+\alpha)}\begin{bmatrix}s+2\beta & 1\\ -\alpha & s\end{bmatrix}$$

$$\therefore (SI - A)^{-1} = \frac{1}{s^2 + 2\beta s + \alpha}\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}s+2\beta & 1\\ -\alpha & s\end{bmatrix}\begin{bmatrix}0\\ \alpha\end{bmatrix}$$

$$= \frac{1}{s^2 + 2\beta s + \alpha}[s + 2\beta \quad 1]\begin{bmatrix}0\\ \alpha\end{bmatrix}$$
$$= \frac{\alpha}{s^2 + 2\beta s + \alpha}$$
$$\therefore \omega_n = \sqrt{\alpha}\; 2 \times \xi \times \sqrt{\alpha} = 2\beta$$
$$\xi = \frac{\beta}{\sqrt{\alpha}}$$
$$\xi = \frac{\beta}{\sqrt{\alpha}}, \omega_n = \sqrt{\alpha}$$

31. A moving coil instrument having a resistance of 10Ω, gives a full-scale deflection when the current is 10mA. What should be the value of the series resistance, so that it can be used as a voltmeter for measuring potential difference up to 100V?
(A) 99Ω
(B) 9Ω
(C) 990Ω
(D) 9990Ω
[Ans. D]
Meter resistance $R_m = 10\Omega$
$I_{max} = 10 \text{ mA} = I_{FSD}$
$R_{se} = ?$
$$R_{se} = R_m\left[\frac{V_{max}}{V} - 1\right]$$
$[V = I_{FSD} \times 10]$
$= 10\text{mA} \times 10$
$= 0.1\text{V}$
$$= 10\Omega\left[\frac{100\text{V}}{0.1\text{V}} - 1\right]$$
$= 10[1000 - 1] = 9990\Omega$

32. A 30kV, 50Hz, 50MVA generator has the positive, negative and zero sequence reactance of 0.25pu, 0.15pu and 0.05pu respectively. The neutral of the generator is grounded with a reactance so that the fault current for a bolted LG fault and that of a bolted three-phase fault at the generator terminal are equal. The value of grounding reactance in ohms (round off to one decimal place) is ____________
[Ans. *]Range: 1.7 to 1.9
30KV, 50Hz



I_f for LG fault $= I_f$ for 3ϕ fault

$= 3I_a^{(1)} = (I_f)3\phi$

$$\frac{3\times 1}{X_1 + X_2 + X_0 + 3X_n} = \frac{1}{X_1}$$

$$3X_1 = X_1 + X_2 + X_0 + 3X_n$$

$$\frac{2X_1 - X_2 - X_0}{3} = X_n$$

$$X_n = \frac{2X\,0.25 - 0.15 - 0.05}{3}$$

$$= \frac{0.5 - 0.15 - 0.05}{3} = 0.1$$

$$Z_B = \frac{V_B^2}{S_B} = \frac{(30k)^2}{50m} = 18$$

$$X_n = (X_n)_{pu} \times Z_B = 0.1 \times 18 = 1.8\Omega$$

33. A three-phase 50Hz, 400kV transmission line is 300km long. The line inductance is 1mH/km per phase and the capacitance is 0.01μF/km per phase. The line is under open circuit condition at the receiving end and energized with 400kV at the sending end, the receiving end line voltage in kV (round off to two decimal places) will be ___________

[Ans. *]Range: 414 to 423

Given that

3ϕ, 50 Hz, 400kV line , length l = 300km

$L = 1\text{mH/km}, C = 0.01\mu\text{F/km}$

Under open circuit condition

$V_s = 400$ kV(LT)

No load receiving end voltage

$$(V_R)_{NL} = \frac{V_s}{A}$$

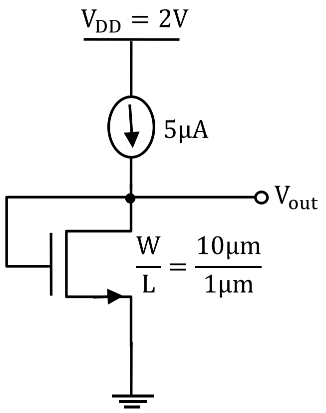
$$A = \cos\beta l$$

where $\beta = \omega\sqrt{LC} = 2\pi \times 50\sqrt{1\times 10^{-3} \times 0.01 \times 10^{-6}}$

$= 9.9345 \times 10^{-4}$rad/km

$\beta l = 0.298$
$A = \cos \beta l = 0.9559$
$(V_R)_{LL} = \frac{400kV}{0.9559} = 418.447\ kV$

34. The enhancement type MOSFET in the circuit below operates according to the square law. $\mu_n C_{ox} = 100\mu A/V^2$, the threshold voltage (V_T) is 500mV. Ignore channel length modulation. The output voltage V_{out} is:



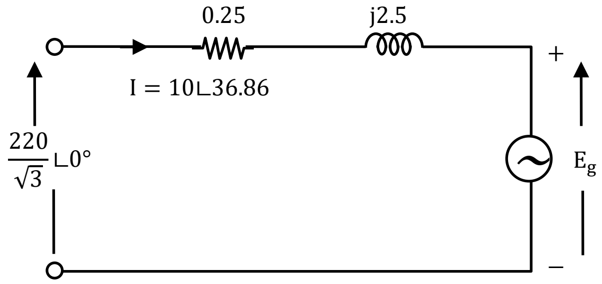
(A) 500mV
(B) 100mV
(C) 600mV
(D) 2V

[Ans. C]
S = Analog
C = MOSFET
T = Operation

$I_D = 5\mu A; \quad \mu_n Cos \frac{\omega}{L} = 100 \times 10\mu A/V^2$
$= 1000\mu A/V^2$
$V_T = 500mV$
Now, $V_{GS} = V_{DS} \quad \therefore V_{DS} > (V_{GS} - V_T)$
$\therefore$ MOSFET is in saturation
$\therefore I_D = \frac{\mu_n cos}{2} \omega/L \ (V_{GS} - V_T)^2$
$5\mu = \frac{1000}{2} \mu(V_o - 500)^2$
$\Rightarrow \frac{1}{100} = (V_o - 500m)^2$
$\Rightarrow (V_o - 500m) = \frac{1}{10}$
$\Rightarrow V_o = 0.1 + 0.5 = 0.6$
$\Rightarrow V_o = 600mV$

35. A 220V (line), three-phase, Y-connected, synchronous motor has a synchronous impedance of $(0.25 + j2.5)\Omega$/phase. The motor draws the rated current of 10A at 0.8pf leading. The rms value of line-to-line internal voltage in volts (round off to two decimal places) is ___________

[Ans. *]Range: 243 to 248



$I = 10\angle\cos^{-1}0.8 = 10\llcorner 36.86$

$E_g\text{perphase} = \frac{220}{\sqrt{3}}\angle 0° - \ 10\angle 36.86(0.25 + j2.5)$

$E_{gph} = 141.66\angle - 8.73$ Volts

E_g line $= E_{gpn} \times \sqrt{3}$

$E_g$line $= 245.36$ Volts Rms

36. A delta-connected, 3.7kW, 400V (line), three-phase, 4-pole, 50Hz squirrel-cage induction motor has the following equivalent circuit parameters per phase referred to the stator. $R_1 = 5.39\Omega, R_2 = 5.72\Omega, X_1 = X_2 = 8.22\Omega$. Neglect shunt branch in the equivalent circuit. The starting line current in amperes (round off to two decimal places) when it is connected to a 100V (line), 10Hz, three-phase AC source is ___________

[Ans. *]Range: 13 to 16

$X_L = j\omega L \ \Rightarrow X_L = j2\pi fL$

$\Rightarrow X_L \propto f$

$X_1|_{f=50} = X_2|_{50Hz} = 8.22\Omega \Rightarrow X_1|_{10Hz} = X_2|_{10Hz} = \frac{8.22}{5}$

$= 1.644\Omega$

$\therefore$ Starting phase current$\left(I_{starting}\right)_{ph} = \frac{(V)_{ph}}{z_{total}}$

$\frac{R_2}{S} = R_2$ ($\because$ S = 1 at starting)

$\Rightarrow \left(I_{starting}\right)_{ph} = \frac{100}{\sqrt{(5.39 + 5.72)^2 + (2 \times 1.644)^2}}$

$(I_{st})_{line} = \sqrt{3} \times (I_{st})_{ph}$

$\Rightarrow (I_{st})_{line} = 14.949$ Ampere

37. The closed loop line integral

$$\oint_{|z|=5} \frac{z^3 + z^2 + 8}{z + 2} dz$$

Evaluated counter-clockwise is:

(A) $+8j\pi$

(B) $-4j\pi$

(C) $-8j\pi$

(D) $4j\pi$

[Ans. A]

$$f(z) = \frac{z^3 + z^2 + 8}{z + 2}$$

f(z) has singular point at $z = -2$

$z = -2$ lies inside the given contour

Using residue theorem

$$\oint f(z)dz = 2\pi i(\text{Res}|_{z=-2})$$

$$\text{Res}|_{z=-2} \underset{z \to -2}{\text{lt}} (z + 2)f(z)$$

$$\underset{z \to -2}{\text{lt}} (z + 2)\left(\frac{z^3 + z^2 + 8}{z + 2}\right)$$

$$(-2)^3 + (-2)^2 + 8$$

$$= 4$$

$$\therefore \oint f(z)dz = 2\pi i(4)$$

$$= 8\pi i$$

38. The transfer function of a phase lead compensator is given by

$$D(s) = \frac{3\left(s + \frac{1}{3T}\right)}{\left(s + \frac{1}{T}\right)}$$

The frequency (in rad/sec) at which $\angle D(j\omega)$ is maximum is:

(A) $\sqrt{\frac{3}{T^2}}$

(B) $\sqrt{\frac{1}{3T^2}}$

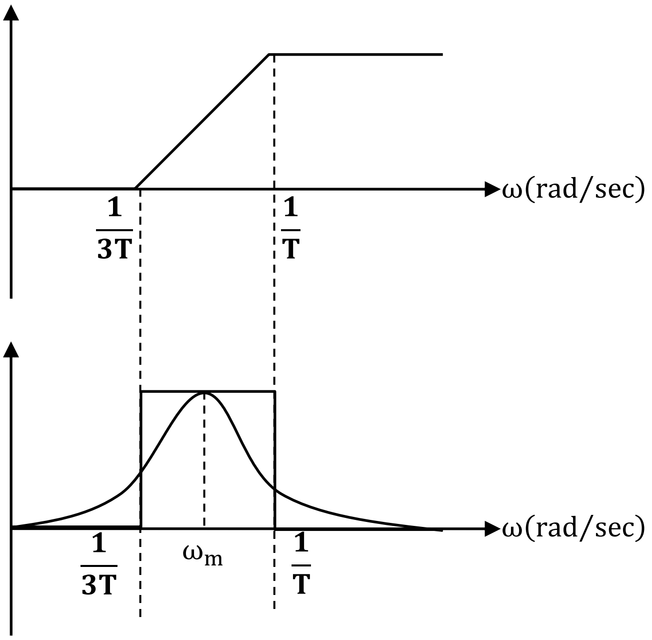
(B) $\sqrt{3T}$

(C) $\sqrt{3T^2}$

[Ans. B]

$$D(s) = \frac{3\left(s+\frac{1}{3T}\right)}{s+\frac{1}{T}} \quad \text{(Lead Compensator)}$$

|M(dB)|



Phase will be maximum at suppose ω_m(rad/sec)

So, $\quad \phi_{max}$ at $\omega_m = GM\left(\frac{1}{3T}, \frac{1}{T}\right)$

$$\Rightarrow \omega_m = \sqrt{\frac{1}{3T}\frac{1}{T}} = \sqrt{\frac{1}{3T^2}} \text{ rad/sec}$$

39. In a DC-DC boost converter, the duty ratio is controlled to regulate the output voltage at 48V. The input DC voltage is 24V. The output power is 120W. The switching frequency is 50 kHz. Assume ideal components and a very large output filter capacitor. The converter operates at the boundary between continuous and discontinuous conduction modes. The value of the boost inductor (in μH) is ___________

[Ans. *]Range: 24 to 24

$$V_0 = \frac{V_s}{1-2}$$

$$\alpha = 1 - \frac{V_s}{V_0} = 0.5$$

$$P_s = I_s V_s$$

$$\frac{120}{24} = I_s = I_L$$

$$I_L = 5$$

$I_L = \frac{\Delta I_L}{2}$

[For critical inductance]

$\Delta I_L = \frac{DV_s}{fL}$

$I_L = \frac{DV_s}{2fL}$

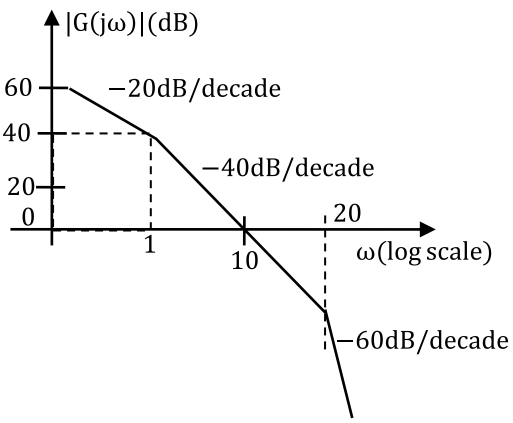
$L = \frac{DV_s}{2fI_L}$

$L = \frac{0.5 \times 24}{2 \times 5 \times 50 \times 10^3}$

$L = 2.4 \times 10^{-5}$

$L = 24\mu H$

40. The asymptotic Bode magnitude plot of a minimum phase transfer function G(s) is shown below.



Consider the following two statements.

Statement I: Transfer function G(s) has three poles and one zero

Statement II: At very high frequency($\omega \rightarrow \infty$), the phase angle $\angle G(j\omega) = -\frac{3\pi}{2}$

Which one of the following options is correct?

(A) Both the statements are false

(B) Statement I is false and statement II is true

(C) Both the statements are true

(D) Statement I is true and statement II is false

[Ans. B]

From the given bode plot, there are two (2) corner frequencies which are at $\omega = 1\text{rad/sec}$ & $\omega = 20\text{rad/sec}$. As bode plot is having initial slope of −20 dB/dec hence it has 1 pole at origin.

At $\omega = 1\text{rad/sec}$; change in slope= [−40 − (−20)] dB/dec

= −20dB/dec

Hence there is 1 pole at $\omega = 1$ rad/sec

At $\omega = 20$ rad/sec , change in slope $= [-60 - (-40)\text{dB/dec}$
$= -20\text{dB/dec}$
Hence there is 1 pole at $\omega = 20$ rad/sec

$$\text{So, TF} = \frac{K}{S(S+1)\left(1+\frac{S}{20}\right)}$$

For Statement -1
From the transfer function TF
No. of poles $= 3$ & No of zeros $= 0$
So, statement $-$ 1 is false
For Statement-2

$$\angle\, TF(s) = \frac{\angle K}{\angle S \angle S + 1\angle\left(1+\frac{S}{20}\right)}$$

$$\angle TF(j\omega) = \frac{\angle K}{\angle j\omega \angle 1 + j\omega \angle 1 + \frac{j\omega}{20}}$$

$$= -90° - \tan^{-1}\omega - \tan^{-1}\frac{\omega}{20}$$

$$\lim_{\omega\to\infty} \angle TF(j\omega) = -90° - \tan^{-1}(\infty) - \tan^{-1}\left(\frac{\infty}{20}\right) = -90° - 90° - 90°$$

$$= -270° \text{ (or) } \left(\frac{-3\pi}{2}\right)$$

So statement 2 is true

41. A fully-controlled three-phase bridge converter is working from a 415V, 50Hz AC supply. It is supplying constant current of 100A at 400V to a DC load. Assume large inductive smoothing and neglect overlap. The rms value of the AC line current in amperes (round off to two decimal places) is ____________

[Ans. *]Range: 81 to 82

The Rms value of AC line current is given by

$$I_s = I_0\sqrt{\frac{2}{3}}$$

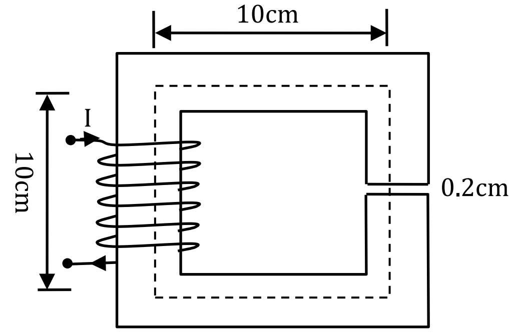
$I_0 = 100\text{A}$ given

$$I_s = 100\sqrt{\frac{2}{3}}$$

$I_s = 81.649$ Amp

42. The magnetic circuit shown below has uniform cross-sectional area and air gap of 0.2cm. The mean path length of the core is 40cm. Assume that leakage and fringing fluxes are negligible. When the core relative permeability is assumed to be infinite, the magnetic flux density computed in the air gap is 1 tesla. With same Ampere-turns, if the core relative

permeability is assumed to be 1000(linear), the flux density in tesla (round off to three decimal places) calculated in the air gap is ___________



[Ans. *]Range: 0.820 to 0.850

Reluctance $R = \frac{1}{\mu}\frac{l}{A} = \frac{l}{\mu_o \mu_r A}$

When $\mu = \infty$; $R_{core} = 0$

When $\mu = 1000$; $R_{core} = \dfrac{40 \times 10^{-2}}{1000\mu_o A} = \dfrac{4 \times 10^{-4}}{\mu_o A}$ AT/wb

$R_{air\ gap} = \dfrac{0.2 \times 10^{-2}}{\mu_o (1) A} = \dfrac{2 \times 10^{-3}}{\mu_o A}$ AT/wb

$R_{total} = R_{core} + R_{air\ gap}$

i. $\mu = \infty$; $R_1 = 0 + \frac{2\times10^{-3}}{\mu_o A}$

ii. $\mu = 1000$; $R_2 = \frac{4\times10^{-4}}{\mu_o A} + \frac{2\times10^{-3}}{\mu_o A} = \frac{2.4\times10^{-3}}{\mu_o A}$

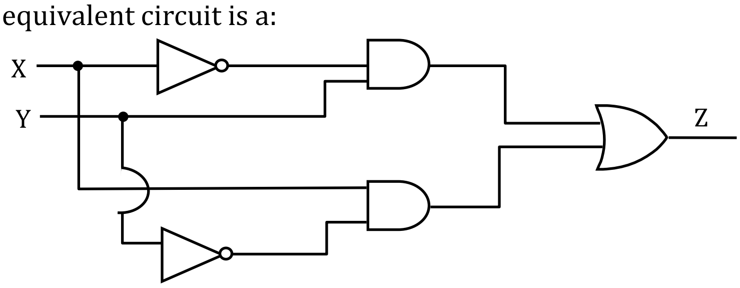
Given MMF is constant.

$\Rightarrow S = R\phi = \text{constant}$

$\Rightarrow \dfrac{R_1}{R_2} = \dfrac{\phi_2}{\phi_1} = \dfrac{B_2}{B_1} \Rightarrow B_2 = B_1 \times \dfrac{2.0}{2.4} = 1 \times \dfrac{2.0}{2.4}$

$\Rightarrow B = 0.83$ Tesla

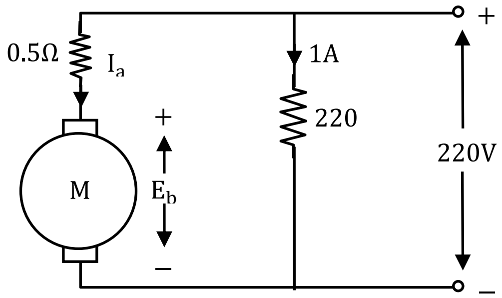
43. In the circuit shown below, X and Y are digital inputs and Z is a digital output. The equivalent circuit is a:



(A) NAND gate
(B) NOR gate
(C) XOR gate

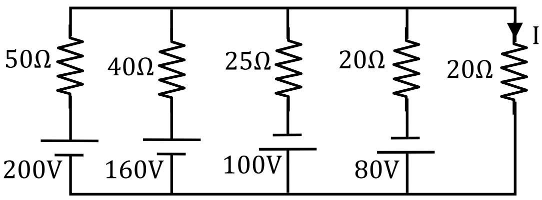
(D) XNOR gate
[Ans. C]
$Z = \overline{X}Y + X\overline{Y}$
$= X \oplus Y$
$\therefore$ Option (C)is the correct answer

44. A 220V DC shunt motor takes 3A at no-load. It draws 25A when running at full-load at 1500rpm. The armature and shunt resistance are 0.5Ω and 220Ω respectively. The no-load speed in rpm (round off to two decimal places) is ___________
[Ans. *]Range: 1564 to 1596

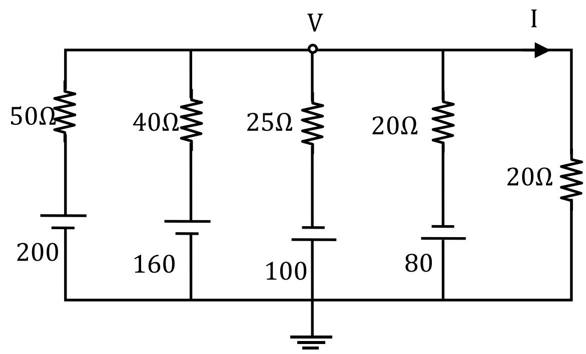


At no load: $I_a = 2A$
$E_b = 220 - 2(0.5) = 219V$
At full load: $I_a = 24$
$E_b = 220 - 24(0.5) = 208V$
$\therefore \frac{N_{nl}}{N_{fl}} = \frac{E_{bML}}{E_{bFL}} = \frac{219}{208}$
$\Rightarrow N_{nl} = \frac{219}{208} \times 1500\text{rpm} = 1579.3 \text{ rpm}$

45. The current I flowing in the circuit shown below in armature is ___________



[Ans. *]Range: 0 to 0



$$\frac{V-200}{50}+\frac{V-160}{40}+\frac{V+100}{25}+\frac{V+80}{20}+\frac{V}{20}=0$$

$$\frac{4V-800+5V-800+8V+800+10V+800+10V}{200}=0$$

$$V=0$$

$$\therefore I=\frac{V}{20}=0\ \text{amp}$$

46. A DC-DC buck converter operates in continuous conduction mode. It has 48V input voltage and it feeds a resistive load of 24Ω. The switching frequency of the converter is 250Hz. If switch-on duration is 1ms, the load power is:

(A) 6W

(B) 24W

(C) 48W

(D) 12W

[Ans. A]

Continuous conduction mode means R-L load

$V_s = 48$ volts

$R_0 = 24\Omega$

$f = 250$ Hz $T_{ON} = 1$msec

$$D=\frac{T_{ON}}{T}=10^{-3}\times 250$$

$= 0.25$

$V_0 = DV_s = 12$ volts

$$I_0=\frac{V_0}{R}=\frac{12}{24}=\frac{1}{2}\text{Amp}$$

$$\text{Power}=V_0\times I_0=12\times\frac{1}{2}=6\ \text{Watts}$$

47. The output expression for the Karnaugh map shown below is:

RS \ PQ	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

(A) $Q\overline{R} + S$

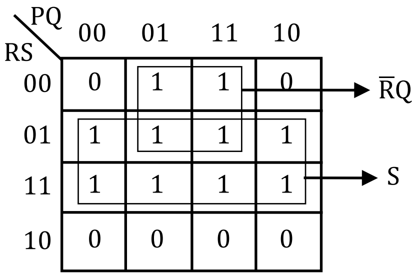
(B) $QR + S$

(C) $QR + \overline{S}$

(D) $Q\overline{R} + \overline{S}$

[Ans. A]

Given K-Map is



$\therefore$ The minimized function $= S + \overline{R}Q$

48. A periodic function f(t) with a period of 2π is represented as its Fourier series,

$f(t) = a_0 + \Sigma_{n=1}^{\infty} a_n \cos nt + \Sigma_{n=1}^{\infty} b_n \sin nt$

If $f(t) = \begin{cases} A \sin t, & 0 \le t \le \pi \\ 0, & \pi < t < 2\pi \end{cases}$

The Fourier series coefficients a_1 and b_1 of f(t) are:

(A) $a_1 = \frac{A}{\pi}; b_1 = 0$

(B) $a_1 = \frac{A}{2}; b_1 = 0$

(C) $a_1 = 0; b_1 = \frac{A}{\pi}$

(D) $a_1 = 0; b_1 = \frac{A}{2}$

[Ans. D]

Given , $T_0 = 2\pi$

$$\Rightarrow \omega_0 = \frac{2\pi}{T_0} = \frac{2\pi}{2\pi} = 1$$

$$a_1 = \frac{2}{T_0}\int_{<T_0>} f(t).\cos\omega_0 t\, dt$$

$$= \frac{2}{2\pi}\int_0^{2\pi} f(t).\cos t dt$$

$$= \frac{1}{\pi}\int_0^{\pi} A\sin t\cos t\ dt$$

$$= \frac{1}{2\pi}\int_0^{\pi} A\sin 2t\ dt$$

$$\frac{A}{2\pi}\left[-\frac{\cos 2t}{2}\right]_0^{\pi}$$

$$= \frac{A}{4\pi}[-\cos(2\pi) + \cos(0)]$$

$$= \frac{A}{4\pi}[-1+1]$$

$$a_1 = 0$$

$$b_1 = \frac{2}{T_0}\int_{<T_0>} f(t)\sin\omega_0 t\, dt$$

$$= \frac{2}{2\pi}\int_0^{2\pi} f(t)\sin t\ dt$$

$$= \frac{2}{2\pi}\int_0^{\pi} A\sin t.\sin t\, dt$$

$$= \frac{A}{2\pi}\int_0^{\pi} 2\sin^2 t\, dt$$

$$= \frac{A}{2\pi}\int_0^{\pi} (1-\cos 2t)\ dt$$

$$= \frac{A}{2\pi}\left[\int_0^{\pi} 1\ dt - \int_0^{\pi}\cos 2t dt\right]$$

$$= \frac{A}{2\pi}\left[(t)_0^{\pi} - \left(\frac{\sin 2t}{2}\right)_0^{\pi}\right]$$

$$= \frac{A}{2\pi}\left[(\pi-0) - \frac{1}{2}(\sin 2\pi - \sin 0)\right]$$

$$= \frac{A}{2\pi}[\pi - 0]$$

$b_1 = \frac{A}{2}$

49. The voltage across and the current through a load are expressed as follows

$v(t) = -170\sin\left(377t - \frac{\pi}{6}\right)$ V

$i(t) = 8\cos\left(377t + \frac{\pi}{6}\right)$ A

The average power in watts (round off to one decimal place) consumed by the load is___________

[Ans. *]Range: 585 to 590

$V = -170\sin(377t - 30°) = -170\angle -30°$

$I = 8\cos(377t + 30°)$

$= 8\sin(90° + 377t + 30°)$

$= 8\angle 120°$

$S^* = VI^* = -\left(\frac{170}{\sqrt{2}}\angle -30°\right)\left(\frac{8}{\sqrt{2}}\angle -120°\right)$

$S^* = -(680\angle -150°)$

$S^* = 588.89 + j340$

$P_{avg} = 588.9$ watts

50. Consider an 2×2 matrix $M = [v_1 \quad v_2]$, where v_1 and v_2 are the column vectors. Suppose $M^{-1} = \begin{bmatrix} u_1^T \\ u_2^T \end{bmatrix}$, where u_1^T and u_2^T are the row vectors. Consider the following statements:

Statement 1: $u_1^T v_1 = 1$ and $u_2^T v_2 = 1$

Statement 2: $u_1^T v_2 = 0$ and $u_2^T v_1 = 0$

Which of the following options is correct?

(A) Statement 1 is true and statement 2 is false

(B) Both the statements are false

(C) Both the statements are true

(D) Statement 2 is true and statement 1 is false

[Ans. C]

We know that

$M^{-1}m = I$

$\begin{bmatrix} u_1^T V_1 & u_1^T V_2 \\ u_2^T V_1 & u_2^T V_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

On comparing the corresponding element we get

$u_1^T V_1 = 1$ and $u_2^T V_2 = 1$

So, S1 is true

And $u_2^T V_1 = 0$ and $u_1^T V_2 = 0$

So. S2 is true

51. A 0.1μF capacitor charged to 100V is discharged through a 1kΩ resistor. The time in ms (round off to two decimal places) required for the voltage across the capacitor to drop to 1V is _____________

[Ans. *]range: 0.45 to 0.47

Capacitor is discharging so, in case of discharging of capacitor

$V_c(t) = V_c(0)e^{-\frac{t}{\tau}}$

where $\tau = RC = 1 \times 10^3 \times 0.1 \times 10^{-6} = 10^{-4}$ sec

$\therefore V_c(t) = 1V = 100e^{-\frac{t}{10^{-4}}}$

$\Rightarrow 0.01 = e^{\frac{-t}{10^{-4}}}$

$t = -10^{-4} \ln(0.01)$

$= 10^{-4} \times 4.6051$

$= 0.46$ m sec

52. A single-phase fully-controlled thyristor converter is used to obtain an average voltage of 180V with 10A constant current to feed a DC load. It is fed from single-phase AC supply of 230V, 50Hz. Neglect the source impedance. The power factor (round off to two decimal places) of AC mains is ____________

[Ans. *]Range: 0.75 to 0.80

power factor for 1ϕ f Controlled converter

power factor = CDf × Df

$\text{power factor} = \frac{2\sqrt{2}}{\pi} \times \text{Cos}\,\alpha$

for α

$V_0 = \frac{2V_m}{\pi} \times \cos\alpha$

$V_0 = 180°$

$V_m = 230 \times \sqrt{2}$

$\cos\alpha = \frac{V_0 \times \pi}{2V_m}$

$\cos\alpha = \frac{180 \times \pi}{2 \times \sqrt{2} \times 230} = 0.87$

power factor = 0.9 × 0.87 = 0.783

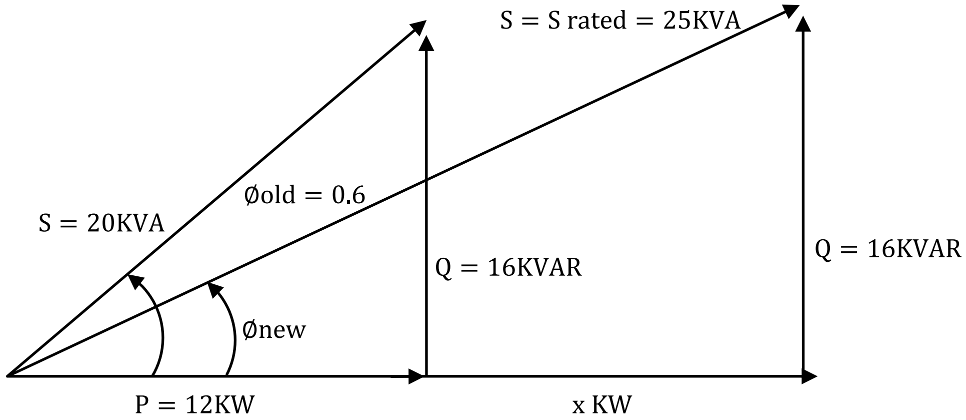
53. A single-phase transformer of rating 25kVA, supplies a 12kW load at power factor of 0.6 lagging. The additional load at unity power factor in kW (round off to two decimal places) that may be added before this transformer exceeds its rated kVA is _____________

[Ans. *] Range: 7.10 to 7.30

$P = 12KW \text{ and } \cos\phi = 0.6 \text{ lag} \Rightarrow S = \frac{P}{\cos\phi} = 20KVA$

$Q = S\sin\phi = 20(0.8) = 16KVAR$

$\vec{S} = P + jQ = (12 + j16)KVA$



* Additional load added at UPF will be directly added to real power 'P' as shown in fig

$\therefore P_{new} = 12KW + x\,KW = (12 + x)KW$

$S\text{ rated} = \sqrt{P_{new}^2 + Q^2} \Rightarrow 2^5 = \sqrt{(12 + x)^2 + 16^2}$

$\Rightarrow x^2 + 24x + 144 + 256 = 625$

$\Rightarrow x^2 + 24x - 225 = 0 \Rightarrow \{ \begin{matrix} x_1 = -31.209 \rightarrow \text{Invalid} \\ x_2 = 7.209 \rightarrow \text{Valid} \end{matrix}$

$\Rightarrow$ Additional load $\Rightarrow 7.209KW$

54. The probability of a resistor being defective is 0.02. There are 50 such resistors in a circuit. The probability of two or more defective resistors in the circuit (round off to two decimal places) is ____________

[Ans. *]Range: 0.25 to 0.27

Given

Probability of detective resistor $p = 0.02$

Probability of non-detective resistor $q = 1 - 0.02$

$= 0.98$

Number of resistors $n = 50$

by Poisson approach $\lambda = np = 1$

$P(X \geq 2) = 1 - [P(X = 0) + P(X = 1)]$

$= 1 - [e^{-1} + e^{-1}]$

$= 0.264$

55. If $A = 2xi + 3yj + 4zk$ and $u = x^2 + y^2 + z^2$, then div(uA) at (1,1,1) is ____________

[Ans. *] Range : 45 to 45

Using the identity

$\nabla(\phi\vec{A}) = \nabla\phi \cdot \vec{A} + \phi(\nabla \cdot \vec{A})$

here $\phi = 4 = x^2 + y^2 + z^2$

and $\vec{A} = 2x\hat{i} + 3y\hat{j} + 4z\hat{k}$

$\nabla(\phi\vec{A}) = (2x\hat{i} + 2y\hat{j} + 2z\hat{k}) \cdot (2x\hat{i} + 3y\hat{j} + 4z\hat{k})$

$+(x^2 + y^2 + z^2)(2 + 3 + 4)$

$\nabla(\phi\vec{A}) = 4x^2 + 6y^2 + 8z^2 + 9x^2 + 9y^2 + 9z^2$

$\nabla(\phi\vec{A})| = 4 + 6 + 8 + 9 + 9 + 9$

$(1, 1, 1)$

$\nabla(\phi \cdot \vec{A}) = 45$