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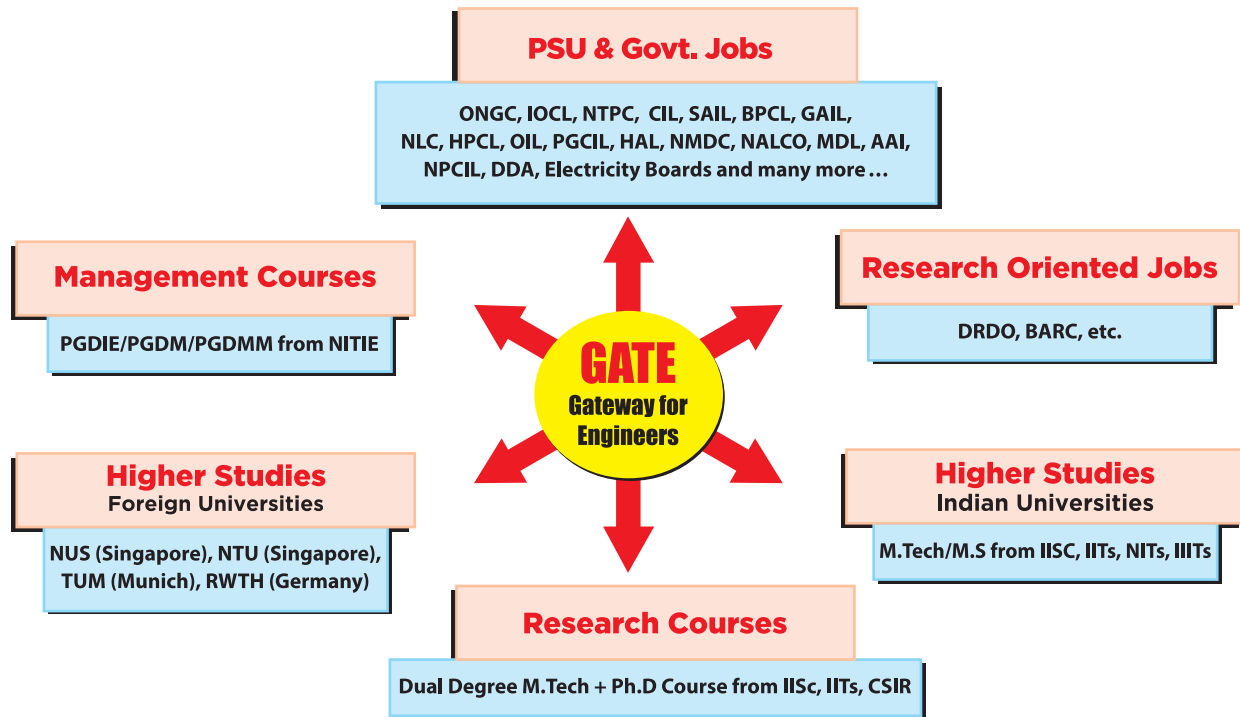
Revision through Questions for GATE 2020

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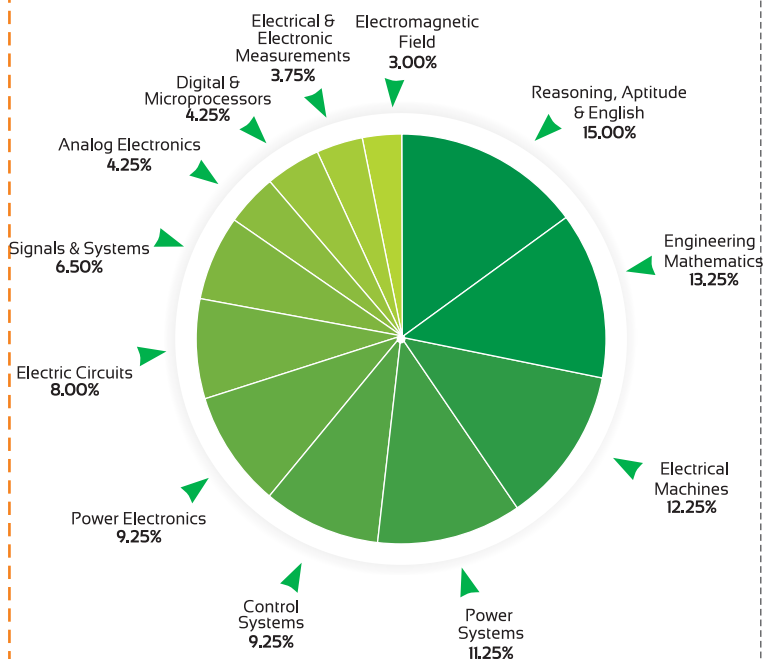
ELECTRICAL ENGG.

Q.1 - Q.25
out of 200 Questions

Day 1 of 8



SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS

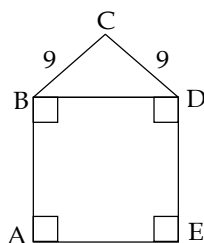


Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

Day 1 : Q.1 to Q. 25 : General Aptitude

- Q.1** Choose the correct set of words to complete the sentence:
Politicians must be _____ for the people, but they should never be _____ for public welfare.
(a) disinterested, uninterested (b) disinterested, disinterested
(c) uninterested, uninterested (d) uninterested, disinterested
- Q.2** How many numbers between 1 to 300 are divisible by only 11 or only 13 but not by both?
(a) 45 (b) 46
(c) 48 (d) 50
- Q.3** Triangles ABC and CDE have a common vertex C with side AB of triangle ABC being parallel to side DE of triangle CDE . If length of side $AB = 4$ cm and length of side $DE = 10$ cm and perpendicular distance between sides AB and DE is 9.8 cm, then the sum of areas of triangle ABC and triangle CDE is _____ cm^2 .
- Q.4** A and B will participate in a sack race (In a sack race, people hop to reach the finish line). In the time that A takes 3 hops, B takes 4 hops but the distance covered by A in 4 hops is equal to distance covered by B in 5 hops. What is the ratio of A's speed: B's speed?
(a) 3 : 5 (b) 12 : 20
(c) 15 : 16 (d) 1 : 1
- Q.5** In the sentence given below, a part of sentence is underlined, choose the correct alternative of the phrasing of the underlined part:
While their ostrich like attitude is aggravating, what is very serious is loss of wealth and loss of business.
(a) their refusal to face facts (b) their heavy handedness
(c) their annoying behaviour (d) their big ego
- Q.6** What is the sum of all possible solutions to $|x - 3|^2 + |x - 3| = 20$?
(a) -1 (b) 6
(c) 7 (d) 12
- Q.7** A lizard is crawling up a minaret to reach the top. The top of the minaret is 1800 cm from its position. After every minute of crawling it halts for half a minute. In every halt it slides down by 30 cm from its position. Time the lizard will take to reach the top of the minaret if it can crawl 150 cm per minute is
(a) 21 minutes 48 seconds (b) 25 minutes
(c) 20 minutes (d) 32 minutes 40 seconds
- Q.8** How many 5 letter words (with or without meaning) can be formed using all the following 5 letters A, B, C, D and E so that letter A is to the left of letter B?
(a) 120 (b) 60
(c) 48 (d) 24

- Q.9** Choose the option that best substitutes the underlined part of the sentence :
TCS is edging closer to become the country's first 100 bn \$ company. The company is fortunate to have excellent relationships among its employees : they each have a relationship of respect for all the others.
- (a) they each have a relationship of respect for all the others.
(b) they have respect for one another.
(c) each one has respect for one another.
(d) they each have a relationship of respect for each other.
- Q.10** What is the remainder when $1! + 2! + 3! \dots 100!$ is divided by 18?
(a) 0 (b) 1
(c) 5 (d) 9
- Q.11** The percentage profit earned by selling an article for ₹1920 is equal in the percentage loss incurred by selling the same article for ₹1280. At what price (in ₹) should the article be sold to make 25% profit?
- Q.12** A faulty wall clock is known to gain 15 minutes every 24 hours. It is synchronized to the correct time at 9 AM on 14th August. What will be the correct time to the nearest minute when the clock shows 2 PM on 18th August of the same year?
(a) 12:45 PM (b) 12:58 PM
(c) 1:00 PM (d) 2:00 PM
- Q.13** As shown in the figure below, two sides of triangle BCD are each 9 feet long. Triangle BCD shares side BD with square ABDE, and angle CBD measures 45° . What is the total area of figure ABCDE in square feet? (Note: Figure not drawn to scale.)



- (a) 121.5 (b) $40.5 + 81\sqrt{2}$
(c) 202.5 (d) 221
- Q.14** A farmer can plow his wheat field in 12 days. After working for 5 days, his daughter joins him and together they finish plowing the field in 4 days. How many days would it take the daughter to plow the wheat field alone?
- Q.15** A series of numbers are written using digits 1, 2, 3, 4 and 5 in the following pattern:
1, 2, 2, 3, 3, 3, 4, 4, 4, 4, 5, 5, 5, 5, 5, 1, 1, 1, 1, 1, 1, (six 1's) and so on. Which of the following digits will come at the 100th position in this sequence?
(a) 1 (b) 2
(c) 3 (d) 4

- Q.16** A part has been omitted from the sentence given below and it is to be filled with idiom(s), to make the sentences grammatically meaningfully correct. Mark the answer accordingly.
Although Mr. Naipaul was _____, he never boasted about anything or try to use the resources available to him in an unethical way.
1. An armchair traveller
 2. Born with a silver spoon
 3. A big fish in a small pond
- (a) Only 2 (b) Both 2 and 3
(c) Both 1 and 3 (d) None of these
- Q.17** In the given question, a set of conclusions is given. There are four options comprising of three or more statements. You need to choose the option that contains the set of statements from which the given conclusions logically follow.
All horses cannot be cottages. No glance is a cottage.
- (a) Some glances are horses. Some horses are blemishes. No blemish is a cottage.
 - (b) No horse is a blemish. All cottages are blemishes. All glances are horses.
 - (c) Some horses are blemishes. All glances are blemishes. Some cottages are not blemishes.
 - (d) All horses are blemishes. Some blemishes are not cottages. No blemish is a glance.
- Q.18** Vessel A contains six green and four red balls and vessel B contains four green and six red balls. One ball is drawn at random from vessel A and placed in vessel B. Then one ball is transferred at random from vessel B to vessel A. If one ball is now drawn at random from vessel A, the probability that it is green is
- (a) $\frac{23}{55}$ (b) $\frac{32}{65}$
 - (c) $\frac{33}{65}$ (d) $\frac{32}{55}$
- Q.19** Four runners started running the race in the same direction along a circular path of 7 km. Their speed are 4, 3, 9, 3.5 km/hr. individually. If they started their race at 6 AM then at what time they all will be at the starting point?
- (a) 2 PM (b) 8 PM
 - (c) 8 AM (d) 6 PM
- Q.20** The average number of goals scored per match by Sunil Chhetri in matches where he was in the team of starting 11 is 1.5 and the average number of goals scored by him in matches where he came on as a substitute is 0.5. He scored 390 goals more in matches where he was in the team of starting 11 than in matches in which he came on as a substitute. If he played 388 matches in total, the average number of goals scored by him per match is
- Q.21** In a family of 4 members, the eldest member expires after 5 years at the age of 88 and 10 years after that a baby is born in the family such that the difference of family's eldest to youngest member alive after 20 years from present is 57. At present, the age of youngest member is 14 years and the average age of remaining member is 54. The age of the two eldest members alive after 5 years would be
- (a) 88, 47 (b) 42, 19
 - (c) 47, 42 (d) 37, 42

Q.22 Which of phrases given below should replace the phrase printed in **bold** type to make the sentence grammatically correct?

The **crime has growth rapidly** in Russia since the disintegration of the communist system.

- (a) rapid crime has grown
- (b) crime has grown rapidly
- (c) crimes grow rapidly
- (d) crimes have been rapidly grown

Q.23 A sphere is inscribed in a cube with an edge of 10 units. What is the shortest possible distance in units from one of the vertices of the cube to the surface of the sphere?

- (a) $10(\sqrt{3} - 1)$
- (b) 5
- (c) $10(\sqrt{2} - 1)$
- (d) $5(\sqrt{3} - 1)$

Q.24 Based on the given statements, select the most appropriate option to solve the question.

Sheetal wants to sell her bicycle at either a profit of $K\%$ or a loss of $K\%$. What is the value of K ?

Statement 1: Difference between the amount Sheetal gets in the 2 cases is ₹2560.

Statement 2: If Sheetal's profit is Rs K , her profit in percentage is 7.5%.

- (a) Statement 1 alone is sufficient, but statement 2 alone is NOT sufficient.
- (b) Statement 2 alone is sufficient, but statement 1 alone is NOT sufficient.
- (c) Both statements together are sufficient, but neither statement alone is sufficient.
- (d) Statement 1 and 2 together are NOT sufficient.

Q.25 Select the pair which has the same relationship as the two words

IMPLAUSIBLE : ABSURD :: ?

- (a) shadowy : illuminated
- (b) flamboyant : public
- (c) surprising : shocking
- (d) superfluous : truncated

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Detailed Explanations

1. (a)

'Disinterested' means 'free from bias, free from personal/selfish motives'.

'Uninterested' means 'lacking interest'.

2. (b)

Between 1 to 300:

There are 27 multiples of 11.

There are 23 multiples of 13.

There are 2 multiples of 143 (of both 11 and 13).

So, there are $27 - 2 = 25$ numbers divisible by 11 only.

And, there are $23 - 2 = 21$ numbers divisible by 13 only.

In all, there are $25 + 21 = 46$ numbers divisible by 11 or 13 but not by both.

3. 40.6 (40 to 41)

Given

$$AB \parallel DE$$

$\Rightarrow$

$$\angle B = \angle D \quad (\text{Alternate angles})$$

and

$$\angle A = \angle E \quad (\text{Alternate angles})$$

$\therefore$

$$\triangle ABC \sim \triangle EDC \quad (\text{AAA similarity})$$

$\Rightarrow$

$$\frac{h_1}{h_2} = \frac{AB}{DE} = \frac{4}{10} = \frac{2}{5}$$

and

$$h_1 + h_2 = 9.8 \text{ cm} \quad (\text{given})$$

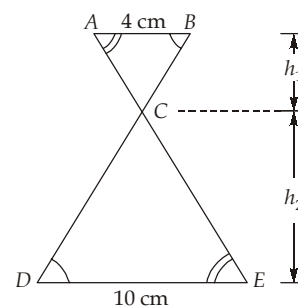
$\therefore$

$$h_1 = 2.8 \text{ cm and } h_2 = 7 \text{ cm}$$

$$\text{Area of } \triangle ABC = \frac{1}{2} \times 4 \times 2.8 = 5.6 \text{ cm}^2$$

$$\text{Area of } \triangle EDC = \frac{1}{2} \times 10 \times 7 = 35 \text{ cm}^2$$

$$\therefore \text{ Sum of areas of } \triangle ABC \text{ and } \triangle EDC = 40.6 \text{ cm}^2$$



4. (c)

Let time taken by A and B to complete 3 and 4 hops respectively be 't'

Therefore time taken by A and B to do 1 hop is $\frac{t}{3}$ and $\frac{t}{4}$ respectively

Let distance covered in A and B's 4 and 5 hops respectively be 'd'

Therefore distance covered by A and B in 1 hop is $\frac{d}{4}$ and $\frac{d}{5}$ respectively

$$\text{A's speed: B's speed} = \frac{\left(\frac{d}{4}\right)}{\left(\frac{t}{3}\right)} : \frac{\left(\frac{d}{5}\right)}{\left(\frac{t}{4}\right)} = \left(\frac{3}{4}\right) \times \left(\frac{d}{t}\right) : \left(\frac{4}{5}\right) \times \left(\frac{d}{t}\right) = 15 : 16$$

5. (a)

'Ostrich like attitude' means 'when you overlook or ignore a problem'.

6. (b)

First of all $|x - 3|^2 = (x - 3)^2$, so we have: $(x - 3)^2 + |x - 3| = 20$.

when $x < 3$, $x - 3$ is negative, thus $|x - 3| = -(x - 3)$. In this case we will have $(x - 3)^2 - (x - 3) = 20$

$$\Rightarrow x = -1 \text{ or } x = 8.$$

Discard $x = 8$ because it's not in the range we consider (< 3).

when $x \geq 3$, $x - 3$ is non-negative, thus $|x - 3| = x - 3$. In this case we will have $(x - 3)^2 + (x - 3) = 20$

$$\Rightarrow x = -2 \text{ or } x = 7.$$

Discard $x = -2$ because it's not in the range we consider (≥ 3).

Thus there the two solutions: $x = -1$ and $x = 7$

$$\Rightarrow \text{The sum} = 6.$$

7. (a)

$$\text{Number of trials} = \frac{1800}{150 - 30} = \frac{1800}{120} = 15$$

Let us take 14 trials of sliding up

For every trial of these 14 trials, its effective upward movement is $(150 - 30) = 120$ cm

$$\text{The time taken for this} = \left(14 \times 1 + 14 \times \frac{1}{2} \right) = 21 \text{ minutes}$$

$$\text{Total distance} = (14 \times 120) = 1680 \text{ cm}$$

$$\text{Remaining} = 1800 - 1680 = 120 \text{ cm}$$

$$\text{Remaining 120 cm it can reach in } \frac{(60 \times 120)}{150} = 48 \text{ seconds}$$

$$\text{Total time} = 21 \text{ minutes } 48 \text{ seconds}$$

8. (b)

Total ways of arranging 5 letters in any possible order $= 5 \times 4 \times 3 \times 2 \times 1 = 5! = 120$

In half of the cases A will be to the left of B and in other half A will be to the right of B

Hence, desired outcome

9. (b)

This is a situation in which there is the same relationship, respect, between any possible pair of people in the group. This is a saturation that calls for the structure "each other" or "one another".

Choice (a) doesn't use this, and what is used is very wordy and awkward, so it is incorrect.

These structures, "each other" and "one another", demand a plural subject. Choices (c) and (d) make the mistake of using a singular subject, so these are incorrect.

Option (b) is the right answer.

10. (d)

Factorial of the positive integers greater than 5 is divisible by 18.

So, we have to find out the remainder when $1!+2!+3!+4!+5! (= 153)$ is divided by 18. (All other terms yield zero remainder)

So, Remainder = 9.

11. (2000)

Let Percentage Profit/Loss = x and Cost Price = C

$$\text{Now, } C + xC = 1920$$

$$C - xC = 1280$$

$$\text{Solving for } C \Rightarrow 2C = 3200 \Rightarrow C = 1600$$

$$\text{Sale Price with 25\% profit} \Rightarrow 1.25 \times 1600 = 2000.$$

12. (b)

9 AM of 14th August to 2 PM on 18th August = 101 hours

$$\left(24 + \frac{15}{60}\right) \text{ hours of incorrect clock} = 24 \text{ hours of correct clock}$$

$$1 \text{ hour of incorrect clock} = \frac{96}{97} \text{ hours of correct clock}$$

$$\begin{aligned} 101 \text{ hours of incorrect clock} &= \frac{96}{97} \times 101 \text{ hours of correct clock} \\ &= 99 \text{ hours and approx 58 minutes} \end{aligned}$$

So, correct time will be

$$2 \text{ PM, } 14^{\text{th}} \text{ August} + (99 \text{ hours and } 58 \text{ minutes}) = 12:58 \text{ PM on } 18^{\text{th}} \text{ August}$$

13. (c)

The length of the hypotenuse of the triangle is the length of one of the sides multiplied by $\sqrt{2}$,

i.e. $9\sqrt{2}$ feet. Therefore the area of the square is $9\sqrt{2} \times 9\sqrt{2} = 81 \times 2 = 162$ sq. feet.

The area of the triangle must be exactly one quarter of the area of the square. If you don't see that directly, imagine the triangle being flipped down into the square. Therefore, the total

$$\text{area is } \left(162 + \frac{162}{4}\right) \text{ sq. feet} = 202.5 \text{ sq. feet.}$$

14. (16)

Farmer works for $5 + 4 = 9$ days

If he completes entire work in 12 days, he will finish $\frac{9}{12}$ or $\frac{3}{4}$ th work in 9 days.

Remaining work, $1 - \frac{3}{4} = \frac{1}{4}$, is done by daughter in 4 days..

So if daughter does $\frac{1}{4}$ work in 4 days, she will complete the whole work in $4 \times 4 = 16$ days.

15. (d)

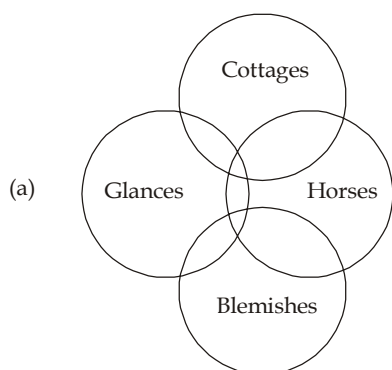
We will be required to get the value of n such that $\frac{n(n+1)}{2} = 100$. If $n = 13$, $\frac{n(n+1)}{2} = 91$ which means that 100th digit will be occupied by 14th set of digits or it will be equal to 4.

16. (b)

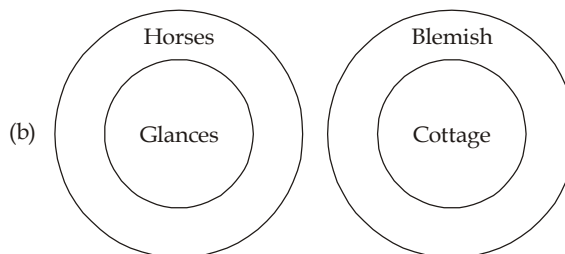
'Armchair traveller' = Someone who reads books or watches TV programmes about other places and countries, but doesn't actually travel anywhere. "Born with a silver spoon" = born into a very rich family. "A big fish in a small pond" = an important or highly-ranked person in a small group or organisation. Since, the sentence does not contain any reference about travelling, (1) cannot be true here.

17. (b)

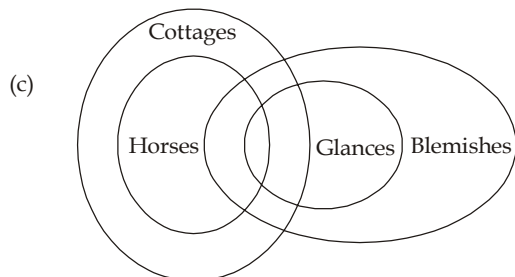
The statements given in option (b) lead to the required conclusions.



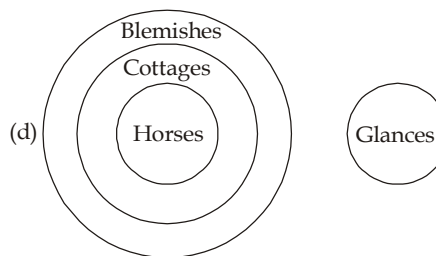
In this scenario conclusion II does not follow



In this scenario both the conclusions are true



In this case we see that neither of the conclusions is true



In this scenario conclusion I does not follow

18. (d)

The probability that a green ball is transferred from A to B and a green ball is transferred from

vessel B to vessel A, $P_{\text{green, green}} = \left(\frac{6}{10}\right) \times \left(\frac{5}{11}\right) = \frac{30}{110}$.

Similarly other cases, $P_{\text{green, red}} = \left(\frac{6}{10}\right) \times \left(\frac{6}{11}\right) = \frac{36}{110}$.

$$P_{\text{red, green}} = \left(\frac{4}{10}\right) \times \left(\frac{4}{11}\right) = \frac{16}{110}$$

$$P_{\text{red, red}} = \left(\frac{4}{10}\right) \times \left(\frac{7}{11}\right) = \frac{28}{110}$$

Probability of drawing a green ball from vessel A after the transfers in these four cases are

$\frac{6}{10}, \frac{5}{10}, \frac{7}{10}, \frac{6}{10}$ respectively.

Therefore the required probability

$$= \left(\frac{30}{110}\right) \times \left(\frac{6}{10}\right) + \left(\frac{5}{10}\right) \times \left(\frac{36}{110}\right) + \left(\frac{7}{10}\right) \times \left(\frac{16}{110}\right) + \left(\frac{6}{10}\right) \times \left(\frac{28}{110}\right) = \frac{32}{55}$$

19. (b)

The time required by individual to complete one revolution is

$\frac{7}{4}, \frac{7}{3}, \frac{7}{9}, \frac{7}{3.5}$ hours

To reach at starting point, the time required is LCM of $\frac{7}{4}, \frac{7}{3}, \frac{7}{9}$ and $\frac{2}{1}$ hours.

$$= \frac{\text{LCM}(7, 7, 7, 2)}{\text{HCF}(4, 3, 9, 1)} = 14 \text{ hours}$$

After 14 hours, all 4 will be at starting point.

or, $6 + 14 = 20 = 8 \text{ PM}$

all will be at starting point.

20. 1.253 (1.2 to 1.3)

Let the number of matches in which he was in the team of starting 11 be x and the matches in which he came on as a substitute be y .

Thus, $x + y = 388$... (i)

Number of goals scored in matches in which he was in the team of starting 11 = Average $\times$ number of matches = $1.5x$

Number of goals scored in matches in which he came on as a substitute = $0.5y$

Thus, $1.5x = 0.5y + 390$... (ii)

Solving both equations for x and y , we have $x = 292$ and $y = 96$

So, the total number of goals scored by him = $1.5 \times 292 + 0.5 \times 96 = 486$ goals

Therefore, average number of goals scored per match = $486 \div 388 = 1.253$

21. (c)

At present,

Let the members be M, N, O and P

Where age of $P > O > N > M$

Since P died after 5 years at the age of 88. So, present age of P = $88 - 5 = 83$

Youngest member = M = 14 years

$$N + O + P = 54 \times 3$$

$$N + O = 162 - 83 = 79 \quad \dots (i) \quad (O > N)$$

10 years after the death of P means 15 years hence from present, let Q be born.

20 years from present means at that time Q = 5 years and is youngest.

Eldest member at that time = O (age = $O + 20$)

$$(O + 20) - 5 = 57$$

$$O = 57 - 15 = 42 \text{ years}$$

So, $N = 79 - 42 = 37 \text{ years}$

After 5 years, members alive are = M, N, O

$$M = 14 + 5 = 19 \text{ years}$$

$$N = 37 + 5 = 42 \text{ years}$$

$$O = 42 + 5 = 47 \text{ years}$$

Required ages of N and O are 42 and 47.

22. (b)

23. (d)

It would be easier if we visualize this problem. As sphere is inscribed in cube then the edges of the cube equal to the diameter of sphere,

$$\text{Diameter} = 10 \text{ units}$$

Next, Diagonal of a cube = $\sqrt{10^2 + 10^2 + 10^2} = 10\sqrt{3}$.

Now, half of (Diagonal minus Diameter) is the gap between the vertex of cube and surface of the sphere, which will be the shortest distance:

$$x = \frac{\text{Diagonal} - \text{Diameter}}{2} = \frac{10\sqrt{3} - 10}{2} = 5(\sqrt{3} - 1)$$

24. (c)

Let us assume $k = \frac{K}{100}$ and the cost price = C

Based on S1, we can write $C \times \left(1 + \frac{K}{100}\right) - C \times \left(1 - \frac{K}{100}\right) = 2560$

i.e. $\frac{2CK}{100} = 2560$ or $Ck = 1280$ which does not give the value of k or K . Hence Statement 1 is NOT sufficient.

Based on S2, $C \times 0.075 = K$ which gives $C = 40K/3 = 4000k/3$ which will NOT give the value of k or K .

When we combine the information given in both the statements, we will be able to find C as well as k or K . Hence option (c) is the correct option.

25. (c)

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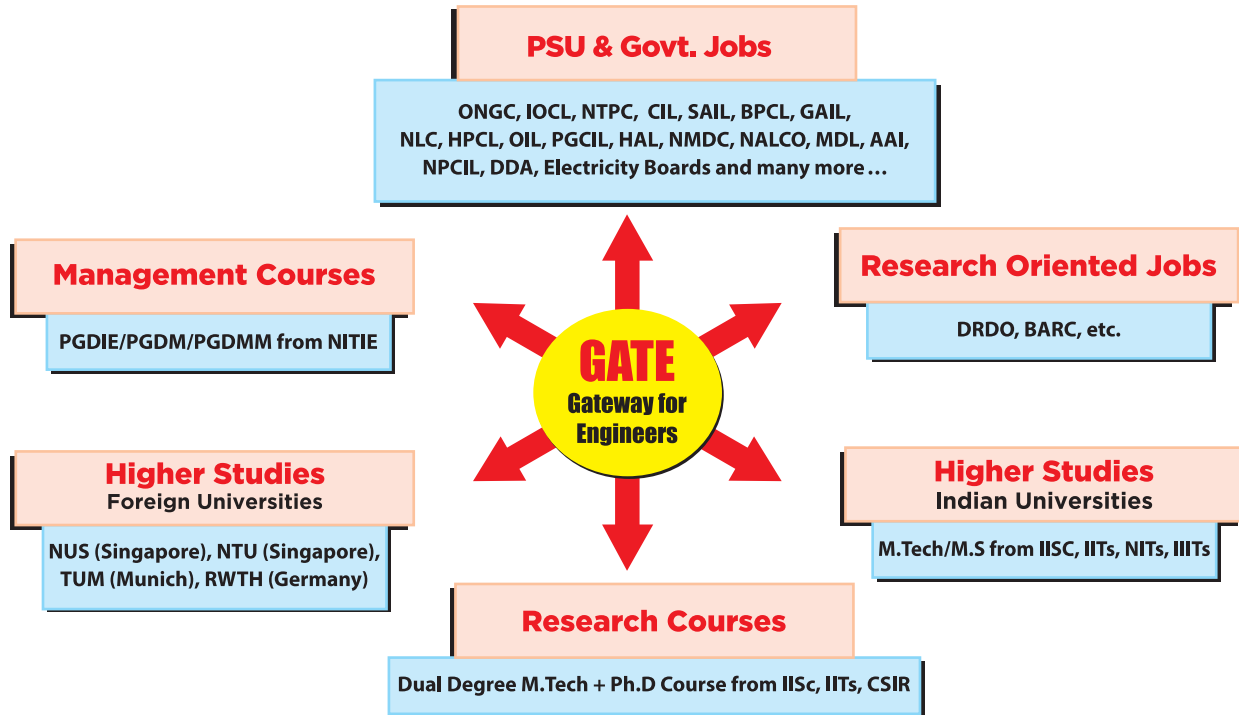
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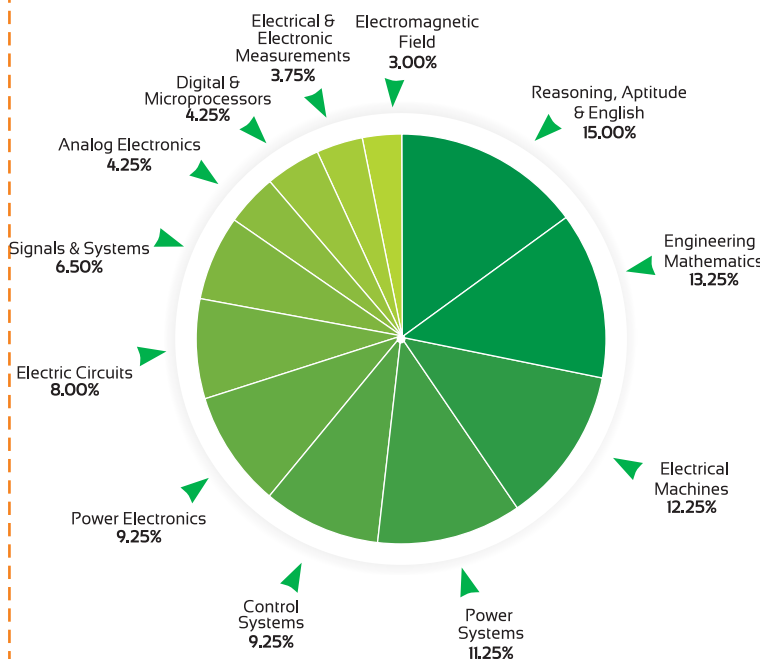
ELECTRICAL ENGG.

Q.26 - Q.50
out of 200 Questions

Day 2 of 8



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Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

Day 2 : Q.26 to Q. 50 : Electrical Machines

- Q.26** A 20 kW, 200 V short shunt dc generator is supplying rated load at rated terminal voltage. The armature, series field winding and shunt field winding resistances are $0.02\ \Omega$, $0.05\ \Omega$ and $100\ \Omega$ respectively. Considering brush drop as 2 V, generated emf is _____ V.
- Q.27** Two shunt generators are in parallel with no load voltages 60 V and 50 V and full load power delivered 400 W and 500 W respectively at 20 V terminal voltage. The common voltage while delivering 700 W to load is
(a) 30.5 V (b) 22.6 V
(c) 20 V (d) 27.5 V
- Q.28** A compensated dc machine has 20000 AT/Pole. The ratio of pole arc to pole pitch is 0.8. The interpolar airgap length and flux density are 1.2 cm and 0.3 T. For rated armature current $I_a = 1000\text{ A}$, the number of turns on each interpole are,
(a) 7 (b) 8
(c) 5 (d) 9
- Q.29** A separately excited generator, when running at 1200 rpm, supplies 100 A at 220 V to a fixed load resistance. If the field resistance is unaltered, the value of load current when speed drops to 1000 rpm, will be _____.
(Armature resistance is $0.08\ \Omega$ and total drop at brush is 2.0 V)
(a) 83.19 A (b) 98.15 A
(c) 67.54 A (d) 78.15 A
- Q.30** A 4-pole, DC generator with wave wound armature has 50 slots containing 18 conductors in each slot. The induced emf is 357 volts and the speed is 9000 rpm. The flux per pole will be _____ mWb.
- Q.31** A 20 kW, 300 V dc shunt motor is driving a constant torque load with line current of 100 A at a speed of 1600 rpm. Motor has armature and field winding resistance as $0.02\ \Omega$ and $100\ \Omega$ respectively. If $50\ \Omega$ external resistance is added in field circuit, then motor is running at (Assume linear magnetization curve)
(a) 1594.8 rpm (b) 1812.9 rpm
(c) 2392.19 rpm (d) 2100 rpm
- Q.32** A 3-phase, 440 V, 50 Hz, six pole salient pole synchronous motor is drawing a 10 A current at 0.8 power factor leading. It has $X_d = 10\ \Omega$ and $X_q = 7\ \Omega$. The magnitude of torque angle (δ) is
(a) 9.4° (b) 12.1°
(c) 10.7° (d) 13.5°
- Q.33** A 3- ϕ synchronous generator of 1000 kVA, 0.8 p.f. lag, 6.6 kV star connected cylindrical rotor of negligible resistance and synchronous reactance of 0.8 p.u. The synchronizing coefficient is _____ kW/elec. degrees.
- Q.34** A 20 kVA, 400 V, 50 Hz three phase star connected synchronous generator has effective armature resistance and synchronous reactance $0.5\ \Omega/\text{phase}$ and $3\ \Omega/\text{phase}$ respectively. Voltage regulation for 0.8 leading power factor is at full load _____ %.

Q.35 A 400 MVA, 22 kV synchronous generator is tested for OCC and SCC. The following data are obtained from these characteristics extrapolated where needed,

$$I_f = 1120 \text{ A,}$$

$$V_{OC} = 22 \text{ kV,}$$

$$I_{SC} = 13.2 \text{ kA}$$

At I_f corresponding to $I_{SC} = I_{\text{rated}}$ it is found that V_{OC} (airgap line) = 24.2 kV (line).

The value of SCR is _____.

Q.36 Two three-phase alternators operate in parallel. The rating of machine-1 is 80 MW and that of machine-2 is 150 MW. Both alternators are fitted with governors having a droop of 4%.

How will the machines share a common load of 150 MW?

- (a) Machine - 1 shares 50 MW and machine - 2 shares 100 MW load
- (b) Machine - 1 shares 96.83 MW and machine - 2 shares 53.17 MW load
- (c) Machine - 1 shares 52.17 MW and machine - 2 shares 97.83 MW load
- (d) Machine - 1 shares 53.17 MW and machine - 2 shares 96.83 MW load

Q.37 A 100 kVA, 1000 V/400 V, 1- ϕ transformer when excited at rated voltage on *h.v.* side, draws a no load current of 3.0 A at 0.75 lagging power factor. If it is excited from the *l.v.* side at rated voltage, the no load current and power factor will be respectively,

- (a) 7.5 A, 0.6 lag
- (b) 7.5 A, 0.75 lag
- (c) 6.5 A, 0.70 lag
- (d) 6.5 A, 0.75 lag

Q.38 At 400 V and 50 Hz the total core loss of a transformer was found to be 3200 W. When the transformer is supplied at 200 V and 25 Hz, the core loss is 1000 W. The hysteresis and eddy current loss at 400 V and 50 Hz will be respectively

- (a) 1600 W, 1600 W
- (b) 800 W, 2400 W
- (c) 2400 W, 800 W
- (d) 1200 W, 2000 W

Q.39 A 3- ϕ , 3000 kVA, 0.95 lagging pf load is supplied by a Vee connection at 400 V. The kVA output and operating power factor angle of both transformers respectively are

- (a) $1000\angle 9.1^\circ$ kVA and $1000\angle 9.1^\circ$ kVA
- (b) $1732\angle 48.19^\circ$ kVA and $1732\angle -11.8^\circ$ kVA
- (c) $1732\angle -48.19^\circ$ kVA and $1732\angle 11.8^\circ$ kVA
- (d) $1000\angle -9.1^\circ$ kVA and $1000\angle -9.1^\circ$ kVA

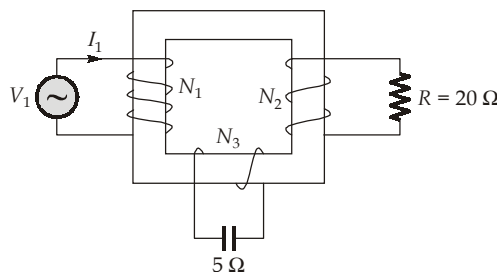
Q.40 A 100 MVA, 220 kV/110 kV, Δ - Δ , 3- ϕ power transformer has a resistance of 0.02 per unit and a reactance of 0.05 per unit. The transformer supplies a load of 80 MVA at 0.8 pf lagging. The percentage voltage regulation of the transformer is _____ %.

Q.41 The short circuit current of an 3- ϕ induction motor is 5 times the full load current and full load slip is 0.035. To start the motor using auto transformer starter with 40 percent of full load torque, the suitable tapping on auto transformer will be

- (a) 42.3%
- (b) 45.7%
- (c) 48.3%
- (d) 67.6%

Q.42 A 3-phase induction motor draws 1 MVA at a p.f. of 0.8 lag. A synchronous condenser is connected in parallel to draw an additional 750 kVA at 0.6 p.f. lead. The p.f. of the total load supplied by the mains is _____.

- Q.43** The rotor copper loss of a three phase 550 V, 50 Hz, 6 poles induction motor developing 4.5 kW output power and mechanical losses of 850 W at 950 rpm is _____ W.
- Q.44** A 3- ϕ induction motor at rated voltage and frequency has a starting torque of 150% and a maximum torque of 200% of full load torque. Neglecting stator resistance and rotational losses, the slip at maximum torque will be
(a) 0.12 (b) 0.22
(c) 0.35 (d) 0.45
- Q.45** A 220, 8 pole, 50 Hz, 3- ϕ star connected, wound rotor induction motor has a rotor impedance of $(0.02 + j0.08) \Omega$ /phase at standstill and has negligible stator impedance. The maximum torque developed by the motor is _____ N-m.
- Q.46** A 500 W, 230 V, 50 Hz capacitor start motor has the following impedances for the main and auxiliary winding (at starting)
 $Z_{\text{main}} = (4 + j2.5)\Omega$
 $Z_{\text{aux}} = (10 + j2.4)\Omega$
If a capacitance of 180 μF is added in auxiliary winding, then phase angle between main and auxiliary winding current is _____ (in degree).
- Q.47** Below figure shows an ideal three winding transformer in which windings are wound on the same core. The turns ratio $N_1 : N_2 : N_3$ is equal to 9 : 3 : 1. A resistor of 20Ω is connected across winding-2. A capacitor of reactance 5Ω is connected across winding-3. Winding-1 is connected across a 400 V, a.c. supply. If the supply is phasor $V_1 = 400\angle 0^\circ \text{ V}$, then the supply current phasor I_1 is given by,



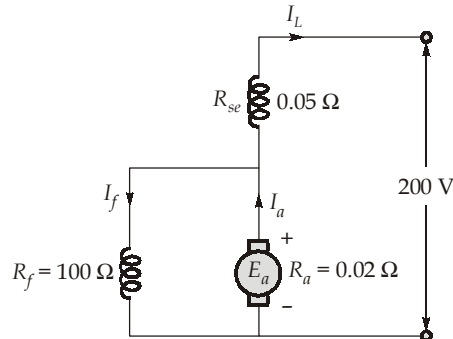
- (a) $\frac{10}{81}(9 + j4)\text{A}$ (b) $-\frac{10}{81}(9 + j4)\text{A}$
(c) $\frac{20}{81}(9 + j4)\text{A}$ (d) $-\frac{20}{81}(9 + j4)\text{A}$
- Q.48** A 375 W, 230 V, 50 Hz capacitor start single-phase induction motor has the following constants for the main the auxiliary windings (at starting): $Z_m = (12.50 + j15.75) \Omega$ (main winding). $Z_a = (24.50 + j12.75) \Omega$ (auxiliary winding). Neglecting the magnetizing branch, the value of the capacitance (in μF) to be added in series with the auxiliary winding to obtain maximum torque at starting is _____ μF .
- Q.49** An iron ring of mean length 60 cm has an air gap of 1 mm and a winding of 250 turns. If the permeability of iron is 400 and when a current of 1 A flows through the coil, the flux density is _____ $\times 10^{-3} \text{ Wb/m}^2$.

- Q.50** A single phase, 230 V, 50 Hz, 4 pole, capacitor start induction motor has the following standstill impedance. Main winding; $Z_m = (8.0 + j 5.0) \Omega$ and auxiliary winding; $Z_a = (9.0 + j 6.0) \Omega$. The value of the starting capacitor required to produce 90° phase difference between the current in the main and auxiliary windings will be _____ μF .

○○○○

Detailed Explanations

26. 209.041 (206.124 to 211.203)



Rated load at rated terminal voltage,

$$I_L = \frac{20000}{200} = 100 \text{ A}$$

Using dc generator equation,

$$E = V + I_a R_a + I_L R_{se} + V_{BD} \quad \dots(i)$$

$$E_a = I_a R_a + I_L R_{se} + V_{BD} + 200$$

and

$$I_a = I_f + I_L \quad \dots(ii)$$

and

$$I_f = \frac{200 + I_L \times R_{se}}{100}$$

$$= \frac{200 + 100 \times 0.05}{100}$$

$$I_f = 2.05 \text{ A}$$

From equation (ii),

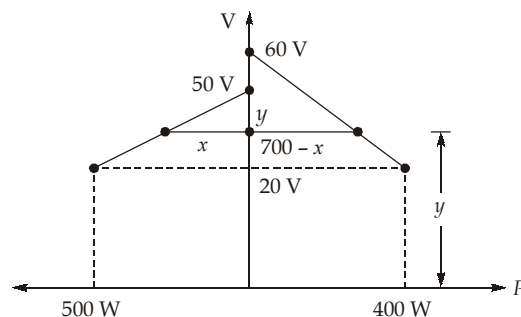
$$I_a = 2.05 + 100 = 102.05$$

From equation (i),

$$E_a = 102.05 \times 0.02 + 100 \times 0.05 + 200 + 2$$

$$= 209.041 \text{ V}$$

27. (d)



From similarity of triangles for generator 1,

$$\frac{50 - y}{x} = \frac{50 - 20}{500}$$

$$50 - y = 0.06 x$$

$$0.06x + y = 50 \quad \dots(i)$$

For second triangle,

$$\frac{60 - y}{700 - x} = \frac{60 - 20}{400}$$

$$60 - y = 70 - 0.1x$$

$$0.1x - y = 10 \quad \dots(ii)$$

Solving the equations (i) and (ii), we get

$$y = 27.5 \text{ V}$$

$$\text{Voltage} = 27.5 \text{ V}$$

28. (a)

$$AT_{CW}/\text{Pole} = AT_a(\text{peak}) \times \frac{\text{Pole arc}}{\text{Pole pitch}}$$

$$= 20000 \times 0.8 = 16000$$

$$AT_a(\text{peak}) \text{ interpolar region} = 20000 - 16000 = 4000$$

$$AT_i = AT_a(\text{peak}) + \frac{B_i}{\mu_0} l_{gl}$$

$$= 4000 + \left[\frac{0.3}{4\pi \times 10^{-7}} \times 1.2 \times 10^{-2} \right] = 6865 \text{ AT/P}$$

$$N_i = \frac{6865}{1000} \approx 7 \text{ turns}$$

29. (a)

Given that,

$$N_1 = 1200 \text{ rpm,}$$

$$V_1 = 220 \text{ V,}$$

$$I_{a1} = 100 \text{ A,}$$

$$R_a = 0.08 \Omega \text{ and } N_2 = 1000 \text{ rpm}$$

The load resistance is,

$$R_L = \frac{V_1}{I_{a1}} = \frac{220}{100} = 2.2 \Omega$$

The induced emf is, $E_1 = 220 + 2 + (0.08 \times 100)$
 $= 230 \text{ V}$

Since, the excitation is constant, we get

$$E \propto N$$

$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

$$E_2 = \frac{1000}{1200} \times 230 = 191.67 \text{ V}$$

Let new terminal voltage is,

$$V_2 = I_{a2} R_L$$

Thus, we get, $E_2 = V_2 + 0.08 I_{a2} + 2$
 $= 2.2 I_{a2} + 0.08 I_{a2} + 2$

New load current is,

$$I_{a2} = \frac{E_2 - 2}{2.28} = \frac{191.67 - 2}{2.28}$$

$$= 83.188 \text{ A} \approx 83.19 \text{ A}$$

30. **1.32 (1.20 to 1.40)**

We know that, emf generated,

$$E = \frac{P\phi NZ}{60A}$$

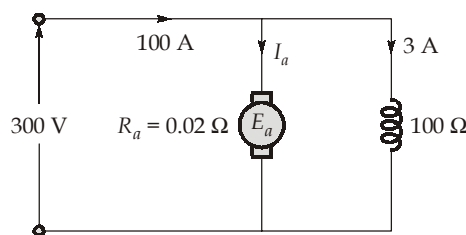
$$= \phi \times 50 \times 18 \times \frac{9000}{60} \times \frac{4}{2}$$

$$\Rightarrow 357 = \phi \times 50 \times 18 \times \frac{9000}{60} \times \frac{4}{2}$$

$$\Rightarrow \phi = 1.32 \text{ mWb}$$

31. (c)

Case-I:



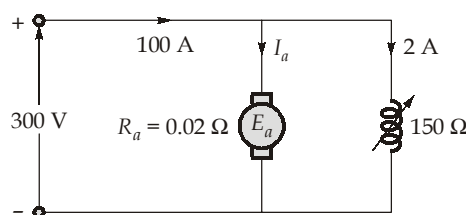
Armature current, $I_{a1} = 100 - 3 = 97 \text{ A}$

Back emf, $E_{a1} = 300 - 97 \times 0.02$

$$E_{a1} = 298.06 \text{ V}$$

Case-II:

When 50 Ω external resistance added in field circuit,



Load torque is constant

$$T \propto \phi I_a$$

$$\phi_2 I_{a2} = \phi_1 I_{a1}$$

$$\phi \propto I_f$$

$$I_{a2} = I_{a1} \frac{\phi_1}{\phi_2} = 97 \times \frac{3}{2} = 145.5 \text{ A}$$

$$E_{a2} = 300 - 145.5 \times 0.02$$

$$E_{a2} = 297.09 \text{ V}$$

We know that,

$$E_a \propto \phi \omega_m$$

$$\frac{E_{a2}}{E_{a1}} = \frac{\phi_2}{\phi_1} \times \frac{N_2}{N_1}$$

$$\frac{297.09}{298.06} = \frac{2}{3} \times \frac{N_2}{1600}$$

$$N_2 = 2392.19 \text{ rpm}$$

32. (c)

$$\vec{E}' = \vec{V}_t - j\vec{I}_a X_q$$

$$X_q = 7 \Omega$$

$$\text{p.u. value of } X_q = \frac{\text{ohmic value}}{\text{base value}}$$

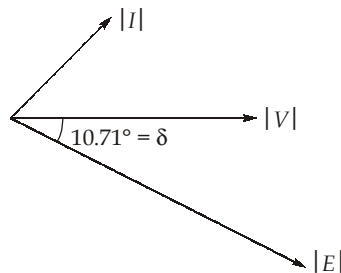
$$\text{Base ohms} = \frac{\left(\frac{440}{\sqrt{3}}\right)}{10} = 25.4 \Omega$$

$$\text{p.u. value of } X_q = \frac{7}{25.4} = 0.2756 \text{ p.u.}$$

$$\vec{E} = 1 - (j0.2756) \times 1 \angle \cos^{-1}(0.8)$$

$$= 1.18 \angle -10.71^\circ \text{ p.u.}$$

$\therefore$ Torque angle, $\delta = 10.71^\circ$



33. 32.23 (32.00 to 32.50)

$$\vec{E} = \vec{V} + j\vec{I}X_s$$

$$= 1 + (j0.8 \times 1 \angle -\cos^{-1}(0.8))$$

$$= 1.61 \angle 23.4^\circ \text{ p.u.}$$

$$\left(\frac{\partial P_e}{\partial \delta}\right)_{\delta=\delta_0} = \frac{EV}{X_s} \cos \delta$$

$$= \frac{1.61 \times 1}{0.8} \cos(23.4^\circ) = 1.847 \text{ p.u./elec. rad}$$

$$1 \text{ p.u.} = 1000 \text{ kVA}$$

$$\text{Synchronizing coefficient} = \frac{1847}{\left(\frac{180}{\pi}\right)} = 32.23 \text{ kW/elec. degree}$$

34. -9.56 (-11.23 to -9.31)

$$\text{Excitation emf, } (\vec{E}_f) = \vec{V} + \vec{I}_a Z_s$$

$$\text{Armature current, } I_a = \frac{20 \times 10^3}{\sqrt{3} \times 400} = 28.87 \text{ A}$$

$$\vec{E}_f = \frac{400}{\sqrt{3}} + (28.87 \angle 36.87^\circ) \times (0.5 + j3)$$

$$\vec{E}_f = 205.85 \angle 22.25^\circ \text{ V}$$

$$\begin{aligned} \text{Voltage regulation} &= \frac{|E_f| - |V|}{|V|} \times 100 \\ &= \frac{205.85 - \left(\frac{400}{\sqrt{3}}\right)}{\left(\frac{400}{\sqrt{3}}\right)} \times 100 = -9.56\% \end{aligned}$$

35. 1.258 (1.20 to 1.40)

$$\text{Base, (MVA)}_B = 400; (22 \text{ kV})_B \text{ (line) or } 12.7 \text{ kV}_B \text{ (phase)}$$

$$\text{Base current, } I_B = \frac{400}{22\sqrt{3}} = 10.49 \text{ kA}$$

$$\text{Base impedance, } Z_B = \frac{22 / \sqrt{3}}{10.49} = 1.21 \Omega$$

$$I_f = 1120 \text{ A,}$$

$$V_{OC} = V_{\text{rated}} = \frac{22}{\sqrt{3}} = 12.7 \text{ kV (phase)}$$

$$I_{SC} = 13.2 \text{ kA}$$

$$X_{S(\text{sat})} = \frac{12.7}{13.2} = 0.962 \Omega$$

$$(\text{or}) \quad X_{S(\text{sat})} \text{ p.u.} = \frac{0.962}{1.21} = 0.795 \text{ p.u.}$$

$$\text{SCR} = \frac{1}{X_{S(\text{sat})} \text{ p.u.}} = \frac{1}{0.795} = 1.258$$

36. (c)

Let the original frequency = f_0

Drooping frequency = 4% of $f_0 = 0.04 f_0$

Let load shared by machine 1 = P_1

Load shared by machine 2 = P_2

For Machine - 1:

For a load of 80 MW, the drop in frequency,

$$= 0.04 f_0$$

For a load of P MW, the drop in frequency,

$$= \frac{0.04 f_0 \times P}{80}$$

Operating frequency of first machine

$$= \left(f_0 - \frac{0.04}{80} f_0 P_1 \right) \quad \dots(i)$$

Similarly for Machine - 2

The operating frequency of machine- 2

$$= \left(f_0 - \frac{0.04}{150} f_0 P_2 \right) \quad \dots(ii)$$

Since both alternators are running in parallel, they must operate at same frequency at steady state.

From equation (i) and (ii), we get

$$f_0 - \frac{0.04}{80} f_0 P_1 = f_0 - \frac{0.04}{150} f_0 P_2$$

$$P_1 = \frac{8}{15} P_2 \quad \dots(iii)$$

Total load shared by machines:

$$P_1 + P_2 = 150 \text{ MW} \quad \dots(iv)$$

From equation (iii) and (iv), we get

$$\frac{8}{15} P_2 + P_2 = 150$$

$$P_2 = \frac{150 \times 15}{23} = 97.83 \text{ MW}$$

and,

$$P_1 = 52.17 \text{ MW}$$

37. (b)

When *h.v.* side is excited,

$$\begin{aligned} \text{core loss} &= VI \cos \phi \\ &= 1000 \times 3 \times 0.75 = 2250 \text{ W} \end{aligned}$$

When *l.v.* side is excited,

$$\text{core loss} = VI \cos \phi = 2250 \text{ W}$$

$$I = \frac{2250}{V \times \cos \phi} = \frac{2250}{400 \times 0.75} = 7.5 \text{ A}$$

Power factor is same for a transformer.

38. (b)

For first case; $\frac{V_1}{f_1} = \frac{400}{50} = 8$

For second case; $\frac{V_2}{f_2} = \frac{200}{25} = 8$

Since, $\frac{V_1}{f_1} = \frac{V_2}{f_2} = 8$; the flux density B_m remains constant

Now, Hysteresis loss, $P_h = K_1 f$
and Eddy current loss, $P_e = K_2 f^2$
Then, Iron loss, $P_i = K_1 f + K_2 f^2$

$$\text{or, } \frac{P_i}{f} = K_1 + K_2 f \quad \dots(i)$$

Now, from Ist case:

$$\frac{3200}{50} = K_1 + K_2 \times 50 \quad \dots(ii)$$

From IInd case:

$$\frac{1000}{25} = K_1 + 25 K_2 \quad \dots(iii)$$

From (ii) and (iii), we get

$$K_1 = 16$$

$$\text{and } K_2 = \frac{24}{25}$$

$$\text{Hysteresis loss, } P_h = 16 \times 50 = 800 \text{ W}$$

$$\text{and, eddy current loss, } P_e = \frac{24}{25} \times 2500 = 2400 \text{ W}$$

39. (b)

kVA supplied by Vee connection transformer,

$$S_{Vee} = \frac{1}{\sqrt{3}} \times S_{3-\phi} = \frac{3000}{\sqrt{3}} = 1732 \text{ kVA}$$

$$\text{p.f. angle of transformer-1} = \phi + 30^\circ = \cos^{-1}(0.95) + 30^\circ = 48.19^\circ$$

$$\cos \phi_1 = \cos 48.19^\circ = 0.67 \text{ lagging}$$

$$\text{p.f. angle of transformer-2} = \phi - 30^\circ = \cos^{-1}(0.95) - 30^\circ = -11.8^\circ$$

$$\cos \phi_2 = \cos 11.8^\circ = 0.98 \text{ leading}$$

$$\vec{S}_1 = 1732 \angle 48.19^\circ \text{ kVA}$$

$$\vec{S}_2 = 1732 \angle -11.8^\circ \text{ kVA}$$

40. 3.70 (3.50 to 4.00)

Base current in secondary side,

$$I_{2(\text{base})} = \frac{100 \times 10^6}{\sqrt{3} \times 110 \times 10^3} = 524.86 \text{ A}$$

Since the transformer supplies a load of 80 MVA at 0.8 pf lagging, so secondary line current of the transformer is

$$I_s = \frac{80 \times 10^6}{\sqrt{3} \times 110 \times 10^3} \approx 420 \text{ A}$$

$$\begin{aligned} (I_s)_{pu} &= \frac{420}{525} \angle -\cos^{-1}(0.8) \\ &= 0.8 \angle -36.87^\circ \text{ p.u.} \end{aligned}$$

Per unit no load voltage of this transformer is

$$\begin{aligned} E_{NL} &= V_s + I_z \\ &= 1 \angle 0^\circ + (0.8 \angle -36.87^\circ) (0.02 + j0.05) \\ &= 1.037 \angle 1.24^\circ \text{ p.u.} \end{aligned}$$

According to definition of V.R. = $\frac{\text{No load voltage} - \text{Full load voltage}}{\text{Full load voltage}} \times 100$

$$\text{V.R.} = \frac{1.037 - 1}{1} \times 100\% = 3.7\%$$

41. (d)

We know that,

$$\frac{\text{Starting torque}}{\text{Full load torque}} = \frac{T_{st}}{T_{fl}} = x^2 \left(\frac{I_{sc}}{I_{fl}} \right)^2 \times s_{fl}$$

$$\text{or,} \quad 0.4 = x^2 \times (5)^2 \times 0.035$$

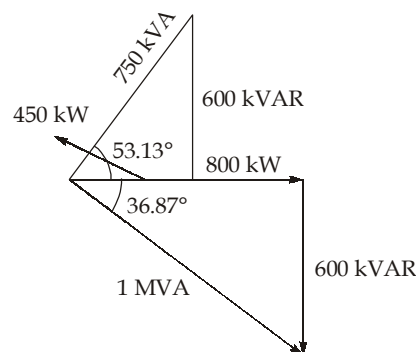
$$\text{or,} \quad x^2 = \frac{0.4}{25 \times 0.035}$$

$$x = \sqrt{\frac{0.4}{25 \times 0.035}} = 0.676$$

$\therefore$ The percentage of tapping is 67.6%.

42. (1)

The given condition can be explained with phasors,



Active power consumed by induction motor,

$$= 1 \text{ MVA} \times 0.8 = 800 \text{ kW}$$

Reactive power consumed by induction motor,

$$= 800 \text{ kW} \times \tan(36.87^\circ) = 600 \text{ kVAR}$$

Active power consumed by synchronous condenser,

$$= 750 \text{ KVA} \times 0.6 = 450 \text{ kW}$$

Reactive power delivered by synchronous condenser

$$= 450 \text{ kW} \times \tan(53.13^\circ) = 600 \text{ kVAR}$$

$$Q_{\text{net}} = 0 \quad \text{i.e. } \phi = 0^\circ$$

$\therefore$ The power factor of the total load is unity

$$\cos \phi = 1$$

43. 281.58 (281.00 to 282.00)

$$\text{The rotor copper loss} = \frac{s}{1-s} \times \text{Gross mechanical power developed}$$

$$\text{Synchronous speed, } N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

$$\text{Slip, } s = \frac{N_s - N_r}{N_s} = \frac{1000 - 950}{1000} = 0.05$$

$$\begin{aligned} \text{The rotor copper loss} &= \left(\frac{0.05}{1-0.05} \right) \times (4500 + 850) \\ &= 281.58 \text{ W} \end{aligned}$$

44. (d)

$$\begin{aligned} T_s &= 1.5 T_f \\ T_{\max} &= 2 T_f \end{aligned}$$

$$\text{For maximum torque, } s_{mT} = \frac{r_2}{x_2}$$

$$\frac{T_s}{T_{\max}} = \frac{1.5 T_f}{2 T_f} = \frac{2 s_{mT}}{1 + s_{mT}^2}$$

$$\text{i.e. } 1.5 s_{mT}^2 - 4 s_{mT} + 1.5 = 0$$

$$\therefore s_{mT} = 0.45$$

45. 3850.51 (3845.00 to 3855.00)

The slip at maximum torque is,

$$S_{\max, T} = \frac{R_2}{X_2} = \frac{0.02}{0.08} = 0.25$$

$$\text{Synchronous speed, } N_s = \frac{120 \times 50}{8} = 750 \text{ rpm}$$

$$\begin{aligned} \omega_s &= \frac{2\pi}{60} \times N_s = \frac{2\pi}{60} \times 750 \\ &= 78.54 \text{ rad/sec} \end{aligned}$$

$$\text{Stator voltage, } V_1 = \frac{220}{\sqrt{3}} = 127 \text{ V}$$

Maximum torque developed by the motor,

$$T_{\max} = \frac{3V_1^2}{2\omega_s \times X_2} = \frac{3 \times (127)^2}{2 \times 78.54 \times 0.08} = 3850.51 \text{ N-m}$$

46. 88.8 (87.13 - 89.14)

Impedance for auxiliary winding after adding capacitor of 180 μF

$$\begin{aligned} Z_{\text{aux}} &= 10 + j2.4 - \frac{j1}{2\pi \times 50 \times 180 \times 10^{-6}} \\ &= (10 - j15.284) \Omega \end{aligned}$$

Impedance angle is given by

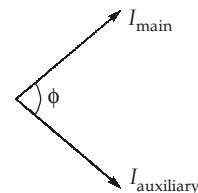
$$\phi = \tan^{-1}\left(\frac{X}{R}\right)$$

$$\therefore \phi_{\text{main}} = \tan^{-1}\left(\frac{2.5}{4}\right) = 32^\circ$$

$$\phi_{\text{aux}} = \tan^{-1}\left(-\frac{15.284}{10}\right) = -56.8^\circ$$

$$\begin{aligned}\phi &= \phi_{\text{main}} - \phi_{\text{aux}} \\ &= 32^\circ + 56.8^\circ\end{aligned}$$

$$\text{Phase angle, } \phi = 88.8^\circ$$



47. (c)

From the given diagram,

$$\begin{aligned}N_1 : N_2 : N_3 &= 9 : 3 : 1 \\ \text{Induced emf} &= 400 \angle 0^\circ \text{ V}\end{aligned}$$

As we know that; $\frac{E_1}{E_2} = \frac{N_1}{N_2}$

$$\Rightarrow E_2 = \frac{N_2}{N_1} E_1 = \left(\frac{3}{9}\right) \times 400 \angle 0^\circ = \frac{400}{3} \angle 0^\circ \text{ V}$$

and $\frac{E_1}{E_3} = \frac{N_1}{N_3}$

$$\Rightarrow E_3 = \left(\frac{1}{9}\right) 400 \angle 0^\circ = \frac{400}{9} \angle 0^\circ \text{ V}$$

Current in secondary winding;

$$\Rightarrow I_2 = \frac{E_2}{R} = \frac{400/3}{20} = \frac{20}{3} \text{ A}$$

Current in tertiary winding;

$$\Rightarrow I_3 = \frac{E_3}{-jX_c} = \frac{400/9}{-j5} = \frac{80}{9} \angle 90^\circ \text{ A}$$

I_2 referred to primary side,

$$I'_2 = \left(\frac{N_2}{N_1}\right) I_2 = \left(\frac{3}{9}\right) \times \frac{20}{3} = \frac{20}{9} \angle 0^\circ \text{ A}$$

I_3 referred to primary side,

$$I'_3 = \left(\frac{N_3}{N_1}\right) I_3 = \frac{1}{9} \times \frac{80}{9} \angle 90^\circ \text{ A} = \frac{80}{81} \angle 90^\circ \text{ A}$$

Then supply current,
$$I_1 = \frac{20}{9} \angle 0^\circ + \frac{80}{81} \angle 90^\circ$$
$$= \frac{20}{81} (9 + j4) \text{ A}$$

48. **149.51 (149.00 to 150.00)**

Auxiliary winding impedance = $(24.5 + j12.75) \Omega$

Let X_c be the reactance of the capacitor connected in auxiliary winding

$$Z_a = (24.5 + j12.75 - jX_c) \Omega$$

$$X_a = (X_c - 12.75), R_a = 24.5 \Omega$$

$$\therefore \phi_a = \tan^{-1} \frac{X_c - 12.75}{24.5} \quad \dots(i)$$

$$Z_m = 12.5 + j15.75$$

$$= 20.10 \angle 51.56^\circ \Omega$$

$$\phi_m = 51.56^\circ$$

For maximum torque at starting, condition on ϕ_a and ϕ_m is given by $\left[\phi_a = \frac{90^\circ - \phi_m}{2} \right]$

$$\phi_a = \frac{90 - 51.56}{2} = 19.22^\circ \quad \dots(ii)$$

Comparing equation (i) and (ii),

$$\tan(19.22^\circ) = \frac{X_c - 12.75}{24.5}$$

$$0.3486 = \frac{X_c - 12.75}{24.5}$$

$$X_c = 8.541 + 12.75$$

Capacitive reactance,

$$X_c = 21.291 \Omega$$

$$\frac{1}{2\pi fc} = 21.291$$

$$\Rightarrow C = \frac{1}{2\pi \times 50 \times 21.291} = 149.51 \mu\text{F}$$

49. **125.66 (125.00 to 126.00)**

$$\text{The reluctance of core, } R = \frac{l}{\mu A}$$

Where, l = mean length of core

A = cross sectional area of core

$$\text{Net reluctance } R = R_{\text{air}} + R_{\text{iron}}$$

$$= \frac{l_{\text{airgap}}}{\mu_0 \cdot A} + \frac{l_{\text{core}}}{\mu_0 \mu_r \cdot A}$$

$$= \frac{1 \times 10^{-3}}{4\pi \times 10^{-7} \times A} + \frac{60 \times 10^{-2}}{4\pi \times 10^{-7} \times 400 \times A}$$

$$= \frac{(1 + 1.5) \times 10^{-3}}{4\pi \times 10^{-7} \times A} = \frac{2.5 \times 10^{-3}}{4\pi \times 10^{-7} \times A}$$

$$\text{Total flux} = \frac{A.T.}{\text{Reluctance}} = \frac{1 \times 250 \times 4\pi \times 10^{-7} \times A}{2.5 \times 10^{-3}}$$

$$\begin{aligned} \text{Flux density} &= \frac{\text{Total flux}}{\text{Area}} = \frac{250 \times 4\pi \times 10^{-7} \times A}{2.5 \times 10^{-3} \times A} \\ &= 125.66 \times 10^{-3} \text{ Wb/m}^2 \end{aligned}$$

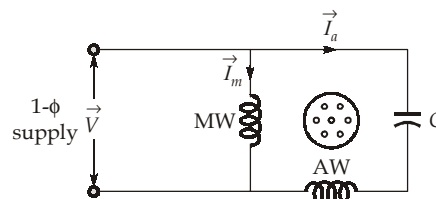
50. **156.03 (154.00 to 158.00)**

Main windings impedance;

$$\begin{aligned} Z_m &= (8.0 + j 5.0) \Omega \\ &= 9.434 \angle 32^\circ \Omega \end{aligned}$$

Auxiliary winding impedance,

$$\begin{aligned} Z_a &= (9.0 + j 6.0) \Omega \\ &= 10.82 \angle 33.69^\circ \Omega \end{aligned}$$



Consider the above circuit;

$\vec{I}_m$ lags behind voltage $\vec{V}$ by angle θ_m

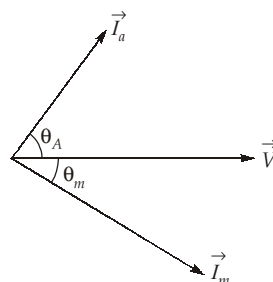
$$\theta_m = 32.00^\circ$$

Total impedance of auxiliary winding circuit,

$$\vec{Z}_{aw} = \vec{Z}_a + \frac{1}{j\omega C} = 9 - j\left(\frac{1}{\omega C} - 6\right) = Z_{aw} \angle -\theta_A$$

$$\text{Where, } \theta_A = \tan^{-1} \left(\frac{\frac{1}{\omega C} - 6}{9} \right)$$

from the circuit diagram, we can draw the phasor as below:



Where, $\theta_A + \theta_m = 90^\circ$

$$\tan^{-1} \left(\frac{\frac{1}{\omega C} - 6}{9} \right) + 32^\circ = 90^\circ$$

$$\text{or, } \tan^{-1} \left(\frac{\frac{1}{\omega C} - 6}{9} \right) = 58^\circ$$

$$\text{or, } \frac{1}{\omega C} - 6 = 14.4$$

$$\frac{1}{\omega C} = 20.4$$

$$C = \frac{1}{2\pi \times 50 \times 20.4} = 156.03 \mu\text{F}$$

○○○○



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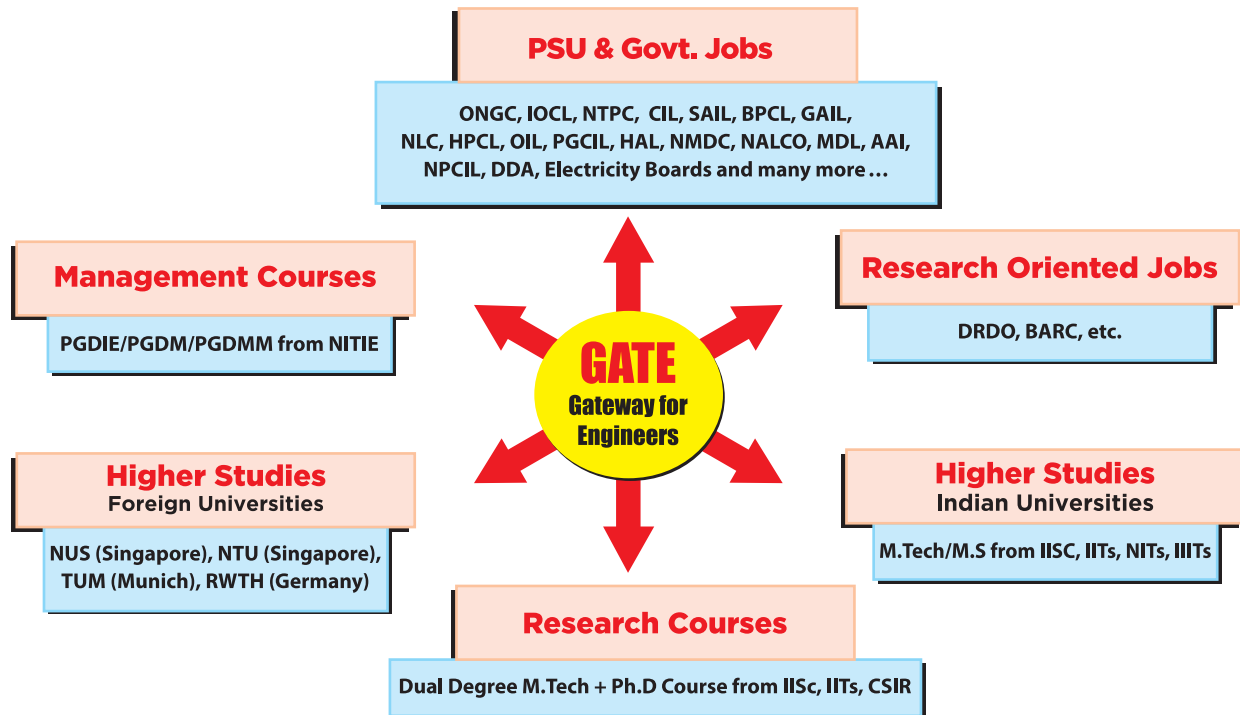
Revision through Questions for GATE 2020

EE

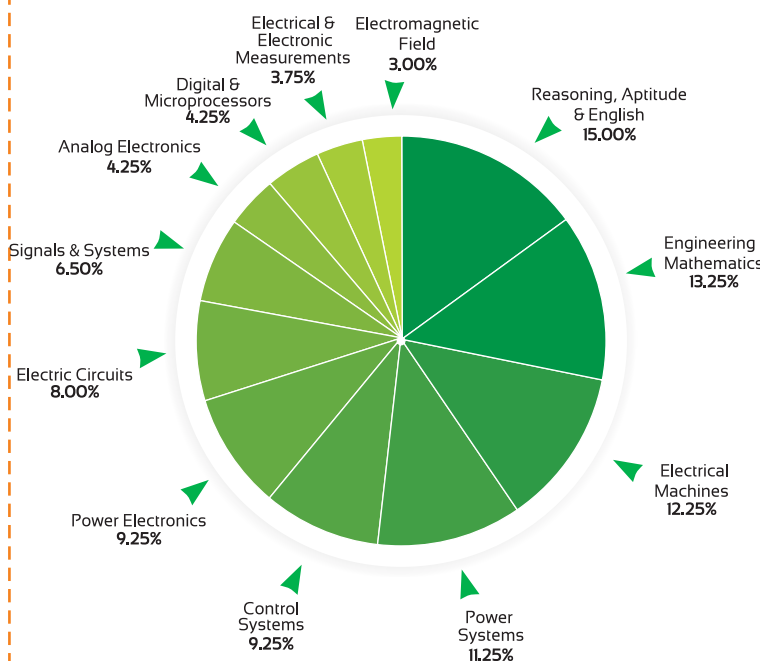
ELECTRICAL ENGG.

Q.51 - Q.75
out of 200 Questions

Day 3 of 8



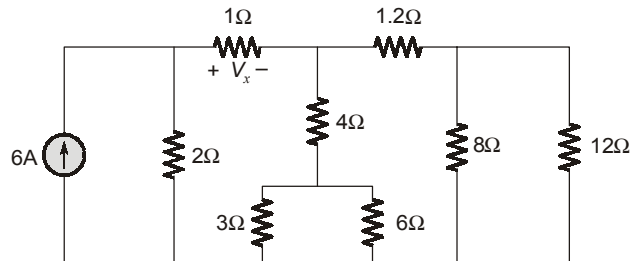
SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

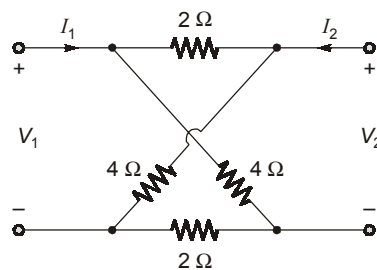
Day 3 : Q.51 to Q. 75 : Electric Circuits + Digital Electronics

Q.51 In the circuit shown below the value of voltage V_x is



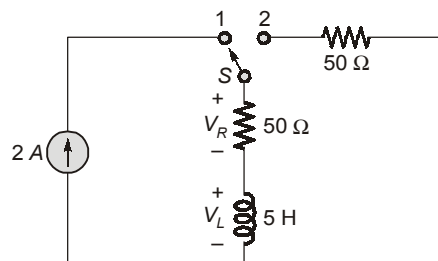
- (a) 1 V (b) 2 V
(c) 3 V (d) 4 V

Q.52 In the circuit shown below, open circuit parameters Z_{11} and Z_{21} are respectively,

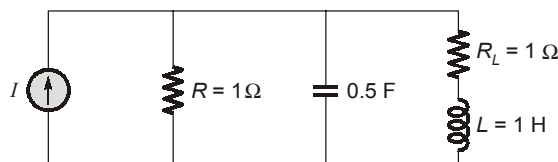


- (a) 3 Ω and 1 Ω (b) 4 Ω and 2 Ω
(c) 3 Ω and 4 Ω (d) 2 Ω and 1 Ω

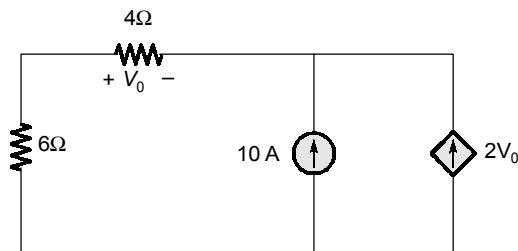
Q.53 In the circuit shown below switch S is kept at position 1 for a long time. Then at $t = 0$ the switch is transferred to position 2. The voltage (magnitude) across inductor at $t = 0^+$ is _____ (in Volts).



Q.54 In the circuit shown below, the value of admittance at resonant frequency is _____ Ω .

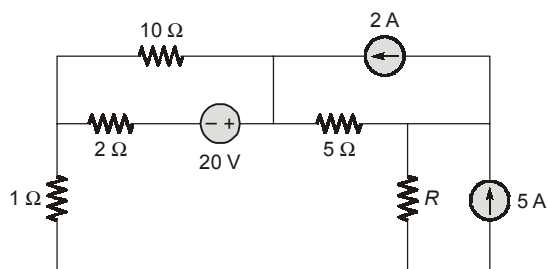


Q.55 The power absorbed by the dependent source is



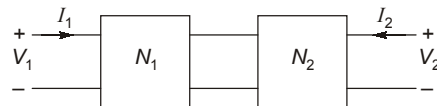
- (a) 90.75 W (b) 92.25 W
(c) 98.75 W (d) 99.25 W

Q.56 The maximum power transferred to resistor R in the circuit shown below is

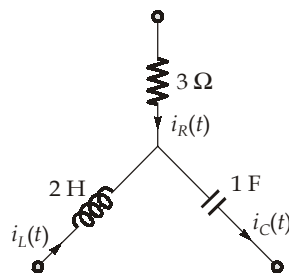


- (a) 66 W (b) 55 W
(c) 45 W (d) 60 W

Q.57 Two identical networks are connected in cascade as shown in figure. Transmission matrix for each network is $\begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix}$. The value of Z_{12} is ____ (in ohms).



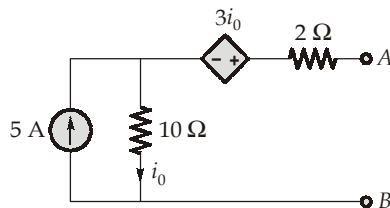
Q.58 Consider a circuit shown below,



At steady state, the current through resistor is given by $15\cos t$ and the voltage across the inductor is $2\sin t$. The RMS value of the current through the capacitor is

- (a) $\frac{15}{\sqrt{2}}$ A (b) $12\sqrt{2}$ A
(c) $7\sqrt{2}$ A (d) $8\sqrt{2}$ A

Q.59 Consider the circuit shown in the figure below:



The Thevenin's equivalent resistance seen across the terminal A and B is

- (a) 2 Ω (b) 10 Ω
(c) 12 Ω (d) 15 Ω

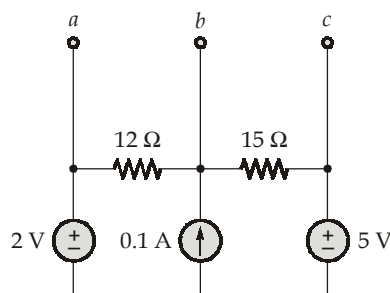
Q.60 The voltage equations for a two port network are given as

$$V_1 = 16I_1 + 24I_2 \text{ and } V_2 = 32I_1 + 14I_2$$

If a load of $R \angle 0^\circ \Omega$ is connected across the output port of this network, the input impedance becomes 8 Ω, then the value of R will be _____ Ω.

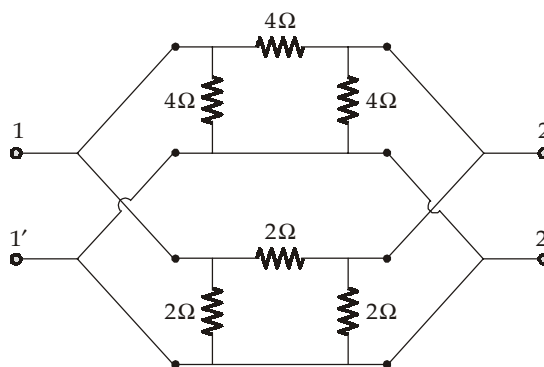
Q.61 For a series RL circuit, the charging time needed for an inductor current to reach 30% of its steady state value is given as 2 sec. If the value of $R = 5 \Omega$, then the value of inductor will be _____ H.

Q.62 In the network shown below, remove terminal C and obtain the Norton equivalent seen at terminals a and b.

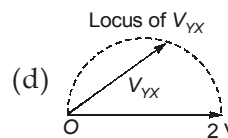
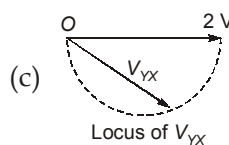
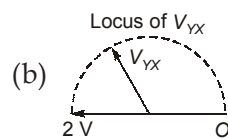
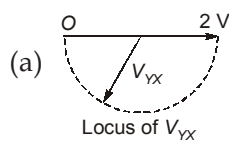
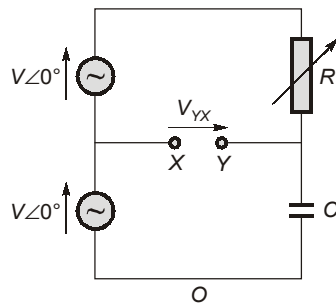


- (a) -0.3 A parallel with 6.67 Ω (b) -0.21 A in parallel with 0.67 Ω
(c) 0.4 A parallel with 3.4 Ω (d) 0.42 A in parallel with 6.67 Ω

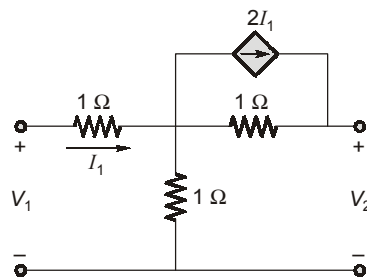
Q.63 In the h-parameter model of the 2 port network given in the figure shown, the value of h_{22} (in mho) is _____. (Answer upto three decimal)



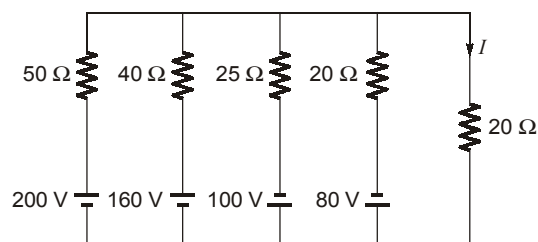
Q.64 In the figure given below all phasors are with reference to the potential at point "O". The locus of voltage phasor V_{YX} as R is varied from zero to infinity is shown by



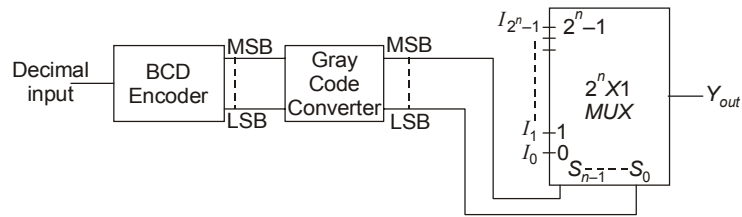
Q.65 In the two-port network shown, the h_{11} parameter (where, $h_{11} = \frac{V_1}{I_1}$, when $V_2 = 0$) in ohms is _____ (up to 2 decimal places).



Q.66 The current I flowing in the circuit shown below in ampere is _____.

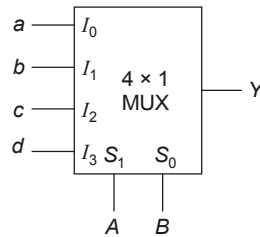


Q.67 Consider the circuit given below.

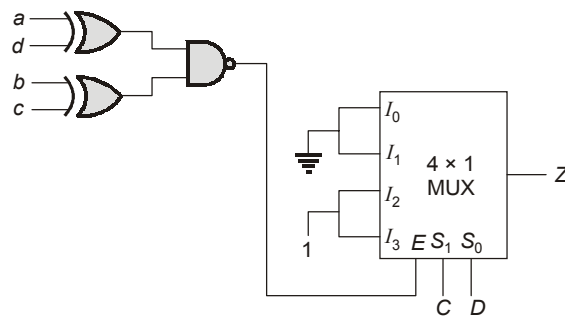


If the decimal input is 92 then Y_{out} corresponds to I_m , then value of m is _____.

Q.68 If $f(A, B, C) = \sum m(0, 1, 4, 5)$ is output of the 4×1 MUX shown below.

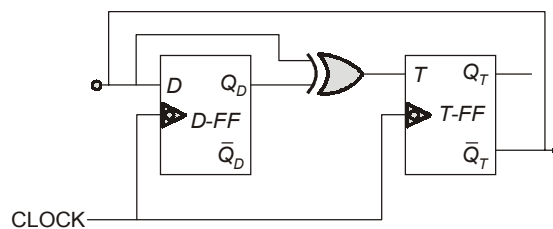


Then the output Z of 4×1 MUX shown below will be



- (a) 0
(b) $C\bar{D}$
(c) CD
(d) 1

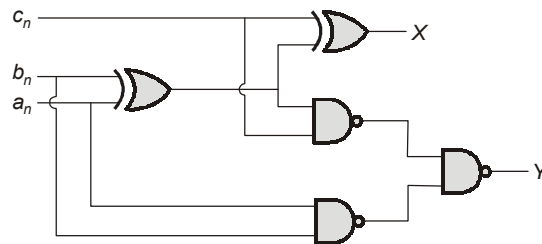
Q.69 A digital circuit is designed with one D-flip flop and one T-flip flop.



The initial value of $Q_D Q_T = 00$, then after how many clock pulses, the $Q_D Q_T = 10$ will appear

- (a) 4
(b) 6
(c) 8
(d) Never

Q.70 Consider the circuit shown below:

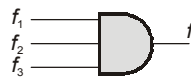


The propagation time for each NAND gate is 10 nsec. The time required to get the output Y will be _____ nsec. (Assume that all other gates are designed using NAND)

Q.71 Consider the logical functions given below.

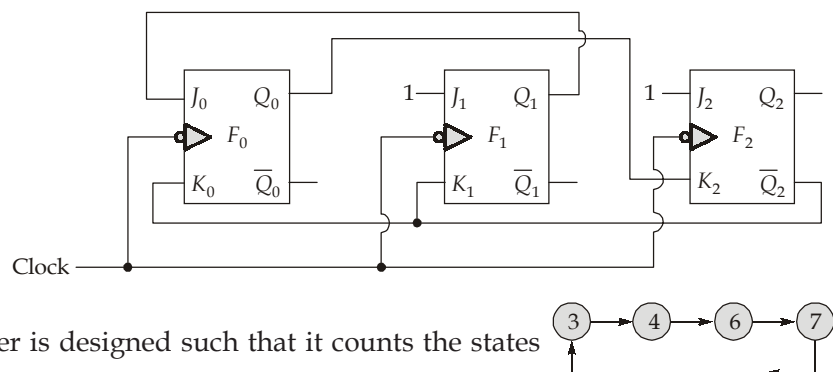
$$f_1(A, B, C) = \Sigma(2, 3, 4)$$

$$f_2(A, B, C) = \pi(0, 1, 3, 6, 7)$$

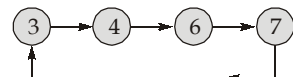


If f is logic zero, then maximum number of possible minterms in function f_3 are ____.

Q.72 Consider the counter circuit shown in the figure below:



The counter is designed such that it counts the states



then which of the following statements about this counter is true?

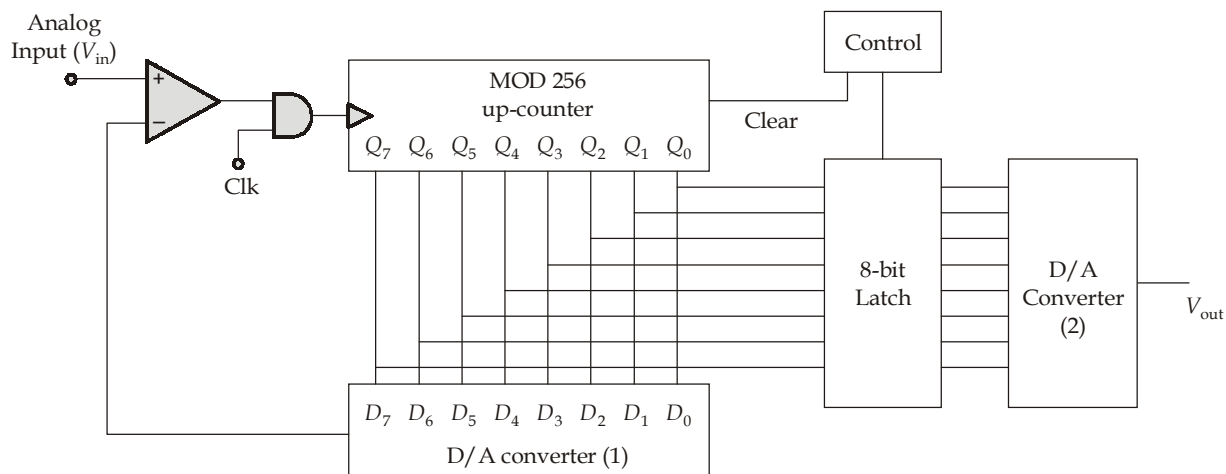
- (a) The counter enters into a lockout state if the counter starts from $(0)_{10}$
- (b) The counter enters into a lockout state if the counter starts from $(2)_{10}$
- (c) The counter enters into a lockout state if the counter starts from $(1)_{10}$
- (d) The counter do not enters into a lockout state.

Q.73 Let $X = X_2X_1X_0$ and $Y = Y_1Y_0$ be unsigned positive 3-digit and 2-digit numbers respectively. The output function ' f ' = 1 only when $X > Y$ otherwise '0'. Then the value of output f is equal to

- (a) $(X_2 + Y_1 + Y_0)(X_2 + \bar{X}_1 + \bar{Y}_0)(X_2 + X_1 + \bar{Y}_1)(X_2 + X_1 + X_0)(X_2 + X_0 + \bar{Y}_1)$
- (b) $(X_2 + \bar{Y}_1 + \bar{Y}_0)(X_2 + X_1 + \bar{Y}_0)(X_2 + \bar{X}_1 + Y_1)(X_2 + X_1 + X_0)(X_2 + X_0 + Y_1)$
- (c) $(X_2 + \bar{Y}_1 + \bar{Y}_0)(X_2 + X_1 + \bar{Y}_0)(X_2 + X_1 + \bar{Y}_1)(X_2 + X_1 + X_0)(X_2 + X_0 + \bar{Y}_1)$
- (d) $(X_2 + \bar{Y}_1 + \bar{Y}_0)(X_2 + \bar{X}_1 + \bar{Y}_0)(X_2 + X_1 + \bar{Y}_1)(X_2 + \bar{X}_1 + \bar{X}_0)(X_2 + X_0 + Y_1)$

Q.74 The number of minterms left after minimizing the following Boolean expression $f(A, B, C, D) = [D' + AB' + A'C + AC'D + A'C'D]'$ will be _____ .

Q.75 Consider the circuit shown below:



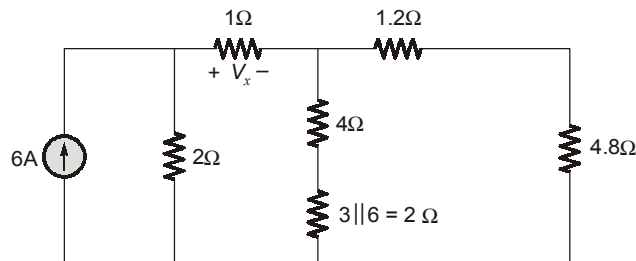
If the resolution of D/A converter (1) is equal to 0.25 V and the resolution of the D/A converter (2) is equal to 0.5 V, then the output voltage V_{out} for a input signal of 2.3 V is equal to _____ V.

○○○○

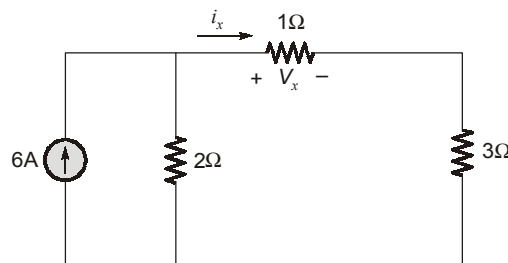
Detailed Explanation

51. (b)

The given circuit can be reduced to below circuit



Further it can be reduced as ;



Now applying current division, we get

$$i_x = \frac{2}{2+1+3} \times 6 = 2\text{A};$$

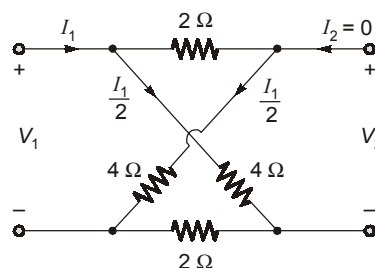
$$V_x = 1 \times 2 = 2\text{ V}$$

52. (a)

For Z_{11} and Z_{21}

$$Z_{11} = \left. \frac{V_1}{I_1} \right|_{I_2=0}, \quad Z_{21} = \left. \frac{V_2}{I_1} \right|_{I_2=0}$$

From the circuit as shown below, we can get



Output port O.C,

$$Z_{11} = \frac{V_1}{I_1} = 6 \parallel 6 = 3\Omega$$

$$Z_{21} = \left. \frac{V_2}{I_1} \right|_{I_2=0},$$

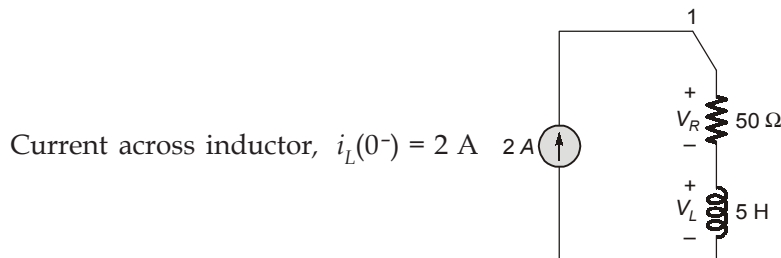
Using KVL, we can get

$$-V_2 + \frac{4I_1}{2} - 2\frac{I_1}{2} = 0; \quad \Rightarrow \quad V_2 = I_1$$

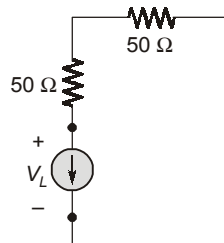
then
$$\frac{V_2}{I_1} = Z_{21} = 1 \Omega$$

53. 200 (198.00 to 202.00)

At $t = 0^-$, the circuit behaves as shown below



Now at $t = 0^+$, the circuit behaves as shown below



Now applying KVL in the circuit, we get,

$$\begin{aligned} V_L + 50(2) + 50(2) &= 0 \\ V_L &= -200 \text{ Volts} \\ |V_L| &= 200 \text{ Volts} \end{aligned}$$

54. 1.50 (1.40 to 1.60)

The circuit admittance seen by the current source is

$$\begin{aligned} Y &= \frac{1}{R} + j\omega C + \frac{1}{R_L + j\omega L} \\ &= \frac{1}{R} + j\omega C + \frac{R_L - j\omega L}{R_L^2 + \omega^2 L^2} \\ &= \frac{1}{R} + \frac{R_L}{R_L^2 + \omega^2 L^2} + j\left(\omega C - \frac{\omega L}{R_L^2 + \omega^2 L^2}\right) \end{aligned}$$

at resonance, imaginary part of Y must be zero

$$\begin{aligned} \omega_0 C &= \frac{\omega_0 L}{R_L^2 + \omega_0^2 L^2} \\ R_L^2 + \omega_0^2 L^2 &= \frac{L}{C} \\ \omega_0 &= \left[\frac{1}{LC} - \frac{R_L^2}{L^2} \right]^{1/2} \end{aligned}$$

Substituting value of L, R, C

$$\omega_0 = \left[\frac{1}{1 \times 0.5} - \frac{1^2}{1^2} \right]^{1/2} = 1 \text{ rad/sec}$$

admittance at resonance is,

$$Y = \frac{1}{R} + \frac{R_L}{R_L^2 + \omega_0^2 L^2}$$

$$= 1 + \frac{1}{1 + 1^2 \cdot 1^2} = 1.5 \Omega$$

55. (c)

Applying KCL at node

$$\frac{V_0}{4} + 10 + 2V_0 = 0;$$

Solving we get,

$$V_0 = -4.444 \text{ V}$$

Current through the controlled source

$$i = 2V_0 = -8.888 \text{ A}$$

and the voltage across it,

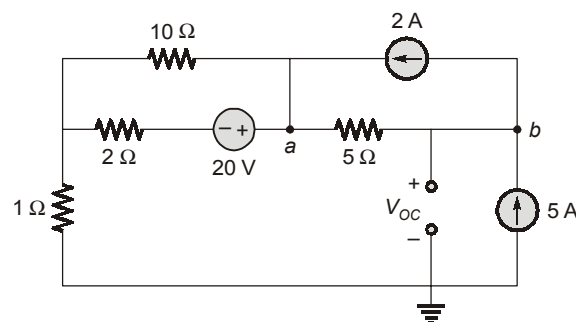
$$V = (6 + 4) \times \frac{V_0}{4} = -11.111 \text{ volts}$$

Hence, power absorbed by dependent source

$$P = (-8.888)(-11.111) = 98.75 \text{ W}$$

56. (a)

First R is removed and circuit behaves as shown below,



Current through 1Ω resistor = 5 A (downwards)

Hence, $V_{1\Omega} = 5 \text{ V}$

At node- a , assuming node voltage V volts, applying KCL,

$$\frac{V - 5}{10} + \frac{V - 20 - 5}{2} + \frac{V - V_{oc}}{5} = 2$$

$$0.1 V - 0.1 (5) + 0.5 V - 10 - 0.5 (5) + 0.2 V - 0.2 V_{oc} = 2$$

$$0.8 V - 0.6 (5) = 12 + 0.2 V_{oc}$$

$$0.8 V - 0.2 V_{oc} = 12 + 3 = 15$$

...(i)

at node- b , nodal analysis

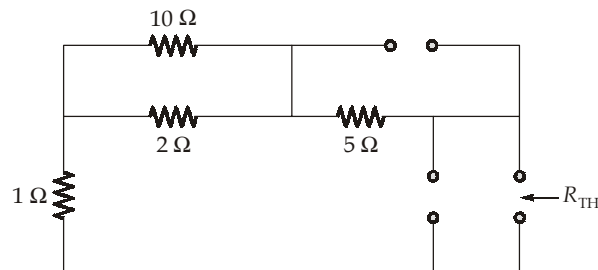
$$\frac{V_{oc} - V}{5} + 2 = 5$$

$$0.2 V_{oc} - 0.2 V = 3$$

...(ii)

Solving equation (i) and (2)

$$V_{oc} = 45 \text{ V}$$



$$\begin{aligned} R_{Th} &= \{(10 \parallel 2) + 1\} + 5 \\ &= \left(\frac{20}{12} + 1\right) + 5 = 7.67 \Omega \end{aligned}$$

$$P_{\max} = \frac{V_{oc}^2}{4R} = \frac{45^2}{4 \times 7.67} = 66 \text{ W}$$

57. 11.11 (11.00 to 11.50)

If two networks are connected in cascade, their transmission matrices are multiplied to get overall transmission matrix

$$T = \begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix} \begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} 13 & 12 \\ 9 & 16 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$$V_1 = 13 V_2 - 12 I_2 \quad \dots(i)$$

$$I_1 = 9 V_2 - 16 I_2 \quad \dots(ii)$$

$$Z_{12} = \left. \frac{V_1}{I_2} \right|_{I_1=0}$$

Putting $I_1 = 0$ in equation (ii),

$$9 V_2 = 16 I_2$$

$$V_2 = \frac{16}{9} I_2$$

$$V_1 = 13 V_2 - 12 I_2 = 13 \times \frac{16}{9} I_2 - 12 I_2$$

$$\frac{V_1}{I_2} = Z_{12} = 11.11 \Omega$$

58. (c)

We know that,

$$v_L(t) = L \frac{di_L(t)}{dt}$$

$$\text{or, } i_L(t) = \frac{1}{L} \int v_L(t) dt = \frac{1}{2} \int 2 \sin t dt$$

$$i_L(t) = -\cos t \text{ A}$$

$$\text{also, } i_R(t) = 15 \cos t \text{ A}$$

By KCL,

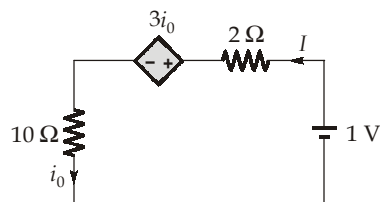
$$i_R(t) - i_C(t) + i_L(t) = 0$$

$$\text{or, } i_C(t) = i_L(t) + i_R(t) = 15 \cos t - \cos t = 14 \cos t \text{ A}$$

$$\text{RMS value of } i_C(t) = \frac{14}{\sqrt{2}} = 7\sqrt{2} \text{ A}$$

59. (d)

In order to find R_{Th} , let us take the inactive network and connect a 1 V source across the open terminals,



$$\text{Here, } R_{Th} = \frac{1 \text{ V}}{I}$$

$$\text{and } I = i_0$$

By applying KVL to the loop, we get,

$$2I + 3i_0 + 10I = 1 \text{ V}$$

$$2I + 3I + 10I = 1 \text{ V}$$

$$\text{or, } I = \frac{1 \text{ V}}{15 \Omega}$$

$$\text{or, } R_{Th} = \frac{1 \text{ V}}{I} = 15 \Omega$$

60. (82)

Given equations,

$$V_1 = 16I_1 + 24I_2 \quad \dots(i)$$

$$V_2 = 32I_1 + 14I_2 \quad \dots(ii)$$

$$\text{Also, } V_2 = -I_2 \times R$$

$$\therefore 32I_1 = -(14 + R)I_2$$

$$\text{or, } I_2 = \frac{-32}{(R+14)} I_1 \quad \dots(iii)$$

Using equation (i) and (iii), we get,

$$V_1 = 16I_1 + 24\left(\frac{-32}{R+14}\right)I_1$$

or

$$\frac{V_1}{I_1} = 16 - \frac{24 \times 32}{R+14} = 8$$

$$8 = \frac{24 \times 32}{R+14}$$

$$96 = R + 14$$

or,

$$R = 96 - 14 = 82 \, \Omega$$

61. 28.036 (27.95 to 28.15)

For series RL circuit, if the circuit is initially relaxed then,

$$i(t) = i(\infty) (1 - e^{-t/\tau})$$

$$0.3i(\infty) = i(\infty) (1 - e^{-t/\tau})$$

$$0.7 = e^{-t/\tau}$$

Taking $\ln$ both the sides, we get,

$$\ln 0.7 = \frac{-t}{\tau} \quad \left(\text{where, } \tau = \frac{L}{R} = \frac{L}{5} \right)$$

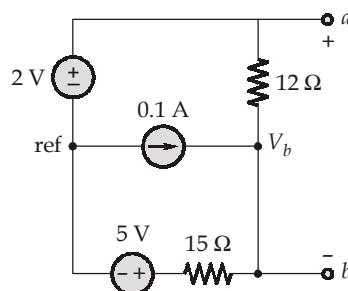
$$\ln 0.7 = \frac{-2}{L/5} = \frac{-10}{L}$$

or,

$$L = \frac{-10}{\ln 0.7} = 28.036 \, \text{H}$$

62. (a)

Removing terminal C the circuit can be rearranged as,



V_{Th} is the voltage dropped by $12 \, \Omega$ resistor

$$V_{Th} = V_a - V_b = 2 - V_b$$

Apply KCL at node b

$$\frac{V_b - V_a}{12} - 0.1 + \frac{V_b - 5}{15} = 0$$

By solving, we get $V_b = 4 \, \text{V}$

$$V_{Th} = -2 \, \text{V}$$

$$R_{Th} = \frac{12 \times 15}{12 + 15} = 6.667 \, \Omega$$

and

$$I_N = \frac{V_{Th}}{R_{Th}} = -0.3 \, \text{A}$$

63. 1.125 (1.000 to 1.500)

When two port networks are connected in parallel then individual Y-parameters are added

$$Y_1 = \begin{bmatrix} \frac{1}{4} + \frac{1}{4} & -\frac{1}{4} \\ -\frac{1}{4} & \frac{1}{4} + \frac{1}{4} \end{bmatrix} = \begin{bmatrix} 0.5 & -0.25 \\ -0.25 & 0.5 \end{bmatrix}$$

$$Y_2 = \begin{bmatrix} \frac{1}{2} + \frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & \frac{1}{2} + \frac{1}{2} \end{bmatrix} = \begin{bmatrix} 1 & -0.5 \\ -0.5 & 1 \end{bmatrix}$$

$$Y = Y_1 + Y_2 = \begin{bmatrix} 1.5 & -0.75 \\ -0.75 & 1.5 \end{bmatrix}$$

Y-parameter is,

$$I_1 = Y_{11} V_1 + Y_{12} V_2 = 1.5 V_1 - 0.75 V_2 \quad \dots(i)$$

$$I_2 = Y_{21} V_1 + Y_{22} V_2 = -0.75 V_1 + 1.5 V_2 \quad \dots(ii)$$

In h-parameter,

$$I_2 = h_{21} I_1 + h_{22} V_2$$

In equation (i), If

$$I_1 = 0$$

So,

$$1.5 V_1 = 0.75 V_2$$

$$V_1 = \frac{1}{2} V_2$$

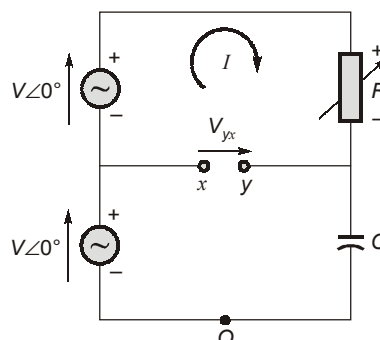
Substituting equation (ii), we get

$$I_2 = \frac{-0.75}{2} V_2 + 1.5 V_2$$

$$I_2 = 1.125 V_2$$

$$\left. \frac{I_2}{V_2} \right|_{I_1=0} = h_{22} = 1.125$$

64. (a)



Let capacitive reactance = X_C

$$I = \frac{V\angle 0^\circ + V\angle 0^\circ}{R - jX_C} = \frac{2V}{R - jX_C}$$

Using KVL,

$$\begin{aligned} V_{YX} + IR - V &= 0 \\ \Rightarrow V_{YX} &= V - IR \\ V_{YX} &= V - \left(\frac{2V}{R - jX_C} \right) R \\ &= \frac{V(R - jX_C) - 2VR}{R - jX_C} \\ &= -\frac{V(R + jX_C)}{(R - jX_C)} \end{aligned}$$

Method-1:

$$\begin{aligned} V_{YX} &= -V \left[\frac{R + jX_C}{R - jX_C} \right] \\ \text{When, } R &= 0 \\ V_{YX} &= -V \left[\frac{0 + jX_C}{0 - jX_C} \right] = V \\ V_{YX} &= -V \times \left[\frac{1 + j \frac{X_C}{R}}{1 - j \frac{X_C}{R}} \right] \end{aligned}$$

$$\begin{aligned} \text{When, } R &\rightarrow \infty \\ V_{YX} &= -V \end{aligned}$$

Method-2:

$$\begin{aligned} V_{YX} &= -V \left[\frac{R + jX_C}{R - jX_C} \right] \\ &= V \angle 180^\circ \times \left(\frac{\sqrt{R^2 + X_C^2} \angle \tan^{-1} \left(\frac{X_C}{R} \right)}{\sqrt{R^2 + X_C^2} \angle \tan^{-1} \left(\frac{-X_C}{R} \right)} \right) \\ &= V \angle \left(180^\circ + 2 \tan^{-1} \left(\frac{X_C}{R} \right) \right) \end{aligned}$$

Magnitude of $V_{YX} = V$

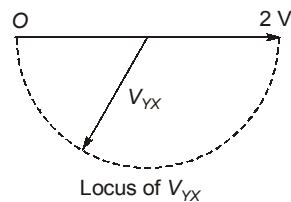
So, option (c) and (d) can not be correct, as magnitude is 2 V in these two options.

$$\text{Angle of } V_{YX} = 180^\circ + 2 \tan^{-1} \left(\frac{X_C}{R} \right)$$

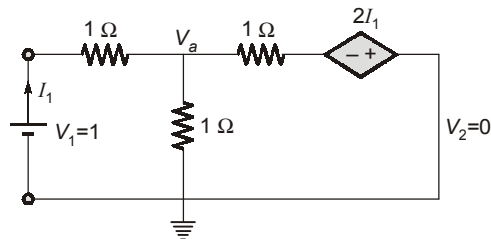
$$\begin{aligned} \text{When, } R &= 0 \\ \angle V_{YX} &= 180^\circ + 2 \tan^{-1}(\infty) \\ &= 180^\circ + 2 \times 90^\circ = 360^\circ \end{aligned}$$

$$\begin{aligned} \text{When, } R &= \infty \\ \angle V_{YX} &= 180^\circ + 2 \tan^{-1}(0) = 180^\circ \end{aligned}$$

on the basis of above analysis, the locus of V_{YX} is drawn below:



65. (0.50)



By KCL,

$$\frac{V_a - 1}{1} + \frac{V_a}{1} + \frac{V_a + 2I_1}{1} = 0$$

$$3V_a + 2I_1 = 1 \quad \dots(i)$$

$$I_1 = \frac{1 - V_a}{2} \quad \dots(ii)$$

Substitute equation (ii) in equation (i),

$$V_a = -1$$

$$I_1 = \frac{1 - V_a}{2} = \frac{1 - (-1)}{2} = 1$$

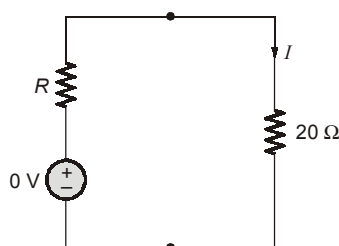
$$h_{11} = \frac{V_1}{I_1} = \frac{1}{1} = 1 \Omega$$

66. (0)

By Millman's theorem, $E = \frac{\frac{200}{50} + \frac{160}{40} - \frac{100}{25} - \frac{80}{20}}{\frac{1}{50} + \frac{1}{40} + \frac{1}{25} + \frac{1}{20}} = 0 \text{ V}$

$$\frac{1}{R} = \frac{1}{50} + \frac{1}{40} + \frac{1}{25} + \frac{1}{20}$$

Simplified circuit,



$\therefore$

$$I = 0 \text{ A}$$

67. (219)

Decimal input = 92

BCD = 10010010

Output of Gray code converter = 11011011

Y_0 corresponds to I_m with $(S_n \dots S_0)$ is = $(11011011)_2$

$m = 219$

68. (a)

For the given 4×1 MUX, 'A' and 'B' are select lines and 'C' be the input

	I_0	I_1	I_2	I_3
$\bar{C}$	0	2	4	6
C	1	3	5	7
	1	0	1	0

So,

$$I_0 = 1 = a$$

$$I_1 = 0 = b$$

$$I_2 = 1 = c$$

$$I_3 = 0 = d$$

So,

$$a \oplus d = b \oplus c = 1$$

So, output of NAND gate is 0.

as. E(Enable) is 0, so the output Z of 4×1 MUX = 0

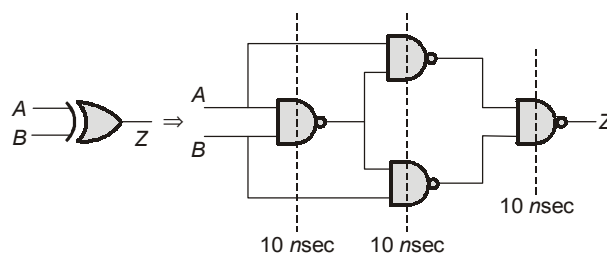
69. (d)

	Q_D	Q_T
Clock pulse	0	0
1	1	1
2	0	0
3	1	1
4	0	0
...		

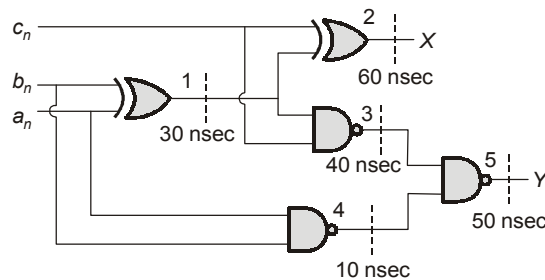
So, output will either be 00 or 11 and never 10.

70. (50)

An Ex-OR gate can be represented as



So, for EX-OR gate, it will take 30 nsec to get the output.



So, to get the output Y , it will take 50 nsec.

71. (6)

$$f_1(A, B, C) = \Sigma(2, 3, 4)$$

$$f_2(A, B, C) = \pi(0, 1, 3, 6, 7) = \Sigma(2, 4, 5)$$

For function f to be zero

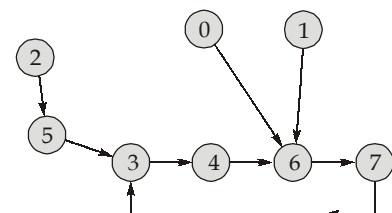
$$\begin{aligned} f_3(A, B, C) &= \overline{[f_1(A, B, C) \cap f_2(A, B, C)]} \\ &= \Sigma(0, 1, 3, 5, 6, 7) \end{aligned}$$

Maximum minterms possible are 6.

72. (d)

Test for Lockout

Present State			Present Input						Next State		
Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q_2	Q_1	Q_0
0	0	0	1	0	1	1	0	1	1	1	0
0	0	1	1	1	1	1	0	1	1	1	0
0	1	0	1	0	1	1	1	1	1	0	1
1	0	1	1	1	1	0	0	0	0	1	1



Hence, the counter does not enter into lockout state.

73. (c)

Now, $X > Y$ if

(a) $X_2 = 1$

(b) $X_2 = 0$ and $X_1X_0 > Y_1Y_0$

X_1X_0	Y_1Y_0				
	00	01	11	10	
00	0	0	0	0	$(X_2 + X_0 + \bar{Y}_1)$
01	1	0	0	0	$(X_2 + X_1 + X_0)$
11	1	1	0	1	$(X_2 + X_1 + \bar{Y}_1)$
10	1	1	0	0	$(X_2 + \bar{Y}_1 + \bar{Y}_0)$
					$(X_2 + X_1 + \bar{Y}_0)$

$X_2 = 0$

X_1X_0	Y_1Y_0			
	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

$X_2 = 1$

74. (1)

$$\begin{aligned}
 & [D' + AB' + A'C + AC'D + A'C'D]' \\
 &= [D' + AC'D + AB' + A'C + A'C'D]' \\
 &= [D' + AC' + AB' + A' [C + C'D]]' \\
 &= [D' + AC' + AB' + A' [C + D]]' \\
 &= [D' + AC' + AB' + A'C + A'D]' \\
 &(\because D' + A'D = D' + A') \\
 &= [D' + A' + AC' + AB' + A'C]' \\
 &(\because A' + A'C = A') \\
 &(\because A' + AC' + AB' = A' + A(C' + B') = A' + C' + B') \\
 &= [D' + A' + C' + B']' \\
 &= ABCD
 \end{aligned}$$

Hence, only 1 minterm left after minimization.

75. (5)

$\because$ DAC 1 has resolution of 0.25 V,
Thus for an input of 2.3 V, the output of ADC will be $(00001010)_2$.
Now, the resolution of DAC 2 = 0.5 V,
Thus, the output voltage of DAC 2 = Resolution $\times$ decimal equivalent.
 $= 0.5 \times 10 = 5 \text{ V}$

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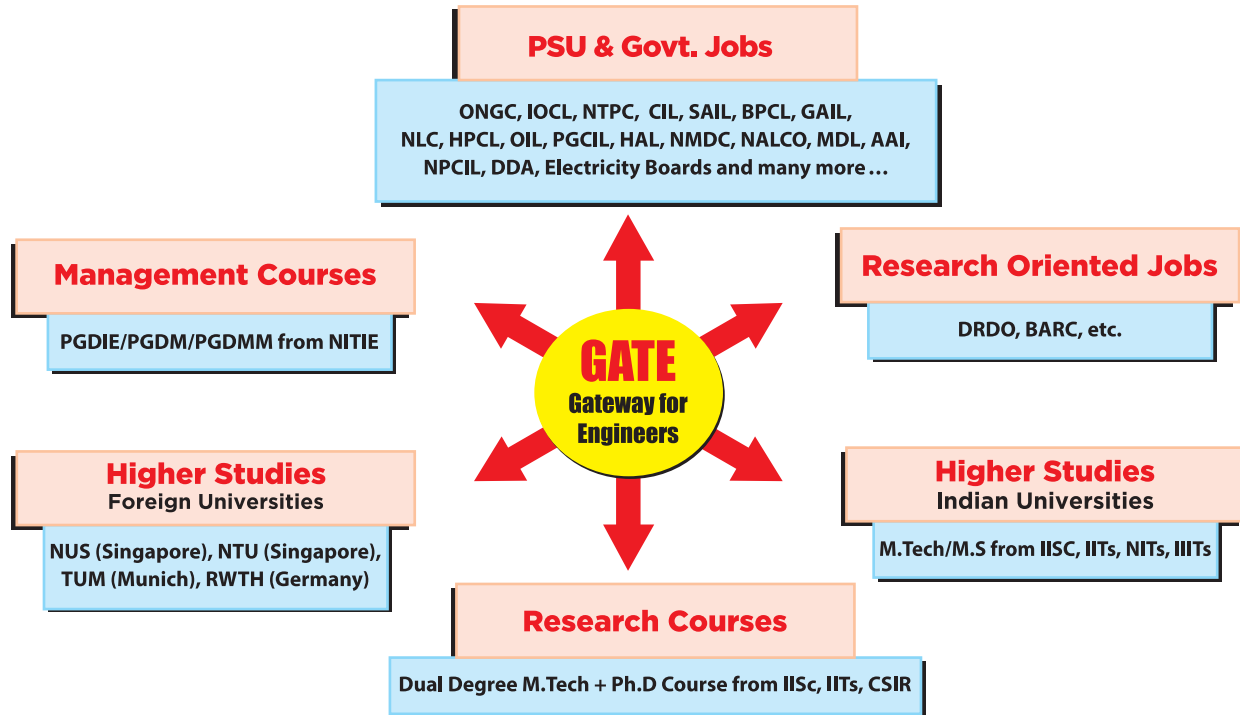
Revision through Questions for GATE 2020

EE

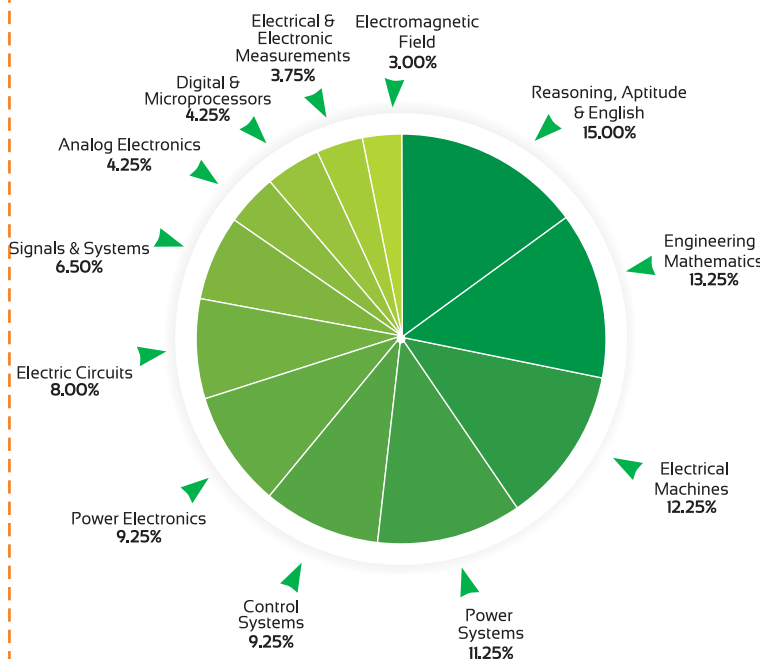
ELECTRICAL ENGG.

Q.76 - Q.100
out of 200 Questions

Day 4 of 8



SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

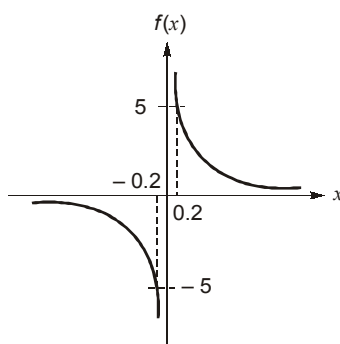
Day 4 : Q.76 to Q. 100 : Engineering Mathematics

- Q.76** A vector $\vec{F} = (y^2 - z^2 + 3yz - 2x)\hat{i} + (3xz + 2xy)\hat{j} + (2xy - axz + 2z)\hat{k}$ is known to be solenoidal. The value of "a" is
 (a) 2 (b) -3
 (c) -2 (d) Can't be determined
- Q.77** The area bounded by the straight line $y = x - 2$ and the parabola $y^2 = 2x + 4$ is _____ unit².
- Q.78** The coordinates of a particle moving in a plane are given by, $x = 4t - \frac{t^2}{2}$ and $y = 3 + 6t - \frac{t^3}{6}$. Here t is time in seconds and x and y are in meters. The magnitude of the velocity of the particle at $t = 2$ sec is _____ m/s.
- Q.79** The value of the integral $\int_0^1 \frac{dx}{(1+x^2)^{3/2}}$ will be _____.
- Q.80** The value of $\lim_{x \rightarrow 0} \frac{e^{ax} - e^{-ax}}{\ln(1+bx)}$ is
 (a) $\frac{a}{b}$ (b) $\frac{2a}{b}$
 (c) $\frac{b}{a}$ (d) does not exist
- Q.81** A function is defined by $f(x) = 2x^3 - 3x^2 - 12x + 5$ for $-2 \leq x \leq 3$. Which one of the following statements is true about this function?
 (a) function is decreasing for $(-2, -1)$ (b) function has a minima for $x = -1$
 (c) function has a maxima for $x = 2$ (d) function is decreasing for $(-1, 2)$
- Q.82** Consider the 2×2 matrix $\begin{bmatrix} 1 & 2 \\ p & 5 \end{bmatrix}$. The range of possible values of p , for which both the eigen values of the matrix are real and positive, is
 (a) $-\frac{5}{2} \leq p \leq \frac{5}{2}$ (b) $2 \leq p \leq \frac{5}{2}$
 (c) $-2 \leq p \leq \frac{5}{2}$ (d) $-\frac{5}{2} \leq p \leq 2$
- Q.83** Consider the system of linear equations given below:
 $-2x + y + z = l$
 $x - 2y + z = m$
 $x + y - 2z = n$
 If $l + m + n = 0$, then the system of equations has
 (a) no solution (b) trivial solutions
 (c) unique solution (d) infinitely many solutions

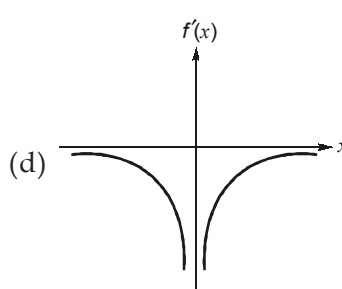
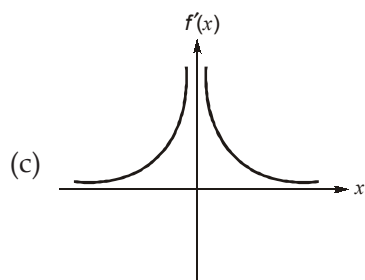
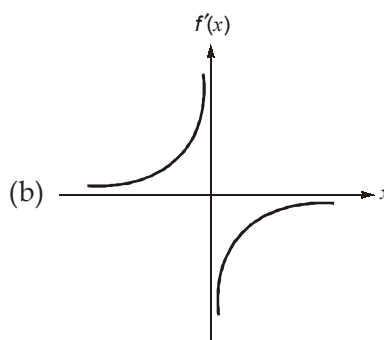
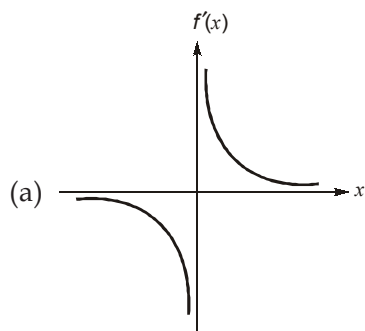
Q.84 The matrix $A = \begin{bmatrix} 1 & 4 \\ 2 & 3 \end{bmatrix}$ satisfies the following polynomial: $A^5 - 4A^4 - 7A^3 + 11A^2 - 2A + kI = 0$.
The value of k is _____.

Q.85 Let $AX = B$ represents a system of equations where A is 2×3 real matrix. The system is known to be inconsistent. The highest possible rank of A is
(a) 1 (b) 2
(c) 3 (d) can't be determined

Q.86 Consider a function $f(x)$ as given in the figure below



If $f'(x)$ represents the differentiation of the function $f(x)$, then the function $f'(x)$ can be represented as



Q.87 At the point $x = 2$, the function

$$f(x) = \begin{cases} x^3 - 8 & 2 < x < \infty \\ x - 2 & -\infty < x \leq 2 \end{cases} \text{ is}$$

- (a) continuous and differentiable (b) continuous and not differentiable
(c) discontinuous and differentiable (d) discontinuous and not differentiable

Q.88 If $y = e^{\sin^{-1} x}$ and $z = e^{-\cos^{-1} x}$, then the value of $\left. \frac{d^2 y}{dz^2} \right|_{x=1/\sqrt{2}}$ will be

- (a) 0 (b) $\frac{1}{\ln 2}$
(c) $\frac{1}{(\ln 2)^2}$ (d) $\frac{1}{2}$

Q.89 The particular integral of the differential equation $D^2(D^2 + 4)y = 96x^2$ for $x = 2$ will be

- (a) 8 (b) 5
(c) 9 (d) 2

Q.90 The rate at which a body cools is proportional to the difference between the temperature of the body and that of surrounding air. If the body cools from initial temperature of 100°C to 75°C in 1 minute, then temperature of the body after 5 minutes will be _____ $^\circ\text{C}$.
(Assume the temperature of surrounding air is 25°C)

Q.91 The solution of differential equation $(1 + xy)ydx + (1 - xy)xdy = 0$ is

- (a) $\ln\left(\frac{x}{y}\right) - \frac{1}{x+y} = C$ (b) $\ln\left(\frac{x}{y}\right) - \frac{1}{xy} = C$
(c) $\ln\left(\frac{x}{y}\right) + \frac{1}{xy} = C$ (d) $\ln\left(\frac{x}{y}\right) + \frac{1}{x+y} = C$

Q.92 An urn A contains 2 white and 4 black balls. Another urn B contains 5 white and 7 black balls. A ball is transferred from urn A to urn B, then a ball is drawn from urn B. The probability, that the drawn ball is white, is

- (a) $\frac{2}{13}$ (b) $\frac{10}{39}$
(c) $\frac{16}{39}$ (d) $\frac{12}{39}$

Q.93 The probability density function of a continuous random variable is given by,

$$f(x) = \begin{cases} x & ; 0 \leq x \leq 1 \\ 2-x & ; 1 \leq x \leq 2 \\ 0 & ; \text{Otherwise} \end{cases}$$

The mean value of the random variable is

- (a) 1 (b) 1.5
(c) 1.67 (d) 0

Q.94 The chances that doctor A will diagnose a disease X correctly is 60%. The chances that a patient will die by his treatment after correct diagnosis is 40% and the chances of death by wrong diagnosis is 70%. A patient of doctor A, who had disease X, died. The chances that his disease was diagnosed correctly is _____%.

Q.95 A and B throw alternatively a pair of dice. A wins if he throws 6 before B throws 7 and B wins if he throws 7 before A throws 6. If A starts the game, then the probability that B wins the game is

- (a) $\frac{5}{6}$ (b) $\frac{31}{61}$
(c) $\frac{30}{61}$ (d) $\frac{36}{71}$

Q.96 If the probability of a bad reaction from a certain injection is 0.001, then the probability that out of 2000 individuals more than two will get a bad reaction is

- (a) $1 - \frac{5}{e^2}$ (b) $1 - \frac{5}{e^3}$
(c) $\frac{5}{e^2}$ (d) $\frac{5}{e^3}$

Q.97 If the residue of the function $\frac{1 - e^{pz}}{z^4}$ at its pole is $-\frac{4}{3}$, then the value of p is _____.

Q.98 The value of the integral $\frac{1}{2\pi i} \oint_C \frac{e^{2z}}{1 - e^z} dz$ is evaluated along the circle C , defined as $|z| = 1$. The value of the integral is _____.

Q.99 The type of the partial differential equation $\frac{\partial f}{\partial t} = \frac{\partial^2 f}{\partial x^2}$ is

- (a) Parabolic (b) Elliptic
(c) Hyperbolic (d) Non-linear

Q.100 In a certain city, 40 percent of the people consider themselves conservatives (C), 35 percent consider themselves to be liberals (L) and 25 percent consider themselves to be independents (I). During a particular election, 45 percent of the conservatives voted, 40 percent of the liberals voted and 60 percent of the independents voted. The probability percentage of a person that voted is liberal is _____ %

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Detailed Explanation

76. (a)

$$\nabla \cdot \vec{F} = 0 \quad [\text{For solenoidal vector}]$$

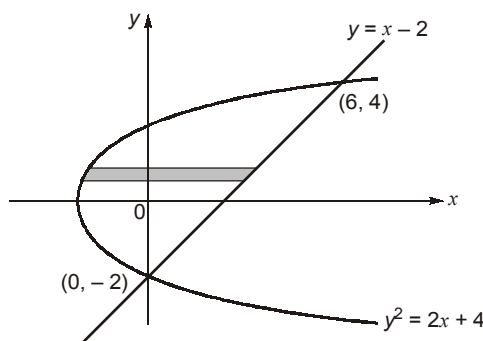
$$\frac{\partial(y^2 - z^2 + 3yz - 2x)}{\partial x} + \frac{\partial(3xz + 2xy)}{\partial y} + \frac{\partial(2xy - axz + 2z)}{\partial z} = 0$$

$$-2 + 2x - ax + 2 = 0$$

$$\text{From here, } a = 2$$

77. (18)

The point of intersection of line and parabola are (0, -2) and (6, 4).



$$\begin{aligned} \text{Area} &= \int_{-2}^4 \int_{\left(\frac{y^2-4}{2}\right)}^{y+2} dx dy = \int_{-2}^4 x \Big|_{\frac{y^2-4}{2}}^{y+2} dy \\ &= \int_{-2}^4 \left(y + 2 - \frac{y^2}{2} + 2 \right) dy = \left(\frac{y^2}{2} + 4y - \frac{y^3}{6} \right) \Big|_{-2}^4 = 18 \end{aligned}$$

78. 4.47 (4.35 to 4.60)

$$\vec{r} = \left(4t - \frac{t^2}{2} \right) \hat{i} + \left(3 + 6t - \frac{t^3}{6} \right) \hat{j}$$

$$\vec{v} = \frac{d\vec{r}}{dt} = (4 - t)\hat{i} + \left(6 - \frac{t^2}{2} \right) \hat{j}$$

$$\vec{v}|_{t=2} = 2\hat{i} + 4\hat{j}$$

$$|\vec{v}|_{t=2} = \sqrt{2^2 + 4^2} = 4.47 \text{ m/s}$$

79. 0.707 (0.65 to 0.75)

Let, $x = \tan \theta$
 $dx = \sec^2 \theta d\theta$

When $x = 0$, $\theta = 0$ when $x = 1$, $\theta = \frac{\pi}{4}$.

So,

$$I = \int_0^{\pi/4} \frac{\sec^2 \theta d\theta}{(1 + \tan^2 \theta)^{3/2}} = \int_0^{\pi/4} \frac{\sec^2 \theta d\theta}{\sec^3 \theta}$$

$$= \int_0^{\pi/4} \frac{1}{\sec \theta} d\theta = \int_0^{\pi/4} \cos \theta d\theta = + \sin \theta \Big|_0^{\pi/4}$$

$$I = \frac{1}{\sqrt{2}} = 0.707$$

80. (b)

$$\lim_{x \rightarrow 0} \frac{e^{ax} - e^{-ax}}{\ln(1 + bx)} = \lim_{x \rightarrow 0} \frac{(e^{ax} - e^{-ax}) \times 2ax \times b}{2ax \times b \times \ln(1 + bx)}$$

$$= \lim_{x \rightarrow 0} \left(\frac{e^{ax} - e^{-ax}}{2ax} \right) \times \lim_{x \rightarrow 0} \frac{bx}{\ln(1 + bx)} \left(\frac{2a}{b} \right)$$

$$= \lim_{x \rightarrow 0} \left(\frac{\sinh ax}{ax} \right) \lim_{x \rightarrow 0} \frac{bx}{\ln(1 + bx)} \left(\frac{2a}{b} \right)$$

$$= 1 \times 1 \times \frac{2a}{b}$$

$$= \frac{2a}{b}$$

81. (d)

$$f(x) = 2x^3 - 3x^2 - 12x + 5$$

$$f'(x) = 6x^2 - 6x - 12$$

For minima/maxima, $f'(x) = 0$

$$6x^2 - 6x - 12 = 0$$

$$x^2 - x - 2 = 0$$

$$(x + 1)(x - 2) = 0$$

$$x = -1, 2$$

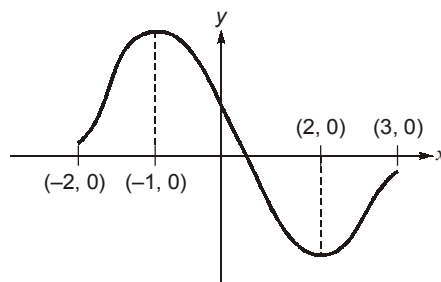
$$f''(x) = 12x - 6$$

$$f''(-1) = -12 - 6 = -18 < 0 \Rightarrow \text{maxima}$$

$$f''(2) = 24 - 6 = 18 > 0 \Rightarrow \text{minima}$$

The function has maxima at $x = -1$ and minima at $x = 2$.

The function is decreasing between -1 and 2 .



82. (c)

$$\begin{vmatrix} 1-\lambda & 2 \\ p & 5-\lambda \end{vmatrix} = 0$$

$$(1-\lambda)(5-\lambda) - 2p = 0$$

$$\lambda^2 - 6\lambda + 5 - 2p = 0$$

Let the roots are λ_1 and λ_2 .

From the characteristic equation,

$$\lambda_1 + \lambda_2 = 6$$

$$\lambda_1 \lambda_2 = 5 - 2p \geq 0$$

[For roots to be positive]

$$p \leq \frac{5}{2}$$

... (i)

For roots to be real,

$$6^2 - 4(5 - 2p) \geq 0$$

$$36 - 20 + 8p \geq 0$$

$$p \geq -2$$

... (ii)

From equations (i) and (ii),

$$-2 \leq p \leq \frac{5}{2}$$

83. (d)

$$AX = B$$

$$\text{Augmented matrix, } [A : B] = \begin{bmatrix} -2 & 1 & 1 & : & l \\ 1 & -2 & 1 & : & m \\ 1 & 1 & -2 & : & n \end{bmatrix}$$

$$R_3 \rightarrow R_3 + R_2 + R_1:$$

$$[A : B] = \begin{bmatrix} -2 & 1 & 1 & : & l \\ 1 & -2 & 1 & : & m \\ 0 & 0 & 0 & : & l+m+n \end{bmatrix}$$

$$\text{Since, } l+m+n = 0$$

$$\text{Rank of } [A : B] = 2$$

$$\text{Rank of } [A] = \text{Rank of } [A : B] = 2 < 3 \text{ (Number of variables)}$$

$\Rightarrow$ Infinitely many solutions are possible.

84. (-15)

The characteristic equation of matrix A is

$$|A - \lambda I| = 0$$

$$\begin{vmatrix} 1-\lambda & 4 \\ 2 & 3-\lambda \end{vmatrix} = 0$$

$$\lambda^2 - 4\lambda - 5 = 0$$

or

$$A^2 - 4A - 5I = 0$$

Now the given polynomial can be written as,

$$A^5 - 4A^4 - 7A^3 + 11A^2 - 2A + kI = (A^3 - 2A + 3I)(A^2 - 4A - 5I) + (k + 15)I$$

Since,

$$A^2 - 4A - 5I = 0$$

For the given polynomial to be zero,

$$k + 15 = 0$$

$$k = -15$$

85. (a)

minimum (2, 3) $\Rightarrow$ highest possible rank = 2

if rank of $A = 2$, it will consistent. In order to be inconsistent, maximum rank of A is '1'.

86. (d)

Given function is $y = \frac{1}{x}$ [hyperbolic function]

$$\frac{dy}{dx} = -\frac{1}{x^2}$$

hence, option (d) is correct.

87. (b)

$$\lim_{x \rightarrow 2^-} f(x) = \lim_{x \rightarrow 2^-} (x - 2) = 0$$

$$\lim_{x \rightarrow 2^+} f(x) = \lim_{x \rightarrow 2^+} (x^3 - 8) = 0$$

Also

$$f(2) = 0$$

Thus

$$\lim_{x \rightarrow 2^-} f(x) = \lim_{x \rightarrow 2^+} f(x) = f(2)$$

$\therefore f$ is continuous at $x = 2$

and $Lf'(2) = 1$ and $Rf'(2) = 12$

$\therefore f$ is not differentiable at $x = 2$.

88. (a)

$$\ln y = \sin^{-1}x,$$

$$\ln z = -\cos^{-1}x$$

$$\ln y - \ln z = \sin^{-1}x + \cos^{-1}x$$

$$\ln\left(\frac{y}{z}\right) = \frac{\pi}{2}$$

$$y = ze^{\pi/2}$$

$$\frac{dy}{dz} = e^{\pi/2}$$

$$\frac{d^2y}{dz^2} = 0$$

89. (a)

For particular integral,

$$PI = \frac{96x^2}{D^2(D^2 + 4)} = 96 \frac{1}{4D^2 \left(1 + \frac{D^2}{4}\right)} x^2 = \frac{96}{4} \left[\frac{\left(1 - \frac{D^2}{4}\right) x^2}{D^2} \right]$$

$$= 24 \frac{\left(x^2 - \frac{1}{2}\right)}{D^2}$$

$$PI = 24 \left[\frac{x^4}{4 \times 3} - \frac{x^2}{4} \right] = 2x^2(x^2 - 3)$$

$$PI|_{x=2} = 2 \times 2^2(4 - 3) = 8$$

90. 34.88 (34.60 to 35.20)

$$\frac{dT}{dt} = k(T - 25)$$

T = Temperature of the body in °C and t = time in minutes.

$$\frac{dT}{T - 25} = k dt$$

$$\ln(T - 25) = kt + C_1$$

$$T - 25 = Ce^{kt}$$

At $t = 0$, $T = 100^\circ\text{C}$ and at $t = 1$ minute, $T = 75^\circ\text{C}$.

$$(100 - 25) = Ce^0$$

$\Rightarrow$

$$C = 75$$

$$50 = 75 e^k \Rightarrow e^k = \frac{2}{3}$$

At $t = 5$ minutes, $T - 25 = 75 e^{k \times 5}$

$$T = 25 + 75 \times \left(\frac{2}{3}\right)^5 \approx 34.88^\circ\text{C}$$

91. (b)

$$M = (1 + xy)y$$

and

$$N = (1 - xy)x$$

$$\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x} = 4xy \neq 0$$

$$Mx - Ny = 2x^2y^2 \neq 0$$

$$\frac{1}{Mx - Ny} = \frac{1}{2x^2y^2}$$

$$\text{IF (Integrating factor)} = \frac{1}{2x^2y^2}$$

$$\left(\frac{1}{x^2y} + \frac{1}{x}\right)dx + \left(\frac{1}{xy^2} - \frac{1}{y}\right)dy = 0 \quad \dots(i)$$

equation (i) is exact

$$\frac{1}{y} \int \frac{1}{x^2} dx + \int \frac{1}{x} dx - \int \frac{1}{y} dy = C$$

$$\frac{-1}{xy} + \ln x - \ln y = C$$

or $\ln\left(\frac{x}{y}\right) - \frac{1}{xy} = C$

92. (c)

Case-I: White ball is transferred from urn A to urn B

$$\text{Probability of drawing white ball from B} = \frac{2}{2+4} \times \frac{6}{13} = \frac{2}{13}$$

Case-II: Black ball is transferred from A to B

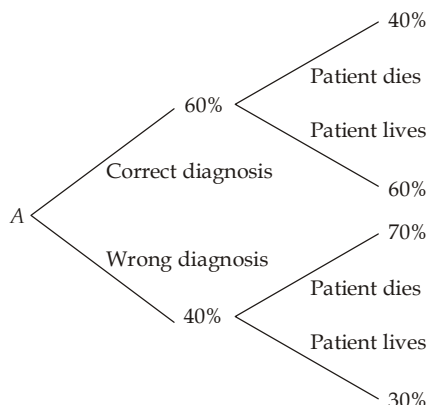
$$\text{Probability of drawing black ball from B} = \frac{4}{2+4} \times \frac{5}{13} = \frac{10}{39}$$

$$\text{Required probability} = \frac{2}{13} + \frac{10}{39} = \frac{16}{39}$$

93. (a)

$$\begin{aligned} \text{Mean} &= \int_{-\infty}^{\infty} xf(x) dx = \int_0^1 x^2 dx + \int_1^2 (2-x)x dx \\ &= \left. \frac{x^3}{3} \right|_0^1 + \left(x^2 - \frac{x^3}{3} \right) \Big|_1^2 = \frac{1}{3} + 4 - 1 - \frac{8-1}{3} = 1 \end{aligned}$$

94. 46.15 (46.00 to 46.25)



Probability that patient dies who had diseases X is

$$= \frac{40}{100} \times \frac{60}{100} + \frac{70}{100} \times \frac{40}{100} = \frac{52}{100}$$

Probability that he dies of correct diagnosis

$$= \frac{60 \times 40}{100 \times 100} = \frac{24}{100}$$

$$\text{Required probability} = \frac{24/100}{52/100} = \frac{6}{13}$$

$$\text{Required chances} = \frac{6}{13} \times 100 = 46.15\%$$

95. (b)

Number of ways of throwing 6 is five $\Rightarrow (1 + 5), (2 + 4), (3 + 3), (4 + 2), (5 + 1)$

Number of ways of throwing 7 is six $\Rightarrow (1 + 6), (2 + 5), (3 + 4), (4 + 3), (5 + 2), (6 + 1)$

$$\text{Probability of throwing 6, } p_1 = \frac{5}{36}$$

$$\text{Probability of failing to throw 6, } p_2 = 1 - \frac{5}{36} = \frac{31}{36}$$

$$\text{Probability of throwing 7, } q_1 = \frac{6}{36}$$

$$\text{Probability of failing to throw 7, } q_2 = 1 - \frac{6}{36} = \frac{30}{36}$$

$$\text{Probability of B winning} = p_2 q_1 + p_2 q_2 p_2 q_1 + p_2 q_2 p_2 q_2 p_2 q_1 + \dots$$

$$= p_2 q_1 [1 + p_2 q_2 + (p_2 q_2)^2 + (p_2 q_2)^3 + \dots]$$

$$= \frac{p_2 q_1}{(1 - p_2 q_2)} = \frac{\frac{31}{36} \times \frac{6}{36}}{1 - \frac{31}{36} \times \frac{30}{36}} = \frac{31 \times 6}{366} = \frac{31}{61}$$

96. (a)

Since the probability of occurrence is very small, this follows Poisson distribution

$$\begin{aligned} \text{mean} = m &= np \\ &= 2000 \times 0.001 \\ &= 2 \end{aligned}$$

Probability that more than 2 will get a bad reaction

$$= 1 - p(0) - p(1) - p(2)$$

$$= 1 - \left[e^{-m} + \frac{e^{-m} \cdot m^1}{1!} + \frac{e^{-m} \cdot m^2}{2!} \right]$$

$$= 1 - \left[e^{-2} + \frac{e^{-2} \cdot 2}{1} + \frac{2^2 \cdot e^{-2}}{2} \right] = 1 - \left[\frac{1}{e^2} + \frac{2}{e^2} + \frac{2}{e^2} \right]$$

$$= 1 - \frac{5}{e^2}$$

97. (2)

$$f(z) = \frac{1 - e^{pz}}{z^4}, \text{ then } f(z) \text{ has a pole at } z = 0 \text{ of order 4}$$

Residue of $f(z)$ at $z = 0$

$$\begin{aligned} &= \frac{1}{(n-1)!} \lim_{z \rightarrow z_0} \frac{d^{n-1}}{dz^{n-1}} (z - z_0)^n \cdot f(z); \quad \text{Here } n = 4, z_0 = 0 \\ &= \frac{1}{3!} \lim_{z \rightarrow 0} \frac{d^3}{dz^3} \left(\frac{z^4 \cdot (1 - e^{pz})}{z^4} \right) = \frac{1}{6} (-p^3 \cdot e^{pz}) \Big|_{z=0} \\ &= -\frac{p^3}{6} \\ &\frac{4 \times 6}{3} = p^3 \\ &p^3 = 8 \\ &p = 2 \end{aligned}$$

98. (-1)

$$\begin{aligned} 1 - e^z &= 0 \\ e^z &= 1 \\ z &= 2n\pi i; \quad n = 0, \pm 1, \pm 2, \dots \end{aligned}$$

The poles lie inside the circle is at $z = 0$ only

$$\begin{aligned} \text{Residue at } (z = 0) &= \lim_{z \rightarrow 0} \frac{ze^{2z}}{1 - e^z} = \lim_{z \rightarrow 0} \frac{z \left(1 + \frac{2z}{1!} + \frac{(2z)^2}{2!} + \dots \right)}{1 - 1 - \frac{z}{1!} - \frac{z^2}{2!} - \dots} \\ &= \lim_{z \rightarrow 0} \frac{z \left(1 + \frac{2z}{1!} + \frac{(2z)^2}{2!} + \dots \right)}{-z \left(1 + \frac{z}{2!} + \dots \right)} = -1 \end{aligned}$$

$$\text{The value of } \frac{1}{2\pi i} \oint_c \frac{e^{2z}}{1 - e^z} dz = -1$$

99. (a)

General form of second order partial differential equation

$$aU_{xx} + bU_{xy} + cU_{yy} = 0$$

Given differential equation,

$$\frac{df}{dt} = \frac{d^2 f}{dx^2}$$

has $a = 1, b = 0, c = 0$

$$b^2 - 4ac = 0$$

Hence parabolic.

100. 29.8 (29 to 31)

$$P\left(\frac{L}{V}\right) = \frac{P(L) \cdot P\left(\frac{V}{L}\right)}{P(V)}$$

$$P\left(\frac{L}{V}\right) = \text{person who voted and is a liberal}$$

$$P(L) = \text{person who are liberals}$$

$$P(V) = \text{person who voted}$$

$$\begin{aligned} P(V) &= P(C) \cdot P\left(\frac{V}{C}\right) + P(L) \cdot P\left(\frac{V}{L}\right) + P(I) \cdot P\left(\frac{V}{I}\right) \\ &= (0.40)(0.45) + (0.35)(0.40) + (0.25)(0.60) \\ &= 0.47 \end{aligned}$$

$$P\left(\frac{L}{V}\right) = \frac{(0.35)(0.40)}{0.47} = \frac{14}{47} = 0.298$$

$$P\left(\frac{L}{V}\right) = 29.8\%$$

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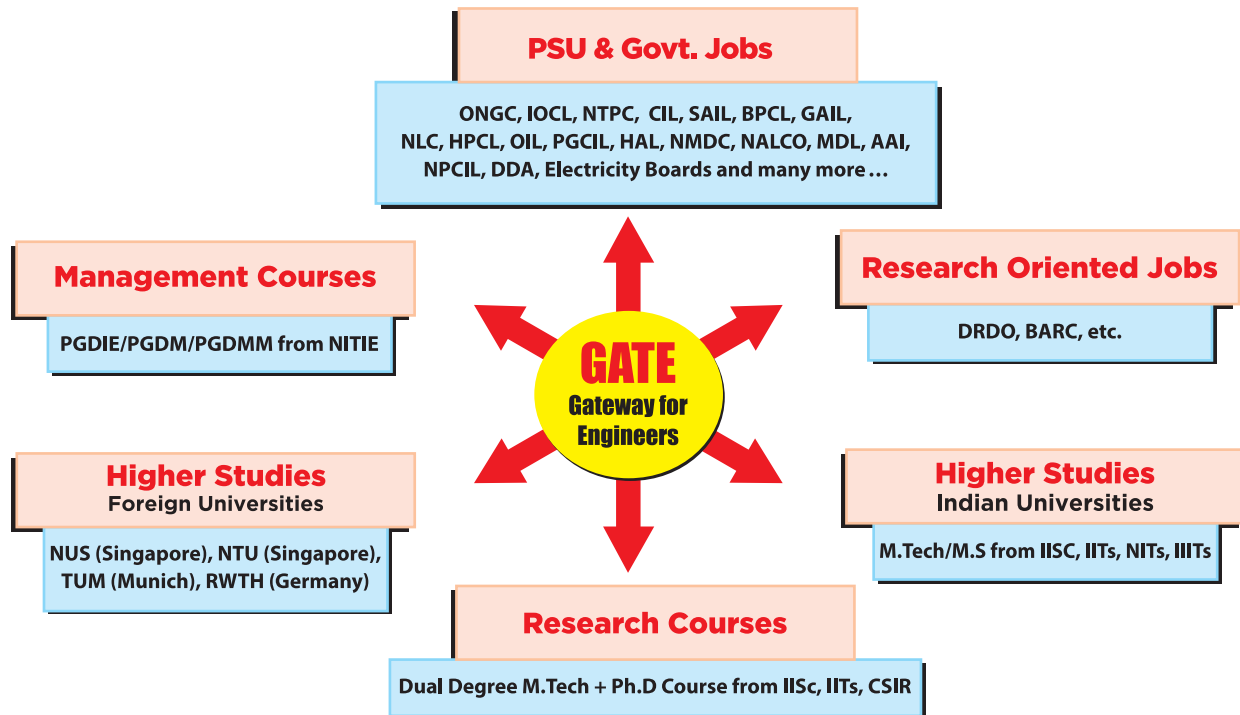
Revision through Questions for GATE 2020

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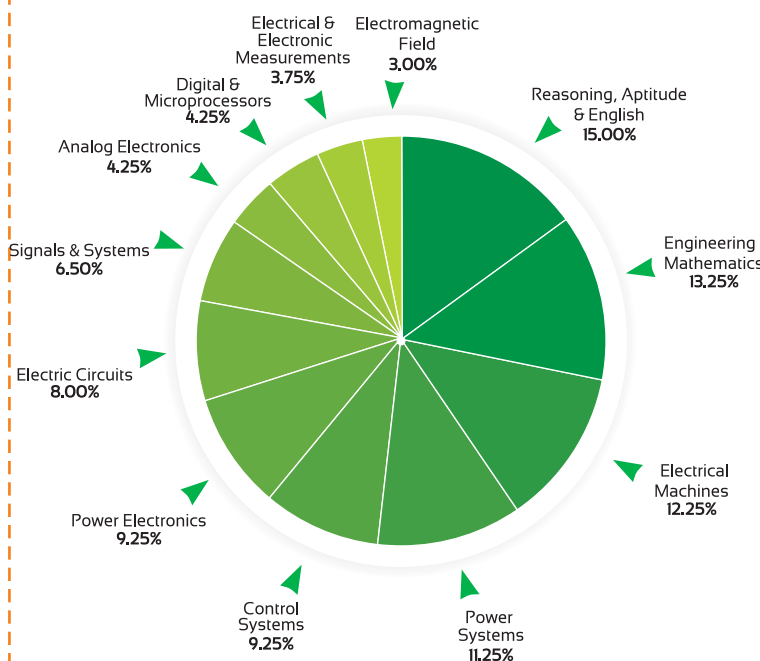
ELECTRICAL ENGG.

Q.101 - Q.125
out of 200 Questions

Day 5 of 8



SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

Day 5 : Q.101 to Q.125 : Power Systems

Q.101 For a power system, with following specifications:

$$A = 0.99 \angle 0^\circ = D,$$

$$B = 36.54 \angle 90^\circ \Omega,$$

$$C = 0.05 \times 10^{-6} \angle -90^\circ \text{ s}$$

The value of shunt inductor to prevent ferranti effect is

- (a) 10.54 H (b) 11.63 H
(c) 12.87 H (d) 18.45 H

101. (b)

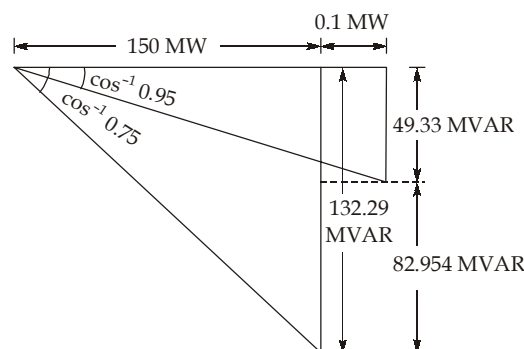
We know that,
$$X_L = \frac{B}{1-A} = \frac{36.54}{1-0.99} = 3654 \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{3654}{2 \times \pi \times 50}$$

$$\Rightarrow L = 11.63 \text{ H}$$

Q.102 A load is absorbing 150 MW power at 0.75 lagging power factor. An overexcited synchronous motor is added to improve the pf to 0.95 lag. This motor consumes 100 kW, then the reactive VARs supplied by the motor is _____ MVAR (Give answer upto 3 decimals)

102. 82.954 (81.000 to 85.000)



Without Synchronous motor:

$$\begin{aligned} Q_1 &= S_1 \sin \phi_1 \\ &= \frac{150}{0.75} \sin(\cos^{-1} 0.75) \\ Q_1 &= 132.29 \text{ MVAR} \end{aligned}$$

With Synchronous motor:

$$\begin{aligned} Q_2 &= S_2 \sin \phi_2 \\ &= \frac{150 + 0.1}{0.95} \sin(\cos^{-1} 0.95) \\ Q_2 &= 49.33 \text{ MVAR} \end{aligned}$$

$$\text{VAR supplied by motor} = 82.954 \text{ MVAR}$$

Q.103 The A, B, C, D constants of a 220 kV line are:

$$A = D = 0.91 \angle 5^\circ,$$

$$B = 120 \angle 70^\circ \Omega$$

and $C = 0.002 \angle 90^\circ \text{ S}$

If the sending end voltage of the line for a given load delivered at nominal voltage is 240 kV, then the percentage voltage regulation is

- (a) 19.87% (b) 12.23%
(c) 8.33% (d) 9.09%

103. (a)

At no load, $V_S = A V_R$

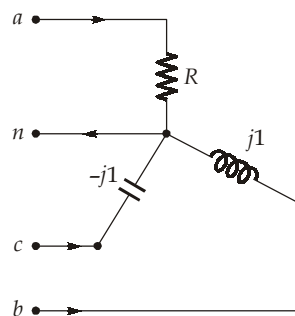
$$V_{R(NL)} = \frac{V_S}{A} = \frac{240}{0.91} = 263.73 \text{ kV}$$

The percentage voltage regulation is,

$$\begin{aligned} \%VR &= \frac{V_{R(NL)} - V_{R(FL)}}{V_{R(FL)}} \times 100 \\ &= \frac{263.73 - 220}{220} \times 100 = 19.87\% \end{aligned}$$

Q.104 A three phase load is connected to a three phase balanced supply as shown in the figure. If

$$V_{an} = 10 \angle 0^\circ \text{ V}, V_{bn} = 10 \angle -120^\circ \text{ V} \text{ and } V_{cn} = 10 \angle 120^\circ \text{ V}$$



The value of R for $I_n = 0 \text{ A}$ is _____ Ω .

104. 0.57 (0.40 to 0.80)

From the given voltages,

$$I_a = \frac{V_{an}}{R} = \frac{10 \angle 0^\circ}{R}$$

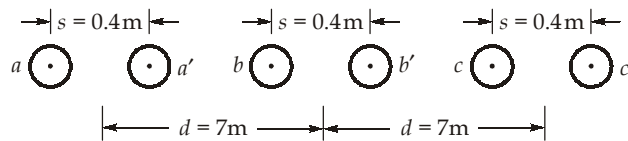
$$I_b = \frac{V_{bn}}{jX_L} = \frac{10 \angle -120^\circ}{j1} = 10 \angle 150^\circ \text{ A}$$

$$I_c = \frac{V_{cn}}{-jX_C} = \frac{10 \angle 120^\circ}{-j1} = 10 \angle -150^\circ \text{ A}$$

Given,

$$\begin{aligned} I_n &= 0 = I_a + I_b + I_c \\ &= \frac{10 \angle 0^\circ}{R} + 10 \angle 150^\circ + 10 \angle -150^\circ = 0 \\ R &= 0.577 \Omega \end{aligned}$$

Q.105 A three phase bundled conductor line with two conductors per phase as shown below,



all conductors are ACSR with radius of 1.725 cm.

The mutual GMD between bundles of phases c and a is _____ m.

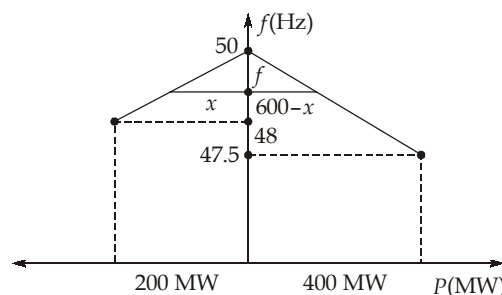
105. 14.00 (13.50 to 14.50)

Mutual GMD between bundles of phases c and a is given by,

$$\begin{aligned} D_{ca} &= \sqrt[4]{D_{ac} \cdot D_{ac'} \cdot D_{a''c} \cdot D_{a''c'}} \\ &= \sqrt[4]{2d \cdot (2d + s) \cdot (2d - s) \cdot 2d} \\ &= \sqrt[4]{14 \times 14 \times 14.4 \times 13.6} \\ &= 13.99 \approx 14 \text{ m} \end{aligned}$$

Q.106 Two generators rated 200 MW and 400 MW are operating in parallel. The droop characteristics of their governors are 4% and 5%, respectively from no-load to full load. Assume that generators are operating at 50 Hz at no load. If a load of 600 MW is to be shared between the two generators then the system frequency in steady state is _____ Hz.

106. 47.69 (47.00 to 48.00)



$$\frac{50 - f}{x} = \frac{50 - 48}{200}$$

$$0.01 x + f = 50 \quad \dots(i)$$

and

$$\frac{50 - f}{600 - x} = \frac{50 - 47.5}{400}$$

$$50 - f = 3.75 - 6.25 \times 10^{-3} x$$

$$6.25 \times 10^{-3} x - f = -46.25 \quad \dots(ii)$$

Solving equation (i) and (ii), we get

$$x = 230.77 \text{ MW}$$

From equation (i),

$$(0.01 \times 230.77) + f = 50$$

$$f = 47.69 \text{ Hz}$$

Q.107 In a three phase, three core cable, if the capacitance between any two cores is $0.3 \mu\text{F}/\text{km}$ when it is connected to 10 kV, 50 Hz bus bar then the kVA taken by 10 km line is _____ kVA.

107. 188.49 (188.00 to 189.00)

Capacitance between any two cores of cable is

$$= 0.3 \times 10^{-6} \text{ F/km}$$

$$C = \frac{1}{2} C_N = 0.3 \times 10^{-6} \text{ F/km}$$

$$C_N = 0.6 \times 10^{-6} \text{ F/m}$$

Capacitance per phase, $C_N = 0.6 \times 10^{-6} \times 10 = 6 \mu\text{F}$

$$\begin{aligned} \text{KVA taken by cable} &= 3 V_{ph} I_{ph} \\ &= 3 V_{ph} I_{ph} \omega C \\ &= 3 V_{ph}^2 2\pi f C \end{aligned}$$

$$\begin{aligned} &= 3 \times \left(\frac{10000}{\sqrt{3}} \right)^2 \times 2\pi \times 50 \times 6 \times 10^{-6} \\ &= 188.49 \text{ kVA} \end{aligned}$$

Q.108 For a power system:

Line to line fault current = $-j 2.5 \text{ p.u.}$

3- ϕ fault current = $-j 5 \text{ p.u.}$

The positive and negative sequence reactances are

- (a) $X_1 = 0.3 \text{ p.u.}, X_2 = 0.1 \text{ p.u.}$ (b) $X_1 = j0.2 \text{ p.u.}, X_2 = j 0.49 \text{ p.u.}$
(c) $X_1 = 0.1 \text{ p.u.}, X_2 = 0.3 \text{ p.u.}$ (d) $X_1 = 0.25 \text{ p.u.}, X_2 = 0.15 \text{ p.u.}$

108. (b)

3- ϕ fault current:

Let system is under no load condition before fault,

$$\therefore E = 1 \angle 0^\circ \text{ p.u.}$$

$$3\text{-}\phi \text{ fault current, } I_f = \frac{E}{X_1}$$

$$\Rightarrow X_1 = \frac{1}{-j5} = j0.2 \text{ p.u.}$$

Line-line fault current:

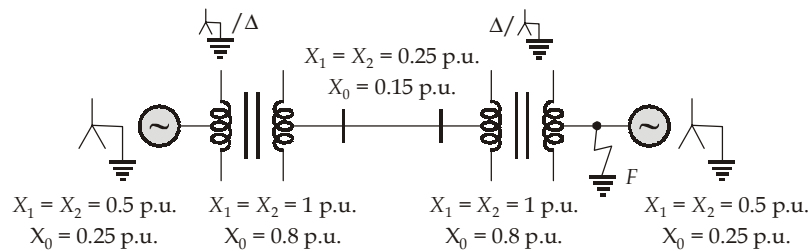
$$I_f = \frac{\sqrt{3}E}{X_1 + X_2}$$

$$\Rightarrow X_1 + X_2 = \frac{\sqrt{3}}{-j2.5}$$

$$\Rightarrow j 0.2 + X_2 = j 0.69 \text{ p.u.}$$

$$\Rightarrow X_2 = j 0.49 \text{ p.u.}$$

Q.109 Single line to ground fault is occurred on the following power system as shown below:

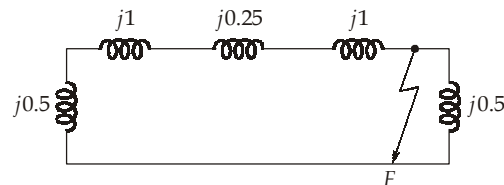


All per unit values are on common base. The fault current is

- (a) $-j 2.896$ p.u. (b) $-j 0.9648$ p.u.
(c) $-j 2.969$ p.u. (d) $-j 0.9897$ p.u.

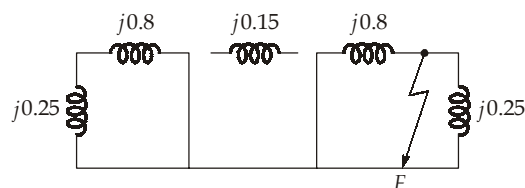
109. (a)

Positive and negative sequence reactance diagram:



$$Z_1 = Z_2 = j 2.75 \parallel j 0.5 = j 0.423 \text{ p.u.}$$

Zero sequence reactance diagram:



$$Z_0 = j 0.8 \parallel j 0.25 = j 0.19 \text{ p.u.}$$

Considering system at no load before fault

i.e. $E = 1.0 \angle 0^\circ$ p.u.

$$(I_F) = 3 \left(\frac{E}{Z_1 + Z_2 + Z_0} \right) = 3 \left(\frac{1}{j0.423 + j0.423 + j0.19} \right)$$

$$I_f = -j2.896 \text{ p.u.}$$

Q.110 The line reactances of a power network are as follows:

From Bus	To Bus	Reactance
0	1	0.3 p.u.
1	2	0.5 p.u.

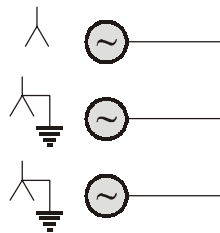
The bus impedance matrix with '0' as reference bus is,

- (a) $\begin{bmatrix} 0.3 & 0.6 \\ 0.6 & 0.8 \end{bmatrix}$ (b) $\begin{bmatrix} 0.5 & 0.3 \\ 0.3 & 0.8 \end{bmatrix}$
(c) $\begin{bmatrix} 0.3 & 0.3 \\ 0.6 & 0.8 \end{bmatrix}$ (d) $\begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.8 \end{bmatrix}$

110. (d)

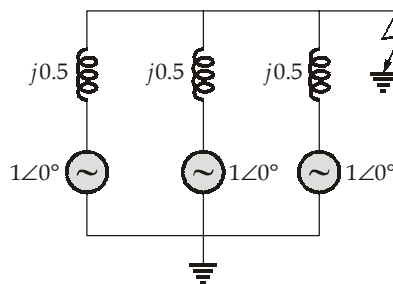
$$Z_{\text{Bus (new)}} = \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.3 + 0.5 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.8 \end{bmatrix}$$

Q.111 There are three generators connected in parallel. For each generator positive, negative and zero sequence reactance are 0.5 p.u., 0.4 p.u. and 0.25 p.u. respectively. For a pre-fault voltage of 1.0 p.u., the single line to ground fault current magnitude if fault is occurred at terminals of generators is _____ p.u. (Give answer upto 3 decimals).



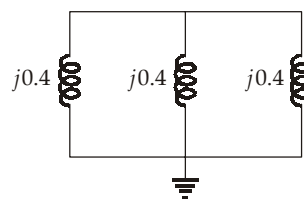
111. 7.058 (7.043 to 7.061)

Positive sequence reactance diagram:



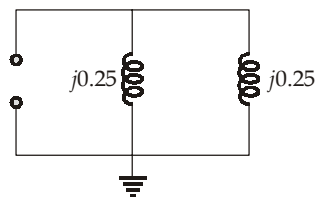
$$\Rightarrow Z_{01} = j\frac{0.5}{3}$$

Negative sequence reactance diagram:



$$\Rightarrow Z_{02} = j\frac{0.4}{3}$$

Zero sequence reactance diagram:



$$\Rightarrow Z_{00} = j\frac{0.25}{2}$$

$$I_f = 3 \left(\frac{E}{Z_{01} + Z_{02} + Z_{00}} \right) = 3 \left(\frac{1}{j0.425} \right)$$

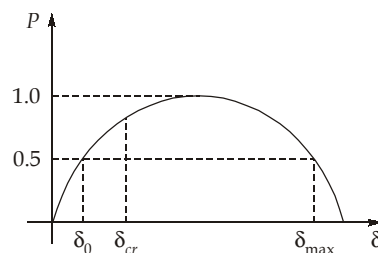
$$I_f = -j7.058 \text{ p.u.}$$

$\Rightarrow$

$$|I_f| = 7.058 \text{ p.u.}$$

Q.112 A generator operating at 50 Hz delivering 50% of maximum power to an infinite bus through a transmission line. Suddenly, a short circuit occurs, and power is reduced to zero. The critical clearing angle is _____ degree (Give answer upto 3 decimals).

112. 79.562 (79.501 to 79.623)



$$P_m = P_{\max} \sin \delta_0$$

$$\sin \delta_0 = 0.5$$

$$\delta_0 = 30^\circ \text{ or } \frac{\pi}{6} \text{ rad}$$

and

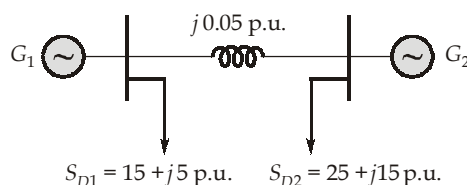
$$\delta_{\max} = \pi - \delta_0 = \pi - \frac{\pi}{6} = \frac{5\pi}{6} \text{ rad or } 150^\circ$$

$$\cos \delta_{cr} = \frac{P_m}{P_{\max}} (\delta_{\max} - \delta_0) + \cos \delta_{\max} = \frac{0.5}{1} \left(\frac{5\pi}{6} - \frac{\pi}{6} \right) + \cos(150^\circ)$$

The critical clearing angle,

$$\delta_{cr} = \cos^{-1}(0.18117) = 79.562^\circ$$

Q.113 In the system shown below,



If the station loads are equalized by the flow of power in the cable and generator G_1 can generate a maximum of 20 p.u. real power, then the power factor at station 2 is _____ lagging. (Desired voltage profile is flat i.e. $|V_1| = |V_2| = 1 \text{ p.u.}$)

113. 0.78 (0.75 to 0.80)

By equalizing the station,

$$P_{G_1} = P_{G_2} = 20 \text{ p.u.}$$

Now,

$$5 = \frac{|E||V|}{|X|} \sin \delta = \frac{1 \times 1}{0.05} \sin \delta$$

$$\delta = 14.47^\circ$$

Q.115 A transformer circuit breaker is equipped with 500/5 A C.T.s connected to a induction type over current relays. The relays have 125% plug setting and 0.4 time setting. If a 3- ϕ fault current of 7500 A flows from C.T. and relays follow given below characteristic table at (TMS = 1), then operating time of the relay will be

PSM	4	8	12	16
Operation time(sec.)	5	3	2.8	2.2

- (a) 1.12 sec (b) 2.24 sec
(c) 2.81 sec (d) 1.01 sec

115. (a)

The secondary current, $I_s = \frac{I_p}{n}$

Where, $n = \frac{500}{5}$

$\therefore I_s = 7500 \times \frac{5}{500} = 75 \text{ A}$

Relay current setting = 125% of 5A = $1.25 \times 5 = 6.25 \text{ A}$

$\therefore$ Plug setting multiplier (PSM) = $\frac{75}{6.25} = 12$

Using data in characteristic table

Operating time corresponding to PSM = 12 is 2.8 sec (at TMS = 1)

Operating time of relay = $2.8 \text{ sec} \times 0.4 = 1.12 \text{ sec}$.

Q.116 A 3-phase, 50 Hz, synchronous generator has rating 200 MVA. The Kinetic energy of the machine at synchronous speed is 800 MJ. The machine is running steadily at synchronous speed and delivering 50 MW power at power angle of 10 electrical degrees. If the load is suddenly removed, assuming the acceleration is constant for 8 cycles, the value of power angle after 4 cycles is _____ ele. degrees.

116. 11.81 (11.40 to 12.20)

Given, $P_e = 50 \text{ MW}$

K.E. = 800 MJ

$f = 50 \text{ Hz};$

$\delta_0 = 10^\circ$

Time for 8 cycles = $\frac{8}{50} = 0.16 \text{ sec}$

Time for 4 cycles = 0.08 sec

$P_a = 50 \text{ MW}$

$M = \frac{K.E.}{180 f} = \frac{GH}{180 \times f}$

$M = \frac{800}{180 \times 50} = 0.088$

We know that, $M \frac{d^2 \delta}{dt^2} = P_a$

$$\frac{d^2\delta}{dt^2} = \frac{P_a}{M}$$

Integrating twice we have,

$$\delta = \frac{P_a}{M} \left[\frac{t^2}{2} \right] + \delta_0 = \frac{50}{0.088} \left[\frac{0.08^2}{2} \right] + 10^\circ$$

New value of power angle = $1.81^\circ + 10^\circ = 11.81^\circ$

Q.117 The sending end and receiving end voltages of a transmission line are 115 kV. The line is delivering a load of 100 MW. The per phase line impedance is $(4 + j7) \Omega$. The maximum steady state power that can be transmitted over the line is

- (a) 225.2 MW (b) 425 MW
(c) 826.5 MW (d) 650 MW

117. (c)

Given,

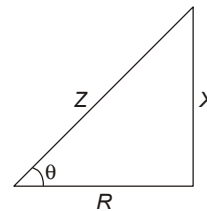
$$|V_S| = |V_R| = 115 \times 10^3 \text{ volts}$$

$$P_{R, \max} = \frac{|V_R||V_S|}{|Z|} - \frac{|V_R|^2}{|Z|} \cos \theta$$

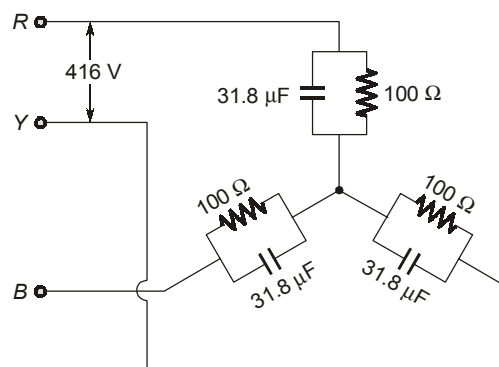
$$\cos \theta = \frac{R}{Z}$$

$$P_{R, \max} = \frac{|V_R||V_S|}{|Z|} - \frac{|V_R|^2 R}{|Z|^2}$$

$$= \frac{(115 \times 10^3)^2}{\sqrt{4^2 + 7^2}} - \frac{(115 \times 10^3)^2 \times 4}{4^2 + 7^2} = 826.51 \text{ MW}$$



Q.118 In the circuit shown below,



If the source is 50 Hz supply then total active power consumed by the load is

- (a) 576 W (b) 1814 W
(c) 1726 W (d) 2433 W

118. (c)

$$\begin{aligned}\text{The admittance per phase, } Y &= \frac{1}{R} + j\omega C \\ &= \frac{1}{100} + j(2\pi \times 50 \times 31.8 \times 10^{-6})\end{aligned}$$

$$\vec{Y} = 0.0141 \angle 44.97^\circ \text{ } \Omega$$

$$\begin{aligned}\text{Per phase current} &= \vec{I}_{ph} = \vec{V}_{ph} \vec{Y} \\ &= \left(\frac{416}{\sqrt{3}} \angle 0^\circ \right) (0.0141 \angle 44.97^\circ)\end{aligned}$$

$$\vec{I}_{ph} = 3.386 \angle 44.97^\circ \text{ A}$$

$$\begin{aligned}\text{Total active power, } P &= 3 |\vec{V}_{ph}| |\vec{I}_{ph}| \cos \phi \\ P &= 3 \times \frac{416}{\sqrt{3}} \times 3.386 \times \cos(44.97^\circ) \\ &= 1726.05 \text{ W}\end{aligned}$$

Q.119 A single phase ac system supplies a load of 200 kW and if this system is converted to 3-phase, 3 wire ac system by running a third similar conductor. The 3-phase load that can now be supplied, if the voltage between the conductors is same is _____ kW.
(Assume the power factor and transmission efficiency to be same in two cases)

119. 400.00 (399.00 to 401.00)

Single phase two wire system:

$$\text{Power supplied, } P_1 = VI_1 \cos \phi$$

$$\text{Power loss, } W_1 = 2I_1^2 R$$

$$\% \text{ power loss} = \frac{2I_1^2 R}{VI_1 \cos \phi} \times 100 \quad \dots(i)$$

Three phase three wire system:

$$\text{Power supplied, } P_2 = \sqrt{3} VI_2 \cos \phi$$

$$\text{Power loss, } W_2 = 3I_2^2 R$$

$$\% \text{ power loss} = \frac{3I_2^2 R}{\sqrt{3} VI_2 \cos \phi} \times 100 \quad \dots(ii)$$

As the transmission efficiency is same in two cases then the percentage power loss is also same.

$$\frac{2I_1^2 R}{VI_1 \cos \phi} = \frac{3I_2^2 R}{\sqrt{3} VI_2 \cos \phi}$$

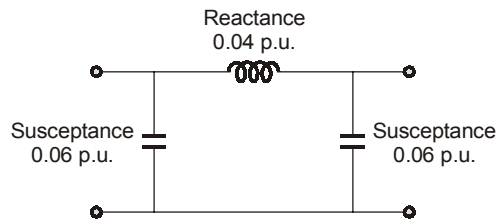
$$2I_1 = \sqrt{3} I_2$$

$$I_2 = \frac{2}{\sqrt{3}} I_1$$

Q.121 The bus admittance matrix for a power system network is

$$\begin{bmatrix} -j8.75 & j1.25 & j2.50 \\ j1.25 & -j6.25 & j2.50 \\ j2.50 & j2.50 & -j5.00 \end{bmatrix}$$

The transmission line connected between buses 2 and 3, which is represented by the circuit shown below

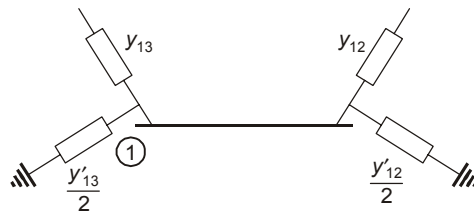


If this transmission line is terminated from service, the modified bus admittance matrix is

- (a) $\begin{bmatrix} -j8.75 & j1.25 & j2.50 \\ j1.25 & j18.63 & 0 \\ j2.50 & 0 & -j19.88 \end{bmatrix}$
- (b) $\begin{bmatrix} -j8.75 & j1.25 & j2.50 \\ j1.25 & j18.69 & 0 \\ j2.50 & 0 & j19.94 \end{bmatrix}$
- (c) $\begin{bmatrix} -j8.75 & j1.25 & j2.50 \\ j1.25 & -j18.63 & j2.50 \\ j2.50 & j2.50 & -j19.88 \end{bmatrix}$
- (d) $\begin{bmatrix} j8.75 & j1.25 & j2.50 \\ j1.25 & -j18.69 & 0 \\ j2.50 & 0 & -j19.94 \end{bmatrix}$

121. (b)

$$Y_{11} = \frac{y'_{12}}{2} + \frac{y'_{13}}{2} + y_{12} + y_{13}$$



Hence the line between buses 2 and 3 is terminated in the new Y_{bus}

$$Y_{23} = Y_{32} = 0$$

Rest all the elements will be same except Y_{22} and Y_{33}

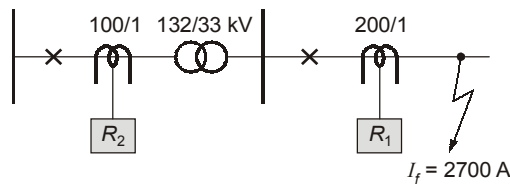
$$Y_{22(\text{new})} = -j6.25 - \frac{1}{j0.04} - j0.06 = j18.69 \text{ p.u.}$$

$$Y_{33(\text{new})} = -j5.00 - \frac{1}{j0.04} - j0.06 = j19.94 \text{ p.u.}$$

The modified bus admittance matrix is,

$$[Y]_{bus} = \begin{bmatrix} -j8.75 & j1.25 & j2.50 \\ j1.25 & j18.69 & 0 \\ j2.50 & 0 & j19.94 \end{bmatrix} \text{ p.u.}$$

Q.122 In the figure shown below,



If both the relays R_1 and R_2 are set for 100% plug setting, the actual operating time of R_1 and TMS for R_2 respectively are:

(Assume time grading margin of 0.6s and TMS for relay 1 is 0.15)

PSM	3.6	6.75	13.5
Time in sec for time multiplier	6	3.6	2.6

- (a) 0.22 sec; $TMS_{R2} = 0.112$ (b) 0.32 sec; $TMS_{R2} = 0.123$
(c) 0.39 sec; $TMS_{R2} = 0.275$ (d) 0.41 sec; $TMS_{R2} = 0.142$

122. (c)

Plug setting multiplier of relay 1

$$= \frac{2700}{1 \times 1 \times \left(\frac{200}{1}\right)} = 13.5$$

Operating time corresponding to 13.5 PSM is 2.6.

Actual operating time of relay 1

$$= 2.6 \times TMS = 2.6 \times 0.15 = 0.39 \text{ s}$$

$$\frac{V_2}{V_1} = \frac{I_1}{I_2}$$

$$\frac{33}{132} = \frac{I_1}{2700}$$

$$I_1 = 675 \text{ A}$$

$$\text{PSM of relay 2} = \frac{675}{1 \times 1 \times \left(\frac{100}{1}\right)} = 6.75$$

Operating time corresponding to PSM 6.75 is 3.6 s.

$$\text{TMS for relay 2} = \frac{0.39 + 0.6}{3.6} = 0.275$$

Q.123 A 60 Hz generator, connected directly to an infinite bus operating at a voltage of $1 \angle 0^\circ$ p.u., has a synchronous reactance of 1.35 p.u. The generator no load voltage is 1.1 p.u. and its inertia constant H is 4 MJ/MVA. The generator is suddenly loaded to 60 percent of its maximum power limit. The frequency of the resulting natural oscillations of the generator rotor is

- (a) 1.246 Hz (b) 0.882 Hz
(c) 0.921 Hz (d) 1.16 Hz

123. (b)

$$0.6 P_{\max} = P_{\max} \sin \delta$$

$$\delta = \sin^{-1}(0.6) = 36.8698^\circ$$

$$\left. \frac{\partial P_e}{\partial \delta} \right|_{\delta=36.8698^\circ} = P_{\max} \cos(36.8698^\circ)$$

$$= \frac{1.1 \times 1}{1.35} \cos(36.8698^\circ) = 0.6518 \text{ p.u./rad}$$

$$\text{Frequency of oscillations} = \sqrt{\frac{(\partial P_e / \partial \delta)_{36.8698^\circ}}{M}}$$

Where,

$$M = \frac{H}{\pi f} = \frac{4}{\pi \times 60} = 0.0212 \text{ p.u. s}^2/\text{rad}$$

$$f = \sqrt{\frac{0.6518}{0.0212}}$$

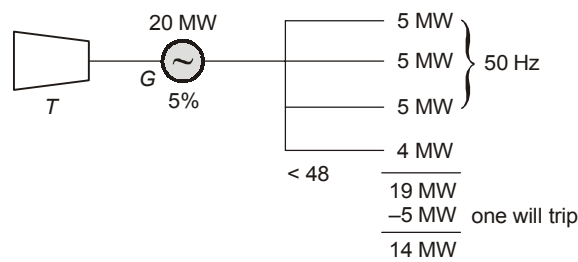
$$f = 5.54 \text{ rad/sec} = 0.882 \text{ Hz}$$

Q.124 An isolated 50 Hz synchronous generator is rated at 20 MW. Which is also the maximum continuous power limit of its prime mover. It is equipped with a speed governor with 5% droop. Initially the generator is feeding three loads of 5 MW each at 50 Hz. One of these loads is programmed to trip permanently if the frequency falls below 48 Hz. If an additional load of 4 MW is connected, then the frequency will settle down at _____ Hz.

124. 50.125 (50.00 to 5.25)

$$\frac{\Delta f_1}{\Delta P_1} = \frac{2.5 \text{ Hz}}{20 \text{ MW}}$$

If 4 MW load is suddenly added, then one of the 5 MW load is tripped.



Load before adding 4 MW is 15 MW, and after adding 4 MW it came down to 14 MW so the difference is

$$\Delta P_2 = 1 \text{ MW}$$

$$\frac{\Delta f_1}{\Delta P_1} = \frac{\Delta f_2}{\Delta P_2}$$

$$\frac{2.5}{20} = \frac{\Delta f_2}{1}$$

$$\Delta f_2 = 0.125 \text{ Hz}$$

Hence, the frequency will settle down at 50.125 Hz.

Q.125 The generator having a synchronous reactance of $X_d = 1.7241$ p.u. is connected to a very large system. The terminal voltage is $1.0\angle 0^\circ$ p.u. and generator is supplying to the system a current of 0.8 p.u. at 0.9 p.f. lagging. If the real power output and terminal voltage of the generator remains constant but the excitation of the generator is increased by 20% then the reactive power delivered to the bus is _____ p.u.

125. 0.632 (0.40 to 0.80)

$$\text{Synchronous internal voltage} = |E_i|\angle\delta^\circ = \vec{V}_t + j\vec{X}_d\vec{I}$$

$$|E_i|\angle\delta = 1.0\angle 0^\circ + (j1.7241)(0.8\angle -25.8419^\circ)$$

$$|E_i|\angle\delta = 2.026\angle 37.7849^\circ \text{ p.u.}$$

Active power from the generator,

$$P_e = \frac{|E_i||V_t|}{|X|}\sin\delta = \frac{2.026 \times 1}{1.7241}\sin(37.7849^\circ) = 0.72 \text{ p.u.}$$

Increasing excitation by 20% with P and V_t constant gives,

$$P_e = 0.72 = \frac{1.0 \times 1.2 \times 2.026}{1.7241}\sin\delta$$

$$\delta = \sin^{-1}(0.51059) = 30.70^\circ$$

$$Q_{\text{new}} = \frac{|V_t|}{X_d}(|E_i|\cos\delta - |V_t|)$$

$$Q_{\text{new}} = \frac{1.0}{1.7241}[1.20 \times 2.026 \cos(30.70) - 1.0]$$

$$Q_{\text{new}} = 0.632 \text{ p.u.}$$

○○○○



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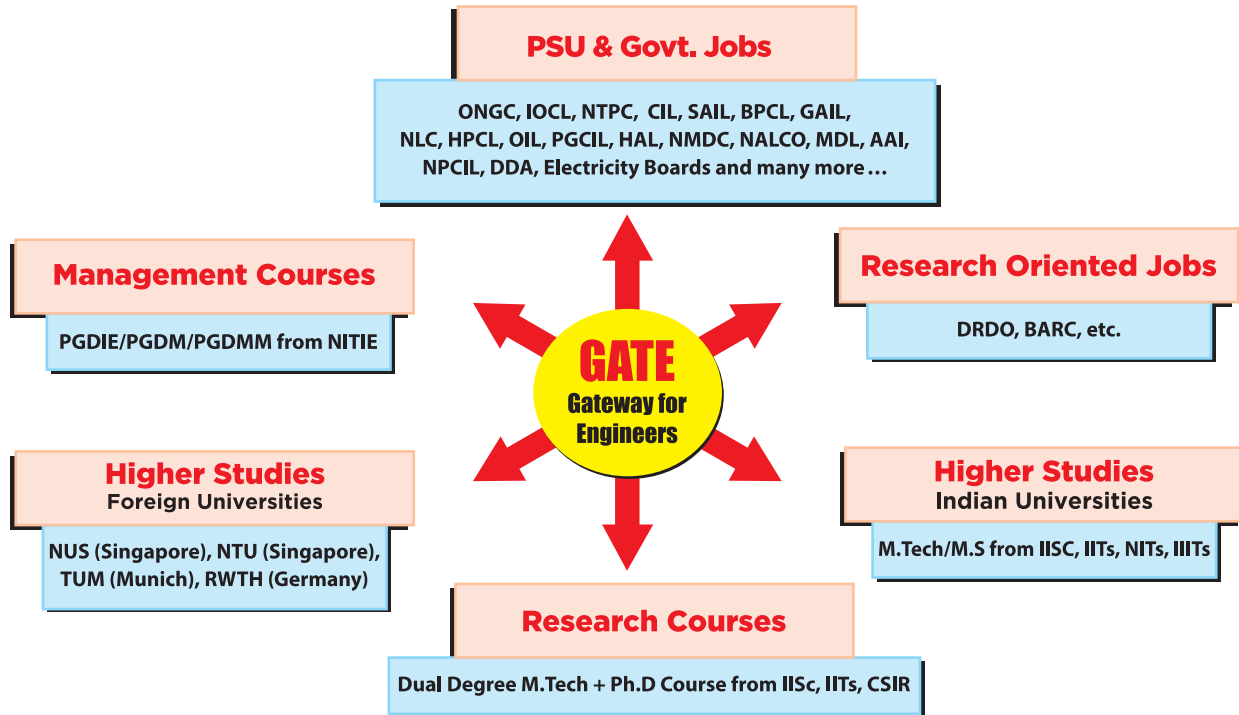
Revision through Questions for GATE 2020

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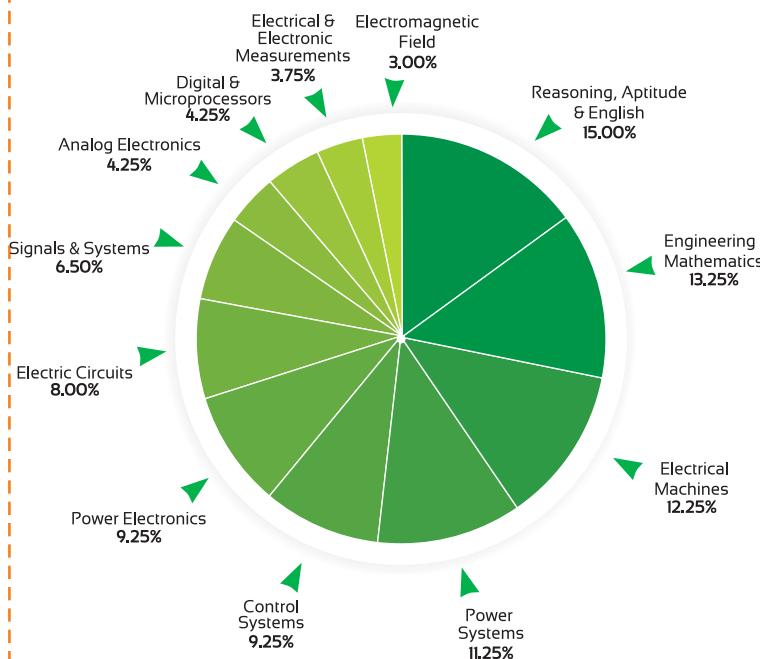
ELECTRICAL ENGG.

Q.126 - Q.150
out of 200 Questions

Day 6 of 8



SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

Day 6 : Q.126 to Q. 150 : Control Systems + EMT

Q.126 The set of differential equation $\dot{x}_1 = -x_1$ and $\dot{x}_2 = -x_2 + u(t)$ where x_1, x_2 are states and u is the step input. The nature of the system is

- (a) over damped (b) under damped
(c) critically damped (d) can't determine

126. (c)

State space equation, $\dot{x}_1 = -x_1$

$$\dot{x}_2 = -x_2 + u(t)$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$\dot{x} = Ax + Bu$$

By equating, we get $A = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$,

$$B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

Characteristics equation is given by

$$|sI - A| = 0$$

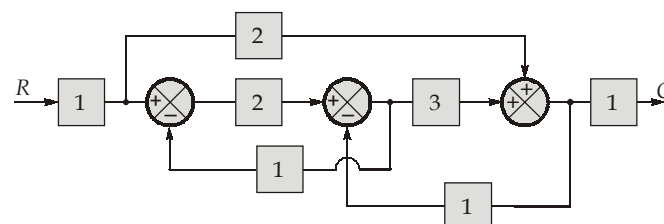
$$\begin{vmatrix} s & 0 \\ 0 & s \end{vmatrix} - \begin{vmatrix} -1 & 0 \\ 0 & -1 \end{vmatrix} = 0$$

$$\begin{vmatrix} s+1 & 0 \\ 0 & s+1 \end{vmatrix} = 0$$

$$(s+1)^2 = 0$$

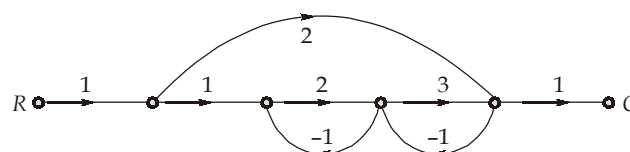
the roots are negative, real and equal. So, system is critically damped.

Q.127 For the given control system block diagram, the transfer function C/R is _____.



127. (2)

For the given block diagram the signal flow graph will be as shown below



As per signal flow graph,

The loop gain are

$$L_1 = (-1) \times 2 = -2$$

$$L_2 = (-1) \times 3 = -3$$

The graph determinant:

$$\begin{aligned}\Delta &= 1 - (L_1 + L_2) \\ &= 1 - [-2 + (-3)] = 6\end{aligned}$$

The forward path are

$$P_1 = 1 \times 2 \times 1 = 2$$

So, Path factor $\Delta_1 = 1 - L_1 = 1 - (-2) = 3$

$$P_2 = 1 \times 1 \times 2 \times 3 = 6$$

All loops are touching P_2 ,

So, path factor $\Delta_2 = 1$

Using Mason's gain formula,

$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{2 \times 3 + 6 \times 1}{6} = 2$$

Q.128 A second order system has natural frequency of oscillation 10 rad/sec and damped frequency of oscillation 8 rad/sec. The ratio of rise time to peak time is _____ sec.

128. 0.70 (0.66 to 0.74)

Natural frequency of oscillation,

$$\omega_n = 10 \text{ rad/sec}$$

Damped frequency of oscillation,

$$\omega_d = 8 \text{ rad/sec}$$

as

$$\omega_d = \omega_n \sqrt{1 - \xi^2}$$

$$8 = 10 \sqrt{1 - \xi^2}$$

$$1 - \xi^2 = 0.64$$

$$\xi = 0.6$$

ans

$$\text{as } \phi = \cos^{-1} \xi$$

$$\phi = \cos^{-1} (0.6) = 53.13^\circ$$

as rise time

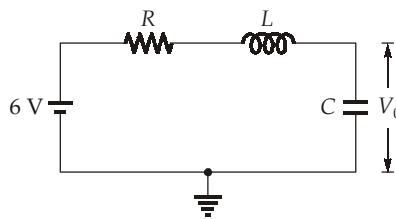
$$t_r = \frac{\pi - \phi}{\omega_n \sqrt{1 - \xi^2}},$$

$$\text{peak time, } t_p = \frac{\pi}{\omega_n \sqrt{1 - \xi^2}}$$

$$\frac{t_r}{t_p} = \frac{\pi - \phi}{\pi} = \frac{180^\circ - 53.13^\circ}{180^\circ} = 0.70$$

$$= 0.7$$

Q.129 For the RLC series circuit shown below, the damping ratio ξ will be,
Consider, $R = 1 \text{ k}\Omega$; $L = 10 \text{ mH}$; $C = 0.01 \mu\text{F}$



- (a) $\xi = 0.25$ (b) $\xi = 0.5$
(c) $\xi = 0.1$ (d) $\xi = 0.75$

129. (b)

The transfer function of the system is

$$\begin{aligned}\frac{V_0(s)}{V_i(s)} &= \frac{\frac{1}{Cs}}{R + Ls + \frac{1}{Cs}} = \frac{1}{LCs^2 + RCs + 1} \\ &= \frac{\frac{1}{LC}}{s^2 + \frac{Rs}{L} + \frac{1}{LC}}\end{aligned}$$

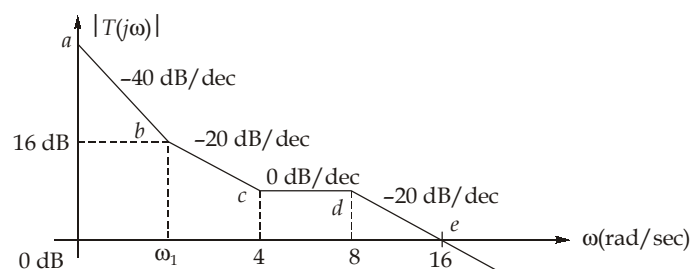
Comparing the above characteristic polynomial with $s^2 + 2\xi\omega_n s + \omega_n^2$

$$\Rightarrow \omega_n = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10 \times 10^{-3} \times 0.01 \times 10^{-6}}} = 10^5 \text{ rad/s}$$

and $2\xi\omega_n = \frac{R}{L}$

$$\Rightarrow \xi = \frac{R}{2} \cdot \sqrt{\frac{C}{L}} = \frac{1 \times 10^3}{2} \sqrt{\frac{0.01 \times 10^{-6}}{10 \times 10^{-3}}} = 0.5$$

Q.130 The asymptotic log-magnitude curve for open loop transfer function is sketched below,



Open loop transfer function is

- (a) $T(s) = \frac{10(s+8)(s+4)}{s^2(s+1.268)}$ (b) $T(s) = \frac{16(s+1.268)(s+4)}{s^2(s+8)}$
(c) $T(s) = \frac{10(s+1.268)(s+8)}{s^2(s+4)}$ (d) $T(s) = \frac{8(s+1.268)(s+8)}{s^2(s+4)}$

130. (b)

From the above Bode plot,

For section de, slope is -20 dB/dec

$$\therefore -20 = \frac{y - 0}{\log 8 - \log 16}$$

$$y = 6.02 \text{ dB}$$

Now, for section bc, slope is -20 dB/dec

$$\therefore -20 = \frac{16 - 6.02}{\log \omega_1 - \log 4}$$

$$\omega_1 = 1.268 \text{ rad/sec}$$

To find value of gain K

$$y = mx + c$$

$$16 = -40 \log 1.268 + 20 \log K$$

$$K = 10.14$$

From all the result, transfer function is,

$$T(s) = \frac{10.14 \left(\frac{s}{1.268} + 1 \right) \left(\frac{s}{4} + 1 \right)}{s^2 \left(\frac{s}{8} + 1 \right)}$$

$$T(s) = \frac{16(s + 1.268)(s + 4)}{s^2(s + 8)}$$

Q.131 An open loop transfer function of a unity feedback system is given by

$$G(s) = \frac{2s(s + 10)}{(s + 4)}$$

If the gain of the system is increased to 16 and the zeros are removed, then the steady state error for step input is _____.

131. 0.20 (0.12 to 0.25)

New open loop transfer function is,

$$G(s) = \frac{16}{(s + 4)}$$

For step input, the steady state error is given by,

$$e_{ss} = \frac{A}{1 + K_p} = \frac{A}{1 + \lim_{s \rightarrow 0} G(s)H(s)}$$

$$= \frac{A}{1 + \lim_{s \rightarrow 0} \frac{16}{s + 4}}$$

$$= \frac{A}{5} = \frac{1}{5} = 0.20$$

Q.132 The open loop transfer function of a unity negative feedback system is

$$G(s) = \frac{K}{s(1 + 0.2s)(1 + 0.05s)}$$

The value of K for gain margin of 20 dB is _____.

132. 2.5 (1.9 to 3.2)

For the given $G(s)$, the sinusoidal transfer function is

$$\begin{aligned} G(j\omega) &= \frac{K}{j\omega(1 + j0.2\omega)(1 + j0.05\omega)} \\ &= \frac{K}{-0.25\omega^2 + j\omega(1 - 0.01\omega^2)} \end{aligned}$$

At the phase crossover frequency ω_{pc} , the $G(j\omega)$ is real.

$\therefore$ equate imaginary part to zero and solve for ω_{pc} .

$$\therefore \omega_{pc}(1 - 0.01\omega_{pc}^2) = 0$$

Since $\omega_{pc} \neq 0$

$$\therefore 1 - 0.01\omega_{pc}^2 = 0$$

$$\Rightarrow \omega_{pc} = 10 \text{ rad/s}$$

The Nyquist plot intersects the real axis at a point where $G(j\omega)$ is real.

$$\begin{aligned} |G(j\omega)|_{\omega=\omega_{pc}} &= \frac{K}{0.25\omega_{pc}^2} \\ &= \frac{K}{0.25 \times 100} = \frac{K}{25} = 0.04 K \end{aligned}$$

Given that, gain margin = 20 dB,

$$20 \log \frac{1}{|G(j\omega)|_{\omega=\omega_{pc}}} = 20 \text{ dB}$$

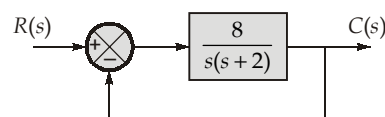
$$\frac{1}{|G(j\omega)|_{\omega=\omega_{pc}}} = 10$$

$$|G(j\omega)|_{\omega=\omega_{pc}} = 0.1$$

$$\text{i.e. } 0.1 = 0.04 K$$

$$K = \frac{0.1}{0.04} = 2.5$$

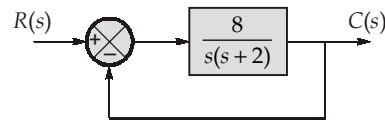
Q.133 A unity negative feedback control system is shown in the figure below.



Derivative feedback with appropriate value of feedback constant is added to get the damping ratio of 0.707. Then percentage change in error for ramp input with and without derivative feedback is _____. (Give answer upto two decimals)

133. 100.00 (98.00 to 101.00)

Without derivative feedback



$$G(s)H(s) = \frac{8}{s(s+2)}$$

Steady state error for unit ramp input is given by

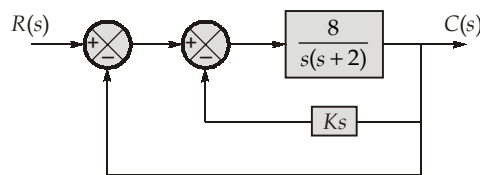
$$e_{ss} = \frac{1}{K_V}$$

$$K_V = \lim_{s \rightarrow 0} s \cdot G(s)H(s)$$

$$K_V = \lim_{s \rightarrow 0} s \cdot \frac{8}{s(s+2)} = \frac{8}{0+2} = 4$$

$$e_{ss} = \frac{1}{4} = 0.25$$

With derivative feedback



$$T(s) = \frac{C(s)}{R(s)} = \frac{8}{s^2 + s(2+8K) + 8}$$

For

$$\xi = 0.707$$

$$2\xi\omega_n = 2 + 8K$$

$$2 \times 0.707 \times \sqrt{8} = 2 + 8K$$

$$K = 0.2499 \approx 0.25$$

$$G(s)H(s) = \frac{8}{s^2 + 4s}$$

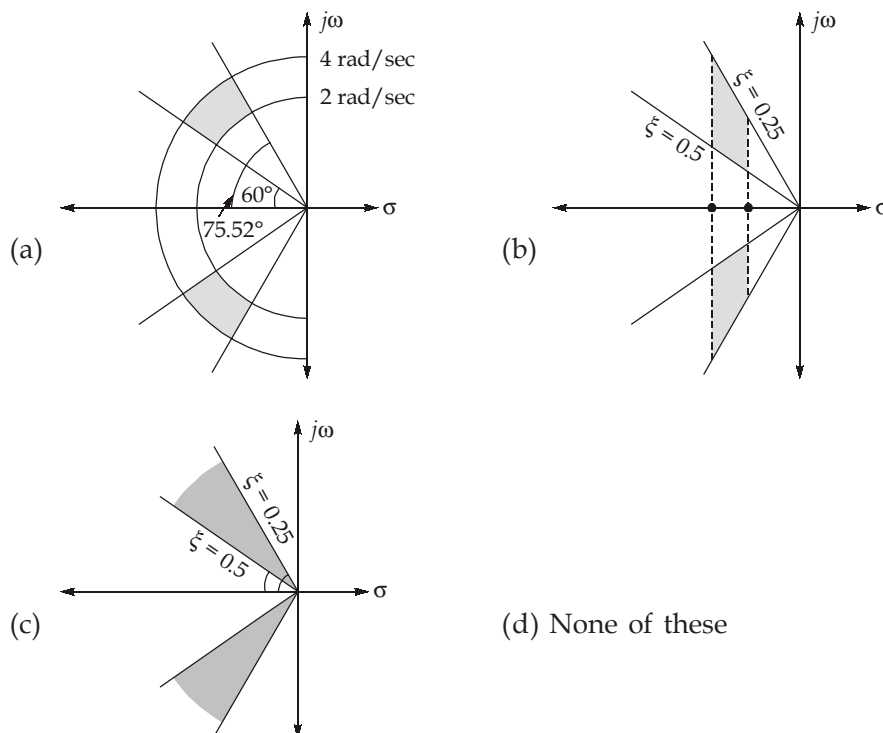
$$K_V = \lim_{s \rightarrow 0} s \cdot G(s)H(s) = \lim_{s \rightarrow 0} s \cdot \frac{8}{s(s+4)}$$

$$K_V = 2.0$$

$$e_{ss} = \frac{1}{K_V} = 0.5$$

$$\begin{aligned} \% \text{ change} &= \frac{0.5 - 0.25}{0.25} \times 100 \\ &= 100\% \end{aligned}$$

Q.134 A second order system is designed such that, damping ratio should vary between 0.25 to 0.5 and natural frequency should vary from 2 rad/sec to 4 rad/sec, then roots lie on



134. (a)

Damping ratio, $\xi = \cos \theta$

For

$$\xi = 0.25$$

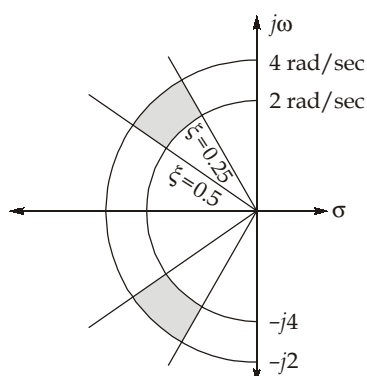
$$\theta = \cos^{-1}(0.25) = 75.52^\circ$$

$$\xi = 0.5$$

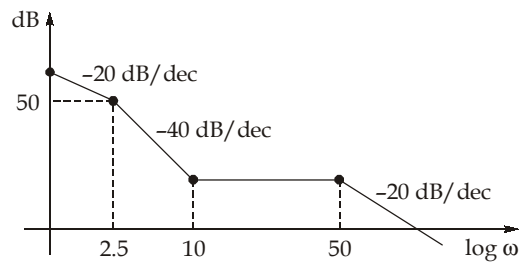
$$\theta = \cos^{-1}(0.5) = 60^\circ$$

and ω_n varies from 2 rad/sec to 4 rad/sec.

Thus common area, where roots lie is



Q.135 Magnitude plot of a unity negative feedback system is shown in figure



Steady state error for unit ramp input is _____ $\times 10^{-3}$. (Give answer upto three decimals)

135. 1.265 (1.031 to 1.512)

From line equation, $y = mx + C$
 $50 = -20(\log 2.5) + C$
 and $C = 20 \log K$
 Where, $K = DC \text{ gain}$

$$\frac{50 + 20 \log 2.5}{20} = \log K$$

$$\log K = 2.898$$

$$K = 790.67$$

And steady state error for unit ramp input is given by

$$e_{ss} = \frac{1}{K_V} = \frac{1}{790.67}$$

$$= 1.265 \times 10^{-3}$$

Q.136 Characteristic equation of a system is given as

$$s^7 + 9s^6 + 24s^5 + 24s^4 + 24s^3 + 24s^2 + 23s + 15 = 0$$

then number of roots lie in RHS of s-plane is _____.

136. (2)

Routh array:

s^7	1	24	24	23
s^6	9	24	24	15
s^5	21.33	21.33	21.33	
s^4	15	15	15	
s^3	0	0	0	
s^2				
s^1				
s^0				

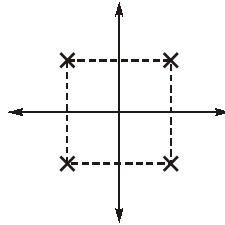
Auxiliary equation will be

$$15s^4 + 15s^2 + 15 = 0$$

Roots of auxiliary equations

$$s^2 = -\frac{1}{2} \pm j\frac{\sqrt{3}}{2}$$

$$s = 1\angle 60^\circ, 1\angle 240^\circ, 1\angle -60^\circ, 1\angle 120^\circ$$



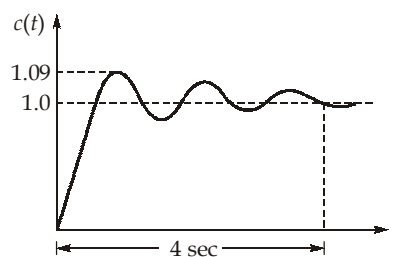
Differentiating above equation

$$60s^3 + 30s = 0$$

s^7	1	24	24	23
s^6	9	24	24	15
s^5	21.33	21.33	21.33	
s^4	15	15	15	
s^3	60	30	0	
s^2	7.5	15	0	
s^1	-90	0		
s^0	15			

Two roots of auxiliary equation are in RHS of s-plane and there are two sign changes after auxiliary equations, therefore two roots will be in RHS of s-plane.

Q.137 Unit step response of second order system is shown in figure



Transfer function of the system is

(a) $\frac{5}{s^2 + 2s + 5}$

(b) $\frac{9.3}{s^2 + 2s + 9.3}$

(c) $\frac{2.7}{s^2 + 2s + 2.7}$

(d) $\frac{10}{s^2 + 2s + 10}$

137. (c)

From time response curve,

$$t_s = \frac{4}{\xi \omega_n} \quad (\text{For 2\% tolerance band})$$

$$4 = \frac{4}{\xi \omega_n}$$

$$\xi \omega_n = 1$$

and

$$M_p = e^{-\pi \xi / \sqrt{1-\xi^2}}$$

$$0.09 = e^{-\pi \xi / \sqrt{1-\xi^2}}$$

$$\ln(0.09) = -\frac{\pi \xi}{\sqrt{1-\xi^2}}$$

$$(2.41)^2 (1 - \xi^2) = \pi^2 \xi^2$$

$$(2.41)^2 = \xi^2 (\pi^2 + (2.41)^2)$$

$$\sqrt{\frac{(2.41)^2}{\pi^2 + (2.41)^2}} = \xi$$

$$\text{Damping ratio, } \xi = 0.61$$

$$\omega_n = \frac{1}{0.61} = 1.64$$

Standard second order transfer function:

$$T(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$T(s) = \frac{2.7}{s^2 + 2s + 2.7}$$

Q.138 State space representation of a system is given by

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

$$y(t) = x_2(t)$$

Where, $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ and $r(t) = t u(t)$;

then zero state response is

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

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

(c) $\frac{2}{s(s^2 + s + 2)}$

(d) None of these

138. (a)

Response of the system in Laplace form is,

$$Y(s) = X_2(s) \quad \dots(i)$$

For zero state response,

$$X(s) = \phi(s) BR(s) \quad \dots(ii)$$

Where,

$$\phi(s) = [sI - A]^{-1}$$

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

State space representation is

$$\dot{x}(t) = A x(t) + B r(t)$$

$$y(t) = C x(t)$$

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

$$B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$[sI - A] = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix} = \begin{bmatrix} s & -1 \\ 2 & s+1 \end{bmatrix}$$

$$[sI - A]^{-1} = \frac{\begin{bmatrix} s+1 & 1 \\ -2 & s \end{bmatrix}}{s^2 + s + 2}$$

From equation (ii), we get

$$X(s) = \frac{1}{s^2 + s + 2} \begin{bmatrix} s+1 & 1 \\ -2 & s \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 1 \end{bmatrix} \left[\frac{1}{s^2} \right]$$

$$X(s) = \begin{bmatrix} \frac{1}{s^2(s^2 + s + 2)} \\ \frac{1}{s(s^2 + s + 2)} \end{bmatrix}$$

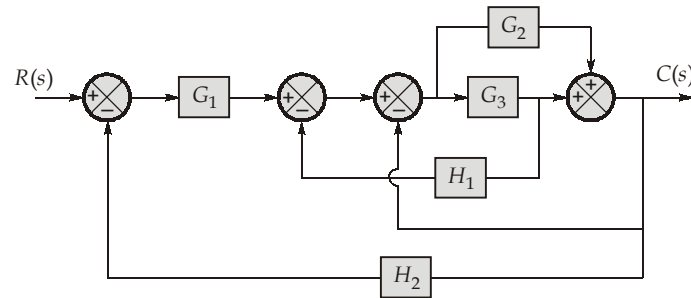
From equation (i), we get

$$Y(s) = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} X_1(s) \\ X_2(s) \end{bmatrix}$$

$$Y(s) = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{s^2(s^2 + s + 2)} \\ \frac{1}{s(s^2 + s + 2)} \end{bmatrix}$$

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

Q.139 A control system is represented by the block diagram shown in figure

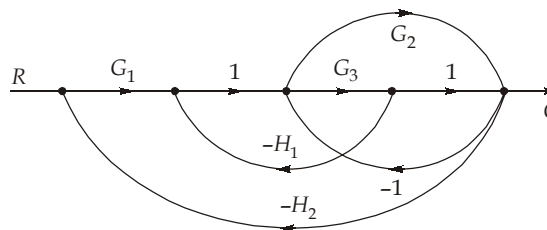


$\frac{C(s)}{R(s)}$ ratio is

- (a) $\frac{G_1 G_3 + G_1 G_2}{1 + G_3 + G_2 + G_3 H_1 + G_1 G_3 H_2 + G_1 G_2 H_2}$
- (b) $\frac{G_1 G_3 + G_1 G_2}{1 + G_3 H_1 + G_1 G_3 H_2 + G_1 G_2 H_2}$
- (c) $\frac{G_1 G_3 + G_1 G_2}{1 + G_3 H_1 + G_2 + G_1 G_3 H_2 + G_1 G_2 H_2}$
- (d) $\frac{G_1 G_3 + G_1 G_2}{1 + G_3 H_1 + G_3 + G_1 G_3 H_2 + G_1 G_2 H_2}$

139. (a)

Signal flow graph of the system is



Forward paths:

$$P_1 = G_1 G_3$$

$$P_2 = G_1 G_2$$

Feedback loops:

$$L_1 = -G_3$$

$$L_2 = -G_2$$

$$L_3 = -G_3 H_1$$

$$L_4 = -G_1 G_3 H_2$$

$$L_5 = -G_1 G_2 H_2$$

Mason's gain formula,

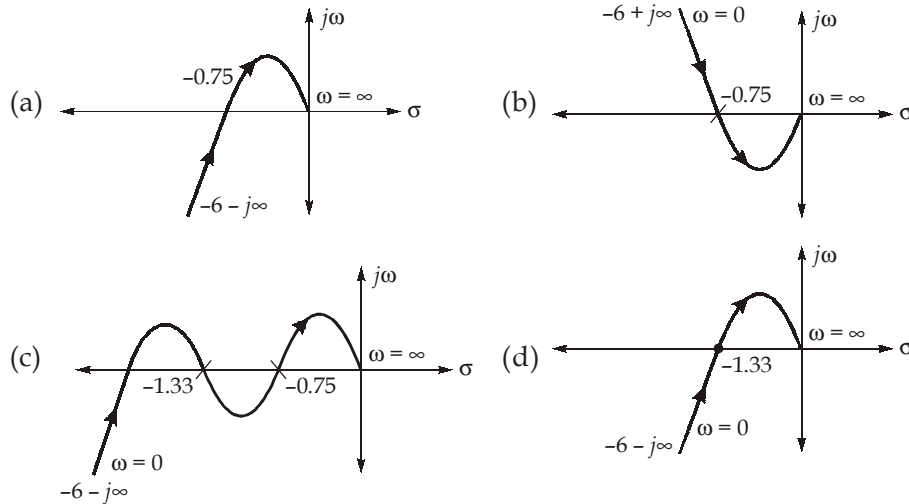
$$\frac{C}{R} = \frac{P_K \Delta_K}{\Delta}$$

$$\frac{C}{R} = \frac{G_1 G_3 + G_1 G_2}{1 + G_3 + G_2 + G_3 H_1 + G_1 G_3 H_2 + G_1 G_2 H_2}$$

Q.140 The frequency response of

$$G(s) = \frac{1}{s(1+2s)(1+4s)}$$

plotted in the complex $G(j\omega)$ plane (for $0 < \omega < \infty$) is



140. (d)

Given, $G(s) = \frac{1}{s(1+2s)(1+4s)}$

$$G(j\omega) = \frac{1}{j\omega(1+2j\omega)(1+j4\omega)}$$

$$G(j\omega) = \frac{(1-j2\omega)(1-j4\omega)}{j\omega(1+4\omega^2)(1+16\omega^2)}$$

$$= \frac{1-j6\omega-8\omega^2}{j\omega(1+4\omega^2)(1+16\omega^2)}$$

$$= \frac{-6}{(1+4\omega^2)(1+16\omega^2)} - \frac{j(1-8\omega^2)}{\omega(1+4\omega^2)(1+16\omega^2)}$$

At $\omega = 0$; $G(j\omega) = -\frac{6}{1} - \frac{j(1)}{0} = -6 - j\infty$

At $\omega = \infty$; $G(j\omega) = -\frac{6}{\infty} - \frac{j}{\infty} = -0 - j0$

plot cuts the negative real axis, when

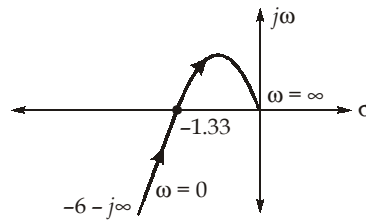
$$\text{Im} [G(j\omega)] = 0$$

$$1 - 8\omega^2 = 0$$

$$\omega = \frac{1}{2\sqrt{2}} \text{ rad/sec}$$

$$G(j\omega) = \frac{-6}{\left(1+4 \times \frac{1}{8}\right)\left(1+16 \times \frac{1}{8}\right)} = -1.33$$

From above points, polar plot can be drawn as



Q.141 Loop transfer function of a feedback system is $G(s)H(s) = \frac{1}{2s\left(s + \frac{1}{2}\right)}$. Then, the Nyquist plot of

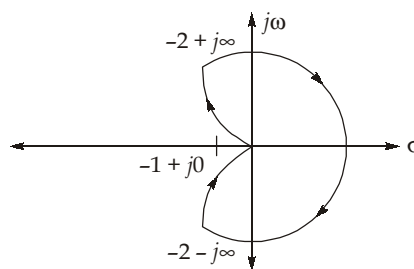
$G(s)H(s)$ encircles $-1 + j0$.

- (a) once in clockwise direction (b) does not encircle
(c) once in anticlockwise direction (d) twice in clock wise direction

141. (b)

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

Nyquist plot of the above system is,



Nyquist plot does not encircle $(-1 + j0)$ point.

Q.142 Open loop transfer function of a system is $G(s)H(s) = \frac{10}{s(s+3)(s+4)}$. Phase margin of system is _____ in degree.

142. 64.06 (62.16 to 65.13)

$$G(j\omega) H(j\omega) = \frac{10}{j\omega(j\omega + 3)(j\omega + 4)}$$

At gain crossover frequency,

$$|G(j\omega)H(j\omega)| = 1$$

$$1 = \frac{10}{\omega\sqrt{9 + \omega^2}\sqrt{16 + \omega^2}}$$

$$1 = \frac{100}{\omega^2(9 + \omega^2)(16 + \omega^2)}$$

$$\begin{aligned}\omega^2(9 + \omega^2)(16 + \omega^2) &= 100 \\ \omega^2(144 + 25\omega^2 + \omega^4) &= 100 \\ \omega^6 + 25\omega^4 + 144\omega^2 - 100 &= 0 \\ \omega_{gc}^2 &= 0.625, -14.85, -10.78 \\ \omega_{gc} &= 0.791 \text{ rad/sec} \\ \angle G(j\omega) H(j\omega) &= -90^\circ - \tan^{-1}\left(\frac{\omega}{3}\right) - \tan^{-1}\left(\frac{\omega}{4}\right) \\ &= -90^\circ - \tan^{-1}\left(\frac{0.791}{3}\right) - \tan^{-1}\left(\frac{0.791}{4}\right) \\ \phi &= -115.94^\circ \\ \text{Phase margin} &= 180^\circ + \phi \\ &= 180 - 115.94 = 64.06^\circ\end{aligned}$$

Q.143 The open loop transfer function of a unity negative feedback control system is given by

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

The ramp input to the system is 2 rpm and steady state error being 0.05° . The natural frequency of oscillations if the system is critically damped, will be _____ rad/sec.

143. (480)

Steady state error, $e_{ss} = 0.05^\circ$

$$e_{ss} = \frac{0.05 \times \pi}{180} \text{ rad}$$

Given, $\text{input} = \frac{2\pi}{60} \times 2 = \frac{\pi}{15} \text{ rad/sec}$

Steady state error is given by,

$$\begin{aligned}e_{ss} &= \lim_{s \rightarrow 0} s \cdot R(s) \frac{1}{1 + G(s)H(s)} \\ &= \lim_{s \rightarrow 0} s \cdot \frac{\pi}{15s^2} \cdot \frac{1}{\left(1 + \frac{K}{s(1+sT)}\right)} = \lim_{s \rightarrow 0} \left(\frac{\pi}{15 \left(s + \frac{K}{1+sT}\right)} \right)\end{aligned}$$

$$e_{ss} = \frac{\pi}{15K}$$

and given $e_{ss} = \frac{\pi \times 0.05}{180^\circ}$

Equating both, we get

$$K = 240$$

Closed loop transfer function

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

$$2 \xi \omega_n = \frac{1}{T}$$

and $\omega_n = \sqrt{\frac{K}{T}}$

for critically damped system,

$$\xi = 1$$

$$\omega_n = \frac{1}{2T}$$

$$\sqrt{\frac{K}{T}} = \frac{1}{2T}$$

$$T = \frac{1}{4K}$$

and $\omega_n = \frac{1}{2T}$

$$\omega_n = \frac{4K}{2} = \frac{4 \times 240}{2} = 480 \text{ rad/sec}$$

Q.144 The state variable formulation of a system is given as

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u, \quad x_1(0) = 0, \quad x_2(0) = 0 \quad \text{and} \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}.$$

The system is

- (a) controllable but not observable (b) not controllable but observable
(c) both controllable and observable (d) both not controllable and not observable

144. (a)

$$A = \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix}, \quad B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

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

For controllability, $|B : AB| \neq 0$

or
$$\begin{vmatrix} 1 & -2 \\ 1 & -1 \end{vmatrix} = -1 - (-2) = 1$$

$$\neq 0$$

The system is controllable.

$$C^T = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$A^T C^T = \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} -2 \\ 0 \end{bmatrix}$$

For observability, $|C^T : A^T C^T| \neq 0$

or $\begin{vmatrix} 1 & -2 \\ 0 & 0 \end{vmatrix} = 0$

The system is not observable.

Q.145 The transformation of the vector $\vec{B} = y\hat{a}_x - x\hat{a}_y + z\hat{a}_z$ in to cylindrical coordinates gives

- (a) $\vec{B} = \rho\hat{a}_\rho + \hat{a}_\phi + \hat{a}_z$ (b) $\vec{B} = \hat{a}_\rho - \hat{a}_\phi + \hat{a}_z$
(c) $\vec{B} = \rho^2\hat{a}_\phi + z\hat{a}_z$ (d) $\vec{B} = -\rho\hat{a}_\phi + z\hat{a}_z$

145. (d)

$$B_\rho = \vec{B} \cdot \hat{a}_\rho = y(\hat{a}_x \cdot \hat{a}_\rho) - x(\hat{a}_y \cdot \hat{a}_\rho)$$

$$B_\rho = y \cos \phi - x \sin \phi \quad \dots(i)$$

Where,

$$y = \rho \sin \phi$$

and

$$x = \rho \cos \phi$$

Substituting in equation (i), we get

$$B_\rho = \rho \sin \phi \cos \phi - \rho \cos \phi \sin \phi = 0$$

$$B_\phi = y(\hat{a}_x \cdot \hat{a}_\phi) - x(\hat{a}_y \cdot \hat{a}_\phi)$$

$$= y(-\sin \phi) - x \cos \phi$$

$$B_\phi = -\rho \sin^2 \phi - \rho \cos^2 \phi = -\rho$$

$\therefore$

$$\vec{B} = -\rho\hat{a}_\phi + z\hat{a}_z$$

Q.146 Five equal point charges are located at $x = 2, 3, 4, 5, 6$ m. If the potential at the origin is 540 V, then the amount of individual charge will be _____ nC.

146. 41.38 (40.00 to 41.70)

The electric potential is given by

$$V = \frac{1}{4\pi\epsilon_0} \sum_{m=1}^n \frac{Q_m}{R_m}$$

$$540 = \frac{Q}{4\pi\epsilon_0} \left(\frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} \right)$$

$$\frac{540 \times 4 \times \pi}{1.45} \times \frac{1}{36\pi} \times 10^{-9} = Q$$

$$Q = 41.38 \text{ nC}$$

Q.147 Given a vector $\vec{A} = 30e^{-r}\hat{a}_r - 2z\hat{a}_z$ in cylindrical co-ordinates. If a volume is enclosed by

$$r = 2, \phi = 2\pi \text{ and } z = 5 \text{ then } \int (\nabla \cdot \vec{A}) dv = \underline{\hspace{2cm}}.$$

147. 129.43 (129.00 to 130.00)

In cylindrical coordinates,

$$\begin{aligned}\nabla \cdot \vec{A} &= \frac{1}{\rho} \frac{\partial}{\partial \rho}(\rho A_\rho) + \frac{1}{\rho} \frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z} \\ &= \frac{1}{r} \frac{\partial}{\partial r}(30r e^{-r}) + \frac{\partial}{\partial z}(-2z) \\ \nabla \cdot \vec{A} &= \frac{30e^{-r}}{r} - 30e^{-r} - 2 \\ \int (\nabla \cdot \vec{A}) dv &= \int_0^5 \int_0^{2\pi} \int_0^2 \left(\frac{30e^{-r}}{r} - 30e^{-r} - 2 \right) r dr d\phi dz \\ &= \int_0^5 \int_0^{2\pi} \int_0^2 (30e^{-r} - 30re^{-r} - 2r) dr d\phi dz \\ &= \int_0^5 \int_0^{2\pi} \left[-30e^{-r} - 30(-e^{-r} - re^{-r}) - r^2 \right] d\phi dz \\ &= \left(30re^{-r} - r^2 \right) \Big|_0^2 \times 2\pi \times 5 \\ \int (\nabla \cdot \vec{A}) dv &= 129.43\end{aligned}$$

Q.148 A cylindrical capacitor has radii $a = 1$ cm and $b = 2.5$ cm. If the space between the plates is filled with an inhomogeneous dielectric with $\epsilon_r = \frac{(10+\rho)}{\rho}$, where ρ is in centimeters, then the capacitance per meter of the capacitor is _____ pF/m.

148. 434.60 (434.00 to 435.00)

$$\begin{aligned}V &= -\int_b^a \frac{Q}{2\pi \epsilon_0 \epsilon_r \rho L} d\rho \\ &= -\frac{Q}{2\pi \epsilon_0 L} \int_b^a \frac{d\rho}{\rho \left(\frac{10+\rho}{\rho} \right)} = \frac{-Q}{2\pi \epsilon_0 L} \int_b^a \frac{d\rho}{10+\rho} \\ V &= \frac{-Q}{2\pi \epsilon_0 L} \ln(10+\rho) \Big|_b^a = \frac{Q}{2\pi \epsilon_0 L} \ln \left(\frac{10+b}{10+a} \right)\end{aligned}$$

Thus the capacitance per meter is, ($L = 1$ m)

$$\begin{aligned}C &= \frac{Q}{V} = \frac{2\pi \epsilon_0}{\ln \left(\frac{10+b}{10+a} \right)} = 2\pi \cdot \frac{10^{-9}}{36\pi} \cdot \frac{1}{\ln \frac{12.5}{11}} \\ &= 434.6 \text{ pF/m}\end{aligned}$$

Q.149 Two long parallel current carrying wires are separated by 5 cm in air and are carrying current of 40 A in the opposite direction. The force per meter length between the two wires will be

- (a) -6.4×10^{-3} N (b) 6.4×10^{-3} N
(c) -3.2×10^{-3} N (d) 3.2×10^{-3} N

149. (a)

The expression for force per meter length is,

$$F = \frac{\mu_0 I_1 I_2}{2\pi D}$$

Where, $I_1 = I_2 = 40$ A

distance, $D = 5 \times 10^{-2}$

$$F = 2 \times 10^{-7} \times \frac{40 \times 40}{5 \times 10^{-2}}$$

$$F = 6.4 \times 10^{-3} \text{ N}$$

The direction of force will be repulsive in nature,

Then, $F = -6.4 \times 10^{-3}$ N

Q.150 A filamentary current of 10 A is directed in from infinity to the origin on the positive x-axis.

The magnetic field intensity $\vec{H}$ at (0, 0, 1) is

- (a) $\frac{5}{2\pi} \hat{a}_z$ (b) $\frac{10}{4\pi} \hat{a}_x$
(c) $\frac{5}{4\pi} \hat{a}_x$ (d) $\frac{10}{4\pi} \hat{a}_y$

150. (d)

According to the Biot-Savart's law,

$$\vec{H} = \int \frac{I d\vec{L} \times \vec{R}}{4\pi R^3}$$

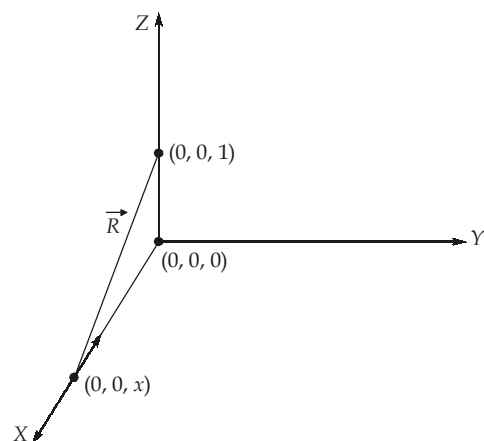
$$\vec{R} = -x \hat{a}_x + \hat{a}_z$$

$$R = \sqrt{1+x^2}$$

$$\vec{H} = \int_{-\infty}^0 \frac{10 dx (-\hat{a}_x) \times (-x \hat{a}_x + \hat{a}_z)}{4\pi (x^2 + 1)^{3/2}}$$

$$\vec{H} = \frac{10}{4\pi} \int_{-\infty}^0 \frac{dx}{(x^2 + 1)^{3/2}} \hat{a}_y$$

$$\vec{H} = \frac{10}{4\pi} \left[\frac{x}{\sqrt{1+x^2}} \right]_{-\infty}^0 \hat{a}_y = \frac{10}{4\pi} \hat{a}_y$$



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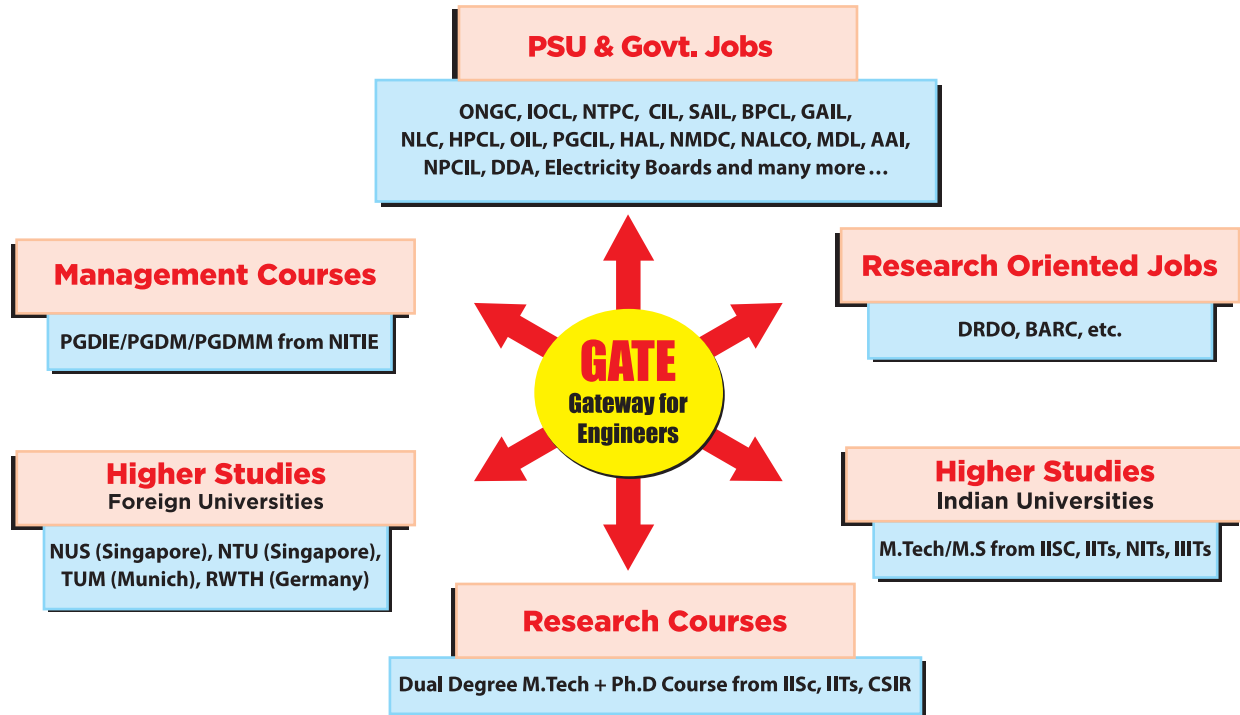
Revision through Questions for GATE 2020

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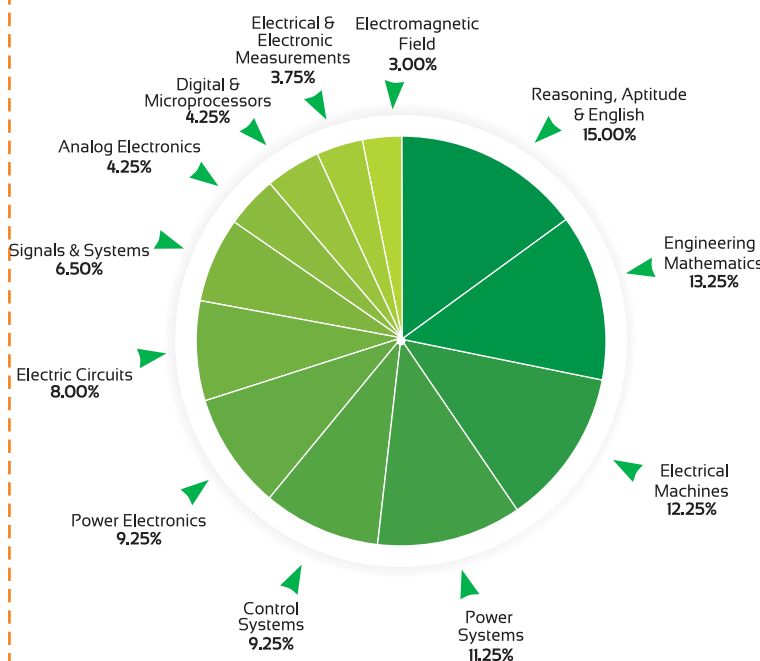
ELECTRICAL ENGG.

Q.151 - Q.175
out of 200 Questions

Day 7 of 8



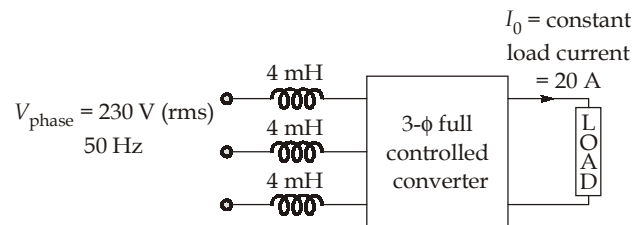
SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

Day 7 : Q.151 to Q. 175 : Power Electronics

Q.151 In the converter circuit shown below,



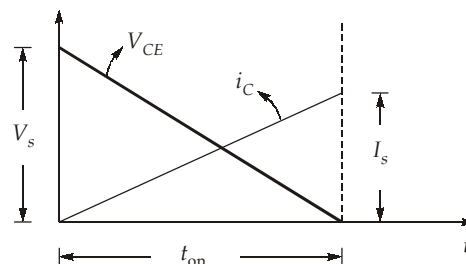
the voltage drop due to commutation is _____ V.

151. (24)

Voltage drop due to commutation is,

$$\begin{aligned}\Delta V_d &= \frac{3}{\pi} \omega L_s I_d \\ &= \frac{3}{\pi} (2\pi \times 50) \times 4 \times 10^{-3} \times 20 \\ \Delta V_d &= 24 \text{ V}\end{aligned}$$

Q.152 For the switching waveform shown below



If $V_s = 100 \text{ V}$, $I_s = 10 \text{ A}$, $t_{\text{on}} = 1.2 \mu\text{s}$ and $f = 10 \text{ kHz}$, then average value of switch on power loss is _____ W.

152. (2)

$$\begin{aligned}\text{Average switch on power loss} &= \frac{1}{T} \int_0^{t_{\text{on}}} (V_{CE} \times i_c) dt \\ &= \frac{1}{T} \int_0^{t_{\text{on}}} \left[\left(\frac{I_s}{t_{\text{on}}} \right) t \times \left(V_s - \frac{V_s}{t_{\text{on}}} t \right) \right] dt = \frac{V_s I_s}{6} \cdot t_{\text{on}} \cdot f \\ &= \frac{100 \times 10}{6} \times 1.2 \times 10^{-6} \times 10 \times 10^3 \\ P &= 2 \text{ W}\end{aligned}$$

Q.153 If two single phase semi-converters are connected in series, then the maximum value of average output voltage is $\frac{AV_m}{\pi}$. The value of A is _____.

153. (4)

The average output voltage of the series connected single phase semi converter is,

$$V_o = V_{o1} + V_{o2} = \frac{V_m}{\pi} (1 + \cos \alpha_1) + \frac{V_m}{\pi} (1 + \cos \alpha_2)$$

$$V_o = \frac{V_m}{\pi} (2 + \cos \alpha_1 + \cos \alpha_2)$$

The maximum value of output voltage occurs at

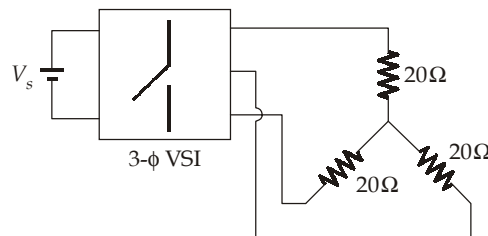
$$\alpha_1 = \alpha_2 = 0$$

$$V_o = \frac{4V_m}{\pi}$$

$\therefore$

$$A = 4$$

Q.154 In a 3- ϕ inverter circuit is shown in the figure the load is balanced and get in scheme 180° conduction mode. All the devices are assumed to be ideal. If the DC bus voltage $V_s = 300$ V then the power consumed by the three phase load is _____



(a) 1 kW

(b) 2 kW

(c) 3 kW

(d) 4 kW

154. (c)

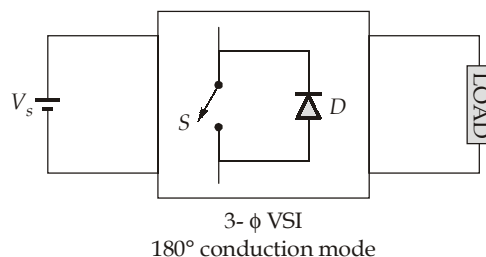
$$\begin{aligned} \text{Line voltage, } V_L &= \sqrt{\frac{2}{3}} \times V_s = \sqrt{\frac{2}{3}} \times 300 \\ &= 244.94 \text{ V} \end{aligned}$$

$$\text{Phase voltage, } V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{244.94}{\sqrt{3}} = 141.42 \text{ V}$$

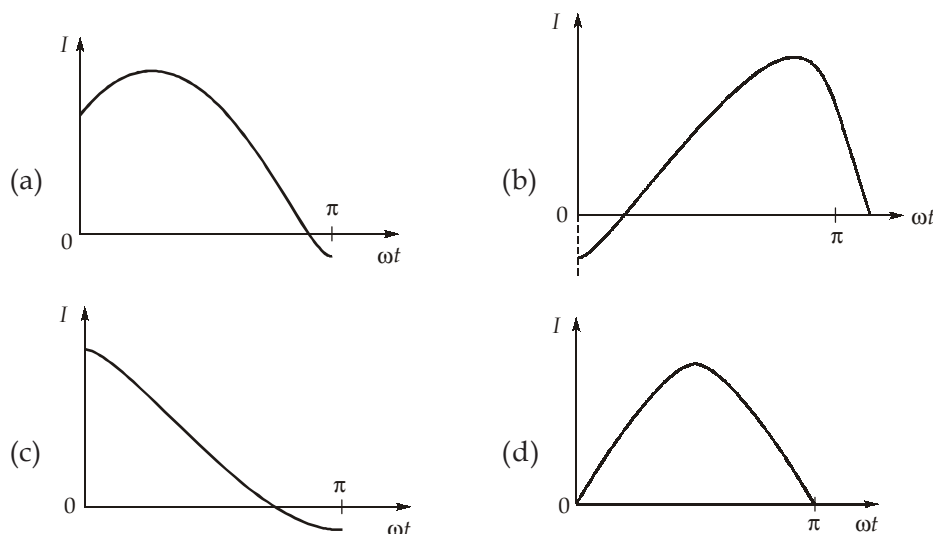
Power consumed by 3- ϕ load

$$P = \frac{3V_{ph}^2}{R} = \frac{3 \times (141.42)^2}{20} = 3 \text{ kW}$$

Q.155 In the circuit shown below,

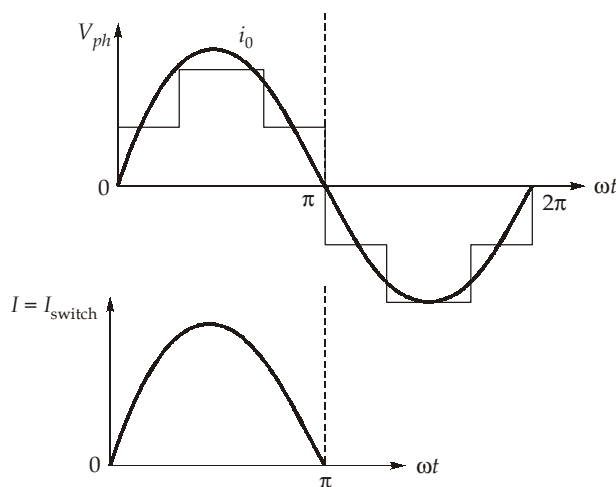


The switch 's' current waveform if load takes a current of sinusoidal waveform which is in phase with output voltage



155. (d)

The phase voltage wave of output voltage for 180° conduction, and also given that current is sinusoidal and in phase with voltage.



Q.156 A three phase inverter is connected to a direct voltage source of 240 V. If in the ac side current is sinusoidal with a peak value of 20 A and current is leading the voltage by 60°, then the power flow through the inverter is _____ W.
(Assume mode of conduction is 180° and load is star connected)

156. 2291.83 (2290.00 to 2293.00)

Power flow through the inverter is,

$$P_{avg} = 3 V_{ph} I_{ph} \cos \phi$$

Output phase voltage is having harmonics but output phase current does not have harmonics (since it is a pure sine wave), output average power does not have harmonic power

$$V_{S1} = \frac{2V_s}{\pi\sqrt{2}} = \frac{2 \times 240}{\pi\sqrt{2}} = 108.038 \text{ V}$$

Power flow through the inverter,

$$= 3 \times 108.038 \times \frac{20}{\sqrt{2}} \times \cos 60^\circ = 2291.83 \text{ W}$$

Q.157 The output voltage e_1 and e_2 of two full bridge inverters are added using output transformers. In order to eliminate the fifth harmonic from the output voltage, the phase angle between e_1 and e_2 should be

- (a) $\frac{\pi}{3}$ rad (b) $\frac{\pi}{4}$ rad
(c) $\frac{\pi}{5}$ rad (d) $\frac{\pi}{6}$ rad

157. (c)

$$e_1 = \frac{4V_s}{n\pi} \sin n\omega t$$

$$e_2 = \frac{4V_s}{n\pi} \sin n(\omega t + \phi)$$

$$V_0 = e_1 + e_2$$

$$= \frac{4V_s}{n\pi} [\sin n\omega t + \sin(n\omega t + n\phi)]$$

$$V_0 = \frac{4V_s}{n\pi} [\sin n\omega t + \sin n\omega t \cos n\phi + \cos n\omega t \sin n\phi]$$

In order to eliminate fifth harmonic,

$$V_{05} = 0$$

i.e. $\sin 5\omega t + \sin 5\omega t \cos 5\phi + \cos 5\omega t \sin 5\phi = 0$ to satisfy the above equation,

$$\cos 5\phi = -1 \text{ and } \sin 5\phi = 0$$

$$\cos 5\phi = \cos \pi; \quad \sin 5\phi = \sin \pi$$

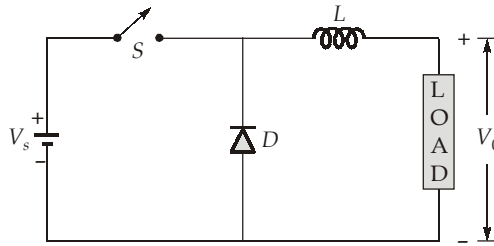
$$\phi = \frac{\pi}{5}; \quad \phi = \frac{\pi}{5}$$

$\therefore$ The phase angle between e_1 and e_2 should be $\phi = \frac{\pi}{5}$ to eliminate fifth harmonic in the output.

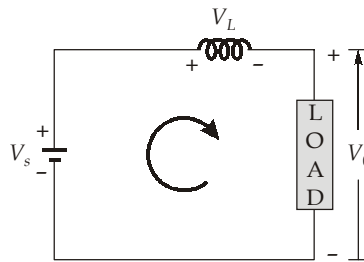
Q.158 The critical value of inductance in the load circuit of a step down chopper is (Where D is duty cycle of the chopper)

- (a) $L \propto D(1 + D)$ (b) $L \propto (D^2 - D)$
(c) $L \propto (D - D^2)$ (d) $L \propto \sqrt{D}$

158. (c)



During T_{on} , the circuit behaves as,



By applying KVL in the loop

$$-V_s + V_L + V_0 = 0$$

$$V_s - V_0 = L \frac{di}{dt}$$

$$V_s - V_0 = \frac{L \Delta I}{T_{on}}$$

$$\Delta I = \frac{(V_s - DV_s)T_{on}}{L} = \frac{V_s(1-D)T_{on} \times T}{L \times T}$$

$$= \frac{V_s(1-D)D}{L \times f}$$

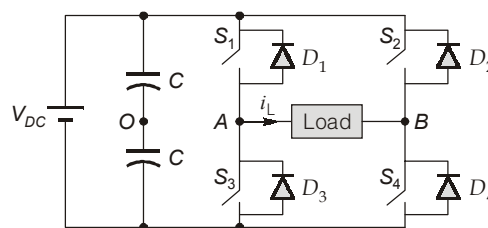
$$L = \frac{V_s(1-D)D}{\Delta I \times f}$$

Taking all other parameters constant,

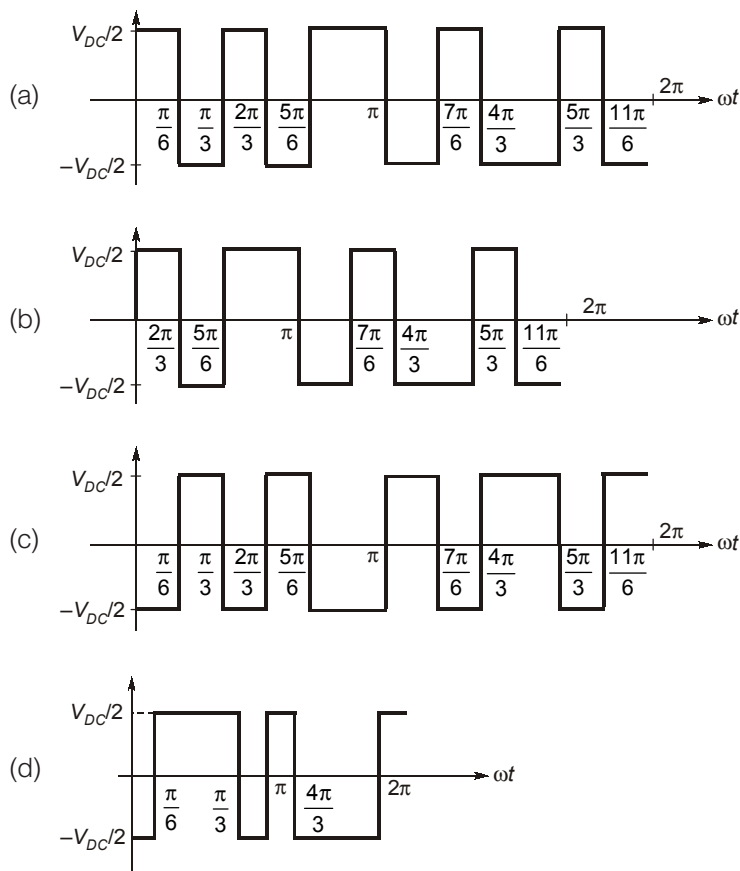
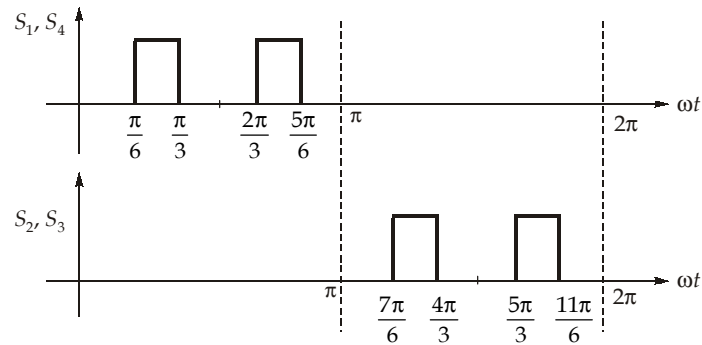
$$L \propto (1-D) D$$

$$L \propto (D - D^2)$$

Q.159 A single-phase voltage source inverter shown in figure is feeding power to a load. The triggering pulses of the devices are also shown in the figure,

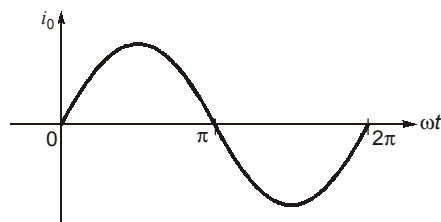


If the load current is sinusoidal and is zero at $0, \pi, 2\pi, \dots$, the node voltage V_{AO} has the waveform.

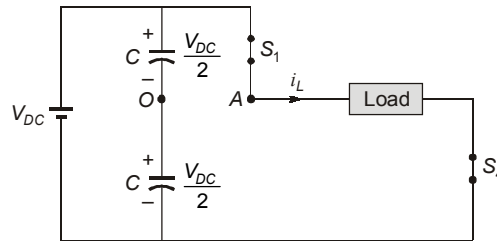


159. (c)

The load current waveform is

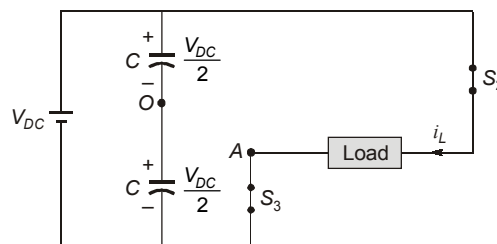


During the period switches are triggered the voltage across AO is
 S_1 and S_4 ON

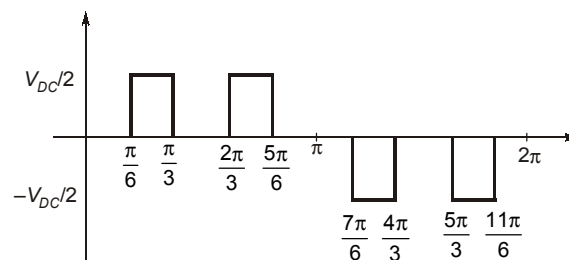


$$\text{Voltage } V_{AO} = \frac{V_{DC}}{2}$$

S_2 and S_3 ON



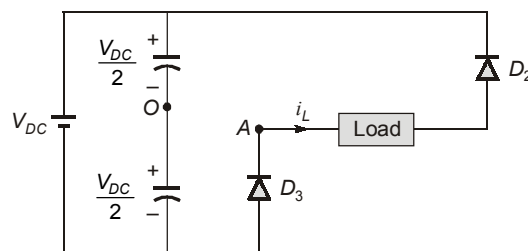
$$\text{Voltage } V_{AO} = -\frac{V_{DC}}{2}$$



When the switches are off.

The current direction from 0 to π is positive so it is in the direction given in the circuit.

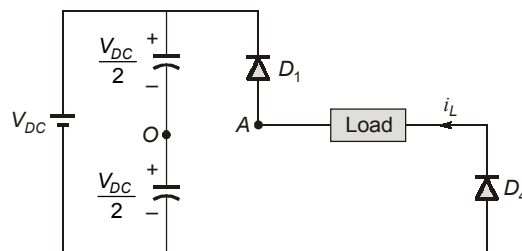
$$0 \leq \omega t \leq \pi$$



$$\text{Voltage } V_{AO} = -\frac{V_{DC}}{2}$$

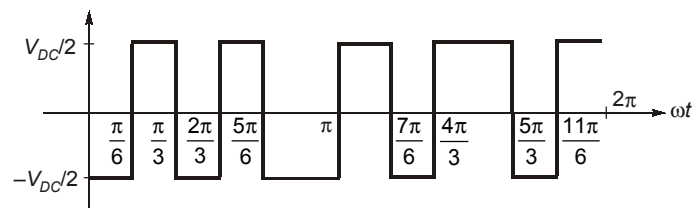
$$\pi \leq \omega t \leq 2\pi$$

The load current is negative so the current direction will be opposite to given direction.



$$\text{Voltage } V_{AO} = \frac{V_{DC}}{2}$$

so, the complete voltage V_{AO} is



Q.160 In a step up converter, the duty ratio is adjusted to regulate the output voltage V_0 at 48 V. The input voltage varies in a wide range from 12 V to 36 V. The maximum power output is 120 W. For stability reasons, it is required that the converter always operate in a discontinues current conduction mode. The switching frequency is 50 kHz. Assuming ideal components and C as very large, the maximum value of inductor that can be used is _____ μH .

160. 9.00 (8.90 to 9.10)

To find the maximum value of L that keeps the current conduction discontinuous, we will take the inductor current is at the edge of continous conduction.

$$\text{Current, } I_0 = \frac{P_0}{V_0} = \frac{120}{48} = 2.5 \text{ A}$$

$$2I_L = \frac{KV_s}{fL} \quad [\text{At the edge of discontinuous conduction}]$$

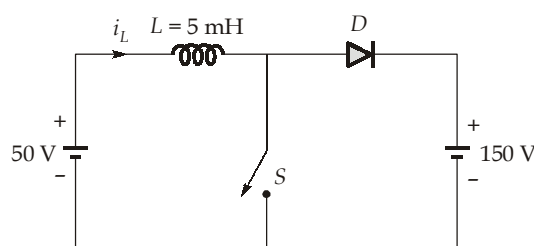
$$\begin{aligned} I_{L(\text{avg})} &= I_{S(\text{avg})} \\ \text{from no loss circuit, } V_0 I_0 &= V_S I_S \\ 48 \times 2.5 &= 12 \times I_S \end{aligned}$$

$$I_{S(\text{avg})} = 10 \text{ A}$$

[$V_S = 12 \text{ V}$ because large value of inductor is required for $K = 0.75$]

$$L = \frac{KV_s}{2I_S f} = \frac{0.75 \times 12}{2 \times 10 \times 50 \times 10^3} = 9 \mu\text{H}$$

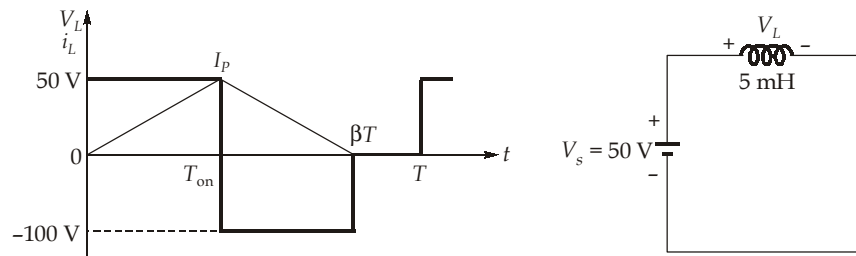
Q.161 In the circuit shown below,



If the switching frequency is 5 kHz, duty ratio is 0.4 and circuit reached to steady state then the average value of inductor current is _____ A.

(Assuming the switch and diode to be ideal and discontinuous mode of current conduction)

161. 0.24 (0.10 to 0.40)



During T_{on} the circuit behaves as,

$$V_s = L \frac{di}{dt}$$

$$di = \frac{V_s}{L} dt$$

Integrating on both sides, we get

$$I_p = \frac{V_s}{L} T_{on}$$

$$T_{on} = \alpha T = \frac{\alpha}{f} = \frac{0.4}{5 \times 10^3} = 80 \times 10^{-6} \text{ s}$$

$$I_p = \frac{50}{5 \times 10^{-3}} \times (80 \times 10^{-6}) = 0.8 \text{ A}$$

During T_{off} it is $T_{on} \leq t \leq \beta T$

Apply KVL in the circuit,

$$V_L = V_s - V_0$$

$$(V_L)_{avg} = 0$$

$$V_s T_{on} + (V_s - V_0)(\beta T - T_{on}) = 0$$

$$V_s \beta T = V_0(\beta T - T_{on})$$

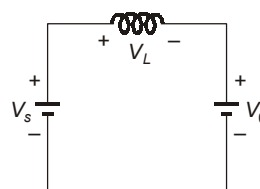
$$\frac{V_0}{V_s} = \frac{\beta}{\beta - \alpha}$$

$$\beta = 0.6$$

From the graph of I_L ,

$$I_{L(avg)} = \frac{\frac{1}{2} \times b \times h}{T}$$

$$= \frac{\frac{1}{2} \times \beta T \times I_p}{T} = \frac{1}{2} \times 0.6 \times 0.8 = 0.24 \text{ A}$$



164. (a)

The average output voltage of single phase half-wave converter with FD

$$V_0 = \frac{V_m}{2\pi}(1 + \cos \alpha)$$

The average output voltage of single phase semi converter is,

$$V_0 = \frac{V_m}{\pi}(1 + \cos \alpha)$$

$$= I_0 R + E_b \approx E_b \quad (\because I_0 R \text{ drop is neglected})$$

Now, $V_0 \propto E_b \propto N$

$$V_0 \propto N$$

So, $\frac{V_{0HW}}{V_{0Semi}} = \frac{1000}{N_2}$

$$\frac{1}{2} = \frac{1000}{N_2}$$

$$N_2 = 2000 \text{ rpm}$$

Q.165 A single phase fully controlled converter is connected to a 240 V supply. If the converter is fired at an advance angle of 45° and overlap angle of 10° , then the mean load voltage is _____ V.

165. -164.9 (-166.00 to -162.00)

For firing advance angle of 45° , the full converter is in the inverting mode i.e. $\alpha > 90^\circ$

So, $\alpha = 180^\circ - 45^\circ = 135^\circ$

The mean output voltage,

$$V_{0x} = \frac{\text{Maximum mean output voltage at no load}}{2} \times [\cos \alpha + \cos(\alpha + \mu)]$$

Maximum mean output voltage,

$$V_{0m} = \frac{2V_m}{\pi}$$

$$V_{0x} = \frac{V_m}{\pi} [\cos \alpha + \cos(\alpha + \mu)]$$

$$= \frac{240\sqrt{2}}{\pi} [\cos 135^\circ + \cos 145^\circ]$$

$$= -164.9 \text{ V}$$

Q.166 In the circuits shown below,

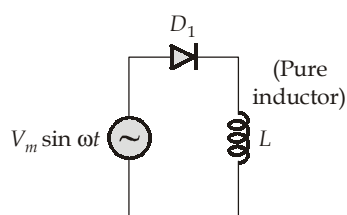


Fig. (a)

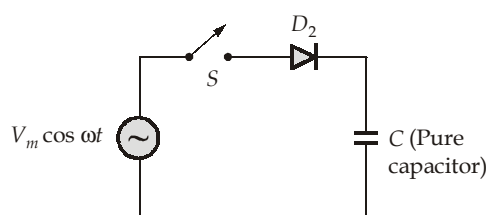


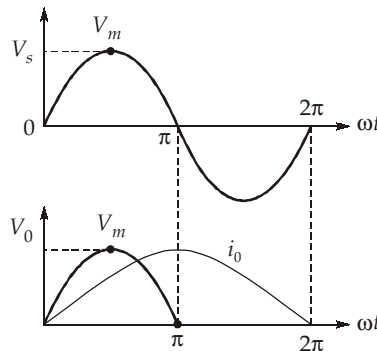
Fig. (b)

If switch in figure (b) is closed at $t = 0$, then the diodes D_1 and D_2 conducts respectively as

- (a) 180° and 90° (b) 90° and 180°
(c) 360° and 90° (d) 360° and 0°

166. (d)

In figure (a),



Inductor stores energy upto π radian and dissipates energy upto 2π radians.

So, diode conducts for 360° in figure (a).

In figure (b), the source is a 'cosine' function, so capacitor charges to its maximum value instantaneously as switch is closed at $t = 0$.

So, diode conducts for 0° in figure (b).

Q.167 A single phase full converter is supplied from 230 V, 50 Hz source. The load consists of $R = 10 \Omega$ and a large inductance so as to render the load current constant. For a firing angle of 30° , the average and rms values of thyristor currents respectively are

- (a) 8.96 A and 10 A (b) 8.96 A and 12.67 A
(c) 12.67 and 8.96 A (d) 12.67 and 10 A

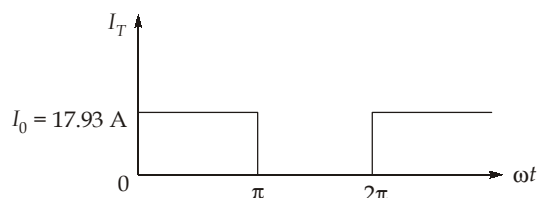
167. (b)

Average output voltage of single phase full converter is,

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

$$V_0 = \frac{2\sqrt{2} \times 230}{\pi} \cos 30^\circ = 179.33 \text{ V}$$

$$I_0 = \frac{V_0}{R} = \frac{179.33}{10} = 17.93 \text{ A}$$



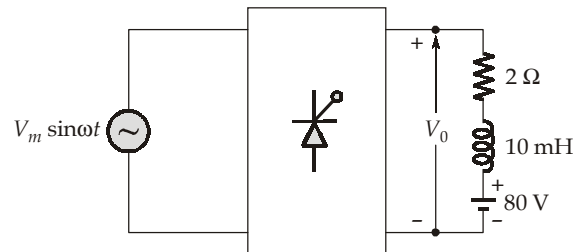
The average value of thyristor current,

$$I_{T \text{ avg}} = 17.93 \times \frac{\pi}{2\pi} = 8.96 \text{ A}$$

The rms value of thyristor current,

$$I_{T \text{ rms}} = 17.93 \times \sqrt{\frac{\pi}{2\pi}} = 12.67 \text{ A}$$

Q.168 A phase controlled single phase rectifier, supplied by an AC source, feeds power to an RLE load as shown in the figure,



The rectifier output voltage has an average value given by $V_0 = \frac{2V_m}{\pi} \cos \alpha$, where $V_m = 252 \text{ V}$ and α is the firing angle. If the power delivered to the lossless battery is 1600 W, firing angle α (in degrees) is _____.

168. 41.58 (41.00 to 42.00)

The power delivered to the lossless battery is,

$$E_b I_0 = 1600$$

$$I_0 = \frac{1600}{80} = 20 \text{ A}$$

The rectifier output voltage,

$$V_0 = E_b + I_0 R$$

$$\frac{2V_m}{\pi} \cos \alpha = 80 + (20 \times 2)$$

$$\frac{2 \times 252}{\pi} \cos \alpha = 120$$

$$160.42 \cos \alpha = 120$$

$$\text{Firing angle, } \alpha = 41.58^\circ$$

Q.169 A single phase half bridge inverter has a resistive load of 10Ω and the center tap dc input voltage is 96 V. The fundamental power consumed by the load is

- (a) 640 W (b) 705 W
(c) 747 W (d) 820 W

169. (c)

Given, $\frac{V_{dc}}{2} = 96$

$$V_{dc} = 192 \text{ V}$$

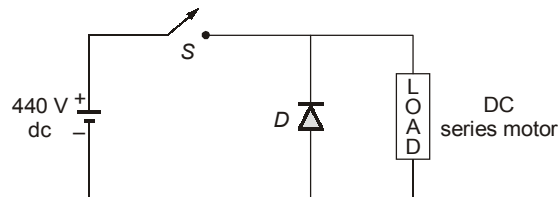
Rms value of the fundamental voltage in the output,

$$V_{01} = \frac{2V_s}{\sqrt{2\pi}} = \frac{2 \times 192}{\sqrt{2\pi}} = 86.43 \text{ V}$$

Fundamental power in the output

$$= \frac{(V_{01})^2}{R} = \frac{(86.43)^2}{10} = 747 \text{ W}$$

Q.170 A dc series motor is controlled by the circuit shown below.



The armature and field resistance are 0.06Ω and 0.04Ω respectively. The average armature current is 200 A and chopper frequency is 500 Hz . If the back emf is 200 V , then the pulse width would be equal to

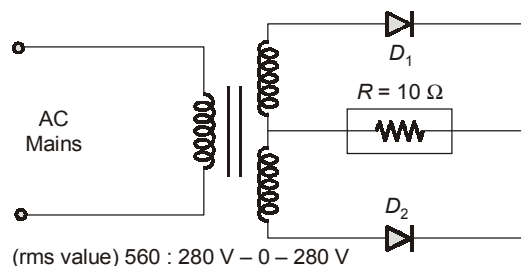
- (a) 0.5 ms (b) 1 ms
(c) 1.5 ms (d) 2 ms

170. (b)

The given chopper is a step down chopper,

$$\begin{aligned} V_0 &= \alpha V_s \\ V_0 &= I_0 (R_a + R_{se}) + E_b = \alpha V_s \\ &= 200 (0.06 + 0.04) + 200 = \alpha \cdot 440 \\ \alpha &= \frac{220}{440} \\ \alpha &= 0.5 \\ T_{\text{on}} &= \alpha \cdot T \\ &= 0.5 \times \frac{1}{500} = 1 \text{ ms} \end{aligned}$$

Q.171 The center tap full wave single phase rectifier circuit uses 2 diodes as shown below,



the rms voltage across each diode is

- (a) 790.1 V (b) 395.9 V
(c) 280 V (d) 201.3 V

171. (b)

The waveform of voltage across diode,

$$V_m = V_{rms} \sqrt{2}$$

$$V_m = 280 \times \sqrt{2} = 395.97 \text{ V}$$

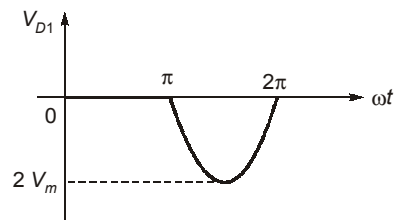
Peak value of waveform shown above is

$$2 V_m = 2 \times 395.97$$

$$2 V_m = 791.94 \text{ V}$$

The rms value of the wave form shown above is,

$$V_{D1, rms} = \left(\frac{\text{peak value}}{\sqrt{2}} \right) \times \sqrt{\frac{\pi}{2\pi}} = \frac{791.94}{\sqrt{2} \times \sqrt{2}} = 395.97 \text{ V}$$



Q.172 A single phase fully controlled bridge rectifier is operated from 240 V, 50 Hz ac mains. Load draws a continuous and ripple free current of 12 A. The reactive power drawn by the load from source, if the firing angle is 30° will be _____ kVAR.

172. 1.29 (1.10 to 1.45)

$$\text{Average output voltage, } V_0 = \frac{2V_m}{\pi} \cos \alpha = \frac{2\sqrt{2} \times 240}{\pi} \cos 30^\circ = 187.127 \text{ V}$$

$$\text{Load current given, } I_0 = 12 \text{ A}$$

$$\begin{aligned} \text{Reactive power drawn} &= V_0 I_0 \tan \alpha = 187.127 \times 12 \times \tan 30^\circ \\ &= 1.29 \text{ kVAR} \end{aligned}$$

Q.173 A 3 phase, 440 V, 50 Hz supply is feeding a 440 V dc, 15 kW, 1500 rpm separately excited dc motor with ripple free continuous current through a thyristor bridge. Neglecting all the losses, the power factor of the ac mains at half the rated speed is

- (a) 0.353 (b) 0.372
(c) 0.90 (d) 0.955

173. (a)

Hence it is mentioned in the given data that there is no losses.

$$V_0 = \frac{3V_{mL}}{\pi} \cos \alpha = E$$

Since

$$E \propto N$$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

$$E_1 = 2E_2$$

$$E_2 = \frac{E_1}{2} = \frac{V_0}{2} = 220 \text{ V}$$

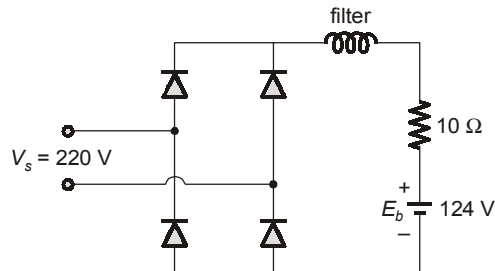
$$\frac{3 \times \sqrt{2} \times 440}{\pi} \cos \alpha = 220$$

$$\cos \alpha = \frac{220 \times \pi}{3 \times \sqrt{2} \times 440} = 0.3702$$

Input power factor of the supply

$$= \frac{3}{\pi} \cos \alpha = \frac{3}{\pi} \times 0.3702 = 0.353$$

Q.174 In the circuit shown below,



The ripple voltage (a.c. component) is
(Assume ripple free load current)

- (a) 95.75 V (b) 98.12 V
(c) 82.6 V (d) 88.13 V

174. (a)

Hence the load current is continuous,

The average output voltage of the waveform will be,

$$\begin{aligned} V_0 &= \frac{2V_m}{\pi} \\ &= \frac{2 \times \sqrt{2} \times 220}{\pi} = 198.07 \text{ V} \end{aligned}$$

The rms value of output voltage

$$= \frac{V_m}{\sqrt{2}} = \frac{\sqrt{2} \times 220}{\sqrt{2}} = 220 \text{ V}$$

$$\begin{aligned} \text{The ripple voltage} &= V_r = \sqrt{V_{0,\text{rms}}^2 - V_0^2} \\ &= \sqrt{220^2 - 198.07^2} = 95.75 \text{ V} \end{aligned}$$

Q.175 A 3-phase full converter bridge is connected to supply voltage of 230 V per phase and a frequency of 50 Hz. The source inductance is 4 mH and load current on dc side is constant at 20 A at 30° firing angle. The percentage voltage regulation due to source inductance is

- (a) 3.84% (b) 4.92%
(c) 4.16% (d) 5.15%

175. (d)

Voltage regulation due to source inductance

$$\begin{aligned} &= \frac{3\omega L_s I_0}{\pi} \times \frac{1}{V_0 \text{ at no load}} \times 100 \\ &= \frac{3\omega L_s I_0}{\pi} \times \frac{\pi}{3V_{mL} \cos \alpha} \times 100 \end{aligned}$$

$$= \frac{\omega L_s I_0}{V_{mL} \cos \alpha} \times 100$$

$$= \frac{2\pi \times 50 \times 4 \times 10^{-3} \times 20}{\sqrt{2} \times \sqrt{3} \times 230 \times \cos 30^\circ} \times 100$$

% voltage regulation due to source inductance

$$= 5.15\%$$

○○○○



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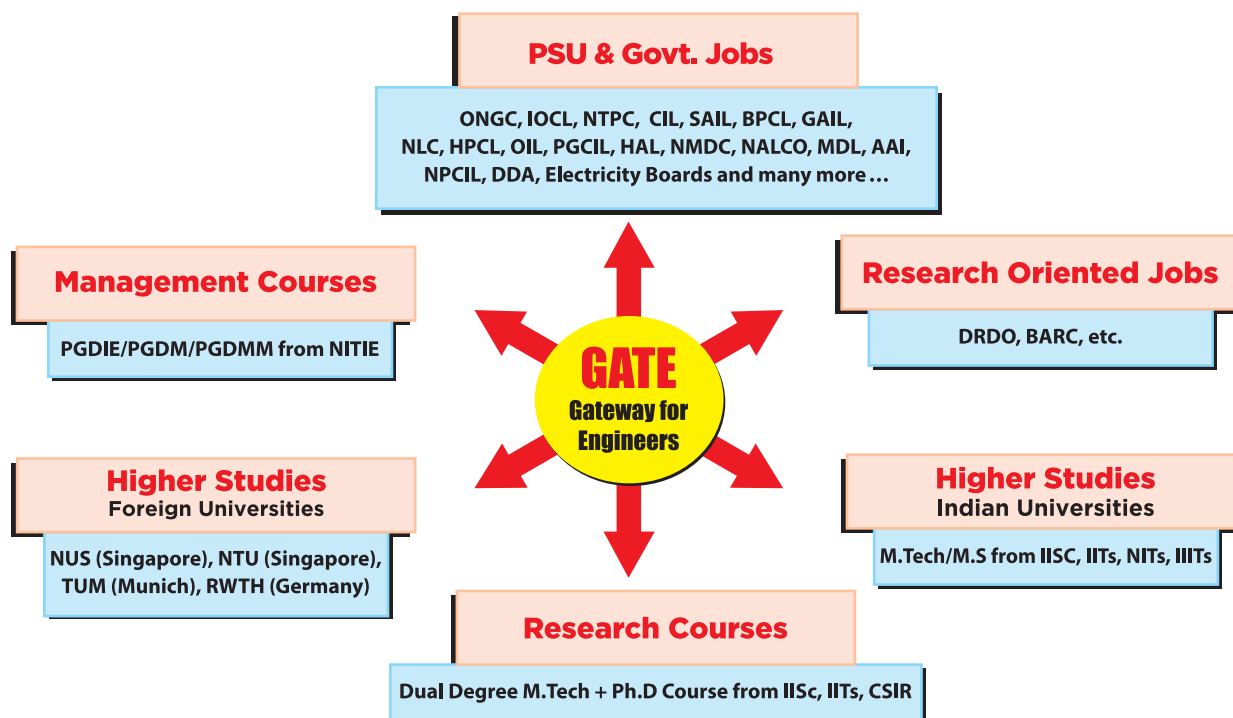
Revision through Questions for GATE 2020

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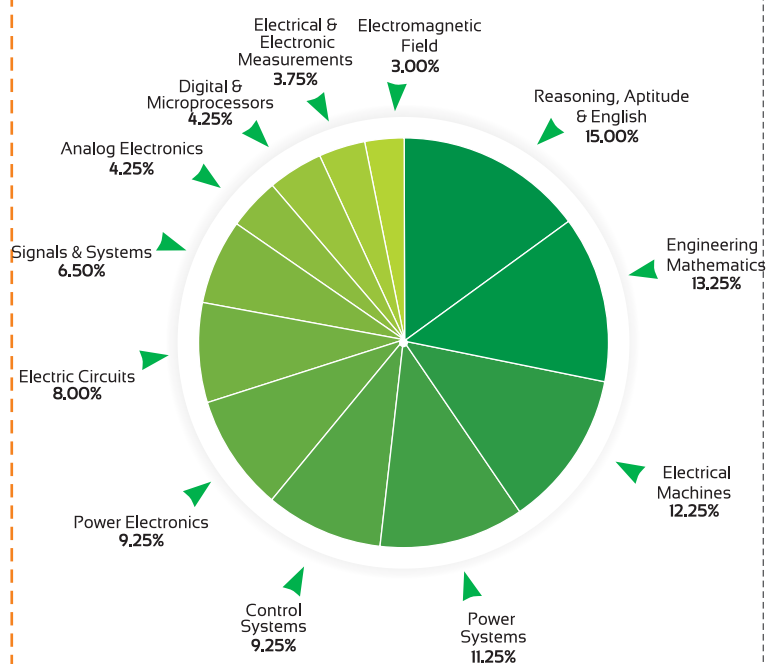
ELECTRICAL ENGG.

Q.176 - Q.200
out of 200 Questions

Day 8 of 8



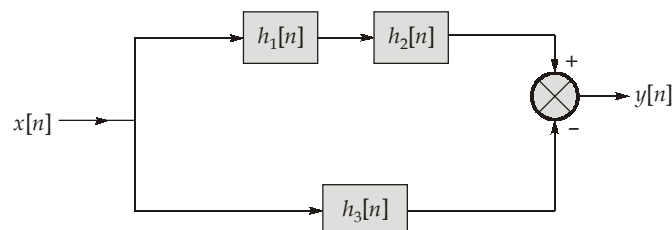
SUBJECTWISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	13.25%
Electrical Machines	12.25%
Power Systems	11.25%
Control Systems	9.25%
Power Electronics	9.25%
Electric Circuits	8.00%
Signals & Systems	6.50%
Analog Electronics	4.25%
Digital & Microprocessors	4.25%
Electrical & Electronic Measurements	3.75%
Electromagnetic Field	3.00%
Total	100%

$$\begin{aligned}
 x(t) &= -\frac{2 \sin t}{t} u(t) \\
 x(0) &= -\lim_{t \rightarrow 0} \left(\frac{2 \sin t}{t} u(t) \right) \\
 &= -2 \lim_{t \rightarrow 0} u(t) \\
 &= -2 \left(\frac{1}{2} \right) \\
 &= -1
 \end{aligned}$$

Q.178 Consider the interconnection of three LTI systems as shown in below figure.



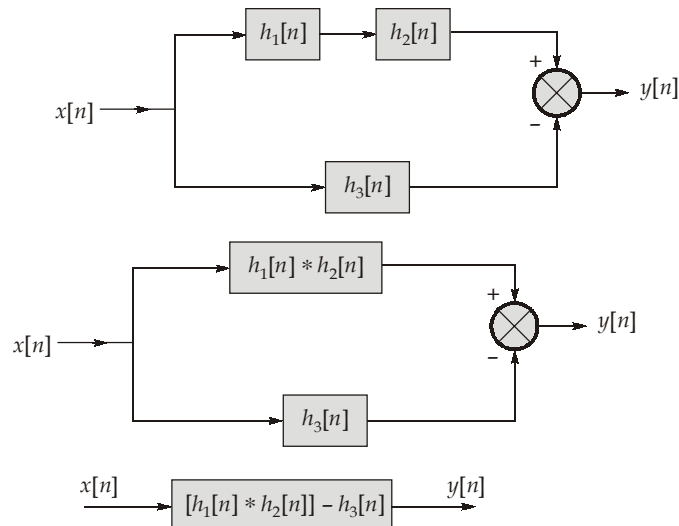
Assume,

$$\begin{aligned}
 h_1[n] &= u[n + 2], \quad h_2[n] = \delta[n - 2] \\
 h_3[n] &= u[n] - u[n - 2]
 \end{aligned}$$

Then the impulse response of overall system at $n = 2$ is _____.

178. (1)

Given,



From the given figure, overall impulse response,

$$\begin{aligned}
 \therefore h[n] &= [h_1[n] * h_2[n]] - h_3[n] \\
 &= [u[n + 2] * \delta[n - 2]] - [u[n] - u[n - 2]] \\
 &= u[n] - u[n] + u[n - 2]
 \end{aligned}$$

$$\{ \therefore x[n] * \delta[n - n_0] = x[n - n_0] \}$$

$$h[n] = u[n - 2]$$

$$\text{at } n = 2; \quad h[2] = u[2 - 2] = u[0] = 1$$

Q.179 For $x(n) = \left(\frac{1}{3}\right)^{nu(n)} + (\sqrt{3} + j)^{-n} u(n)$;

If ROC: $a < |z| < 1$, then the value of a will be

179. (0.5)

First part: $\left(\frac{1}{3}\right)^{nu(n)} = \begin{cases} \left(\frac{1}{3}\right)^{n \times 0} & n < 0 \\ \left(\frac{1}{3}\right)^{n \times 1} & n \geq 0 \end{cases} = \begin{cases} 1 & n < 0 \\ \left(\frac{1}{3}\right)^n & n \geq 0 \end{cases}$

$$\left(\frac{1}{3}\right)^{nu(n)} = u(-n-1) + \left(\frac{1}{3}\right)^n u(n)$$

Second part:

$$(\sqrt{3} + j)^{-n} u(n) = \left(\frac{1}{\sqrt{3} + j}\right)^n u(n)$$

$$\therefore |z| = \left|\frac{1}{\sqrt{3} + j}\right| = \frac{1}{2}$$

$$\therefore \text{ROC: } |z| > \frac{1}{2}$$

Combining both ROC's

$$\frac{1}{3} < |z| < 1$$

$$|z| > \frac{1}{2}$$

$$\text{Net ROC: } \frac{1}{2} < |z| < 1$$

Comparing with given ROC: $a < |z| < 1$

$$\therefore a = \frac{1}{2}$$

Q.180 The Laplace transform of a signal given below is

$$x(t) = \begin{cases} \cos(\pi t); & 0 < t < 1 \\ 0 & ; \text{ otherwise} \end{cases}$$

(a) $\frac{1 - e^{-s}}{s^2 + \pi^2}$

(b) $\frac{1 - e^{-\pi s}}{s^2 + \pi^2}$

(c) $\frac{s[1 + e^{-s}]}{s^2 + \pi^2}$

(d) $\frac{s[1 - e^{-s}]}{s^2 + \pi^2}$

180. (c)

We know that the Laplace transform of

$$\cos(at)u(t) = \frac{s}{s^2 + a^2}$$

$$\therefore \cos(\pi t)u(t) = \frac{s}{s^2 + \pi^2}$$

now, the given function $x(t)$ can be written as,

$$\begin{aligned} x(t) &= \cos(\pi t)u(t) - \cos \pi t u(t-1) \\ &= \cos(\pi t)u(t) - \cos \pi(t-1+1)u(t-1) \\ &= \cos(\pi t)u(t) - \cos [\pi(t-1) + \pi] u(t-1) \\ &= \cos \pi t u(t) - [\cos \pi(t-1) (-1) - 0] u(t-1) \\ &= \cos \pi t u(t) + \cos \pi(t-1) u(t-1) \end{aligned}$$

By taking Laplace transform,

$$X(s) = \frac{s}{s^2 + \pi^2} + \frac{s e^{-s}}{s^2 + \pi^2} \quad [\because x(t-t_0) = X(s) \cdot e^{-st_0}, \text{ by shifting property}]$$

$$X(s) = \frac{s[1 + e^{-s}]}{s^2 + \pi^2}$$

Q.181 The z-transform of the discrete-time signal $x[n] = n2^n \sin\left(\frac{\pi}{2}n\right)u[n]$ is

(a) $\frac{2(z^2 - 4)}{(z^2 + 4)^2}$

(b) $\frac{2z(z^2 + 4)}{(z^2 - 4)^2}$

(c) $\frac{z(z^2 - 4)}{(z^2 + 4)^2}$

(d) $\frac{2z(z^2 - 4)}{(z^2 + 4)^2}$

181. (d)

Given discrete-time signal

$$x[n] = n2^n \sin\left(\frac{\pi}{2}n\right)u[n]$$

we know that,

$$Z\left[\sin\left(\frac{\pi}{2}n\right)u[n]\right] = \frac{z \sin\left(\frac{\pi}{2}\right)}{z^2 - 2z \cos\left(\frac{\pi}{2}\right) + 1} = \frac{z}{z^2 + 1}$$

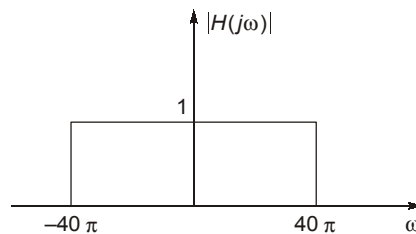
Using the multiplication by exponential property,
we have

$$\begin{aligned} Z\left[2^n \sin\left(\frac{\pi}{2}n\right)u[n]\right] &= Z\left[\sin\left(\frac{\pi}{2}n\right)u[n]\right] \Bigg|_{z \rightarrow \left(\frac{z}{2}\right)} \quad \left[\begin{array}{l} x[n] \longleftrightarrow X(z) \\ a^n x[n] \longleftrightarrow X\left(\frac{z}{a}\right) \end{array} \right] \\ &= \frac{z}{z^2 + 1} \Bigg|_{z \rightarrow \frac{z}{2}} = \frac{2z}{z^2 + 4} \end{aligned}$$

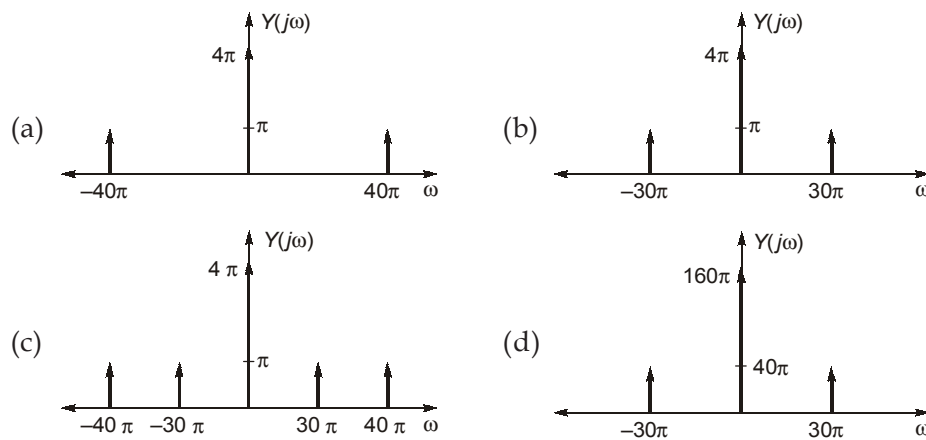
Using differentiation in z-domain property

$$\begin{aligned} Z\left[n 2^n \sin\left(\frac{\pi}{2}n\right)u[n]\right] &= -z \frac{d}{dz} \left\{ Z\left[n 2^n \sin\left(\frac{\pi}{2}n\right)u[n]\right] \right\} \quad \left[\begin{array}{l} x[n] \longleftrightarrow X(z) \\ nx[n] \longleftrightarrow -z \frac{d}{dz} X(z) \end{array} \right] \\ &= -z \frac{d}{dz} \left(\frac{2z}{z^2 + 4} \right) = -z \left[\frac{(z^2 + 4)(2) - 2z(2z)}{(z^2 + 4)^2} \right] = -z \left[\frac{-2z^2 + 8}{(z^2 + 4)^2} \right] \\ Z\left[n 2^n \sin\left(\frac{\pi}{2}n\right)u[n]\right] &= \frac{2z(z^2 - 4)}{(z^2 + 4)^2} \end{aligned}$$

Q.182 A continuous time signal $x(t)$ is defined as $x(t) = 2 + \cos(50\pi t)$ is sampled with sampling interval $T_s = 0.025$ sec and passed through an ideal low pass filter whose frequency response is as shown in figure below



The spectrum of output will be



182. (d)

Given, $x(t) = 2 + \cos(50\pi t)$

Frequency of signal $\omega_{\text{sig}} = 50\pi$

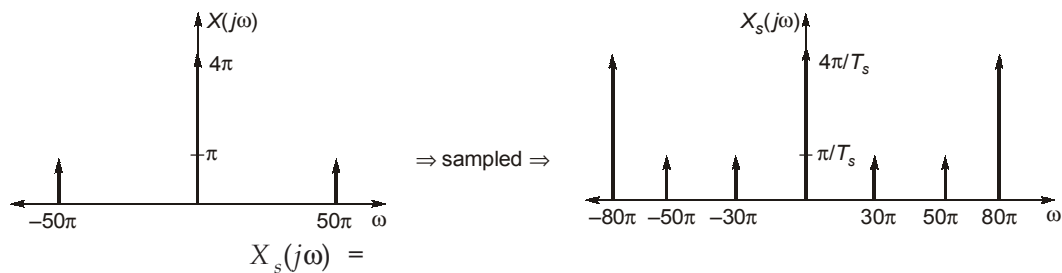
$T_s = 0.025$ sec

$\therefore$ sampling frequency $\omega_s = \frac{2\pi}{T_s} = 80\pi$ rad/sec

then, $X(j\omega) = 4\pi\delta(\omega) + \pi[\delta(\omega + 50\pi) + \delta(\omega - 50\pi)]$

Let the sampled signal be represented as $X_s(j\omega)$, where $X_s(j\omega)$ is given as

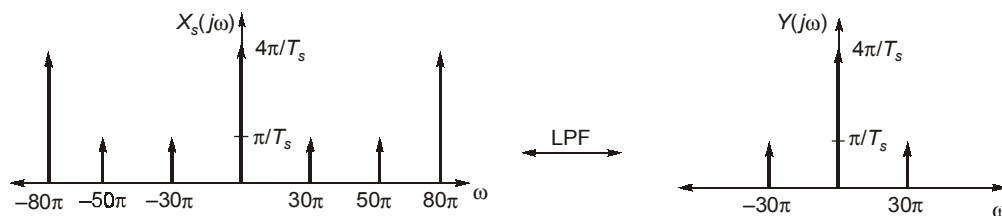
$$X_s(j\omega) = \frac{1}{T_s} \sum_{n=-\infty}^{\infty} X(j(\omega - n\omega_s))$$



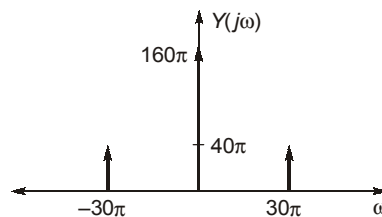
$$40 \sum_{m=-\infty}^{\infty} [4\pi\delta(\omega - 80\pi)] + \pi\delta(\omega - 50\pi - 80\pi n) - \pi\delta(\omega + 50\pi - 80\pi n)]$$

now, the sampled input $X_s(j\omega)$ is passed through a low passed filter having cut-off frequency at $\omega = 40\pi$.

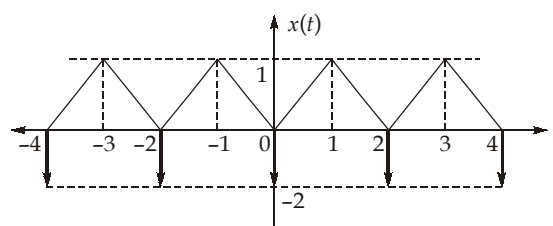
Therefore the output $Y(j\omega)$ will contain only the components which are less than $\omega = 40\pi$.



Now by putting $T_s = 0.025$, we will get



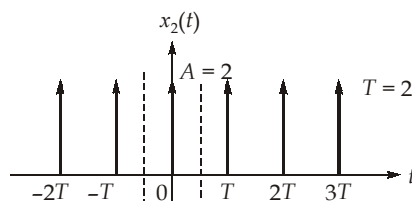
Q.183 For the figure shown below, the trigonometric Fourier series coefficient is given as a_k . Then the value of “ $-a_2$ ” is _____.



183. (2)

Let,

$$x(t) = x_1(t) - x_2(t)$$

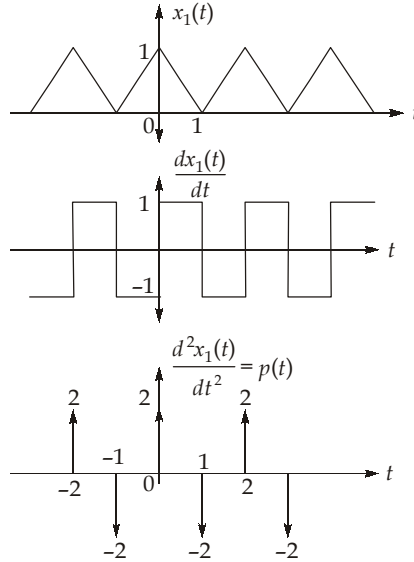


$$c_{k_2} = \frac{1}{T} \int_{-T/2}^{T/2} A \delta(t) dt = \frac{A}{T} = \frac{2}{2} = 1$$

Now,

$$x(t) = x_1(t) - x_2(t)$$

$$c_k = c_{k_1} - c_{k_2}$$



$$p(t) \leftrightarrow p_k$$

$$\frac{d^2x_1(t)}{dt^2} \leftrightarrow (jk\omega_0)^2 c_{k_1}$$

$$(jk\omega_0)^2 c_{k_1} = p_k$$

$$p_k = \frac{A}{T} - \frac{A}{T} e^{-jk\frac{(2\pi)}{T}}$$

$$p_k = \frac{2}{2} - \frac{2}{2} e^{-jk\frac{(2\pi)}{2}} = 1 - e^{-jk\pi} = 1 - (-1)^k$$

$$c_{k_1} = \frac{p_k}{(jk\omega_0)^2} = \frac{1 - (-1)^k}{(jk\omega_0)^2}$$

$$c_{k_1} = \frac{1 - (-1)^k}{-k^2 \omega_0^2}, \quad \omega_0 = \frac{2\pi}{2} = \pi$$

$$c_{k_1} = \frac{1 - (-1)^k}{-k^2 \pi^2}$$

$$c_{k_2} = \frac{A}{T} = \frac{2}{2} = 1$$

$$c_k = c_{k_1} - c_{k_2}$$

$$c_k = \frac{1 - (-1)^k}{-k^2 \pi^2} - 1$$

$$c_k = \frac{a_k}{2} - \frac{jb_k}{2}$$

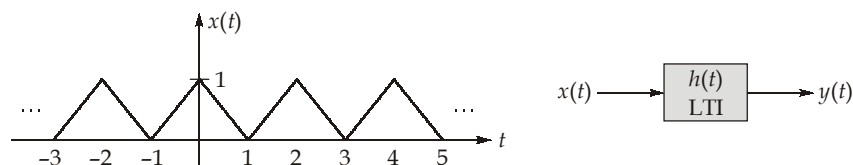
$$\Rightarrow \frac{a_k}{2} = \frac{1 - (-1)^k}{-k^2 \pi^2} - 1 \quad (\because b_k = 0, \text{ as the signal is even})$$

$$\frac{a_2}{2} = \frac{1 - (-1)^2}{-4\pi^2} - 1$$

$$a_2 = (0 - 1)^2$$

$$-a_2 = 2$$

Q.184 If $x(t)$ is represented as given below and $h(t) = \text{Sa}\left(\frac{9\pi}{2}t\right)$ then the Nyquist rate for output $y(t)$ in Hz will be _____



184. (3)

Time period for $x(t)$, $T_0 = 2$ sec

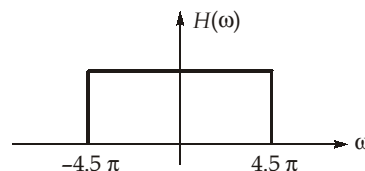
$$\omega = \frac{2\pi}{T_0} = \frac{2\pi}{2} = \pi \text{ rad/sec}$$

$$x(t) = \text{dc} + \text{odd harmonics of cos terms}$$

$$= a_0 + a_1 \cos \omega_0 t + a_3 \cos 3\omega_0 t + \dots$$

Frequency component available in input: $0, \pi, 3\pi, 5\pi, \dots$

$$h(t) = \text{Sa}(4.5\pi t)$$



L.P.F. cut off frequency,

$$\omega_c = 4.5\pi$$

Frequency component present in $y(t)$: $0, \pi, 3\pi, \dots$

upto 4.5π only 3 frequency components: $0, \pi, 3\pi$

So, $\omega_m|_{y(t)} = 3\pi \text{ rad/sec}$

Nyquist rate of output,

$$\omega_{ny}|_{y(t)} = 2\omega_m = 6\pi \text{ rad/sec}$$

So, $f_{ny}|_{y(t)} = \frac{6\pi}{2\pi} = 3 \text{ Hz}$

Q.185 Let $y[n]$ denote the convolution of $h[n]$ and $x[n]$, where $h[n] = \left(\frac{1}{4}\right)^n u[n]$ and $x[n]$ is a causal sequence. If $y[0] = 1/2$ and $y[1] = 1$, then $x[1]$ equal to _____.

185. 0.87 (0.60 to 1.00)

Given, $x[n]$ is a causal sequence,

$\therefore x[n]$ will be zero for $n < 0$.

$$y[n] = \sum_{k=-\infty}^{\infty} x[k] h[n-k]$$

and

$$h[n] = \left(\frac{1}{4}\right)^n u[n]$$

$$h[n] = \begin{cases} \left(\frac{1}{4}\right)^n & ; n \geq 0 \\ 0 & ; n < 0 \end{cases}$$

$$\therefore h[0] = 1, \quad h[1] = \frac{1}{4}, \quad h[2] = \frac{1}{16}$$

$$y[0] = x[0] h[0] + x[1] h[-1] + \dots$$

$$\frac{1}{2} = x[0] (1) + x[1] \times 0$$

$$\therefore x[0] = \frac{1}{2}$$

$$y[1] = x[0] h[1] + x[1] h[0] + x[2] h[-1] + \dots$$

$$1 = \left(\frac{1}{2}\right)\left(\frac{1}{4}\right) + x[1](1) + x[2](0)$$

$$1 - \frac{1}{8} = x[1]$$

$$\therefore x[1] = \frac{7}{8} = 0.875$$

Q.186 A signal $x(t) = e^{-t} u(t)$ is passed through an ideal low pass filter with cut-off frequency of ω_c rad/sec, then the value of ω_c for the output energy of low pass filter is 75% of the input energy will be _____ rad/sec.

186. 2.414 (2.00 to 2.60)

Given input signal $x(t) = e^{-t} u(t)$

Energy of the input signal

$$\begin{aligned} E_i &= \int_{-\infty}^{\infty} |x(t)|^2 dt = \int_{-\infty}^{\infty} |e^{-t} u(t)|^2 dt \\ &= \int_0^{\infty} e^{-2t} dt = \left[\frac{e^{-2t}}{-2} \right]_0^{\infty} = \frac{1}{2} = 0.5 \text{ Joule} \end{aligned}$$

now, ESD [Energy spectral density] of the output $y(t)$ is given by

$$E_y(\omega) = |H(\omega)|^2 E_x(\omega)$$

$$\therefore E_x(\omega) = |X(\omega)|^2$$

$$X(\omega) = FT[x(t)] = FT[e^{-t} u(t)] = \frac{1}{1 + j\omega}$$

$$E_x(\omega) = |X(\omega)|^2 = \frac{1}{1 + \omega^2}$$

for a LPF, the square of the transfer function is given is

$$|H(\omega)|^2 = \begin{cases} 1, & |\omega| < \omega_c \\ 0, & \text{otherwise} \end{cases}$$

$$E_y(\omega) = |H(\omega)|^2 E_x(\omega) = \begin{cases} \frac{1}{1 + \omega^2}, & |\omega| < \omega_c \\ 0, & \text{otherwise} \end{cases}$$

$\therefore$ The total energy of the output signal is

$$E_0 = \frac{1}{2\pi} \int_{-\infty}^{\infty} E_y(\omega) d\omega \quad [\because E_y(\omega) \text{ is an even function of } \omega]$$

$$= \frac{1}{\pi} \int_0^{\infty} E_y(\omega) d\omega = \frac{1}{\pi} \int_0^{\omega_c} \frac{1}{1 + \omega^2} d\omega$$

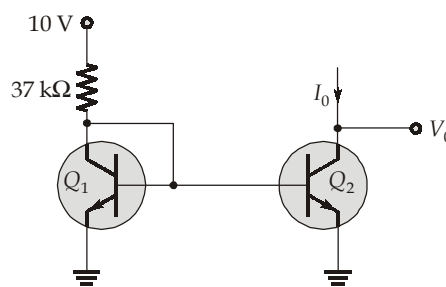
$$\text{at } \omega = \omega_c \quad 0.75 \left[\frac{1}{2} \right] = \frac{1}{\pi} \tan^{-1}(\omega_c)$$

$$\tan^{-1} \omega_c = 0.75 \times \frac{\pi}{2}$$

$$\omega_c = \tan \left[0.75 \times \frac{\pi}{2} \right]$$

$$\omega_c = 2.414 \text{ rad/sec}$$

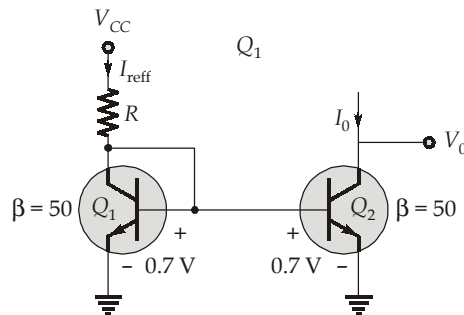
Q.187 Consider the circuit shown in the figure below:



Both the transistors Q_1 and Q_2 are matched with $\beta = 50$. The value of $V_{BE} = 0.7 \text{ V}$, the value of current I_0 is equal to _____ mA.

187. 0.241 (0.22 to 0.26)

The circuit can be redrawn as,



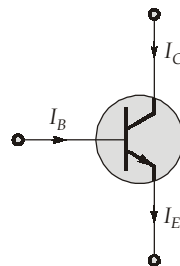
For current mirror circuit,

$$I_{\text{reff}} = \frac{V_{CC} - V_{BE}}{R} = \frac{10 - 0.7}{37 \times 10^3} = 0.251 \text{ mA}$$

now,

$$I_0 = \frac{I_{\text{reff}}}{\left(1 + \frac{2}{\beta}\right)} = \frac{0.251}{\left(1 + \frac{2}{50}\right)} = 0.241 \text{ mA}$$

Q.188 Consider the BJT shown below:



Which of the following relation is correct?

- (a) $I_C + I_E + \beta I_B = 0$ (b) $I_C = \beta I_B + \frac{1}{1 + \beta} I_{CO}$
 (c) $I_C = \beta I_B + \frac{1}{1 - \alpha} I_{CO}$ (d) $I_C = \alpha I_B + (1 + \beta) I_{CO}$

188. (c)

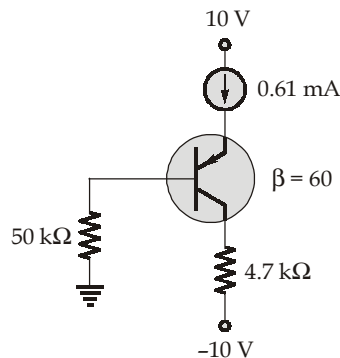
$$I_C = \beta I_B + (1 + \beta) I_{CO}$$

but $\beta = \frac{\alpha}{1 - \alpha}$

$$\therefore I_C = \beta I_B + \left(1 + \frac{\alpha}{1 - \alpha}\right) I_{CO} = \beta I_B + \frac{1 - \alpha + \alpha}{1 - \alpha} I_{CO}$$

$$I_C = \beta I_B + \frac{1}{1 - \alpha} I_{CO}$$

Q.189 Consider the circuit shown in the figure below.



When the transistor is biased in active region. The value of voltage $|V_{BE}| = 0.7 \text{ V}$, then the value of power dissipated by the transistor is equal to _____ mW.

189. 5.028 (4.90 to 5.10)

Assuming the transistor to be in active region, we get,

$$I_C = \alpha I_E = \frac{\beta}{1+\beta} \cdot I_E = \frac{60}{61} \times 0.61 \times 10^{-3} \\ = 0.6 \text{ mA}$$

Now, the voltage at $V_C = -10 + 4.7 \times 0.6 = -7.18 \text{ V}$

$$\text{Value of } I_B = \frac{I_C}{\beta} = \frac{0.6}{60} \times 10^{-3} = 1 \times 10^{-5} \text{ A} = 10 \mu\text{A},$$

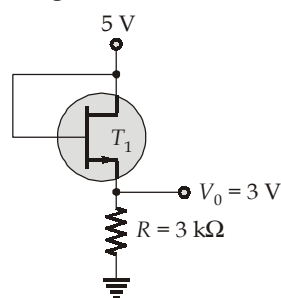
$$\text{now, } V_B = I_B R_B \\ = 10 \times 10^{-6} \times 50 \times 10^3 = 0.5 \text{ V}$$

$$\therefore V_E = V_B + V_{EB} = 0.5 + 0.7 = 1.2 \text{ V}$$

$$V_{EC} = 1.2 - (-7.18) = 8.38 \text{ V}$$

$$\therefore \text{Power dissipated} = V_{EC} \times I_C = 8.38 \times 0.6 \times 10^{-3} = 5.028 \text{ mW}$$

Q.190 Consider the circuit shown in the figure below:



For the transistor T_1 , the value of $\mu_n C_{ox} = 50 \text{ mA/V}^2$ and $V_t = 1 \text{ V}$. Then the value of $\left(\frac{W}{L}\right)$ for the transistor is _____ .

(Assuming, there is no channel length modulation)

190. 0.04 (0.01 to 0.10)

In the transistor $V_{GS} = V_{DS}$

Since, the gate and drain terminals are shorted,

the transistor will always be in saturation mode.

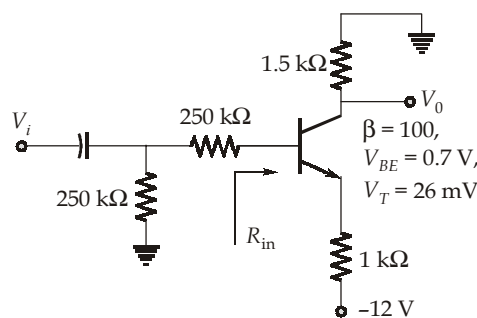
$$\text{thus, } I_D = \frac{\mu_n C_{ox}}{2} \left(\frac{W}{L} \right) (V_{GS} - V_t)^2$$

$$\text{now, } I_D = \frac{V_0}{R} = \frac{3}{3} \times 10^{-3} = 1 \text{ mA}$$

$$\text{thus, } 1 \times 10^{-3} = \frac{50 \times 10^{-3}}{2} \left(\frac{W}{L} \right) \times (2 - 1)^2$$

$$\left(\frac{W}{L} \right) = \frac{1}{25} = 0.04$$

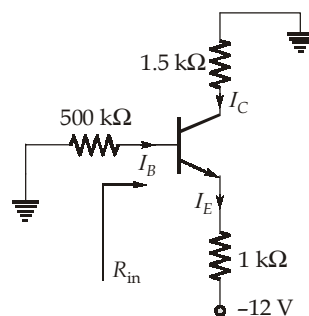
Q.191 Consider the circuit given below:



The value of input resistance R_{in} is _____ $k\Omega$.

191. 102.38 (102.00 to 102.50)

Base emitter loop



$$500 k I_B + 0.7 + 1 k (I_B + I_C) = 12$$

$$I_C = 100 I_B$$

$$I_E = 101 I_B$$

from here

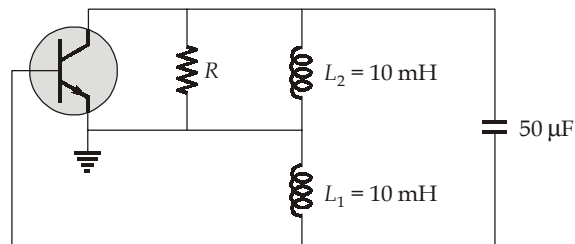
$$I_B = 18.80 \mu A$$

$$r_\pi = \beta \times \frac{V_T}{I_C} = \frac{V_T}{I_B} = \frac{26}{18.8} k\Omega = 1.383 k\Omega$$

$$R_{in} = r_\pi + (1 + \beta) R_E$$

$$= 1.383k + 101 \times 1k = 102.383 k\Omega$$

Q.192 Consider the circuit shown in the figure below.



If the biasing condition of the circuit is met for the circuit to start oscillating, then the frequency of oscillation is equal to _____ Hz.

192. 159.15 (158.60 to 159.60)

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

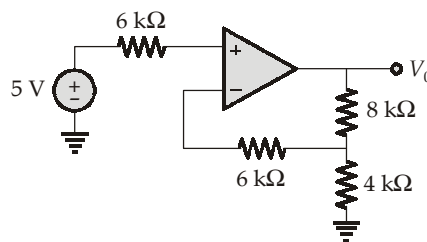
$$L_{eq} = L_1 + L_2 = 10 \times 10^{-3} + 10 \times 10^{-3}$$

$$= 20 \times 10^{-3} \text{ H}$$

$$C = 50 \times 10^{-6} \text{ F}$$

$$\therefore f = \frac{10^3}{2\pi} = 159.15 \text{ Hz}$$

Q.193 Consider the circuit shown in the figure below:



Then, the value of output voltage V_0 is equal to _____ V.

193. (15)

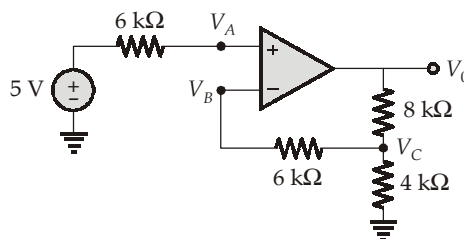
Applying virtual ground concept,

we have $V_A = V_B = 5 \text{ V}$

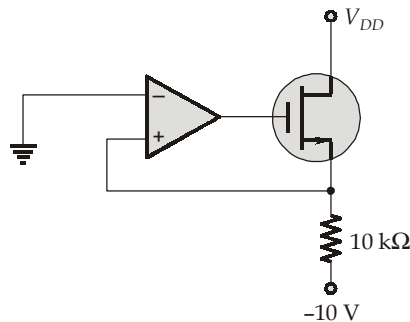
$\therefore$ Current does not flow in the $6 \text{ k}\Omega$ branch thus,

$$V_C = 5 \text{ V}$$

$$\text{Thus, } V_0 = \left(\frac{8+4}{4} \right) \times V_C = 3 \times 5 = 15 \text{ V}$$



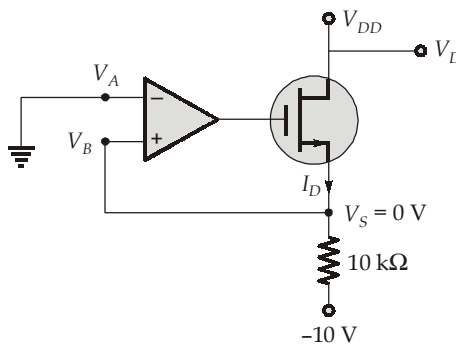
Q.194 Consider the circuit shown in the figure below:



The MOSFET is biased in saturation region having $V_T = 2.5$ V and $\frac{\mu_n C_{ox} W}{L} = 0.5$ mA/V. The minimum value of V_{DD} for which the MOSFET will remain in saturation region is _____ V.

194. (2)

For the transistor



$$V_S = V_B = V_A$$

due to virtual ground,

thus,

$$V_S = 0 \text{ V}$$

Hence,

$$I_D = \frac{0 - (-10)}{10 \times 10^3} = 1 \text{ mA}$$

$$I_D = \frac{\mu_n C_{ox} W}{2L} (V_{GS} - V_T)^2$$

$\therefore$

$$V_{GS} - V_T = \sqrt{\frac{I_D}{\frac{\mu_n C_{ox} W}{2L}}}$$

$$V_{GS} - V_T = \sqrt{\frac{1 \times 10^{-3}}{0.5 \times 10^{-3} \times 2}}$$

$$V_{GS} - V_T = 2 \text{ V}$$

For the MOSFET to be in saturation region

$$V_{DS} \geq V_{GS} - V_T$$

∴ at the edge of saturation

$$\begin{aligned} V_{DS} &= V_{GS} - V_T = 2 \text{ V} \\ \therefore V_S &= 0 \\ \therefore V_D &= V_G - V_T \\ \Rightarrow V_{DD} &= 2 \text{ V} \end{aligned}$$

Q.195 Two wattmeter method is used to measure power in circuit supplied by a 3- ϕ , 440 V, 50 Hz feeding a balanced 3- ϕ load. The readings obtained from the wattmeter 1 and wattmeter 2 were 4 kW and 1 kW respectively. It was found that while taking second reading (1 kW) the current coil of second wattmeter were interchanged. The value of power factor will be _____ (upto 3 decimal places)

195. 0.327 (0.320 to 0.332)

Wattmeter -1 reading, $P_1 = 4 \text{ kW}$

Wattmeter -2 reading, $P_2 = 1 \text{ kW}$

For second reading as the terminals current coil were reversed

∴ Actual reading = -1 kW

$$\begin{aligned} \text{Power factor} &= \cos \phi = \cos \left[\tan^{-1} \sqrt{3} \frac{(P_1 - P_2)}{P_1 + P_2} \right] \\ &= \cos \left[\tan^{-1} \sqrt{3} \frac{(4 - (-1))}{(4 + 1)} \right] \\ &= \cos \left[\tan^{-1} \sqrt{3} \left(\frac{5}{3} \right) \right] = \cos(70.893^\circ) = 0.327 \end{aligned}$$

Q.196 A dynamometer type wattmeter with pressure coil angle of 2° measure 400 W for 1 - ϕ inductive load supplied by 230 V. If this wattmeter is replaced by another wattmeter with pressure coil angle 1° reading obtained is 320 W. The value of current drawn by load is

- (a) 10.45 A (b) 12.42 A
(c) 19.99 A (d) 16.32 A

196. (c)

Given, Supply voltage, $V = 230 \text{ V}$

Reading of dynamometer type wattmeter

$$P = VI \cos(\phi - \beta) \cos \beta$$

$$\text{If } \beta = 2^\circ \quad 400 = 230 \times I \times \cos(\phi - 2^\circ) \cos 2^\circ \quad \dots(i)$$

$$\text{If } \beta = 1^\circ \quad 320 = 230 \times I \times \cos(\phi - 1^\circ) \cos 1^\circ \quad \dots(ii)$$

Using (i) and (ii), we get

$$\frac{VI \cos(\phi - 2^\circ) \cos 2^\circ}{VI \cos(\phi - 1^\circ) \cos 1^\circ} = \frac{400}{320}$$

$$[\cos \phi \cos 2^\circ + \sin \phi \sin 2^\circ] = 1.25 \times [\cos 1^\circ \cos \phi + \sin 1^\circ \sin \phi]$$

$$\sin \phi [\sin 2^\circ - 1.25 \times \sin 1^\circ] = \cos \phi [1.25 \cos 1^\circ - \cos 2^\circ]$$

$$\tan \phi = \left\{ \frac{1.25 \cos 1^\circ - \cos 2^\circ}{\sin 2^\circ - 1.25 \sin 1^\circ} \right\}$$

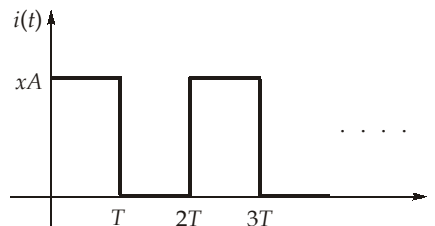
$$\phi = 87.01^\circ$$

$$\begin{aligned}\text{Using power relation} &= VI \cos(\phi - 1^\circ) \cdot \cos 1^\circ = 320 \\ 230 \times I \cos(87.01^\circ - 1^\circ) \cos 1^\circ &= 320\end{aligned}$$

$$I = \frac{320}{230 \times \cos(86.01^\circ) \cos 1^\circ}$$

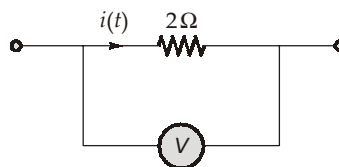
$$I = 19.99 \text{ A}$$

Q.197 A resistance of 2Ω in a circuit is carrying a current which has a waveform as shown below:



A moving iron voltmeter is connected across the resistance which shows reading as 18 V. The value of x shown in waveform will be _____ (upto 2 decimal places)

197. 12.73 (12.70 to 12.76)



Moving iron instrument reads rms value

$$\therefore V_{\text{rms}} = 18 \text{ V}$$

$$\text{We know, } V_{\text{rms}} = I_{\text{rms}} R$$

$$I_{\text{rms}} = \frac{18}{2} = 9 \text{ A}$$

RMS value of the given waveform

$$i_{\text{rms}} = \sqrt{\frac{1}{2T} \{x^2(T) + 0(T)\}}$$

$$i_{\text{rms}} = \frac{x}{\sqrt{2}}$$

$$\begin{aligned}\therefore x &= 9 \times \sqrt{2} \\ &= 12.727 \approx 12.73\end{aligned}$$

Q.198 A wattmeter is used to measure the power supplied to a circuit at a certain power factor. The supply frequency is 60 Hz. The wattmeter's potential coil has resistance of 6000Ω and inductance of 3 H. If the expected error in reading is 6%, then the value of power factor in the circuit will be _____ (upto 3 decimal place).

198. 0.953 (0.948 to 0.958)

Given, expected error (% ϵ_r) = 6%

Potential coil inductance, $L_p = 3 \text{ H}$

Potential coil resistance, $R_p = 6000 \Omega$

Supply frequency, $f = 60 \text{ Hz}$

$$\% \epsilon_r = \tan \phi \tan \beta \times 100$$

$$= \tan \phi \left(\frac{2\pi f L_p}{R_p} \right) \times 100 \quad (\text{Where } \phi \text{ is power factor angle})$$

$$6 = \tan \phi \left(\frac{2\pi \times 60 \times 3}{6000} \right) \times 100$$

$$\tan \phi = \frac{6}{18.85} = 0.3183$$

$$\phi = \tan^{-1} (0.3183)$$

$$\phi = 17.65^\circ$$

So, power factor, $\cos \phi = 0.953$

Q.199 A slide wire in a potentiometer is 200 cm long and has resistance value of 500Ω . This potentiometer has a working battery voltage of 5 V. The setup is standardized with 1.018 V standard cell with sliding contact at length of 101.8 cm of slide wire. The value of measurement range will be _____ V.

199. 2 (1.8 to 2.0)

Standardization is done with emf : 1.018 V

The sliding contact was at 101.8 cm

The resistance of 101.8 cm long slide wire

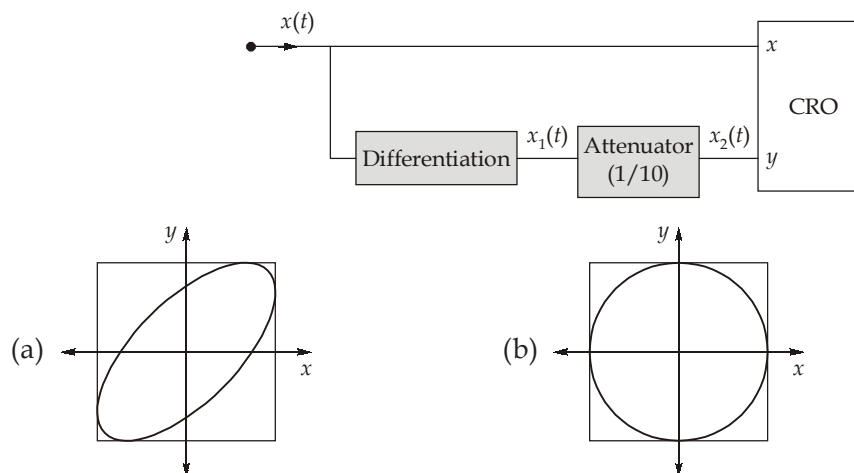
$$\frac{101.8}{200} \times 500 = 254.5 \Omega$$

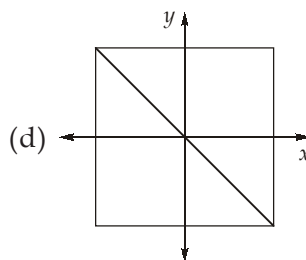
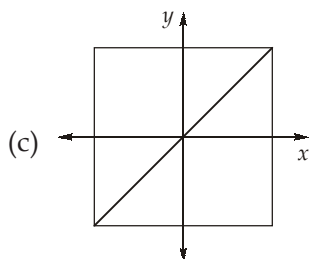
$$\text{The current in slide wire} = \frac{V}{R} = \frac{1.018}{254.5} = 4 \text{ mA}$$

The measurement range of slide wire

$$= (4 \times 10^{-3}) (500) = 2 \text{ V}$$

Q.200 A CRO setup working in x - y mode is shown below. If the input $x(t)$ is a sinusoidal signal with amplitude of 12 units and $\omega = 10 \text{ rad/sec}$, then the waveform observed on CRO screen will be





200. (b)

Given, input signal $x(t) = 12 \sin(10t)$

$$x_1(t) = \frac{dx(t)}{dt} = 12 \times 10 \cos 10t$$

$$= 120 \cos 10t$$

$$x_2(t) = \frac{x_1(t)}{10} = 12 \cos 10t$$

So, $x_1(t)$ and $x_2(t)$ are same signals with phase displacement of 90° . The CRO output is circle.

○○○○